*** INVITATION TO QUOTERS ***

NOTICE IS HEREBY GIVEN THAT THE BOARD OF PUBLIC WORKS OF THE CITY OF BLOOMINGTON, INDIANA WILL RECEIVE SEALED QUOTES FOR THE FOLLOWING:

CLASS 'A' PORTLAND CEMENT CONCRETE (per INDOT specification included for reference)

Separate sealed quote(s) for the above product(s), will be received in the Office of the Department of Public Works in the Showers Center, 401 N. Morton Street, Bloomington, Indiana, at or before 10:00 a.m. (local time) on Tuesday, April 2, 2013. Sealed quotes will be opened and read aloud at a public meeting at 10:00 a.m. (local time) on Tuesday, April 2, 2013 in the McCloskey Conference Room. Any quotes received after this designated time will be returned unopened. Quotes will be reviewed and the award may be made at the April 9, 2013, Board of Public Works meeting.

Specifications and all necessary quote forms may be obtained at the following location;

http://bloomington.in.gov/sections/viewSection.php?section_id=537

Each quoter shall file with his or her sealed proposal a bond equal to 5 percent of the quote, and all documents required by the City of Bloomington and the State of Indiana, as set forth in the Instructions to Quoters.

Each quoter for contracts over $10,000 must submit their written Affirmative Action Plan to the City **AT LEAST TWENTY-FOUR HOURS BEFORE THE BIDDING DEADLINE.** Each quoter must insure that all employees and applicants for employment are not discriminated against because of any race, religion, color, sex, national origin, ancestry, or handicap. All the protected classes must be included in your Affirmative Action Plan for it to be acceptable. In addition to other requirements, your plan **MUST** include a workforce breakdown, an internal grievance procedure, for implementation of the Plan, specific plans for recruitment from minorities, equal access to training programs, a non-retaliation statement, and an explanation of your methods of communicating the operations of your Affirmative Action Plan to your employees and prospective recruits.

You should submit your plan **SEPARATELY** from the sealed quote. The Contract Compliance Officer for the City of Bloomington is Barbara McKinney. **EACH QUOTER MUST REVIEW HIS OR HER AFFIRMATIVE ACTION PLAN WITH BARBARA MCKINNEY IN ADVANCE OF THE QUOTING DEADLINE.** Her telephone number is (812) 349-3429. Her office hours are from 8:00 a.m. to 5:00 p.m. Monday through Friday. **EACH QUOTER's WORKFORCE BREAKDOWN FIGURES MUST BE UPDATED EVERY SIX MONTHS.** QUOTERS WHO FAIL TO SUBMIT ACCEPTABLE PLANS ARE SUBJECT TO DISQUALIFICATION.

The Board of Public Works reserves the right to waive any informality and to accept or reject any or all quotes submitted.

Quotes may be held by the Board of Works for a period not-to-exceed sixty (60) days, from the date of the opening of quotes for the purpose of reviewing the quotes and investigating the qualifications of the quoter prior to awarding the contract.

BOARD OF PUBLIC WORKS
CITY OF BLOOMINGTON
Charlotte Zietlow, President

CITY OF BLOOMINGTON
PUBLIC WORKS

INSTRUCTIONS TO QUOTERS

Concrete is to be delivered to job sites within the City of Bloomington Municipal Boundary (corporation limits) for the City of Bloomington, Indiana.

The vendor must be willing to establish separate accounts and to provide individual billings to each property owner where concrete is delivered, as ordered and designated by City Street Department. The property owner will be responsible for paying invoices and the City will not be responsible for delinquent accounts. Property owners will be charged the same price as quoted to the City of Bloomington. Vendor may require payment in advance if it is determined that the property owner is a bad credit risk.

It shall be the responsibility of the vendor to provide itemized monthly billings to Street Department for concrete to be paid for by Street Department.

Should Quoter not be able to provide specified concrete within the properly notified timeframe on the next business day, the City of Bloomington may seek an alternative supplier for that day.

Prices quoted shall hold until January 31, 2014. The contract to supply materials or supplies may be renewed beyond the expiration date to another term, not to exceed one additional year, by agreement of both the City and the Bidder.

Quoter must state as a part of the bid, any charges for partial loads and/or any minimum load amounts.

Quoter must agree to honor quote prices for purchases made by all City of Bloomington Departments and Contractors performing work under contract for the City of Bloomington.

Quoter shall provide specified concrete within 24 hours notice for delivery during regular business hours (7:00a.m. – 4:00p.m.) Monday through Friday. Deliveries shall be no more than 60 minutes from scheduled delivery time.

All material shall meet the specifications as described in Sections 600, 700, 900 (attached) of the Indiana Department of Transportation (INDOT) Standard Specifications dated 2012 or newer. Batch plants and delivery vehicles shall meet all INDOT requirements for the storage, preparation, mixing and delivery of concrete material. Supplied material will be subject to testing for conformance to all specifications, and a concrete mix design shall be submitted for each type of Class A Concrete supplied. Material found not to meet the required specifications will be removed and replaced at the expense of the material supplier.

All quotes will be submitted on Form #95 (attached) as prescribed by Indiana State Board of Accounts, and include all requirements stated above and in compliance with all quote documentation with regard to the manufacture and delivery of material.

Questions should be directed to Joe Vandeventer, Street Superintendent, Bloomington Street Department, 812.349.3448.

BID, OFFER OR PROPOSAL FOR SALE OR LEASE OF MATERIALS

CLASS A PORTLAND CEMENT CONCRETE
(PLEASE TYPE OR PRINT MATERIAL NAME)

_____
(DATE)

1. Governmental Unit: City of Bloomington Board of Public Works
2. County: Monroe
3. Bidder (Firm): _____

Address: _____

City/State/Zip Code: _____

4. Telephone Number: _____
5. Agent of Bidder (if applicable): _____

Pursuant to notices given, the undersigned offers bid(s) City of Bloomington Board of Public Works. In Accordance with the following attachment(s) which specify the class or item number or description, quantity, unit price and total amount.

The Contract will be awarded by classes or items, in accordance with specifications. Any changes or alterations in the items specified will render such bid void as to that class or item. Bidder promises that he/she has not offered nor received a less price than that price stated in his/her bid for the materials included in said bid. Bidder further agrees that he/she will not withdraw his/her bid from the office in which it is filed. A certified check or bond will be filed with each bid if required, and liability for breach shall be enforceable upon the contract, the bond or certified check or both as case may be.

_____
SIGNATURE OF BIDDER OR AGENT

BID OFFER OR PROPOSAL

Attach separate sheet listing each item bid based on specifications published by governing body. The following is an example of this bid format:

CLASS OR ITEM	QUANTITY	UNIT	DESCRIPTION	UNIT PRICE	AMOUNT

NON-COLLUSION AFFIDAVIT

STATE OF INDIANA)
) SS:
_____ COUNTY)

The undersigned bidder or agent, being duly sworn on oath, says that he/she has not, nor has any other member, representative, or agent of the firm, company, corporation or partnership representative represented by him/her, entered into any combination, collusion or agreement with any person relative to the price to be bid by anyone at such letting nor to prevent any person from bidding nor to induce anyone to refrain from bidding, and that this bid is made without reference to any other bid and without any agreement, understanding or combination with any other person in reference to such bidding.

He/She further says that no person or persons, firms, or corporation has, have or will receive directly or indirectly, any rebate, fee, gift, commission or thing of value on account of such sale.

_____
BIDDER (FIRM)

_____
SIGNATURE OF BIDDER OR AGENT

Subscribed and sworn to me this _____ day of _____ 20 _____

My Commission Expires: _____ _____
Notary Public

County of Residence: _____

ACCEPTANCE

There now being sufficient unobligated appropriated funds available, the contracting authority of City of Bloomington Board of Public Works hereby accepts the terms of the attached bid for classes or items numbered and promises to pay the undersigned bidder upon delivery of the price quoted for the materials stipulated in said bid.

BOARD OF PUBLIC WORKS MEMBERS:

_____
JAMES MCNAMARA, MEMBER

_____ _____
CHARLOTTE ZIETLOW, PRESIDENT DR. FRANK N. HRISOMALOS, MEMBER

BID, OFFER OR PROPOSAL FOR SALE OR LEASE OF MATERIALS

CLASS 'A' PORTLAND CEMENT CONCRETE

	CLASS OR ITEM	QUANTITY	UNIT	DESCRIPTION	UNIT PRICE	TOTAL AMOUNT
1.	CONCRETE CLASS A	+/- 1000	CYD	CLASS 'A' CONCRETE*		
2.	CONCRETE W/ADDITIVE	+/- 500	CYD	CLASS 'A' CONCRETE WITH 2% CALCIUM*		
3.	CONCRETE W/ADDITIVE	+/- 200	CYD	CLASS 'A' CONCRETE WITH REINFORCEMENT*		
4.	MINIMUM LOAD FEE	1	TRIP	CHARGE IF LESS THAN 3 CYD ORDERED		

*Per INDOT Specifications. Sections 600, 700, and 900 attached for reference. Other sections may be applicable for conformance to complete specifications. It is the responsibility of the supplier to ensure they familiarize and understand all requirements for material bidding, and disqualification may occur at the discretion of the Board of Public Works should a supplier or their material not meet the requirements.

City of Bloomington
Human Rights Commission

2013

RE: Affirmative Action and Living Wage Ordinance

To Prospective Bidder:

Affirmative Action: All bidders with the City of Bloomington for projects in excess of $10,000.00 must submit an affirmative action plan to my office. This plan must ensure that applications are employed and that employees are treated in a manner that provides equal employment opportunity and tends to eliminate inequality based upon race, religion, color, sex, national origin, ancestry or disability.

In addition, pursuant to the **Responsible Bidders Ordinance**, all bidders with the City of Bloomington for public work bids of $150,000.00 or more must include two additional protected categories in their affirmative action plan: sexual orientation and gender identity.

Even if your company already has a plan on file with the City, you must check with me to make sure that it complies with our current requirements. If you already have a plan, but it does not cover all of the City's current requirements, you may submit a separate supplement with your plan to fill any gaps.

You must submit your written affirmative action plan (or supplement) to me at least twenty-four hours before the bid deadline. You must submit your plan to me separately from your bid. The twenty-four hours will give me sufficient time to review your and the other bidders' plans. I recommend that you submit your affirmative action plan to me earlier, if possible, so that you and I will have time to work out any problems that may be in your plan. Bidders who fail to submit acceptable plans by the deadline are subject to disqualification.

I strongly advise you to confirm with me that I have received your plan and that it meets our requirements well before the bid deadline. We will make every effort to work with you to clear up problems, but it remains your responsibility to confirm that I received your plan and that it complies with our requirements. If you fail to confirm that I received and approved your plan, you risk losing your eligibility to bid. We will be glad to provide a receipt upon request. Please let us know if you want a receipt when you submit your plan.

You must ensure that all the protected classes listed above are included in your plan. In addition to other requirements, your plan MUST include a workforce breakdown, and internal grievance procedure, a non-retaliation statement, designation of a person by name or position who is responsible for implementing the plan, applicability to both applicants and employees, recruitment of minorities, equal access to training programs, and an explanation of your methods of communicating the operations of your affirmative action plan to your employees and prospective applicants.

Accompanying this letter you will find the following materials:

1) A workforce breakdown form. You MUST submit a workforce breakdown (sometimes called a "utilization report") with your Affirmative Action Plan. This form is provided for your convenience. If you already have a current form you have completed for another jurisdiction that includes the same type of information, you may substitute for instead of using our form. Your workforce breakdown figures must be updated every six months. Even if you already have an acceptable affirmative action plan on file with my office, you should submit a new workforce breakdown each time you bid for a City Contract, to be sure we have up to date figures.

401 North Morton Street – Bloomington, IN 47404 Phone: (812) 349.3429 - Fax: (812) 349.3441
www.bloomington.in.gov
email: human.rights@bloomington.in.gov

2) An affirmative Action Plan checklist. I will use this checklist to review your Affirmative Action Plan. If you compare your plan with this list, you should be able to tell whether your plan fulfills the City's requiremnts. If you omit any of the elements on the checklist, your plan will not be approved.
3) Two sample Affirmative Action Plan: one for bidders covered by the Responsible Bidders Ordinance and one for all other bidders. These may be useful if your company has never designed an Affirmative Action Plan before. Feel free to adopt one of these plans as your own or to amend them to meet your needs.

Additional materials, such as the City of Bloomington's Contract Compliance Regulations, are available from my office upon request.

Living Wage: Also, please be aware that you may be required to comply with the Bloomington Living Wage Ordinance. Whether the LWO applies to your project depends upon the size and type of your project and the number of people you employ. If you have questions about the applicability of the LWO, click on the LWO flow chart at www.bloomington.in.gov/livingwage or call me. For 2013, the living wage for covered employees is $11.85 an hour.

If you have any questions, contact me at 812.349.3429 or email me at mckinneb@bloomington.in.gov. My office hours are Monday through Friday, 8:00a.m.-5:00p.m.

Thank you,

Barbara E. McKinney
Human Rights Director/Contract Compliance Officer

BLOOMINGTON HUMAN RIGHTS COMMISSION

Model Affirmative Action Plan
for
Bidders Covered by Responsible Bidder Ordinance

Policy Statement

_____, Inc., declares its policy to provide equal opportunity in employment, training and advancement, and to administer its employment practices without regard to race, color, religion, sex, national origin, ancestry, disability, sexual orientation or gender identity. Our policy of nondiscrimination will prevail throughout every aspect of our employment practices, including recruitment, hiring, training and all other terms and conditions of employment. We shall implement an affirmative action plan to make it widely known that equal employment opportunities are available on the basis of individual merit. We shall survey and analyze our employment workforce annually to determine what steps, if any, are needed to conform effectively with this equal employment policy.

Responsible Officer

Mr. or Ms._____ (or the _____ officer) is the equal employment opportunity officer for our company and is responsible for implementing this affirmative action policy.

Publication of Policy

Our employees will be made aware of our commitment to affirmative action through the following procedures:

- posting notices on employee bulletin boards,
- including our policy statement and plan in our personnel manual,
- regularly sending out notice of our policy in paycheck envelopes,
- and training supervisors to recognize discriminatory practices.

We will make potential employees aware of our policy through the following procedures:

- including the words "Equal Opportunity Employer" in all of our advertisements and notices for job openings,
- notifying employment agencies about our commitment, and
- sending notice of our policy to unions.

Implementing Our Policy

Our affirmative action plan will be implemented by widening our recruitment sources. We shall advertise in newspapers and other media that reach people in protected classes. We shall send job notices to schools with large percentages of students in the protected classes and to local groups that serve these classes.

We shall examine our hiring practices periodically to insure that we consider only job-related qualifications in filling our positions. We shall discard irrelevant educational requirements and unnecessary physical requirements. We shall retain only job-related questions on our employment application.

We shall keep affirmative action information on each applicant, but separate from his or her application. We shall keep records on our hiring decisions to evaluate the success of our affirmative action measures. We shall decide placement, duties, benefits, wages, training prospects, promotions, layoffs and terminations without regard to race, sex, religion, color, national origin, ancestry, disability, sexual orientation or gender identity.

Grievance Procedure

If an employee feels he or she has been discriminated against on the basis of race, sex, religion, color, national origin, ancestry, disability, sexual orientation or gender identity he or she may bring the complaint to his or her immediate supervisor. If the complaint is not resolved readily at that level, he or she may submit it to _____ (personnel officer, corporate president, other) who will make a final decision on its validity. This grievance process does not preclude his or her complaining to local, state or federal civil rights agencies. We will not retaliate against an employee or applicant for voicing a grievance or for filing a complaint with the appropriate agency.

Our current workforce breakdown is shown on the attached form.

_____ _____

Corporate President Date

BLOOMINGTON HUMAN RIGHTS COMMISSION

MODEL AFFIRMATIVE ACTION PLAN

POLICY STATEMENT

_____, Inc., declares its policy to provide equal opportunity in employment, training and advancement, and to administer its employment practices without regard to race, color, religion, sex, national origin, ancestry or disability. Our policy of non-discrimination will prevail throughout every aspect of our employment practices, including recruitment, hiring, training and all other terms and conditions of employment. We shall implement an affirmative action plan to make it widely known that equal employment opportunities are available on the basis of individual merit. We shall survey and analyze our employment workforce annually to determine what steps, if any, are needed to conform effectively with this equal employment policy.

RESPONSIBLE OFFICER

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Our Affirmative Action Plan will be implemented by widening our recruitment sources. We shall advertise in newspapers and other media that reach people in protected classes. We shall send job notices to schools with large percentages of students in the protected classes and to local groups that serve these classes.

We shall examine our hiring practices periodically to insure that we consider only job-related qualifications in filling our positions. We shall discard irrelevant educational requirements and unnecessary physical requirements. We shall retain only job-related questions on our employment application.

We shall keep affirmative action information on each applicant, but separate from his or her application. We shall keep records on our hiring decisions to evaluate the success of our affirmative action measures. We shall decide placement, duties, benefits, wages, training prospects, promotions, layoffs and terminations without regard to race, sex, religion, color, national origin, ancestry, or disability.

GRIEVANCE PROCEEDURE

If an employee feels he or she has been discriminated against on the basis of race, sex, religion, color, national origin, ancestry or disability he or she may bring the complaint to his or her immediate supervisor. If the complaint is not resolved readily at that level, he or she may submit it to _____ (personnel officer, corporate president, other) who will make a final decision on its validity. This grievance process does not preclude his or her complaining to local, state, or federal civil rights agencies. We will not retaliate against an employee or applicant for voicing a grievance or for filing a complaint with the appropriate agency.

Our current workforce breakdown is shown on the attached form.

_____ _____

Corporate President Date

AFFIRMATIVE ACTION PLAN CHECKLIST

NOTE: This is **not** an Affirmative Action Plan Effective Date: _____

Contractor: Plan MUST Include:		**Yes**	**No**	**Comments:**
Policy statement of equal employment opportunity		☐	☐	
Covers:	Applicants for employment	☐	☐	
	Employees	☐	☐	
On basis of:	Race	☐	☐	
	Religion	☐	☐	
	Color	☐	☐	
	Sex	☐	☐	
	National Origin	☐	☐	
	Ancestry	☐	☐	
	Disability	☐	☐	
	Sexual Orientation*	☐	☐	
	Gender Identity*	☐	☐	
Designates a person responsible for implementation of the Plan		☐	☐	
Provides for communication of the policy:				
	Within the Organization	☐	☐	
	Outside the Organization	☐	☐	
	(e.g., recruitment sources, unions)			
Applies to all terms and conditions of employment (e.g., hiring, placement, promotion, duties, wages, benefits, use of facilities, layoff, discipline, termination)		☐	☐	
Provision for: Recruitment from minority groups		☐	☐	
Provision for: Equal access to training programs		☐	☐	
Grievance Procedure		☐	☐	
Prohibits retaliation for filing grievances		☐	☐	
Workforce Breakdown		☐	☐	
(figures up to date within 6 months)				

WORKFORCE BREAKDOWN FORM

COMPANY NAME: _____

ADDRESS: _____

_____

REPRESENTATIVE: _____

CONTACT PHONE NUMBER _____

Position, Title Class or Category	Total Number Employees in Each Position	Total Number Minority Employees	Percent of Total	Total Number Female Employees	Percent of Total	Total Number Employees with Disabilities	Percent of Total

I swear or affirm under penalties of perjury that this workforce breakdown is accurate, to the best of my knowledge.

_____ _____

Signature and Title of Representative: Date:

Additional Contract Clause Attachment

The following clause is added and incorporated as an additional contract term.

Liquidated Damages. The City and Quoter recognize that time is of the essence in Quoter's delivery of the Class "A" Portland Cement Concrete ("concrete") to locations specified by the City following 24 hours notice by the City specifying delivery location and time. The City will suffer financial loss if the concrete delivery is not completed within the times specified. The City and Quoter also recognize the delays, expense, and difficulties involved in proving in a legal or arbitration proceeding the actual loss suffered by Owner if the delivery is not completed on time. Accordingly, instead of requiring any such proof, the City and Quoter agree that as liquidated damages for delay (but not as a penalty), Quoter shall pay the City the following amount for each hour that expires after the scheduled delivery time provided by the City. If Quoter shall neglect, refuse, or fail to provide the concrete within the delivery times specified or any proper extension thereof granted by Owner, Quoter shall pay City the following amount for each hour that expires after the delivery time specified by the City.

Item	Liquidated Damages, per hour
Failure to Deliver Concrete to the Location at the Time Specified by the City	$150.00

The City shall have the right to deduct the liquidated damages from any money in its hands, otherwise due, or to become due, to Quoter, or to initiate applicable dispute resolution procedures and recover liquidated damages for nonperformance of this Contract within the time stipulated.

Delays and Damages. Quoter shall accept the risk of any delays caused by the City. In the event Quoter is delayed in the completion of the work because of such conditions, Quoter shall have no claim against the City for damages or contract adjustment other than an extension of the delivery time and the waiving of liquidated damages during the period occasioned by the delay.

Acceptance. Signed _____

Printed Name _____

Title _____

Date _____

STATE OF INDIANA)
) SS:
COUNTY OF _____)

AFFIDAVIT REGARDING E-VERIFY

The undersigned, being duly sworn, hereby affirms and says that:

1. The undersigned is the _____ of _____.
(job title) (company name)

2. The company named herein that employs the undersigned has contracted with or is seeking to contract with the City of Bloomington to provide services.

3. The undersigned hereby states that, to the best of his/her knowledge and belief, the company named herein does not knowingly employ an "unauthorized alien," as defined at 8 United States Code 1324a(h)(3).

4. The undersigned hereby states that, to the best of his/her knowledge and belief, the company named herein is enrolled in and participates in the E-verify program.

_____
Signature

_____
Printed name

STATE OF INDIANA)
) SS:
COUNTY OF MONROE)

Before me, a Notary Public in and for said County and State, personally appeared _____ and acknowledged the execution of the foregoing this _____ day of _____, 2013.

_____
Notary Public

_____
Printed name

My Commission Expires: _____

County of Residence: _____

STATE OF INDIANA)
) SS:
COUNTY OF _____)

AFFIDAVIT REGARDING NO INVESTMENT IN IRAN

The undersigned, being duly sworn, hereby affirms and says that:

1. The undersigned is the _____ of _____.
(job title) (company name)

2. The company named herein that employs the undersigned has contracted with or is seeking to contract with the City of Bloomington to provide services.

3. As required by Indiana Code 5-22-16.5-13, the undersigned hereby certifies under penalties of perjury that the company named herein is not engaged in investment activities in Iran.

_____
Signature

_____
Printed name

STATE OF INDIANA)
) SS:
COUNTY OF MONROE)

Before me, a Notary Public in and for said County and State, personally appeared _____ and acknowledged the execution of the foregoing this _____ day of _____, 2013.

_____
Notary Public

_____
Printed name

My Commission Expires: _____

County of Residence: _____

SECTION 600 – INCIDENTAL CONSTRUCTION

SECTION 601 – GUARDRAIL

601.01 Description

This work shall consist of the fabrication, assembly, and installation of guardrail, guardrail transitions, and guardrail end treatments, in accordance with these requirements, and as shown on the plans. This work may also consist of the extension of existing guardrail with new guardrail, the removal of existing guardrail, or adjusting the height of existing guardrail.

MATERIALS

601.02 Materials

Materials shall be in accordance with the following:

Alternate Material Blocks	926.03
Guardrail Posts	910.10
Rail Accessories, Fittings, and Hardware	910.11
Steel Thrie-Beam Rail	910.09
Steel W-Beam Rail	910.09
Timber Posts and Blocks	911.02(f)

All guardrail, post, accessories, fittings, and hardware shall be supplied from a source listed on the Department's list of approved Certified Guardrail Suppliers in accordance with 910.12. Guardrail end treatments shall be selected from the Department's list of approved Guardrail End Treatments in accordance with 601.07 and impact attenuators shall be selected from the Department's list of Approved Impact Attenuators in accordance with 601.08.

PCC in anchors and in pads or bases for impact attenuators shall be class A and in accordance with 702. Sheet signs and sign posts shall be in accordance with 802.

Barrels used in impact attenuators shall be yellow with black lids. The aggregate used in the barrels shall be uncrushed gravel, class F or higher, in accordance with 904 and the following gradation requirements.

Sieve Size	% Passing
1/2 in. (12.5 mm)	100
No. 50 (300 µm)	0-5
No. 100 (150 µm)	0-2

All other impact attenuators shall have end reflectorization as shown on the plans or attached to the nose of the attenuator in accordance with the attenuator manufacturer's recommendation.

Thrie beam guardrail elements shall be steel and shall be in accordance with the applicable requirements for steel beam guardrail shown in 910.09, 910.10, 910.11, and 910.12.

The components, assembly, post spacing, post lengths, and installation for each location shall be as shown on the plans. Double-facing of the guardrail will be required at the locations shown on the plans. In locations where conditions will not allow the use of 7 ft (2.13 m) posts, 6 ft (1.83 m) posts may be substituted when approved.

The base metal thickness of the steel W-beam rail element for a curved guardrail system shall be 0.105 in. (2.7 mm). The base metal thickness of the steel W-beam terminal connector shall be 0.138 in. (3.5 mm). The wood breakaway posts shall be S4S timber and shall otherwise be in accordance with 911. The curved rail timber posts shall be in accordance with 911. All structural tubing shall be in accordance with ASTM A 500. The remaining steel components shall be in accordance with 910.

CONSTRUCTION REQUIREMENTS

601.03 General Requirements

Posts shall be installed plumb at the spacing and embedment depth shown on the plans. Posts shall be driven where subsurface conditions permit the use of normal driving equipment. Where subsurface conditions prohibit driving the posts, a 12 in. (300 mm) diameter hole shall be bored to the required embedment depth. The hole shall be backfilled with suitable material in 6 in. (150 mm) maximum lifts, compacted as directed, and then the posts driven.

Posts damaged during installation shall be repaired or replaced as directed with no additional payment.

When new guardrail is being installed to replace existing guardrail and traffic is to be maintained during the work, the installation of the new guardrail shall follow the removal of the existing guardrail as closely as practical. Adequate safety protection shall be provided as directed between the time that the existing guardrail is removed and the time that the installation of the new guardrail is completed.

When new guardrail is being installed where there is no existing guardrail and traffic is to be maintained during the work, the mounting of the blocks and the rail elements to the posts shall be completed as soon as practical after the posts are installed. The time between the installation of the posts and the mounting of the blocks and rail elements shall not exceed 24 h. Drums shall be placed to mark all installed guardrail posts left bare overnight. The spacing of these devices shall be numerically equal to the worksite speed limit, but not less than 20 ft (6 m).

All damaged galvanized surfaces shall be coated in accordance with 910.11(a)4.

The nested W-beam guardrail element shall consist of 2 rail elements, one set inside the other. The length of nested guardrail placed over a culvert shall not be spliced.

601.04 Guardrail Erection

Blocks and rail elements shall be erected in a manner resulting in a smooth, continuous installation. All bolts shall be of sufficient length to extend beyond the nuts and shall be drawn tight. Rail installed along a radius of 150 ft (46 m) or less shall be shop curved. Rail elements shall be lapped as shown on the plans.

601.05 Curved W-Beam Guardrail Systems

This work shall consist of the fabrication, assembly, and installation of specified types of curved W-beam guardrail connector system or curved W-beam guardrail terminal system in accordance with the requirements herein and as shown on the plans.

The installation of the terminal end buffer may utilize an alternate single piece having similar dimensional shape to the terminal end buffer as shown on the plans, and which mates with the W-beam guardrail.

Where the W-beam terminal connector is lapped on the outside of the guardrail, a galvanized 1 in. (25 mm) inside diameter, 2 in. (50 mm) outside diameter, 0.134 in. (3.4 mm) thick, narrow plain washer shall be placed under the splice bolt heads.

Nuts for the anchor cable assembly shall be hand tightened, plus 1 complete turn at the anchor plate end. All other nuts shall be torqued to 50 ft lb (67.8 Nm).

The installation of the type 5 anchor shall include tightening the cable with the swaged end to eliminate all slack.

The W-beam rail in the type 5 anchor shall be attached to the steel pipe with 5/8 in. diameter by 1 1/4 in. ((M16 by 32 mm) button head bolt with no washer. Connection to the post will not be required.

601.06 Guardrail Transitions

Guardrail transitions shall be required to connect guardrail to bridge rail, guardrail to piers, and new W-beam guardrail to existing rub rail type guardrail. The required type of guardrail transition shall be as shown on the plans. The fabrication, assembly, and installation of thrie-beam components and timber posts and blocks for guardrail transitions will be required for the locations shown on the plans.

601.07 Guardrail End Treatments

Guardrail end treatments shall be required to terminate guardrail installations at the locations shown on the plans. The type I guardrail end treatment shall be either as shown on the plans, or shall be selected from the Department's list of approved

Guardrail End Treatments. The type II guardrail end treatment shall be as shown on the plans. The type OS or MS guardrail end treatments shall be selected from the Department's list of approved Guardrail End Treatments. The reflectorization of guardrail end treatments, and the grading requirements shall be as shown on the plans.

Double facing of guardrail end treatment type I will be required when it is used in conjunction with double faced guardrail.

Each unit shall be installed in accordance with the manufacturer's recommendations.

Assembly and installation shall be supervised or performed at all times by an installer trained and certified by the unit's manufacturer, and shall be in accordance with the manufacturer's recommendations at the locations shown on the plans. A copy of the installer's certificate shall be provided to the Engineer prior to the start of the work.

The Contractor shall provide the Department with original copies of all necessary current manufacturer's installation manuals and working drawings in accordance with 105.02.

When installing end treatments to existing rub rail type guardrail, the rub rail, if not spliced at the last existing post, shall be cut and the end repositioned behind the flange of the post. If the rub rail is spliced at the last existing post, the existing splice material shall be removed and the end of the rub rail repositioned behind the flange of the post. In both cases, the rub rail shall be connected to the post as shown on the plans.

Guardrail end treatments shall be installed within 24 h of the completion of the guardrail installation to which they are to be attached. Drums in accordance with 801.09 shall be placed for overnight marking of the bare end of the guardrail when the installation of the guardrail end treatment will not be completed until the day following the completion of the guardrail installation to which it is to be attached.

601.08 Impact Attenuators

Impact attenuators shall be placed or reset to obtain the proper height where shown on the plans. The unit for each new location shall be of the width recommended by the manufacturer and for the test level specified and shall be chosen from those shown on the Department's list of approved Impact Attenuators. Each unit shall be placed in accordance with the manufacturer's recommendations, on a PCC pad.

Assembly and installation or resetting shall be supervised or performed at all times by an installer trained and certified by the unit's manufacturer, and shall be in accordance with the manufacturer's recommendations at the locations shown on the

plans. A copy of the installer's certificate shall be provided to the Engineer prior to the start of work.

The Contractor shall provide the Department with original copies of all necessary current manufacturer's installation manuals and working drawings in accordance with 105.02.

Transition panels and all other necessary hardware shown in the manufacturer's recommendations to be required for bi-directional traffic protection shall be included in the installation or resetting, if the unit is installed at a location where traffic is passing the unit on both sides in opposite directions.

If a spare parts package is required for the unit being installed, such package shall consist of those parts which are shown on the list provided in the contract documents for the stage and test level required. The spare parts shall correspond to those shown on the list for the unit to be placed. The package shall be delivered to the location directed and will become the property of the Department.

Impact attenuators may be placed on the Department's approved list based on the manufacturer's documentation subject to the Department's acceptance. The manufacturer shall provide a copy of the test report stating that its product fully complies with the requirements of NCHRP 350 crash test level 3, and that its product has been approved by the FHWA. Products will be maintained on the Department's approved list by a manufacturer's certification submitted annually in October and the Department's continued acceptance. This certification shall state that the product has not been changed since the NCHRP 350 crash testing, that the NCHRP 350 test results still apply to this product, and that the FHWA approval is still applicable.

601.09 Extension of Existing Guardrail

Extension of existing rub rail type guardrail with new W-beam guardrail shall require adjusting the post heights in the last 25 ft (7.6 m) of existing rub rail type guardrail adjacent to the extension as shown on the plans. Guardrail transition type VH shall be used to make this adjustment. The post spacing of the guardrail transition type VH shall equal that of the last 25 ft (7.6 m) of existing rub rail type guardrail adjacent to the extension. The rub rail shall be terminated at the last existing post in the transition in accordance with 601.06.

601.10 Removal of Existing Guardrail

Removal of existing guardrail shall be in accordance with the applicable requirements of 202 and these requirements. The locations shall be as shown on the plans. When it is specified that the removed guardrail is to become the property of the Department, the rail elements, posts, and blocks shall be removed without being damaged. The removed material shall be stored as directed.

601.11 Adjusting Existing Guardrail Height

The height of the existing guardrail shall be adjusted by the use of moveable blocks as shown on the plans. The height shall be measured to the top of the rail element along the face of the rail. Existing fixed blocks shall be replaced with moveable blocks installed at the proper height. Existing moveable blocks shall be disconnected from the posts and re-mounted at the proper height.

601.12 Resetting Guardrail

This work shall consist of the removal of existing guardrail and, and if necessary, storing it, and then re-erecting it where shown on the plans or as directed.

601.13 Method of Measurement

Guardrail, guardrail with rub rail, shop curved guardrail, adjusting guardrail height, guardrail removal, and resetting guardrail will be measured by the linear foot (meter) along the top of the rail element, complete in place. Nested guardrail will be measured per each 100 lft (30 m) run placed. Modified posts for nested guardrail will be measured per each, complete in place. Guardrail transitions, W-beam guardrail cable terminal anchors, and guardrail end treatments will be measured per each, complete in place. Guardrail buried end treatments type II will be measured per each. Impact attenuators and reseting impact attenuators will be measured per each for the type and width and test level, complete in place. The curved W-beam guardrail connector system and the curved W-beam guardrail terminal system will be measured per each for the type specified. Grading at guardrail end treatments, the reflectorization of guardrail end treatments, and concrete used in anchoring guardrail end treatments will not be measured for payment.

Impact attenuator spare parts packages will be measured per each for the type and width, test level, and stage for which it is specified.

601.14 Basis of Payment

W-beam guardrail will be paid for at the contract unit price per linear foot (meter) for the specified post spacing. Thrie-beam and thrie-beam double faced guardrail will be paid for at the contract unit price per linear foot (meter) for guardrail, thrie-beam and guardrail, thrie-beam, double faced, complete in place. Nested guardrail will be paid for at the contract unit price per each 100 lft (30 m) run, complete in place for guardrail, W-beam, nested. W-beam guardrail cable terminal anchor will be paid for at the contract unit price per each, complete in place. Modified posts for nested guardrail will be paid for at the contract unit price per each for modified posts, nested guardrail. W-beam guardrail with rub rail will be paid for at the contract unit price per linear foot (meter) for guardrail, WR-beam complete in place. Shop curved guardrail, adjusting guardrail height, guardrail removal, and resetting guardrail will be paid for at the contract unit price per linear foot (meter). Guardrail transitions and guardrail end treatments will be paid for at the contract unit price per each for the type specified. Guardrail buried end treatments type II will be paid for at the contract unit price per each, complete in place. Impact attenuators and reseting impact attenuators will be paid for at the contract unit price per each for the

type and width, and test level specified. The curved W-beam guardrail connector system and curved W-beam guardrail system will be paid for at the contract unit price per each for the type specified, complete in place.

Impact attenuator spare parts packages will be paid for at the contract unit price per each for the type and width, test level, and stage for which it is specified.

Where existing guardrail height is adjusted, such work will be paid for at the contract unit price per linear foot (meter). The cost of removal, all necessary storage, new adjustable post brackets, attachment of rail section, and miscellaneous nuts and bolts as required shall be included in the cost of adjust guardrail height.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Guardrail Connector System, W-Beam, Curved, _____ (type)	EACH
Guardrail End Treatment, _____ (type)	EACH
Guardrail Transition, VH, ____ ft ____ in. (m) Spacing	EACH
Guardrail, Adjust Height	LFT (m)
Guardrail, Remove	LFT (m)
Guardrail, Reset	LFT (m)
Guardrail, Terminal System, W-Beam Curved, _____ (type)	EACH
Guardrail, Thrie-Beam	LFT (m)
Guardrail, Thrie-Beam, Double Faced	LFT (m)
Guardrail, Transition, _____ (type)	EACH
Guardrail, W- Beam, Shop Curved, _____ ft _____ in. (m) Spacing	LFT (m)
Guardrail, W-Beam, ____ ft ____ in. (m) Spacing	LFT (m)
Guardrail, W-Beam, Cable Terminal Anchor	EACH
Guardrail, W-Beam, Double Faced, _____ ft _____ in. (m) Spacing	LFT (m)
Guardrail, W-Beam, Nested	EACH
Guardrail, WR-Beam	LFT (m)
Impact Attenuator Spare Parts Package, _____ (type-width) _____ (test level), _____ (stage)	EACH
Impact Attenuator, _____ (type-width), _____ (test level)	EACH

Impact Attenuator, Reset, _____, _____ .....EACH
type-width test level

Modified Posts, Nested Guardrail .....EACH

The substitution of 6 ft (1.83 m) posts for 7 ft (2.13 m) posts where conditions will not allow the use of the longer post will be at the same contract unit price of the longer post.

The cost of resetting guardrail shall include the removal, necessary storage, resetting and replacement of damaged or missing parts and new posts as required.

The cost of reflectorization of impact attenuators and guardrail end treatments shall be included in the respective pay items.

The cost of all grading required for the guardrail buried end treatment shall be included in the cost of guardrail end treatment, type II.

The cost of earthwork, grading, and transition panel if required, and PCC pad shall be included in the cost of impact attenuator.

The cost of excavation, concrete footings, reinforcement, and structural steel tubing required for modified posts, nested guardrail, shall be included in the cost of the pay item.

The cost of all materials, including replacing damaged or missing parts, labor, and necessary incidentals required to reset impact attenuators, will be included in the cost of impact attenuator, reset.

Where guardrail transition type TGB is used with bridge railing type TR, the cost of eliminating the thrie-beam terminal connector and driving the posts to the height above ground shown on the plans shall be included in the cost of the guardrail transition.

SECTION 602 – CONCRETE BARRIER

602.01 Description

This work shall consist of the construction of concrete barriers and concrete glare screens in accordance with these specifications, and as shown on the plans.

MATERIALS

602.02 Materials

Materials shall be in accordance with the following:

Barrier Delineators ..... 926.02(c)
Bridge Deck Overlay Materials..... 722.04

Cast-in-Place Barriers..... 702
Cast-in-Place Concrete Glare Screens 702
Construction Warning Lights 923.03
Penetrating Sealer..... 709, 909.09
Precast Barriers..... 707
Precast Concrete Glare Screen 707
Reinforcing Bars..... 910.01

CONSTRUCTION REQUIREMENTS

602.03 Concrete Barrier and Concrete Glare Screen

Concrete barrier and concrete glare screen may be precast or cast-in-place. The option selected shall be used continuously throughout the project. Irregular sections shall be cast-in-place regardless of the option selected.

Concrete glare screen may only be precast when constructed in combination with new precast barrier. Concrete glare screen shall be cast-in-place when constructed in combination with cast-in-place barrier, and also when constructed on top of existing concrete barrier.

Excavation and compaction shall be in accordance with 605.03(a). Backfilling shall be in accordance with applicable requirements of 605.03(d).

(a) Precast Concrete Barrier and Concrete Glare Screen

Precast concrete barrier and concrete glare screen shall be constructed in accordance with applicable requirements of 707, except the minimum 28-day compressive strength shall be 3,000 psi (20.7 MPa). The precast units shall not be shipped or used until this strength is attained. The surfaces of individual precast units shall vary no more than 1/4 in. in 10 ft (6 mm in 3 m) from the specified cross section, as measured from a longitudinal straightedge. The maximum variation in the vertical and horizontal alignment of adjacent units shall be 1/4 in. (6 mm) across the joint, as measured from a 10 ft (3 m) longitudinal straightedge. Approved bedding may be used to obtain proper alignment of the concrete barrier sections.

(b) Cast-in-Place Concrete Barrier and Concrete Glare Screen

Cast-in-place concrete barrier and concrete glare screen shall be constructed in accordance with applicable requirements of 706.03 or by the use of an approved slip-form machine. The surfaces of the concrete shall vary no more than 1/4 in. in 10 ft (6 mm in 3 m) from the specified cross section, as measured from a longitudinal straightedge. Where concrete pavement or concrete shoulder abuts the concrete barrier, 1/2 in. (13 mm) preformed joint filler shall be placed as shown on the plans.

Where the concrete barrier is to be placed on PCCP, epoxy coated reinforcing bars shall be placed as shown on the plans. The epoxy coated reinforcing bars shall be installed in the PCCP by drilling and grouting.

The barrier wall shall be constructed in single pours without subsequent vertical extensions.

(c) Finishing

Concrete barrier and concrete glare screen shall be finished in accordance with 702.21. If slip-form construction is used, an approved brush finish will be permitted. Curing material in accordance with 912.01(e) shall be applied as a bond breaker to all areas which result in concrete to concrete contact. It shall be applied at a minimum rate of 1 gal./75 sq ft (1 L/1.8 m^2). If material is applied at a rate less than the minimum rate, a 2nd application shall be applied.

(d) Sealing

Regardless of the method of construction, all exposed surfaces of the concrete barrier and concrete glare screen shall be sealed in accordance with the applicable requirements of 709.

(e) Joints

The type, size and location of joints and preformed joint filler shall be as shown on the plans.

(f) Reflectorization

All concrete barrier shall be reflectorized with barrier delineators spaced a minimum of 40 ft (12 m) apart and centered 2 ft (600 mm) above the surface of adjacent pavement or shoulder. The reflectorization shall be on both sides of the wall if traffic is on both sides. All delineators damaged during installation or placement of the concrete barrier shall be replaced with no additional payment. The color of the reflectors shall match the color of the adjacent pavement traffic markings.

602.04 Blank

602.05 Method of Measurement

Concrete barrier will be measured by the linear foot (meter) along the centerline of the barrier, including irregular barrier sections around median obstructions such as bridge piers. Barrier delineators will be measured per each provided there is a pay item shown in the Schedule of Pay Items. Concrete glare screen will be measured by the linear foot (meter) along the centerline of the glare screen.

602.06 Basis of Payment

Concrete barrier will be paid for at the contract unit price per linear foot (meter), complete in place. Barrier delineators used on concrete barrier will be paid for at the contract unit price per each, complete in place.

Concrete glare screen will be paid for at the contract unit price per linear foot (meter), complete in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Barrier Delineator	EACH
Concrete Barrier	LFT (m)
Concrete Barrier Glare Screen	LFT (m)

The cost of polyethylene film, surface seal or curing-sealing material for concrete barrier and curing material shall be included in the cost of concrete barrier.

SECTION 603 – FENCES

603.01 Description

This work shall consist of the construction of fence and gates in accordance with 105.03.

603.02 Materials

Materials shall be in accordance with the following:

Barbed Wire	910.18(b)4
Chain Link Fabric	910.18(b)
Concrete, Class B	702
Concrete, Packaged Dry	901.08
Farm Field/Woven Wire	910.18(a)
Fence Posts	910.13
Gates	910.18(d)
Tension Wire	910.18(b)1

CONSTRUCTION REQUIREMENTS

603.03 General Requirements

Clearing and grubbing shall be in accordance with 201.03.

At locations where breaks in a run of fencing are required, or at intersections with existing fences, appropriate adjustment in post spacing shall be made in accordance with the requirements for the type of closure indicated.

When the plans require that posts, braces, or anchors be imbedded in concrete, temporary guys or braces shall be installed, if required to hold the posts in proper position. Unless otherwise permitted, no materials shall be installed on posts or strain placed on guys and bracing set in concrete until 96 h have elapsed from the time of placing of the concrete.

The tops of all posts shall be set to the required grade and alignment. Cutting of the posts will only be allowed with the approval of the Engineer. Post caps shall be installed at the time the fence fabric is placed on the posts.

Wire or fencing of the size and type required shall be firmly attached to the posts and braces in the manner indicated. All wires shall be stretched taut and installed to the required elevations.

At each location where an electric transmission, distribution, or secondary line crosses any of the types of fences covered by these specifications, a ground, conforming to applicable requirements of the National Electric Safety Code, shall be furnished and installed.

603.04 Setting Posts

Posts, including the concrete foundation for posts, braces and anchors shall be set so that the entire fence is inside the right-of-way and the fence can be placed on the side of the post facing the roadway. If an object, such as a tree, is located on the right-of-way and is to remain in place, the fence may be adjusted to miss the obstruction. There shall be a gradual offset for at least 3 posts in each direction of the obstruction.

Line posts for farm field type fence shall be set on 16 ft (4.9 m) centers, and for chain link fence on 10 ft (3 m) centers. In either case, a tolerance of ± 2 ft (± 0.6 m) in spacing will be allowed at special locations as approved. Spacing of these posts shall be as uniform as practicable under the existing conditions. However, additional posts shall be set to maintain the bottom clearance dimensions as required.

Pull posts shall be set at 500 ft (150 m) maximum intervals in straight runs and at each vertical angle point of 10° or more.

Corner posts shall be set at each horizontal angle point of 10° or more.

End, corner, and pull posts for both types of fence, line posts for chain link fence and diagonal braces for farm field type fence shall be set in concrete as shown on the plans.

Except where rock is encountered, intermediate or line posts shall be driven and furnished with an approved anchor plate or other satisfactory device to hold the post in proper alignment and plumb. The plate or anchor shall be welded or riveted to the post with no less than 2 rivets.

Gate posts shall be set in concrete as shown on the plans.

Extra length posts shall be required at stream crossings as shown on the plans or as directed and also at ground depressions where it is not practicable for the fencing to follow closely the contour of the ground. These posts shall be set in concrete as shown on the plans.

At small stream crossings and ground depressions, the space below the fence fabric shall be closed with barbed or ground tension wire, either on horizontal lines or fanned, as shown on the plans or as directed. The wires shall be stretched taut between and fastened to the posts to prevent vertical movement of the wires. Barbed or tension wire shall not be placed where its installation would cause collecting drifts in the channel.

603.05 Placing Barbed and Tension Wire and Fabric

The bottom of the fabric shall be placed above the ground line as shown on the plans. Over irregular ground, a minimum of 1 in. (25 mm) and a maximum of 4 in. (100 mm) clearance will be permitted. All necessary excavation and backfilling required shall be in accordance with 201.03.

The tension required to stretch the fabric and wire shall be applied by mechanical fence stretchers and with single wire stretchers designed and manufactured for the purpose, and in accordance with the fence manufacturer's recommendations.

All splices in the fabric and wire shall be securely made in accordance with the best practice and the manufacturer's recommendations, and by the use of tools designed for that purpose.

Farm field fence shall be placed by fastening one end and then applying sufficient tension to remove all slack before making permanent attachments elsewhere. The line wires shall be fastened to end, corner, and pull posts by wrapping the wires around the posts and tying the wire back on itself with no less than 1 1/2 tightly wrapped twists. Tying shall be with tools designed for the purpose in accordance with the fence manufacturer's recommendations. This same method shall be used in placing barbed or tension wire. Fence fabric shall be fastened to intermediate or line posts with at least 5 wire ties. Barbed or tension wire shall be fastened in the same manner with 1 fastening device for each post.

The top and bottom tension wires of chain link fence shall be placed, stretched taut, and secured at the ends and to all posts before the fabric is placed. The ends of the fabric shall be secured by the use of stretcher-bars threaded through the loops of the fabric and secured to the posts by means of clamps with bolts and nuts. The number of clamps shall be as indicated on the plans. The fabric shall be placed by securing one end and then applying tension to remove all slack before making attachments elsewhere. The fabric shall be fastened to the line posts and to the top and bottom tension wires with tie wires spaced as shown on the plans.

603.06 Resetting Fence

Resetting fence shall consist of the removal of existing fence within the specified limits and, if necessary, storing and then resetting it in accordance with the plans, or as directed. Resetting fence shall be in accordance with 603.03, 603.04, and 603.05. Damaged or missing parts, including posts shall be replaced.

603.07 Method of Measurement

Fence and resetting fence will be measured by the linear foot (meter) for the type specified. Measurement will be made along the top of the fence from outside to outside of end posts for each continuous run of fence.

Gates will be measured as complete units of the size and type specified.

603.08 Basis of Payment

The accepted quantities of fence and resetting fence will be paid for at the contract unit price per linear foot (meter) for the type specified, complete in place. Gates will be paid for at the contract unit price per each for fence gate, of the type and size specified, complete in place.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Fence Gate, _____, _____ in. (mm) x _____ ft (m) (type, height, length)	EACH
Fence, _____, _____ in. (mm) (type, height)	LFT (m)
Fence, _____, Reset (type)	LFT (m)
Fence, Farm Field, Barbed Wire, _____ in. (mm)	LFT (m)
Fence, Farm Field, Tension Wire, _____ in. (mm)	LFT (m)

The cost of adding grounding in accordance with the National Electric Safety Code including all materials, and labor shall be included in the cost of the fence.

The cost of fence, and corner, end, line, and pull posts shall be included in the cost of the fence.

The cost of fence, post and miscellaneous hardware shall be in the cost of the gate.

The cost of all miscellaneous hardware related to the type of fence including brace connections, caps, clips, clamps, hinges, rivets, ties, truss rods, diagonal braces and stretcher bars shall be included in the cost of the fence.

The cost of concrete for posts, braces or anchors shall be included in the cost of the fence and gates.

The cost of removal, storage, re-installation, and the replacement of damaged or missing parts shall be included in the cost of the resetting fence.

SECTION 604 – SIDEWALKS, CURB RAMPS, STEPS, AND HANDRAILS

604.01 Description

This work shall consist of constructing HMA or PCC sidewalks; curb ramps; concrete steps; or the reconstruction of PCC sidewalks in accordance with 105.03.

MATERIALS

604.02 Materials

Materials shall be in accordance with the following:

Coarse Aggregate, Class D or Higher, Size No. 53.....904
Concrete, Class A 702
Detectable Warning Elements 905.05
Fine Aggregate, Size No. 23, No. 24, or No. 15.....904
Joint Filler.....906.01
Paint.....909.05
Reinforcing Bars.....910.01
Silica Sand.....ASTM C 778

Hand railing shall be aluminum pipe in accordance with ASTM 221, alloy 6063, temper T52 or galvanized steel pipe in accordance with ASTM A 53, grade B, all as specified.

The detectable warning surface in concrete curb ramps shall be selected from the Department's list of approved Detectable Warning Elements in accordance with 905.05.

The mortar bed material shall be high-strength mortar in accordance with ASTM C 387. Part of the mix water shall be replaced with a Type II polymer modifier meeting the requirements of ASTM C 1438. The proportioning of water and polymer modifier shall be as recommended by the manufacturer of the polymer modifier.

A type C certification in accordance with 916 shall be furnished for the masonry mortar and polymer modifier prior to use of the material.

A type C certification in accordance with 916 for the silica sand shall be furnished prior to use of the material.

CONSTRUCTION REQUIREMENTS

604.03 Portland Cement Concrete Sidewalks and Curb Ramps

(a) General Requirements

The location of curb ramps shall take precedence over the location of drainage structures and signal, utility, or light poles. Drainage structures shall not be located

within the limits of the curb ramp, exclusive of flared sides. Poles shall be located so as not to impede the usage or safety of the curb ramps. Crosswalk markings shall be located such that the curb ramps shall be contained within the markings unless otherwise specified. The flared sides need not fall within the crosswalk lines. The normal gutter flow line shall be maintained throughout the curb ramp area, and appropriate drainage structures shall be used, as needed, to intercept the flow prior to the curb ramp area. Positive drainage shall also be provided to carry water away from the intersection of the curb ramp and the gutter line.

The bottom edge of curb ramps and the top of curb shall be flush with the edge of the adjacent pavement or the gutter line.

The curb ramp running slope shall not exceed 12:1, except where conditions necessitate, a 10:1 slope may be utilized for a maximum rise of 6 in. (150 mm). Curb ramp cross slope shall not exceed 50:1 except where infeasible.

(b) Excavation

Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms. The foundation shall be shaped and compacted to a firm even surface in accordance with the section shown on the plans. All soft and yielding material shall be removed and replaced with acceptable material.

(c) Forms

Forms shall be of wood, metal, or other approved material and shall extend for the full depth of the concrete. Forms shall be straight, free from warp, and of sufficient strength to resist the pressure of the concrete without springing. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal.

(d) Placing Concrete

The foundation shall be thoroughly moistened immediately prior to the placing of the concrete. The proportioning, mixing, and placing of the concrete shall be in accordance with 702. The thickness of the concrete in the curb ramp, including flared sides, shall be as shown on the plans for the type specified.

(e) Finishing

The surface shall be finished with a wooden float. No plastering of the surface will be permitted. Ramp surfaces shall be coarse broomed and corrugated transverse to the slope as shown on the plans. The surface texture of the flared sides shall be coarse broomed with the striations transverse to the slope.

All exposed edges shall be finished with a 1/4 in. (6 mm) radius.

(f) Joints

The type and location of joints and the size of preformed joint filler shall be as shown on the plans.

All concrete joints shall be finished with a 1/4 in. (6 mm) radius.

Preformed 1/2 in. (13 mm) joint filler shall be placed around all appurtenances, such as manholes and utility poles which extend into and through the sidewalk, and between the sidewalk and any fixed structure, such as a building or bridge. The preformed joint filler shall extend for the full depth of the sidewalk or curb ramp, and shall be flush with the surface of the adjacent concrete.

(g) Detectable Warning Elements

Detectable warning elements shall be manufactured or field cut to completely fill the area of the curb ramp as shown on the plans. Elements shall be installed to be level across joints or seams and shall be flush with the edges of adjoining concrete.

Brick elements shall be placed in a mortar setting bed within the hardened concrete block out. The concrete base of the block out shall have a rough textured finish, such as would be produced by a screed or wood float. The depth of the block out shall be such that a mortar bed thickness of 3/8 to 3/4 in. is achieved for the nominal depth of the element. The hardened concrete base shall be free of all material which might prevent the mortar setting bed from adhering. The concrete base shall be dampened with water, but be surface dry immediately prior to the placing the mortar setting bed. The mortar setting bed shall be laid out the desired thickness, no more than 2 ft ahead of laying the elements. The elements shall be buttered with mortar on the bottom before placement into the setting bed. Elements from various manufacturers shall not be mixed at any individual concrete ramp location.

Brick elements shall be laid out in a running or stacked bond pattern with a 1/16 in average joint width. The joint width shall not exceed 1/8 in. Whole elements should be laid 1st, followed by elements cut to size, keeping the number of joints to a minimum. A masonry saw shall be used to produce a clean, accurate, straight cut. The joint between elements shall be completely filled with a dry fine aggregate. The fine aggregate may be obtained from a non-Certified Aggregate Producer, but it shall be natural sand having a gradation where at least 95% of the material passes the No. 4 sieve. Excess fine aggregate shall be removed from the surface of the elements.

Cast iron elements shall be installed in accordance with the manufacturer's recommendations. When required, cutting of the elements shall be in accordance with the manufacturer's recommendations. Cut edges shall be ground to a smooth shape consistent with the manufactured edges.

Approved elements other than brick or cast iron shall be installed in accordance with the manufacturer's recommendations.

(h) Curing

Concrete shall be cured for at least 72 h. Curing shall be in accordance with 504.04 except curing compound shall not be used in the area where detectable warning elements are to be installed. During the curing period all pedestrian traffic shall be excluded.

(i) Painting

The exposed surfaces of the curb throughout the width of curb ramps shall be painted yellow in accordance with 808.06. Silica sand shall be applied to the wet paint along the top of the curb at the rate of 6.0 lb/gal. (0.7 kg/L).

604.04 PCC Steps

PCC steps shall be in accordance with the applicable provisions of 604.03. In addition, all exposed edges shall be rounded to a 1/4 in. (6 mm) radius.

604.05 Reconstructed PCC Sidewalk

Where existing concrete sidewalk is to be reconstructed, all disintegrated concrete, brick, stone, or other material shall be completely removed and replaced with new concrete sidewalk in accordance with 604.03.

Such sidewalk shall be constructed to a minimum depth of 4 in. (100 mm) unless another depth is designated and to the width of the adjoining walk, or to a width of no less than 48 in. (1,200 mm) from the face of curb, or to such other width as directed.

The removal of concrete sidewalk shall be to uniform lines as directed. The sidewalk to be removed shall be cut in a straight line with an approved power driven concrete saw. The sawing shall be such that the portion of sidewalk to remain in place shall not be damaged. All portions which are damaged or removed back of the established line shall be replaced.

Unless otherwise directed, sidewalk which must be removed shall be removed between tool marks or joints. At locations where the sidewalk and curb are adjacent and the curb is deteriorated, the curb shall also be replaced as directed.

The new sidewalk shall have a joint pattern similar to the surrounding sidewalk. Sidewalk placed at drives shall be 6 in. (150 mm) thick, or the same depth of the existing drive, whichever is greater.

604.06 Re-Laid Sidewalk

This work consists of the removal and re-laying of concrete, stone-slab, or brick sidewalk at the locations shown on the plans or as directed. In the operations of removing and re-laying, care shall be taken not to damage any of the sidewalk. Before re-laying, a cushion of fine aggregate shall be spread on the prepared subgrade to a depth of no less than 2 in. (50 mm). Cracked or damaged sections shall not be re-laid but shall be disposed of as directed.

604.07 HMA Sidewalk

(a) Excavation and Forms

Excavation and forms, when required, shall be in accordance with 604.03(b) and 604.03(c).

(b) Bed Course

Bed course material shall be coarse aggregate No. 53 and shall be placed in lifts not exceeding 4 in. (100 mm) in depth. Each lift shall be thoroughly compacted.

(c) Placing HMA Sidewalk

HMA sidewalk material shall be placed on a compacted bed course in 1 or more courses. The mixture shall consist of HMA base, intermediate, or surface, type A in accordance with 402. A MAF in accordance with 402.05 will not apply. Aggregate requirements of 904.03(d) do not apply. Compaction shall be accomplished by means of a hand operated or power roller of an acceptable type and weight (mass) in accordance with 402.15. In areas inaccessible to the roller, hand tamping will be permitted. In any case, the HMA sidewalk material shall be uniformly compacted.

If the finished compacted surface is too open or remains sticky, the surface shall be given a coating of fine aggregate, well broomed over the surface, leaving no excess.

604.08 Backfilling and Finishing Shoulders and Slopes

After forms have been removed, the space on each side of the sidewalks shall be filled to the required elevation with suitable material which shall be firmly compacted and neatly graded. Adjacent shoulders and slopes shall be finished to the required grade and cross section.

604.09 Hand Rails

This railing shall be erected in a workmanlike manner, straight and true to grade. Posts shall be vertical and railings shall be parallel to the walk surface or the plane of the steps and spaced as shown on the plans. Fastenings shall be as indicated on the plans. Railing posts on masonry shall be held in place in a manner that develops the full strength of the railing post in bending.

Fabrication and placement of railings shall be completed in accordance with the applicable requirements of 711. Ends of tube sections shall be milled or sawed. Cut ends shall be true, smooth, and free from burrs and ragged edges. Welds shall be ground smooth. The rail system shall be continuous except as shown on the plans. Joints shall be spliced as detailed on the plans. Welding of steel shall be in accordance with 711.32 and welding of aluminum shall be in accordance with the applicable requirements of 803. Radiographic, magnetic particle, and dye penetrant inspection will not be required.

All aluminum surfaces in contact with concrete shall be coated with an aluminum impregnated caulking compound prior to installation. After installation and alignment, openings between metal surfaces and concrete shall be sealed in a watertight manner with the caulking compound.

Steel pipe railing not designated to be painted shall be galvanized after fabrication and prior to installation. Railing designated to be painted shall receive 1 shop coat of paint after fabrication and 2 field coats after installation. The type and color of paint shall be as specified on the plans. Cleaning and painting shall be in accordance with 619.

604.10 Method of Measurement

Concrete sidewalk, reconstructed concrete sidewalk, and re-laid concrete sidewalk will be measured by the square yard (square meter) of finished surface. HMA for sidewalk will be measured by the ton (megagram) of mixture placed. Bed course material will be measured by the ton (megagram).

Concrete curb ramps will be measured by the square yard (square meter) in accordance with the pay limits shown on the plans.

Concrete steps will be measured by the cubic yard (cubic meter) based on the neat lines shown on the plans.

Hand rails will be measured by the linear foot (meter) in accordance with the dimensions shown on the plans or as directed. Measurements will be made from end to end of the railing along the centerline.

Curb and curb and gutter will be measured in accordance with 605.09. Reinforcing bars, if used, will be measured in accordance with 703.07.

604.11 Basis of Payment

The accepted quantities of concrete sidewalk will be paid for at the contract unit price per square yard (square meter) for sidewalk, concrete. HMA for sidewalk will be paid for at the contract unit price per ton (megagram), complete in place. Bed course material will be paid for at the contract unit price per ton (megagram). Concrete steps will be paid for at the contract unit price per cubic yard (cubic meter) for steps, concrete. Reconstructed sidewalk and re-laid sidewalk will be paid for at the contract unit price per square yard (square meter) for sidewalk, reconstruct, or sidewalk, re-lay. Joint material will be paid for at the contract unit price per linear foot (meter), complete in place.

The accepted quantities of curb ramps will be paid for at the contract unit price per square yard (square meter) for curb ramp, concrete, per the type, complete in place.

Hand rails will be paid for at the contract unit price per linear foot (meter).

Curb and curb and gutter will be paid for in accordance with 605.10.

Reinforcing bars, if used, will be paid for in accordance with 703.08. Curb, if directed to be replaced, will be paid for in accordance with 605.10.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Bed Course Material	TON (Mg)
Curb Ramp, Concrete, _____ type	SYS (m2)
Hand Rail, _____ type	LFT (m)
HMA for Sidewalk	TON (Mg)
Joint Material	LFT (m)
Sidewalk, Concrete	SYS (m2)
Sidewalk, Concrete, Reconstruct	SYS (m2)
Sidewalk, Concrete, Re-Lay	SYS (m2)
Steps, Concrete	CYS (m3)

The cost of excavation, backfill, and necessary incidentals shall be included in the cost of the pay items in this section.

The removal and disposal of concrete sidewalk which is unsuitable for re-laying and which has not been damaged due to negligence will be paid for in accordance with 202.13. Concrete sidewalk which is specified to be re-laid or to remain in place and which is damaged shall be removed and disposed of and replaced with no additional payment.

If directed, concrete sidewalk shall be constructed to a depth greater than that shown on the plans. Such additional thickness will be converted into the equivalent square yards (square meters) quantity of concrete sidewalk of the thickness shown on the plans and will be paid for as such.

The cost of furnishing and applying sand to finished compacted surfaces shall be included in the cost of HMA for sidewalk.

The cost of the concrete base, detectable warning element, thin set mortar, fine aggregate for filling joints, and the painting of curb through the width of the curb ramp including the silica sand shall be included in the cost of the curb ramp.

The cost of aluminum impregnated caulking compound and the painting of steel hand railing shall be included in the cost of the hand rail.

SECTION 605 – CURBING

605.01 Description

This work shall consist of the construction of curb or curb turnouts; combination curb and gutter, combined curb and gutter turnouts; or resetting curb in accordance with 105.03.

MATERIALS

605.02 Materials

Materials shall be in accordance with the following:

Coarse Aggregate, Class D or Higher, Size No. 53	904
Concrete	502
Joint Materials	906
Joint Mortar	907.12
Precast Concrete Curbing	904.04(e)
Reinforcing Bars	910.01

605.03 Precast Cement Concrete Curbing

(a) Excavation

Excavation shall be made to the required depth and the base upon which the curb is to be set shall be compacted to a firm even surface. All soft and unsuitable material shall be removed and replaced with suitable material which shall be thoroughly compacted.

(b) Installation

The curb shall be set in accordance with the line and grade required. The face and top of the curb shall be checked with a 10 ft (3 m) straightedge. Portions showing irregularities of 1/4 in. (6 mm) or more shall be removed and replaced with no additional payment. All spaces under the curbing shall be filled with bed course material. The bed course material shall be coarse aggregate No. 53 and shall be thoroughly tamped.

(c) Joints

Curbing shall be laid with joints as indicated on the plans. These joints shall be filled with mortar as specified. Where a portland cement concrete pavement is to be constructed contiguous to a curbing, joints shall be constructed in the curbing directly in line with pavement expansion joints. The joint in the curbing shall be the same width as the pavement joint and shall be filled with an expansion joint filler of the nominal thickness as the pavement joint. Any voids between the joint filler and the curb shall be filled with mortar.

(d) Backfilling

After the curb has set, any remaining excavated areas shall be filled with approved material. This material shall be placed and thoroughly tamped in layers not exceeding 6 in. (150 mm) in depth.

605.04 Cast in Place Cement Concrete Curbing

(a) Excavation

Excavation and bedding shall be in accordance with 605.03(a).

(b) Forms

Forms shall be of wood or metal, straight, free from warp, and of such construction that there will be no interference to the inspection of grade or alignment. All forms shall extend for the entire depth of the curb and shall be braced and secured sufficiently so that no deflection from alignment or grade shall occur during the placing of the concrete.

(c) Proportioning and Placing

Concrete shall be proportioned, mixed, and placed in accordance with 502, except utilization of the Department provided spreadsheet is not required for the CMDS. Where integral curb and gutter is specified, that portion of the curb below the upper surface elevation of the adjoining pavement shall be constructed by extending the pavement to the outer vertical plane of the curb at the time the pavement is placed. The concrete used in this extension shall be the same composition as that of the pavement.

As an option, an integral curb and gutter may be placed at the same time as the PCCP pavement by the slip form method. The slip form machine must have an attachment to place, consolidate and shape the concrete to the required shape and dimensions. The reinforcing tie bars or stirrups between the pavement and the curb shall be omitted.

After the concrete for the upper portion is placed in the forms, it shall be tamped and spaded or vibrated until mortar entirely covers the surface. The top shall be floated smooth and the outer upper corner rounded to a 1/4 in. (6 mm) radius.

The face and top of the curb, integral curb, and gutter shall be checked with a 10 ft (3 m) straightedge. Portions showing irregularities of 1/4 in. (6 mm) or more shall be removed and replaced.

Consolidation of concrete placed in the forms shall be by vibration or other acceptable methods. Forms shall be left in place for 24 h or until the concrete has set sufficiently so that they can be removed without injury to the curbing. Upon removal of the forms, the exposed curbing face shall be rubbed immediately to a uniform surface. Rubbing shall be accomplished by the use of water and a carborundum

brick. For the purpose of matching adjacent concrete finishes or for other reasons, other methods of finishing may be permitted. No plastering will be permitted.

(d) Curb Turnouts and Combined Concrete Curb and Gutter Turnouts

Turnouts will be required with specified inlets or with concrete gutter and paved side ditch in accordance with 607 and as shown on the plans. Concrete gutter and paved side ditch shall be constructed monolithically with the curb turnout.

(e) Joints

Joints in integral curbs shall be located at joints in adjoining PCCP. The joints shall be saw cut or formed with 1/4 in. (6 mm) thick preformed joint material. Joint sealant is not required for joints in integral curbs.

Curbing not constructed integral with adjacent pavement shall be constructed with intermediate joints located at 10 ft (3 m) intervals. These joints may be sawed or formed with metal separator plates, and the depth and width shall be in accordance with the plans.

Preformed expansion joints, 1/4 in. (6 mm) thick, shall be placed at the beginning and end of all curb returns and also at castings.

(f) Curing

Immediately upon completion of the rubbing, the curbing shall be moistened and kept moist for 3 days, or cured by the use of membrane forming material. The method and details of curing shall be subject to approval.

(g) Backfilling

After the concrete has set sufficiently, the spaces in front and back of the curb shall be refilled with suitable material to the required elevations in layers of not more than 6 in. (150 mm) and be tamped thoroughly.

(h) Curb Machine

Curb machines may be used to construct curb provided the curb can be constructed to the requirements of the specifications.

605.05 Reflecting Cement Concrete Curbing

Construction methods for this item shall be in accordance with 605.03 and the following requirements.

The reflecting surface of the curbing shall be a mortar mix consisting of 1 part white portland cement to 1 3/4 parts of light colored, washed, mortar sand. This mortar mix shall have a thickness of approximately 1 in. (25 mm). Alternately, the entire curbing may be constructed of concrete made with white portland cement.

Washed mortar sand shall meet all the requirements for mortar sand and shall be of a light satisfactory color. The reflecting surface mortar shall be placed

immediately after the placing of the base concrete. No more than 20 min shall elapse between the placing of the base concrete and the placing of the reflecting surface.

Scoring or surface deformation and finish of the reflecting surface shall be in accordance with the details shown on the plans.

605.06 Concrete Center Curbing

The subgrade shall be prepared the same as for the adjoining pavement. If subbase is provided for the adjoining pavement, it shall be carried through for the full width of the curb and at the same thickness as that for the pavement.

The temperature limitations of 502.11 shall apply to placing the concrete. The surface shall be troweled smooth with a metal trowel. Curing shall be in accordance with 504.04.

Forms shall be removed within 24 h after the concrete has been placed. Plane surfaces and exposed sides of the curb shall be checked with a 10 ft (3 m) straightedge. Portions showing irregularities of 1/4 in. (6 mm) or more shall be removed and replaced in compliance with these specifications.

Joints in center curbs adjacent to PCCP shall be aligned with joints in adjoining PCCP. Joints in center curbs adjacent to asphalt shall be spaced at 18 ft (15.5 m) maximum. The joints shall be saw cut or formed with 1/4 in. (6 mm) thick preformed joint material. Joint sealant is not required for joints in center curbs.

Where an expansion joint is constructed in PCCP adjacent to concrete center curb, the expansion joint shall be carried through the center curb in accordance with applicable requirements of 503.03(f).

605.07 HMA Curbing

(a) Excavation

Excavation shall be in accordance with 605.03(a).

(b) Preparation of Bed

When curbing is to be constructed on a fresh laid HMA surface, the curb may be laid only after the surface has been cleaned.

When curbing is to be constructed on a cured or aged portland cement concrete base, asphalt pavement, or asphalt treated base, the bed shall be thoroughly swept and cleaned with compressed air. The surface shall be thoroughly dried and, immediately prior to placing of the HMA mixture, shall receive a tack coat in accordance with 406. During application, the spread of this tack coat to areas outside of the area to be occupied by the curb shall be prevented.

(c) Mixture

The mixture shall be in accordance with 402.07(d).

Acceptance of HMA curbing mixtures will be a type D Certification in accordance with 916. The test results shown on the certification shall be the quality control tests representing the material supplied and include gradation and binder content. The gradation tolerances shall be ± 2.5% on the No. 200 (75 µm) sieve, ± 4.0% on the No. 4 (4.75 mm) sieve, and binder content tolerance shall be ± 0.5% from DMF.

(d) Placing

HMA curbing shall be constructed by use of a self-propelled automatic curber, curb machine or paver with curbing attachments. The curbing shall be in accordance with the section shown on the plans. The automatic curber or machine shall meet the following requirements and shall be approved prior to use.

1. The weight of the machine shall be such that required compaction is obtained without the machine riding above the bed on which curbing is being constructed.

2. The machine shall form curbing that is uniform in texture, shape, and density.

The construction of curbing by means other than the automatic curber or machine may be permitted when short sections or sections with short radii are required, or for such other reasons as may seem warranted. The resulting curbing shall conform in all respects to the curbing produced by the use of the machine. The face and top of the HMA curb shall be checked with a 10 ft (3 m) straightedge. Portions showing irregularities of 1/4 in. (6 mm) or more shall be removed and replaced.

Weather limitations shall be in accordance with 402.12.

(e) Painting and Sealing

When sealing or painting is required, it shall be performed only on a curbing which is clean and dry and which has reached the ambient temperature.

605.08 Resetting Curbing

(a) Salvage of Curbing

Curbing specified for resetting shall be cleaned, removed, and stored. Any existing curbing that is to be reset which is lost, damaged, or destroyed as a result of operations or because of failure to store and protect it in a manner that would eliminate its loss or damage, shall be replaced.

(b) Curb Removal

Curbing, which is unsuitable for resetting and which has not been damaged due to negligence, shall be removed and disposed of as directed.

(c) Excavation

Excavation and bedding shall be in accordance with 605.03(a).

(d) Resetting

The curb shall be set on a firm bed in accordance with the required line and grade. All sections of curbing shall be set so that the maximum opening between adjacent sections is 3/4 in. (19 mm) wide for the entire exposed top and face. Any dressing of the ends of the curbing necessary to meet this requirement shall be done as needed. Cutting or fitting may be necessary in order to install the curbing at the locations as directed.

After the curb has been set, the joints shall be completely filled with mortar as specified.

(e) Backfilling

The spaces in front and back of the curb shall be refilled to the required elevation with suitable material. This material shall be tamped thoroughly in layers of not over 6 in. (150 mm) in depth.

605.09 Method of Measurement

Curbing, both new and reset, and curb removal will be measured by the linear foot (meter) along the front face of the section at the finished grade elevation. Combined curb and gutter will be measured along the face of the curb. Curb turnout will be measured longitudinally by the linear foot (meter) as curb of the type specified, from the ends of the radii which touch the front face of the longitudinal curb portion. Combined curb and gutter turnout will be measured longitudinally by the linear foot (meter) as curb and gutter of the type specified, from the ends of the radii which touch the front face of the longitudinal curb portion. No deduction in length will be made for drainage structures installed in the curbing such as catch basins or drop inlets. Concrete center curb will be measured by the linear foot (meter), unless it is of variable width, in which case measurement will be by the square yard (square meter).

Bed course material will be measured by the ton (megagram).

605.10 Basis of Payment

The accepted quantities of curb work will be paid for at the contract unit price per linear foot (meter) for curb; curb and gutter; curb, reset; or center curb, of the type specified. Variable width center curb will be paid for at the contract unit price per square yard (square meter) for center curb, of the width specified. Bed course material will be paid for at the contract unit price per ton (megagram), complete in place.

Curb turnout will be paid for at the contract unit price per linear foot (meter) of the type of curb specified. Combined curb and gutter will be paid for at the contract unit price per linear foot (meter) for curb and gutter of the type specified.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Bed Course Material	TON (Mg)
Center Curb, _____ type	SYS (m2)
Center Curb, _____ type	LFT (m)
Curb and Gutter, _____ type	LFT (m)
Curb, _____ type	LFT (m)
Curb, Remove	LFT (m)
Curb, Reset, _____ type	LFT (m)

The cost of tack coat, reinforcing bars or welded wire reinforcement for curb, curb and gutter, or center curb shall be included in the cost of the pay items. The cost of replacement curb portions for those which show irregularities or 1/4 in. (6 mm) or more shall be included in the cost of curb.

SECTION 606 – SHOULDER CORRUGATIONS

606.01 Description

This work shall consist of placing corrugations in paved shoulders in accordance with 105.03. Corrugations shall not be constructed within the limits of reinforced concrete bridge approaches or on bridge decks.

The operation shall be coordinated such that milled materials do not encroach on pavement lanes carrying traffic and all milled materials are disposed of in accordance with 104.07.

The corrugations shall be constructed by cutting smooth strips in existing or newly constructed shoulders. The operation shall be conducted by means of a cutting machine that provides a series of smooth cuts without tearing or snagging. The equipment shall include guides to maintain uniformity and consistency in the alignment of the strips.

606.02 Method of Measurement

HMA and PCCP shoulder corrugations will be measured by the linear foot (meter), measured parallel to the center line of the roadway. Gaps in PCCP shoulder corrugations at the D-1 joints will be included as milled PCCP corrugations.

606.03 Basis of Payment

HMA and PCCP shoulder corrugations will be paid for at the contact unit price per linear foot (meter), when specified.

Payment will be made under:

Pay Item	Pay Unit Symbol
Milled HMA Shoulder Corrugations	LFT (m)
Milled PCCP Shoulder Corrugations	LFT (m)

SECTION 607 – PAVED SIDE DITCH OR CONCRETE GUTTER

607.01 Description

This work shall consist of placing a portland cement concrete lining, gutter, or reinforced concrete gutter turnout for side ditches in accordance with 105.03.

MATERIALS

607.02 Materials

Materials shall be in accordance with the following:

Concrete, Class A	702
Reinforcing Bars	910.01

CONSTRUCTION REQUIREMENTS

607.03 General Requirements

The excavation shall be to the required depth and shape of the bottom of the type and size of the side ditch being constructed, the details of which are shown on the plans. All soft, yielding, or unsuitable materials encountered at the required excavation elevation shall be removed and replaced with approved materials which shall be compacted and finished to a firm, smooth surface.

The applicable requirements of 605.04(b) shall apply to forms.

Placing, finishing, and curing shall be in accordance with 605.04 except the curing period shall be no less than 72 h. The finished surface need not be brushed.

Reinforcement will be required for all paved side ditch, cut-off-walls, and lugs as shown on the plans.

Paved side ditch transitions will be required at intersections with earth ditches and pipe culverts.

Transitions of 10 ft (3 m) or less will be required between 2 different types of paved side ditches.

Cut-off wall and lug details shall be as shown on the plans. A cut-off wall shall be constructed at the beginning and end of any paved side ditch. Lugs shall be poured monolithic with paved side ditch on steep grades. Their locations shall be as shown on the plans or as otherwise directed. Backfilling shall be in accordance with 605.04(g).

607.04 Cement Concrete Gutter and Turnout

Concrete gutter and concrete gutter turnout shall be constructed as shown on the plans or where directed. Construction shall be in accordance with all applicable requirements set out herein for paved side ditch.

607.05 Method of Measurement

Paved side ditch or cement concrete gutter will be measured by the linear foot (meter) along the centerline of the ditch per each type specified. Each cutoff wall or lug will be measured as 8 lft (2.4 m) of paved side ditch or cement concrete gutter. Paved side ditch transitions at earth ditches and pipe culverts will be measured as equivalent lengths in linear feet (meters) of the paved side ditch specified at each location. Transitions at the intersection of 2 different types of paved side ditch will be converted to equivalent lengths in linear feet (meters) of the larger type of paved side ditch specified at each site.

Reinforced concrete gutter turnout will be measured as 50 lft (15 m) of concrete gutter. Additional length, if required, will be measured by the linear foot (meter) of concrete gutter.

607.06 Basis of Payment

The accepted quantities of paved side ditch or cement concrete gutter of the type specified, including cutoff walls and lugs measured in accordance with 607.05, will be paid for at the contract unit price per linear foot (meter) complete in place. Concrete gutter turnout will be paid for at the contract unit price per linear foot (meter) for gutter, concrete, of the type specified.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Gutter, Concrete, _____ type	LFT (m)

Paved Side Ditch, _____ ..... LFT (m)
type

The cost of reinforcing bars or welded wire reinforcement, excavation, joints, and necessary incidentals shall be included in the cost of the pay items.

SECTION 608 – SHOULDER DRAINS

608.01 Description

This work shall consist of constructing shoulder drains in accordance with these specifications and in accordance with 105.03.

MATERIALS

608.02 Materials

Materials shall be in accordance with the following:

Coarse Aggregates, Class D or Higher, Size No. 8 904

CONSTRUCTION REQUIREMENTS

608.03 General Requirements

Unless otherwise designated, shoulder drains shall be installed on both sides of the pavement by trenching from the edges of the pavement through the shoulders and backfilling with aggregate at low points in the grade and at other locations when so directed. This work shall precede the finishing of the shoulders.

The width of the trench shall be approximately 12 in. (300 mm) unless otherwise directed. Other dimensions shall be as shown on the plans.

After the trench has been prepared, it shall be backfilled to the required elevation with aggregate, and then be well compacted. After this, any remaining unfilled trench area shall be filled with material approved for shoulders and compacted by rolling or tamping or both. The finished shoulder elevation shall conform with that required at that point.

608.04 Method of Measurement

Shoulder drains will be measured by the ton (megagram) of aggregate placed.

608.05 Basis of Payment

The accepted quantities of aggregate for shoulder drains will be paid for at the contract unit price per ton (megagram) for aggregate for shoulder drains complete in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Aggregate for Shoulder Drains	TON (Mg)

Excavation, trenching, backfilling, and other related miscellaneous items will not be paid for separately, but the cost thereof shall be included in the cost of the pay item.

SECTION 609 – REINFORCED CONCRETE BRIDGE APPROACHES

609.01 Description

This work shall consist of constructing reinforced concrete bridge approaches, RCBA, on a prepared subgrade and subbase in accordance with 105.03.

MATERIALS

609.02 Materials

Materials shall be in accordance with the following:

Coarse Aggregate, Class D or Higher, Size No. 53	904
Concrete, Class C*	702
Curing Materials	912.01
Joint Materials	906.02(a)1
Reinforcing Bars, Epoxy Coated	910.01
Support Devices	910.01(b)9

*Coarse Aggregate shall be Class AP, Size No. 8

CONSTRUCTION REQUIREMENTS

609.03 General Requirements

Subgrade shall be prepared in accordance with 207. Subbase shall be prepared in accordance with 302.

609.04 Forms

Forms shall be either steel or wood and shall be in accordance with 508.04(c)1 or 508.04(c)2.

609.05 Joints

Longitudinal construction joints will only be permitted as shown on the plans. The type I-A joint shall be constructed as shown on the plans.

Type I-A joints shall be created by sawing slots using sawing equipment in accordance with 508.07. The joint shall be cut in 2 operations. The initial saw cut shall commence as soon as the concrete has hardened sufficiently to permit sawing without raveling, usually 2 to 12 h after placement.

The 2nd saw cut shall be made after the concrete has sufficiently cured, but before opening the RCBA to all traffic. Slurry or saw residue remaining in the slot shall be immediately flushed. Construction traffic shall not be allowed on the RCBA after the 2nd saw cut until the joint is sealed.

The sawed slot shall be cleaned to remove all foreign matter from the entire depth of cut. Joint sealing shall be in accordance with 503.05.

609.06 Reinforcing Bars

Furnishing and placement of reinforcing bars shall be in accordance with 703.

609.07 Thickness

The depth of the RCBA will be checked by the Engineer prior to pouring, by making stringline measurements every 3 ft (0.9 m) across the width of the approach. Any location deficient in depth by 1/2 in. (13 mm) or more shall be corrected prior to placing the concrete.

609.08 Concrete Placement

The subbase shall be uniformly moist at the time of concrete placement. Delivery and placement of concrete shall be in accordance with 702.

609.09 Finishing

The RCBA shall be finished with equipment in accordance with 508.04(c)3 and 508.04(c)4. The operations shall be controlled so that an excess of mortar and water is not worked to the top. Long handled floats may be used to smooth and fill in open textured areas. The edges of formed RCBA shall be tooled or chamfered.

The finished RCBA surface shall be textured with a double thickness burlap drag or a minimum 4 ft (1.2 m) wide turf drag. Immediately after the finishing operation is complete and before the surface film has formed, the surface of the RCBA shall be textured by transverse grooving in accordance with 504.03. The grooves may be formed by mechanized equipment using a vibrating beam roller, a series of discs or other approved device. Manual tools such as fluted floats, spring steel tined rakes, or finned floats with a single row of fins may be used. The grooves shall be relatively uniform and smooth and shall be formed without tearing the surface or bringing coarse aggregate to the top.

All areas of hardened RCBA which do not conform to the requirements due to either a deficiency in the grooving or a rough open textured surface shall be corrected. Corrections shall be made by cutting transverse grooves in the hardened surface with an approved cutting machine and retexturing to a satisfactory finish as directed.

609.10 Curing

RCBA shall be wet cured in accordance with 702 or shall have liquid membrane forming curing compound applied to exposed surfaces within 30 min after the

finishing operations have been completed. The edges of the RCBA shall be cured immediately upon removal of the forms. The edge shall be covered with curing materials equal to the material used on the surface or banked with soil 12 in. (300 mm) wide or greater.

When conditions arise which prevent timely application of curing materials the surfaces shall be kept wet with a fine spray of water. The fine spray of water shall continue until application of curing materials is resumed.

Liquid membrane forming curing compound shall be applied in a continuous uniform film at a rate not less than 1 gal./150 sq ft (1 L/3.7 m^2). Additional applications, if needed, shall follow the previous application within 30 min. The curing compound may be warmed in a water bath during cold weather at a temperature not exceeding 100°F (38°C). Thinning with solvents will not be permitted. Non-uniform film rates will result in the discontinuance of that application method.

A new coat of curing compound shall be applied to areas damaged by rain or other means during the curing period. The recoating shall be applied as soon as possible and at a rate equal to that specified for the original coat.

609.11 Smoothness

The smoothness of the surface of the RCBA will be measured by means of a 10 ft (3 m) long straightedge as soon as practical following curing or completion of adjoining roadway or structure sections. All surface variations shall be corrected to 1/8 in. (3 mm) or less.

Smoothness variations outside specified tolerances shall be corrected in accordance with 502.20.

609.12 Opening to Traffic

RCBA may be opened to traffic after 14 days. The RCBA may be opened earlier if test beams indicate a modulus of rupture of 550 psi (3,800 kPa) or greater.

The Contractor and Engineer will conduct an inspection of the new RCBA for any damage. The inspection and all necessary repairs shall be completed prior to opening to traffic.

609.13 Method of Measurement

Reinforced concrete bridge approaches will be measured by the square yard (square meter). Dense graded subbase will be measured in accordance with 302.08. Reinforcing bars will be measured in accordance with 703.07.

Subgrade preparation will not be measured for payment. Finishing and curing of the RCBA will not be measured for payment. Construction joints or type I-A joints will not be measured.

609.14 Basis of Payment

Reinforced concrete bridge approaches will be paid for at the contract unit price per square yard (square meter). Dense graded subbase will be paid for in accordance with 302.09. Reinforcing bars will be paid for in accordance with 703.08.

Payment will be made under:

Pay Item	Pay Unit Symbol
Reinforced Concrete Bridge Approach, _____ in. (mm) thickness	SYS (m2)

The cost of all materials, water, equipment, and all labor for the compaction of the subgrade, shall be included in the cost of the RCBA.

The cost of finishing, furnishing and placing curing materials shall be included in the cost of the RCBA.

The cost of corrections for smoothness or re-texturing shall be included in the cost of the RCBA.

The cost of all labor and materials for the placement of construction joints and type I-A joints shall be included in the cost of the RCBA.

SECTION 610 – APPROACHES AND CROSSOVERS

610.01 Description

This work shall consist of constructing or resurfacing public road intersections; turn lanes, passing lanes, acceleration lanes, deceleration lanes, or recovery lanes where the total longitudinal dimension is less than 100 lft (30 m), excluding tapers; mail box approaches; private and commercial driveways; and crossovers; in accordance with 105.03.

MATERIALS

610.02 Materials

Materials shall be in accordance with the following:

Aggregate Base..... 301.02
HMA..... 402.02
PCCP 502.02
Subbase..... 302.02

CONSTRUCTION REQUIREMENTS

610.03 General Requirements

Subgrade for approaches shall be prepared in accordance with 207. Aggregate base shall be constructed in accordance with 301. HMA for approaches shall be constructed in accordance with 402. HMA mixture for approaches shall be HMA surface or intermediate, type A, B, C, or D in accordance with 402.04. A MAF in accordance with 402.04 will not apply.

Dense graded subbase shall be constructed in accordance with 302. PCCP for approaches shall be constructed in accordance with 502. The CMDS shall be submitted to the Engineer for approval. Utilization of the Department provided spreadsheet is not required.

610.04 Existing Approaches and Crossovers

If an existing surface is to be left in place as an approach pavement or crossover, the surface shall be patched in accordance with 304.04 or 305.04, or as directed. Existing approaches or crossovers that have been rubblized shall be primed in accordance with 405 prior to being paved.

610.05 Method of Measurement

Compacted aggregate base will be measured by the ton (megagram) in accordance with 109.01(b). HMA mixture for approaches will be measured by the ton (megagram) of the type specified, in accordance with 109.01(b). Dense graded subbase will be measured in accordance with 302.08. PCCP for approaches will be measured by the square yard (square meter) of the thickness specified. Subgrade treatment will be measured in accordance with 207.05.

HMA patching in accordance with 610.04, will be measured by the ton (megagram) in accordance with 304.06. PCCP patching in accordance with 610.04, will be measured by the square yard (square meter) in accordance with 305.06.

Prime coat will be measured in accordance with 405.09. Tack coat will be measured in accordance with 406.06. Seal coat will be measured in accordance with 404.13.

610.06 Basis of Payment

The accepted quantities of HMA mixture for approaches will be paid for at the contract unit price per ton (megagram) of the type specified, complete in place. Compacted aggregate base will be paid for in accordance with 301.10. PCCP for approaches will be paid for at the contract unit price per square yard (square meter) of the thickness specified, complete in place. Dense graded subbase will be paid for in accordance with 302.09. Subgrade treatment will be paid for in accordance with 207.06.

HMA patching will be paid for in accordance with 304.07. PCCP patching will be paid for in accordance with 305.07.

Prime coat will be paid for in accordance with 405.10. Tack coat will be paid for in accordance with 406.07. Seal coat will be paid for in accordance with 404.14.

The quantities of materials placed on the 3 ft (0.9 m) wedge on approaches, when placed with the mainline pavement shall be included in the mainline HMA items and paid for in accordance with 401.22 or 402.20. The quantities, when placed separately from the mainline pavement, shall be included in the quantities for HMA for approaches and paid for in accordance with 610.06.

The quantities of materials for the paving or resurfacing of turn lanes, passing lanes, acceleration lanes, deceleration lanes, and recovery lanes greater than 100 lft (30 m), excluding tapers, shall be included in the mainline quantities and paid for in accordance with 401.22, 402.20, 501.31, or 502.23 whichever is applicable.

The accepted quantities of HMA material for mailbox approaches will be included with quantities required to construct the shoulder section when the shoulder is to be paved. If the shoulder is not to be paved, the HMA material for mailbox approaches will be paid for as HMA mixture for approaches of the type specified.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
HMA for Approaches, Type __*__	TON (Mg)
PCCP for Approaches, _____ thickness	SYS (m2)

* Mixture type in accordance with 402.04.

The cost of excavation, shaping, leveling, forming, compaction, placing, and all necessary incidentals shall be included in the cost of the pay items in this section.

The cost for curbing placed monolithically with the PCCP on approaches shall be included in the cost of PCCP for approaches.

SECTION 611 – MAILBOX INSTALLATIONS

611.01 Description

This work shall consist of the construction of mailbox installations in accordance with 105.03.

MATERIALS

611.02 Materials

Materials shall be in accordance with the following:

Mailbox Support Galvanized Hardware .....ASTM A 153
Nominal Standard Galvanized Pipe.....ASTM A 53
Treated Wood Posts.....911.02(e)

CONSTRUCTION REQUIREMENTS

611.03 Mailbox Assembly

Existing mailboxes and assemblies shall be removed without damage from the highway right-of-way. Mailboxes, which must remain in service between removal and erection of the new assembly, shall be securely mounted to an empty 55 gal. (208 L) metal drum. The temporary assembly shall be located where it is accessible for mail delivery but placed as far as possible from the traveled roadway. The apparent owner of the existing mailbox shall be contacted and allowed to take possession of the existing mailbox and assembly. If the owner refuses to take possession, the existing mailbox and assemblies shall be removed.

Mailbox assemblies shall be furnished and installed as shown on the plans. Alternate mailbox assemblies which have been crash tested and approved in accordance with NCHRP 350 requirements may be considered upon receipt of a written request. Alternate mailbox assemblies approved for use shall be furnished and installed in conformance with the manufacturer's recommendations.

Mailboxes complying with the requirements of the United States Postal Service, including markings and sizes, shall be furnished and installed with the mailbox assembly. The mailbox shall be of comparable size to the existing mailbox previously removed from the highway right-of-way. The markings shall include "approved by U.S. Postmaster" stamped on the mailbox by the manufacturer and the address number, box number, or house number, in 2 in. (50 mm) or larger reflective material placed on the side of the mailbox in view of motorists in the nearest travel lane.

611.04 Method of Measurement

Mailbox assemblies will be measured by the number of units installed.

611.05 Basis of Payment

Mailbox assemblies will be paid for at the contract unit price for each, complete in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Mailbox Assembly, Double	EACH
Mailbox Assembly, Single	EACH

The cost of wood or pipe posts, support hardware, mailbox, and removal of existing mailbox and its assembly shall be included in the cost of the mailbox assembly.

SECTION 612 – UNDERSEALING

612.01 Description

This work shall consist of furnishing and pumping an asphalt material under cement concrete pavement in accordance with 105.03.

MATERIALS

612.02 Materials

Utility asphalt, UA-II or UA-III shall be in accordance with 902.01(d).

CONSTRUCTION REQUIREMENTS

612.03 Shoulders

All holes, low areas, or displaced areas in the shoulders immediately adjacent to the pavement edge shall be filled with loam, clay, or other approved material and compacted to the elevation of the pavement. Such areas, including all other shoulder areas immediately adjacent to the pavement edge, shall be compacted with a roller or another approved method.

612.04 Drilled Holes

Where the existing pavement has transverse joints, holes not to exceed 1.5 in. (38 mm) in diameter shall be drilled on the centerlines of the pavement lane to be treated. Such holes, unless otherwise directed, shall be located longitudinally between transverse joints or cracks at approximately 30 to 36 in. (750 to 900 mm) from the joints or cracks. Intermediate holes, if necessary, shall be spaced as directed.

If the existing pavement does not have transverse joints, holes not to exceed 1.5 in. (38 mm) in diameter shall, unless otherwise permitted or directed, be located on the centerline of the pavement lane to be treated and be spaced as directed.

An approved method shall be used to prevent the drill from entering the subgrade after penetrating the pavement. Automatic stops on mechanical equipment and marked drill bits on hand operated jackhammers may be approved subject to satisfactory operation.

Just prior to pumping operations, the surface of the pavement around each hole for an area of at least 1/2 the width of the lane being treated shall be thoroughly sprinkled with water to prevent the undersealing material from adhering to the pavement surface.

612.05 Pumping Asphalt

After the above procedure is complete, the asphalt shall then be pumped through the holes and under the pavement with an approved type of self-propelled pressure distributor, the pressure to be as directed. A metallic hose shall connect the asphalt tank through an asphalt pump to a 1 in. (25 mm) nozzle and a return metallic hose shall connect the nozzle to the asphalt distributor tank.

The nozzle shall be equipped with a 3-way valve so designed that the asphalt may circulate back to the distributor tank when pumping operations are not in progress. The nozzle shall be inserted in the hole, driven to a snug fit, and pumping of the asphalt continued until the undersealing is complete, or to such other amount as directed. In case of an existing asphalt resurface on concrete, holes shall be drilled through the resurface and the underlying concrete and the nozzle shall be of sufficient length that it can be driven to a snug fit into the concrete without the upper part of the nozzle being below the elevation of the existing asphalt resurface. Upon completion of the pumping operation, the nozzle shall be removed and a wood plug driven into the hole without an excessive back flow of asphalt material. After the material has hardened, the plug shall be removed and a hardwood plug at least 3 in. (75 mm) long and a minimum of 1/16 in. (2 mm) larger than the diameter of the drilled hole shall be driven flush with the surface of the concrete pavement. All material extruded during the pumping operations shall be immediately cleaned from the pavement surface and removed from the limits of the contract within a period of 24 h.

Where undersealing operations are being performed under traffic, necessary signs, barricades, watchers, and flaggers shall be used to maintain 1 lane traffic in the immediate vicinity of pumping operations. Traffic may be permitted to use the pumped areas upon removal of the original plugs and after the hardwood plugs are driven.

All storage tanks, pipes, retorts, booster tanks, and distributors used for storing or handling the asphalt materials shall be kept clean and in good operating condition at all times so there is no contamination of the materials.

The asphalt shall not be heated above 500°F (260°C) at any time and, when pumped under the pavement, the temperature shall be no less than 350°F (177°C). All material heated beyond 500°F (260°C) shall be rejected.

No material shall be applied on a frozen subgrade nor when the atmospheric temperature is 40°F (4°C) or lower and falling. The asphalt shall be placed only when general weather conditions are suitable.

When directed, certain portions may be required to be undersealed a 2nd time. The number of holes involved in this 2nd undersealing shall not exceed 5% of the number of holes indicated in the Schedule of Pay Items.

612.06 Method of Measurement

Asphalt material will be measured by the ton (megagram). Drilled holes for underseal will be measured per each hole drilled.

612.07 Basis of Payment

This work will be paid for at the contract unit price per ton (megagram) for asphalt material for underseal. Drilled holes for underseal will be paid for at the contract unit price per each, complete in place.

Additional holes and materials required for a 2nd undersealing operation will be paid for at the contract unit prices for the quantities involved.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Asphalt Material for Underseal	TON (Mg)
Drilled Hole for Underseal	EACH

The cost of shoulder material, wood and hardwood plugs, and necessary incidentals shall be included in the cost of the pay items.

SECTION 613 – SALVAGED ROAD MATERIALS

613.01 Description

This work shall consist of removing approved material from an existing road within the limits of the contract, including intersecting approaches, and using it in reconstruction of the road in accordance with these specifications or as directed.

613.02 Materials

Approved materials may be asphalt treated or untreated gravel, stone, slag, or all combinations of these or other materials which are suitable for salvaging.

613.03 Construction Requirements

Before any filling or further work is done at locations where material is to be salvaged, such material shall be removed and stored in stockpiles outside the construction limits and adjacent thereto, or it may be incorporated directly into the work without stockpiling if conditions permit.

The quantities removed, if available, shall be sufficient to complete the item of work or certain portions thereof for which it is intended. The depth of excavation shall be as directed.

The incorporation of the salvaged material into the work shall be in accordance with applicable provisions of the specifications for which the material is to be used

or in accordance with the special provisions, depending on the nature of the material and the use to which it is put.

613.04 Method of Measurement

Salvaged road material will be measured by the cubic yard (cubic meter) in stockpiles after removal from its original position or, if the Contractor prefers, it will be measured by the cubic yard (cubic meter) in its original position. All measurements will be made by means of cross sections. The volumes will be computed by the average end area method.

If salvaged road material is used as subbase, the combined pay quantities of subbase and salvaged road material for subbase shall equal but shall not exceed the total theoretical volume as calculated to the neat lines shown on the plans for subbase. If the volume of salvaged road material used as subbase determined by the cross section method does exceed the total theoretical volume of subbase, the final pay quantity for salvaged road material for subbase shall be the total theoretical volume.

The final pay quantity of subbase will be determined by deducting the final pay quantity of salvaged road material for subbase from the total theoretical volume of subbase.

If salvaged road material is obtained from within the pay limits of the new construction, such cubic yardage (cubic meterage) of salvaged material will be deducted from the excavation quantities to be measured for payment.

613.05 Basis of Payment

The accepted quantities of salvaged road material for the use shown on the Schedule of Pay Items will be paid for at the contract unit price per cubic yard (cubic meter), complete in place.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Salvaged Road Material for _____	CYS (m3)

The cost of removal of the material, storage, incorporating it into the work, and necessary incidentals shall be included in the cost of the pay item.

SECTION 614 – CONCRETE HEADER

614.01 Description

This work shall consist of the construction or reconstruction of PCC headers adjacent to railroad tracks, bridges, and similar locations in accordance with 105.03.

MATERIALS

614.02 Materials

Materials shall be in accordance with the following:

Concrete 702
Reinforcing Bars..... 910.01

If the header is adjacent to cement concrete base or pavement, the header concrete shall be the same composition as that of the base or pavement header constructed monolithic with the base or pavement. If the adjacent base or pavement is thickened, that portion forming the thickening shall be considered as part of the header.

If the header is adjacent to asphalt pavement, the concrete shall be class A in accordance with 702 using class AP coarse aggregate.

CONSTRUCTION REQUIREMENTS

614.03 PCC Header

Construction shall be in accordance with the applicable provisions of 702 and with these requirements.

Welding shall be in accordance with 711.32.

Headers at railroad crossings shall be as shown on the plans.

614.04 Reconstructed Cement Concrete Header

This work shall be in accordance with the plans. Round plug welds or rectangular shaped plug welds may be used to weld the steel angle to the existing steel edge protection. Round plug welds shall be a minimum of 1 in. (25 mm) diameter.

Welding shall be in accordance with 711.32.

614.05 Method of Measurement

Cement concrete header and reconstructed cement concrete header will be measured by the linear foot (meter).

614.06 Basis of Payment

The accepted quantities of this work will be paid for at the contract unit price per linear foot (meter) for header, cement concrete, of the type specified, or header, cement concrete, reconstruct, complete in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Header, Cement Concrete, _____ type	LFT (m)
Header, Cement Concrete, Reconstruct	LFT (m)

The cost of edge protection, metal chairs, excavation, and necessary incidentals shall be included in the cost of the pay items.

SECTION 615 – MONUMENTS, MARKERS, AND PARKING BARRIERS

615.01 Description

This work shall consist of furnishing and setting, setting only, or resetting right-of-way markers, monuments for marking section or other lines, bench mark posts and tablets, and parking barriers in accordance with 105.03.

MATERIALS

615.02 Materials

Materials shall be in accordance with the following:

Coarse Aggregate, Class A or Higher, Size No. 8 or 91	904
Fine Aggregate, Size No. 23	904
Portland Cement	901.01(b)
Reinforcing Bars	910.01

615.03 Reinforced Cement Concrete Right-of-Way Markers

These markers shall conform with the dimensions and lettering shown on the plans. The reinforcement shall be securely held in place by at least 4 spacers of an approved design. The concrete ingredients shall be graded and proportioned to produce a strong dense concrete.

When tested as hereinafter described, a specimen shall support a total load of at least 2,400 lb (10,700 N) before the 1st crack appears. The specimen will be tested as a simple beam. The distance between supports shall be exactly 24 in. (610 mm) with the load applied at the rate of approximately 1,200 lb (5,400 N) per min in the center of the span. Loading will continue until the 1st crack appears.

The cement concrete shall absorb no more than 8% water. Specimens for absorption may be taken from the markers tested for strength. The absorption test shall be as described in accordance with AASHTO T 280 except the specimen tested shall be the full cross section marker.

The markers shall have a smooth workmanlike finish free from cracks, patches, honeycomb, exposed reinforcement, and excessive bubble holes. Each marker shall

be plainly marked near the bottom with the trademark or initials of the manufacturer and the date of manufacture. These letters and figures shall be no less than 1 in. (25 mm) in height and shall be indented 1/8 in. (3 mm).

Right-of-way markers furnished under this specification shall be covered by a type C certification in accordance with 916.

615.04 Monuments

Monuments shall be of the type specified in the Proposal book, the details of which are shown on the plans. Any portion extending above the ground shall be finished in accordance with 702.21.

Where concrete is required, it shall be class A in accordance with 702. When placed in the forms it shall be tamped in layers until mortar covers the outer surface. The tops of the monument shall be floated smooth. Monuments may be cast in place or cast outside and then set.

The pin shall be set perpendicular to and flush with the top of the monument while the concrete is plastic and left undisturbed until the concrete has set. The pin shall be copper and shall be 1 in. (25 mm) in diameter and 5 in. (125 mm) long. If for type D monuments, the hole shall be drilled in the center with a 1/8 in. (3 mm) drill for a depth of 1.5 in. (38 mm). The hole shall be filled with lead flush with the end of the pin. Castings for protected monuments shall be in accordance with 910.05(a).

615.05 Bench Mark Posts

Bench mark posts shall be of the dimensions shown on the plans and cast in accordance with applicable provisions of 615.03, except the strength shall be determined by concrete cores taken from the finished product. At least 2 concrete cores will be taken from each unit and the average strength of the unit shall be at least 4,000 psi (28 MPa) with no individual core strength less than 3,600 psi (25 MPa). Tablets will be furnished by the Department and shall be set in the posts as indicated on the plans.

615.06 Parking Barriers

Parking barriers shall be of the dimensions shown on the plans. The barriers shall be cast and tested in accordance with the applicable requirements of 615.03, except the strength shall be determined by concrete cores taken from the finished product. At least 2 concrete cores will be taken from each unit and the average strength of the unit shall be at least 4,000 psi (28 MPa) with no individual core strength less than 3,600 psi (25 MPa).

CONSTRUCTION REQUIREMENTS

615.07 Setting Right-of-Way Markers

The back face of these markers shall be set on the right-of-way lines approximately 1,000 ft (300 m) apart as hereinafter provided. They shall be set at all

corners of irregular right-of-way lines, opposite each P.C. and P.T. of curves, and not to exceed 500 ft (150 m) apart on the inside and outside of curves. Care shall be used in locating markers on tangents so that a marker is plainly visible from each of those adjacent.

Markers shall be set plumb, to the depth required on the plans, and with the letters facing the pavement. Portions of the holes not occupied by markers shall be backfilled and compacted in layers with suitable material up to the level of the original ground. The markers shall not be displaced during backfilling.

615.08 Resetting Right-of-Way Markers

When the proposal provides that existing right-of-way markers be reset, the existing markers shall be removed and reset at designated locations in accordance with 615.07.

615.09 Setting Monuments

If the location of a monument falls within the limits of a cement concrete pavement, a copper pin, the details of which are shown on the plans, shall be set perpendicular to and flush with the top of the finished pavement. It shall be placed just before the concrete takes initial set and then left undisturbed until the concrete has set. Other monuments shall be of the type shown on the plans, depending on the type or surface of the pavement in which they are to be placed or if they are to be placed outside of pavement. Necessary excavation shall be to the required depth. The bottom of the excavation shall be firm and true to line and grades given. After a monument is in place, the remaining excavated areas shall be backfilled with suitable material firmly tamped in layers. The monument shall not be disturbed.

Existing monuments which are not required to be disturbed or re-established, but which are disturbed during construction operations, shall be re-established.

615.10 Re-Established Monuments

It may be necessary to re-establish existing monuments in pavements or bases which are disturbed unavoidably or covered by operations embraced in the contract.

If the existing monument is, or contains a brass or copper pin, the pin shall be extended to the surface of the new pavement by attaching a brass or copper pin with at least a 1 in. (25 mm) diameter and of the length required. Such extensions shall be attached by tapping the original pin and providing a necessary screw attachment such that the extension can be fastened securely to the original pin. The tapped hole shall be at least 1/4 in. (6 mm) in diameter and no less than 1 in. (25 mm) deep. The screw attachment shall have the same diameter as for the hole in the original pin and shall be no less than 1 in. (25 mm) in length.

Where an existing monument of the type specified above has not been re-established on a previous contract, the monument shall be re-established in the same manner as set out above.

Where existing monuments are protected and encased in cast iron, such castings shall be adjusted to meet the elevation of the proposed surface by means of an asphalt coated, cast iron, adjustment casting. The size shall be the same as the original casting and of the depth necessary to meet the elevation of the proposed new surface.

615.11 Setting Bench Mark Posts and Tablets

Bench mark posts shall be set at locations marked on the plans or as directed. Excavation shall be to the depth indicated and to dimensions sufficient to provide for the concrete backfilling. This concrete shall be class A and shall extend for 6 in. (150 mm) around and below the post. The bottom shall be monolithic with the sides. The remainder of the excavation up to the original ground line shall be backfilled with suitable material well tamped in layers. Care shall be taken not to disturb the post. When specified on the plans, or directed, bench mark tablets furnished by the Department shall be placed in newly constructed or existing drainage structures located within the limits of the contracts.

615.12 Reset Bench Mark Posts

When the Proposal book provides that existing bench mark posts be reset, the existing bench mark posts shall be removed and reset at designated locations in accordance with 615.11.

615.13 Method of Measurement

Right-of-way markers, reset right-of-way markers, monuments, re-established monuments, castings adjusted to grade monuments, bench mark posts, and reset bench mark posts will be measured by the number of units installed. Parking barriers will be measured by the number of units installed.

615.14 Basis of Payment

The acceptable quantities of right-of-way markers, reset right-of-way markers, monuments, re-established monuments, castings adjusted to grade monuments, bench mark posts, and reset bench mark posts, and parking barriers will be paid for at the contract unit price per each complete in place.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Bench Mark Post	EACH
Bench Mark Post, Reset	EACH
Casting Adjusted to Grade, Monument	EACH
Monument, _____ type	EACH
Monument, Re-Establish	EACH
Parking Barrier	EACH

Right-of-Way Marker ..... EACH
Right-of-Way Marker, Reset ..... EACH

The cost of setting tablets in structures or bench mark posts, extensions for monuments, adjustment castings, re-establishing disturbed existing monuments, and other necessary incidentals shall be included in the cost of the pay items.

SECTION 616 – RIPRAP AND SLOPEWALL

616.01 Description

This work shall consist of placing broken stone or concrete which may or may not be grouted, precast slabs, or slopewall in accordance with these specifications and in accordance with 105.03.

MATERIALS

616.02 Materials

Materials shall be in accordance with the following:

Asphalt Joint Filler 906.01
Clay 903.01
Concrete, Class A 702
Fine Aggregate, Size No. 23 904
Geotextile 918.02
Portland Cement ..... 901.01(b)
Precast Concrete Riprap ..... 904.04(e)
Riprap 904.04
Steel Welded Wire Reinforcement, Smooth ..... 910.01(b)5
Water 913.01

CONSTRUCTION REQUIREMENTS

616.03 Placing Dumped Riprap

Dumped riprap shall be placed to produce a surface of approximate regularity but need not necessarily be hand placed. The finished surface shall vary no more than 9 in. (225 mm) from a true plane. The thickness perpendicular to its surface shall be no more than 2 ft (0.6 m) nor less than 1 ft (0.3 m) unless otherwise directed.

616.04 Placing Grouted Riprap

The aggregate, preparation of the slope, and the depth of riprap aggregate for grouted riprap shall be in accordance with 616.05. After the aggregate has been placed and accepted, all openings shall be filled with cement grout. The finished surface shall be approximately smooth, solid, and true to line, grade, and section.

Grout shall be composed of 1 part portland cement and 4 parts fine aggregate. The portland cement and fine aggregate shall be dry-mixed to a uniform mixture.

Water shall be added as the mixing continues until the grout attains a consistency that will allow it to flow into the openings.

616.05 Placing Revetment, Class 1, and Class 2 Riprap

Revetment, class 1 and class 2 riprap may be placed by dumping and shall be placed to the required thickness. The finished surface shall be free from clusters of small stones or of large ones. The finished surface shall vary from a true plane no more than 9 in. (225 mm) for revetment riprap or 18 in. (450 mm) for class 1 or class 2 riprap but shall not be less than the minimum depth specified.

616.06 Placing Uniform Riprap

Uniform riprap shall be placed to produce a surface of approximate regularity with edges having projections no more than 3 in. (75 mm) above the required cross section. The material shall be hand laid or placed by other approved means.

616.07 Blank

616.08 Placing Precast Cement Concrete Riprap

The slope on which the riprap is to be placed shall be in accordance with that shown on the plans unless otherwise designated. Laying shall begin in a trench below the toe of the slope and progress upward. Each piece shall be laid by hand perpendicular to the slope. It shall be firmly embedded against the slope in such a manner that the vertical joint space between individual units does not exceed 3/8 in. (10 mm), unless otherwise permitted. Half blocks, odd shaped blocks, or class A concrete shall be used to fill the voids at the ends of sections to be placed or on curved shaped sections. The top course shall conform, as nearly as practicable, with the prescribed berm or shoulder elevation. Any adjustment necessary to achieve this shall be obtained by constructing a wedge course near the top of the slope as directed. This wedge course, when required, shall consist of class A concrete. If the thickness of the course does not permit class A concrete, it shall be constructed of a 1:2 mortar proportioned by volume. Toewalls, when required, shall consist of class A concrete.

616.09 Slopewall

The slope on which slopewall is to be placed shall be in accordance with that shown on the plans unless a different slope is designated.

The concrete mixture shall be class A. Where paved slopewall abuts or surrounds columns, piers, or other structures, 5/8 in. (16 mm) of asphalt joint filler shall be used between the slopewall and such structure. Welded steel wire reinforcement shall be placed within the middle 1/3 of the slopewall thickness unless otherwise directed. The fabric shall extend through all construction joints. The surface of the slopewall shall be cured for 48 h in accordance with 501.20. Construction joints may be either butt or keyway type.

Inspection holes shall be provided at the locations shown on the plans or as directed. The holes shall be approximately 3 ft by 3 ft (0.9 m by 0.9 m) in size.

Precast concrete riprap, type B, as shown on the plans, may be used in lieu of slopewall of 4 in. (100 m) thickness.

616.10 Undermined Paved Side Ditch

Treatment of undermined existing paved side ditch and placement of revetment riprap shall be as shown on the plans or as otherwise directed.

Undermined paved side ditch shall be broken up and left in place. If it is determined that erosion is excessive, the eroded area shall be backfilled with a cohesive material, compacted, regraded, and lined with revetment or uniform riprap.

616.11 Installation of Geotextile Under Riprap

Storage and handling of geotextiles shall be in accordance with the manufacturer's recommendations, except that the geotextile shall not be exposed to direct sunlight, ultraviolet rays, water, temperature greater than 140°F (60°C), mud, dirt, dust, and debris, to the extent that its strength, toughness, or permeability requirements are diminished. Each geotextile roll shall be labeled or tagged to provide product identification sufficient for inventory and quality control purposes. Exposure of geotextiles to the elements between lay down and cover shall be a maximum of 14 days. At the time of installation, the geotextile shall be rejected and replaced with no additional payment if defects, rips, flaws, deterioration or damage incurred during manufacture, transportation, storage, or construction is evident.

The surface to receive the geotextile shall be prepared to a relatively smooth condition free of obstructions, depressions, and debris within the limits indicated on the plans.

Geotextiles used along channels shall be placed with the machine direction of the geotextile parallel to the channel. Successive geotextile sheets shall be overlapped in such a manner that the upstream sheet is placed over the down stream sheet and the upslope sheet over the downslope sheet.

Geotextiles used for 2:1 slopes or greater shall be placed with the machine direction of the geotextile sheets perpendicular to the toe of slope. The geotextile sheets shall be overlapped in the direction of the anticipated movement of water.

Adjacent pieces of geotextile may be joined by sewing if approved, or by overlapping and pinning. The minimum overlap shall be 18 in. (460 mm) except when placed under water. When placed under water, the overlap shall be a minimum of 3 ft (0.9 m). Securing pins shall be steel, 3/16 in. (5 mm) in diameter, 18 in. (460 mm) long, pointed at one end and fabricated with a head to retain a steel washer having an outside diameter of no less than 1 1/2 in. (38 mm). Securing pins with washers shall be inserted through both strips of overlapped geotextile at spacing

intervals in Table 1 along a line through the midpoint of the overlap. The geotextile strip shall be placed so that the lower strip will be overlapped by the next higher strip. Pins shall be driven until the washer bears against the geotextile and secures it firmly to the ground.

Whether the fabric is joined by sewing or pinning, additional pins shall be installed as necessary to prevent any slippage of the fabric regardless of location.

TABLE 1

Slope	Pin Spacing
steeper than 3:1	2 ft (0.6 m)
3:1 to 4:1	3 ft (0.9 m)
4:1 or flatter	5 ft (1.5 m)

The geotextile shall be placed in such a manner that placement of the overlying materials will not excessively stretch or tear the geotextile and will not pull the required overlap or seam apart. Construction equipment will not be allowed on the exposed geotextile. Placement of riprap or stone shall start from the base of the slope, moving upslope and from the center outward. Riprap shall not be allowed to roll downslope and the height of drop for riprap shall be kept to less than 2 ft (0.6 m).

616.12 Method of Measurement

Dumped, revetment, class 1 and class 2 riprap obtained from outside the right-of-way will be measured by the ton (megagram). If obtained from inside the right-of-way, no measurement will be made if placed as shown on the plans unless direct payment is specified. If placed at locations not shown on the plans, measurement will be made by the square yard (square meter).

Grouted riprap and precast concrete riprap, including the area occupied by the wedge course, will be measured by the square yard (square meter), parallel to the slope. Slopewall will be measured by the square yard (square meter). Holes for inspecting slopewalls will be measured per each. Geotextiles used under riprap will be measured by the square yard (square meter), complete in place. Uniform riprap will be measured by the ton (megagram).

Treatment of undermined paved side ditch will be measured by the linear foot (meter) of paved side ditch, broken and left in place.

616.13 Basis of Payment

The accepted quantities of dumped, revetment, class 1, and class 2 riprap obtained from outside the right-of-way will be paid for at the contract unit price per ton (megagram). Dumped, revetment, class 1, and class 2 riprap obtained from within the project limits will be paid for at the contract unit price per square yard (square meter). Uniform riprap will be paid for at the contract unit price per ton (megagram). Grouted riprap will be paid for at the contact unit price per square yard

(square meter) of the specified depth. Precast concrete riprap, and concrete slopewall will be paid for at the contract unit price per square yard (square meter), all complete in place. If slag is used as dumped riprap and payment will be made per ton (megagram), the pay quantity will be adjusted in accordance with 904.01.

The accepted quantities of geotextiles used under riprap will be paid for at the contract unit price per square yard (square meter), complete in place.

Inspection holes will be paid for at the contract unit price per each.

The treatment of undermined paved side ditch will be paid for at the contact unit price per linear foot (meter) for paved side ditch, break. Backfill required for treatment of paved side ditch will be paid for at the contract unit price per cubic yard (cubic meter) for borrow, cohesive.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Borrow, Cohesive	CYS (m3)
Geotextiles	SYS (m2)
Inspection Hole	EACH
Paved Side Ditch, Break	LFT (m)
Riprap, Class _____	TON (Mg) SYS (m2)
Riprap, Dumped	TON (Mg) SYS (m2)
Riprap, Grouted, _____ in. (mm) depth	SYS (m2)
Riprap, Precast Concrete	SYS (m2)
Riprap, Revetment	TON (Mg) SYS (m2)
Riprap, Uniform	TON (Mg)
Slopewall	SYS (m2)
Slopewall, Concrete, _____ in. (mm) depth	SYS (m2)

If the contract includes a pay item for removing materials from within the project limits which are used as grouted riprap, the cost of such removal shall be included in the cost of the pay item for the removal work. The cost of placing such material shall be included in the cost of the riprap pay item.

The cost of paved side ditch required at the top of riprap and along the edge of riprap will be paid for in accordance with 607.06. The cost of welded steel wire reinforcement shall be included in the cost of the slopewall.

The cost of excavation below the finished riprap or slopewall shall be included in the cost of the riprap and slopewall pay items. The cost of excavation, grading, sewing, pinning, and necessary incidentals shall be included in the cost of geotextiles.

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SECTION 619 – PAINTING BRIDGE STEEL

619.01 Description

This work shall consist of preparing surfaces and applying paint to steel bridges in accordance with 105.03.

MATERIALS

619.02 Materials

Materials shall be in accordance with the following:

Epoxy Intermediate Paint	909.02(b)
Finish Coat for Weathering Steel	909.02(e)
Multi-Component Inorganic Zinc Silicate Primer	909.02(a)1
Organic Zinc Primer	909.02(a)2
Polyurethane Finish Coat	909.02(c)
Structural Steel Coating Systems	909.03
Waterborne Finish Paint	909.02(d)

Material safety data sheets shall be provided in the QCP for all materials to be delivered to the project site.

Caulk used to form the drip bead on weathering steel shall be a clear, 100% silicone caulk.

Caulk used on joints of lapping members shall be compatible with either the structural steel paint system or the partial paint system, and in accordance with the paint manufacturer's recommendations.

CONSTRUCTION REQUIREMENTS

619.03 Quality Control and Quality Assurance

The Contractor shall be responsible for the quality of work on the contract and shall ensure that all work has been performed by accepted quality control methods. A QCP shall be prepared and submitted by the Contractor in accordance with ITM 803. No work may begin until written notice has been received that the QCP was accepted

by the Engineer. The QC manager shall furnish the current referenced SSPC Standards at the project site.

Cleaning and painting shall be done by a Contractor certified as SSPC-QP 2 for cleaning and painting existing bridge steel on steel bridges constructed before 1995, regardless of whether the existing coating is advertised as non-hazardous based or hazardous based. Cleaning and painting shall be done by a Contractor that at a minimum is certified as SSPC-QP 1 for cleaning and painting new bridge steel or for cleaning and painting existing bridge steel on steel bridges constructed after 1994.

The Department will accept work performed on the project through quality assurance inspections and testing. Acceptance testing will be performed and will be the basis for which acceptance will be made.

(a) Test Methods and Procedures

The current version of the following test methods and procedures shall be performed as a minimum for quality control by the Contractor. These and other tests may be performed for acceptance testing by the Engineer. The results of the following tests and procedures shall be compiled and submitted to the Engineer on a daily basis.

TEST/PROCEDURE	METHOD AND PROCEDURE
Clean Compressed Air	ASTM D 4285
Cleaning of Steel	SSPC-Vis 1, -Vis 3
Cleanliness of Recycled Ferrous Metallic Abrasives	SSPC-AB 2
Dry Film Thickness	SSPC-PA 2
Relative Humidity	ASTM E 337
State of Cure of Inorganic Zinc Primers	ASTM D 4752
Surface Profile	ASTM D 4417, Method B or C

Relative humidity, dew point, and surface temperature shall be recorded before the application of any coating and at least once per hour during the application of any coating.

Air compressor output and blasting abrasives shall be inspected at least once every 4 hours for contamination.

Visual inspections for cleaning shall be performed after each phase of the applicable cleaning operations for compliance with the specified requirements for each lot. The surface shall be wiped with a white glove or white rag to ensure the surface is free of dust and other contaminants.

The blast cleaned surface shall be inspected for surface profile, oil contamination, dust, and blasting residue, and accepted prior to the application of the primer.

The required number of surface profile measurements and dry film thickness measurements shall be in accordance with SSPC-PA 2.

If a lot is non-conforming, corrective action shall be taken to make the lot acceptable. Corrective action shall be submitted in writing and performed as approved. A phase shall not be covered until the whole lot has been accepted.

(b) Acceptance Testing

Acceptance testing of painting steel bridge work will be in accordance with ITM 803. The results of the acceptance testing will be compared to the specific requirements for that phase of work. The Contractor shall not proceed to the next phase of work until written approval has been received from the Engineer that the current phase is accepted.

619.04 Prosecution of Work

Prosecution of work shall be in accordance with the applicable requirements of 108.03. Once the cleaning and painting operations have begun, it shall be performed on all work days without stoppage until all work has been completed. If the contract contains more than 1 bridge, a schedule shall be included in the QCP which provides the sequence of work on the bridges. Once work has begun on a bridge, it shall be performed until complete, including all cleanup.

Permission shall be obtained in writing to start or continue work at the hold points as follows:

(a) prior to the acceptance of the QCP and start of work;
(b) immediately following each phase of surface preparation;
(c) immediately before the application of the 1st coat;
(d) prior to the application of each succeeding coat; and
(e) after the final coat has cured.

A minimum of 1 day's notice shall be given in advance of each of the hold points.

619.05 Inspection Access to Bridges

Safe and reasonable access to all points of the bridge shall be provided for the Engineer's inspections immediately upon request.

619.06 Maintaining Traffic

The traffic lanes may be restricted when surface preparation or painting phases are being performed on a portion of the bridge over the traveled roadway, or as directed, when the need exists.

Construction signs in accordance with 801.04 shall be furnished and placement at each project site shall be as shown in the QCP. However, a “Bridge Painting Ahead” sign may be used in place of the “Road Construction Ahead” sign.

The traffic maintenance plan shall include a type of barrier system which shall protect against blasting of vehicles or pedestrians, eliminate abrasive materials and debris from falling onto the traveled portion of the pavement, and prevent the spreading of abrasive materials and debris in the area which may create a traffic hazard. If the intended purpose of the protective devices has not been accomplished, work shall stop until adequate corrections have been made. All abrasive material or debris shall be removed by the end of each day’s work in accordance with 619.07.

619.07 Environmental and Safety Requirements

Pollution control and waste disposal of existing paint residue and debris shall be in accordance with the following requirements.

Workers shall be protected in accordance with IOSHA requirements. All personnel on the project site shall wear personal protective equipment. The protective equipment shall be furnished by the Contractor, including to Department personnel. Training shall be given to all personnel provided with the protective equipment. Protective equipment shall include, but not be limited to, clean air supplied respirators, air purifying respirators, conventional hood as applicable, eye protection, and protective clothing. Two rooms for changing and washing shall be provided on bridges containing hazardous-based coatings.

(a) Pollution Control

Blasting materials, scrapings, wire brushings, and paint particles shall be contained in accordance with SSPC-Guide 6, Class 2A with method A, level 2 emissions, specifically for non-hazardous primed bridges, and SSPC-Guide 6, Class 2A or better with method A, level 0 emissions, for hazardous primed bridges.

If a spill, as defined in IDEM Regulation 327 IAC 2-6.1 does occur, all work shall stop and immediate action shall be taken to clean up the site. Spills of material, that enter or threaten to enter the water, shall be handled in accordance with IDEM Regulation 327 IAC 2-6.1. The IDEM Emergency Response Branch, the local health department, and all water intake users within 500 ft (150 m) of the bridge shall be immediately contacted and advised of the spill. Written documentation of all such contacts and actions shall be kept. All applicable Federal, State, and local rules and regulations described in 619.07(b)1 shall be observed.

Each bridge shall generate a separate waste stream and shall not be commingled with other materials. The 1st sample of waste residue from the bridge shall be sampled after the 1st day of removal and shipped to be tested within 24 h in a manner agreed to by the Department and as described in the QCP. The Engineer will witness the extraction of each waste residue sample. The Department will maintain custody of each waste residue sample until it is shipped. A duplicate of each waste

residue sample will be retained by the Department. Each waste residue sample shall be taken by random method as described in the QCP which reflects representation of the entire bridge. Each waste residue sample shall represent approximately 25% of the cleaning area. All samples shall be analyzed for all contaminants listed in ITM 803 by the TCLP. Residue shall be placed in an approved container. Such containers shall be labeled and maintained to comply with 40 CFR 264.

No waste shall remain on the booms or on any water surface overnight. All blasting debris shall be cleaned up after each day's work. All waste material shall be properly stored at the project site to prevent loss or pollution.

If hazardous materials are found in the 1st or subsequent waste residue sample of an advertised, non-hazardous site, the Contractor shall immediately stop all cleaning and painting operations on that bridge. The Contractor shall notify the Engineer that hazardous materials have been found and, if not addressed in the QCP, the Contractor shall submit revisions to the QCP that detail the necessary changes due to the presence of hazardous materials. The Contractor shall not return to work until the revised QCP is approved in writing.

(b) Waste Disposal

Disposal of existing paint and debris shall be in accordance with SSPC-Guide 7 and the following requirements.

1. Laws to be Observed

Federal and State laws and regulations regulate the disposal of bridge painting debris. Bridge paint debris shall be manifested or certified and shall be disposed of at an appropriate disposal facility.

The Contractor shall have direct knowledge regarding compliance with laws pertaining to pollution control and waste management such as follows.

a. subtitle C of the RCRA, 40 CFR 261, 262, 263, 265, and 268;

b. the Solid Waste Rule, 329 IAC 10;

c. the Hazardous Waste Rule, 329 IAC 3.1;

d. the Air Pollution Rule 329 IAC 6-4;

e. the Water Pollution Rule, 327 IAC 2-6.1;

f. the United States Department of Transportation regulations 49 CFR 172.300; and

g. OSHA worker safety regulations 29 CFR 1926.

2. Time Limitations

The maximum time limit from the date the generated waste is placed in a container and the date the material is transported to a permitted treatment, storage, and disposal facility shall be 90 calendar days.

3. Marking of Spent Material Containers

Spent material containers shall be marked with the date that waste residue is 1st placed in the container. Until laboratory results are received concerning the category of the waste residue, the containers shall be labeled "LEAD PAINT WASTE DEBRIS" or "ZINC PAINT WASTE DEBRIS", as appropriate. The labeling shall include the contract number, bridge number, sample number, and sample date. Labeling of containers as hazardous waste will not be required until the appropriate laboratory analysis determines the waste residue to be hazardous in accordance with the current RCRA hazardous waste definitions. Immediately upon notice that the waste residue is hazardous, the containers shall be marked in accordance with 49 CFR 172, Subpart D.

4. Instruction for Disposal of Paint Waste Residue

Sampling and analysis of the paint waste residue shall be performed to determine if the wastes are hazardous. If the waste residue is not found to be hazardous in accordance with current RCRA hazardous waste definitions, the waste residue material shall be disposed of at an appropriate disposal facility. If the waste residue is found to be hazardous, IDEM will be notified and an EPA identification number will be obtained. This number will be provided to the Contractor within 30 days of the start of waste generation for bridges having hazardous waste paint debris. The waste residue from different bridges shall not be mixed. The Contractor shall have the following responsibilities:

a. determining the location for disposal, treatment, or recycling of the waste residue, obtaining the Engineer's approval of the site, and arranging with the approved site for acceptance of the materials;

b. preparing a hazardous waste manifest, as required by Federal and State requirements, for signature;

c. scheduling the shipment of waste residue to the permitted disposal site;

d. ensuring that the hazardous waste manifest is carried in the transportation vehicle;

e. ensuring that all required hazardous materials placards are properly displayed on the vehicle;

f. ensuring prompt movement of the vehicle to the disposal site; and

g. returning 1 copy of signed manifest documents to the Engineer. A copy of the chemical and physical analysis of the waste, all deposit receipts, manifests, and required paperwork for disposal shall be given to the Engineer and all waste residues disposed of before the contract will be accepted.

5. Instructions for Disposal of Other Project Generated Waste

The other wastes that may be generated on the project include, but are not limited to, spent solvents from cleaning of equipment and empty or partially empty containers of paint, paint thinners, spent abrasives, and solvents. The Contractor shall recycle or dispose of all project generated waste materials.

If the waste is defined as a hazardous waste in accordance with the current RCRA definitions, the waste shall be recycled or disposed of in accordance with 619.07(b)4. All project generated waste and the method of recycling or disposal shall be identified in the QCP.

619.08 Surface Preparation

Cleaning of steel surfaces shall be performed by an SSPC certified contractor. This requirement will not apply to the following:

(a) shop cleaning;

(b) sections of beams or other structural members less than 180 sq ft (16.7 m^2) of total area to be painted for the contract where heat-straightening or similar repairs have taken place.

Surfaces to be painted shall be cleaned in accordance with the SSPC classification, unless otherwise specified. Compressed air shall pass through an oil and water extractor before entering another apparatus.

Pressure washing in accordance with 619.08(a) and solvent cleaning in accordance with 619.08(b) shall be performed to remove all oils, soluble salts, visible grease, and any other surface contaminants before all other cleaning methods are started. The Contractor may propose alternate cleaning methods in the QCP that will accomplish the removal of all oils and soluble salts.

Field cleaned steel surfaces shall be primed the same day as cleaned. If rust forms after cleaning, the surface shall be cleaned again before painting. Work shall be stopped when there is disagreement about whether a surface has been adequately cleaned. Written notification shall be provided specifically identifying the problem.

Cleaning shall be scheduled so that dust or other contaminates do not fall on wet, newly painted surfaces.

A dust collector suitable for the containment type and size shall be used during all blast cleaning operations in preparation for all structural steel paint systems and as directed for a partial paint system.

On existing bridges when abrasive blast cleaning is used, clean, dry, uniformly graded steel grit or a recyclable steel grit, in accordance with SSPC-AB 3 or SSPC-AB 2, shall be used. The steel grit used shall produce an angular profile that is free of oil, soluble salts, and other similar substances which can contaminate the blasted surface. The recycling equipment shall be capable of separating the blasting abrasive from the paint debris.

The surface profile of cleaned new steel surfaces and cleaned existing steel surfaces shall not be less than 1.5 mil (38 µm) and not greater than 3.5 mil (89 µm).

(a) Pressure Washing

All surfaces to be painted and the tops of pier and abutment caps shall be washed. The washing shall be accomplished by means of a low pressure power water washer with potable water. The pressure shall be between 800 and 1,500 psi (5 and 10 MPa). If detergents or other additives are added to the water, the surface shall be rinsed with potable water before the detergents dries. All washed surfaces shall be completely free of all oils and soluble salts and shall be approved prior to other surface preparation activities.

(b) Solvent Cleaning

After pressure washing has been approved, solvent cleaning shall be in accordance with SSPC-SP1.

(c) Near-White Blast Cleaning

Near-white blast cleaning shall be in accordance with SSPC-SP10/NACE No. 2.

(d) Commercial Blast Cleaning

Commercial blast cleaning shall be in accordance with SSPC-SP6/NACE No. 3.

(e) Hand Tool Cleaning

Hand tool cleaning shall be in accordance with SSPC-SP2.

(f) Brush-Off Blast Cleaning

Brush-off blast cleaning shall be in accordance with SSPC-SP7/NACE No. 4.

(g) Power Tool Cleaning

Power tool cleaning shall be in accordance with SSPC-SP3.

(h) Power Tool Cleaning to Bare Metal

Power tool cleaning to bare metal shall be in accordance with SSPC-SP11.

Upon completion of cleaning operations and prior to beginning painting operations, the Contractor shall remove all sharp fins, burrs, slivers, thermal cutting residue, abrupt deformities, corners more acute than a 1/32 in. (1 mm) radius, and other impediments to uniform coating application and performance by grinding. After completion of the grinding operation, the Contractor shall vacuum or blow off under full containment any residual dust remaining from the cleaning or grinding operation.

The Engineer will check the prepared surface for dust prior to the Contractor beginning painting operations. This work will not have any weather or temperature restrictions.

619.09 Paint Systems

Paint systems shall be applied in accordance with the manufacturer's recommendations. The dry film thickness of a paint coating will be measured with a calibrated film thickness gauge in accordance with SSPC PA 2. All paint coatings shall have a dry film thickness not less than 80% of the required dry film thickness.

(a) Structural Steel Paint System

The coating system shall consist of an inorganic zinc primer with a dry film thickness of 3 mil (75µm), an epoxy intermediate coat with a dry film thickness of 4 mil (100 µm), and a polyurethane finish coat with a dry film thickness of 3 mil (75 µm) for the painting of steel bridges and other structural steel.

(b) Partial Paint System

The coating system shall consist of organic zinc primer with a dry film thickness of 3 mil (75 µm) and a waterborne finish coat with a dry film thickness of 3 mil (75 µm) for partial painting of steel bridges and other structural steel.

619.10 Painting

Painting shall be performed by a SSPC certified contractor, except as noted in 619.08.

Concrete at all junction points of concrete and steel shall be adequately shielded or otherwise protected so the application of paint on steel is full and complete, and that spraying onto the concrete is minimized.

If a blasted or painted surface is unsatisfactory, removal of the paint, thorough cleaning of the surface, and repainting or other correction will be required as directed. Where defects or damages occur in a film of any coating, all defective areas shall be removed to soundly bonded paint or bare steel and painted to the specified thickness.

No lettering shall be painted on bare or painted steel surfaces, except marks required for erection and project information stenciled in accordance with 619.10(g).

Joints of all lapping members shall be caulked after either the application of the epoxy intermediate coat of the structural steel paint system or the application of the organic zinc primer of the partial paint system. The intermediate or primer coat shall be cured to the manufacturer's recommended coating cure time prior to caulking.

1. All vertical and diagonal lapping members shall be caulked along the top and sides. The bottom shall remain open for drainage.

2. All horizontal lapping members shall be caulked along the leading edge and sides of steel members facing toward oncoming traffic or facing toward the prevailing wind direction.

3. All horizontal members shall remain uncaulked along the side of steel members facing away from oncoming traffic or prevailing wind direction.

(a) Weather Limitations

Field painting will not be permitted between November 15 and the following April 1 unless different date ranges are requested in the QCP and approved in writing. Painting shall begin only when the 24 h ambient temperature is to remain above 50°F (10°C) after paint application, and the steel surface temperature is between 50°F and 100°F (10°C and 38°C) unless different temperature ranges are requested in the QCP and approved in writing. Coating, painting, and curing shall be done only when the relative humidity is to remain between 30% and 80%. The pot life and induction time shall be in accordance with the manufacturer's recommendations for the existing temperature and humidity.

Paint shall not be applied when the air is misty, or when conditions are otherwise unsuitable. The surface temperature of the steel to be painted shall not be within 5°F (3°C) of the dew point. When painting in a protected area to eliminate the above conditions, the steel shall remain under cover until the paint is dry. All wet paint which has been exposed to excessive humidity, rain, snow, or condensation shall be permitted to dry. Damaged paint shall then be removed. The surface shall be re-cleaned and repainted as directed. The Engineer will be the sole authority to decide when work may begin or shall stop due to weather conditions.

(b) Storage

Paint shall be stored in accordance with the manufacturer's recommendations. If paint is permitted to remain in storage, the containers shall be turned end for end at least once per week. The paint shall be used within the manufacturer's recommended shelf life.

(c) Mixing

Paint shall be thoroughly mixed so that the pigment is completely in suspension and the consistency is uniform. Mechanical mixers shall be used in accordance with the manufacturer's instructions. The paint shall remain in this condition during application to the steel surface. After initial mixing and before application, zinc primer shall be strained through a metal screen not coarser than the No. 30 (600 µm) sieve.

Partially empty containers of paint shall not be used. Partial mixing of containers will not be permitted. All paint containers shall remain closed until needed for mixing.

(d) Thinning

When required for proper application, the thinning of field paint will be permitted. Only thinners recommended by the manufacturer and as approved shall be used. Thinners shall be added to paint in accordance with the manufacturer's recommendations. The maximum quantity added shall not exceed the manufacturer's recommendations. The thinned paint shall not exceed IDEM regulations for volatile organic compounds.

The Contractor shall contact IDEM and the local air pollution control board for information about any volatile organic compound regulations or restrictions.

(e) Application of Paint

All paint coatings shall be of colors to produce a distinct contrast with adjacent coatings, including the color of a clean steel surface.

Paint shall be applied by either an airless or conventional spray method which has been recommended by the paint manufacturer. The compressed air used for painting shall pass through an oil and water extractor before entering the paint pot. However, areas to be painted which are inaccessible to spray application or areas requiring touchup may be painted with brush or daubers. Epoxy intermediate and polyurethane finish paints may be applied by brushes or rollers provided the coating cures to a smooth and uniform finish. Spray shall be adjusted to produce a uniform coating.

1. Stripe Coat

If using the structural steel paint system in accordance with 619.09(a), a stripe coat in accordance with SSPC-PA Guide 11 shall be applied. All sharp edges, welds, outside corners, bolt heads, nuts, threads, crevices, plate seams, back-to-back angle seams, pitted steel, rivet heads, and other sharp discontinuities shall be striped on the 2nd and 3rd coats, and then repainted with the remaining steel surfaces. Striping shall extend at least 1 in. (25 mm) from edges. If specified, the stripe coat shall be allowed to dry to the manufacturer's recommended recoat dry time prior to painting the 2nd and 3rd coats on the remaining steel surfaces.

If using the partial paint system in accordance with 619.09(b), a stripe coat in accordance with SSPC-PA Guide 11 shall be applied. All sharp edges, welds, outside corners, bolt heads, nuts, threads, crevices, plate seams, back-to-back angle seams, pitted steel, rivet heads, and other sharp discontinuities shall be striped on each of the coats, and then repainted with the remaining steel surfaces. Striping shall extend at least 1 in. (25 mm) from edges. If specified, the stripe coat shall be allowed to dry to the manufacturer's recommended recoat dry time prior to painting the remaining steel surfaces. Painting techniques shall minimize dry overspray. Dry overspray shall be removed prior to application of other coatings and after application of the finish coat.

For both paint systems, the stripe coat may be applied with either a brush or a sprayer. If the Contractor-chosen method of applying the stripe coat is not producing results acceptable to the Engineer, the Engineer will require the stripe coat application method to be changed.

(f) Curing Time

The minimum curing time between coatings shall be 24 h for inorganic zinc primers and 8 h for the epoxy intermediate coat. The curing time will vary depending on the temperature and humidity. The inorganic zinc primer shall be cured to a minimum solvent resistance rating of 4 in accordance with ASTM D 4752 prior to the application of the epoxy intermediate coat. It shall be demonstrated that the inorganic zinc primer is in accordance with this requirement. The epoxy intermediate coat shall be cured in accordance with the manufacturer's recommendations prior to the application of the polyurethane finish coat. The polyurethane finish coat shall be applied within 12 calendar days of application of the epoxy intermediate coat.

The curing time of all other paint systems or coatings shall be in accordance with the manufacturer's recommendations.

(g) Stencil Identification

After the finish coat has been approved, project identification information shall be painted with a stencil in 2 in. (50 mm) black capital letters onto the outside of both fascia beams, at the right end of the beam and near the end bent, which reads as follows:

_____
bridge number

_____
contract number

PAINTED _____
date

619.11 Shop Painting

Abrasive used for cleaning steel in the shop shall be an abrasive that produces an angular profile. The inorganic zinc primer coat shall be applied to all structural steel in the shop. The remaining 2 coats shall be applied in the field after final erection. A structural steel paint system in accordance with 619.09(a) shall be used. When shear connectors have been specified, the top of the top flange shall not be painted. Erection marks may be painted on zinc painted surfaces. Machine finished surfaces for sliding contact shall be coated with heavy grease as soon as practicable after being accepted, but before removal from the shop.

Shop painted beams shall not be loaded for shipment until the paint has been allowed to cure for a minimum of 48 h.

(a) Non-Weathering Steel

All structural steel shall be cleaned in accordance with 619.08(c).

All structural steel shall receive an inorganic zinc primer, including faying surfaces of high strength bolted connections and areas in contact with concrete. Surfaces, other than the contact surfaces described above, which are inaccessible after erection shall be painted in the shop with the full paint system required on the completed bridge.

(b) Weathering Steel

All structural steel shall be left unpainted, except as shown on the plans. All diaphragms, stiffeners, and other appurtenances located within the limits shown on the plans shall be included in the painting area. Surfaces to be painted shall be cleaned in accordance with 619.08(c). Surfaces shall be painted in accordance with 619.09(a), except the finish coat shall be in accordance with 909.02(e).

619.12 Field Painting New Steel Bridge

All structural steel surfaces which are accessible after final erection shall be painted with the remaining coatings specified for structural steel paint system in accordance with 619.09(a) in the field after final erection.

If application of inorganic zinc primer on a steel surface is not performed in the shop before erection of the bridge, the surfaces which are exposed shall be cleaned in accordance with 619.08(a), 619.08(b), and 619.08(c). These surfaces shall then be painted with the structural steel paint system after final erection.

Surface areas where the inorganic zinc primer was damaged during shipping, handling, and erection shall be cleaned in accordance with 619.08(a), 619.08(b), and either 619.08(d) or 619.08(h). Likewise, all bolt and field connections shall be cleaned in the same manner. All the damaged areas, and bolt and field connections shall then be painted with the inorganic zinc primer applied in the shop. This requirement will not apply to temporary steel bridges.

Where steel surfaces have been painted with the full paint system and the paint coatings have been damaged, the affected steel surface areas shall be cleaned in accordance with 619.08(h). Structural steel paint system shall then be re-applied.

For weathering steel girders, caulk shall be applied to act as a drip bead as shown in the plans.

619.13 Painting Existing Steel Bridges

The surfaces to be cleaned and painted shall include the surfaces of all steel members of the superstructure, substructure, floor beams, stringers, plates, castings, bearing assemblies, ornamental handrails, lattice work, and other steel appurtenances. When shear connectors have been specified, the top of the top flange within the limits of each shear connector group and a distance of 3 in. (75 mm) of beyond these limits shall not be painted.

If the contract specifies clean steel bridge, the bridge steel shall be cleaned in accordance with 619.08(a), 619.08(b), and either 619.08(d) or 619.08(h). The structural steel paint system in accordance with 619.09(a) shall be used for painting.

If the contract specifies clean steel bridge, partial, the bridge steel shall be cleaned in accordance with 619.08(a), 619.08(b), and either 619.08(d), or 619.08(g), or 619.08(h). The partial paint system in accordance with 619.09(b) shall be then be used for painting.

619.14 Drain Castings Treatment

Roadway drain castings located in a bridge deck shall be satisfactorily cleaned in accordance with 619.08(g) or 619.08(f). The castings shall not be shot-blasted.

The roadway drain castings shall be painted with a black finish coat in accordance with 909.02(c).

If a roadway drain casting extension pipe is damaged or missing, it shall be replaced. The extension pipe shall be in accordance with 715.

619.15 Responsibility for Damage

Unless otherwise permitted by the Engineer in writing, full containment shall be provided when performing the surface preparation operation and when applying all coats of paint (except primer coats) with spray equipment. All persons and property shall be protected from damage or injury from the surface preparation operations and painting operations by providing containment as described in the QCP. Persons and property shall include, but not be limited to, pedestrians, vehicles, and other traffic upon or underneath a bridge, all portions of the bridge superstructure and substructure, and all adjacent property. The Contractor shall be responsible for damages in accordance with 107.17.

619.16 Blank

619.17 Method of Measurement

Cleaning and painting will not be measured for payment. Grinding to remove sharp edges of all beams and girders, all fins, burrs, slivers, thermal cutting residue, and abrupt deformities will not be measured for payment.

Cleaning roadway drain castings, caulking joints of lapping members, and caulking on weathering steel will not be measured for payment.

If a bridge is advertised as having existing hazardous materials, no measurement will be made of the area covered by mill scale. For bridges advertised as having existing non-hazardous materials, the area of structural steel covered by mill scale will be measured for payment after a proper cleaning of the entire containment area or an agreed large portion there of and removing all other existing materials, including all paint and rust. The percentage of the area of structural steel covered by existing mill scale will be representative of this entire area. The pre-established remedies for this changed condition apply in accordance with 104.02(d) and 619.18.

Roadway drain casting extension pipe will be measured in accordance with 715.13.

The estimated weight (mass), length, number of steel spans, surface area of steel, and type of primer shown on the plans or in the Proposal book is incidental information. Such information is approximate only. The Department will not guarantee its accuracy.

619.18 Basis of Payment

Existing steel bridges to be cleaned, or partially cleaned, whichever is specified, will be paid for at the contract lump sum price for clean steel bridge or clean steel bridge, partial, at the bridge number specified. Existing steel bridges to be painted, or partially painted, whichever is specified, will be paid for at the contract lump sum price for paint steel bridge or paint steel bridge, partial, at the bridge number specified.

(a) Pre-Established Remedies for Changed Conditions

1. Discovery of Hazardous Materials but No Mill Scale on a Site Advertised as Non-Hazardous

The payment will be an additional 25% of the clean steel bridge item as computed in 619.18(b)1 in accordance with 109.05 as payment for all additional costs incurred.

2. Discovery of Mill Scale but No Hazardous Materials on a Site Advertised as Non-Hazardous

If, on a bridge advertised as having existing non-hazardous materials and the presence of hazardous materials has not been confirmed by laboratory analysis, the area of structural steel covered by mill scale comprises greater than 15% of the area of structural steel in accordance with 619.17, additional compensation for the removal of the mill scale will be made as an adjustment to the clean steel bridge item in accordance with the following:

a. For areas of structural steel greater than 15% and up to and including 25% of the area covered by mill scale, an additional payment of 15% of the clean steel bridge item as computed in accordance with 619.18(b)1 will be made.

b. For areas of structural steel greater than 25% and up to and including 50% of the area covered by mill scale, an additional payment of 30% of the clean steel bridge item as computed in accordance with 619.18(a)1 will be made.

c. For areas of structural steel greater than 50% and up to and including 75% of the area covered by mill scale, an additional payment of 45% of the clean steel bridge item as computed in accordance with 619.18(b)1 will be made.

d. For areas of structural steel greater than 75% of the area covered by mill scale, an additional payment of 60% of the clean steel bridge item as computed in accordance with 619.18(b)1 will be made.

3. Discovery of Hazardous Materials and Mill Scale on a Site Advertised as Non-Hazardous

If the laboratory analysis of a waste residue sample on a bridge advertised as having non-hazardous materials yields results indicating the presence of hazardous materials, the entire bridge shall be considered as having mill scale and the following pre-established remedy for this changed condition in accordance with 104.02(d) shall apply. If agreed to in writing between the Contractor and the Department, the work shall proceed with the Contractor assuming all risks for removal of mill scale. An additional 55% of the clean steel bridge item as computed in 619.18(b)1 in accordance with 109.05 will be paid as additional compensation for the removal and disposal of the hazardous materials, the removal of the mill scale, the additional containment required, and all other incidental items associated with the removal of the hazardous materials and mill scale.

(b) Prices used in Pre-Established Remedies to Changed Conditions

The following prices will be computed and used as the price for the pay item identified below in all pre-established remedies to changed conditions referenced in this section.

The price for the clean steel bridge item, per bridge, used in all pre-established remedies to changed conditions referenced in this section will be limited to the lesser of the following:

1. 70% of the sum of the clean steel bridge item and paint steel bridge item for that bridge; or

2. the actual amount for the clean steel bridge item for that bridge shown in the Schedule of Pay Items.

Roadway drain casting extension pipe will be paid for in accordance with 715.14.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Clean Steel Bridge, Partial, QP- ____, Br. No. ____	LS
Clean Steel Bridge, QP- ____, Br. No. ___	LS
Paint Steel Bridge, Partial, Br. No.____	LS
Paint Steel Bridge, Br. No.____	LS

The cost to prepare a QCP shall be included in the cost of the pay items of this section. The cost of providing the Department with access to the bridge and seasonal or weather limitations shall be included in the cost of the pay items of this section.

If a bridge is advertised as having existing hazardous materials, no additional payment will be made for the removal of mill scale. The cost of the removal of mill scale shall be included in the cost of clean steel bridge or clean steel bridge, partial.

If a bridge is advertised as having existing non-hazardous materials and the percentage of the area covered by mill scale is less than or equal to 15% of the total structural steel surface area of a bridge measured in accordance with 619.17 no additional payment will be made for the removal of mill scale. The cost of the removal of mill scale shall be included in the cost of clean steel bridge or clean steel bridge, partial.

The cost of furnishing all materials, equipment, and labor required for washing, solvent cleaning, scraping, steel brushing, or other acceptable methods for removing paint in the locations directed shall be included in the cost of clean steel bridge or

clean steel bridge, partial. The cost of cleaning roadway drain castings shall be included in the cost of clean steel bridge or clean steel bridge, partial.

The cost of providing containment in accordance with 619.15 and personal protective equipment shall be included in the cost of the pay items of this section.

The cost of furnishing all materials, equipment, and labor required to perform the quality control tasks outlined in 619.03 shall be included in the cost of clean steel bridge or clean steel bridge, partial.

The cost of all grinding shall be included in the cost of clean steel bridge, or clean steel bridge, partial.

The cost of furnishing all materials including caulk, equipment, and labor to perform caulking and painting, including the stripe coats, with the structural steel paint system or the partial paint system shall be included in the cost of paint steel bridge or paint steel bridge, partial. The cost of switching stripe coat application methods shall be included in the cost of paint steel bridge or paint steel bridge, partial. The cost of furnishing all materials, equipment, and labor to perform painting of the roadway drain castings shall be included in the cost of paint steel bridge or paint steel bridge, partial.

The cost of all equipment, material, labor, testing, use of special cleaning methods, shipping of waste residue samples, handling and disposal of spent materials, waste residues, waste residue containers and all other debris associated with environmental control and cleaning shall be included in the cost of the clean steel bridge or clean steel bridge, partial pay item.

SECTION 620 – BLANK

SECTION 621 – SEEDING AND SODDING

621.01 Description

This work shall consist of either or both plain and mulched seeding or placing approved sod. It includes furnishing and placing seed, fertilizer, inoculants, top soil, and mulch, if required, in a prepared seed bed or furnishing and placing sod at locations in accordance with 105.03.

MATERIALS

621.02 Materials

Materials shall be in accordance with the following:

Fertilizer 914.03
Grass Seed 914.04
Grass Seed, Temporary 914.02

Leguminous Inoculants 914.06
Mulch ..... 914.05(a)
Plastic Net..... 914.09(g)
Sod, including Nursery Sod..... 914.07
Top Soil 914.01
Water ..... 914.09(a)
Wire Staples ..... 914.09(f)

CONSTRUCTION REQUIREMENTS

621.03 Preparation of Ground Before Seeding

The area to be seeded shall be made smooth and uniform and shall be in accordance with the finished grade and cross section shown on the plans or as otherwise designated and shall be trimmed in accordance with 210.

The seed bed, if not loose, shall be loosened to a minimum depth of 3 in. (75 mm) before fertilizer or seed is applied. In areas of excessive vehicular traffic, such as parking of construction equipment near a bridge repair, the soil shall be loosened to a minimum depth of 6 in. (150 mm). Areas to be covered with topsoil shall be milled or disked slightly before the topsoil is placed. A disk, spike-toothed harrow, or other similar device may be used for this purpose. Such loosening will be required to ensure bond of the topsoil with the surface on which it is put and to form a uniform surface. The topsoil shall then be spread to a sufficient depth to produce the thickness specified after it has been compacted lightly with an approved roller, tamping device, or other method.

For temporary seeding, the seed bed, if not loose, shall be scarified. The area to be temporary seeded need not be made smooth and uniform.

621.04 Preparation of Ground Before Applying Erosion Control Blankets

Prior to placing the blankets, the area to be covered shall be relatively free of all rocks or clods over 1 1/2 in. (38 mm) in diameter, and all sticks or other foreign material, which prevent the close contact of the blanket with the seed bed. If as a result of a rain, prepared seed bed becomes crusted or eroded, or if eroded places, ruts, or depressions exist, the soil shall be reworked until it is smooth. Such areas which are reworked shall be re-seeded.

621.05 Applying Fertilizer, Seed, and Mulch

(a) Fertilizer

Fertilizer as specified shall be spread uniformly over the area to be seeded. Fertilizer shall be spread at the rate of 800 lb/ac (900 kg/ha) unless otherwise specified.

(b) Seed

Seed may be drilled in or mixed with water. The mixture shall be sprayed over the area to be seeded. An approved mechanical method which shall place the seed in direct contact with the soil may be used. In places inaccessible to mechanical equipment, or where the area to be seeded is small, a hand operated cyclone seeder or other approved equipment may be used. Seed of warm season grasses, forbs, or aquatic species shall not be covered more than 1/8 in. (3 mm). All other seed shall not be covered more than 1/2 in. (13 mm).

Leguminous seeds, unless otherwise specified, shall be inoculated with a culture in accordance with 914.06. The culture shall be mixed with sufficient water to distribute it thoroughly. The seed shall be wetted thoroughly with the solution and allowed to dry sufficiently to be in condition for sowing. Inoculated seed shall be sown within 30 h after treatment. Where seeding is to be done by hydraulic methods, the inoculate may be added to the water in the spray tank.

(c) Mulch

Mulching material, when specified, shall be applied uniformly in a continuous blanket at the rate of 2 t/ac (4.5 Mg/ha). Mulch shall be placed within 24 h after seeding. The percent of moisture in the mulch shall be determined in accordance with 621.14(c).

Mulching material shall be punched into the soil so that it is partially covered. The punching operation shall be performed longitudinally with the mulch tiller. The tools used for punching purposes shall be disks that are notched and have a minimum diameter of 16 in. (400 mm). The disks shall be flat or uncupped such as notched coulters commonly used on moldboard plows. Disks shall be placed a minimum of 8 in. (200 mm) apart along the axle or shaft. Shaft or axle sections of disks shall not exceed 8 ft (2.4 m) in length.

The mulch tiller for punching shall be constructed so that weight may be added or hydraulic force from the tractor may push the puncher into the ground. If heavy weights are not used, several trips over the area may be necessary to work part of the mulch into the soil. Care shall be exercised to obtain a reasonably even distribution of mulch incorporated into the soil.

After procedures for holding the mulch in place have been completed, mulch, other than when applied by hydroseeder, shall be watered thoroughly. The seed or soil beneath it shall not be displaced. The mulching material shall be maintained in place satisfactorily until final completion and acceptance of the contract except as provided in 107.18. When seeding is performed between June 1 and August 15, a 2nd thorough watering shall be applied approximately 21 days after seeding.

On slopes steeper than 3:1, or when specified, the following methods will be permitted.

1. Method A

The mulch may be held in place by means of a commercially produced mulch binder which is in accordance with all applicable State and Federal regulations. Such product shall be applied in accordance with the manufacturer's written instructions. A copy of the written instructions shall be supplied to the Engineer prior to the seeding work. The product shall contain a coverage indicator to facilitate visual inspection for evenness of application. If the mulch fails to stay in place, the Contractor shall repair all damaged areas. A change in the mulch binder may be requested by the Engineer.

2. Method B

The mulch may be held in place by spraying it with a satisfactory liquid asphalt or asphalt emulsion. The bituminous material may be applied immediately after the mulch is in place or it may be injected into the mulch as it leaves a power driven mulch spreader. If applied to the surface, the amount shall be approximately 0.06 gal./sq yd (0.25 L/m^2). If applied as the mulch comes from the spreader, the amount shall be approximately 60 gal./ton (0.25 L/kg) of mulch material. The exact amount shall be as directed.

3. Method C

The mulch may be held in place with binder twine fastened down with wooden pegs not less than 6 in.(150 mm) long spaced 4 ft (1.2 m) apart. The twine shall be placed parallel to and also at 60° with the pavement edge in both directions. The distance between the intersections of the diagonal strands measured along the strands shall be 12 ft (3.7 m). The strand parallel to the pavement shall cross the diagonal strands at their intersections to form equilateral triangles 12 ft (3.7 m) on a side.

4. Method D

The mulch may be held in place with a polymeric plastic net. The plastic net shall be unrolled such that it lays out flat, evenly, and smoothly, without stretching the material. The plastic net shall be held in place by means of wire staples. The wire staples shall be driven at a 90° angle to the plane of the soil slope. Staples shall be spaced not more than 4 ft (1.2 m) apart with rows alternately spaced. The plastic net shall be secured along the top and bottom of the soil slope with staples spaced not more than 1 ft (0.3 m) on center. The ends and edges of the plastic net shall be overlapped approximately 4 in. (100 mm) and stapled. Overlaps running parallel to the slope shall be stapled 1 ft (0.3 m) on center and overlaps running perpendicular to the slope shall be stapled at least 3 ft (0.9 m) on center. The plastic net shall be placed with the length running from top of slope to toe of slope, or the plastic net shall be placed with the length running horizontally or parallel to the contour.

5. Method E

The area may be covered with erosion control blankets. The Contractor will be permitted to use excelsior blanket, paper mat, or straw mat.

(d) Excelsior Blankets

Excelsior blankets may be used where mulched seeding is specified or where erosion control blanket is specified. Excelsior blankets shall be placed within 24 h after seeding operations have been completed. The ground shall be prepared in accordance with 621.04. After the area has been properly shaped, fertilized, and seeded, the blanket shall be laid out flat, evenly, and smoothly, without stretching the material. Excelsior blankets shall be held in place by means of wire staples. The staples shall be driven at a 90° angle to the plane of the soil slope. Staples shall be spaced not more than 5 ft (1.5 m) apart in 3 rows for each strip, with a row along each edge and 1 row alternately spaced in the middle. The upslope edge shall be fastened by staples spaced 12 in. (300 mm) apart. The ends and edges of the blankets shall be tightly butted together, but not lapped. When excelsior blanket is used, the blanket shall be placed with the length running from top of slope to toe of slope, or the blanket shall be placed with the length running horizontally or parallel to the contour. The staples used for stapling shall be in accordance with 914.09(f).

(e) Paper Mat

Paper mat may be used for mulch for seeding where mulched seeding is specified or where erosion control blanket is specified. Paper mat shall be placed within 24 h after seeding operations have been completed. The ground shall be prepared in accordance with 621.04.

After the area has been properly shaped, fertilized, and seeded, 2 anchor trenches shall be dug, one along the foot of the slope and the other 1 ft (0.3 m) back from the crown of the slope. These anchor trenches shall be 4 in. (100 mm) deep and at least 6 in. (150 mm) wide. One edge of the paper mat shall be placed into the top trench and stapled 9 in. (230 mm) on center. The trench shall then be filled with soil. The paper mat shall then be unrolled such that it lays out flat, evenly, and smoothly, without stretching the material. Paper mat shall be held in place by means of wire staples. The staples shall be driven at a 90° angle to the plane of the soil slope. Staples shall be placed not more than 3 ft (0.9 m) apart with rows alternately spaced. The paper mat shall be secured in the bottom anchor trench in the same manner as it was secured in the upper anchor trench. The ends and edges of the mat shall be overlapped at least 4 in. (100 mm) and stapled.

Overlaps running parallel to the slope shall be stapled 18 in. (460 mm) on center and overlaps running perpendicular to the slope shall be stapled at least 9 in. (230 mm) on center. When paper mat is used, the mat shall be placed with the length running from top of slope to toe of slope, or the mat shall be placed with the length running horizontally or parallel to the contour.

(f) Straw Mat

Straw mat may be used for mulch for seeding on projects where mulched seeding is specified or where erosion control blanket is specified. Straw mat shall be placed within 24 h after seeding. The ground shall be prepared in accordance with 621.04. After the area has been properly shaped, fertilized, and seeded, the straw mat

shall be unrolled over the designated area so that the plastic mesh is on top and the straw fibers are snugly and uniformly in contact with the soil surface without stretching the material. The rolls shall be butted snugly together and stapled in place. The staples shall be driven through the blanket at a 90° angle to the plane of the ground surface. Each staple shall anchor the plastic mesh. The staples shall be spaced at approximately 3 ft (0.9 m) increments, both longitudinally and transversely.

For placement on slopes, the straw mat shall be placed with the length running from the top of slope to the toe of slope and shall extend a minimum of 3 ft (0.9 m) over the crown of the slope. On slope applications, 6 staples shall be installed across the uphill end of the roll. The downhill ends of the lowermost rolls across the slope shall also be anchored with 6 staples, placed on uniform spacing.

For placement in ditch lines, the straw mat shall be unrolled parallel to the centerline of the ditch. The mat shall be placed so that there are no longitudinal seams within 24 in. (600 mm) of the bottom centerline of the ditch. In ditch lines, 6 staples shall be placed at uniform spacing across the upstream end of each roll.

(g) Wood Cellulose Fiber Mulch

Wood cellulose fiber may be used where mulched seeding is specified. Wood cellulose fiber mulch shall be placed at the rate of 1 ton/ac (2,200 kg/ha) within 24 h after seeding operations have been completed. Application shall be by hydraulic mulching and consist of mixing wood cellulose fiber mulch and grass seed with water. It shall be mixed in standard hydraulic mulching equipment to form a homogeneous slurry. The slurry shall be sprayed, under pressure, uniformly over the soil surface. The hydraulic mulching equipment shall contain a continuous agitation system that keeps all materials in uniform suspension throughout the mixing and distribution cycles. Fertilizer shall be applied in accordance with 621.05(a).

621.06 Seed Mixtures

Seed mixtures are classified as follows. Mixes including warm season grasses, forbs, or aquatic species will be specified in the plans.

(a) Seed Mixture R

This seed mixture shall be applied at the rate of 170 lb/ac (190 kg/ha) consisting of 95 lb/ac (106 kg/ha) of low endophyte Kentucky 31 Fescue or approved equal, 65 lb/ac (73 kg/ha) perennial ryegrass, and 10 lb/ac (11 kg/ha) Jasper Red Fescue or approved equal. Fertilizer and mulching material, where specified or directed, shall be applied in accordance with 621.05.

(b) Seed Mixture U

This seed mixture shall be applied at the rate of 150 lb/ac (168 kg/ha) consisting of 95 lb/ac (106 kg/ha) of a 4-way blend of turf type tall fescues such as Tribute, Rebel II, Trailblazer or approved equal, 20 lb/ac (22 kg/ha) Jasper Red Fescue or approved equal, and 35 lb/ac (40 kg/ha) certified fine bladed perennial ryegrass such

as Regal, Blazer, or approved equal. Fertilizer and mulching material, where specified or directed, shall be applied in accordance with 621.05.

(c) Seed Mixture P

This seed mixture shall be applied at the rate of 80 lb/ac (90 kg/ha) consisting of 30 lb/ac (34 kg/ha) of "Fults" Puccinella Distans, 30 lb/ac (34 kg/ha) of Jasper Red Fescue, or approved equal, and 20 lb/ac (22 kg/ha) of perennial ryegrass. Fertilizer shall be applied at the rate of 400 lb/ac (450 kg/ha). Fertilizer and mulching material, where specified or directed, shall be applied in accordance with 621.05.

(d) Blank

(e) Seed Mixture D

This seed mixture is intended for ditch situations which experience seasonal to chronic saturated soils. This seed mixture shall be used on maintenance contracts or where otherwise specified. This mixture shall be applied at the rate of 14 lb/ac (16 kg/ha). It shall consist of the materials and be applied at the rates shown below.

Material	English Units Application Rates	Metric Units Application Rates
Fowl Mana Grass	1 oz/ac	80 g/ha
Wetland Carex Species	3 oz/ac	220 g/ha
Rice Cut Grass	2 oz/ac	150 g/ha
Bullrush	2 oz/ac	150 g/ha
Leptochloa Fasicularis	2 oz/ac	150 g/ha
Barnyard Grass	2 oz/ac	150 g/ha
Prairie Wild Rye	2 oz/ac	150 g/ha
Perennial Ryegrass	10 lb/ac	11.2 kg/ha
Jasper Red Fescue	2 lb/ac	2.4 kg/ha
"Fults" Puccinella Distans	2 oz/ac	150 g/ha
Redtop	1 lb/ac	1.2 kg/ha

If certain species in this mix are unavailable, substitutions may be submitted for approval. The mix shall be applied as specified per acre (hectare). The method of planting shall be by means of hydroseeding or by means of a hand method with a minimal amount of mulch applied in a separate operation. Fertilizer shall not be added to this seed mixture.

(f) Seed Mixture T

This seed mixture shall be used to establish a temporary cover for disturbed soil during the construction operations. Seed mixture T shall be used for soil stabilization and temporary ground cover. Temporary cover mixtures shall be placed as directed and be subject to seasonal limitations as defined herein. This mixture is not intended to be used as a permanent seed mixture. The mix shall be mulched in accordance with 621.05(c) when slopes exceed 3:1. From December 1 to March 14 and from

June 16 to August 31, mulching alone shall be used to stabilize the soil. This mixture shall not be used to satisfy the requirements of the warranty bond.

1. Spring Mix

Spring mix shall be used from March 15 through June 15. This mixture shall be applied at the rate of 150 lb/ac (168 kg/ha). The mix shall consist of oats.

2. Fall Mix

Fall mix shall be used from September 1 through November 30. This mixture shall be applied at the rate of 150 lb/ac (168 kg/ha). This mix shall consist of winter wheat.

(g) Seed Mixture Grass

This seed mixture shall be placed when specified as shown below.

1. Type 1

This seed mixture shall be placed at the rate of 195 lb/ac (220 kg/ha) consisting of 15 lb/ac (18 kg/ha) of Smooth Bromegrass, 10 lb/ac (12 kg/ha) of Orchardgrass, and the mixture specified in 621.06(a).

2. Type 2

This seed mixture shall be placed at the rate of 110 lb/ac (124 kg/ha) consisting of 15 lb/ac (17 kg/ha) of Smooth Bromegrass, 10 lb/ac (11 kg/ha) of Orchardgrass, 40 lb/ac (45 kg/ha) of Certified Common Kentucky Bluegrass, 30 lb/ac (34 kg/ha) of Creeping Red Fescue, and 15 lb/ac (17 kg/ha) of Perennial Rye Grass.

(h) Seed Mixture Legume

This seed mixture shall be placed when specified as shown below. Mulched seeding, when specified, shall be in accordance with 621.07.

1. Type 1

This seed mixture shall be placed at the rate of 190 lb/ac (214 kg/ha) consisting of 10 lb/ac (12 kg/ha) of Sericea Lespedeza or Korean Lespedeza, 10 lb/ac (12 kg/ha) of medium Red Clover or Alsike Clover, and the mixture specified in 621.06(a).

2. Type 2

This seed mixture shall be placed at the rate of 100 lb/ac (112 kg/ha) consisting of 10 lb/ac (11 kg/ha) of Sericea Lespedeza or Korean Lespedeza, 10 lb/ac (11 kg/ha) of medium Red Clover or Alsike Clover, 10 lb/ac (11 kg/ha) of Birdsfoot Trefoil, 40 lb/ac (45 kg/ha) of Certified Kentucky Bluegrass, 30 lb/ac (34 kg/ha) of Creeping Red Fescue, and 10 lb/ac (11 kg/ha) of Annual Rye Grass.

"Do Not Spray" signs shall be placed near the beginning and end of this work, at 200 ft (60 m) intervals, or as otherwise directed. The sign shall be 16 gage (1.6 mm) aluminum. The size and message arrangement shall be as shown on the plans. The

sign background shall be white. The sign lettering shall be black. The sign shall not be reflectorized. Paint and primer shall be in accordance with 909.04. The sign post shall be placed as shown on the plans. The post shall otherwise be in accordance with 910.15.

621.07 Mulched Seeding

Mulched seeding, when specified, shall consist of applying the seed mixtures in accordance with 621.06(a), 621.06(b), and 621.06(c) as specified. This mixture shall include fertilizer and mulching material in the amounts set out herein. If erosion control blanket is specified, the Contractor will be permitted to use excelsior blanket, paper mat, or straw mat in accordance with 621.05(d), 621.05(e), or 621.05(f), respectively.

621.08 Preparation of Ground Before Sodding

The area to be sodded shall be smooth, uniform, and shall be in accordance with the required cross section. Surfaces prepared for sod shall be of sufficient depth below unseated areas that newly laid sod shall be in accordance with the surrounding surface.

For those areas which shall be covered with topsoil, the procedure for the application of topsoil shall be in accordance with 621.03.

After the area has been prepared for sod, fertilizer shall be applied at the rate of 400 lb/ac (450 kg/ha). The surface shall be loosened to a depth of 1 to 2 in. (25 to 50 mm) and then raked before the sod is placed. All clods, lumps, boulders, or waste material shall be removed satisfactorily.

In areas where the above method of preparation is impracticable, a different method may be approved.

621.09 Laying Sod

Sod strips shall be laid in the designated direction. The sod shall be fitted to the surrounding grade and fixed objects. The sod strips shall be butted together closely to avoid open joints. Overlapping of sod will not be permitted. After laying and initial watering, the sod shall be tamped or rolled as directed to ensure contact with the soil underneath and shall be in accordance with the surrounding surface. After compaction, the sod shall present a smooth even surface free from lumps and depressions. On slopes of 3:1 or flatter, the use of broken sod strips will be permitted. Where broken pieces are laid, no overlaps will be allowed.

Sod placed in ditches with grades steeper than 1% and on slopes 3:1 and steeper shall be pegged. The pegs shall be spaced not over 2 ft (610 mm) apart in each strip measured lengthwise of the strip. Pegs shall be driven down until no more than 1 in. (25 mm) protrudes above the surface of the sod. Grades and slopes flatter than specified herein shall be pegged as directed.

Pegs shall be wood at least 1/2 in. by 3/4 in. by 12 in. (13 mm by 19 mm by 300 mm). In lieu of pegs, T-shaped wire pins may be used. The pins shall be machine bent from 8 gage (4 mm) low carbon steel with a minimum of a 8 in. (200 mm) leg, a 4 in. (100 mm) head, and a 1 in. (25 mm) secondary drive. Pins shall be driven flush with the top of the sod.

621.10 Watering Sod

Sod shall be watered immediately after laying. The amount of watering shall be sufficient to saturate the sod and the upper few inches (millimeters) of the underlying soil. The sod shall be watered once every day of the 1st week, once every 2nd day of the 2nd week, once every 3rd day of the 3rd week, and once a week thereafter. Sod shall be maintained for a minimum of 4 weeks from the time it is laid before being accepted. During periods of ample rainfall, watering may be modified to simulate the above schedule. The requirements of 107.18 shall apply.

621.11 Seeding or Sodding Disturbed Areas Outside Construction Limits

Areas outside shown construction limits which are disturbed by the Contractor shall be repaired to their original condition or better. The areas shall be seeded with a seed mixture grass type 2 in accordance with 621.06(g)2 or seed mixture legume type 2 in accordance with 621.06(h)2 as directed. If the contract contains seed mixtures other than the 2 listed here, the Contractor may seed the disturbed area with the mixture contained in the contract provided the area is less than 1 ac (0.5 ha) in size. If the area disturbed is well maintained and part of a residential or commercial lot, it shall be sodded unless the Engineer determines otherwise.

621.12 Seasonal Limitations

The Contractor shall post a warranty bond for all permanent seeding done from October 16 through January 31. Only completed seeding with seed mixtures R, U, or P shall satisfy the requirements of the warranty bond. Seeding without mulch shall not be done between May 1 and August 15.

Sod placed during the months of June, July, and August shall be subject to the following conditions.

(a) sod shall be in good, live, growing condition; and

(b) sod shall be placed within 36 h after cutting and protected from damage during that period.

Winter sodding will be permitted when the temperature is above 35°F (2°C). No frozen sod shall be laid and no sod shall be laid on frozen soil. Sod shall be properly protected from drying out and shall be laid within 48 h after cutting.

621.13 Method of Measurement

Fertilizer and mulching material will be measured by the ton (megagram). Seed mixtures will be measured by the pound (kilogram). Topsoil will be measured by the

cubic yard (cubic meter) in accordance with 211.09. Mulched seeding and sodding will be measured by the square yard (square meter). Water will be measured by the 1,000 gal. (kiloliter). Mobilization and demobilization for seeding will be measured per each trip, when directed, to the project site. “Do Not Spray” signs will be measured by the number of signs installed.

621.14 Basis of Payment

The accepted quantities of fertilizer and mulching material, furnished and delivered complete in place, will be paid for at the contract unit price per ton (megagram), except as set out below for sodding. Seed mixtures will be paid for at the contract unit price per pound (kilogram) for the class and type specified. Mulched seeding will be paid for at the contract unit price per square yard (square meter) for the class and type specified, complete in place. Topsoil will be paid for at the contract unit price per cubic yard (cubic meter). Sodding and nursery sodding will be paid for at the contract unit price per square yard (square meter), complete in place. “Do Not Spray” signs will be paid for at the contract unit price per each.

Payment for mobilization and demobilization for seeding will be made for the initial movement to the project site so that permanent or temporary seeding or mulching work, as specified, is performed. When 1 or more operations are completed within the same mobilization, payment will be made for 1 mobilization. Payment will be for all work necessary to move personnel and equipment to and from the project site. Payment will also be made for additional mobilization, when directed.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Erosion Control Blanket	SYS (m2)
Fertilizer	TON (Mg)
Mobilization and Demobilization for Seeding	EACH
Mulched Seeding _____, _____ (class type)	SYS (m2)
Mulching Material	TON (Mg)
Seed Mixture _____, _____ (class type)	LBS (kg)
Sign, “Do Not Spray”	EACH
Sodding	SYS (m2)
Sodding, Nursery	SYS (m2)
Topsoil	CYS (m3)
Water	kGAL. (kL)

The cost of leguminous inoculants, preparing seed beds, sowing, raking, and all other necessary incidentals shall be included in the cost of seed mixtures. The cost of furnishing and placing fertilizer, seed mixtures, and mulching material, in addition to

the incidentals listed above for seed mixtures shall be included in the cost of mulched seeding.

The cost of furnishing, hauling, and placing the material, including material used as tie-down, repair of areas for which mulch fails to stay in place, all labor, equipment, and necessary incidentals shall be included in the cost of mulching material.

Repair of areas outside the construction limits which must be disturbed to construct the work required by the contract will be paid for in accordance with 201.07(e).

Water will be paid for only when ordered after the 30 day period, in accordance with 621.10.

Payment will not be made for topsoil which is obtained from within the right-of-way.

The cost of fertilizer, water, excavation of earth bed, disposal of surplus material, and all necessary incidentals shall be included in the cost of sodding or nursery sodding.

(a) Warranty Bond

Permanent seeding that requires a warranty bond to meet the requirements of 621.12 shall be warranted against failure resulting from lack of germination or method of application. The seeding shall be warranted to germinate and shall be free of obvious erosion occurrences. The intent of the warranty bond shall be to permit the final acceptance of the contract and payment of the retainage. All seeding which has significantly failed to attain approximately 60% germination shall be replaced with no additional payment. A properly executed maintenance bond with a surety shall be provided prior to the completion of the work. A warranty shall be made, with no additional payment, to replace all seeding in areas which has not effectively performed useful service as specified, as well as for the repair of designated erosion areas caused by seeding failure. Such warranty shall be in writing with proper execution of the maintenance bond with a proper surety. The warranty shall be equivalent to 1 1/2 times the cost of the seeding work completed after October 15 with a minimum bond amount of $25,000. All requirements for seeding work will still apply during the warranty period unless otherwise directed.

For the terms of the warranty, a reseeding unit shall be defined as an area equal to or larger than 2,000 sq ft (185 m^2) in size. An erosion unit may be of an area of significance as determined.

The warranty shall cover work completed from October 16 through January 31. The Department will determine if the Contractor shall be released from the warranty. This determination will be made within 10 calendar days after documented request

for inspection is made by the Contractor. Such determination will not be made prior to April 1. All replacement work shall be finished prior to June 15 with no additional payment. The requirements of 107.17 will apply to the warranty area only. The Engineer will certify in writing as to the completion of the work and will make proper notification for the releasing of the bond.

If the Contractor does not complete the necessary repairs before June 15, and there are no justifiable reasons for the Department to grant an extension, the Contractor shall forfeit the bond for the seeding work only. If a bond is forfeited, the Contractor will be required to explain to the Department why the Contractor's experience reduction factors do not warrant an increase.

(b) Changed Fertilizer

A fertilizer may be required with a higher nitrogen content than that specified, or the fertilizer specified may be required to be enriched by adding chemicals in order to be in accordance with such requirements. All additional cost incurred due to such procedure will be paid at the prices shown by certified vouchers. Such payment will include and will be full compensation for furnishing the required chemicals, or furnishing and processing the additional materials required.

(c) Mulching

The percent of moisture shall be determined at the time the mulching material is weighed. Facilities shall be provided for weighing in accordance with 109.01(b). Arrangements shall be made in advance so that the percent of moisture will be determined at the time of weighing and that the weight (mass) of the material will be checked. Moisture content of the mulch will be determined on the basis of air dry weight as follows:

$$\text{Moisture Content \%} = \frac{\text{Wet Weight (Mass) of sample} - \text{Air Dry Weight (Mass) of sample}}{\text{Air Dry Weight (Mass) of Sample}} \times 100$$

The gross, or wet, weight (mass) of mulching material furnished and placed will be paid for if the moisture content does not exceed 10%. If the moisture content exceeds 10%, the weight (mass) to be paid for will be the gross, or wet, weight (mass) minus the weight (mass) of excess moisture computed as follows:

$$\text{Weight (Mass) to be paid for} = G \times \frac{110}{(100 + M)}$$

G = Gross, or wet, weight (mass) of mulching material

M = Moisture content, percent, in the mulching material to the nearest 0.5%

Mulching material which contains more than 50% moisture will be rejected. Wood cellulose fiber mulch containing more than 15% moisture will be rejected.

SECTION 622 – PLANTING TREES, SHRUBS, AND VINES

622.01 Description

This work shall consist of furnishing, delivering, and planting trees, shrubs, and vines, and also seedlings for wildlife habitat. This work shall also consist of the performance of incidental planting procedures and plant establishment work to provide a complete operation in accordance with 105.03.

MATERIALS

622.02 Materials

Materials shall be in accordance with the following:

Backfill Material	914.01
Fertilizer	914.03
Mulch	914.05(b)
Pipe	914.09(e)
Plants	914.08
Porous Material	914.09(d)
Tree Wound Dressing	914.09(c)
Water	914.09(a)

Soil conditioners such as peat moss or calcine clay may be added with written permission.

Guy wire shall be minimum No. 14 gage (2 mm) galvanized wire.

CONSTRUCTION REQUIREMENTS

622.03 Care and Handling of Plants

(a) Bare Rooted Plants

If the outside air temperature exceeds 35°F (2°C) when the plants are delivered, the plants shall be planted immediately or placed in inside or outside storage. If they are stored outside, the roots shall first be puddled in a paste solution of backfill and water. The plants shall then be separated and their root systems heeled-in by completely covering with moist soil. If they are stored inside, the roots shall be puddled in a paste solution of backfill and water. Straw, peat moss, or corncobs shall be worked in and around the root system and kept moist. Plants which are delivered in boxes, wrapped bundles, or other forms of closed containers, including trucks, and which are stored inside may remain in the container for 48 h from time of delivery, provided the containers are opened immediately and the plants are watered if necessary.

If the outside temperature is 35°F (2°C) or less when plants are delivered, the plants shall be placed in inside storage immediately. Inside storage procedures shall be in accordance with the above requirements. Plants may be transferred to outside storage when the outside temperature exceeds 35°F (2°C) provided they are puddled again and then heeled-in.

Temperature inside the storage building shall be maintained between 35°F (2°C) and 55°F (13°C). Plants shall not remain in storage, either inside or outside, for more than 7 days, unless otherwise permitted because of unfavorable planting conditions.

Plants may be rejected on failure to comply with these specifications.

(b) Balled and Burlapped Plants and Container Grown Plants

Plants shall be planted or placed in storage before being exposed for 10 consecutive hours at temperatures less than 35°F (2°C). Storage of plants shall be in a moist storage building or they shall be placed outside in a compact group with balls or containers completely covered with corncobs and kept moist. Plants shall not remain in storage for more than 10 days, unless otherwise permitted because of unfavorable planting conditions.

Plants may be rejected on failure to comply with these specifications.

622.04 Collected Plants

At least 24 h before starting to dig collected plants, notification shall be given of the time and place of digging so inspection of the work and of the plants can be made, if so desired.

Collected plants shall be dug carefully in a satisfactory manner. All operations of digging, transporting, and replanting collected plants shall be in accordance with all applicable laws and regulations of the state.

622.05 Excavation for Plant Holes

Stakes will be set to locate plant holes for each tree, shrub, or vine. The outline of each seeding bed will be staked and the planting on the required centers shall be as directed. Stakes for the staking operation shall be furnished. The location stakes shall be removed as directed. Excavation shall be such that the plant holes are cylindrical in shape with the sides approximately vertical. Material excavated from the holes may be used for backfill providing it is in accordance with 914.01. Otherwise, it shall be distributed uniformly within the construction area as directed. The excavated material shall not be stockpiled on turf or in ditches. Material unsuitable for the growth of vegetation, including rocks and boulders, shall be disposed of outside the right-of-way as directed and in accordance with 203.01 and 203.10. Plant holes shall be in accordance with the details and tables shown on the plans. If plants have not been planted within 10 days after excavation of the hole, the

hole shall be refilled and re-excavated at the time of planting. No additional payment will be made for this operation.

If, after staking or excavation of the plant holes at the locations shown on the plans, it becomes apparent that the location is unsuitable for planting due to accumulation of ground water, possible flooding because of terrain conditions, or unsuitable soil conditions, plant holes shall be relocated as directed. Such relocation shall be done with no additional payment.

622.06 Planting Season

The planting season shall be from September 1 through the following May 25, with the exception that trees shall be planted from October 1 through the following April 15, provided that trees are dormant. Crown vetch plants and seedlings shall be planted only from April 15 through May 30, unless approved in writing. Bare rooted plants shall be planted only when the outside air temperature exceeds 35°F (2°C). Unless otherwise approved, deciduous plants, except those container grown, shall be dormant at the time they arrive at the work or storage site. Evergreens shall not have active terminal growth. At least 40% of the total number of balled and burlapped, and container grown plants, not including crown vetch plants, shall be planted from the beginning of the planting season through December 31. Bare root seedlings for wildlife habitat shall be planted from October 1 through the following April 30. Container grown seedlings for wildlife habitat shall be planted at any time.

The initial planting and spring replacements, in accordance with 622.18, shall be completed satisfactorily within the planting season which expires prior to the completion date of the contract. These plants shall have an establishment period which shall be from the end of the specified planting period to the fall inspection. If the initial planting and spring replacements are not completed within the specified time, the completion date may be extended 1 year to provide an establishment period. If the completion date is extended, all requirements of 622.18 shall apply until final inspection and acceptance.

622.07 Pruning

Before the plant is placed in the plant hole, any bruised or broken parts of roots shall be cut off smoothly as approved unless otherwise specified or directed. All plants shall be pruned either before or after planting. Such pruning generally shall consist of thinning out or cutting back secondary branching to reduce the foliage by 1/3 to 1/2 in accordance with accepted horticultural practices. Pruning operations shall maintain the general crown outline and characteristic branching pattern for each species. Pruning or cutting back of terminal leaders which are over 3/8 in. (10 mm) in diameter at the point of cut will not be permitted. Broken or dead branches, or any other objectionable parts of the plant, shall be removed throughout the life of the contract. Pruning tools shall be kept sharp and shall be sterilized in denatured alcohol after each hour of use. All cut surfaces 3/8 in. (10 mm) or more in diameter shall be painted with a tree wound dressing.

Bare rooted shrubs shall be cut back to 1/2 their minimum specified height as shown on the plans. Pruning shall be performed after the shrubs have been sealed with Department seals and prior to the leaf buds breaking dormancy. At the time of the spring and fall inspections, bare rooted shrubs will be accepted at their original specified height provided they are healthy, in good growing condition, and are no less than 1/2 the minimum specified height.

622.08 Planting, Backfilling, and Watering

The plant shall be placed in the plant hole at the proper position for depth, alignment, final grade of the surrounding ground level, and vertical position of the trunk. The planting procedure shall be performed in such a manner that the top of the ball of the plant is as shown on the plans at the time of planting. The planting procedure shall be in accordance with the details as shown on the plans. Backfill material in accordance with 914.01 shall be placed around all plants except seedlings. The quantities of backfill material required per plant shall be as shown on the plans.

In areas which are designated on the plans as beds for group planting, the soil shall be tilled to a minimum depth of 6 in. (150 mm) in such a manner that all sod and vegetation is destroyed. These areas shall be tilled at least 2 times with an interval of 14 days between tilling operations. Planting may be done immediately after the second tilling. Additional tilling shall be performed if vegetation appears before mulch is applied. Sod and vegetation shall be removed in lieu of the tilling operation when the soil temperature or moisture conditions are such that the sod and vegetation would not be destroyed by tilling. At other times, sod and vegetation may be removed in lieu of tilling. If the excavation resulting from sod removal is greater than 1 in. (25 mm) deep, it shall be backfilled with topsoil to 1 in. (25 mm) above the original ground. After sod and vegetation removal and backfilling, the bed area shall be cultivated to a depth of 6 in. (150 mm). Large clods, rocks, and other debris encountered in the cultivation work and any excess soil shall be removed. The outline of beds for group plantings shall be no closer than 3 ft (0.9 m) to the center of any of the outer plants in the area.

In addition to the water applied at the time of planting, unless excessive moisture prevails, the minimum supplemental waterings required shall be 2 between May 1 and June 15, and 1 every 14 days between June 15 and September 15. Sufficient water shall be applied to individual plants to saturate the backfill and the mulch area. Plants in beds shall receive water equivalent to the quantity used for individual plants. Liquid fertilizer, in accordance with 622.09, may be applied with the supplemental watering and the method of application shall be approved. Lance watering will not be permitted.

Container grown seedlings for wildlife habitat which have been planted from June 1 through August 31 shall be maintained after installation for 30 days. Maintenance shall include watering the seedlings at the time of planting and once every 7 days.

(a) Plants with Bare Roots

With the plant in its proper position, the plant hole shall be backfilled with material in accordance with 914.01. The backfill material shall be worked firmly around the roots as the hole is gradually filled. The plant shall be raised gently and lowered slightly as the soil is added to help eliminate air pockets around the roots. Soil shall be added in layers of about 6 in. (150 mm) and each layer tamped to make it firm and to hold the plant perpendicular. Water shall be used to settle the soil and to eliminate air pockets around the roots, unless otherwise directed. The top 4 in. (100 mm) of soil necessary to fill the plant hole completely shall be a very fine mixture and shall be placed on top of the firmed backfill and allowed to remain loose and untamped.

(b) Balled and Burlapped Plants

Balled and burlapped plants shall be handled by the ball and placed in the holes in such a manner that the soil of the ball does not become loosened from the roots. The soil directly beneath the ball shall be firmed to minimize settling. Guy stakes shall be driven before backfilling operations begin. After the hole has been partially backfilled and the material firmed under and around the ball, the burlap shall be cut away and removed from the stem of the plant. Backfilling and firming shall then be completed in a manner to avoid loosening the soil from the root ball. Watering shall be done in accordance with 622.08(a). Backfill material shall be in accordance with 914.01.

(c) Seedlings for Wildlife Habitat

Seedlings shall be from 6 to 18 in. (150 to 450 mm) in height. Seedlings shall be planted as directed in the locations shown on the plans. Species shall be selected from the list as shown on the plans. Alternate species selection shall be subject to approval. Seedlings shall be planted no closer to each other than the distance shown on the plans. Seedlings shall not be planted in rows, but instead shall be planted in a natural appearing pattern. Failure to comply with this procedure will require the replanting of the seedlings as directed with no additional payment. All damaged seedlings shall be replaced with no additional payment if replanting is required.

622.09 Liquid Fertilizer Application

All plants shall be fertilized with a water soluble 5-10-10 fertilizer, or an equivalent amount of plant nutrients, at the rate of 0.75 lb/100 gal. (0.36 kg/400 L) of water. Fertilizer shall be applied to each installed plant until the mulched area over the plant hole is saturated. Three applications shall be made: 1 on or about July 1; 1 about August 1; and 1 about September 1.

622.10 Mulching

Mulch, in accordance with 914.05(b), shall be placed as a top layer around each plant as soon as it has been installed. The mulch shall cover the entire area as described in 622.08 and shall be placed around individual plants in accordance with the plans.

622.11 Guying and Staking

Guying and staking shall be in accordance with the details shown on the plans. Guy wire shall be placed through rubber hose material around each tree then twisted to secure the tree in a relatively stable position. Three wood stakes shall be spaced equally about each tree. The guy wire shall be secured to each stake at an approximately right angle. Support of multi-stem trees of 4 to 6 ft (1.2 to 1.8 m) in height shall consist of inner limb guying and bracing stakes. The securement point and placement of guy wire shall be so as to avoid abrasion of tree limbs. The guys and stakes shall be maintained for the duration of the contract. Prior to final inspection, all materials used to support trees shall be removed and disposed of, except as otherwise directed for trees requiring additional bracing time. However, supports for fall replacement shall remain in place. If approved, stakes may be left flush with the ground.

622.12 Plant Protection

(a) Borer Control Coatings

Within 5 days after planting and prior to wrapping, all trees, except evergreens, shall be protected against borer attack with an insecticide mixture applied to the tree trunk with a paint brush or a suitable hand sprayer. The application shall cover the trunk from the root crown to the 1st major branches. The mixture shall consist of enough powdered skim milk to form a smooth slurry when added to either dieldrin 18 at the rate of 2 qt to 50 gal. (1 L to 100 L) of water or thiodan 50 at the rate of 1 lb to 50 gal. (1 kg to 420 L) of water.

(b) Wrapping for Rodent Protection

Within 7 days after planting, all crabapple and shade trees with a 1/2 in. (13 mm) diameter or larger, except for multi-stem forms, shall be wrapped with a double layer of 18 by 14 mesh per in. aluminum mill finish screen wire mesh around the trunk of each tree as shown on the plans. The height of screen wire shall be from the existing grade to below the lowest branch. The screen wire shall be overlapped at the ends. The screen wire shall be secured to itself with hog rings or other approved methods, and to the rods by approved means.

Plastic coil type protective wrapping will be acceptable as an alternative to the screen wire and reinforcement rod method of tree protection or staked trees of less than 2 in. (50 mm) caliper. The wrapping shall be loosened twice each calendar year. The 1st adjustment shall be made between May 15 and June 15. The 2nd adjustment shall be made between September 1 and September 30. The plastic tree protective wrapping shall extend to the height of the bottom limb.

The Contractor may submit other proposed methods of rodent protection to the Department's landscape architect for approval prior to installation. The design of the protection shall ensure an average air space diameter of 2 in. (50 mm) greater than the tree's calipered size at installation. The protection shall permit air movement

through its surface to dry the tree trunk following periods of precipitation. The protection shall not damage the tree nor hinder its growth.

Multi-stem trees shall be wrapped with commercially available wrapping paper wrapped tightly around the trunks from the ground to the lowest branch with a minimum of 1/2 in. (13 mm) overlap. The wrapping paper shall be tied securely with stout cord at top and bottom and at 2 intermediate intervals.

622.13 Retaining Walls and Tree Wells

Retaining walls around the roots of trees or shrubs, and tree wells around the trunks of trees or shrubs shall be constructed at the locations and to the shape and dimensions shown on the plans or as otherwise designated. They shall be of mortar and masonry, or other type as specified. Mortar shall not be used in any portion of the tree well extending below the top of contiguous porous material used for tree root protection. The inside face of a tree well shall be no less than 2 ft (0.6 m) from the outside edge of the trunk of the tree or shrub. No material shall be placed between the tree trunk and the wall of the tree well.

622.14 Tree Root Protection

Where tree root protection is specified, the entire area of the root spread shall be protected. The limits of this area shall be as designated, but in general this area corresponds to the area of the ground surface lying beneath the limb spread of the tree. The area shall be cleaned of all vegetation and debris. Porous material, in accordance with 914.09(d), shall be placed uniformly over the area to a depth in proportion to the height of fill, varying proportionally from 3 in. (75 mm) for fills of 1 ft (300 mm) or less to 12 in. (300 mm) for fills of 4 ft (1.2 m) or more, or to such other depth as may be designated. A layer of No. 23 sand or other approved material shall then be placed in sufficient quantity to choke the top layer of porous material and will be measured and paid for as porous material.

Where the earth fill is less than 12 in. (300 mm) and tree root protection is specified without the construction of a tree well, the thickness of the porous material at the tree trunk shall be increased to the height of the fill and extend outward from the tree truck in collar form for a distance of 12 in. (300 mm), unless otherwise shown on the plans.

No fill shall be placed over the root spread of any tree or shrub that is to be protected in the above manner until the required depth of porous material has been placed.

622.15 Pipe Underdrains

Pipe underdrains, when shown on the plans or directed, shall be placed to drain tree wells or porous material for tree root protection. These shall be placed in accordance with applicable provisions of 718.

622.16 Damage to Plants

During all operations of tree protection, care shall be used to prevent unnecessary cutting of roots and to prevent scarring or damage to selected trees or shrubs. Motorized equipment shall not be operated within the drip line of trees unless permitted. Where trimming of branches or cutting of roots is necessary, all cuts shall be made cleanly with proper sharp tools in accordance with generally accepted horticultural practices. Scarred areas and cut surfaces 3/8 in. (10 mm) or more in diameter shall be covered completely with a tree wound dressing.

622.17 Grass and Weed Control

Weeding and mowing of grass in and around all group plantings, beds, and individual trees and shrubs shall be performed until final acceptance. The grass and weed control areas shall be the areas within 2 ft (0.6 m) of the outer limits of all group plantings and shrub beds and within 2 ft (0.6 m) of the outer limits of the mulch area of individual shrubs. For the care of individual trees, the area shall extend to a perimeter centered from the point itself to 2 ft (0.6 m) beyond the stub stakes of the guy wires or 2 ft (0.6 m) beyond the mulched area. In general, theses areas shall be in accordance with the plans.

622.18 Care, Inspection, and Replacement

(a) Care

Watering, fertilizing, weeding, cultivating, spraying to control insect infestation and disease, and all other good horticultural practices necessary to maintain the plants in a living healthy condition shall be performed up to the time for termination of responsibility for care as set out herein. The plants shall be cared for throughout the life of the contract. All plants stolen, damaged, or destroyed by fire, automobiles, vandalism, or any other cause, with the exception of plants damaged or destroyed by Department maintenance operations, shall be replaced with no additional payment as soon as practicable. Plants damaged or destroyed by the Department will be replaced by the Department prior to the date of final acceptance.

(b) Inspection and Replacement

On or about May 1, a spring inspection of initial plantings will be made during and before the end of the planting season and prior to the beginning of the establishment period. Plants not living, unhealthy, in a poor growing condition, or otherwise not meeting the specifications shall be replaced with no additional payment, prior to May 15 for trees and prior to May 25 for other plants. These replacements shall be in accordance with all other requirements of the initial planting. All plants found to be not living or in an unhealthy condition between this replacement and final inspection shall be removed from the project immediately, as directed, and shall be replaced after September 15 as detailed below.

A fall inspection will be made on or about September 15, at which time the condition of the materials planted within the specified planting season will be determined. At the time of this inspection, all plants which are found to be dead,

unhealthy, in a poor growing condition, or otherwise not meeting the specifications will be rejected. Rejected plants shall be removed and disposed of as soon as practicable and replaced prior to November 15 with no additional payment. Replacement materials and operations shall be in accordance with the requirements of the initial planting.

A final inspection of the contract will be made as soon as possible after replacement. All plants shall be cared for and maintained until final inspection and acceptance.

All seedlings for wildlife habitat shall be in accordance with ASNS Seedling Trees and Shrubs and will be inspected by a landscape architect within 1 week of planting. Spring and fall inspections as described above will not be required. The inspection, planting, and maintenance of seedlings as required will constitute final acceptance.

622.19 Crown Vetch Plants and Seedlings

The requirements of 622.09 and 622.18 will not apply to these items. Seedlings shall be fertilized as specified on the plans. Crown vetch plants and seedlings, including replacements, shall be watered as necessary to keep them in a living, healthy, and good growing condition.

On or about June 5, these items will be inspected. If it is estimated that 90% or more of the plan quantity of any individual item in a specific area is living, healthy, and in a good growing condition, replacements will not be required. If less than 90% are alive, healthy, and in a good growing condition, all items not meeting these requirements shall be replaced. Replacements shall be marked in the same manner as the original planting, except the markers shall be yellow.

Replacement planting shall be accomplished prior to June 15.

A final inspection will be made on or about the following September 15. If it is estimated that 90% of the contract quantity of any individual item is living, healthy, and in a good growing condition, payment will be made for the contract quantity. If less than 90% meet these requirements, the pay quantity for the item will be established.

622.20 “Do Not Mow or Spray” Signs and “Do Not Disturb” Signs

These signs shall be placed at the boundaries of areas where seedlings for wildlife habitat have been placed. The locations and spacing of the signs shall be as shown on the plans or as directed. The sign shall otherwise be in accordance with 621.06(h).

622.21 Method of Measurement

Furnishing and planting trees, shrubs, and vines will be measured by the number of units of each type and size specified, installed, and accepted. Seedlings for

wildlife habitat, “Do Not Mow or Spray” signs, and “Do Not Disturb” signs will be measured by the number installed and accepted. Retaining wall masonry, either mortared or not mortared as specified, will be measured by the cubic yard (cubic meter). Porous material for root protection will be measured by the ton (megagram). Drain tile will be measured by the linear foot (meter).

622.22 Basis of Payment

The number of trees, shrubs, and vines of each variety planted, determined as provided above, will be paid for at the contract unit price per each for plant, of the type, form, and size shown in the Schedule of Pay Items. Seedlings for wildlife habitat, “Do Not Mow or Spray” signs, and “Do Not Disturb” signs will be paid for at the contract unit price per each.

Masonry wall and masonry tree well will be paid for at the contract unit price per cubic yard (cubic meter). Porous material for root protection will be paid for at the contract unit price per ton (megagram). Drain tile will be paid for at the contract unit price per linear foot (meter) of the diameter specified.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Drain Tile, _____ in. (mm) (diameter)	LFT (m)
Masonry Tree Well	CYS (m3)
Masonry Wall	CYS (m3)
Plant, Annual	EACH
Plant, Aquatic	EACH
Plant, Biannual	EACH
Plant, Broadleaf Evergreen, Cone, Broad Upright, _____ (size)	EACH
Plant, Broadleaf Evergreen, Globe, Dwarf, _____ (size)	EACH
Plant, Broadleaf Evergreen, Spreading, Semispreading, _____ (size)	EACH
Plant, Coniferous Evergreen, Cone, Broad Upright, _____ (size)	EACH
Plant, Coniferous Evergreen, Globe, Dwarf, _____ (size)	EACH
Plant, Coniferous Evergreen, Prostrate Broad Spreading, Semispreading, _____ (size)	EACH
Plant, Deciduous Shrub, _____ (size)	EACH
Plant, Deciduous Tree, Multi-Stem, _____ (size)	EACH

Plant, Deciduous Tree, Single Stem, _____ size ..... EACH
Plant, Ground Cover ..... EACH
Plant, Perennial ..... EACH
Plant, Root Tuber, Corm, Bulb ..... EACH
Plant, Rose Grade ..... EACH
Porous Material for Root Protection ..... TON (Mg)
Seedling ..... EACH
Sign, "Do Not Disturb" ..... EACH
Sign, "Do Not Mow or Spray" ..... EACH

The cost of furnishing all materials, labor, and necessary incidentals shall be included in the cost of the pay items.

Progress payment for planting trees, shrubs, or vines will be based on the premise that 75% of the work has been completed when such trees, shrubs, or vines have been completely planted. The remaining portion of the payment will be for maintenance and plant replacement.

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SECTION 628 – FIELD OFFICE, FIELD LABORATORY, COMPUTER SYSTEMS, OFFICE MACHINES AND COMMUNICATIONS

628.01 Description

This work shall consist of providing the specified facilities, equipment, supplies and services in accordance with 105.03.

628.02 Field Office and Laboratory Requirements

When specified, the Contractor shall provide a field office, computer systems, office machines, field laboratory, services, equipment and supplies for the Department's exclusive use in accordance with the minimum requirements listed below.

(a) Field Office

The field office shall be located as mutually agreed by the Engineer and the Contractor. If a building exists within the limits of the right-of-way that is acceptable as a field office and the building is scheduled to be removed under the terms of the

contract, the building may be equipped and furnished as the field office. A building within the right-of-way that is furnished under this specification shall be removed prior to the date of the last work and other acceptable facilities for the field office shall then be provided.

The field office may be a permanent building or a trailer and shall be of the type shown on the Schedule of Pay Items. The building or trailer furnished for the field office shall be in accordance with all applicable state and local codes and applicable IOSHA/OSHA requirements.

The field office shall be complete and ready for use by the Department, including all utility connections and specified computer systems, office machines, internet service, equipment and supplies, prior to the start of work. If the Contractor is unable to provide the permanent field office prior to the start of the work, the Engineer shall be notified in writing and the Contractor and the Engineer will agree on temporary field office arrangements prior to the start of work. A temporary field office will not be accepted by the Department for more than 2 months, at which time a permanent field office shall be ready for the Department's use.

The field office shall at a minimum be the size listed below for the type field office specified.

1. Type A – 400 sq ft (37 m^2)
2. Type B – 550 sq ft (51 m^2)
3. Type C – 650 sq ft (60 m^2)

Minimum dimensions shall be 8 ft (2.4 m) wide and 7 ft (2.1 m) in height, from floor to ceiling. For a trailer, the calculation of minimum area will be based on the exterior box dimensions.

The office shall have a solid and level floor with no holes, a weatherproof roof and shall be dust-proof, and wind-tight. The field office shall have at least 2 doors for ingress and egress and shall have a minimum of 6 windows for a type A field office and 8 windows for a type B or C field office, not including any windows in the doors.

Each door shall have a satisfactory lock. At least 1 door must always be able to be unlocked and opened from inside the field office. If a padlock is used to secure a door, it shall be a high security type which is invulnerable to bolt cutters, hacksaws, hammers, or prybars. The padlock shall be mounted in such a manner that locking and unlocking the door is satisfactorily convenient. Installation of additional hardware to protect the lock or use of multiple padlocks on a door will not be permitted. However, additional hardware to receive the padlock will be acceptable. The Contractor shall furnish the number of keys to the office as directed by the Engineer. The Department will maintain a list of all Department personnel who are given keys.

Windows shall be hinged or sliding and have a minimum area of 5 sq ft (0.45 m^2) each. Windows shall be provided with satisfactory locks and screens. Windows, including windows in the doors, shall be provided with shades, blinds, or other approved coverings.

The field office shall have heating and air-conditioning equipment capable of maintaining a uniform temperature between 68°F and 80°F (20°C and 26°C).

The field office shall have a minimum 100 amp, 120/240 volt electrical service, shall have sufficient receptacles to satisfactorily accommodate all required electrical equipment without the use of extension chords or splitters and shall be provided with satisfactory office type lighting.

The field office shall include a minimum of 1 separately lockable storage area suitable to store a nuclear density/moisture gauge. The storage area shall have a minimum storage volume of 63 cu ft (1.8 m^3) with a minimum floor area of 9 sq ft (0.8 m^2) .

If the field office is a trailer, the trailer shall be securely supported by adequate blocking. The blocking shall provide a foundation to prevent settlement. The trailer shall be secured to the ground with a trailer tie down system that is in accordance with all state and local requirements. Each trailer shall be furnished with steps meeting IOSHA/OSHA requirements at each doorway.

The field office location shall be selected in order to provide satisfactory parking and trash disposal facilities for Department use. Parking spaces shall be either paved or surfaced with compacted aggregate, size No. 53, or other acceptable materials suitable for all-weather usage.

(b) Field Office Equipment and Supplies

The following minimum equipment and supplies shall be furnished for each field office of the type specified.

Office Type	**A**	**B**	**C**
Bloodborne Pathogen Kit	1	1	1
Broom and Dust Pan	1	1	1
Calculators	1	2	2
Carbon Monoxide Detector	1	1	1
Chairs	4	8	12
Cleaning Supplies	Yes	Yes	Yes
Drafting Stools	1	1	1
Drafting Tables	1	1	1
Drinking Water	Yes	Yes	Yes
File Cabinet Drawers	4	8	12
Fire Extinguishers	1	2	2

First-Aid Kit	1	1	1
Folding Office Tables	1	2	2
Microwave Oven	1	1	1
Office Desks & Office Chairs	2	4	4
Paper Shredder	1	1	1
Pencil Sharpener	1	1	1
Refrigerator/Freezer	1	1	1
Shelving	16 lft (4.9 m)	20 lft (6.1 m)	24 lft (7.3 m)
Six-hook Coat Rack	1	1	1
Smoke Detector	1	1	2
Telephones Lines	2	2	2
Telephones	2	2	3
Toilet Facilities	Yes	Yes	Yes
Voice Mail	1	1	1
Waste Paper Baskets	2	4	4

The office and the equipment shall be furnished in a condition satisfactory to the Department.

Adequate quantities of basic hygiene and office cleaning supplies shall be provided. These supplies shall include, but are not limited to, hand soap, hand sanitizer, paper towels, toilet paper, window cleaner, all-surface cleaner, toilet disinfectant, toilet brush and a toilet plunger.

Potable drinking water with both hot and cold water capabilities shall be furnished. Drinking cups and paper towels shall be provided.

Fire extinguishers shall be 5-pound, Class ABC or higher rated and shall be maintained in a fully charged and operable condition and shall meet all IOSHA/OSHA requirements.

First-aid kits shall meet the requirements of ANSI Z308.1 current at the time of letting.

Shelving shall have a minimum width of 10 in. (250 mm).

At least 1 telephone shall be a cordless phone having a frequency of at least 900 MHz.

The telephone voice mail system shall be capable of providing both a minimum 1 min outgoing message and 30 min total recording time for incoming messages. It shall have a remote operation feature, which may be used to retrieve, replay, erase, and save messages. An answering machine meeting these requirements may be substituted for the voice mail system.

Filing cabinets shall at a minimum be fire resistant steel filing cabinets with a class D or higher classification established by UL or Safe Manufacturers National Association. Cabinet drawers shall have a filing depth of 25 in. (635 mm). All cabinets shall have a lock and at least 4 drawers shall be fire proof.

Office desktops shall be at least 48 in. (1,220 mm) wide and 25 in. (635 mm) deep. All desks shall contain at least 2 drawers, 1 of which shall be provided with a lock.

Folding office tables shall be a minimum size of 30 by 60 in. (760 by 1,520 mm).

Office chairs shall be height adjustable and equipped with castors. Other required chairs may be stackable or folding chairs.

Drafting tables shall contain a tilt top work table for drafting purposes. Dimensions shall be at least 30 by 60 in. (760 by 1,520 mm). The drafting stool shall be proportional to each drafting table.

Supplies to be furnished shall include all items required for proper operation of the required equipment. This includes, but is not limited to, operating manuals and paper supplies.

Calculators shall be electric powered, have a printer and a minimum 12-digit capacity.

The shredder shall have a minimum capacity of 12 sheets (20 lb paper), shall be capable of shredding paper clips and staples and shall include a 5 gallon capacity waste basket.

The microwave oven shall have a minimum 1 cu ft capacity with a minimum 1,100 watts and shall have digital controls.

The field office and all equipment and supplies shall be maintained and replenished in a satisfactory manner during the term of the contract or until released by the Engineer. If the field office or required equipment and supplies are not maintained by the Contractor, the Engineer may withhold partial payments until the field office is operational to the Department's satisfaction.

(c) Field Office Computer System

The Contractor shall provide 1 field office computer system for the Department's exclusive use for each field office specified. The Contractor has the option to provide either a desktop or a laptop computer system in accordance with the minimum requirements listed below.

1. Field Office Desktop Computer System

a. Processor – Intel or AMD compatible, 2.0 GHz
b. Memory – 1.0 GB, 533 MHz
c. Hard Drive – 60 GB, 5,400 rpm
d. Optical Drive – 24X CD-RW drive
e. Ports – Two USB 2.0 compliant ports
f. Network/Wireless – Ethernet or wireless card to be compatible with the selected internet and office network connections
g. Graphics – Integrated graphics card
h. Monitor – 22 in. widescreen digital flat panel
i. Keyboard –USB enhanced multimedia keyboard
j. Mouse – USB 2-button scroll mouse

2. Field Office Laptop Computer System

a. Processor – Intel or AMD compatible, 2.0 GHz
b. Memory – 1.0 GB, 533 MHz
c. Hard Drive – 60GB, 5,400 rpm
d. Module Bay Device – 24X CD-RW drive
e. Ports – Two USB 2.0 compliant ports
f. Network/Wireless – Ethernet or wireless card to be compatible with the selected internet and office network connections
g. Graphics – Integrated graphics card
h. Display – 15” XWGA LCD panel
i. Battery – 9 cell lithium ion
j. External Monitor – 22 in. widescreen digital flat panel
k. External Keyboard – USB enhanced multimedia keyboard
l. External Mouse – USB 2-button scroll mouse
m. Miscellaneous – One compatible port replicator with AC adapter, 1 additional AC adapter, 1 DC adapter and 1 padded carrying case

3. Computer Software

The Contractor shall provide software for the computer system in accordance with the minimum requirements listed below.

a. Operating System Software – Windows XP Professional
b. Productivity Software – Microsoft Office 2003 Small Business and Adobe Acrobat Professional
c. Security Software – McAfee Virus Scan Plus

All software shall include the most current updates and patches at the time the computer system is provided to the Department. The Contractor shall provide for installation of updates and patches for the operating system, productivity and

security software during the term of use of the computer system by the Department. Updates and patches shall be provided by an automatic update method.

The Department may install and maintain proprietary software on the computer in order to run the Department's construction management programs.

4. Miscellaneous Computer Requirements

The initial condition of the computer system shall be nearly pristine. All owner installed e-mail accounts, games, spyware, online services, applications, network or other profiles previously set up on the system shall be removed prior to placement in the field office. If the system was provided for a previous Department contract, all software not specified shall be removed prior to placement in the current field office.

The Contractor shall provide an uninterruptible power supply, UPS, minimum 120 VA, 100 Watts and full time surge suppression for each field office computer system specified in the contract.

The Contractor shall provide all cables, connections and software required to connect the field office computer system to the printer and the scanner.

When more than 1 computer system is specified for a field office, the Contractor shall provide either an Ethernet or wireless office network to allow all computer systems in the field office to access the field office internet service, the printer and the scanner.

The Contractor shall provide appropriate dust covers for all field office desktop computer systems.

The Contractor shall provide all manuals necessary for operation of the computer system and software with the system and shall include all documentation normally furnished with the equipment and software when purchased.

The Department will be utilizing the computer system to run or access Department provided construction management software applications. These applications are known to run on Intel and AMD compatible equipment when using the Windows XP Professional operating system. If the Department experiences problems running these applications due to hardware or software compatibility, the Contractor shall replace the equipment to ensure compatibility to the satisfaction of the Engineer within 5 business days.

The computer system shall be maintained in good working order. If a portion of the system becomes defective, inoperable, damaged, or stolen, that portion shall be repaired or replaced within 5 business days after the Contractor is notified by the Engineer. If the computer system and related accessories are not maintained by the Contractor as required, the Engineer may withhold partial payments until the computer system is operational to the Department's satisfaction.

(d) Field Office Internet Service

The Contractor shall provide broadband internet service for the field office. Broadband internet service shall be capable of a minimum average upload speed of 350Kbps unless otherwise approved by the Engineer.

(e) Field Office Machines

The Contractor shall provide a fully operational copier, printer, document scanner and fax machine for the Department's exclusive use in the field office in accordance with the minimum requirements listed herein.

In lieu of separate copier, printer, scanner and fax machines, the Contractor may provide an all-in-one unit that meets all the requirements for any combination of the individual machines being provided. Separate machines shall be provided for those machine functions that are not included in an all-in-one type machine.

1. Copier

The copier shall be a dry ink copier capable of using plain paper and of making full size, black and white copies of letter, legal and ledger US paper size original documents. The copier shall be capable of reducing and increasing copy sizes. The copier shall have a self-feeding paper tray, an automatic document feeder and be capable of producing at least 12 copies per minute.

2. Printer

The printer shall be a laser printer compatible with the computer system provided by the Contractor for use by the Department in the field office. The printer shall be capable of printing single-sided, black and white letter and legal US paper size documents at a rate of 20 pages per minute and capable of automatic duplex printing.

3. Document Scanner

The document scanner shall be compatible with the computer system provided by the Contractor for use by the Department in the field office. The scanner shall be capable of scanning letter and legal size documents and shall have an automatic document feeder and be capable of 600 dpi black and white resolution.

4. Fax Machine

The fax machine shall be connected to 1 of the required telephone service lines in the field office. The machine shall have an automatic document feeder with a 10-page capacity and be capable of faxing letter and legal size sheets. It shall be able to automatically dial 40 preprogrammed fax numbers and have the capability to program at least 2 groups of numbers. The machine shall have a 2 MB memory, shall be equipped with a telephone handset and be capable of automatic redial.

5. Miscellaneous Office Machine Requirements

The Contractor shall provide letter, legal and ledger size paper, ink cartridges and toner as required by the Engineer for the operation of each piece of equipment provided.

If any office machine becomes defective, inoperable, damaged, or stolen, that machine shall be repaired or replaced within 5 business days after the Contractor is notified by the Engineer. If any of the office machines are not maintained by the Contractor as required, the Engineer may withhold partial payments until the machine is operational to the Department's satisfaction.

(f) Field Laboratory

The field laboratory shall be located as mutually agreed by the Engineer and the Contractor. The laboratory shall consist of an acceptable building or trailer in accordance with 628.02(a) in which the Department will house and use equipment to perform testing procedures for the contract.

The following equipment and supplies shall be furnished for each field laboratory of the type specified. The equipment and supplies shall meet the requirements of 628.02(a) as applicable.

Laboratory Type	**A**	**B**	**C**
Bloodborne Pathogen Kit	1	1	1
Broom and Dust Pan	1	1	1
Carbon Monoxide Detector	1	1	1
Chairs	2	2	2
Cleaning Supplies	Yes	Yes	Yes
Drinking Water	Yes	Yes	Yes
File Cabinet Drawers	4	4	4
Fire Extinguishers	1	2	2
First-Aid Kit	1	1	1
Folding Office Tables	1	1	1
Office Desks & Office Chairs	1	1	1
Shelving	16 lft (4.9 m)	20 lft (6.1 m)	24 lft (7.3 m)
Six-hook Coat Rack	1	1	1
Smoke Detector	1	1	2
Telephones Lines	1	1	1
Telephones	1	1	1
Toilet Facilities	Yes	Yes	Yes
Voice Mail	1	1	1
Waste Paper Baskets	2	2	2

If a field office is provided that is large enough to include the required space for the laboratory, the Engineer may agree to accept the field office for use as both office and laboratory, in which case the equipment and supplies listed for the laboratory will not be required.

If the field laboratory is a separate structure that is located directly adjacent to the field office, the toilet facilities, drinking water, telephones, voice mail/answering machine, telephone lines and cleaning supplies will not be required.

628.03 Additional Computer Systems and Mobile Internet Service

When specified, the Contractor shall provide the following computer systems and internet services for the Department's exclusive use.

(a) Additional Field Office Computer System

The additional field office computer system shall be either a desktop or laptop computer system in accordance with 628.02(c)1 or 628.02(c)2 except that the monitor for a desktop system may be a 19 in. flat panel and the external monitor for a laptop system will not be required. The requirements of 628.02(c)3 and 628.02(c)4 shall apply to each additional field office computer.

(b) Mobile Laptop Computer System

The mobile laptop computer system shall be in accordance with 628.02(c)2 except that the external monitor, integrated graphics card, external keyboard and port replicator with AC adapter will not be required. Mobile laptop computers will be used by the Department for contracts that do not include a field office. The requirements of 628.02(c)3 and 628.02(c)4 shall apply to each mobile laptop computer except that those requirements specifically for a field office computer will not apply.

(c) Mobile Internet Service

The mobile broadband internet service access card will be used by the Department in a laptop computer provided by either the Contractor or the Department.

The card shall connect to the laptop via a type II PC card slot, an express card slot or a USB 2.0 compliant port. The card and service shall be capable of a minimum average upload speed of 350 Kbps. The internet service rate plan shall include unlimited data and time usage with no roaming charge for national domestic use. All software necessary for the operation of the card shall be provided to the Engineer.

The Contractor shall not purchase any card or enter into any service agreement until authorized by the Engineer. The Engineer will provide a minimum of 10 business days notice prior to the date the card will be required.

628.04 Cellular Telephones/Radios

The Contractor shall provide radio or cellular telephone/radio equipment and services, as specified below, for use by the Department on the contract.

Each radio or cellular telephone/radio unit shall be capable of 2-way radio communication with all other units provided under this contract. Each radio or cellular telephone/radio unit shall have a service coverage area that includes the project limits. Each radio or cellular telephone/radio unit shall include a belt clip system, a 120v AC charger, and a 12v DC mobile charger.

All equipment shall be covered by normal manufacturer's warranties. All radio or cellular telephone/radio units and associated equipment will remain the property of the Contractor and will be returned to the Contractor upon completion of the contract.

The Contractor shall provide the following services for each radio or cellular telephone/radio unit.

(a) Radio Service

Radio service shall include the following:

1. unlimited direct connect radio service;
2. no cellular telephone service.

(b) Cellular Telephone/Radio Service

Cellular telephone/radio service shall include the following:

1. cellular telephone anytime minutes per month as shown in the schedule of pay items;
2. unlimited nights and weekends service;
3. unlimited direct connect radio service;
4. voice mail and caller ID.

The Department will be responsible for damage and/or loss of the units beyond that covered by normal manufacturer's warranties, while in use by the Department. The Contractor shall provide replacement cellular telephone/radio units, batteries, chargers, etc within 1 business day of notification of need for the item.

The Contractor shall not enter into any agreement with any service provider or purchase any radio or cellular telephone/radio units for use by the Department until authorized by the Engineer. The Engineer will notify the Contractor a minimum of 10 business days prior to the need for the units.

628.05 Method of Measurement

Field office and field laboratory will be measured by the month for the specified type. Partial months will be rounded up to the next 1/2 or whole month. The Department will provide 2 weeks advanced notice prior to when the facility will be vacated.

If a field laboratory is specified and is included in the same space as the field office, the field laboratory will not be measured for payment.

Additional field office computer system, mobile laptop computer system, mobile internet service, and cellular telephone/radio service will be measured by the month for each system or service provided. Partial months will be rounded up to the next 1/2 or whole month. The Department will provide 2 weeks advanced notice prior to when mobile internet service and cellular telephone/radio service will no longer be required.

628.06 Basis of Payment

Field office and field laboratory will be paid for at the contract unit price per month, complete in place until released.

Additional field office computer system, mobile laptop computer system and mobile internet service will be paid by the month for each system or service provided.

Radio and cellular telephone/radio units will be paid for at the contract unit price per each. Radio and cellular telephone/radio service will be paid for at the contract unit price per month per each phone. Monthly charges for cellular telephone minutes in excess of those specified in the contract will be paid for by the dollar amount for the invoiced price per each occurrence as cellular telephone/radio, additional charges.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Cellular Telephone/Radio Service, _____ anytime minutes	MOS
Cellular Telephone/Radio	EACH
Cellular Telephone/Radio, Additional Minutes	DOL
Field Laboratory, _____ type	MOS
Field Office Computer System, Additional, _____ Each qty	MOS
Field Office, _____ type	MOS
Mobile Internet Service, _____ Each qty	MOS
Mobile Laptop Computer System, _____ Each qty	MOS
Radio Only Service	MOS
Radio	EACH

The cost of all heating, cooling, electrical service, telephone service and other miscellaneous utility bills required for the field office or field laboratory shall be included in the cost of the field office or the field laboratory.

If a field office smaller than the specified type is approved by the Engineer, a new unit price will be established for the smaller field office. The new unit price will be equal to the original contract unit price multiplied by the smaller floor area and divided by the specified floor area.

If a temporary field office is provided in accordance with 628.02, payment will be 65% of the unit price during the time the temporary field office is in use by the Department.

The cost of all materials and labor necessary to setup, secure, maintain and remove the field office, including all required equipment and supplies and any material required to provide parking, shall be included in the cost of the field office.

All costs necessary to provide the field office computer system, including the required software, manuals, peripherals and related equipment, technical support and miscellaneous computer requirements shall be included in the cost of the field office.

All costs necessary to establish, install and maintain field office internet service, including any required hardware, software, fees, monthly charges, setup, installation and technical support shall be included in the cost of the field office.

All costs necessary to provide the copier, printer, document scanner and fax machine, including setup, installation, all required connections to computer systems, technical support and miscellaneous office machine requirements shall be included in the cost of the field office.

All costs necessary to establish and maintain a field office network when 1 or more additional field office computer systems are specified shall be included in the cost of the field office.

All cost necessary to provide an additional field office computer system, including the required software, manuals, peripherals and related equipment and technical support shall be included in the cost of the additional field office computer.

All costs necessary to provide the mobile laptop computer system, including the required software, manuals, peripherals and related equipment, technical support and miscellaneous computer requirements shall be included in the cost of the mobile laptop computer.

All costs necessary to establish, install and maintain mobile internet service, including required hardware, software, fees, monthly charges, setup, installation and technical support shall be included in the cost of mobile internet service.

628.06

The Contractor shall provide a copy of the detailed invoice from the service provider for each cellular telephone/radio or radio unit each month.

SECTION 700 – STRUCTURES

SECTION 701 – DRIVEN PILING

701.01 Description

This work shall consist of furnishing and driving foundation piles of the type and dimensions specified including cutting off or building up foundation piles when required. This work shall also consist of providing test piles and performing loading tests when required. Piling shall be installed at the location and to the tip elevation, the penetration depth, and nominal driving resistance shown on the plans in accordance with 105.03.

MATERIALS

701.02 Materials

Materials shall be in accordance with the following:

B Borrow	211
Bentonite Grout	913.06
Concrete Piles	707
Conical Pile Tips	915.01(a)2
End Plates	915.01(a)1
Epoxy Coating for Piles	915.01(d)
Pile Shoes	915.03.1
Reinforcing Bars	910.01
Steel H Piles	915.02
Steel Pipe Piles	915.01
Structural Concrete	702
Timber Piling, Treated	911.02(c)
Timber Piling, Untreated	911.01(e)

Unless otherwise specified, reinforcing bars may be either plain or epoxy coated.

Steel pipe piles shall consist of a steel pipe which is driven into place and filled with class A concrete.

The Contractor may furnish and drive steel pipe piles with thicker walls than specified.

701.03 Handling of Epoxy Coated Piles

Epoxy coated piles shall be protected at all times from damage to the epoxy coating. Damage to epoxy coated piles shall be repaired in accordance with 915.01(d). Epoxy coated piles will be rejected if the total area of repair to the coating exceeds 2% of the total coated surface area.

CONSTRUCTION REQUIREMENTS

701.04 Equipment for Driving Piles

(a) Approval of Pile Driving Equipment

All pile driving equipment, including the pile driving hammer, hammer cushion, helmet or pile drive head, pile cushion, and other appurtenances furnished by the Contractor shall be in working condition and approved in writing by the Engineer prior to delivery of the pile driving equipment to the job site. All pile driving equipment shall be sized such that the piles can be driven to the length required without damage. Approval of pile driving equipment does not relieve the Contractor of the responsibility to drive piles, free of damage, to the required nominal driving resistance and, if specified, the minimum tip elevation shown on the plans. Pile driving equipment will be subject to satisfactory performance during production.

The Contractor shall submit to the Office of Geotechnical Services, a completed pile and driving equipment data form at least 15 calendar days prior to driving piles. A copy shall also be furnished to the Engineer. The pile and driving equipment data form is available on the Department's website. The Contractor will be notified of the acceptance of the proposed pile driving system within 15 calendar days of the receipt of the pile and driving equipment data form. Acceptance of pile and driving equipment does not relieve the Contractor of the responsibility to provide equipment suitable for driving the specified piling to the required bearing without damage.

If the method of pile driving approval is in accordance with the dynamic formula shown in 701.05(a), a wave equation analysis is not required. The alternate method will be used to determine if the pile driving equipment is acceptable for use.

If the nominal driving resistance is to be determined by dynamic pile load test in accordance with 701.05(b) or static load test in accordance with 701.05(c), the Engineer will use wave equation analysis for driving system approval. To be approved, the proposed driving system shall obtain the nominal driving resistance between the specified blow count range of 30 and 120 blows per foot, and shall maintain driving stresses below the specified driving stress limits for the pile type being driven. If wave equation predicted driving stresses are greater than specification limits or the wave equation blow count for the nominal driving resistance is outside the specified blow count range, the Contractor shall modify or replace the proposed equipment until subsequent wave equation analyses indicate the piles can be driven to the nominal driving resistance within the allowable blow count range and within driving stress limits.

If the driving system requires revision, the Contractor will be notified of the acceptance of the revised driving system within 7 calendar days of receipt of a revised pile and driving equipment data form.

The Contractor shall use the approved pile driving system. No changes shall be made without prior written approval from the Engineer, with the exception that the concrete pile cushion thickness may be increased to control driving stresses. A change in the pile driving system will only be considered after the Contractor has submitted a new pile and driving equipment data form. The Contractor will be notified of the acceptance of a proposed change in driving equipment within 3 work days of receipt of the pile and driving equipment data form. If the Engineer determines the Contractor's hammer is not functioning properly and is unable to drive the piles to the required penetration depth or nominal driving resistance, the hammer shall be removed from service.

1. Wave Equation Analysis Method

For the pile driving equipment to be acceptable, the driving stresses predicted by the wave equation analysis shall not exceed the values where pile damage impends. These limiting values shall be calculated as follows:

a. The maximum compressive and tensile driving stresses for steel piles = $0.9F_y$.

b. The maximum compressive driving stress for prestressed concrete piles = $(0.85f'_c - f_{pe})$, where f_{pe} is the effective prestress value.

c. The maximum tensile driving stress, psi (MPa), for prestressed concrete piles = $3\sqrt{f'_c} + f_{pe}$, where f'_c and f_{pe} are expressed in psi

$0.25\sqrt{f'_c} + f_{pe}$, where f'_c and f_{pe} are expressed in MPa.

d. The effective prestress, f_{pe}, shall be obtained from the approved working drawings.

e. The maximum driving stress, psi (kPa) for timber piles shall not exceed $3F_{co}$, where F_{co} is the base resistance of wood in compression parallel to the grain, in psi (kPa).

2. Alternate Method

If the alternate method is used, the energy of the pile driving equipment shall be rated by the manufacturer at or above the appropriate minimum manufacturer's rated hammer energy for the corresponding nominal driving resistance as shown in the table below. The table below will be used as the basis of approval of pile driving equipment for the alternate method.

ALTERNATE METHOD
MINIMUM PILE HAMMER REQUIREMENTS

Nominal Driving Resistance		Minimum Manufacturer's Rated Energy	
tons	(kilonewtons)	ft·lbs	(joules)
≤ 90	(≤ 800)	12,000	(16,500)
91 - 150	(801 – 1,340)	21,000	(28,500)
151 - 210	(1,341 – 1,870)	26,750	(36,500)
211 - 270	(1,871 – 2,400)	37,600	(51,000)
271 - 300	(2,401 – 2,670)	42,000	(57,000)
> 300	(> 2,670)	Wave Equation Analysis required	

The minimum rated energies do not account for losses and inefficiencies in the pile driving system. If the hammer selected cannot satisfy the minimum criteria in the above table, a wave equation analysis shall be submitted by the Contractor for approval.

(b) Pile Hammers

Piles may be driven with air, steam, diesel, or hydraulic hammers. Gravity hammers, vibratory hammers, and other pile driving methods shall be used only if specified or approved in writing by the Engineer.

1. Gravity Hammers

Gravity or drop hammers shall be used to drive timber piles only. The ram shall have a weight (mass) of between 2,000 and 3,500 lbs (900 and 1,590 kg). The height of drop shall not exceed 12 ft (3.6 m). The weight (mass) of gravity hammers shall not be less than the combined weight (mass) of the helmet and pile. All gravity hammers shall be equipped with hammer guides and helmet to ensure concentric impact on the drive head.

2. Single or Double Acting Steam and Air Hammers

The plant and equipment furnished for steam and air hammers shall have sufficient capacity to maintain, under working conditions, the volume and pressure specified by the manufacturer of the hammer. The hose connecting the air compressor to the hammer shall be at least the minimum size recommended by the manufacturer. The plant and equipment shall be equipped with accurate chamber pressure gauges which are easily accessible to the Engineer. If wave equation analysis is not used for pre-approval, the weight of the striking parts of air and steam hammers shall not be less than 1/3 the combined weights of the drive head and pile being driven. The striking parts shall not weigh less than 2,800 lbs (1,270 kg). Proximity switches and an electronic readout device shall be provided prior to driving piling.

3. Diesel Hammers

Open-end or single acting diesel hammers shall be equipped with a device such as graduated rings or grooves on the ram to permit the Engineer to visually determine hammer stroke at all times during pile driving operations. The Contractor shall provide the Engineer a chart from the hammer manufacturer equating stroke, blows per minute, and potential energy for the approved open-end diesel hammer. The Contractor shall also provide and maintain in working order an approved device that automatically measures and displays the ram stroke for open-end diesel hammers.

Closed-end double acting diesel hammers shall be equipped with an accurate bounce chamber pressure gauge, easily accessible to the Engineer. The Contractor shall provide the Engineer a calibrated chart equating bounce chamber pressure to either equivalent energy or stroke for the closed-end diesel hammer to be used. Calibration of actual hammer performance shall be performed no more than 90 days prior to the beginning of the work.

4. Hydraulic Hammers

The power plant furnished for hydraulic hammers shall have sufficient capacity to maintain at the hammer, under working conditions, the volume and pressure specified by the manufacturer of the hammer. Hydraulic hammers shall also be equipped with a controlled variable stroke system and a readout device to measure ram energy. The plant and equipment shall be equipped with accurate pressure and velocity gauges and an energy readout device which are easily accessible to the Engineer.

5. Vibratory Hammers

Except for pile lengths which have been evaluated from load test piles, the nominal driving resistance of the piles driven with vibratory hammers shall be verified by redriving the 1st pile driven in each group of 10 or fewer piles with an impact hammer of suitable energy to measure the nominal driving resistance before driving the remaining piles in the group. All piles which rely on point bearing capacity shall be redriven with an impact hammer.

(c) Pile Driving Aids

Pile driving aids such as jets and followers, shall not be used unless specified or approved in writing by the Engineer. If specified or approved, pile driving aids shall be used for installing production piles only after the minimum pile tip elevation is established by means of load testing or indicator test piles conventionally driven in accordance with 701.05. The Contractor shall perform all extra load tests or extra work required to drive indicator test piles as determined by the Engineer.

1. Hammer Cushion

All impact pile driving equipment, except gravity hammers, shall be equipped with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to ensure uniform driving behavior. Impact hammers designed

such that a hammer cushion is not required are excluded from this requirement. Hammer cushions shall be made of durable, manufactured materials, provided in accordance with the hammer manufacturer's guidelines. Wood, wire rope, or asbestos hammer cushions shall not be used. A striker plate, as recommended by the hammer manufacturer, shall be placed on the hammer cushion to ensure uniform compression of the cushion material. The condition of the hammer cushion shall be checked with the Engineer when beginning pile driving at each structure or after each 100 h of pile driving, whichever is less. A hammer cushion whose thickness has been reduced to less than 75% of the original thickness shall be replaced.

2. Helmet

Piles driven with impact hammers shall have an adequate helmet that adequately distributes the hammer blow uniformly and concentrically to the pile head. The helmet shall be axially aligned with the hammer and the pile shall be guided by the leads and not be free-swinging. The helmet shall fit around the pile head and prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

For steel and timber piling, the pile heads shall be cut squarely. For timber piles, the least inside helmet horizontal dimension or hammer base horizontal dimension shall not exceed the pile head diameter by more than 2 in. (50 mm). If the timber pile diameter slightly exceeds the least helmet or hammer base dimension, the pile head shall be trimmed to fit the helmet.

A helmet as recommended by the manufacturer shall be provided to hold the axis of the pile in line with the axis of the hammer. The pile head shall be plane and perpendicular to the longitudinal axis of the pile to prevent eccentric impacts from the drive head.

3. Pile Cushion

The heads of concrete piles shall each be protected with a pile cushion made of plywood, hardwood, or composite plywood and hardwood materials. The use of manufactured pile cushion materials shall be by the hammer manufacturer's recommendation. The pile cushion dimensions shall equal or exceed the cross sectional area of the pile top, and shall be sized to fit the dimensions of the pile cap. The minimum pile cushion thickness placed on the pile head prior to driving shall be either as recommended by wave equation analysis or not less than 4 in. (100 mm) if the dynamic formula is used. A new pile cushion shall be provided for each pile. The pile cushion shall be replaced if, during the driving of the pile, the cushion is either compressed more than 1/2 the original thickness or begins to smolder or burn. Pile cushions shall be protected from weather and kept dry prior to use. Pile cushions shall not be soaked in liquid unless approved by the Engineer.

A used pile cushion in acceptable condition shall be used for restrike tests. The used pile cushion shall be the same pile cushion from the end of initial driving on that pile unless the condition of that pile cushion is no longer within specification

limits. If the original pile cushion is not within specification limits, a used cushion of similar thickness as the end of drive pile cushion shall be used.

4. Leads

Piles shall be supported in line and position with leads while being driven. Pile driver leads shall be constructed in a manner that affords freedom of movement of the hammer while maintaining alignment of the hammer and the pile to ensure concentric impact for each blow. Leads may be either fixed or swinging type. Swinging leads, when used, shall be fitted with a pile gate at the bottom of the leads. The leads shall be adequately embedded in the ground, or the pile shall be constrained in a structural frame such as a template to maintain alignment. The leads shall be of sufficient length to make the use of a follower unnecessary, and shall be designed as to permit proper alignment of battered piles.

5. Followers

Followers shall only be used if specified or approved in writing by the Engineer. If a follower is permitted, the 1st pile in each bent and every 10th pile driven thereafter shall be driven full length without a follower, to verify that adequate pile length is being attained to develop the nominal driving resistance. The follower and pile shall be held and maintained in equal and proper alignment during driving. The follower shall be of such material and dimensions to permit the piles to be driven to the required penetration depth determined necessary from the driving of the full length piles.

The final position and alignment of the 1st 2 piles installed with followers in each substructure unit shall not exceed more than 3 in. (75 mm) from the locations shown on the plans before additional piles are installed.

6. Jets

Jetting shall only be permitted if specified or approved in writing by the Engineer. The Contractor shall determine the number of jets and the volume and pressure of water at the jet nozzles necessary to freely erode the material adjacent to the pile without affecting the lateral stability of the final in-place pile. The Contractor shall be responsible for all damage to the site caused by unapproved or improper jetting operations. If jetting is specified, the jetting plant shall have sufficient capacity to permit installation to the required elevation, location, and alignment in accordance with 701.09(b). Unless otherwise directed, external jet pipes shall be removed once the pile tip is 5 ft (1.5 m) above the prescribed tip elevation, depending on soil conditions. The pile shall then be driven to the nominal driving resistance with an impact hammer. The Contractor shall provide suitable sediment control measures for jet water in accordance with the specifications. Where practical, all piles in a pile group shall be jetted to the required penetration depth before beginning pile driving. Where large pile groups or pile spacing and batter make this impractical, restrike tests on a select number of previously driven piles shall be performed to check nominal driving resistance after jetting operations are completed.

Upon completion of driving a jetted pile, all voids around the pile shall be filled with B borrow and saturated with water.

7. Collars

Where timber piles are used, collars, bands, or other devices shall be provided to protect piles against splitting and brooming.

8. Pile Shoes, End Plates, and Conical Pile Tips

Pile shoes shall be used when specified. End plates or conical pile tips shall be used on pipe piles. Steel pile shoes shall be used on H piles if specified.

If shoes are required on timber piles, the tips of timber piles shall conform to the approved steel shoes to ensure a firm uniform contact and prevent local stresses concentrations in the timber.

701.05 Nominal Driving Resistance of a Driven Pile

The Engineer will use one of the following methods as specified to determine the nominal driving resistance of a driven pile.

(a) Dynamic Formula

The nominal driving resistance will be determined by means of a dynamic formula. Piles shall be driven to the penetration depth necessary to obtain the nominal driving resistance. The nominal driving resistance, as shown on the plans, can be calculated from the formula as follows:

English: $R_{ndr} = 1.75\sqrt{E} \times (\log 10N) - 100$

Metric: $R_{ndr} = 6.7\sqrt{E} \times (\log 10N) - 445$

where:

R_{ndr} = nominal driving resistance in kips (kilonewtons)

E = manufacturer's rated energy in foot·pounds (joules) at the field observed ram stroke and not reduced for efficiency

log 10N = logarithm to the base 10 of the quantity 10 multiplied by N, where N is the number of hammer blows per 1 in. (25 mm) at final penetration.

An indicator test pile shall be the 1st pile driven at each bent and pier and shall be driven to the plan tip elevation or to the nominal driving resistance whichever occurs 1st. All indicator test piles shall be driven with impact hammers unless otherwise directed. The length of indicator test piles shall be greater than the estimated length of production piles in order to provide for variation in soil conditions. Precast concrete and treated timber test piles shall be a minimum of 10 ft

(3 m) longer than the estimated length of piling shown on the plans. Steel piles shall be provided such that additional 10 ft (3 m) of driving will not require an additional splice.

The driving equipment used for driving indicator test piles shall be identical to that proposed for use on the production piling and shall be subject to approval. The Contractor shall excavate the ground at each indicator test pile location to the elevation of the bottom of the footing before the pile is driven, unless otherwise shown on the plans.

To assess the effects of relaxation and setup, each indicator test pile shall be restruck after number of hours specified unless otherwise approved. The hammer shall be warmed up before driving begins by applying at least 20 blows to another fixed object. The maximum amount of penetration required during restrike shall be 3 in. (75 mm), or the total number of hammer blows shall be 20, whichever occurs 1st. If the indicator test pile does attain the nominal driving resistance upon restriking, the penetration resistance attained during initial driving shall be used to establish the adequacy of production piles. If the nominal driving resistance is not attained upon restriking, the Contractor shall redrive the indicator test pile until it achieves the nominal driving resistance and repeat the restrike procedure described above. If the nominal driving resistance is still not obtained, pile driving shall stop immediately and the Office of Geotechnical Services shall be notified.

A record of driving indicator test piles, which includes the number of hammer blows per 1 ft (0.3 m) for the entire driven length, the as-driven length, cutoff elevation, penetration, and all other pertinent information will be kept by the Engineer. The penetration resistance at various hammer strokes versus nominal driving resistance relationship will be determined based on the driving of representative indicator test piles.

If indicator piles are not shown on the plans, all piles shall be driven to the nominal driving resistance and restriking is not required.

(b) Dynamic Pile Load Test

Dynamic monitoring will be performed for the purpose of obtaining the nominal driving resistance, pile driving stresses, pile integrity, and pile driving system performance. Dynamic monitoring will be conducted by PDA in accordance with ASTM D 4945. PDA will be performed on the 1st pile driven. The length of the pile used in the dynamic pile load test shall be a minimum of 10 ft (3 m) greater than the estimated length of production piles in order to provide for variation in soil conditions. The Contractor shall assist the Department in obtaining dynamic measurements with the PDA during initial pile driving and during pile restrikes. If a static load test is required, the dynamic pile load test shall be performed on the same pile as the pile used in the static load test. The restrike for the dynamic pile load test on a static load test pile shall be performed within 48 h of completion of the static

load test. If the contract is a local public agency contract, the Contractor shall perform the pile driving analysis in accordance with ASTM D 4945.

1. Scheduling

The Contractor shall notify the Engineer at least 7 calendar days before the scheduled date of driving piles to be monitored by PDA. The Contractor shall confirm the driving date 3 calendar days prior to the scheduled driving date. The Contractor shall indicate at which foundation production pile driving is to begin. The Engineer will provide final driving criteria for the indicated foundation 1st.

2. Dynamic Monitoring

The Contractor shall make the steel piles available so that the Engineer can predrill the required instrument attachment holes prior to the Contractor placing the pile in the leads. Each pile to be tested shall be instrumented with force and acceleration transducers provided by the Department. The Contractor shall install the transducers before striking the pile. The pile driving may have to be temporarily interrupted for the transducers to be adjusted or replaced, or for the monitoring results assessed.

Prior to placement in the leads, the Contractor shall make each designated concrete or timber pile available for taking of wave speed measurements and for predrilling the required instrument attachment holes. When wave speed measurements are made, the piling shall be in a horizontal position and not in contact with other piling. Predriving wave speed measurements will not be required for steel piles. The Contractor shall mount the instruments near the head of the pile after the pile is placed in the leads.

The Contractor shall drive the test pile to the minimum tip elevation and to the penetration depth at which the dynamic test equipment indicates that the nominal driving resistance shown on the plans and in accordance with 701.04(a) has been achieved. The Contractor may reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer in order to maintain stresses below the values shown in 701.04(a)1. If non-axial driving is indicated by the dynamic test equipment measurements, the Contractor shall immediately realign the hammer system. Upon determination by the Engineer that valid data have been secured, the Contractor shall assist the Engineer with the removal of the instrumentation from the pile.

3. Restrike

The Contractor shall wait the specified minimum time period prior to the restriking of a dynamic load test pile. The Contractor shall assist the Engineer with reattachment of dynamic test instruments. The hammer shall be warmed up before restriking begins by applying at least 20 blows to another pile or other fixed object. The maximum amount of penetration required during restrike will be 3 in. (75 mm), or the total number of hammer blows will be 20, whichever occurs first. If the pile does not achieve the required nominal driving resistance during restrike, the

Engineer will either accept the tip elevation or specify additional pile penetration and testing.

Once the restrike test for the test pile is complete, the Engineer will run CAPWAP analyses and will provide the final driving criteria within 2 business days of the restrike test. Production piles driven prior to receipt of the final driving criteria shall be done at the Contractor's risk. Final driving criteria for additional structures will be provided within 2 business days of the restrike test or, when multiple test piles are restruck the same day, at a rate of 1 substructure location per business day in the order requested by the Contractor.

(c) Static Load Test

A static load test shall be conducted on a non-production test pile at the location shown on the plans. The test pile axial deflection in compression shall be verified by performing actual loading tests of the designated static load test pile in accordance with ASTM D 1143, Quick Load Test Method, with loads applied by hydraulic jack. The test shall be continued until either plunging failure is achieved or the capacity of the loading system is reached. The nominal pile resistance will be determined from the settlement versus load curve generated by the incremental loading in accordance with 701.05(c)1.

The top elevation of all test piles shall be determined immediately after driving and again just before load testing to check for heave. A pile which heaves more than 1/4 in. (6 mm) shall be redriven, or jacked, to the original elevation prior to testing. The Contractor shall wait 36 h between the driving of a load test pile and the commencement of the load testing unless otherwise specified.

The Contractor shall provide complete protection at all times for the pile, supports, and reference beam from wind, direct sunlight, frost action, or other disturbances. The Contractor shall maintain an air temperature in the immediate vicinity of the test pile and reference beam of not less than 50°F (10°C) and shall provide adequate lighting for the duration of the test.

No production piles shall be driven until completion of the static pile load test unless approved by the Engineer. Reaction piles shall be driven prior to driving the static load test pile.

1. Load Test Procedure

The Contractor shall furnish and construct a suitable reaction frame or load platform to provide a load on the pile having a capacity of 2,000 kips (8,900 kN) or 150% of the nominal driving resistance, whichever is less. A minimum of 7 days prior to driving the static load test pile or construction of the reaction frame or load platform, the Contractor shall submit, for review and approval, detailed working drawings to scale for the reaction frame or load platform and loading apparatus including the distances between the load test pile and all reaction piles and reference beam supports. The submittal shall also include a proposed load test and reaction pile

driving sequence, a scaled profile drawing of the loading apparatus detailing the ground surface elevation, the pile cutoff elevation, and the dimensions and locations of all bearing plates, the jack, the load cell, the spherical bearing plate, and the reaction beam or platform. Working drawings for the reaction frame and loading apparatus shall be submitted in accordance with 105.02. The submittal shall include calibration certifications for the hydraulic jacks, load cell, pressure gauges, and hydraulic pumps conducted within 30 days of the load test. If required by the Engineer, the jack, load cell, and pressure gauge shall be recalibrated after the load test. The loading apparatus shall be constructed to allow the various increments of the load to be placed gradually, without causing vibration to the test pile. If the approved method requires the use of tension or reaction piles, the reaction piles, if feasible, shall be of the same type and dimensions as the production piles, and when possible shall be driven in the location of permanent piles. Reaction piles that are the same type and dimensions as the production piles and are driven in the location of permanent piles will be considered permanent piles. Timber or tapered piles installed in permanent locations shall not be used as tension piles. The primary method of determining the applied load shall be from a calibrated load cell. Incremental loads of 5% of the nominal driving resistance shall be placed on the pile at 5 min intervals until continuous jacking is required to maintain the incremental load or the capacity of the load frame is reached. Support for the load test plates, jack, and ancillary devices shall be provided to prevent them from falling in the event of a release of load due to hydraulic failure, test pile failure, or other cause.

The Contractor shall furnish the hydraulic pump, load cell, spherical bearing plate, and 2 reference beams. Each reference beam shall be a W or M section, of minimum length of 20 ft (6 m), and a weight (mass) of 5 to 20 lb/ft (7.5 to 30 kg/m) unless otherwise approved. The Engineer will conduct the static load test and will provide the gauges to measure movement of the test pile. The Contractor shall provide all assistance necessary to perform the static load test. The Contractor shall furnish and install telltale rods encased in a lubricated pipe in the test pile prior to the static load test.

If the nominal pile resistance of a pile from the load settlement curve does not equal or exceed the nominal driving resistance shown on the plans, the Contractor shall redrive the pile to an adequate nominal driving resistance. The increase in nominal driving resistance will be determined by PDA. The pile shall be load tested again after the appropriate waiting period. Load tests shall be repeated as many times as necessary until the pile carries the required load. The pile axial resistance will be determined from the test data in accordance with the Davisson Method as specified in the AASHTO LRFD Bridge Design Specifications.

2. Hydraulic Jacks, Pressure Gauges, and Load Cell

Hydraulic jacks and pressure gauges shall be used for the superimposed load. The jacks, pressure gauges, load cell, and hydraulic pumps shall be calibrated with each other within the last 30 days by an independent laboratory. When a jack, pressure gauge, load cell, and hydraulic pump are calibrated, they shall be calibrated

and used as a unit. All calibration checks shall be within 5% of the applied load if calibrated as a unit. Changing 1 of the 4 components shall require recalibration prior to use. Pressure gauges shall be a minimum of 4 1/2 in. (114 mm) in diameter with gradations in accordance with ASTM D1143. Hydraulic jacks shall have a nominal load capacity exceeding the maximum anticipated jack load by at least 20%. The jack, pump, and any hoses, pipes, fittings, gauges, or transducers used shall be rated to a safe pressure corresponding to the nominal jack capacity. The Contractor shall provide copies of the most recent calibration certification a minimum of 5 days prior to the static load test.

3. General Requirements

On completion of the static load test, a test pile or anchor pile which is not a part of the finished structure shall be removed or cut off at least 1 ft (0.3 m) below either the bottom of footing or the finished ground elevation if not located within the footing area.

701.06 Blank

701.07 Piling Length

The lengths of piles shown on the plans and in the Schedule of Pay Items are estimated lengths and are for bidding purposes only. The Contractor shall provide the actual length of piles necessary to obtain the nominal driving resistance and penetration depth required as determined from results obtained from driving representative test piles or other pertinent data. There will be expected variations in final tip elevations due to differences in nominal pile driving resistance. The final tip elevation of each pile will be determined during the driving operation. If minimum tip elevations are specified, the Contractor shall drive piles to a penetration depth that satisfies this requirement in addition to the nominal driving resistance. If no penetration depth or minimum tip elevation is specified, the pile shall be driven a minimum of 10 ft (3 m) below the bottom of the footing elevation. The Contractor shall also furnish satisfactory evidence as to the identification, such as heat numbers for steel piles, of all portions of a built-up pile.

The limits of the epoxy coated steel pipe portion of the pile, and the limits of the reinforced concrete shall be as shown on the plans.

701.08 Nominal Driving Resistance of Production Piles

Production piles shall be driven the depth necessary to obtain the required nominal driving resistance as determined by 701.05. If a minimum pile tip elevation is shown on the plans, in addition to obtaining the required nominal driving resistance, production piles shall also be driven to the minimum pile tip elevation or to practical refusal.

When the nominal driving resistance is determined in accordance with 701.05(a), for acceptance, the Engineer will record at a minimum the number of hammer blows per inch or per foot of pile movement for the last 24 in. (600 mm) of

driving. When the nominal driving resistance is determined in accordance with 701.05(b), for acceptance, the Engineer will record the blow count per inch or foot of pile movement and the associated hammer stroke for the last 2 consecutive feet (0.6 m) of driving, and the final pile tip elevation as per the pile driving criteria established through the dynamic pile load test.

Practical refusal will be defined as 20 blows per inch (25 mm) of penetration with the hammer operated at its maximum fuel or energy setting, or at a reduced fuel or energy setting recommended by the Engineer based on pile installation stress control and less than 1/4 in. (6 mm) rebound per blow. The Contractor shall stop driving as soon as the Engineer determines that the pile has reached practical refusal.

The nominal driving resistance of jetted piles shall be based on impact driving penetration resistance after the jet pipes have been removed. Jetted piles not attaining the nominal driving resistance at the ordered length shall be spliced and driven with an impact hammer until the nominal driving resistance is achieved in accordance with the driving criteria in 701.05.

The required nominal driving resistance of piles driven with followers will only be considered acceptable if the piles with followers attain the same tip elevation as the full length piles driven without followers, installed in accordance with 701.04(c)5.

The required nominal driving resistance of piles driven with vibratory hammers shall be based on the driving resistance recorded during impact driving after the vibratory equipment has been removed from the 1st pile in each group of 10 piles. Vibrated piles not attaining the nominal driving resistance at the ordered length shall be spliced and driven with an impact hammer until the nominal driving resistance is achieved in accordance with the driving criteria in 701.05. Once the nominal driving resistance is attained, the remaining 9 piles in the group shall be installed to similar penetration depths with similar vibratory hammer power consumption and rate of penetration as the 1st pile.

701.09 Preparation and Driving

For steel and timber piling, the pile heads shall be plane and perpendicular to the longitudinal axis of the pile before the helmet is attached. The pile heads shall be protected with a hammer cushion.

Precast concrete pile heads shall be flat, smooth, and perpendicular to the longitudinal axis of the pile. Prestressing strands shall be cut off below the surface of the end of the pile. The pile head shall be chamfered on all sides. The heads of all concrete piles shall be protected with a pile cushion.

Approval of a pile hammer relative to driving stress damage will not relieve the Contractor of responsibility for piles damaged due to misalignment of the leads, failure of hammer cushion or cushion material, failure of splices, malfunctioning of

the pile hammer, improper construction methods, etc. Piles damaged for such reasons will be rejected and shall be replaced if the Engineer determines that the damage impairs the strength of the pile.

(a) Pilot Holes

Pilot holes are prebored, predrilled, or cored. After a pile is driven thru a pilot hole, all voids around the pile shall be filled with B borrow. Water shall be added to the hole to saturate the final placement of B borrow.

If the Engineer determines that preboring or predrilling has disturbed the nominal driving resistance of previously installed piles, those piles that have been disturbed shall be restored by means of redriving or other approved remedial measures. Redriving or other remedial measures shall be instituted after the preboring or predrilling operations in the area have been completed.

1. Preboring

When shown in the plans, the Contractor shall prebore holes at the locations shown and to the depth specified. Prebored holes shall be 2 in. smaller than the diameter or diagonal of the pile cross section that is sufficient to allow penetration of the pile to the specified penetration depth. If subsurface obstructions, such as boulders or rock layers, are encountered, the hole diameter may be increased to the least dimension which is adequate for pile installation.

Augering, wet-rotary drilling, spudding, or other methods of preboring shall be used only when specified or approved in writing by the Engineer. The procedures shall be carried out so as not to impair the nominal driving resistance of the piles already in place or the safety of existing adjacent structures.

Except for end bearing piles, preboring shall be stopped at least 5 ft (1.5 m) above the pile tip elevation shown on the plans. The pile shall be driven with an impact hammer to the specified penetration resistance. Where piles are to be end-bearing on rock or hardpan, preboring may be carried to the surface of the rock or hardpan. The piles shall then be driven with an impact hammer to ensure proper seating.

2. Predrilling

The hole shall have a minimum diameter of not less than the greatest dimension of the pile cross section plus 4 in. (100 mm). The holes shall be drilled to the elevations shown on the plans.

Before driving piles for end bents, holes to receive piling shall be predrilled or spudded through new embankment to the original ground elevation if the new embankment is 10 ft (3 m) or more in height. If the new embankment is less than 10 ft (3 m) in height, predrilling is not required. If new embankment in the area of the end bents is to be constructed of sand, gravel, or other permeable material in

which a predrilled hole would not remain open, the piling shall be driven before the embankment is constructed.

Pilot holes for end bent piles for structures with integral end bents shall be predrilled to the depth specified in the plans, regardless of the height of new embankment.

If pile sleeves are shown on the plans, the drilled holes shall be sleeved to maintain the opening during the driving of the piles.

If bentonite grout is shown on the plans, it shall be used to fill the annular space around the pile. The grout shall be placed at the depths shown on the plans or as directed. The entire annular space shall be filled from the bottom upwards to the top of the pile in 1 pumping operation using a tremie pipe.

Tremie-pipe construction shall include side discharge ports. The tremie pipe can be terminated by means of a tee connection. Tremie-pipe may be polyvinyl chloride, however, joints shall not be glued or cemented.

3. Cored Hole in Rock

When specified, holes shall be cored into rock to accommodate pile placement. The approach grade shall be completed before coring is begun. Holes of the diameter shown on the plans shall then be predrilled through the embankment into solid rock to the elevations shown on the plans or as otherwise directed. The piles shall be driven to practical refusal at the bottom of the cored holes. The holes in cored rock shall then be filled with concrete.

(b) Location and Alignment Tolerance

A maximum deviation of 1 1/2 in. (38 mm) in any direction from the plan position will be permissible in pile trestle bents and exposed pile bents. A maximum deviation of 6 in. (150 mm) in any direction will be permitted for a foundation pile in footings for piers or abutments. The tendency of concrete or steel piles to twist or rotate shall be prevented and corrected. Piles to be swaybraced shall be aligned as necessary so that the swaybracing may be properly welded to the piles by a welder qualified in accordance with 711.32. No pile shall be closer than 4 in. (100 mm) from an edge of the pile cap. Pulling laterally on installed piles to correct misalignment, or splicing a properly aligned section on a misaligned section shall not be done unless approved by the Engineer. The pile head at cutoff elevation shall be within 2 in. (50 mm) of plan elevation for bent caps supported by piles.

Piles driven at integral end bents shall be installed so that the axial alignment of the top 10 ft (3 m) of the pile is within 2% of the specified alignment.

Battered piles shall be installed so that the alignment of the top 10 ft (3 m) of the pile does not vary by more than 3% from the batter rate shown in the plans.

If the location or alignment tolerances are exceeded, the extent of overloading shall be investigated. If the Engineer determines that corrective measures are necessary, such corrective measures shall be designed and constructed by the Contractor. Proposed corrective measures will be subject to approval by the Engineer.

(c) Heaved Piles

The Contractor shall take an elevation reading on each pile in a foundation immediately after each pile in that foundation has been driven and again after all piles in that foundation have been driven. Elevation readings for checking pile heave shall continue until the Engineer determines that such checking is no longer required. All piles which have heaved more than 1/4 in. (6 mm) shall be redriven to the required resistance or penetration. If pile heave is detected for pipe piles, the piles shall be redriven to original position prior to filling with concrete. A hammer-pile cushion system shall be submitted and approved prior to redriving pipe piles which have been filled with concrete.

(d) Installation Sequence

The order of placing individual piles within a pile group shall begin from the center of the group and proceed outward in both directions unless an alternate installation sequence is approved in writing. For a bent with a single row of piles, pile driving shall begin at one end of the bent and proceed toward the opposite end.

(e) Inspection

The Engineer shall be given a minimum of 24 h notice before driving piling. No pile shall be driven except in the presence of the Engineer.

Prior to placing concrete in driven pipe piles, the Contractor shall supply suitable lighting for the inspection of each pipe pile by the Engineer throughout its entire length.

(f) Pouring Concrete

After all water and other foreign substances have been removed from the pipe piles and the final approval given, reinforcing bars, if specified, shall be placed, and the pipe piles shall be filled with class A concrete in the presence of the Engineer. Concrete shall be deposited into pipe piles in a stream with a cross-sectional area that is no more than approximately 50% of the area of the pipe pile to prevent air pockets from forming. At a minimum, concrete shall be vibrated in the upper 25 ft (7.5 m) of the pipe piles. Concrete shall not be placed in pipe piles until all pile driving has progressed beyond a radius of 15 ft (4.5 m) from the pile to be filled. All pile driving within the above limits shall be discontinued until the concrete in the last pile cast has cured for a minimum of 48 h.

701.10 Unsatisfactory Piles

The method used in driving piles shall not subject the piles to excessive or undue abuse which produces deformation of the steel, injurious splitting, splintering,

and brooming of the wood, or crushing and spalling of the concrete. All piles damaged during driving due to internal defects, improper driving, being driven out of its proper location, or being driven below the designated cutoff elevation shall be corrected as directed.

Piles which have been bent, or otherwise damaged, during installation shall be considered unsatisfactory unless the nominal driving resistance is proven by load tests performed by the Contractor. If such tests indicate inadequate pile resistance, corrective measures such as the use of the bent piles at reduced pile resistance, installation of additional piles, strengthening of the bent piles, or replacement of the bent piles shall be done as approved by the Engineer.

A concrete pile will be considered defective if a visible crack appears around the entire periphery of the pile or if a defect is observed, as determined by the Engineer.

701.11 Splicing Piles

Full length piles shall be placed in the leads if practical. However, if splicing is necessary, the following methods shall be used.

(a) Steel Piles

Splicing of steel piles shall be made as shown on the plans. The top of the pile to be extended shall be restored to its original cross section shape. The mating end of the other pile shall be beveled as shown on the plans. A wire brush or grinder shall be used to remove any scale, dirt, slag, or other foreign material that is detrimental to fabricating a sound weld from all surfaces to be welded. For H piles, a mechanical splice shall not be used within 20 ft (6 m) of the ground surface unless it is proven that the splice can transfer the full pile strength in compression, tension, and bending. Splices for pipe piles shall be watertight. All work shall be done with approved methods and materials and by welders qualified in accordance with 711.32. If the temperature of the piles is below 50 °F (10 °C), both piles to be spliced shall be preheated to a minimum temperature of 70 °F (21 °C) in the vicinity of the splice immediately prior to welding. The temperature of the piles shall be maintained at a minimum of 50 °F (10 °C) until the welding is complete. There shall not be more than 2 splices exposed to view in each length of piling after driving is completed. A mechanical splice shall not be used in integral end bents.

(b) Timber Piles

Timber piles shall not be spliced.

(c) Concrete Piles

Full length concrete piles shall be used where practical. If splicing is necessary, concrete splice details shall conform to the contract documents. Mechanical splices including drive-fit splices may also be used if the splice can transfer the full pile strength in compression, tension and bending.

701.12 Blank

701.13 Cut-Off Lengths

The tops of all steel pile shall be cut off at the elevation shown on the plans. All unused cut-off lengths shall become the property of the Contractor and shall be removed from the project site.

The length of timber pile above the elevation of cut-off shall be sufficient to permit the complete removal of all material injured by driving. Immediately after making final cut-off on treated timber foundation piles, the cut area shall be given an application of copper napthenate until visible evidence of further copper napthenate penetration has ceased. The copper naphthenate solution shall have minimum 2% copper metal.

Timber piling supporting timber structures where the piles are cut off, but not concrete capped, shall be treated with an application of copper naphthenate as described above. A layer of saturated building felt or fiberglass cloth which overlaps the side of the pile at least 2 in. shall be securely fastened and completely covered with 20 gage thick galvanized metal or aluminum sheeting. All cuts, injuries, and holes, which occur from removal of nails or spikes that penetrate the treating zone as well as bolt holes for connections, shall be treated by applying coal-tar roof cement in accordance with ASTM D 5643.

701.14 Method of Measurement

The driven length of treated timber piles, untreated timber piles, steel pipe piles, steel H piles, and concrete piles will be measured by the linear foot (meter) to the nearest 0.1 ft (0.03 m). This includes piles used as indicator test piles, dynamic test piles, or static load test piles. Measurement will be made only for the actual number of linear feet (meters) of piling complete in place. For concrete piles, this length will not include extensions or the portion of the pile cutoff to make the extension.

Dynamic pile load test, static pile load test, indicator test pile restrike, dynamic test pile restrike, pile shoes, and conical pile tips will be measured per each.

Epoxy coated piles, prebored holes, and cored holes in rock will be measured by the linear foot (meter) complete in place of the diameter specified.

Concrete encasement, class A concrete, reinforcing bars, epoxy coating, reaction piles if not used as production piles, splices, end plates, predrilling, cleaning of drilled holes, drilling fluids, sealing materials, casing, jetting, followers, spudding, or other methods used to facilitating pile driving will not be measured for payment.

701.15 Basis of Payment

All treated timber piles, untreated timber piles, steel pipe piles, steel H piles, and concrete piles driven will be paid for by the linear foot (meter). Payment will be

made only for the actual number of linear feet (meters) of piling complete in place. Extensions for concrete piles will be paid for in accordance with 109.05.

Driven piles used as indicator test piles or dynamic test piles that are left in place and subsequently used as production piles will be paid for by the linear foot (meter) as either production indicator test piles or production dynamic test piles. Reaction piles used in a static pile load test that are left in place and subsequently used as a production pile will be paid for by the linear foot (meter) as the type of production pile they represent. Driven piles used as indicator test piles, dynamic test piles, or static load test piles that are not used as production piles will be paid for by the linear foot (meter) as non-production dynamic, indicator, or static test piles respectively.

If the quantity of driven piling is less than the plan quantity or the quantity as ordered by the Engineer, the Department will pay 50% of the cost to re-stock unused piling if the Contractor elects to re-stock piling and provides a paid invoice showing the re-stocking fee. Payment will be made for piling, restock.

Epoxy coated piles may be furnished and driven at lengths greater than those shown on the plans. These additional lengths of epoxy coated piles left in place and accepted will be paid for as either steel pipe piles or steel H piles.

Prebored holes and cored holes in rock will be paid for at the contract price in linear feet (meters).

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Conical Pile Tip, _____, _____ (pile size, type)	EACH
Cored Hole in Rock, _____ in. (mm) (diameter)	LFT (m)
Dynamic Pile Load Test	EACH
Pile, Concrete _____ x _____ (size)	LFT (m)
Pile, Prestressed Concrete _____ x _____ (size)	LFT (m)
Pile, Steel Pipe, _____, _____ (pipe wall thickness, diameter)	LFT (m)
Pile, Steel Pipe, Epoxy Coated, _____, _____ (pipe wall thickness, diameter)	LFT (m)
Pile, Steel H, Epoxy Coated, HP _____ x _____ (size)	LFT (m)
Pile, Steel H, HP _____ x _____ (size)	LFT (m)

Pile, Steel H, Reinforced Concrete Encased, HP _____ x _____ ..... LFT (m)
size

Pile, Timber ..... LFT (m)

Pile, Timber, Treated ..... LFT (m)

Pile Shoe, _____, _____ ..... EACH
pile size type

Piling, Restock ..... LS

Prebored Hole, _____ in. (mm) ..... LFT (m)
diameter

Static Pile Load Test, _____ ..... EACH
pile size

Test Pile, Dynamic, _____, Non-Production ..... LFT (m)
pile size

Test Pile, Indicator, _____, Non-Production ..... LFT (m)
pile size

Test Pile, Static Load, _____, Non-Production ..... LFT (m)
pile size

Test Pile, Dynamic, Production ..... LFT (m)

Test Pile, Indicator, Production ..... LFT (m)

Test Pile, Dynamic, Restrike ..... EACH

Test Pile, Indicator, Restrike ..... EACH

All costs associated with the dynamic pile load test except the cost of the test pile and test pile restrike shall be included in the cost of the dynamic pile load test.

All costs associated with the static pile load test except the cost of the test pile shall be included in the cost of the static pile load test. The cost of reaction piles used in the static load test and not incorporated into the work as production piles shall be included in the cost of the static load test.

The cost of furnishing and placing concrete, B borrow, or bentonite grout necessary to fill pilot holes, and all necessary incidentals shall be included in the cost of the pay items of this section.

The cost of the following shall be included in the cost of the piling.

(a) predrilling pilot holes;
(b) pile sleeves;
(c) maintaining open holes during pile driving;
(d) broken, bent, damaged, or misplaced piles;
(e) concrete filling or concrete encasement;
(f) corrective location or alignment measures;
(g) epoxy coating;
(h) splicing piles and jetted sites;
(i) modifying or replacing pile driving equipment;
(j) redriving piles which have heaved more than 1/4 in. (6 mm);

(k) plain and epoxy coated reinforcing bars;
(l) repairing epoxy coating;
(m) replacing epoxy coated piling;
(n) restriking production piles not shown as test piles;
(o) piles which are not acceptable or damaged during driving;
(p) piles which were not driven in accordance with these specifications;
(q) piles driven with the tops lower than the cutoff elevation;
(r) spudding or jetting of piles;
(s) end plates for pipe piles; and
(t) all labor, equipment, and necessary incidentals.

No additional payment will be made if the Contractor elects to furnish and drive thicker walled pipe piles than specified.

An increase in the size of a pile cap to satisfy edge distance clearance requirements, when approved, shall be at no additional cost to the Department.

If the method for driving the piles is specified as 701.05(b) and the contract is a local public agency contract, the Contractor shall include the cost of acquiring the PDA consultant in the cost of the Dynamic Pile Load Test.

The cost of mobilization and demobilization for pile driving operations shall be included in the cost of mobilization and demobilization in accordance with 110.04.

The cost to control sediment in water from jetting operations shall be included in the cost of the piling.

SECTION 702 – STRUCTURAL CONCRETE

702.01 Description

This work shall consist of furnishing and placing portland cement concrete for structures and incidental construction in accordance with these specifications and in reasonably close conformance with the lines, grades, and dimensions as shown on the plans or as directed.

702.02 Classes of Concrete

The following classes of concrete shall be used where specified.

Class of Concrete	**A**	**B**	**C**
Cement content in lb/cu yd	564	470	658
(kg/m^3) of concrete	(335)	(279)	(391)
Maximum water/cement ratio in lb (kg) of water per lb (kg) of cement	0.490	0.620	0.443

Unless specified otherwise, the concrete used shall be class A. When class A is specified, class C may be used as a substitution. When class B is specified, class A or class C may be used as a substitution.

Concrete in superstructure, integral bents, and railings shall be class C. Concrete in bent caps, unless poured integrally with the superstructure; pier caps; abutment caps; pier stems; abutment walls; mudwalls; columns; crashwalls; collision walls; and wingwalls, unless poured with integral end bents, shall be class A. Concrete in footings shall be class B.

702.03 Materials

Materials shall be in accordance with the following:

Admixtures for Use in Concrete 912.03
Castings 910.05
Coarse Aggregate
For exposed concrete, Class A or Higher,
Size No. 8 904
For non-exposed concrete, Class B or Higher,
Size No. 8 904
Curing Materials 912.01
Curing-Sealing Materials 912.02
Elastomeric Bearings 915.04
Fabric for Waterproofing 918.01
Fine Aggregate Size No. 23 904
Fly Ash 901.02
Geotextile for Use With Underdrains 918.03
Ground Granulated Blast Furnace Slag 901.03
High Density Bearing Strips 906.08
Permanent Metal Forms 910.03
Polychloropene Joint Membrane and Adhesive ..... 906.02(a)4
Portland Cement ..... 901.01(b)
Utility Asphalt, UA-1 ..... 902.01(d)
Water 913.01

Drainage pipe through concrete masonry shall be in accordance with 715.

Grout material for field drilled holes shall be either a high-strength, non-shrink, non-metallic, cementitious grout in accordance with U.S. Army Corps of Engineers Specification CRD-C 621 or an approved 100% solids chemical anchor system.

702.04 Shipping and Storage

The cement shall be well protected from rain and moisture. All cement damaged by moisture or which fails to meet the specified requirements shall be rejected and removed from the work. Cement stored for a period longer than 60 days shall be

retested before being used on the work. Cement of different brands, types, or from different mills shall be stored separately.

CONSTRUCTION REQUIREMENTS

702.05 Proportioning

The proportion of ingredients of each batch shall be within the following limits, and shall be approved.

The relative yield of the concrete shall be determined in accordance with 505. The concrete when produced shall provide a relative yield of 1.00 ± 0.02. When the relative yield is outside the tolerances, adjustments to the batch weights shall be made. The minimum amount of cement shall be used for the desired class of concrete. The cement content shall not be increased more than 60 lb/cu yd (36 kg/m^3). The relative yield of the concrete shall be maintained as stated above. If type IP or type IP-A cements are to be used in the structural concrete, the cement content shall be increased by a multiplier of 1.06 times the minimum amount of cement required or the desired increased cement content for the specified class of concrete (i.e. 1.06 x 564 = 598 lb/cu yd (1.06 x 335 = 355 kilograms per cubic meter) for class A concrete).

Fly ash from an approved source may be used as a partial replacement for portland cement. The substitution of fly ash for portland cement will not be permitted in conjunction with the use of blended portland cement nor ground granulated blast furnace slag. Mix designs will be based on using a maximum 20% cement reduction with a minimum 1.25:1 ash-to-cement replacement ratio by weight.

Ground granulated blast furnace slag from an approved source may be used as a partial replacement for portland cement. The substitution of ground granulated blast furnace slag for portland cement will not be permitted in conjunction with the use of blended portland cement nor fly ash. Mix designs will be based on using a maximum 30% cement substitution with a 1:1 slag-to-cement ratio, by weight.

Blended portland pozzolan cements, fly ash, and ground granulated blast furnace slag used as a pozzolan may only be used in concrete bridge decks between April 1 and October 15 of the same calendar year.

Fine aggregate shall be no less than 35% nor more than 45% of the total weight of aggregates used, except the limit may be increased to 50% when slag coarse aggregate is used. The aggregates shall be proportioned to use the maximum amount of coarse aggregate which produces a workable mix.

When fly ash or ground granulated blast furnace slag is used, an acceptable concrete mix design shall be submitted. Fly ash or ground granulated blast furnace slag and all other material sources proposed for portland cement concrete mix designs shall be furnished at least 15 days prior to the initiation of work. Prior to use,

it shall be demonstrated by trial batch that the concrete mix design will produce concrete complying with all requirements. A concrete mix design will not be considered approved until this trial batch demonstration is successfully completed, including flexural strength data. The required 550 psi (3,800 kPa) flexural strength shall be obtained at an age consistent with the contract work schedule, but not to exceed 28 days.

Once a mix design has demonstrated for the contract that the concrete mix design with a specific fly ash source or a specific ground granulated blast furnace slag source produces a concrete which is in accordance with the mix design requirements, further trial batch demonstration will be at the Engineer's discretion for this contract and subsequent contracts.

All concrete shall have an air content of 6.5% ± 1.5% by volume. Air content shall be determined in accordance with 505. When fly ash is used, the 1st concrete truck on the contract will be tested by the Department for complete compliance with plastic concrete requirements for air content, slump, and yield. If not in complete compliance, the concrete will be rejected and no further concrete with fly ash in it will be considered on the contract until it is demonstrated by an additional trial batch that the concrete mix design, or modification thereof, complies. All demonstration testing shall be conducted by the Contractor. During the placement of concrete containing fly ash, the air content of the concrete shall be determined to be at least equal to the testing requirements set out in the Department's Manual for Frequency of Sampling and Testing and Basis for Use of Materials. Additional testing may be required, as conditions warrant. All such air content testing of the concrete shall be performed by a certified technician. A certified technician must have successfully completed a concrete course offered by the Department's Human Resources Division, the National Ready Mix Concrete Association, the American Concrete Institute, or approved equal.

Portland cement concrete with fly ash or ground granulated blast furnace slag which does not consistently comply with Department concrete requirements due to the presence of the fly ash or ground granulated blast furnace slag will be grounds for rejection of its further use. In the event of such a rejection of further use, all unsatisfactory work shall be corrected with no additional payment and the contract shall be completed using portland cement without fly ash.

Powdered admixtures shall be measured by weight and paste or liquid admixtures by weight or volume, and all shall be within 3% of the amount required. When admixtures are used in small quantities in proportion to the cement, as is the case for air-entraining admixtures, mechanical dispensing equipment shall be provided.

Class C concrete shall contain either a water-reducing admixture or a water-reducing retarding admixture. The type used shall not be changed during any individual contiguous pour. The type admixture to be used will be selected based on

the expected concrete or air temperature. When either temperature is expected to be 65°F (18°C) or above, a water-reducing retarding admixture shall be used. A water-reducing admixture shall be used when both temperatures are expected to be below 65°F (18°C) unless retardation is required due to the structure design or the proposed pour sequence such as the requirements for floor slab pours set out in 704.04. Air-entraining cements will not be permitted in class C concrete.

The manufacturer's data, which relates recommended addition rates to ambient temperatures, shall be furnished. The proposed addition rates and adjustments to the rates, as conditions require, will be approved using this data and the anticipated temperature. The addition rate shall not be reduced below the minimum rate recommended by the manufacturer, regardless of the concrete or air temperature. The air entraining admixture and water-reducing retarding admixture shall be added to the batch separately. The method and equipment for adding water-reducing retarding admixture will be approved.

If the contract requires stay-in-place metal forms for the bridge deck or if the Contractor elects to use such forms, the bridge deck concrete shall incorporate class AP coarse aggregate instead of class A.

702.06 Batching

Unless otherwise permitted, the minimum batch shall be 2 cu yd (1.5 m^3). Measuring and batching of materials shall be done at a batching plant. Different kinds or sources of coarse aggregate or different brands of cement shall not be used in any unit of the structure except in an emergency and then only by written permission.

(a) Portland Cement

Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed. All bulk cement shall be weighed on an approved weighing device. The bulk cement weighing hopper shall be sealed and vented to preclude dusting during operation. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement does not lodge in it nor leak from it. Accuracy of batching shall be ± 1% of the required weight.

If fly ash is used as a pozzolan in portland cement concrete, the cement and fly ash shall be weighed and discharged separately when a manual operation is utilized. When an automatic batching plant is utilized, the fly ash may be weighed into the cement weigh hopper in 1 cumulative operation with the portland cement always being weighed in first.

(b) Water

Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within 1% of the required amount.

(c) Aggregates

The batch plant site, layout, equipment, and provisions for transporting material shall be such as to assure a continuous supply of reasonably uniform material to the work. Aggregate stockpiles shall be located in areas sufficiently well drained to prevent the dirt underneath from becoming softened and pumping into the aggregate to a level from which the aggregate is to be removed and used in the work. Stockpiles shall be built in layers not to exceed 6 ft (1.8 m) in depth. Upper layers shall be prevented from spilling over the sides of the layers below.

The removal of aggregates from stockpiles shall be done in such a manner that segregation will not occur. Aggregate which has become mixed with dirt shall not be used in the work.

Washed aggregates shall drain for at least 12 h prior to use. An increase in the drainage time may be required, as directed, at any time when the moisture becomes non-uniform in aggregates from any source. Aggregates from different sources shall not be stockpiled together without written approval.

Batching shall be conducted so as to obtain the weights of materials required within a tolerance of ± 2%.

(d) Bins and Scales

The batching plant shall include bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a bin, hopper, and scale for cement shall be included. If fly ash is used, the separation of cement and fly ash bins will be as approved. Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant.

Means of control shall be provided so that as the quantity required in the weighing hopper is approached the material may be added slowly and shut off with precision. A port or other opening for removing an overload from the hopper shall be provided. A port for sampling cement shall be provided and may be either the overload port or a separate port located at any point from the bottom of the storage bin to the weigh hopper. The sampling port shall be located and constructed so as to provide a representative sample of the cement being used. Weighing hoppers shall be constructed so as to eliminate accumulation of tare materials and to discharge fully.

For applied loads of 1,000 lb (4,450 N) and greater on the cement scale and applied loads of 4,000 lb (17,800 N) and greater on the aggregate scale, the scales shall be accurate to 0.5%. For applied loads of less than 1,000 lb (4,450 N) and 4,000 lb (17,800 N) for the cement and aggregate scales, respectively, the scales shall be accurate to 2.0% or 1 graduation, whichever is larger. Poises shall be designed to be locked in any position to prevent unauthorized change of position. Scales will be inspected as often as necessary to ensure their continued accuracy. No less than ten 50 lb (23 kg) weights shall be provided at all times for testing of scales.

Batching plants may be equipped with approved automatic weighing devices to proportion aggregates and bulk cement.

(e) Batching

When batches are hauled to the mixer, bulk cement shall be transported either in waterproof compartments or between the fine and coarse aggregates. When cement is placed in contact with the aggregates, batches may be rejected unless mixed within 1 1/2 h of such contact. Sacked cement may be transported on top of the aggregates.

Batches shall be delivered to the mixer separate and intact. Each batch shall be dumped cleanly into the mixer without loss and, when more than 1 batch is carried on the truck, without spillage of material from 1 batch compartment into another.

702.07 Mixing

Concrete may be mixed at the site of construction, at a central point, or wholly or in part in truck mixers. Retempering concrete by adding water or by other means will not be permitted after initial set. When concrete is delivered in transit mixers, additional water may be added occasionally to increase the slump, if permitted, and additional mixing shall be performed as directed and all operations completed within the time limits in accordance with 702.09(c). The amount of water added shall be determined accurately and noted on the batch ticket. Such addition of water will not be permitted as a continuing operation. The total of all water included in the mix shall not exceed the maximum in accordance with 702.02. Concrete that is not within the specified slump limits at time of placement shall not be used. Except as required in 702.05 for class C concrete, a water reducing admixture, type A, or a water reducing and retarding admixture, type D, may be used in the concrete. Chemical admixtures type B, type C, and type E will be permitted only with prior written permission.

702.08 Mixing at Site of Work

For concrete to be acceptable, not more than 1 h shall elapse from the time mixing water has entered the mixer until the mixed batch is deposited into the forms.

The concrete shall be mixed in an approved batch mixer which has a rated capacity of not less than 188 lb (85 kg) except for pours of 20 cu yd (15 m^3) or less, or where otherwise specifically permitted, a 94 lb (43 kg) minimum capacity mixer may be used. Mixers shall ensure a uniform distribution of ingredients throughout the mass. No mixer shall be operated beyond its factory rated capacity.

The concrete shall be mixed no less than 60 s after all ingredients, including water, are in the mixer.

During the period of mixing the drum shall rotate at the speed for which it was designed, which shall be no less than 14 nor more than 20 revolutions per minute. If this procedure does not mix the concrete thoroughly, a sufficient additional number

of turn at the same rate shall be made until a thorough mixing of the ingredients is obtained.

The mixer shall be equipped with a batch meter for counting the number of batches discharged and a timer for automatically locking the discharge chute to prevent emptying the mixer prior to the specified minimum mixing time. Mixers shall be equipped with mechanical means for preventing the addition of ingredients, including water, after mixing is started. The 1st batch shall contain an additional quantity of cement, fine aggregate, and water sufficient to coat the inside surface of the drum in order to avoid diminishing the mortar content of the initial batch. The entire contents of the drum shall be removed before the materials for the next batch are introduced. Upon cessation of mixing for any considerable time, the drum shall be cleaned thoroughly.

Structural concrete shall be mixed only in such quantities as are required for immediate use and shall be placed while fresh before initial set has occurred. Hand mixing will not be permitted except in an emergency and then only with permission. Hand mixing shall be done on a watertight platform in such manner and so continued to ensure a homogeneous mixture of the required consistency. Hand mixed batches shall not exceed 1/2 cu yd (0.4 m^3) in volume.

702.09 Ready-Mixed Concrete

(a) General Requirements

Ready-mixed concrete shall be mixed and delivered by means of one of the following operations:

1. Mixed completely in a stationary mixer and the mixed concrete transported to the point of delivery in a truck-agitator or truck-mixer at agitating speed or in approved non-agitating equipment in accordance with 702.09(d). Concrete delivered under these provisions shall be known as central-mixed concrete.

2. Mixed partially in a stationary mixer and the mixing completed in a truck-mixer. Concrete delivered under these provisions shall be known as shrink-mixed concrete.

3. Mixed completely in a truck-mixer. Concrete delivered under these conditions shall be known as transit-mixed concrete.

The source of ready-mixed concrete shall be approved prior to delivery of the concrete. This approval will be based on the capacity and condition of the equipment, volume of production, and length of haul, with consideration of the use to which the concrete is to be put. Original approval will not constitute continued approval if satisfactory concrete or rate of delivery is not maintained.

Approval may be refused or previous approval may be withdrawn for a truck mixer or for a part of equipment not functioning in such manner as to produce and deliver uniform concrete to the site of the work at a uniform rate.

Before a pour is started, the number of trucks to be assigned to the work, the rate of production, and all other conditions necessary for furnishing satisfactory concrete shall be subject to approval. Such assigned equipment shall be in satisfactory operating condition prior to the start of the pour. Equipment once assigned to a pour shall not be diverted for another purpose without approval.

(b) Mixers and Agitators

Mixers and agitators shall be in accordance with the following:

1. Mixers may be stationary mixers or truck-mixers. Agitators may be truck-mixers or truck-agitators. Each mixer and agitator shall have attached to it in a prominent place a metal plate or plates on which are plainly marked, for the various uses for which the equipment is designed, the capacity of the drum or container in terms of the volume of mixed concrete, the speed of rotation of the mixing drum, and manufacturer's name and address. Stationary mixers shall be equipped with an acceptable timing device which does not permit the batch to be discharged until the specified mixing time has elapsed. Truck-mixers shall be equipped with means by which the number of revolutions of the drum may be verified readily. The counters shall be actuated at the time of starting mixing at mixing speed.

2. The mixer, when loaded to the manufacturer's rated capacity without overload, shall be capable of combining the ingredients of the concrete within the specified time into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity in accordance with requirement 4 of 702.09(b).

3. The agitator, when loaded to the manufacturer's rated capacity without overload, shall be capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity in accordance with requirement 4 of 702.09(b).

4. Slump tests may be made of individual samples taken when discharged at approximately the 1/4 and 3/4 points of each load. If the slumps differ by more than 1 in. (25 mm) when the average slump is 3 in. (75 mm) or less, or by more than 2 in. (50 mm) when the average slump is greater than 3 in. (75 mm), the mixer or

agitator shall not be used until conditions are corrected, except as set out in requirement 5 of 702.09(b).

5. Use of equipment may be permitted when operations with a longer mixing time or with a smaller load will permit the requirements in requirement 4 of 702.09(b) to be met.

6. Mixers and agitators shall be examined daily for changes in conditions due to the accumulations of hardened concrete or mortar or to wear of blades. When such change of conditions is found, the tests described in requirement 4 of 702.09(b) shall be repeated.

(c) Mixing and Delivery

Mixers and agitators shall be operated within the limits of the capacity and speed of rotations designated by the manufacturer. The following shall apply in fulfilling these requirements.

1. The complete mixing time for a stationary mixer shall be no less than 60 s. Mixing time shall be measured from the time all cement and aggregates are in the drum. The batch shall be so charged into the mixer that some of the water enters in advance of the cement and aggregates. All required water shall be in the drum by the end of the 1st quarter of the specified mixing time.

2. If a stationary mixer is used for shrink mixing, the time in the stationary mixer may be reduced to the minimum required to intermingle the ingredients, or approximately 30 s. Mixing shall then be completed in a truck-mixer by no less than 50 nor more than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as mixing speed. Additional mixing, if required, shall be at the speed designated by the manufacturer as agitating speed.

3. If the concrete is mixed in a truck-mixer loaded to its rated capacity, the number of revolutions of the drum or blades at mixing speed shall be no less than 70 nor more than 100, but not less than that recommended by the mixer manufacturer.

4. If a truck-mixer or truck-agitator is used for transporting concrete that has been completely mixed in a stationary mixer, further mixing during transportation shall be at the speed designated by the manufacturer of the equipment as agitating speed.

5. If a truck-mixer or truck-agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and its

discharge completed within 90 min after the introduction of the mixing water to the cement and aggregates, or the introduction of cement to the aggregates, unless a shorter time is otherwise specified. When a truck-mixer is used for the complete mixing of the concrete, the mixing operations shall begin within 30 min after the cement has been added to the aggregates.

6. When authorized, a truck-mixer may be charged with aggregates and water at the batching plant and with bagged cement at the point of delivery, provided the truck-mixer is then operated at mixing speed for the required additional revolutions and satisfactory concrete is produced.

7. For truck-mixers, wash water shall not be used as a portion of the mixing water for succeeding batches.

(d) Non-Agitating Equipment

Central mixed concrete may be transported from the mixing plant to the place of use in non-agitating equipment when and as approved. The following shall apply in fulfilling these requirements.

1. Bodies of non-agitating equipment shall be smooth, watertight, metal containers equipped with gates that permit control of the discharge of the concrete. Covers shall be provided for protection of the concrete when required.

2. The concrete shall be delivered to the site of the work in a thoroughly mixed and uniform mass and discharged with the degree of uniformity in accordance with requirement 3 of 702.09(d). Discharge shall be completed within 30 min after the introduction of the mixing water to the cement and aggregates.

3. Slump tests shall be taken in accordance with requirement 4 of 702.09(b). If the slump differs by more than these tolerances the non-agitating equipment shall not be used until the conditions are corrected in accordance with requirement 4 of 702.09(d).

4. If the requirements of requirement 3 of 702.09(d) are not met when the non-agitating equipment is operated at minimum capacity for the maximum time of haul and with the concrete mixed the minimum time, the equipment may still be used when operated using smaller loads, shorter hauls, or longer mixing times, or combinations thereof, which permits the requirements in requirement 3 of 702.09(d) to be met.

702.10 Pumping Concrete

If the Contractor elects to convey concrete by means of pumping, the concrete shall be handled so as to minimize disturbance to the concrete which significantly alters the properties of the concrete being pumped, especially the loss or variability of the air content. The pumping equipment shall be mechanically sound, suitable in kind, and adequate in capacity for the proposed work. The concrete shall not be pumped through aluminum or aluminum alloy pipe. All pipes used for pumping concrete shall be kept clean and free from coatings of hardened concrete. Pump lines shall not rest directly on epoxy coated reinforcing bars. The pumping equipment shall be located such that operational vibrations will not damage freshly placed concrete.

When placing concrete directly from a truck mounted boom, the concrete pump lines shall have a flexible end section at least 10 ft (3 m) long. Methods of placement shall be such as to result in a steady and continuous discharge. If necessary, this may require the use of a restrictive device at or near the end of the discharge tube, the laying the flexible end section horizontally, or other means. For the initial placement of concrete pours which are predominantly vertical, the discharge end of the flexible end section shall be within 2 ft (0.6 m) of the bottom of the pour.

The Contractor shall submit a description of the pumping procedures which it intends to use, and shall notify the Engineer as to the pumping procedure at least 24 h in advance of concrete placement.

702.11 Cold Weather Concrete

When it is necessary to place concrete at or below an atmospheric temperature of 35°F (2°C), or whenever it is determined that the temperature may fall below 35°F (2°C) within the curing period, the water, aggregates, or both shall be heated and suitable enclosures and heating devices provided. Cold weather concrete shall be placed at the risk of the Contractor and shall be removed and replaced with no additional payment if it becomes frozen or otherwise damaged.

When aggregates or water must be heated, the concrete shall have a temperature of at least 50°F (10°C) and not more than 80°F (27°C) at the time of placing. Heating equipment or methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used. The equipment shall be capable of heating the materials uniformly. Neither aggregates nor water used for mixing shall be heated to a temperature exceeding 150°F (66°C). The maximum temperature of concrete produced with heated aggregates shall be 90°F (32°C). Materials containing frost or lumps of frozen material shall not be used. When either aggregates or water are heated to 100°F (38°C), they shall be combined 1st in the mixer before cement is added.

Stockpiled aggregates may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over fire. However, a drier in accordance with 409.02(a) may be used if approved.

When aggregates are heated in bins, steam-coil or water-coil heating or other methods which are not detrimental to the aggregates may be used. The use of salt or other chemicals to accelerate hardening of the concrete will not be permitted unless approved in writing.

Immediately after a pour is completed, the freshly poured concrete and forms shall be covered so as to form a protective enclosure and the air in the enclosure kept at a temperature above 50°F (10°C) for at least 144 h for bridge decks, the top surface of reinforced concrete slab bridges, and for at least 72 h for all other concrete. If for any reason this temperature is not maintained, the heating period shall be extended. When dry heat is used, means shall be provided to maintain adequate moisture in the air within the enclosure.

All necessary measures shall be taken during protective heating to keep the heating equipment in continuous operation and to ensure maintenance of the proper temperature around the concrete. Adequate fire protection shall be provided where heating is in progress and such protection shall be accessible at all times.

Where practicable, forms insulated with at least 2 in. (50 mm) thick blankets made of fiberglass, rock wool, balsam wool, or similar commercial material capable of maintaining the surface of the concrete at no less than 50°F (10°C) may be used in lieu of other protection of concrete involving housing and heating. When forms are insulated, exposed horizontal surfaces shall be protected with a similar layer of the insulating material fastened securely in place. If the insulated forms do not maintain the proper temperature at the surface of the concrete, auxiliary protection and heat shall be used.

702.12 Consistency

Slump will be measured in accordance with 505 and shall be no less than 1 in. (25 mm) nor more than 4 in. (100 mm) except for concrete placed in foundation seals.

702.13 Forms

(a) Construction

Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations, including vibration. Forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber.

Unless otherwise provided, all forms for exposed surfaces except the undersides of girders, slabs, and arch rings shall be lined with approved plywood, metal, or similar satisfactory composition. The lining shall not be sprung into place. Before concrete is placed, all open joints shall be filled with a satisfactory filler which is impervious to moisture, does not stain or otherwise injure the concrete, and produces

a tight joint. The lining shall present a smooth uniform surface. Lining of sufficient thickness to resist the pressure of the concrete without deflection may be applied directly to the studding if it otherwise complies with the foregoing provisions for form lining.

In designing forms, fresh concrete shall be considered as a liquid weighing 150 lb/cu ft (2,400 kg/m^3) for vertical loads and 100 lb/cu ft (1,600 kg/m^3) for horizontal pressure. A live load allowance of 50 lb/sq ft (2.4 kPa) shall be used on horizontal projections of surfaces. The scheme of formwork for work on a span over active railroad tracks shall provide a horizontal clearance of not less than 8 ft (2.4 m) from the centerline of track and a clearance height of not less than 22 ft (6.7 m) from the top of the track rail.

Spreader blocks and bracing shall be removed from the inside of forms before concrete is placed and a portion of wood shall not be left in the concrete.

Forms for exposed concrete edges shall be chamfered 3/4 in. (19 mm). Forms shall be given a bevel or draft in the case of all projections, such as girders and copings, to ensure easy removal.

(b) Ties

Approved ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 1 in. (25 mm) from the face without injury to the concrete. Ties may be metal or fiberglass. Ties shall be capable of supporting the designed loads. Fiberglass ties shall be ground flush with the face of the concrete surfaces. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in color. Filling of the cavities will not be required between the fascia beams or girders on the underside of decks, the bottom surface of slab decks, or the bottom deck surface of box culverts. In general, tie rods shall be designed to also act as struts or spreaders. The use of wood struts will not be permitted in copings, railings, and walls less than 2 ft (0.6 m) thick. Devices which, when removed, leave an opening entirely through the concrete will not be permitted unless approved in writing. Wire ties shall not be used.

(c) Walls

Where the bottom of the forms is inaccessible, the lower form boards shall be left loose or other provisions made so that extraneous material may be removed from the forms immediately before placing the concrete.

(d) Surface Treatment

All forms shall be treated with a formulated form coating that allows them to be released without adhering, discoloring, or otherwise damaging the concrete.

(e) Metal Forms

1. Removable

The specifications for forms as they regard design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, re-use, and oiling apply to metal forms. The metal used for forms shall be of such thickness that the forms remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins, or other connecting devices shall be designed to hold the forms together rigidly and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease, or other foreign matter.

2. Permanent

Fabricated permanent metal forms for concrete deck slabs may be used as an alternate method of forming on a steel beam, steel girder, prestressed concrete I-beam, prestressed concrete spread box beam, or prestressed concrete bulb-T beam bridge. Permanent metal forms shall not be removed, and shall otherwise be in accordance with the applicable requirements of 702.13(e).

The metal forms shall be designed on the basis of dead load of form, reinforcing bars, and plastic concrete plus 50 lb/sq ft (2.4 kPa) for construction loads. The unit working stress in the steel sheet shall be not more than 0.725 of the specified minimum yield strength of the material furnished but not to exceed 36,000 psi (250 MPa). Deflection under the weight of the forms, the plastic concrete and reinforcing bars shall not exceed 1/180 of the form span or 1/2 in. (13 mm) whichever is less. However, the deflection loading shall not be less than 120 lb/sq ft (5.8 kPa) total. The permissible form camber shall be based on the actual dead load condition. Camber shall not be used to compensate for deflection in excess of the foregoing limits. The design span of the form sheets shall be the clear span of the form plus 2 in. (50 mm) measured parallel to the form flutes. If the design span of the form sheets exceeds 9.5 ft (2.9 m), concrete will not be permitted to be placed in the valleys of the corrugations of the metal forms. Physical design properties shall be computed in accordance with requirements of the American Iron and Steel Institute Specifications for the Design of Cold Formed Steel Structural Members.

All reinforcing bars shall have a minimum clearance of 1 in. (25 mm) from the forms. The plan dimensions from the top surface for all primary deck reinforcing bars shall be maintained. The deck reinforcing bars shall be tied down at a maximum of 6 ft (1.8 m) centers. Permanent metal forms shall not remain in place closer than 1 ft from any joint exposed to the underside of the slab, except when an overlay is used on the deck.

Fabricator's working drawings shall be submitted for approval. These drawings shall indicate the grade of steel and the physical and section properties for all permanent metal bridge deck form sheets. If the bridge is a steel beam or steel girder structure, these drawings shall also include a clear indication of locations where the forms are supported by steel beam flanges subject to tensile stress. The drawings shall be certified by a registered professional engineer prior to submittal.

Form sheets shall not be permitted to rest directly on the top of the beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 1 in. (25 mm) at each end. All attachments shall be made by welds, bolts, clips, or other approved means. Except as amended by these specifications, welding and welds shall be in accordance with the requirements of 711.32 pertaining to fillet welds. However, 1/8 in. (3 mm) fillet welds will be permitted.

Form supports at steel beam or girder bridges shall be placed in direct contact with the top flange of the beam or girder and shall be adjusted to maintain the required deck thickness. If straps are used on the top flanges, the straps shall be No. 8 gage (4.2 mm) thick, fit tight, and shall not be galvanized. Welding of form supports to flanges of non-weldable grades of steel and to steel flanges subject to tensile stresses shall not be permitted.

Form supports at prestressed concrete I-beam and box beam bridges shall be placed in direct contact with the sides of the box or edge of the I-beam flange and shall be adjusted to maintain the required deck thickness. The form supports may be attached to steel inserts cast into the top of the box or I-beam, straps extending across the top of the flange, hangers mechanically attached to reinforcing bars extending from the top flange, or by other approved methods. If straps are used across the top flange, they shall be No. 8 gage (4.2 mm) thick, fit tight, and shall not be galvanized. Welding of attachments directly to beam reinforcement shall not be permitted. In addition, the use of recesses cast into the beam to serve as a form support shall not be permitted.

All permanently exposed form metal, where the galvanized coating has been damaged, shall be thoroughly and satisfactorily cleaned, wire brushed, and painted with 2 coats of zinc oxide-zinc dust primer in accordance with Federal Specification TT-P-641(d), type II, with no color added. Minor heat discoloration in areas of welds need not be touched up.

Concrete shall be placed in accordance with 702.20. Particular emphasis should be placed on proper vibration of the concrete to avoid honeycombs and voids, especially at construction joints, expansion joints, attachment hardware, and valleys and ends of form sheets. Pouring sequences, procedures, and mixes shall be approved.

If it is determined that the procedures used during the placement of the concrete warrant inspection of the underside of the deck, at least 1 section of the forms shall be removed at a location and time selected for each span in the contract. This is to be done as soon after placing the concrete as practical in order to provide visual evidence that the concrete mix and the procedures are obtaining the desired results. An additional section shall be removed if it is determined that there has been any change in the concrete mix or in the procedures warranting additional inspection.

After the deck concrete has been in place for a minimum of 2 days, the concrete shall be tested for soundness and bonding to the forms by sounding with a hammer as directed. If areas of doubtful soundness are disclosed by this procedure, the forms shall be removed from such areas for visual inspection after the pour has attained adequate strength. This removal of the permanent metal bridge deck forms shall be with no additional payment. At locations where sections of the forms are removed, form replacement will not be required, but the adjacent metal forms and supports shall be repaired to present a neat appearance and ensure their satisfactory retention. As soon as the form is removed, the concrete surfaces will be examined for cavities, honeycombs, and other defects. If irregularities are found, and it is determined that these irregularities do not justify rejection of the work, the concrete shall be repaired as directed and shall be given a finish in accordance with 702.21. If the concrete where the form is removed is unsatisfactory, additional forms, as necessary, shall be removed to inspect and repair the slab, and the methods of construction shall be modified as required to obtain satisfactory concrete in the slab. All unsatisfactory concrete shall be removed or repaired as directed.

The amount of sounding and form removal may be moderated as directed after a substantial amount of slab has been constructed and inspected, if the methods of construction and the results of the inspections as outlined above indicate that sound concrete is being obtained throughout the slabs. All facilities shall be provided as are required for the safe and convenient conduct of inspection procedures.

(f) Precast Concrete Deck Panels

The construction and furnishing of precast concrete deck panels in accordance with 707.10 will be permitted as an alternate method of forming a bridge deck slab for a prestressed concrete I-beam bridge. Precast concrete deck panels will not be permitted on a prestressed concrete I-beam bridge which is built on a sag vertical curve or on a superelevation transition unless otherwise shown on the plans. Precast concrete deck panels will not be permitted for use on a steel beam, steel girder, prestressed concrete bulb-T beam, or prestressed concrete spread box beam bridge.

The deck panel system shall replace the bottom mat of slab reinforcement and, depending on panel depth, the bottom 2 1/2 or 3 in. (64 or 75 mm) of the class C concrete slab. Formwork is eliminated in the areas between the beams, but forms shall be used for the copings and diaphragms.

Mating surfaces of the deck panels shall have a maximum deviation of 1/8 in. in 6 ft (3 mm in 1.8 m). All other dimensions as shown on the plans shall be fabricated to ± 1/4 in. (± 6 mm), except the vertical location of prestressing strands shall be ± 1/16 in. (± 2 mm). All panel joints shall be mortar tight immediately prior to placing the cast-in-place portion of the deck slab. Immediately prior to placement of concrete, the precast deck panels shall be wetted until free moisture appears and remains without ponding.

(g) Removal and Re-Use of Forms

The forms for any portion of the structure shall not be removed until the concrete is strong enough to withstand damage. If field operations are not controlled by beam or cylinder tests, the following periods, exclusive of days when the ambient temperature is below 40° F (4° C), for removal of forms and supports may be used as a guide.

Centering under beams	15 days
Roadway Slabs	7 days
Walls, Columns, Sides of Beams, and all other parts	12 h

If high-early strength cement is used, these periods may be reduced as directed. If portland-pozzolan cement, type IP or IP-A, fly ash or ground granulated blast furnace slag as a pozzolan is used in the structural concrete, these periods shall not apply and the removal of forms and supports shall be controlled by test beams in accordance with 702.13(h).

In order to obtain a satisfactory surface finish, forms for railings, parapets, and exposed vertical surfaces shall be removed no less than 12 h nor more than 48 h after the concrete is placed, depending on weather conditions.

Copings, corners, and projections shall not be cracked or injured during the removal of the forms. If damage occurs, the amount of concrete adjacent to the damaged portion shall be removed and replaced as directed with no additional payment.

The shape, strength, rigidity, water-tightness, and surface smoothness of re-used forms shall be maintained at all times. Any warped or bulged lumber shall be re-sized before being used. Unsatisfactory forms shall not be used.

(h) Test Beams

When portland-pozzolan cement, type IP or IP-A, is incorporated into the structural concrete elements listed below, when fly ash or ground granulated blast furnace slag is incorporated into the structural concrete elements listed below, or when field operations are being controlled by beam tests, the removal of forms, supports, and housings, and the discontinuance of heating and curing may be permitted when the modulus of rupture reaches or exceeds the following values:

Concrete Used in	**Required Flexural Strength, psi (kPa), Dead Load Only**
Girders, Arches, and similar units	390 (2,690)
Interior Bent or Pier Caps	480 (3,310)

The beams will be cured under the same conditions as the concrete which they represent. Beams will be tested for flexural strength as simple beams with 3rd point loading in accordance with 505.

702.14 Falsework and Centering

Detailed working drawings for falsework and arch centering shall be submitted in accordance with 105.02. Since the quality of the lumber is not known and because of the uncertainty of computing nailed joints, no responsibility will be assumed by the Department for the strength of falsework and centering.

Working drawings for falsework shall include details for support of interior bent caps, hammerhead piers, and the portion of the bridge floor and coping beyond fascia girders or beams if the overhang is 18 in. (460 mm), or more, or if a finishing machine, concrete spreader, or other equipment is to be supported by the overhang.

The scheme of falsework for work on a span over active railroad tracks shall provide a horizontal clearance of not less than 8 ft (2.4 m) from the centerline of track and a clearance height of not less than 22 ft (6.7 m) from the top of the track rail.

(a) Design and Construction

Falsework shall be designed and constructed so as to safely carry the full load coming upon it with a minimum settlement and deflection and with sufficient camber to counteract unavoidable shrinkage, deformation, and settlement. Structures shall have a permanent camber only when so shown on the plans, and the falsework shall be set to provide it.

For designing falsework and centering, a weight of 150 lb/cu ft (2,400 kg/m^3) shall be assumed for plastic concrete. A live load allowance of 50 lb/sq ft (2.4 kPa) shall be added for horizontal projections of surfaces. All beams supporting plastic concrete shall be so designed that there are no appreciable deflection under full load. The beams shall be considered as being unsupported by knee-bracing, such bracing to be considered as relieving sagging and bending only. The use of inclined columns, where properly braced, will be permitted.

The unsupported lengths of wooden columns and compression members shall not exceed 30 times the dimensions of the least side, or 30 times the least diameter.

Unit stresses in timber shall not exceed the following:

For Douglas fir, white oak, long-leaf yellow pine:
Bending.....1,800 psi (12,410 kPa)
Columns.....1,800 [1-L/60D] psi (12,410 [1-L/60D] kPa)

For spruce, cypress, short-leaf pine, white pine, western hemlock:
Bending.....1,500 psi (10,340 kPa)

Columns.....1,500 [1-L/60D] psi
(10,340 [1-L/60D] kPa)

In the above:
L = Length of column in inches (millimeters)
D = Least diameter or least dimension in inches (millimeters).

Hardwood wedges may be required to take up any settlement in the falsework, either before or during the placing of concrete.

Arch centering shall be constructed so as to permit it to be lowered or released gradually and uniformly after pouring arch ribs and rings. Lagging for arch centering shall be of uniform thickness. Unless otherwise permitted, the nominal thickness shall be no less than 2 in. (50 mm). A smooth surface shall be produced on the undersides of arch rings. The upper sides of all lagging shall be oiled before concrete is placed.

Unless driving of piles for falsework bents is precluded by soil or other special conditions or unless otherwise permitted, all bents for falsework shall have driven piles. These shall be so driven to support the required loads without settlement, spacing, and subsequent removal shall be satisfactory.

If permission is given to place frame bents, they shall be placed on continuous concrete mudsills, or as approved.

(b) Removal

Unless otherwise provided or permitted, the following shall apply to the removal of falsework and centering:

1. Falsework under beams, slabs, girders, interior bent or pier caps, and arches shall, in warm weather, remain in place at least 15 days after the concrete is poured except, if directed, this period shall be increased.

2. Falsework and arch centering under multiple-span arch bridges shall not be released from any one span until the adjacent and spandrel walls have cured for the required time and the next adjacent arch ring has been poured for at least 48 h.

3. Falsework under continuously reinforced concrete slab and girder units shall not be released from any span until the entire continuous unit has been completed and all concrete cured for the required period.

4. For concrete poured during March, April, October, and November, or any time between April and October when the average

temperature is less than 50°F (10°C), the above periods shall be increased 20%. For concrete poured during December, January, and February, they shall be increased 40%.

5. If field operations are controlled by beam tests, the provisions of 702.13(h) shall apply to the time of removal of falsework unless other provisions of these specifications prohibit removal.

6. Removal of supports shall be such that permits the concrete to take the stresses, due to its own weight, uniformly and gradually.

7. The removal of falsework shall be at the risk of the Contractor. Permission for removal may be refused if it is determined that there may be resulting damage to the structure.

702.15 Joints

(a) Construction Joints

Construction joints shall be located across regions of low shearing stress and, so far as possible, where they are hidden from view in the finished structure. They shall be made only where shown on the plans, unless otherwise permitted in writing, in accordance with this specification.

Placing of concrete shall be continuous between construction joints. If placing is interrupted and a construction joint becomes necessary, provisions shall be made for interlocking with the preceding layer by constructing raised keyways as shown on the plans or as directed.

When fresh concrete is to be joined to that in place which has already set, the surface of the concrete in place shall be cut over with a suitable tool to remove all loose and foreign material. This surface shall then be scrubbed with wire brooms and kept wet until the new concrete is placed thereon. Immediately before the new concrete is placed, the forms shall be drawn tight against the concrete in place and the exposed surface of the concrete shall be coated with a thin coating of mortar composed on 1 part cement and 2 parts No. 23 sand.

All concrete for slabs, beams, girders, cantilevered brackets, and footings shall be placed in one continuous operation to form monolithic construction. However, if, because of rain or other unavoidable reasons, concreting is interrupted where monolithic construction is required, the concrete shall be kept plastic by placing frequent small batches until this part of the work is completed or until normal operations can be resumed. If the interruption is such that even partial operations can not be carried on and construction joints are unavoidable, the joints shall be made in planes exactly normal to the main reinforcing bars and only where the shear is a minimum. In simply supported slabs, beams, and girders, such regions of minimum shear are at or near the center of the span.

Unless otherwise provided, pours in all abutments for an arch bridge shall be continuous from the top of footing to the skewback. If it is advisable to pour only a portion of the abutment at one time, a vertical construction joint may be placed parallel to the major reinforcement of the arch ring with written permission.

Horizontal construction joints will not be permitted in footings. If there is a probability that the entire amount of concrete can not be poured monolithically, vertical or other construction joints shall be provided as directed.

Horizontal construction joints in the shafts of reinforced piers, retaining walls, and abutments, other than abutments for arch bridges, may be made only if approved. Where such joints show on an exposed surface, special care shall be taken to make the joints truly straight, clean, and watertight. To avoid visible joints so far as possible on exposed faces, the top surface of the concrete shall be finished to the underside of a strip nailed to the form work for the exposed surface of the concrete, the strip to be placed as directed. If such a horizontal joint intersects any coping or any sloping surface where a featheredge would be formed, an inclined bulkhead shall be placed so as to make the joint normal to the sloping surface for a distance of no less than 6 in. (150 mm) or, if there is a coping, no less than the depth of the coping. Horizontal construction joints will not be permitted in the stems of concrete T-beams nor at the junction of T-beam stems and flanges.

(b) Expansion Joints

Structural expansion joints shall be of the form, dimensions, material, and design shown on the plans. Open expansion joints shall be completely open for the dimensions specified and for their entire length. Preformed expansion joint material shall be placed true and even and with abutting sections pressed together tightly. The material shall be of the size shown on the plans and shall be in accordance with 906.01.

(c) Folded Metal Joints

These joints shall be free from kinks and watertight. At bends, the strip shall be 1 piece if possible. Unless otherwise shown on the plans, the joints shall be soldered. Copper shall be in accordance with 910.16. Lead sheets shall be no less than 1/8 in. (3 mm) thick.

(d) Sliding Joints

The surface of the supporting concrete for a sliding joint shall be troweled to a smooth finish and then covered with the required thickness of bituminous material, or otherwise treated if so designated.

(e) Polychloropene Joint Membrane

Polychloropene joint membrane used for semi-integral end bents shall be secured to the concrete with an adhesive. The polychloropene joint membrane shall

be centered vertically on the joint. Any field joint in the polychloropene membrane shall be lapped a minimum of 12 in. (300 mm).

702.16 Drainage Pipes Through Concrete Masonry

At all enclosures where water could not otherwise escape through the concrete, drainage pipes shall be installed as shown on the plans. Before fill is placed around these pipes, geotextile for use with underdrains shall be placed over the drain pipe and securely held in place and loose stone shall be laid by hand over the inlet end to provide a cover which shall be sufficient to retain the fill and permit free drainage. Drains through abutments and retaining walls shall be placed with a slight incline downward towards the exposed face.

702.17 Incased Pipes and Conduits

Pipes and conduits which are to be encased in the concrete shall be installed before the concrete is placed. Unless otherwise provided, such pipes and conduits shall be delivered at the site of the work by those for whose use they are intended. No direct compensation will be allowed for their installation. However, no deduction in concrete quantities will be made for the volume occupied.

702.18 Roadway Surface Drainage

Drainage grates and basins, necessary fittings, and connections to drainage pipes shall be placed as shown on the plans or as directed.

702.19 Pouring Bent Caps

Caps shall not be poured on end bents nor on any other bents falling within the limits of the approach grade until the filling material has been placed.

702.20 Placing Concrete

(a) General Requirements

Concrete shall not be placed until forms and reinforcing bars have been checked and approved. The forms shall be clean of all debris before concrete is placed. The method and sequence of placing concrete shall be approved.

Where concrete floor slabs are to be poured, walkways shall be provided to protect reinforcement from pedestrian traffic. Before placing concrete, continuous walkways shall be placed parallel to the section of floor to be poured and shall remain in place until after the concrete is placed and hardened sufficiently so as not to be injured. Walkways shall be constructed so as not to come in contact with the reinforcement and be of sufficient width to provide for finishing operations entirely from the walkway.

Except as otherwise provided, concrete shall be placed in horizontal layers of no more than 24 in. (600 mm) thick. When less than a complete layer is placed in 1 operation, it shall be terminated by a vertical bulkhead. Each layer shall be placed and consolidated before the preceding layer has taken initial set in order to avoid

planes of separation between the layers and injury to the plastic concrete underneath. On horizontal surfaces and at horizontal construction joints, the forms shall be overfilled approximately 1/2 in. (13 mm) and then struck off to the required elevation prior to the initial set of the concrete.

When placing is temporarily discontinued and as soon as it becomes firm enough to retain its shape, the concrete shall be cleaned of all laitance and other objectionable material to a depth sufficient to expose sound concrete. Unless otherwise authorized, depositing concrete shall not be discontinued within 18 in. (460 mm) of the top of a face. However, if provisions have been made for a coping of less than 18 in. (460 mm) thick, a construction joint may be made at the underside of the coping.

Where new concrete is to abut existing concrete, the existing concrete surfaces and existing exposed reinforcement shall be cleaned free of dust, chips and water. Epoxy resin adhesive, in accordance with 909.11, shall be used to coat the existing concrete surfaces. The epoxy coating shall be tacky at the time that the new concrete is placed. If the epoxy coating has cured beyond the obvious tacky condition, it shall be reapplied prior to placing the new concrete.

After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement.

The external surface of all concrete shall be worked thoroughly, during placing, by means of tools of an approved type. The working shall be such as to force all coarse aggregate from the surface and to bring mortar against the forms to produce a smooth finish substantially free from water and air pockets or honeycomb.

(b) Chutes and Troughs

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement. Open troughs and chutes shall extend as nearly as possible to the point of deposit. Equipment made of or coated with aluminum alloys shall not be used to transport concrete. Pumping of concrete shall be in accordance with 702.10. When the discharge must be intermittent, a hopper or other device for regulating the discharge shall be provided. Placement of supplementary bins or hoppers may be ordered above the point where concrete is being deposited. The concrete shall be allowed to accumulate in these containers in considerable quantity and shall be discharged immediately through pipes extending from the bottoms of these bins or hoppers. All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete. The water used for flushing shall be discharged clear of the concrete already in place.

Concrete shall not be dropped in the forms a distance of more than 5 ft (1.5 m) except when confined by closed chutes or pipes. Each part of the form shall be filled

by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement.

(c) Vibrating

Unless otherwise directed, the concrete shall be compacted with mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to ensure proper and adequate compaction. Vibrators shall be of an approved type and design, adequately powered and capable of transmitting 10,800 impulses per minute in air. The diameter of the head of the vibrator shall be 1 1/4 to 2 1/2 in. (32 to 64 mm). Vibrators shall be manipulated so that the concrete is thoroughly worked around the reinforcement and imbedded fixtures and into corners and angles of the forms. Vibrators shall not be used as a means to cause concrete to flow or run into position in lieu of placing. The vibration at any point shall be of sufficient duration to accomplish compaction but shall not be prolonged to the point where segregation occurs. Vibrators shall not be attached to nor allowed to contact forms or reinforcement or to penetrate beyond any layer of fresh concrete.

(d) Depositing Concrete Under Water

No concrete except for foundation seals shall be deposited under water, without written permission. If such permission is granted, care shall be exercised to prevent the formation of laitance. Concrete shall not be deposited until any laitance, which may have formed on concrete previously placed, has been removed. Pumping shall be discontinued while depositing foundation concrete if it results in a flow of water inside the forms. If concrete, except for foundation seals, is deposited under water, the proportion of cement used shall be increased at least 25% with no additional payment to compensate for losses due to water. Concrete deposited under water shall be placed in a compact mass in its final position by means of a tremie, a closed bottom dump bucket, or other approved method and shall not be disturbed after being deposited.

A tremie shall consist of a tube having a diameter of no less than 10 in. (254 mm) and constructed in sections having flanged couplings fitted with gaskets. Support of the tremie shall be such that permits free movement of the discharge end over the entire top surface of the area on which the concrete is to be deposited and also permit rapid lowering when necessary to retard or stop the flow of the concrete. The discharge end shall be kept closed until immediately prior to depositing in order to prevent water entering the tube and shall be completely sealed except when concrete is actually being deposited. The tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete through the tube shall be started by slightly raising the discharge end, but always keeping it in the previously deposited concrete. The flow shall be continuous until all the required concrete is deposited.

(e) Placing Footing Concrete

Except as otherwise provided for a foundation seal, footing concrete shall not be placed except when the cofferdam is dewatered and so maintained during placement.

If it is necessary to operate the pump while placing footing concrete, or immediately thereafter, the seepage water shall be conducted to a sump at the pump intake in such manner that it does not flow over the fresh concrete. Special care shall be taken to prevent pumping cement out of the fresh concrete.

Footing concrete may be placed directly against sheet piling of the cofferdam when so shown on the plans or authorized in writing. Where class X excavation has been extended beyond established neat lines of a footing, the bottom 12 in. (300 mm) of such footing shall be poured to the actual limits of the excavation. When necessary, the foundation material on which the footing is to rest shall be protected from freezing. Where an existing structure is to be extended, the existing footings shall be protected from damage. Damaged footings shall be repaired as directed with no additional payment.

Piling, if any, shall be driven to or cut off at the proper elevation to permit embedment in the footing concrete equal to that shown on the plans. All laitance or other unsatisfactory material shall be removed from the exposed surface of the concrete in place by some means which does not injure the concrete. If a footing is to be constructed on a foundation seal, it shall be to the dimensions shown on the plans and, if necessary, the height of the shaft adjusted to bring the bridge seat to the required elevation.

Placing concrete in footings shall start at one end of the footing and be continued until the surface of the concrete is brought to the elevation of the top of the footing. The concrete shall be allowed to work forward, displacing any water with as little help as possible. The concrete shall not be dragged through or shoveled into water nor deposited into running water. Placing concrete in more than a few inches of water shall be done only with written permission.

(f) Concrete Foundation Seal

A foundation seal may be required by the plans, as requested, or as directed. When required by the plans, the seal shall be constructed to the size shown, or as specified in writing. Where adverse dewatering conditions are encountered as described in 206.09, a foundation seal may be required to be placed to such dimensions as are necessary. If a foundation seal is requested, written permission shall be obtained before starting such work. If approval is given, the seal shall be placed to designated dimensions.

Seals shall be of class A concrete having a slump of from 5 to 8 in. (130 to 200 mm), placed continuously from start to finish, and in accordance with 702.20(d). To ensure thorough bonding, each successive layer shall be placed before the preceding layer has taken initial set. The cofferdam shall have been vented or ported

at low-water level. The surface of the concrete shall be kept as nearly horizontal at all times as practicable. The seal shall be of the thickness ordered. When the seal has hardened sufficiently to withstand the hydrostatic pressure, the cofferdam shall be dewatered and the remainder of the concrete poured in the dry.

702.21 Finishing Concrete Surfaces

Unless otherwise authorized, the surface of the concrete shall be finished immediately after form removal. Only the minimum amount of covering necessary to allow finishing operations to be carried on shall be removed at one time. Subject to approval, metal ties may be left in the concrete for the purpose of supporting or bracing subsequent work. Such ties shall be in accordance with 702.13(b) and shall be of a type which uses a cone and rod as both spreader and tie. Before final acceptance of the work, the cones shall be removed and the cavities filled, in accordance with 702.13(b).

All concrete surfaces shall be given a finish immediately following the removal of any forms.

The concrete surfaces of pier and bent caps, the front face of mudwalls, and any other concrete surfaces specified shall be sealed. The material used for sealing shall be in accordance with 709. It shall be applied so as to obtain a finished film thickness of at least 10 mils (250 µm). Mixing, surface preparation, and method of application shall be in accordance with the manufacturer's recommendations. However, the surfaces to be sealed shall be prepared in accordance with 709 prior to applying the sealer.

At the time of the removal of forms, the concrete surface shall be scraped to remove all fins and irregular projections. The surface shall then be power ground to smooth all joints and chamfers.

After grinding is completed, a paste of grout shall be applied to the concrete surface with a sponge float to fill all air holes and small irregularities. The paste grout shall be 6 parts of pre-mix mortar mix for masonry and 1 part white portland cement in accordance with ASTM C-150, Type 1.

After the paste grout takes its initial set, the surface of the concrete shall be scraped with a steel drywall knife to remove the paste from the surface.

702.22 Curing Concrete

Concrete in bridge decks or the top surface of reinforced concrete slab bridges shall be cured continuously for at least 168 h commencing immediately after the surface is able to support the protective covering without deformation. Curing of patches or small full depth deck replacement areas on existing bridge decks that are to be overlaid, may be controlled by test beams in accordance with 702.24(a).

Unless otherwise specified or permitted, all other concrete shall be cured for at least 96 h commencing immediately after the surface is able to support the protective covering without deformation. If portland-pozzolan cement, type IP or IP-A, or fly ash is used, the concrete shall be cured for at least 120 h.

Membrane forming curing compound may be used in lieu of protective covering curing methods. Where it has been determined that a surface treatment is to be used, the membrane forming curing compound shall not be used.

The curing of surfaces to be waterproofed may be discontinued when waterproofing is started.

If field operations are controlled by beam tests, the curing time, except for bridge decks and the top surface of reinforced concrete slab bridges, shall be in accordance with 702.13(h).

If further precautions are necessary to ensure strength, they shall be taken as directed.

(a) Protective Covering Curing Methods

Surfaces to be cured shall be protected by covering with cotton mats, burlap, or other satisfactory protective material and shall be kept continuously and thoroughly wet during the curing period. The protective covering shall be suitably anchored to keep the protective materials in place during the curing period. Curbs, walls, handrails, copings, and other surfaces requiring a finish in accordance with 702.21 may have the covering temporarily removed for finishing, but the covering shall be restored as soon as possible.

(b) Membrane Forming Curing Compound

All surfaces shall be given the required surface finish prior to application of the curing compound. During the finishing period, the concrete shall be protected by the water method of curing.

The curing compound shall be mixed thoroughly within 1 h before use. The rate of application shall be as approved, with a minimum spreading rate per application of 1 gal. (3.8 L) of liquid coating for 150 sq ft (14 m^2) of concrete surface. All concrete cured by this method shall receive 2 applications of the curing compound. The 1st coat shall be applied immediately after stripping of forms and acceptance of the concrete finish. If the surface is dry, the concrete shall be wetted with water and the curing compound applied just as the surface film of water disappears. The second application shall be applied after the 1st application has set. During curing operations all unsprayed surfaces shall be kept wet with water.

The coating shall be protected against marring for at least 10 days after application. All coatings marred or otherwise disturbed shall be given an additional coating. If the surface coating is continuously subjected to injury, immediate

application of water curing may be required. If the use of a curing compound results in a streaked or blotchy appearance, the method shall be stopped and water curing applied until the cause of the defective appearance is corrected.

(c) Curing-Sealing Materials

Curing-sealing materials may be used in lieu of protective covering curing methods when surface seal is required. These materials may only be used on concrete surfaces that are not subjected to vehicular wear and that have been formed using the slip form method. Curing-sealing material shall not be applied to cast-in-place concrete.

When curing-sealing materials are used for curing concrete, surface seal will not be required.

The curing-sealing material shall be mixed in accordance with the manufacturer's instructions prior to application. The rate of application shall be as specified in the list of approved Curing-Sealing Materials. All concrete cured-sealed by this method shall receive 2 applications of the curing-sealing compound. The 1st coat shall be spray applied after the finished surface has been achieved. The 2nd coat shall be applied while the 1st coat is still tacky.

The use of curing-sealing material shall be discontinued if plastic shrinkage cracks occur that cannot be corrected by decreasing the application rate. The concrete shall then be cured and surface sealed in accordance with 702.22(a) and 709, respectively.

Polychloroprene used for a semi-integral end bent shall be secured to the concrete with an adhesive. The polychloroprene sheeting shall be centered vertically on the joint, and shall have no gaps. Joints in the sheeting material shall be lapped a minimum of 12 in. (300 mm).

The coating shall be protected against damage after application. All coatings that have been disturbed shall be given an additional coating. If the surface coating is continuously subjected to injury, immediate application of curing in accordance with 702.22(a) may be required. The concrete shall then be surfaced sealed in accordance with 709.

702.23 Waterproofing

The expansion joint shall be waterproofed on the following: the back surfaces of retaining walls; the top surface of all slabs under fills; the extrados of arches; the inside faces of spandrel walls; and abutments up to the finish grade line. The inside face of spandrel walls and extrados of arches shall be waterproofed.

A firmly bonded membrane consisting of 2 layers of dry fabric and three applications of waterproofing material, shall be placed at all expansion joints set out herein. One uncoated layer of fabric shall not touch another layer or the concrete at

any point. There shall be at least 3 complete and separate applications of the waterproofing material. The application shall be sufficiently heavy to conceal the weave in the fabric. Sufficient fabric shall be placed in V-strips at the joints to permit the movement of adjacent sections of concrete without tearing the fabric. The membrane shall be carefully flashed at all exposed edges and laps sealed down thoroughly. Waterproofing shall be planned so that, at the close of work each day, all fabric placed shall have received the final application of waterproofing material.

Concrete surfaces to be waterproofed shall be reasonably smooth and free from projections and holes. Immediately before the application, the surface shall be cleaned of dust and loose materials. Waterproofing shall be done only when the surface is at least dry enough to prevent the formation of steam when the hot material is applied. When the air temperature is below 35°F (2°C), waterproofing shall not be done, unless otherwise permitted.

The material shall be applied so as to cover the area completely. If necessary, more than 1 coat shall be applied in order to secure a satisfactory coating and proper adhesion. Coating and fabric shall stop a uniform distance below the top surfaces of walls. The material shall not be splattered over surfaces or faces of concrete which subsequently are exposed in the finished structure. Utility asphalt for waterproofing shall be heated to a temperature of between 300°F (149°C) and 350°F (177°C). The material shall be stirred frequently to prevent local overheating. The waterproofing material shall not be damaged when backfill is placed against a waterproofed joint.

702.24 Application of Loads to and Acceptance of New Concrete

Except as otherwise hereinafter provided, application of loads to new concrete shall be in accordance with the following:

(a) Equipment or traffic will not be permitted on structures until all concrete required to carry live loads has been poured for at least 15 days or a flexural strength of 550 psi (3,800 kPa) for 3rd point loading has been attained.

(b) Unbalanced backfill will not be permitted until the concrete required to resist it is at least 10 days old or a flexural strength of 440 psi (3,030 kPa) for 3rd point loading has been attained. The unbalanced height shall not exceed 10 ft (3 m) until the concrete is at least 15 days old or a flexural strength of 480 psi (3,310 kPa) for 3rd point loading has been attained.

(c) The dead weight of steel or precast concrete superstructure shall not be placed on concrete until the concrete is at least 5 days old, or longer as directed, or a flexural strength of 400 psi (2,760 kPa) for 3rd point loading has been attained. A dead load shall not be placed on hammer-head piers until the concrete is 15 days old or until test beams attain a flexural strength of at least 480 psi (3,310 kPa) for 3rd point

loading. The concrete floor, if to be placed thereon, shall not be poured until the concrete supporting the superstructure is at least 10 days old or until test beams attain a flexural strength of at least 440 psi (3,030 kPa) for 3rd point loading.

(d) Concrete anchoring inserts to support falsework shall be in place 15 days or the test beams shall attain a flexural strength of at least 480 psi (3,310 kPa) for third point loading, before a dead load of concrete is applied.

For concrete poured during March, April, October, November, or at any other time between April and October when the average temperature is less than 50°F (10°C), the above periods shall be increased 20%. For concrete placed during December, January, and February, the above periods shall be increased 40%. When test beams indicate the required flexural strength, the required time periods may be reduced. If at the expiration of the specified periods test beams do not indicate the required flexural strength, the periods shall be lengthened until the required strength is attained. If portland-pozzolan cement, type IP or IP-A, fly ash, or ground granulated blast furnace slag used as an additive is incorporated into the concrete, the specified periods shall not apply and the application of loads shall be controlled by beam tests. No time extension will be considered for delays due to additional time necessary to attain specified strengths.

Traffic, live loads, and backfill against wingwalls, spandrel walls, and abutments may be allowed when test beams indicate a flexural strength of 480 psi (3,300 kPa) or greater for 3rd point loading. Concrete pavement may be opened to traffic in accordance with 502.18. Beams will be prepared and tested in accordance with 702.13(g). Before traffic is permitted over a concrete structure built to be under fill, it shall be covered with 9 in. (225 mm) or more of earth or other suitable material, or otherwise protected. All other structures shall be properly protected against impact or other damage.

When compressive strength is used as a basis for acceptance of concrete, for determining when a latex modified concrete overlaid bridge deck may be opened to traffic, for determining form removal time, or for determining when a structure may be put into service, standard specimens shall be made and cured in accordance with ASTM C 31, and shall be tested in accordance with ASTM C 39. Strength requirements shall be in accordance with ASTM C 94, with the exception as follows: the strength shall be the average of the strengths of all cylinders tested at the age specified, with a minimum of 2 cylinders. This average shall be equal to or greater than the required strength. If the compressive strength of 1 or more cylinders in 1 strength test is below 75% of the required strength, the entire test will be considered as failed.

Failure to meet the strength requirements will be cause for rejection of the quantity of concrete represented by the cylinders. All molds, facilities, and materials

necessary to prepare and cure the specimens shall be furnished with no additional payment.

702.25 Field Drilled Holes in Concrete

This work shall consist of field drilling holes of the diameter and length shown on the plans or as directed.

When vertical holes are to be drilled into the top of a concrete bridge deck, a minimum clearance of 2 in. (50 mm) shall be maintained between the bottoms of holes and bottom of slab. When vertical holes are to be drilled over a steel beam flange, the holes may be extended to the top of the beam flange. When vertical holes are to be drilled over a concrete I-beam, concrete box beam or concrete girder, the depths of the holes shall be as shown on the plans. If breakout occurs on the bottom of slab during the drilling process, the work shall be stopped, the breakout shall be repaired as directed, and an approved alternate drilling method shall be used to prevent breakout.

When grouted holes are specified, the diameter and length of the holes shall be in accordance with the grout manufacturer's recommendations.

702.26 Artificial Lighting

No portion of the work which cannot be finished during daylight hours shall be started unless written permission to the contrary is given, in which case adequate lighting shall be provided and maintained.

702.27 Method of Measurement

Concrete will be measured by the cubic yard (cubic meter) in accordance with the neat lines shown on the plans or as directed. No deductions will be made for the volume of joint material, embedded reinforcement, encased piles, or for a pipe with an area of less than 1 sq ft (0.1 m^2).

Cast iron grates, basins, and fittings will be measured by the pound (kilogram) based on the theoretical weight (mass) shown on the plans. Bronze plates will be measured by the pound (kilogram) based on a theoretical weight of 536 lb/cu ft (mass of 8,586 kg/m^3). The volume will be computed based on finished dimensions. Drainage pipe through concrete masonry will be measured in accordance with 715. Field drilled holes will be measured by the number of holes drilled.

Concrete in railings will be measured in accordance with 706.06. Reinforcing bars will be measured in accordance with 703.07.

702.28 Basis of Payment

The accepted quantities of structural concrete will be paid for at the contract unit price per cubic yard (cubic meter) of concrete, for the class and use specified. Cast iron grates, basins, and fittings will be paid for at the contract unit price per pound (kilogram). Bronze plates will be paid for at the contract unit price per pound

(kilogram). Steel drain pipe will be paid for at the contract lump sum price. Field drilled holes in concrete will be paid for at the contract unit price per each.

Concrete in railings will be paid for in accordance with 706.07. Reinforcing bars will be paid for in accordance with 703.08. Drainage pipe through concrete masonry will be paid for in accordance with 715.

If a foundation seal is constructed as shown on the plans, it will be paid for at the contract price per cubic yard (cubic meter) for concrete, foundation seal. If ordered to be done, or permitted to be done, payment will be made at a unit price per cubic yard (cubic meter) equal to 3/4 of the contract unit price per cubic yard (cubic meter) for class B concrete in footings. The excavation for the foundation seal will be paid for at the contract unit price per cubic yard (cubic meter) for the class of excavation specified for the footing. Unless otherwise provided, the pay quantity for excavation for foundation seal will be equal to the theoretical volume bounded by the bottom of the proposed footing, the bottom of the approved excavation, and vertical planes 18 in. (460 mm) outside the neat line of the footing and parallel thereto, regardless of the quantity actually removed. If design of the structure requires sheeting to be outside these limits, the limits will be extended to 6 in. (150 mm) beyond the neat lines required by the design of the structure. If the Contractor chooses to construct a rectangular cofferdam around a U-shaped abutment in lieu of following the outline of the footing, the maximum allowable increase in the pay quantity above the theoretical shall not exceed 25%. The pay quantity for the foundation seal will be equal to the excavation volume described above.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Bronze Plates	LBS (kg)
Concrete, A, Substructure	CYS (m3)
Concrete, A, Superstructure	CYS (m3)
Concrete, B, Above Footings	CYS (m3)
Concrete, B, Footings	CYS (m3)
Concrete, C, ____ use	CYS (m3)
Concrete, Foundation Seal	CYS (m3)
Field Drilled Hole in Concrete	EACH
Grates, Basins, and Fittings, Cast Iron	LBS (kg)

The cost of forms, polyvinyl chloride slab for bridge floor drains, falsework, falsework piling, centering, expansion joints, waterproofing, curing, finishing, and necessary incidentals shall be included in the cost of the pay items. The cost of placing epoxy resin adhesive on existing concrete surfaces shall be included in the cost of new concrete which abuts the existing concrete. Payment for concrete used in footings in class X excavation will be made at the contract unit price only for the

cubic yards (cubic meters) placed within the neat lines of the footings as shown on the plans or as revised.

If the Contractor elects to increase the cement content as allowed herein for its advantage, no additional compensation will be made.

The cost of permanent metal forms shall be included in the cost of concrete, C, superstructure. The pay quantity of concrete in the slab will be computed from the dimensions shown on the plans, with no allowance for form deflection or geometry.

The cost of precast concrete deck panels shall be included in the cost of concrete, C, superstructure. The pay quantity of such concrete in the slab will be computed from the dimensions for the formed and poured bridge floor slab shown on the plans. The pay quantity of reinforcing bars will be the plan quantity shown with no adjustment for eliminating the bottom reinforcing bar layer nor for additional reinforcement required due to use of the precast concrete deck panels.

Elastomeric bearings will not be paid for directly, unless otherwise specified. The cost thereof shall be included in the cost of the structural member they support. The cost of protecting existing footings to be extended shall be included in the cost of concrete, B, footings, unless otherwise specified.

The cost of grout for grouting reinforcing bars in place, the length of grouted hole recommended by the grout manufacturer in excess of the length shown on the plans, and the additional length of reinforcing bars required shall be included in the cost of field drilled hole in concrete.

The cost of furnishing and installing polychloroprene sheeting shall be included in the cost of concrete, A, substructure.

The cost of high density plastic bearing strips shall be included in the cost of concrete, A, substructure.

SECTION 703 – REINFORCING BARS

703.01 Description

This work shall consist of furnishing and placing reinforcing bars and threaded tie bar assemblies with reinforcing bars in accordance with 105.03.

703.02 Materials

Materials shall be in accordance with the following:

Reinforcing Bars, Plain or Epoxy Coated	910.01
Reinforcing Bar Splicing System	910.01(b)3
Support Devices	910.01(b)9
Threaded Tie Bar Assembly	910.01(b)2

All plain and epoxy coated reinforcing bars shall be supplied from a source listed on the Department's list of Certified Uncoated Reinforcing Bar Manufacturers and Certified Reinforcing Bar Epoxy Coaters respectively.

The sizes and lengths of reinforcing bars shall be marked plainly to facilitate inspection and checking.

703.03 Bar List

The Contractor shall verify the quantity and size of reinforcing bars against the structure drawings prior to ordering. Errors in the bar list and bending schedule will not be cause for adjustment of the contract unit price.

703.04 Protection of Materials

Plain and epoxy coated reinforcing bars shall be protected from damage during storage, handling, installation and concrete placement. Plain and epoxy coated reinforcing bars shall not be stored in direct contact with the ground. Epoxy coated reinforcing bars shall be protected from exposure to ultraviolet light and moisture during storage. Once placed into the work, epoxy coated reinforcing bars shall not be exposed to ultraviolet light for a total of more than 21 days prior to placement of concrete. At the time of concrete placement, reinforcing bars shall be free of dirt, loose rust or scale, grease, oil, or other foreign substance. If the Engineer suspects the epoxy coating has been damaged by exposure to ultraviolet light, a sample will be obtained and will be tested in accordance with 910.01(b)9.

Damage to the epoxy coating of epoxy coated reinforcing bars shall be repaired or the bars shall be replaced. Repairs to the epoxy coating shall be performed on all damaged areas larger than 1/4 by 1/4 in. (6 by 6 mm). A bar will be rejected if the accumulated area of damaged coating exceeds 2% of the nominal surface area of the bar or if the total area of repaired coating exceeds 5% of the nominal surface area of the bar. All damaged areas shall be cleaned and the repair shall be performed before visible oxidation appears. Coating repair material shall be in accordance with 910.01(b)9.

CONSTRUCTION REQUIREMENTS

703.05 Bending

Reinforcing bars required to be bent shall be accurately cold bent in a bending machine to the shapes shown on the plans. All bars in which cracks or splits occur at bends will be rejected.

703.06 Placing and Fastening

Reinforcing bars shall not be ordered for piers or bents to be founded on soil or rock until the foundation conditions have been investigated. The bottom elevations of such footings will then be determined. Written permission will then be given to

order such reinforcing bars. Sufficient excavation and all necessary soundings shall be made as directed so that exact bottom elevations of footings may be determined.

All dimensions shown on the plans for spacing of reinforcing bars apply to centers of bars unless otherwise noted. All bars shall be accurately placed and, during placing of the concrete, held firmly in the position as shown on the plans. Distances from the forms shall be maintained by means of chairs, ties, hangers, or other approved support devices. All reinforcing bars shall be wired rigidly or fastened securely at sufficient intervals to hold the bars in place. Chairs and supports holding upper layers of reinforcing bars shall support the transverse bars. The upper layer of reinforcing bars in bridge floors shall be tied or fastened at such intervals as necessary to prevent an upward or a lateral movement of a bar from the planned position.

Layers of reinforcing bars shall be separated by spacers. Reinforcing bars shall be separated from horizontal surfaces by being suspended or supported on approved chairs and spacers capable of supporting the designed loads. Supports and spacers shall be of such shape as to be easily encased in concrete. That portion which is in contact with the forms shall be non-corrosive and non-staining material. They shall be of an approved type. Vertical stirrups shall always pass around main tension members and shall be securely attached thereto. The use of pebbles, pieces of broken stone or bricks, metal pipe, wooden blocks, and similar devices for holding bars in position will not be permitted.

After being placed, reinforcing bars will be inspected and approved before the concrete is deposited. The positions of the reinforcing bars shall not be disturbed both during and after depositing the concrete. All concrete placed in violation of this requirement may be rejected and its removal will be required. Where reinforcing bars project from construction joints, all mortar clinging to the reinforcing bars from previous pours shall be removed before the next enveloping pour is made.

All reinforcing bars shall be furnished in the full lengths shown on the plans unless splices are indicated. No other splicing will be allowed except with written permission. Unless otherwise shown on the plans, reinforcing bars shall be lapped 32 diameters to make a splice. Construction joints shall not be made within the limits of lapped bars. For lapped splices, reinforcing bars shall be placed in contact and rigidly clamped or wired in an approved manner. Insofar as possible, splices shall be staggered and well distributed or located at points of low tensile stress. Splices will not be permitted at points where the section does not provide a distance of at least 2 in. (50 mm) between the splice and the nearest adjacent bar or surface of the concrete.

When splicing is indicated or permitted, an appropriate splice system on the list of approved Reinforcing Bar Splicing Systems may be used in lieu of lapped bars. The splicing system shall be installed in accordance with the manufacturer's recommendations.

WWR, when required, shall be placed as shown on the plans or as otherwise directed. The sheets shall overlap sufficiently to maintain uniform strength and shall be securely fastened at lapped ends and edges. The laps shall be no less than 1 mesh in width.

Spiral reinforcement, consisting of evenly spaced continuous spirals, shall be held firmly in place by attachment to vertical reinforcement. The spirals shall be held true to line by vertical spacers. Anchorage for spiral reinforcement shall be provided with 1 1/2 extra turns of the spiral rod or wire at each end of the spiral unit. Splices in spiral rods or wire shall be made with a lap of 1 1/2 turns.

Threaded tie bar assemblies may be used in lieu of spliced reinforcing bars shown on the plans. Threaded tie bar assemblies shall achieve the minimum strength in accordance with 910.01(b)2. The Contractor shall coat any exposed part of threaded bar assemblies in accordance with 910.01(b)2.

703.07 Method of Measurement

Reinforcing bars will be measured by the pound (kilogram) based on the theoretical number of pounds (kilograms) complete in place as shown on the plans or placed as ordered. The quantities of materials furnished and placed shall be based upon the calculated weights (masses) of the reinforcing bars actually placed in accordance with these specifications. The weights (masses) calculated shall be based upon the following tables.

English Table

Bar Designation No.	Weight per linear foot, pounds	Bar Designation No.	Weight per linear foot, pounds
1/4 in.	0.167	8	2.670
3	0.376	9	3.400
4	0.668	10	4.303
5	1.043	11	5.313
6	1.502	14	7.65
7	2.044	18	13.60

Metric Table

Bar Designation No.	Mass per meter, kilograms	Bar Designation No.	Mass per meter, kilograms
10	0.560	29	5.060
13	0.994	32	6.404
16	1.552	36	7.907
19	2.235	43	11.38

22	3.042	57	20.24
25	3.973		

Threaded tie bar assemblies will be measured by the number of assemblies placed.

WWR will not be measured.

703.08 Basis of Payment

The accepted quantities of reinforcing bars will be paid for at the contract price per pound (kilogram), complete in place.

If the substitution of reinforcing bars larger than those specified is permitted, payment will be made for only that weight (mass) which would be required if the specified bars had been used.

If the use of reinforcing bar lengths shorter than those shown on the plans is permitted for convenience in transporting or placing the bars, payment will be based on the weight (mass) of the lengths shown on the plans.

Payment for threaded tie bar assemblies will be at the contract unit price per each, complete in place, If epoxy coating is specified, payment for the assemblies will be at the contract unit price per each for threaded tie bar assembly, epoxy coated.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Reinforcing Bars	LBS (kg)
Reinforcing Bars, Epoxy Coated	LBS (kg)
Threaded Tie Bar Assembly	EACH
Threaded Tie Bar Assembly, Epoxy Coated	EACH

The cost of metal chairs, spacers, clips, wire, or other mechanical means used for fastening or holding reinforcement in place, and laps shall be included in the cost of reinforcing bars. The cost of coating materials and repair of damaged or removed coating materials on reinforcing bars and on metal chairs, spacers, clips, or other mechanical means used for fastening or holding reinforcement in place, and laps shall be included in the cost of epoxy coated reinforcing bars. If threaded tie bar assemblies are used in lieu of spliced reinforcing bars as shown on the plans, the cost of such assemblies shall be included in the cost of reinforcing bars.

If WWR is required, the cost of furnishing and placing it shall be included in the cost of the concrete in which it is placed.

SECTION 704 – CONCRETE FLOOR SLABS

704.01 Description

This work shall consist of placing cement concrete and reinforcing bars as a bridge floor in accordance with these specifications and in reasonably close conformance with the lines, grades, and cross sections as shown on the plans or as directed.

704.02 Materials

Materials shall be in accordance with the following:

Castings	910.05
Concrete, Class C	702
Joint Materials	906
Reinforcing Bars	910.01

CONSTRUCTION REQUIREMENTS

704.03 Forms

Forms shall be in accordance with 702.13.

The forms for transverse and longitudinal construction joints shall have a top plate conforming to either or both the grade and crown shown on the plans or as established. When forms are unsatisfactory in any way, either before or during placing of concrete, the placing shall be suspended until defects are corrected.

The welding of angles, clips, rods, or other designs for form supports to the flanges of steel beams or girders in the areas where flanges are designed to carry tensile stress will not be permitted. The areas where welding will be permitted will be established in writing.

704.04 Placing Reinforcement and Concrete

Applicable provisions of 703 shall apply to placing reinforcing bars. No concrete shall be placed until the reinforcement is entirely and securely in place and has been inspected and approved. Walkways shall be in accordance with 702.20(a). Placing of reinforcement during placing of concrete will not be permitted without prior written approval. Splices, when permitted, shall be at locations of least tension in the steel.

The concrete deck pour sequence and procedure shall be submitted for approval. The minimum pour rate is that which permits the finishing machine to progress at a rate of at least 25 ft/h (7.6 m/h). If this rate is not achieved, placement of transverse construction joints may be directed. The addition of construction joints shall be performed with no additional payment. Placement of concrete, when once started, shall be continuous between joints. Horizontal joints will not be permitted.

Floor drains shall be placed in gutters at locations shown on the plans and fastened securely before placing the surrounding concrete. The tops of the floor drains shall be no more than 1/2 in. (13 mm) below the adjacent gutter grade. The drains shall be constructed so drainage water is not discharged against portions of the structure.

Expansion joints shall be constructed as shown on the plans and the material shall be in accordance with 906.01.

Transverse construction joints as shown on the plans for the floor slab of prestressed concrete beam structures may be eliminated by written approval under the condition as follows:

(a) A retarding or a water-reducing retarding admixture shall be used in the concrete to delay set as required and approved.

(b) Concrete shall be placed for the full width of the structure, unless otherwise approved.

(c) It is determined that the concrete on 2 adjacent spans can be placed within a period of time which is less than the time for the initial set of the concrete section over the pier common to the 2 spans.

704.05 Finishing Concrete

Concrete shall be placed and spread to the approximate contour for the full width being placed. The concrete may then be consolidated by the use of mechanical internal vibrators in accordance with applicable provisions of 702.20(c). Vibrators shall not be used to spread or move the concrete horizontally to the extent that they cause segregation. Excessive vibration shall be avoided.

The use of a self-propelled finishing machine shall be used on all structures when either a new floor or an overlay is placed. Concrete for the full width of all traffic lanes shall then be struck off to proper profile grade and cross section by an approved, self-propelled, oscillating, finishing machine. The finishing machine may be for traffic lane widths or full width of the structure when approved. Manually operated strike-off may be used on areas outside of the width of traffic lanes or where required construction joints limit the length of deck pours to 60 ft (18.3 m) or less.

The finishing machine shall be in accordance with the applicable requirements of 508.04(b) except it shall have a minimum of 1 reciprocating non-vibrating screed. The weight of the machine shall not cause undue deflection of the bridge members or falsework. The machine shall travel on steel rails, pipe, or other approved grade control, which shall be adequately supported by adjustable support securely fastened in place at spacing sufficiently close to prevent any appreciable deflection of the screed. Welding of supports to structural bridge members will not be permitted. Prior

to the placing of concrete, rails for the machine support shall be set to correct elevations shown on the plans or as approved. Rails shall extend a sufficient distance beyond the area to be placed so that the machine clears all finishing operations. The screed or strike-off beam shall be made of metal or the bottom shall be metal-clad. The bottom of the screed or strike-off shall be adjusted to the true cross section of the floor surface. The machine shall make only the number of passes over the slab as required to obtain a uniform surface free of voids and reasonably true to the planned profiles and cross section. Any necessary hand finishing after removing the rails and rail supports shall be accomplished promptly, in order to fill any depressions and remove any roughness of the surface in the area from which the supports are removed. The longitudinal mechanical screeding method will be permitted when approved. A mechanical bridge deck finishing machine using a rotating cylinder setting approximately parallel to the longitudinal movement of the machine and operating transversely may be used for screeding the bridge deck, when approved.

When a finishing machine is not required or used, as soon as the concrete is placed and consolidated it shall be struck-off to the specified cross section and grade by means of a steel template or other satisfactory metal clad implement having a minimum width of 9 in. (225 mm) or greater.

For all methods of striking off the surface, an excess of concrete shall be kept in front of the cutting edge at all times. The strike-off shall go over the entire area only for the number of times necessary to produce the required profile and cross section. In general, the strike-off process shall be in accordance with 504 except a vibrator on the strike-off will not be required.

Immediately after screeding to the required cross section, the surface shall be checked with a long handled 10 ft (3 m) straightedge of light construction laid parallel to the centerline at intervals of no more than 2 ft (0.6 m) transversely and 5 ft (1.5 m) longitudinally. In case it is impracticable to operate the straightedge otherwise, it shall be operated from a footbridge or from bridges on the floor. All high spots shall be removed and depressions filled with fresh concrete and then leveled with a float having a blade approximately 5 ft (1.5 m) long and 8 in. (200 mm) wide. Floating and manipulating concrete to fill depressions shall be held to a minimum. Checking and leveling shall continue until the surface has the required contour and is free of voids. The application of water to the surface for the purpose of lubricating the floats and straight edges may be used only when absolutely necessary and shall be held to a minimum. The water applied for this purpose shall be limited to such quantity as may be applied by heavy fogging as approved.

As soon as the water begins to leave, the surface shall be given a final check with the lightweight straightedge. The required cross section shall be preserved. The final surface shall be free from porous spots caused by the disturbance of coarse aggregate particles during the final checking and brooming. After final checking, the surface shall be tined in accordance with 504.03. If a new bridge deck is to be

overlaid with latex modified concrete, the surface of such deck shall be heavily broom textured to provide maximum bonding of the overlay material.

Just before the concrete has taken the initial set, the ends of slabs, exposed edges, and transverse construction joints shall be rounded to a 1/4 in. (6 mm) radius. Longitudinal construction joints shall not be edged unless otherwise directed.

Smoothness shall be in accordance with 502.20. If, after the above requirements have been met, portions of the floor are not entirely satisfactory, the removal and replacement of such portions may be ordered to secure a satisfactory floor. Such removal and replacement shall be done with no additional payment.

704.06 Curing

Floor slabs shall be cured in accordance with one of the methods of 702.22. If membrane curing is used, no exposed reinforcement shall be coated with the material. Where it has been determined that a surface treatment to prevent scaling is to be used, the Engineer may prohibit the use of the membrane forming curing compound on the floor slab or any part of the superstructure. All vertical surfaces with exposed reinforcement shall be cured in accordance with 702.22. The floor shall be protected from pedestrian and vehicular traffic. If walking is necessary, the surface shall be timber laid on a double burlap cushion or approved equivalent.

Opening to traffic shall be in accordance with the applicable provisions of 702.24.

704.07 Method of Measurement

Concrete floor slab will be measured by the cubic yard (cubic meter) in accordance with 702.27. However, no allowance will be made for variations in beam fillet depths, coping depths, or diaphragm depths, which are deemed necessary due to the beam camber, as constructed, which varies from that shown on the plans. Reinforcing bars will be measured in accordance with 703.07. Castings will be measured in accordance with 702.27.

704.08 Basis of Payment

The accepted quantities of concrete floor slab will be paid for at the contract unit price per cubic yard (cubic meter) for concrete, C, superstructure. Reinforcing bars will be paid for in accordance with 703.08. Castings will be paid for in accordance with 702.28.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Concrete, C, Superstructure	CYS (m3)

The cost of forms, curing, finishing, preformed expansion joints within structure limits, and necessary incidentals shall be included in the cost of the pay items.

SECTION 705 – SIDEWALKS ON STRUCTURES

705.01 Description

This work shall consist of placing cement concrete sidewalks as an integral part of structures in accordance with 105.03.

705.02 Materials

Materials shall be in accordance with the following:

Concrete, Class C	702
Joint Filler	906.01
Reinforcing Bars	910.01

705.03 Construction Requirements

The concrete shall be placed in the forms in such amount that, after being tamped and struck off, the full required thickness results. Reinforcing bars shall be in accordance with 703.

After floating, the surface shall be marked into uniform rectangles by transverse markings formed with a jointer having 1/4 in. (6 mm) radii, if shown on the plans. On cantilevered sidewalks, a marking shall be placed over the center of each bracket and the space between brackets divided into uniformly marked rectangles as directed.

At expansion joints, the sidewalk and curb shall be cut entirely through and the specified type of joint installed. All edges shall be finished to a 1/4 in. (6 mm) radius.

As soon as finished, the sidewalk shall be cured for no less than 96 h in accordance with 704.06.

The surface shall be checked with a 10 ft (3 m) straightedge placed parallel to the centerline at sufficient transverse intervals to check the general contour. An acceptable surface shall vary no more than 1/8 in. (3 mm) from the straightedge, except at grade changes, and shall be free from blemishes.

705.04 Method of Measurement

Sidewalks on structures will be measured by the cubic yard (cubic meter) in accordance with the dimensions shown on the plans or as ordered. Reinforcing bars will be measured by the pound (kilogram) in accordance with 703.07.

705.05 Basis of Payment

The accepted quantities of sidewalks on structures will be paid for at the contract unit price per cubic yard (cubic meter) for concrete, C, superstructure.

Reinforcing bars will be paid for at the contract unit price per pound (kilogram) in accordance with 703.08.

Payment will be made under:

Pay Item	Pay Unit Symbol
Concrete, C, Superstructure	CYS (m3)

SECTION 706 – BRIDGE RAILINGS

706.01 Description

This work shall consist of the furnishing and placing of concrete or steel railings on bridges, on top of or aside wingwalls and retaining walls, and furnishing and placing reinforced concrete moment slabs in accordance with 105.03.

706.02 Materials

Materials shall be in accordance with the following:

Barrier Delineators	926.02(c)
Coarse Aggregate, Class B or Higher, Size No. 8 or 9	904
Concrete, Class C	702
Dowel Bars	910.01(b)10
Joint Materials	906
Organic Zinc Primer	909.02(a)2
Polyurethane Finish Coat	909.02(c)
Reinforcing Bars, Epoxy Coated	910.01
Steel Bridge Railing Components	910.20

Concrete for reinforced concrete moment slabs shall be QC/QA PCCP in accordance with 501 or PCCP in accordance with 502.

Thrie-beam railing and guardrail elements for retrofit bridge railing shall be steel and shall be in accordance with the applicable requirements of 910.09, 910.11 and 910.12 for steel beam guardrail.

CONSTRUCTION REQUIREMENTS

706.03 Concrete Railing

Concrete railings shall not be placed until the falsework for all of the spans have been removed and the spans are self supporting. Concrete railings shall be constructed in accordance with 702 and 703.

Forms shall be smooth, tight fitting, held true to line and grade, and be removed without damaging the concrete. These forms shall be made from selected dressed lumber or steel. Moldings, panel work, and bevel strips shall be constructed

according to the detail plans with mitered joints, true corners and be sharp, clean-cut, and free from cracks, spalls, or other defects. The forms shall be constructed with a plate at the base of the copings. Lumber which is 2 in. (50 mm) thick shall be used for coping forms.

The slip form method may be permitted as a means to place concrete railing on bridge structures. If the slip form method is chosen, a signed and dated QCP shall be prepared and submitted to the Engineer for acceptance at least 15 days prior to the start of slip form barrier rail placement. The QCP shall include, as a minimum, the Contractor's concrete mix design, including materials sources and admixtures; the Contractor's methods of materials control and testing; the Contractor's proposed method of placement, including finishing and curing; and the corrective action that will be taken when defects are found. The QCP shall also contain documentation that shows the Contractor had a successful trial demonstration of the slip form machine previously and that proper consolidation around the reinforcing bars in the wall was achieved. The slip form paver shall consolidate, screed, and finish the freshly placed concrete in 1 complete pass in such a manner that a minimum of hand finishing will be necessary to provide a dense and homogeneous railing in conformance with the plans and specifications. The slump shall be 1/2 ± 1/2 in. (13 ± 13 mm). The joints may be formed or sawed as long as a satisfactory joint is attained. If joints are to be sawed, the full depth saw cut shall be made before uncontrolled shrinkage cracking occurs and within 48 h of concrete placement. Before full depth sawing, partial depth saw cuts of 2 1/2 ± 1/2 in. (64 ± 13 mm) at the joint locations may be made as soon as the concrete has hardened sufficiently to permit sawing without raveling. All saw cuts shall be made at the locations shown on the plans or as directed.

All concrete bridge railings shall be reflectorized in accordance with 602.03(f).

Posts and joints shall be constructed perpendicular to grade. The line and grade shall not follow any unevenness of the superstructure.

If concrete railing is not in compliance with the specified design, does not present a uniform appearance of smoothness or color, or is not otherwise a workmanlike job, the Engineer may require such railing to be removed and replaced. The surface of the concrete shall vary no more than 1/4 in. in 10 ft (6 mm in 3 m) from the specified cross section, as measured longitudinally.

706.04 Concrete Railing With Reinforced Concrete Moment Slab

The railing portion shall be constructed in accordance with 602.03 except it shall be cast in place. Type D-1 contraction joints in the moment slab shall match the locations of the joints in the abutting PCC pavement. If the abutting pavement is HMA, the D-1 contraction joints shall be spaced at 18 ft (5.5 m).

Moment slabs shall be formed with either steel or wood forms in accordance with 508.04(c)1 or 508.04(c)2. Vibration of the concrete shall be in accordance with 702.20(c).

The underdrains for MSE walls layer shall be compacted in accordance with 302.06(b).

Type D-1 contraction joints and dowel bar assemblies shall be in accordance with 503.

Finishing and curing the moment slab shall be in accordance with 504. Finishing and curing the railing shall be in accordance with 702.

Job control testing for acceptance shall be in accordance with 502.05.

706.05 Steel Railings

Fabrication and placement of steel railings shall be completed in accordance with the applicable requirements of 711. Ends of tube sections shall be milled or sawed. Cut ends shall be true, smooth, and free from burrs and ragged edges. The rail system shall be continuous except as shown on the plans. Joints shall be spliced as detailed on the plans. Welding of steel shall be in accordance with 711.32. Radiographic, magnetic particle, and dye penetrant inspection will not be required. Anchor bolts shall be pre-set in concrete.

706.06 Method of Measurement

Concrete railing, including all concrete work above the top of curb, will be measured by the linear foot (meter) or by the cubic yard (cubic meter) in accordance with the dimensions shown on the plans. No deductions will be made for reinforcing bars or joints. Concrete bridge railing transition will be measured per each for the type specified.

Reinforced concrete moment slabs will be measured by the square yard (square meter) for the thickness specified. Underdrains for MSE walls placed under moment slabs will be measured in accordance with 718.09. Type D-1 contraction joints will be measured in accordance with 503.07.

Reinforcing bars in the railing will be measured in accordance with 703.07.

Barrier delineators will be measured in accordance with 602.05.

Steel railing will be measured by the linear foot (meter) in accordance with the dimensions shown on the plans or as directed.

Linear measurements will be made from end to end of the railing along the centerline.

706.07 Basis of Payment

The accepted quantities of concrete railing will be paid for at the contract price per linear foot (meter) or cubic yard (cubic meter), for railing, concrete, of the type

specified. Steel railing will be paid for at the contract unit price per linear foot (meter) of the type specified. Concrete bridge railing transitions will be paid for at the contract unit price per each for the type specified. Reinforced concrete moment slabs will be paid for at the contract unit price per square yard (square meter) for the thickness specified, complete in place. Underdrains for MSE walls placed under moment slabs will be paid for in accordance with 718.10. Type D-1 contraction joints will be paid for in accordance with 503.08. Reinforcing bars for concrete railings and concrete bridge railing transitions will be paid for in accordance with 703.08. Barrier delineator will be paid for in accordance with 602.06.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Coarse Aggregate, No. 8	CYS (m3)
Concrete Bridge Railing Transition, ____ type	EACH
Railing, Steel ____ type	LFT (m)
Railing, Concrete ____ type	LFT (m)
	CYS (m3)
Reinforced Concrete Moment Slab, ____ thickness	SYS (m2)

The cost of painting, washers, rivets, welding, anchor bolts, and necessary incidentals shall be included in the cost of the pay items in this section.

Concrete railing which the Engineer has ordered removed and replaced in accordance with 706.03 shall be with no additional payment.

The cost of the epoxy coated reinforcing bars and tie bars in the moment slab shall be included in the cost of the reinforced concrete moment slab.

The cost of all labor and materials required to provide for the monolithic concrete coping with moment slabs shall be included in the cost of the moment slab.

The cost of furnishing and placing all materials not specified as pay items shall be included in the cost of the pay items in this section.

SECTION 707 – PRECAST AND PRECAST PRESTRESSED CONCRETE STRUCTURAL MEMBERS

707.01 Description

This work shall consist of fabricating, furnishing, and installing reinforced precast concrete structural members, concrete deck panels cast outside the structure, transported to, and incorporated into the structure, or precast prestressed concrete structural members having a design 28-day concrete compressive strength, f'c, of up to and including 8,000 psi (55.2 MPa), all in accordance with 105.03.

707.02 Materials

Materials shall be in accordance with the following:

Admixtures for Concrete	912.03
Backer Rod	906.02(b)
Coarse Aggregates, Class A or Higher, Size No. 91	904
Concrete Curing Materials	912
Concrete Sealers	909.09, 909.10
Elastomeric Bearings	915.04
Fine Aggregates, Size No. 23	904
Fly Ash	901.02
Ground Granulated Blast Furnace Slag	901.03
PCC Sealer/Healer	901.06
Portland Cement	901.01(b)
Reinforcing Bars	910.01
Silica Fume	901.04
Uncoated 7 Wire Strand	910.01(b)7

Structural steel for steel intermediate diaphragms shall be in accordance with 910.02(a) and shall be galvanized in accordance with ASTM A 123 after cutting, bending, and welding. Bolts for steel intermediate diaphragms shall be 7/8 in. (22 mm) and in accordance with 910.02(g), except they shall be type 1. All bolts, nuts, washers, and similar threaded fasteners shall be galvanized in accordance with ASTM A 123 or may be mechanically zinc coated in accordance with ASTM B 695, class 50.

Tensioning rods and steel plates used with adjacent prestressed-concrete box beams shall be in accordance with ASTM A 706, Grade 36 (A 706M, Grade 250). Nuts used with such tensioning rods shall be heavy hex in accordance with ASTM A 563 (A 563M). Grout used with such beams shall be non-shrink in accordance with ASTM C 1107.

All precast non-prestressed structural members shall be manufactured by a Department Certified Precast Concrete Producer in accordance with ITM 813. All precast prestressed structural members including, but not limited to concrete deck

panels, box-beams, I-beams, U-beams, and bulb-T beams shall be manufactured in a Department approved plant in accordance with ITM 814.

CONSTRUCTION REQUIREMENTS

707.03 General Requirements

Dimensions and design requirements for structural members shall be as shown on the plans. Lengths and dimension tolerances shall be as shown on the plans or as otherwise specified. A beam which is to include a field attached curb shall have curb reinforcement located longitudinally within 3/4 in. (20 mm) of the locations shown on the plans. If detailed drawings are not included in the plans, working drawings shall be submitted for approval in accordance with 105.02. Certified mill test reports shall be furnished for all uncoated 7 wire strands.

Where temperature requirements are specified herein, the Contractor shall provide the Department with written verification that the temperature requirements have been met.

Prior to the beginning of fabrication, a prefabrication meeting shall be held at the fabrication facility or another agreed upon location. The meeting shall be conducted by the Contractor and attended by the fabricator's production supervisor and quality control inspector, and the Engineer. The Contractor shall take notes of the meeting and distribute copies to all attending parties within 5 days of the date of the meeting. Items to be discussed at the meeting shall include a minimum of: fabrication and shipping schedule including hours of operation; line of communication between Contractor and Engineer; material test reports; working drawings; special fabrication methods; fabrication hold points for inspection; final inspection and acceptance of materials; method of shipment. The requirement to hold prefabrication meetings may be waived by the Department.

A type A field office in accordance with 628 shall be provided at any facility that fabricates precast prestressed structural members for the Department's exclusive use. In lieu of a field office, a work area and the following items in accordance with 628 for the exclusive use by the Department shall be provided on the property where the structural members are being fabricated.

(a) office desktop
(b) office chair
(c) broadband internet service
(d) telephone
(e) fax machine
(f) copier
(g) filling cabinet.

707.04 Steel and Concrete Requirements

(a) Reinforcing Bars

A tight coat of concrete grout extending 1/2 in. maximum from the top of precast and precast prestressed concrete structural members will be permitted to remain on reinforcing bars extending from precast and precast prestressed structural members. All loose and flaky material on these reinforcing bars shall be removed. Lap splices shall be in accordance with 703.06.

(b) Prestressing Strands

Uncoated 7 wire strands shall be used as prestressing strands. The splicing of straight prestressing strands is acceptable provided that the location of the splice does not occur within a concrete structural member. Splicing of draped strands is not allowed. Spliced prestressing strands shall have the same twist or lap. For single strand tensioning, slippage of the splices should be considered in computing the elongation. For multiple strand tensioning, either all of the strands shall be spliced or not more than 10% of the strands. If all of the strands are spliced the average splice slippage shall be considered in computing the elongation. If 10% or less of the strands are spliced, no slippage allowance will be required.

Wire breaks will be permitted to remain on the prestressed concrete casting bed as follows:

Number of Strands in Bed	Wire Breaks
19 or fewer	0
20 through 39	1
40 through 59	2
60 or more	3

The ends of each permitted wire break shall be tied to the strand. If more than the permissible number of wire breaks appears in a particular strand pattern, or if more than 1 broken wire appears in an individual strand, such strands shall be removed and replaced.

The tolerance for the center of gravity for a prestressing strand group shall be ± 1/4 in. (± 6 mm). The tolerance for the longitudinal position of handling devices shall be ± 6 in. (± 150 mm).

(c) Concrete

Concrete shall be air entrained and in accordance with the applicable requirements of 702.05. The concrete shall have a minimum temperature of 50°F (10°C) and a maximum temperature of 90°F (32°C) at the time of placement. When a chemical admixture type A, D, F, or G is used, it shall be used in combination with an air entraining admixture. A high range water reducing, HRWR, or high range water reducing retarding, HRWRR, admixture system may be used. Chemical admixture types B, C, and E will only be allowed with prior written permission.

Air-entraining cement will not be permitted. The cement content of the mixed concrete shall be sufficient to obtain the specified minimum 28 day compressive strength. The total of portland cement and other cementitious materials shall be a minimum of 564 lbs/cu yd (335 kg/m^3) and shall not exceed 800 lb/cu yd (475 kg/m^3). Silica fume may be added in an amount not to exceed 5% of the total cementitious material.

When a type A, D, or E admixture is not used, or if a type B or C chemical admixture is used, slump shall be no less than 1 in. (25 mm) or more than 3 in. (75 mm). When concrete admixtures type A, D, or E is used, slump shall be no less than 2 in. (50 mm) or more than 5 in. (125 mm). When concrete containing admixture type F, G, or admixture systems is used, the concrete shall have a slump no less than 3 in. (75 mm) or more than 8 in. (200 mm). The amount of time from mixing to placement and consolidation shall be a maximum of 30 min. The concrete shall not be retempered with additional amounts of chemical admixture types F or G after the initial mixing has been completed.

1. Cold Weather Concrete

Cold weather concrete shall be in accordance with 702.11.

2. Hot Weather Concrete

When it is necessary to fabricate concrete structural members during times of hot weather the mix water may be chilled or an appropriate amount of ice may be added to the concrete mix in order to produce concrete of the temperature specified herein.

3. Acceptance Testing

Acceptance of precast and precast prestressed structural members will be based on tests for slump, air content, and compressive strength. All slump, air content, and compressive strength tests shall be performed in the presence of the Engineer. Slump and air content measurements shall be obtained each time cylinders are made. Compressive strengths of the structural members shall be determined from cylinder sets described herein. The 28-day compressive strength shall be equal to or greater than the specified concrete compressive strength. The compressive strength of the concrete for each structural member will be determined from the average strength of the cylinder set representing that member. No individual strength within a cylinder set representing a structural member shall be less than 90% of the specified concrete compressive strength.

All molds, facilities, labor, and materials necessary to prepare, cure, and test the cylinder sets shall be furnished.

a. Cylinder Set

A cylinder set shall consist of at least 3 cylinders obtained from 3 separate batches or loads of concrete used in casting a structural member. The batches or loads to be sampled may be as directed by the Engineer. All cylinders for acceptance

shall be 6 in. diameter by 12 in., molded and field cured in accordance with ASTM C 31. The Contractor may make additional cylinder sets for use in acceptance testing.

All cylinders shall be identified by use of Department-marked cylinder identification tags which are inserted a maximum of 3/8 in. (10 mm) into the top of each freshly molded cylinder. The cylinder number, a unique structural member identification number, temperature, air content, and slump of the concrete represented by each cylinder shall be referenced to the numbers on these cylinder identification tags and provided to the Engineer by the end of each day in which cylinders are cast.

Cylinders shall be stored as near as possible to the point of deposit of the concrete represented. All surfaces of the cylinders shall be protected from the elements in the same manner as the formed structural members. Cylinders shall be cured at the same temperature and moisture environment as the structural members.

Cylinders shall be in the moisture condition resulting from the selected curing treatment prior to testing. To meet these conditions, the cylinders shall be removed from the molds at the time the structural member is removed from the form work. Cylinders shall be tested in accordance with ASTM C 39. The Contractor shall have on file a certificate of calibration for the testing machine. All cylinders in a cylinder set, for a given age, shall be broken within the time tolerances shown in ASTM C 39. The Department will remove cylinder identification tags prior to the Contractor testing the cylinders.

b. Precast, Non-Prestressed Structural Members

When fabricating precast non-prestressed structural members, a minimum of 1 cylinder set shall be made per member cast. The 28-day compressive strength of the concrete for each structural member will be determined by the average strength of the cylinder set representing that member. The fabricator may elect to make additional cylinder sets for use in acceptance testing prior to 28 days.

c. Precast, Prestressed Structural Members

A minimum of 2 cylinder sets shall be made for each structural member cast. One cylinder set shall be tested and used to determine when the precast prestressed structural member has met or exceeded the required strength for detensioning the prestressing bed. If an additional cylinder set as described above has been made, the Contractor may test this set to determine if the required strength for detensioning of the prestressing bed has been met or exceeded, or if the required 28-day compressive strength has been met or exceeded prior to an age of 28 days. The Engineer will accept the results from the compression testing on the additional cylinder set, in place of either the detensioning strength test results, or the 28-day compressive strength test results, if the results equal or exceed the respective compressive strength requirements. If an additional cylinder set was not made, or if the additional cylinder set does not meet or exceed the 28-day compressive strength requirement, the

remaining cylinder set shall be tested at 28 days of age to determine the acceptability of the structural members.

Coring of precast prestressed structural members shall not be performed. Precast prestressed structural members that have been cored will not be accepted. Compressive strength results for cylinders that exceed 28 days in age or results from cylinders that do not have the Department-marked cylinder identification tag intact will result in the structural members not being accepted.

(d) Other Requirements

Precast concrete structural members which are not prestressed shall have a minimum compressive strength of 4,500 psi (31 MPa) in 28 days. Precast prestressed structural members shall be in accordance with the following unless otherwise shown on the plans:

1. Maximum water/cementitious ratio in pounds (kilograms) of water per pound (kilogram) of cementitious material shall be 0.420.

2. Minimum 28-day compressive strength of concrete shall be 5,000 psi (34.5 MPa).

3. Minimum compressive strength of concrete at time of prestressing shall be 4,000 psi (28 MPa).

4. Initial tension of prestressing strands shall be as shown on the plans.

Inspection of the precast prestressed structural member during manufacture and checking and testing aggregates, cement, concrete, and steel specimens shall be performed. All specimens shall be furnished without cost to the Department. Inspection, checking, and testing performed by the Department will not relieve the Contractor or the fabricator from performing their own quality control inspection, testing, and checking as necessary to maintain quality control over the manufacturing, handling, and curing procedure. A permanent record of the force applied to and measured elongation obtained for each prestressing strand and the identification of the strand and structural member to which the record applies shall be provided. This record shall be certified that it accurately represents the force applied and measured elongation by the fabricator's production supervisor and provided to the Engineer prior to shipment.

707.05 Forms

Structural members shall be manufactured in steel forms which are unyielding, smooth, mortar-tight, and of sufficient rigidity to prevent distortion due to pressure of the concrete. They shall be so designed that the finished concrete is in accordance with the required dimensions and contours. The design of the forms shall take into account the effect of vibration of the concrete as it is placed. Forms shall be

chamfered in accordance with 702.13(a). Exposed edges of curbs shall be beveled or edged. Forms shall be set and maintained true to the lines designated until the concrete is sufficiently hardened or for periods hereinafter specified. Interiors of forms shall be treated with an approved formulated form coating which allows them to be released without adhering, discoloring, or otherwise damaging the concrete. Form coating materials shall not come in contact with either reinforcing bars or prestressing strands.

707.06 Placing and Finishing Concrete

The temperature of the prestressing strands and forms shall be monitored between the time of the application of prestressing force and the placement of the concrete. During hot weather, approved means shall be undertaken to cool the forms immediately prior to placement of the concrete.

When abutment anchorage set-ups where prestressing strands are anchored to abutments that are independent from the form, thermal adjustments shall be made if the temperature of the prestressing strands at the time of tensioning differs by more than 25°F (15°C) from the temperature of the concrete mixture during placement. This requirement will not apply to self-stressing beds.

Void boxes, inserts, and attachments shall be securely fastened in order to maintain the proper position during concrete placement and consolidation. All voids shall have weep holes or otherwise be vented during beam production until after the initial concrete set, then sealed before the beams are shipped.

Concrete, during and immediately after depositing, shall be consolidated with vibrators and suitable spading tools. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators used may be internal, external, or a combination of both. Internal vibration shall be of sufficient duration and intensity to consolidate thoroughly, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point so that localized areas of grout are formed.

The entire operation of depositing and consolidating the concrete shall be conducted so that the concrete will be smooth, dense, and free from any honeycomb or pockets of segregated aggregates. The concrete in each structural member shall be placed in 1 continuous operation. The outside vertical faces of fascia structural members and the exposed face and top of the curb section, if applicable, shall be finished in accordance with 702.21.

The tops of all beams and the outside faces and bottom flanges of the fascia beams shall be sealed in accordance with 709.

707.07 Removal of Forms and Curing

Curing shall be in an enclosure designed to minimize heat and moisture loss. Insulated blankets may be used. The concrete in the form shall be maintained at a

minimum temperature of 50°F (10°C) during the entire curing cycle. Curing for precast or precast prestressed structural members shall be done by wet curing without supplemental heat or by accelerated curing. During the period of initial set of the structural member and during the accelerated curing by radiant heat, the concrete shall be kept wet by the method outlined below for wet curing without supplemental heat.

Approval shall be obtained before curing is done by any means other than those outlined below.

Side forms may be removed when no distortion, slump, or misalignment of the concrete will result. Precast structural members which are not prestressed shall remain on the bottom supporting forms for the span until the concrete has reached a strength of at least 2,000 psi (13.8 MPa) as evidenced by cylinders sets made and cured in the same manner as the slab.

(a) Wet Curing without Supplemental Heat

When wet curing without supplemental heat is used, the exposed surfaces of the structural members shall be covered by 2 layers of wet burlap and the burlap shall be kept wet to ensure that free water is present at all times. In lieu of using wet burlap, the Contractor may propose an alternate method which provides a moist environment with free water being present at all times. Written approval from the Engineer will be required prior to use of the proposed alternate method. Additional curing of precast or precast prestressed structural members will not be required provided the minimum specified ultimate strength can be obtained.

In precast prestressed concrete structural members, wet curing without supplemental heat shall continue until such time as the compressive strength of the concrete reaches or exceeds the strength specified for transfer of prestress or detensioning. At this point wet curing is considered to have concluded. Detensioning shall be performed within 6 h after wet curing has concluded. In precast non-prestressed structural members, wet curing without supplemental heat shall continue until such time as the compressive strength of the concrete reaches the strength specified for stripping of forms.

(b) Accelerated Curing

When accelerated curing of the concrete is used, it shall be done by low pressure steam or radiant heat curing. Radiant heat may be applied by means of pipes circulating steam, hot oil or hot water, or by electric heating elements. When steam is used, the jets shall be positioned so that they do not discharge directly on the concrete, forms, or cylinders. The steam shall be at 100% relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement.

Except to maintain a minimum concrete temperature of 50°F (10°C), heat shall not be applied until the concrete has attained initial set. The time of initial set may be determined by ASTM C 403. Once the penetration resistance, as performed in

accordance with ASTM C 403, equals or exceeds 500 psi (3.5 MPa) accelerated curing may begin. When the initial set is not determined by ASTM C 403, the initial application of heat shall be a minimum of 4 h after final concrete placement. When retarders are used and the initial set is not determined by ASTM C 403, this time shall be increased to a minimum of 6 h after final concrete placement. Heat shall always be applied at a controlled rate following the initial set of the concrete, and an effective method of retaining the heat and moisture in the concrete shall be used during the entire curing cycle.

During the initial application of radiant heat or live steam, the temperature measured in the concrete shall increase at an average rate not exceeding 36°F/h (20°C/h). The maximum concrete temperature shall not exceed 158°F (70°C). A minimum of 3 time and temperature recording devices capable of recording temperatures in degrees Fahrenheit or Celsius at intervals not exceeding 15 minutes shall be provided throughout a contiguous form group and common heat source. The time and temperature recording devices shall be located at the portions of the contiguous form group likely to experience the maximum temperatures during curing.

The curing temperature shall be sustained until the concrete has reached the minimum required strength for detensioning the structural members.

As the application of heat is discontinued, the concrete temperature shall decrease at a rate not to exceed 50°F/h (28°C/h). When the concrete temperature has reached 40°F (22°C) or less above the ambient temperature outside the curing enclosure, accelerated curing is considered to have concluded. Detensioning shall be performed after accelerated curing has concluded, provided the compressive strength of the concrete in the structural member has met or exceeded the specified release strength. A thermometer shall be provided to monitor ambient air temperatures. This thermometer does not have to have recording capabilities.

The time and temperature recording devices shall be used to verify compliance with the heating and cooling rates contained herein.

When multiple structural members are cast in the same bed, all members shall meet or exceed the specified release strength prior to detensioning. Additional curing of precast or precast prestressed structural members will not be required provided the minimum specified ultimate strength can be obtained.

A grinder or other methods that induce minimal amounts of heat into the prestressing strand shall be used to cut off prestressing strands. The ends of the concrete structural member where prestressing strands have been cut to be flush with the end of the member shall be coated with bituminous mastic sealant in accordance with 907.11. All prestressing strands that are exposed and protrude from the end of the beam shall be protected from rusting by use of a spray, brush, or roller-applied

rust-inhibiting paint or other material that is not considered detrimental to bonding with concrete.

707.08 Handling and Shipping

Precast and precast prestressed structural members shall not be subjected to excessive abuse which produces crushing or undue marring of the concrete. All structural members damaged during handling, storing, transporting, or erecting shall be replaced. Unless otherwise approved, precast and precast prestressed structural members shall be handled with a suitable hoisting device provided with a spreader sling. The spreader shall be of sufficient length to prevent horizontal forces being produced in the structural member due to lifting and shall be equipped with leads and hooks at each end. The structural members shall be lifted by the devices shown on the plans. Proposed alternate lifting devices and procedures shall be approved prior to use and shown on the working drawings. If any other method of handling is used, it shall be shown on the working drawings and approved prior to use. If the method produces horizontal forces in the precast or precast prestressed structural member, sufficient reinforcement shall be added to compensate for them.

The structural members shall remain in an upright position at all times and shall be supported as indicated herein when in storage and during transportation to the construction site.

In storage, all structural members shall be fully supported across their width on battens not less than 4 in. (100 mm) wide with 1 being placed at each end at the centerline of the bearing. The supports of the structural members while in storage shall be maintained in a level position so no twisting occurs.

Precast structural members shall not be shipped nor used until the concrete compressive strength reaches a minimum of 4,500 psi (31 MPa) for members which are not prestressed and 5,000 psi (34.5 MPa) for members which are prestressed.

During transportation, the structural members shall be supported with truck bolsters or battens no less than 4 in. (100 mm) wide which are padded with no less than 1/2 in. (13 mm) of rubber. The ends of I-beams, U-beams, and bulb-T beams shall extend no more than the depth of the beam and not more than 3 ft 6 in. (1 m) beyond the supports. The ends of box-beams shall extend no more than 1 1/2 times their depth and not more than 3 ft (0.9 m) beyond the supports. The ends of slabs shall extend no more than the depth of the beam beyond the supports. Supports of cantilever beams shall be as shown on the plans. Trucks with double bolsters will be permitted, provided the beams are fully seated on the outer bolsters and the inner bolsters are no more than 8 ft (2.4 m) from the ends of the beams. Wood blocks or other suitable material shall be placed under the tie chains to prevent chipping the concrete.

707.09 Placing Structural Members

Erection of precast prestressed structural members shall commence at the centerline and proceed out to the curb, 1 member at a time. As each structural member is placed, the transverse tie bars, if shown on the plans, shall be inserted and secured. Any shifting of the structural members shall be done while they are held free of the supports by the hoisting device. The use of a steel pinch bar will not be permitted. Structural members shall be set to proper line and grade with uniform bearing on bridge seats, mortar joints, or bearing pads as required on the plans. When required, structural members shall be secured to the pier or bent with dowel rods. Holes for dowels shall be filled with mortar at fixed ends and with crack or joint filler at expansion ends. Longitudinal keyway joints shall be cleaned. A coat of cement mortar shall be scrubbed on the surface. The joint shall be filled with a non-shrinking grout composed of 1 part portland cement, 2 parts No. 23 fine aggregate, and an approved non-shrinking additive or a non-shrink, non-metallic cementation grout in accordance with ASTM C 1107. All bolts or drains shown on the plans as necessary or desirable to be placed in the concrete shall be placed by the methods and at the locations shown on the plans. Necessary tie rods, tie bolts, and hardware for tying structural members together shall be furnished.

Dowel holes shall not be grouted nor concrete or the forming thereof, be placed in floor slabs, diaphragms, or shear keys prior to receipt of complete documentation of the acceptability of the structural members and bearing pads, including the satisfactory laboratory reports and certifications in accordance with 915.04(e). Neither the structural members, nor the bearings will be considered incorporated into the work, and neither will be paid for until this documentation is accomplished satisfactorily.

Railing, when required, shall be of the type shown on the plans. The component parts shall be in accordance with 706, unless otherwise indicated on the plans. Other precast or precast prestressed structural members shall be placed in the structure in accordance with the plans and the specifications or special provisions indicated for the type of structure being built.

Cranes or other heavy erection equipment may be operated on the precast or precast prestressed structural members only if approved in writing and if a proposed operating procedure is submitted showing loading, distribution of loads, resulting stresses, and that the design of the structural members is satisfactory to permit. However, such approval shall not relieve the Contractor of any damage from this operation.

After adjacent prestressed-concrete box beams are in place, the transverse tensioning rods shall be preliminarily tightened as shown on the plans. The rods shall be final tensioned as shown on the plans. The final tensioning shall yield 20,000 psi (138 MPa) as developed by means of a torque of 19 lb/ft (271 N/m). The tensioning-rod recesses and longitudinal joints between beams shall be filled with grout.

707.10 Precast Prestressed Concrete Deck Panels

Precast prestressed concrete deck panels shall be designed as a non-composite section to support the dead load of the panel, reinforcement, plastic concrete, and a construction load of 50 lb/sq ft (2.4 kPa).

When the Contractor elects to use precast prestressed deck panels, the panel shall be designed as a composite section with class C concrete to support the live load. The Contractor shall revise the area of top longitudinal reinforcing bars in the deck over interior supports for negative moment to be equal to the total area of top and bottom longitudinal reinforcing bars.

Working drawings shall be submitted in accordance with 105.02. Design calculations shall be submitted only for total slab thicknesses greater than 8 in. (200 mm) or clear spans in excess of 7 ft 6 in. (2.3 m). Design shall be in accordance with the AASHTO LRFD Bridge Design Specifications as shown on the plans. Details such as type, size, and location of the reinforcing bars, the prestressing strands, WWR, and concrete shall be as shown on the plans.

The concrete for deck panels shall be placed in accordance with 702.20. The concrete shall be vibrated to prevent honeycombs and voids, especially at the corners and edges of the panels. The tops of the deck panels shall be broom or wire brush finished in the direction of the prestressing strands. The corrugations formed shall be uniform in appearance and shall not be more than 1/4 in. (6 mm) in depth. The coarse aggregate shall not be displaced when preparing the roughened surface.

707.11 Method of Measurement

Precast or precast prestressed concrete structural members will be measured by the linear foot (meter). Railing will be measured in accordance with 706.06 if specified as a pay item. Structural steel for intermediate diaphragms will not be measured.

When the Contractor elects to use precast prestressed concrete deck panels, the panels will not be measured for payment.

707.12 Basis of Payment

The accepted quantities of precast or precast prestressed concrete structural members will be paid for at the contract unit price per linear foot (meter) for structural member, concrete, of the type and size specified.

Railing will be paid for in accordance with 706.07 when specified as a pay item.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Structural Member, Concrete, ____, ____ (type, size)	LFT (m)

Reinforcing bars, prestressing strands, elastomeric bearing pads, modifications to bearing pads, bearing beams required for box beams, bearing assemblies required for I-beams, bulb-T beams, U-beams, and box beams, bearing plates, expanded polystyrene, threaded reinforcing bars, threaded inserts in fascia beams, hex bolts, sealer on the outside face and bottom flange of fascia beams and on the tops of all beams, and necessary incidentals shall be included in the cost of the pay items of this section. The cost of tensioning rods and steel plates shall be included in the cost of the pay items of this section. The cost for providing all molds, cylinder identification tags, facilities, labor, and materials necessary to prepare and cure the test specimens required for work in this section shall be included in the cost of the pay items in this section.

No payment will be made for removing and replacing prestressing strands due to excessive wire breakage, or replacing precast or precast prestressed structural members damaged during handling, storing, transporting or erecting.

When the Contractor elects to use precast prestressed concrete deck panels, the cost of the panels shall be included in the cost of class C concrete in superstructure.

The cost of railing shall be included in the cost of the pay items of this section if such railing is not specified as a pay item.

The cost of all materials, including galvanizing, labor, and equipment for furnishing and installing steel intermediate diaphragms shall be included in the cost of structural member, concrete of the type and size specified.

The cost of time and temperature recording devices and their monitoring shall be included in the cost of the structural members.

The cost of a field office or of providing the field office items listed herein shall be included in the cost of the pay items of this section.

SECTION 708 – PNEUMATICALLY PLACED MORTAR

708.01 Description

This work shall consist of preparing stone, concrete, or other surfaces for and the pneumatic application of mortar as a plain or reinforced coating in accordance with these specifications and as shown on the plans or as directed.

708.02 Materials

Materials shall be in accordance with the following:

Fine Aggregate	904.02(d)
Fly Ash	901.02
Portland Cement	901.01(b)

Water 913.01
Welded Steel Wire Reinforcement ..... 910.01(b)5

WWR shall consist of wire, size W 1.5 or approximately No. 10 gage (3.43 mm), spaced and welded at 3 in. (75 mm) intervals, or wire, size W 1 or approximately No. 12 gage (2.68 mm), spaced and welded at 2 in. (50 mm) intervals.

CONSTRUCTION REQUIREMENTS

708.03 Preparing Surface

The surface of all steel to be covered shall be thoroughly cleaned of all paint, rust, grease, dirt, or other foreign materials. All loose or defective portions of masonry to be covered shall be removed and the surface thus exposed cleaned. The use of a sand blast as an aid in cleaning any surface may be required.

708.04 Reinforcement

If WWR is required, it shall be cut into sheets of the proper sizes and bent carefully over a template so that the mesh closely follows the outline of the member to be covered. It shall be attached to such members at intervals of not to exceed 2 ft (0.6 m).

Insofar as feasible, the mesh shall parallel the surface of steel members 3/4 in. (19 mm) out from the face. Where sheets meet, they shall lap at least 4 in. (100 mm) and shall be fastened together securely.

WWR shall be used in all areas where the thickness of the mortar exceeds 3 in. (75 mm) and also if the present steel reinforcement is exposed after the disintegrated concrete has been removed. WWR shall be fastened to the concrete masonry with 1/4 in. (6 mm) machine bolts screwed into lead anchors driven into holes drilled into the concrete, or by pins or nails shot into the concrete by an impact gun. Such bolts or pins shall be spaced on 8 in. (200 mm) centers in each direction and shall be of sufficient length to space the WWR approximately 2 in. (50 mm) from the surface being repaired. Where WWR can be fastened to the reinforcing bars, the bolts, pins, or nails may be omitted.

708.05 Proportioning and Mixing

The dry mixture shall consist of 1 part portland cement to 3 parts sand. The cement and sand shall be dry mixed in an approved proportioning plant or in batch boxes. Measurement may be by volume or weight. Before placing the proportioned materials in the hopper of the application gun, all lumps 1/4 in. (6 mm) or over shall be removed by screening.

708.06 Placing Mortar

This work shall be done only by experienced personnel. No one operating the nozzle will be deemed experienced unless they have satisfactorily completed similar work on other structures of like type.

Just prior to placing mortar, the surface shall be washed with water and compressed air. The mortar shall be placed on a wet surface.

The equipment for placing the mortar shall be operated in accordance with the recommendations of the manufacturer.

In shooting any surface, the nozzle shall be held at such distance and in such position that the flowing stream of material impinges, as nearly as possible, at right angles to the surface being covered. All deposits of loose sand shall be removed. Shooting shall start on those areas where the greatest thickness is required. Mortar shall not be applied more than 2 in. (50 mm) thick in 1 operation. Where a finished thickness of more than 2 in. (50 mm) is required, it shall be obtained in successive operations and enough time allowed to permit the previous layer to set. During application, the required thickness shall be maintained by shooting strips. A full thickness shall be obtained over thin edges of steel.

After completion of a section of coating, all high spots shall be cut off with a sharp trowel or screeded to a true plane as determined by the shooting strips. Finished edges shall be true and even.

708.07 Finishing

After all surfaces have been brought to the required contour and smoothness, they shall be finished with a flash coat approximately 1/8 in. (3 mm) thick. This coat shall produce a uniform color and finish and an approved appearance on all exposed surfaces. Proportioning and mixing of the flash coat shall be in accordance with 708.05 except white portland cement shall be used. Before placing the proportioned materials in the hopper of the application gun, all lumps 1/8 in. (3 mm) or larger shall be removed by screening. No less than 1 bag of the white cement to each 300 sq ft (28 m^2) of surface shall be used.

Immediately after completion, the surface shall be covered with wet burlap or wet cotton mats and these shall be kept wet for at least 96 h. No mortar shall be placed when the air temperature is below 50°F (10°C) nor against a surface which contains frost. After the work has been completed, all rebound and other debris shall be removed from the work.

708.08 Method of Measurement

Pneumatically placed mortar will be measured by the square foot (square meter), complete in place. The area measured will be the actual finished surface. WWR, where used, will be measured by the square foot (square meter), complete in place.

708.09 Basis of Payment

The accepted quantities of pneumatically placed mortar and WWR will be paid for at the contract unit price per square foot (square meter), complete in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Pneumatically Placed Mortar	SFT (m2)
Welded Steel Wire Reinforcement	SFT (m2)

The areas where loose or defective portions of masonry exceed an average of 4 in. (100 mm) in depth will be paid for at a price to be determined by multiplying the contract unit price for pneumatically placed mortar, respectively, by the factors as follows:

(a) for portions thereof whose average depth is greater than 4 in. (100 mm) but less than 6 in. (150 mm) 1.25

(b) for portions thereof whose average depth is greater than or equal to 6 in. (150 mm) but less than 8 in. (200 mm) 1.50

(c) for portions thereof whose average depth is greater than or equal to 8 in. (200 mm) but less than 10 in. (250 mm) 1.75

(d) for portions thereof whose average depth is greater than or equal to 10 in. (250 mm) but less than 12 in. (300 mm) 2.00

(e) for all portions thereof whose average depth is greater than or equal to 12 in. (300 mm), the work shall be done as extra work. Payment will be made in accordance with 104.03.

SECTION 709 – PORTLAND CEMENT CONCRETE SEALERS

709.01 Description

This work shall consist of cleaning the concrete surface by sandblasting and applying a concrete sealer in accordance with 105.03. Surfaces to be sealed with PCC sealers shall be given a finish in accordance with 702.21. Where existing concrete or bridge decks are to be sealed, their surfaces shall be sandblasted to remove all foreign materials.

709.02 Materials

Materials shall be in accordance with the following:

Epoxy Penetrating Sealers	909.09
Other Portland Cement Concrete Sealers	909.10

CONSTRUCTION REQUIREMENTS

709.03 Surface Preparation

The surface to be sealed shall be thoroughly cleaned of all foreign materials by sandblasting if the surface is a bridge deck or older existing concrete, or by air blasting for all other surfaces, just prior to sealing. The air compressor shall be equipped with suitable separators, traps, or filters which remove water, oil, grease, or other substances from the air lines. If rain sufficient to uniformly wet the surface occurs after the cleaning operations and prior to the sealing, the surface to be sealed shall be re-sandblasted or re-airblasted.

709.04 Environmental Requirements

(a) General Requirements

Concrete sealer shall not be applied in rainy conditions or if rain is anticipated within 2 h after application. Concrete sealer shall be applied when the temperature of the concrete surface to be sealed is 40°F (4°C) or above and when the air temperature is 50°F (10°C) or above, unless otherwise approved in writing. Concrete sealer shall not be applied when the ambient temperature is expected to fall below 35°F (2°C) within 12 h after application.

(b) Epoxy Penetrating Sealers

Cast-in-place concrete shall have a minimum of 72 h dry cure prior to the application of epoxy penetrating sealer.

(c) Other Portland Cement Concrete Sealers

The concrete to be sealed shall be cured as stated on the list of approved Other Portland Cement Concrete Sealers prior to sealer application.

(d) Low Temperature Epoxy Penetrating Sealer

A low temperature epoxy penetrating sealer shall be applied in accordance with the requirements for epoxy penetrating sealer. However, the low temperature epoxy penetrating sealer shall be applied when the temperatures of the concrete surface and the air are 35°F (2°C) or above. Low temperature concrete sealer shall not be applied when the ambient temperature is expected to fall below 20°F (-7°C) within 12 h of application.

709.05 Sealer Application

(a) General Requirements

The concrete surface to be sealed shall be completely cleaned and shall be dry and dust free prior to the application of concrete sealer. The concrete sealer shall be applied in a crisscross pattern and should any flat or dry spots appear, more sealer shall be applied. However, there shall be no puddling of material on the surface. The sealed surface shall be allowed to cure in accordance with the manufacturer's

recommendations. No vehicular traffic will be allowed on the sealed surface during the curing time.

A qualified technical representative of the manufacturer may be required to be on the job the 1st day the sealer is used. It shall be this representative's responsibility to instruct the workers in proper mixing, application technique, and safety precautions.

(b) Epoxy Penetrating Sealer

The mixing of the 2-component parts of the epoxy penetrating sealer, their handling and application on the concrete surface shall be in strict accordance with the recommendations of the manufacturer except as may be otherwise specifically covered in these specifications. Under no circumstances shall any solvent be added to the compounds.

The epoxy penetrating sealer shall be applied at the rate of 90 to 110 sq ft/gal. (2.2 to 2.7 m^2/L). The sealer shall be mixed in the exact manner the manufacturer recommends. After the material has been adequately mixed, preferably by power, and the induction time completed in accordance to manufacturer's recommendations, it shall be applied to the cleaned dry surface by brush, roller, squeegee, or other approved method.

All cracks shall be filled before beginning the complete sealing of the entire required surface. This crack filling operation shall cure a minimum of 2 h or in accordance with the manufacturer's recommendations before the complete surface is sealed with the epoxy penetrating sealer. After the surface has been sealed and properly cured, all cracks that are not completely filled shall be retreated. This retreatment of cracks shall be completed within 72 h.

After sufficient amounts of the epoxy penetrating sealer have been applied and before the material has started its initial set or becomes tacky, a light coating of dry clean sand shall be broadcast at a rate of 1 to 2 lb/sq yd (0.6 to 1.10 kg/m^2) onto all treated surfaces which carry vehicular or pedestrian traffic. The sand shall contain not less than 90% silica and shall be in accordance with the following gradation:

SIEVE	PERCENT PASSING
No. 16 (1.18 mm)	100
No. 100 (150 µm)	0-5

After the sand has been applied, the sealed surface shall be allowed to cure.

(c) Other Portland Cement Concrete Sealers

The sealer chosen for use shall be applied at the application rate specified on the list of approved Other Portland Cement Concrete Sealers. The sealer shall be applied without dilution or alteration. Sealers, which are applied by spraying shall be sprayed

onto the concrete surface using low pressure spray equipment with a sufficient number of passes to achieve the minimum application rate and a uniform coverage. The low pressure spray apparatus shall have a 15 psi (105 kPa) maximum nozzle pressure with a course fan spray, such as a garden, form oil, horticulture, or other low pressure sprayer. The spray equipment tanks, and hoses shall be thoroughly clean, free of foreign matter, oil, residue, and water prior to use. Sealers shall be selected from the Department's list of approved Other Portland Cement Concrete Sealers and shall be spread to achieve uniform coverage. If roller spreading is required, a clean new roller shall be used for each application sequence. If brooming is specified, a clean, stiff-bristled broom shall be used to spread and work the sealer into the concrete surface.

(d) Clear Sealers

Clear sealers shall be used on all vertical wall surfaces such as concrete bridge railing, barrier wall, exterior concrete bridge beams, etc., when sealing is specified for these items. The epoxy penetrating sealers are not clear sealers. Clear sealers will be those identified on the list of approved Other Portland Cement Concrete Sealers.

(e) Alternate To Concrete Sealers

In lieu of concrete surface sealing for concrete barrier wall and concrete bridge railing, an alternate concrete mix design may be used. The concrete mix design shall be as specified, except either 3% silica fume by weight (mass) of cementitious material shall be added to the mix design or 30% ground granulated blast furnace slag substitution based on the required cement content shall be incorporated into the mix. The substitution of ground granulated blast furnace slag shall be in accordance with 702.05. A water-reducing admixture or a water-reducing retarding admixture shall be used in the mix design, and the amount of water added shall be adjusted accordingly. The use of these admixtures shall be in accordance with 702.05.

When one of these alternate concrete mix designs are used in lieu of a concrete surface sealer, a finish in accordance with 702.21 will be required.

709.06 Safety Precautions

Epoxy materials are toxic and may be dermititic. Precautions shall be taken to protect workers from the hazards of these materials. Solvents in the epoxy penetrating sealers and some of the other sealers are flammable. All necessary precautions shall be taken pertaining to the handling and potential overspray of these concrete sealers.

709.07 Method of Measurement

Since payment will be made in a lump sum, only those measurements necessary to verify application rates will be made.

709.08 Basis of Payment

The accepted quantities of this work will be paid for at the contract lump sum price for surface seal.

If an alternate concrete mix design in accordance with 709.05(e) is used in lieu of concrete surface sealing or portions thereof, it will be paid for as surface seal.

Payment will be made under:

Pay Item	Pay Unit Symbol
Surface Seal	LS

The cost of all materials, labor, equipment, and necessary incidentals shall be included in the cost of this work.

If a curing-sealing material in accordance with 702.22(c) is used in lieu of sealing concrete surfaces or portions thereof, it will be paid for as surface seal.

SECTION 710 – PATCHING CONCRETE STRUCTURES AND REPOINTING MASONRY IN STRUCTURES

710.01 Description

This work consists of patching concrete piers, end bents, abutments, wingwalls, retaining walls, concrete structure surfaces other than bridge decks, and patching concrete drainage structures, and repointing rubble, dressed stone, or brick masonry structures in accordance with 105.03.

Bridge deck patching shall be in accordance with 722.

710.02 Materials

Materials shall be in accordance with the following:

Coarse Aggregate, Class A or Higher, Size No. 11	904
Concrete, Class A	702.02
Curing Compound	912.01
Epoxy Resin Adhesive	909.11
Fine Aggregate	904.01
Hydrated Lime	913.04
Masonry Cement	901.01(c)
Portland Cement, Type I	901.01(b)
Reinforcing Bars	910.01

Mortar shall consist of 1 part cement to 2 parts No. 23 fine aggregate, by volume.

CONSTRUCTION REQUIREMENTS

710.03 Patching Concrete Structures

(a) Concrete Removal

Areas of unsound concrete to be removed will be marked by the Engineer.

A saw cut shall be made perpendicular to the existing concrete surface a minimum of 1 in. (25 mm) outside marked areas. The cut shall be a minimum 1 in. (25 mm) deep or to the top of the reinforcement, whichever is less.

Removal of unsound concrete shall not exceed 6 in. (150 mm) in depth and shall be performed by means of handchipping. Handchipping tools may be hand or mechanically driven. Jack hammers shall not be heavier than nominal 45 lb (20.5 kg) class and chipping hammers shall not be heavier than nominal 15 lb (6.8 kg) class. Only chipping hammers shall be used when removing concrete within 1 in. (25 mm) of the reinforcement. Mechanically driven tools shall be operated at a maximum angle of 45° to concrete surfaces.

Where the bond between the existing concrete and the reinforcement has been destroyed, concrete adjacent to the reinforcement shall be removed to a minimum clearance of 1 in. (25 mm) around the entire periphery of the exposed reinforcement. Exposed reinforcement shall not be damaged due to the removal operations. Reinforcement damaged by the Contractor shall be replaced.

Regardless of the method of removal, removal operations shall cease if sound concrete is being removed beyond the limits approved by the Engineer. Removal methods shall be adjusted to prevent unnecessary removal of sound concrete prior to resuming removal operations.

(b) Replacement of Reinforcement

Existing reinforcement that has lost 50% or more of its original cross sectional area shall be removed and replaced with new reinforcement of the diameter of the original reinforcement. Replacement reinforcement shall be lapped a minimum of 3 in. (75 mm) along the existing reinforcement.

(c) Patching

After concrete removal operations are completed and just prior to placing patches, all patch areas shall be sandblasted to expose aggregates in concrete surfaces and to remove rust, residual concrete and laitance layers from the surface of the reinforcement. All surfaces shall be free of dust, chips, water, and foreign material to produce a firm, solid surface for adherence of patching concrete. Air lines for sandblasting and air cleaning shall be equipped with oil and water traps.

Surfaces of prepared cavities and all exposed reinforcement within the cavities shall be coated with epoxy resin adhesive in accordance with 722.06(a)1. Cavities of

1/2 in. (13 mm) depth or greater shall be filled with concrete. Cavities of less than 1/2 in. (13 mm) depth shall be filled with mortar.

For patched areas that require forms, forms may be removed after 24 hr and surfaces cured in accordance with 702.22 or the forms may be left in place for 72 hr and no additional curing will be required. Patched areas that do not require forms shall be cured in accordance with 702.22.

Concrete patches shall be finished to match the texture and finish of abutting existing concrete.

710.04 Repointing Rubble Masonry

Joints in rubble masonry shall be cleaned of all loose mortar and foreign material. All spaces around the rubble aggregate, after being cleaned, shall be filled with mortar and trowel finished. All loose rubble shall be settled into place before the mortar has set.

710.05 Repointing Dressed Stone and Brick Masonry

Joints in masonry shall be cleaned of all loose mortar and foreign material for a depth of at least twice the width of the joint. Joints shall be filled with mortar and trowel finished.

710.06 Method of Measurement

Patching concrete structures and repointing rubble, dressed stone and brick masonry in structures will be measured by the square foot (square meter) of actual surface area of patching or repointing. Individual areas of less than 1 sq ft (0.1 m^2) in area will be considered as 1 sq ft (0.1 m^2). Areas greater than 1 sq ft (0.1 m^2) will be recorded as the actual measurement of the repaired area to the nearest 0.1 sq ft (0.01 m^2).

710.07 Basis of Payment

The accepted quantities of patching concrete structures will be paid for at the contract unit price per square foot (square meter) complete in place. Repointing rubble, dressed stone, and brick masonry in structures will be paid for at the contract unit price per square foot (square meter) of repointing masonry complete in place.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Patching Concrete Structures	SFT (m2)
Repointing Masonry in Structures	SFT (m2)

Areas where patching concrete structures or repointing rubble, dressed stone, or brick masonry in structures exceeds an average of 4 in. (100 mm) in depth will be

paid for at a price calculated by means of multiplying the contract unit price for the respective item by the following factors:

(a) for portions thereof whose average depth is greater than 4 in. (100 mm) but less than 6 in. (150 mm) 1.25

(b) for portions thereof whose average depth is greater than or equal to 6 in. (150 mm) but less than 8 in. (200 mm)..... 1.50

(c) for portions thereof whose average depth is greater than or equal to 8 in. (200 mm) but less than 10 in. (250 mm)..... 1.75

(d) for portions thereof whose average depth is greater than or equal to 10 in. (250 mm) but less than 12 in. (300 mm)..... 2.00

(e) for all portions thereof whose average depth is greater than or equal to 12 in. (300 mm), the work shall be done as extra work. Payment will be made in accordance with 104.03.

The cost of removing the existing concrete or masonry cement, furnishing, hauling, and placing all materials, preparing the surface, and all necessary incidentals shall be included in the pay items in this section.

The cost of replacing damaged reinforcement shall be included in the cost of patching concrete structures.

SECTION 711 – STEEL STRUCTURES

711.01 Description

This work shall consist of furnishing, fabricating, erecting, and painting steel structures and parts of structures, except steel piling, in accordance with 105.03.

711.02 Materials

Materials shall be in accordance with the following:

Bronze and Copper-Alloy..... 910.06
Castings 910.05
Elastomeric Bearings..... 915.04
Steel Forgings and Steel Shafting..... 910.04
Structural Steel 910.02

Where grade HPS 70W (HPS 485W) or grade HPS 50W (HPS 345W) steel is shown on the plans, the high performance steel shall be in accordance with 910.02(d).

Where grade 50W (grade 345W) steel is shown on the plans, the weathering steel shall be in accordance with 910.02(b).

Material specifications shall be shown on the working drawings if the materials are different than those shown on the plans. Materials which do not require mill test reports may be changed from those shown on the plans subject to approval.

Sheared plates or universal mill plates shall be used for girder webs. Such plates shall be ordered with sufficient additional width to allow for trimming of edges to provide built-in camber for dead load deflection and vertical curve. Sheared plates thicker than 1/2 in. (13 mm) shall be planed in accordance with 711.14.

FABRICATION

711.03 General Requirements

The fabrication methods used shall be those applicable to and prescribed for the several parts of fabrication as it progresses and shall be in accordance with the requirements thereof and as further set out in this specification. Workmanship and finish shall be first-class, equal to the best general practice in a modern fabricating shop, and in strict accordance with these specifications, the plans, and such additional instructions as may be given.

Fabrication of high performance steel shall be in accordance with the AASHTO Guide Specifications for Highway Bridge Fabrication with HPS 70W Steel, an addendum to ANSI/AASHTO/AWS D1.5M/D1.5, except as modified herein.

The requirements contained herein will not be waived, nor will they be modified to conform with any set of rules that any shop has adopted as its standard unless so authorized in writing.

Structural steel, regardless of its source, shall be fabricated within the continental limits of the United States of America.

711.04 Certification of Fabricators

The fabricator of structural steel furnished under this section shall be certified in accordance with the American Institute of Steel Construction, AISC, certification program. It shall be the fabricator's responsibility to maintain a valid certification and annual endorsements thereto.

Fabricators of main load-carrying components for multi-span bridges that have welded or bolted splices shall be certified under the AISC major steel bridges (CBR) category. Fabricators of fracture critical members shall be certified under the CBR category and shall have the fracture critical endorsement. Fabricators certified as CBR are also certified to fabricate simple and continuous rolled beam structures. Only fabricators meeting the above requirements shall be used to fabricate girders using high performance steel.

Fabricators of main load-carrying components for simple span bridges or bridges that do not have welded or bolted splices shall, as a minimum, be certified under the AISC simple steel bridges structures (SBR) category.

If the fabrication of secondary structural steel members and other miscellaneous structural steel components, such as but not limited to diaphragms, bearing assemblies, and miscellaneous plates does not involve any welding or heating of the steel, the fabrication facility that is fabricating these components will not be required to be AISC certified as described in this section.

Prior to approval for fabrication, the results of the latest AISC certification review shall be made available to the Engineer to determine if items critical to successful fabrication meet the needs of the specific work.

The fabricator shall be certified from the start of the fabrication process, through and including the shop assembly in accordance with 711.44. If the certification lapses during the course of the project, the fabricator shall have plans to maintain certification or complete the fabrication process before the expiration of his certification. Failure of the fabricator to maintain his certification during the fabrication shall result in a 10% reduction in the bid price for structural steel.

Approval of the fabricator shall be requested in writing prior to ordering structural steel. A valid certification with annual endorsement must be submitted with the request.

711.05 Working Drawings

Working drawings shall be submitted in accordance with 105.02.

Working drawings shall include a detailed bill of materials showing weights of materials completed in accordance with 711.73(b) if payment is on a unit weight basis. The working drawings shall indicate whether reaming is to be done in the shop or in the field. The working drawings shall indicate which splices are to be eliminated.

If the contract plans include detailed structural steel drawings, they may be used. Such drawings shall be checked. The Contractor shall provide notification in writing that it is assuming responsibility for their correctness.

711.06 Storage of Materials

Structural material, either plain or fabricated, shall be stored at the bridge shop above the ground upon platforms, skids, or other supports. It shall be kept reasonably free from dirt, grease, and other foreign matter and shall be protected as far as practicable from corrosion.

711.07 Mill Orders and Shipping Statements

If requested, 1 copy of mill orders, change orders, and mill shipping statements for structural steel shall be furnished. The pertinent order, bill, or statement shall be furnished far enough in advance so that inspection may be provided.

711.08 Mill Test Reports

Prior to, or concurrent with, the fabrication, a copy of the mill test report shall be furnished. If the manufacturer's mill test reports are not available, tests shall be made with no additional payment, and 4 certified copies of such tests shall be furnished. Four copies of an affidavit shall be furnished which shall state that the materials to be used for members not designated for calculated stress and not to be marked in accordance with ASTM A 6 (ASTM A 6M), Article 9, are in accordance with the requirements of the specifications for the materials as shown on the plans. The fabricator shall have on file the mill test reports for the material from which these members were obtained.

Those items of structural steel which are considered as being in the category of members not requiring mill test reports and for which tests may not be required shall be listed on the working drawings. Approval of working drawings will indicate if it is satisfactory to waive testing of the items listed.

Mill test reports, reports from subsequent tests, and affidavits shall be marked in a manner to clearly identify them with the contract structure and also with the particular member of the bridge for which these tests were made.

711.09 Notice of Beginning Work

Written notification shall be given 10 days in advance of the date on which fabrication is intended to start. Between the dates of such notification and the start of fabrication, a surface inspection of the proposed materials will be made. Any such materials cut or work done prior to this inspection may be rejected.

711.10 Facilities for Inspection

Facilities for the inspection of material and workmanship in the mill and shop shall be furnished, and the inspectors shall be allowed free access to the necessary parts of the works.

711.11 Straightening Material

Material, before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods that do not injure the metal. Sharp kinks and bends will be cause for rejection of the material.

The straightening of plates, angles, other shapes, and built up members, when permitted, shall be done by methods that do not produce fracture or other injury. Distorted members shall be straightened by mechanical means or, if approved, by the carefully planned and supervised application of a limited amount of localized heat. Heat straightening of ASTM A 709 grade 100 (ASTM A 709M grade 690) steel

members will not be permitted. The temperatures of the heated area shall not exceed 1,200°F (650°C), a dull red, as controlled by temperature indicating crayons, liquids, or bimetal thermometers. Parts to be heat straightened shall be substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat. They shall be allowed to cool very slowly. Water quenching will not be permitted. Following the straightening of a bend or buckle, the surface of the metal shall be inspected for evidence of fracture.

Short term application of heat to high performance steel for purposes of heat curving, heat straightening, camber and sweep adjustment, or for other reasons is limited and shall not exceed 1,100°F (590°C). Heat applications shall be in accordance with Department approved procedures.

711.12 Finish

Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately.

All shop butt welds in flange plates shall be ground smooth and flush with the base metal on all surfaces. This shall apply to parts of equal thickness and parts of unequal thickness. Grinding shall be done in the direction of stress and in such a manner that the metal is kept below the blue brittle range. All defects exposed by grinding shall be cleaned, filled with weld metal, and reground to a uniform finish.

Curved surfaces of shoes shall be machined after weldments have been completed.

For cambered beams, the camber shall be to a smooth curve. Camber for beams shall be checked after shop welding is completed and while beams are supported so as to have no bending moment in the direction of camber. Beams which are not cambered shall be straight within a tolerance of 3/8 in. (10 mm) at center. If camber exists, beams shall be laid out with camber up. Beams shall be checked for camber while beams are supported so as to have no bending moment in the direction of camber.

711.13 Flame Cutting

Structural steel permitted by these specifications may be flame cut, provided a smooth surface free from cracks and notches is secured and provided that an accurate profile is secured by the use of a mechanical guide. Hand cutting shall be done only where approved.

In all flame cutting, the cutting flame shall be so adjusted and manipulated as to avoid cutting inside the prescribed lines. Flame cut surfaces shall meet the ANSI surface roughness rating value of 1,000 except that flame cut surfaces of members not subject to calculated stress shall meet the surface roughness value of 2,000. Flame cut surfaces of members carrying calculated stress shall have their corners rounded to a 1/16 in. (2 mm) radius by grinding after flame cutting.

Re-entrant cuts shall be filleted to a radius of not les than 3/4 in. (19 mm).

Surface roughness exceeding the above values and occasional gouges not more than 3/16 in. (5 mm) deep on otherwise satisfactory flame cut surfaces shall be removed by machining or grinding. Corrections of the defects must be faired with the surface of the cut on a bevel of 1:6 or less. Occasional gouges of flame cut edges more than 3/16 in. (5 mm) deep but not more than 7/16 in. (11 mm) deep may be repaired by welding with low hydrogen electrodes not exceeding 5/32 in. (4 mm) in diameter and with a preheat of 250°F (121°C). The completed weld shall be ground smooth and flush with the adjacent surface.

711.14 Edge Planing

Edge planing will not be required on plates having rolled edges.

Sheared edges of plates more than 1/2 in. (13 mm) in thickness and carrying calculated stress shall be planed to a depth of 1/4 in. (6 mm). Re-entrant cuts shall be filleted before cutting.

Visually observed defects in sheared or flame cut edges of plates 4 in. (100 mm) or less in thickness, except ASTM A 709 grade 100 (ASTM A 709M grade 690) steel plates, shall be investigated or repaired in accordance with the following table. Repairs made by welding shall be in accordance with 711.32.

TABLE

Description of Discontinuity	Repair Required
All discontinuity of 1/8 in. (3mm) Maximum depth	None-depth shall be explored as directed.
Any discontinuity over 1 in. (25 mm) in length with depth over 1/8 in. (3 mm) but not greater than 1/4 in. (6 mm)	Remove and weld.
Any discontinuity over 1 in. (25 mm) in length with depth over 1/4 in. (6 mm) but not greater than 7/16 in. (11 mm)	Remove completely and weld. Aggregate length of welding not over 20% of plate edge length being repaired.
Any discontinuity over 1 in. (25 mm) in length with depth greater than 7/16 in. (11 mm)	Plate rejected. Defective portion may be removed and remainder may be used in 7/16 in. (11 mm) depth.

711.15 Abutting Joints

Abutting joints in compression members and girder flanges of trusses and arches, and in tension members where so specified on the plans, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 1/4 in. (6 mm).

711.16 End Connection Angles

Floorbeams, stringers, and girders having end connection angles shall be built to the exact length shown on the plans measured between the heels of the connection angles, with a permissible tolerance of +0 to 1/16 in. (+0 to 2 mm). Where continuity is to be required, end connections shall be faced. The thickness of the connection angles shall be no less than that shown on the working drawings after facing.

711.17 Blank

711.18 Blank

711.19 Bent Plates

Cold bent, load carrying, rolled steel plates shall be in accordance with the following:

(a) They shall be so taken from the stock plates that the bend line will be at right angles to the direction of rolling.

(b) The radius of bends shall be such that no cracking of the plate occurs. Generally accepted minimum radii, measured to the concave face of the metal, are shown in the following table:

Thickness, t, in inches (mm)	Up to 1/2 in. (13 mm)	Over 1/2 in. (13 mm) to 1 in. (25 mm)	Over 1 in. (25 mm) to 1 1/2 in. (38 mm)	Over 1 1/2 in. (38 mm) to 2 1/2 in. (63 mm)	Over 2 1/2 in. (63 mm) to 4 in. (100 mm)
All grades of structural steel in this specification	2t 51 mm	2 1/2t 63 mm	3t 76 mm	3 1/2t 89 mm	4t 102 mm

If a shorter radius is essential, the plates shall be bent hot at a temperature no greater than 1,200°F (649°C). Hot bent plates shall be in accordance with requirement (a) of 711.19.

(c) Before bending, the corners of the plate shall be rounded to a radius of 1/16 in. (2 mm) throughout that portion of the plate at which the bending is to occur.

711.20 Fit of Stiffeners

Bearing stiffeners of girders and stiffeners intended as supports for concentrated loads shall have full bearing. This bearing shall consist of either milled, ground, or weldable steel in compression areas of flanges, welded as shown on the plans or as otherwise specified on the flanges to which they transmit load or from which they receive load. The opposite end of bearing stiffeners may have a gap between the end of the stiffener and the flange not exceeding 6 times the web thickness.

Stiffeners not intended to support concentrated loads, including transverse intermediate stiffeners and full depth diaphragm connection plates, shall be attached to the compression flange as shown on the plans. These stiffeners may bear on the tension flange or may have a gap between the end of the stiffener and the near face of the flange not exceeding 6 times the web thickness. Regardless of the gap dimension, the distance between the end of the stiffener weld and the near edge of the web-to-flange fillet weld shall not be less than 4 nor more than 6 times the web thickness.

711.21 Bolt Holes

(a) High Tensile Strength Bolts, and Unfinished Bolts

All holes for bolts shall be punched or drilled. Material forming parts of a member composed of not more than 5 thicknesses of metal may be punched 1/16 in. (2 mm) larger than the nominal diameter of the bolts whenever the thickness of the metal is no greater than 3/4 in. (19 mm) for structural steel or 5/8 in. (16 mm) for high-strength steel. If there are more than 5 thicknesses or when the main material is thicker than 3/4 in. (19 mm) for structural steel, or 5/8 in. (16 mm) for high strength steel, or if required in accordance with 711.24, all holes shall be subpunched or subdrilled 3/16 in. (5 mm) smaller and, after assembling, reamed 1/16 in. (2 mm) larger or drilled from the solid to 1/16 in. (2 mm) larger than the nominal diameter of the bolts.

(b) Ribbed Bolts, Turned Bolts, or other Approved Bearing-Type Bolts

All holes for ribbed bolts, turned bolts, or other approved bearing type bolts shall be subpunched or subdrilled 3/16 in. (5 mm) smaller than the nominal diameter of the bolt. They shall be reamed assembled, reamed to a steel template, or, after assembling, drilled from the solid at the option of the fabricator. The finished holes shall always provide a driving fit as shown on the plans or as specified.

711.22 Punched Holes

The diameter of the die shall not exceed the diameter of the punch by more than 1/16 in. (2 mm). If any holes must be enlarged to admit the bolts, such holes shall be reamed. Holes must be clean cut without torn or ragged edges. Poor matching of holes will be cause for rejection.

711.23 Reamed or Drilled Holes

Reamed or drilled holes shall be cylindrical, perpendicular to the member, and shall be in accordance with 711.21 as to size. Where practicable, reamers shall be directed by mechanical means. Drilled holes shall be 1/16 in. (2 mm) larger than the nominal diameter of the bolt. Diameters of holes in all material connecting top shoes to beam or girder flanges shall be 1/8 in. (3 mm) larger than the diameters of the bolts. Bolts connecting the flange to the top shoe shall extend into the top shoe a minimum of 1 in. (25 mm). Open holes for high strength bolts shall be 15/16 in. (24 mm) in diameter unless otherwise shown on the plans. Burrs on the outside

surfaces shall be removed. Poor matching of holes will be cause for rejection. Reaming and drilling shall be done with twist drills. If required, assembled parts shall be taken apart for removal of burrs caused by drilling. Connecting parts requiring reamed or drilled holes shall be assembled and held securely while being reamed or drilled, and shall be match marked before disassembling.

If beams or girders are shop reamed or drilled, progressive beam or girder assembly will be permitted in accordance with 711.44 unless otherwise directed. Beams or girders spliced over the supports may be shop reamed or drilled with the webs either in a horizontal or vertical position. If the webs are vertical, they shall be supported relative to their final erection position. If reamed with the webs horizontal, a minimum of 1 line of beams or girders shall be shop assembled and inspected for fit in accordance with the blocking diagram for webs vertical shown on the plans. Beams or girders spliced at the points of contraflexure shall be shop reamed or drilled while assembled in accordance with the no-load camber and reaming diagram shown on the plans. For hinged beams or girders, holes for pins shall be bored or reamed to the dimensions shown on the plans after the beams or girders are assembled in position in accordance with the no-load camber diagram shown on the plans. Flange splice bars shall be subdrilled and reamed or drilled full size while assembled.

When girder sections are fit up in the shop for reaming or drilling of field splices, the centerlines of opposing flanges shall not deviate more than 1/8 in. (3 mm) with the webs in alignment.

711.24 Subpunching and Reaming of Field Connections

Holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, each face of towers, plate girders, and rigid frames shall be subpunched, or subdrilled if subdrilling is required in accordance with 711.21. These subsize holes shall subsequently be reamed while assembled, or reamed to a template, in accordance with 711.44. All holes for floor beams and stringer field end connections shall be subpunched and reamed to a steel template or reamed while assembled. Reaming or drilling full size of field connection holes through a steel template shall be done after the template has been located as to position and angle, and bolted firmly in place. Templates used for reaming matching members, or the opposite faces of a single member, shall be exact duplicates. Templates used for connections on like parts or members shall be so accurately located that the parts or members are duplicates and require no match marking.

711.25 Accuracy of Punched or Subdrilled Holes

Before any reaming is done, the punching, subpunching, or subdrilling shall be so accurate that after assembling, a cylindrical pin 1/8 in. (3 mm) smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75% of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces will be rejected. If

a hole does not pass a pin which is 3/16 in. (5 mm) smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

711.26 Accuracy of Reamed Holes and Holes Drilled Full Size

When holes are reamed or drilled full size, 85% of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 in. (0.8 mm) between adjacent thicknesses of metal. All steel templates shall have hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. The centerlines shall be used in locating accurately the template from the milled or scribed ends of the members.

711.27 Fitting for Bolting

Mating surfaces of steel shall be cleaned before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together with bolts before reaming is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation. The member shall be free from twists, bends, and other deformation.

711.28 Filler Plates

Filler may be required at the connections due to the variation in depth of a given section or to the use of different sections at a connection point. Where filler plates are shown on the plans at such connections, the specified thickness is the theoretical thickness required. During fabrication the thickness of such fillers shall be adjusted to the actual clearances as determined by measurements of the members involved. The minimum thickness of any filler plate shall be 1/8 in. (3 mm), unless otherwise approved.

711.29 Toothed Expansion Plates

These plates in the roadway expansion joints shall be cut from a single plate by burning in such a way that, after the plate is cut and the toothed plates placed in the same relative position as before burning, no part of the cut shall be wider than 1/4 in. (6 mm). The cuts shall be straight enough that a 1/8 in. (3 mm) plate passes between the parts on any designated straightline cut.

711.30 Blank

711.31 Blank

711.32 Welds

Welding of steel shall be done only as shown on the plans or as specified and only with specific approval. Welding may be done to remedy minor defects, if approved. No temporary or permanent welds, if not shown on the plans or otherwise specified, shall be made without specific written authorization.

(a) AWS Requirements

Welding of steel structures, when authorized, shall be performed in accordance with the following AWS Specifications.

A5.1	Mild Steel Covered Arc-Welding Electrodes.
A5.5	Low-Alloy Steel Covered Arc-Welding Electrodes.
A5.17	Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding.
A5.18	Mild Steel Electrodes for Gas Metal-Arc Welding.
A5.20	Mild Steel Electrodes for Flux-Cored Arc Welding.
D1.5	(AASHTO/AWS) Bridge Welding Code.

Welders, welder operators, and tack welders shall be qualified in accordance with AWS D1.5 Chapter 5 Part B.

(b) Edge Blocks

Edge blocks shall be used when radiographing flange butt shop welds of greater than 1/2 in. (13 mm) thickness. The edge blocks shall have the dimensions shown on the plans. The edge block shall be centered on the weld with a snug fit against the plate being radiographed, with the maximum gap shown on the plans. Edge blocks shall not be tack welded. Edge blocks shall be made of radiographically clean steel. The surface shall have an ANSI finish of 0.125 mil (3 µm) or smoother.

Field welding shall be in accordance with the requirements herein, except where welded connections do not carry calculated stresses. Magnetic particle inspection will not be required, so ANSI/AASHTO/AWS D1.5-88 Table 4.4 “Minimum Preheat and Interpass Temperature” as it refers to thicknesses to 3/4 in. (19 mm) inclusive, shall read “None”. Electrodes with a low hydrogen classification will not be required.

(c) Welding of High Performance Steel

All welding on high performance steel shall be in accordance with the ANSI/AASHTO/AWS D1.5M/D1.5 Bridge Welding Code, hereinafter referred to as the Bridge Welding Code, except as modified herein and by the AASHTO Guide Specifications for Highway Bridge Fabrication with HPS 70W Steel, an addendum to the 2002 Edition of the Bridge Welding Code.

Only submerged arc welding, SAW, and shielded metal arc welding, SMAW, processes will be permitted. Consumable handling requirements shall be in accordance with the Bridge Welding Code, Section 12.6.5 and 12.6.6, when using reduced preheat as described in Table 3 of the Guide, except that SAW consumables for matching weld metal shall meet the hydrogen control level of H4 in accordance with Section 12, Article 12.6.2. Consumable handling requirements shall meet the provisions of The Bridge Welding Code, Section 4, when using the preheat requirements of Table 4.4, except that the diffusible hydrogen level must never exceed H8. SMAW consumables may meet diffusible hydrogen levels of either H4

or H8 except the higher preheat and interpass temperatures as noted in Table 3 of the AASHTO Guide Specifications for Highway Bridge Fabrication with HPS 70W Steel shall apply to H8 conditions.

Filler metals used to make single pass fillet welds for web to flange applications which join HPS 70W steel plates, HPS 70W to grade 50W plates and for attaching stiffeners and connection plates to grade HPS 70W (HPS 485W) webs and flanges, shall be in accordance with the Bridge Welding Code, Table 4.1 for ASTM A 709, grade 50W (ASTM A 709M, grade 345W) base metal. Filler metals for single pass 5/16 in. fillet welds need not meet the requirements for exposed bare applications.

Filler metals used for all complete penetration groove welds joining grade HPS 70W (grade HPS 485W) plate to ASTM A 709, grade HPS 50W (A 709M, grade HPS 345W) or grade 50W (grade 345W) plate shall conform to the requirements for welding Grade 50W base metal.

Filler metals used for all complete penetration groove welds joining grade HPS 70W (grade HPS 485W) plates to grade HPS 70W (grade HPS 485W) plates shall conform to the requirements for HPS 70W (HPS 485W) base metal as follows:

1. Submerged Arc Welding process:

   Wire - LA85 by Lincoln Electric Company
   Flux - MIL800HPNi by Lincoln Electric Company

2. Shielded Metal Arc Welding process

   Matching - E9018MR*
   Undermatching - E7018MR*

* The designator 'MR', for moisture resistant coating, is required for all SMAW electrodes used for welding HPS 70W (HPS 485W) steels.

The Contractor may request approval of alternate consumables for matching weld strengths in lieu of the above filler metals for SAW. The request for approval shall include documentation of successful welding and shall also include diffusible hydrogen tests, both in accordance with the Bridge Welding Code.

All welding procedures shall be qualified in accordance with the Bridge Welding Code Section 5, Qualification. In general, the provisions of Article 5.12 shall apply. Qualification tests shall measure strength, toughness and ductility, with results evaluated in accordance with Article 5.19. If specified on the plans, additional tests shall measure the Charpy V-notch toughness of the coarse grained area of the heat affected zone, HAZ. The notch in the specimens shall be carefully located in the coarse grained area of the HAZ, as determined by macro-etching the specimens prior to machining and testing. The toughness requirement for the HAZ shall be the same as the weld metal.

All procedure qualification tests shall be ultrasonically tested in accordance with the requirements of the Bridge Welding Code, Section 6, Part C. Evaluation shall be in accordance with Table 6.3, UT Acceptance – Rejection Criteria – Tensile Stress. Indications found at the interface of the backing bar may be disregarded regardless of the defect rating.

A representative of the Department must witness all welding procedure qualification tests.

Results of the welding procedure qualification tests and final welding procedure specifications shall be submitted to the Engineer for review and approval.

In general, post weld heat treatment will not be required. The use of such post weld heat treatment will require additional qualification testing.

Wherever magnetic particle testing is done, only the yoke technique will be allowed, as described in Section 6.7.6.2 of the Bridge Welding Code, modified to use alternating current only.

711.33 Stud Shear Connectors

Stud shear connectors shall be in accordance with 711.32 and as shown on the plans.

711.34 Annealing and Stress Relieving

Structural members which are indicated in the contract to be annealed or normalized shall have finished machining, boring, and straightening done subsequent to heat treatment. Normalizing and full annealing shall be in accordance with ASTM A 941. The temperatures shall be maintained uniformly throughout the furnace during the heating and cooling so that the temperatures at 2 points on the member differ by no more than 100°F (38°C) at any one time.

A record of each furnace charge shall identify the pieces in the charge and show the temperatures and schedule actually used. Proper instruments, including recording pyrometers, shall be provided for determining the temperature of members in the furnace. The records of the treatment operation shall be available and meet approval. Members, such as bridge shoes, pedestals, or other parts which are built up by welding sections of plate together shall be stress relieved in accordance with the procedure of the AWS when required by the plans or as otherwise specified.

711.35 Eyebars

Pin holes may be flame cut at least 2 in. (50 mm) smaller in diameter than the finished pin diameter. All eyebars that are to be placed side by side in the structure shall be securely fastened together in the order that they are placed on the pin and bored at both ends while so clamped. Eyebars shall be packed and match marked for shipment and erection. All identifying marks shall be stamped with steel stencils on

the edge of 1 head of each member after fabrication is completed so as to be visible when the bars are nested in place on the structure. The eyebars shall be straight and free from twists, and the pin holes shall be located accurately on the centerline of the bar. The inclination of any bar to the plane of the truss shall not exceed 1/16 in. in 1 ft (5 mm in 1 m).

The edges of eyebars that lie between the transverse centerline of their pin holes shall be cut simultaneously with 2 mechanically operated torches abreast of each other, guided by a substantial template, in such a manner as to prevent distortion of the plates.

711.36 Facing of Bearing Surfaces

The top and bottom surfaces of steel slabs, base plates, and cap plates of columns and pedestals shall be planed, or the plates hot-straightened. Parts in contact with them shall be faced.

Sole plates of beams and girders shall have full contact with flanges. Sole plates and masonry plates shall be planed or heat straightened.

Cast pedestals shall be planed on surfaces to be in contact with steel and shall have surfaces to be in contact with masonry, rough finished.

Surfaces of bronze bearing plates intended for sliding contact shall be finished.

The surface finish of bearing plates, base plates, and other bearing surfaces that are to come in contact with each other or with concrete shall meet the following ANSI surface roughness requirements as defined in ANSI B46.1:

Bridge rollers and rockers ..... ANSI 250
Heavy plates in contact with shoes to be welded..... ANSI 1000
Milled ends of compression members, milled or
ground ends of stiffeners and fillers ..... ANSI 500
Pins and pin holes..... ANSI 125
Sliding bearings..... ANSI 125
Steel slabs..... ANSI 2000

711.37 Pins and Rollers

Pins and rollers shall be turned to the dimensions shown on the working drawings and shall be straight, smooth, and free from flaws. Pins and rollers more than 9 in. (230 mm) in diameter shall be forged. Pins and rollers 9 in. (230 mm) or less in diameter may be forged or cold finished, carbon steel shafting. In pins larger than 9 in. (230 mm) in diameter, a hole no less than 2 in. (50 mm) in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling.

711.38 Boring Pin Holes

Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member, and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut. The distance outside to outside of end holes in tension members, and inside to inside of end holes in compression members shall not vary from that specified more than 1/32 in. (0.8 mm). Boring of holes in built-up members shall be done after the bolting is completed.

711.39 Pin Clearances

The diameter of the pin hole shall not exceed that of the pin by more than 1/50 in. (0.5 mm) for pins 5 in. (125 mm) or less in diameter, nor 1/32 in. (0.8 mm) for larger pins.

711.40 Threads for Bolts and Pins

Threads for all bolts and pins for structural steel construction shall be in accordance with the United Standard Series UNC-ANSI B 1.1, Class 2A for external threads and Class 2B for internal threads, except that pin ends having a diameter of 1 3/8 in. (35 mm) or more shall be threaded 6 threads per 1 in. (25 mm).

711.41 Pilot and Driving Nuts

Two pilot nuts and 2 driving nuts for each size of pin shall be furnished, unless otherwise specified.

711.42 Finishing Cast Steel

The surface shall be finished as called for on the detail plans. Surfaces marked “finish” shall be made to exact size and shape and in such manner that removes all tool marks. If marked “rough finish” the tool marks need not be removed. However, there shall be no irregularities greater than 1/32 in. (0.8 mm) in height on rough finished surfaces.

711.43 Finished Members

The several pieces forming a built-up member shall fit together closely and accurately, and the finished member shall be true to line and free from twists, bends, and open joints.

Cover plates on trusses, beams, and girders shall be so nearly straight that variations do not exceed 1/16 in. in 5 ft (1 mm in 1 m), with a maximum variation not to exceed 3/16 in. (5 mm) at the center of the plates.

711.44 Shop Assembling

The field connections of main members of trusses, arches, continuous beam spans, bents, tower faces, plate girders, and rigid frames shall be assembled in the shop with milled ends of compression members in full bearing and then shall have their sub-size holes reamed to specified size while the connections are assembled. Assembly shall be full truss or girder assembly unless progressive beam or girder

assembly, full chord assembly, progressive chord assembly, or special complete structure assembly is shown on the plans or otherwise specified.

Each assembly including camber, alignment, accuracy of holes, and fit of milled joints will be approved before reaming is commenced.

A camber diagram shall be furnished by the fabricator showing the camber at each panel point of each truss, arch rib, continuous beam line, plate girder, or rigid frame. When the shop assembly is full truss or girder assembly or special complete structure assembly, the camber diagram shall show the camber measured in assembly. When any of the other methods of shop assembly is used, the camber diagram shall show calculated camber.

(a) Full Truss or Girder Assembly

Full truss or girder assembly shall consist of assembling all members of each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at one time.

(b) Progressive Beam or Girder Assembly

Progressive beam or girder assembly shall be accomplished by one of the following methods. In case the structure is on a horizontal curve, other assembly methods may be approved on the working drawings.

1. This method shall consist of the assembly of at least 3 contiguous members, and no less than 150 ft (46 m). At least 1 beam or girder shall be added at the advancing end of the assembly before any member is removed from the rearward end so that the assembly portion of the structure is never shorter than that specified above. Each successive laydown assembly shall always include a previously reamed splice and the main member on each side of this splice.

2. The alternate method shall consist of placing the required number of contiguous shop members so that 2 complete spans are assembled for the 1st laydown. Each successive laydown shall consist of the required number of contiguous members to complete the next 2 spans while retaining in the new laydown the last bearing member from the previous laydown. On laydowns for structures comprised of an odd number of spans, a laydown of 1 span shall be permitted to complete the structure. This laydown shall be the last span unless otherwise approved on the working drawings. Each retained bearing member shall be reassembled in its 2nd laydown with the same relative orientation to a common base line as it was in the 1st laydown.

(c) Full Chord Assembly

Full chord assembly shall consist of assembling, with geometric angles at the joints, the full length of each chord of each truss or open spandrel arch or each leg of each bent or tower, then reaming their field connection holes while the members are assembled and reaming the web member connections to steel templates set at geometric, not cambered, angular relation to the chord lines.

Field connection holes in web members shall be reamed to steel templates. At least one end of each web member shall be milled or shall be scribed normal to the longitudinal axis of the member. The templates at both ends of the member shall be located accurately from one of the milled ends or scribed lines.

(d) Progressive Chord Assembly

Progressive chord assembly shall consist of assembling contiguous chord members in the manner specified for full chord assembly and in the number and length specified for progressive truss or girder assembly.

(e) Special Complete Structure Assembly

Special complete structure assembly shall consist of assembling the entire structure, including the floor system. This procedure is ordinarily needed only for complicated structures such as those having curved girders or extreme skew in combination with severe grade or camber.

711.45 Drifting of Holes

Except where drifting is specifically prohibited by this specification, the drifting done during assembly shall be only to bring the parts into position and not sufficient to enlarge the holes or distort the metal. If a hole must be enlarged to admit the bolt, it shall be reamed.

711.46 Match Marking

Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be match marked and a diagram showing such marks shall be furnished.

711.47 Shop Cleaning and Painting

Shop cleaning and painting shall be in accordance with applicable requirements of 619.

711.48 Shop Cleaning and Storage of Weathering Steel

The fabricator shall protect bare steel sections and sub-assemblies so as not to damage or stain them. The use of paints, crayons, or other materials used for identification purposes shall be avoided on bare steel sections. Storage shall be such to permit free drainage to avoid moisture pockets.

A sound uniform surface for the formation of a protective oxide coating on surfaces shall be prepared as follows.

(a) Hot Rolled Products

These products shall include structural shapes, plates, hot-rolled sheets, and hot-rolled strip. The entire length and perimeter of each fascia beam or girder shall be cleaned in accordance with 619.08(c). The entire length and perimeter of each interior beam or girder shall be cleaned in accordance with 619.08(d). Contamination from grease, oil, or shop marking shall be avoided. If such contamination is unavoidable, such surfaces shall be cleaned in accordance with 619.08(b).

(b) Welded Area

All exposed welds on fascia surfaces shall be prepared by means of power grinding or blast cleaning in accordance with 619.08(d) to remove welding flux, slag, scale, or spatter.

711.49 Furnishing Bolts

Sufficient field bolts shall be furnished to complete the entire structure.

711.50 Weighing of Members

If it is specified that part of the material is to be paid for by actual weight, finished work shall be weighed in the presence of the inspector, if practicable. Satisfactory scales shall be supplied, and all work involved in handling and weighing the various parts shall be performed.

711.51 Full Size Tests

When full size tests of fabricated structural members or eyebars are required by the contract, the plans or specifications shall state the number and nature of the tests, the results to be attained, and the measurements of strength, deformation, or other performance that are to be made. Suitable facilities, material, supervision, and labor necessary for making and recording the tests shall be provided. The cost of testing including equipment, handling, supervision, labor, and incidentals for making the tests shall be included in the contract price for structural steel, unless otherwise specified.

711.52 Acceptance

Acceptance of any material or finished member shall not preclude its rejection if found to be defective, either during fabrication or erection. Rejected material shall be replaced and poor workmanship corrected promptly.

711.53 Shipping

Structural members shall be loaded on trucks or cars in such manner that they can be transported to and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged.

If required, pins, nuts, bolts, and other small details shall be boxed or crated, and the weight of each piece or box marked on it in plain figures.

Written permission shall be obtained prior to shipping plate girders with the webs horizontal.

Splice plates shall not extend beyond the ends of beams or girders after bolting for shipment.

Member lengths shall be subject to the provisions of the current edition of the Oversize-Overweight Vehicular Permit Handbook.

The Contractor shall be responsible for obtaining all required transportation permits.

ERECTION

711.54 General Requirements

The erection methods shall be those prescribed for the several parts which constitute the finished structure and shall be in accordance with the requirements set forth herein. Workmanship and finish shall be first-class and all work done in a substantial and workmanlike manner in accordance with these specifications and in reasonable close conformance with the lines, grades, dimensions, and details shown on the plans, or as directed.

No erection shall be done without the approval of the Engineer. Before starting erection, information shall be fully given as to the erection methods and the amount and character of the equipment proposed to be used, which shall be subject to approval. Approval, if given, shall not be considered as relieving the Contractor of its responsibility for the safety of its methods or equipment or from carrying out the work in full accordance with the plans and specifications.

711.55 Delivery of Materials

If the contract is for erection only, the materials entering into the finished structure will be provided free of charge at the place designated and loaded or unloaded as specified. Material, which is required to be unloaded, shall be unloaded promptly on delivery to the place designated. Otherwise, the Contractor shall be responsible for demurrage charges.

711.56 Handling and Storing

Material to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection. If the contract is for erection only, the material shall be checked against the shipping lists and all shortages or injuries discovered shall promptly be reported in writing. The Contractor shall be responsible for the loss or damage of material after receipt.

711.57 Falsework

The falsework shall be properly designed and substantially constructed and maintained for the loads which come upon it. Plans for falsework or for changes in an existing structure necessary for maintaining traffic shall be prepared and submitted for approval. Approval of these plans shall not be considered as relieving the Contractor of any responsibility.

711.58 Bearings and Anchorages

Masonry bearing plates shall not be placed upon bridge seat bearing areas which are improperly finished, deformed, or irregular. Bearing plates shall be set level in exact position and shall have a full and even bearing on the masonry.

The holes shall be drilled and the anchor bolts, except where the bolts or anchor plates are built into the masonry, shall be set. The bolts shall be set accurately and fixed with portland cement grout completely filling the holes. The location of the anchor bolts in relation to the slotted holes in the expansion shoes shall correspond with the temperature at the time of the erection. The nuts on anchor bolts at the expansion ends of spans shall be adjusted to permit the free movement of the span.

711.59 Field Straightening Material

If it is necessary to straighten beams, plate girders, plates, angles, and other shapes in the field, it shall be done in accordance with the applicable requirements of 711.11.

Before straightening a carrying member, a proposed method of straightening shall be submitted in writing. Approval shall be received prior to commencing the work.

711.60 Field Assembly of Steel

Parts assembled in the field shall be assembled accurately as shown on the plans. Matchmarks shall be followed. The materials shall be handled carefully so that no part is bent, broken, or otherwise damaged. Hammering which would injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned thoroughly before assembling.

Unless erected by the cantilever method, truss spans shall be erected on blocking so placed to give the trusses the required camber. Truss spans shall be completely bolted on the blocking except for stringers and bottom lateral connections which shall be bolted after the span is swung. In emergencies or special cases and with specific approval, truss spans may be swung with main joints fully filled with bolts and drift pins.

Structural steel shall be erected using sufficient full size drift pins to permit placement of bolts without damage thereto and to facilitate setting splices to grade.

At the time of erection, no less than 50% of the holes in all connections shall be filled with bolts. The bolts shall not be tightened more than snug tight at this stage.

Any drifting required shall be only such that draws the parts into position but not sufficient to enlarge the holes or distort the metal. Unfair holes shall be reamed or drilled.

All field splices are optional, except as shown on the plans. Splice elevations have been calculated to include structural steel dead load only, with falsework removed. The tops of beam or girder splice plates shall be adjusted to the splice elevations shown on the plans before bolting field splices.

Splices shall be set to grade with the steel unsupported by falsework and prior to final bolting. After bolting is complete, these elevations will be checked. Adjustment shall be made as directed, if steel elevations are not within allowable tolerances.

711.61 Misfits

The correction of minor misfits involving harmless amounts of reaming, cutting, and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately and approval of the method of correction shall be obtained. The correction shall be made in the presence of the inspector. If the contract provides for complete fabrication and erection, the Contractor shall be responsible for all misfits, errors, and injuries and shall make the necessary corrections and replacements. If the contract is for erection only, the inspector, with the cooperation of the Contractor, shall keep a correct record of labor and materials used. Within 30 days, an itemized bill shall be presented for approval.

711.62 Pin Connections

Pilot and driving nuts shall be used in driving pins. They shall be furnished without charge. Pins shall be driven so that the members take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

711.63 Blank

711.64 Diaphragm Connections

Diaphragm connections other than those shown on the plans may be permitted. If other connections are to be used, details shall be submitted for approval. The Contractor shall assume full responsibility for layout of all diaphragm connections and for the accuracy of all fitted parts. Connections will not be permitted which require welding to the web, except at supports.

711.65 Bolted Connections Using High Strength Bolts

(a) General

This subsection covers the assembly of structural joints using ASTM A 325 (ASTM A 325M) high strength carbon steel bolts, or equivalent fasteners, tightened to a high tension. The bolts are to be used in holes provided in accordance with 711.21, 711.22, and 711.23.

High strength bolts shall be 7/8 in. (22 mm) in diameter unless noted.

(b) Bolts, Nuts, and Washers

Bolts, nuts, and washers shall be in accordance with 910.02(g). All galvanized nuts shall be lubricated with lubricant containing a visible dye. Black bolts shall be oily to the touch when installed. Weathered or rusted bolts shall be cleaned and lubricated prior to installation.

(c) Bolted Parts

The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit together solidly when assembled and shall not be separated by gaskets or any other interposed compressible material. When assembled, all joint surfaces, including those adjacent to the bolt heads, nuts, or washers, shall be free of scale, except tight mill scale, and shall also be free of dirt, lose scale, burrs, other foreign material, and other defects that would prevent solid seating of the parts. Contact surfaces within slip-critical joints shall be free of oil, grease, and any other material that reduces friction between the contact surfaces.

(d) Installation

1. Bolt Tension

Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown in Table A for the size of fastener used.

TABLE A

BOLT TENSION FOR ASTM A 325 (ASTM A 325M) BOLTS

Bolt Size, in. (mm)	Minimum Bolt Tension,* lb (kN)
1/2 (13)	12,050 (54)
5/8 (16)	19,200 (86)
3/4 (19)	28,400 (126)
7/8 (22)	39,250 (175)
1 (25)	51,500 (229)
1 1/8 (29)	56,450 (251)
1 1/4 (32)	71,700 (319)
1 3/8 (35)	85,450 (380)
1 1/2 (38)	104,000 (463)

* Equal to the proof load (length measurement method) given in ASTM A 325 (ASTM A 325M)

Threaded bolts shall be tightened with properly calibrated wrenches or by the turn-of-nut method. If required because of bolt entering and wrench operation clearances, tightening by either procedure may be done by turning the bolt while the nut is prevented from rotating. Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 s.

Installation of all high strength bolts shall be in accordance with AASHTO LRFD Bridge Construction Specifications. The snug tight condition as defined in AASHTO LRFD Bridge Construction Specifications shall be obtained for all final tightening.

A Skidmore-Wilhelm calibrator or other acceptable bolt tension indicating devices will be required on the project site for use during bolt installation. Periodic tests shall be performed to ensure the installed bolt, nut, and washer assembly meets the above requirements. Such tests shall be performed each work day when calibrated wrench tightening is used. For short grip bolts, direct tension indicators with solid plates may be used to perform these tests. Direct tension indicators shall 1st be checked with a longer grip bolt in the Skidmore-Wilhelm calibrator.

2. Washers

All fasteners shall have a hardened washer under the nut or bolt head turned in tightening. Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism.

3. Calibrated Wrench Tightening

If calibrated wrenches are used to provide the bolt tension specified in 711.65(d)1, the settings shall be such as to induce a bolt tension of 5% to 10% in excess of this value. These wrenches shall be calibrated at least once each working day by tightening, in a device capable of indicating actual bolt tension, no less than 3 typical bolts of each diameter from the bolts to be installed. Power wrenches shall be adjusted to stall or cut-out at the selected tension. If manual torque wrenches are used, the torque indication corresponding to the calibrating tension shall be noted and used in the installation of all bolts of the tested lot. Nuts shall be in tightening motion when torque is measured. When using calibrated wrenches to install several bolts in a single joint, the wrench shall be turned to touch up bolts previously tightened which may have been loosened by the tightening of subsequent bolts. This shall be continued until all are tightened to the required amount.

4. Turn-of-Nut Tightening

When the turn-of-nut method is used to provide the bolt tension specified in 711.65(d)1, there shall first be enough bolts brought to a snug tight condition to ensure that the parts of the joint are brought into full contact with each other. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the

full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in all remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table B with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

TABLE B

NUT ROTATION(1) (2) FROM SNUG TIGHT CONDITION

Disposition of Outer Faces of Bolted Parts

Both faces normal to bolt axis, or 1 face normal to axis and other face sloped(3) (bevel washer not used)		Both faces sloped(3) from normal to bolt axis (bevel washers not used)
Bolt length(4) not exceeding 8 diameters or 8 in. (200 mm)	Bolt length(4) exceeding 8 diameters or 8 in. (200 mm)	For all lengths of bolts
1/2 turn	2/3 turn	3/4 turn

(1) For coarse thread heavy hexagon structural bolts of all sizes and lengths and heavy hexagon semi-finished nuts.
(2) Nut rotation is rotation relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation: 1/6 of a turn over and nothing under.
(3) Slope 1:20 maximum.
(4) Bolt length is measured from underside of head to extreme, end of point.

(e) Inspection

1. It will be determined that requirements 2 and 3 of 711.65(e) are met in the work. When the calibrated wrench method of tightening is used, the Engineer shall be given full opportunity to witness the calibration tests prescribed in 711.65(d)3.

2. The installation and tightening of bolts will be observed to determine that the selected tightening procedure is properly used and that all bolts are tightened.

3. The following inspection shall be used unless a more extensive or different inspection procedure is specified.

   a. An inspection wrench which may be either a torque wrench or a power wrench that can be adjusted accurately in accordance with 711.65(d)3 shall be used.

   b. Three bolts of the same grade, size and condition as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. Length may be any length representative of bolts used in the structure. There shall be a washer under the part turned in tightening each bolt.

c. When the inspecting wrench is a torque wrench, each bolt specified in requirement 3b of 711.65(e) shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size in 711.65(d)1. The inspecting wrench shall then be applied to the tightened bolt. The torque necessary to turn the nut or head 5°, or approximately 1 in. (25 mm) at a 12 in. (300 mm) radius, in the tightening direction shall be determined. The average torque measured in the tests of 3 bolts shall be taken as the job inspecting torque to be used in the manner specified in requirement 3e of 711.65(e).

d. When the inspecting wrench is a power wrench, it shall be adjusted so that it shall tighten each bolt specified in requirement 3b of 711.65(e) to a tension at least 5% but no more than 10% greater than the minimum tension specified for its size in 711.65(d)1. This setting of wrench shall be taken as the job inspecting torque to be used in the manner specified in requirement 3e of 711.65(e).

e. Bolts represented by the sample prescribed in requirement 3b of 711.65(e) which have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspection wrench and its job inspecting torque to 10% of the bolts, but no less than 2 bolts, selected at random in each connection. If no nut or bolt head is turned by this application of the job inspecting torque, the connection shall be accepted as properly tightened. If a nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection. All bolts whose nut or head is turned by the job inspection torque shall be tightened and reinspected, or alternatively, the fabricator or erector, at his option, may retighten all of the bolts in the connection and then resubmit the connection for the specified inspection.

711.66 Bolted Connections Using Other Than High Strength Bolts
Bolts for these connections shall be in accordance with 910.02(h).

711.67 Final Clean-Up
Final clean-up shall be conducted in accordance with 104.07.

711.68 Structural Steel Cutting, Rivet and Bolt Removal, and Drilled Bolt Holes in Repair Projects
Field cutting of structural steel shall be done as shown on the plans or as directed.

Rivets or bolts connecting steel at locations shown on the plans or as directed shall be removed. This work shall be done in a manner that does not damage the surrounding steel. If necessary, such work shall be done by drilling.

Bolt holes shall be drilled as directed in the field. A bolt hole is a hole required for 1 bolt drilled through any number and thicknesses of metal plates.

711.69 Jacking and Supporting Beams

When jacking and supporting a beam is required on a bridge repair project, the proposed method for jacking and supporting shall be submitted for approval. This work shall not be performed until a method is approved.

711.70 Field Cleaning and Storage of Weathering Steel

Cleaning of structural steel specified to be left unpainted shall be in accordance with 619.08(b) or 619.08(f) or as determined by the Engineer, depending on the severity of the soilage. Foreign matter which adheres to the steel after it has been blasted, and which inhibits formation of the oxide film shall be removed as soon as practical. The use of acids to remove scale and stains will not be permitted.

Storage shall be such to permit free drainage to avoid moisture pockets.

711.71 Painting

After erection is complete, the structure shall be painted unless otherwise provided. Painting shall be in accordance with the applicable requirements of 619.

711.72 Method of Measurement

Structural steel shapes, fabricated steel, steel castings, iron castings, bolts, pins, rollers, rockers, anchor bolts, and threaded rods will be measured by the pound (kilogram). If the Schedule of Pay Items includes a lump sum item for structural steel, all of the materials listed above shall be included in such pay item. No measurement will be made.

Stud shear connectors placed on new structural steel will not be measured. Stud shear connectors placed on existing structural steel will be measured by the number installed.

Bronze plates will be measured by the pound (kilogram). Pay weight (mass) will be based on a theoretical density of 536 lb/cu ft (8,590 kg/m^3). Volume will be computed based on finished dimensions. No deductions will be made for drilled holes.

Field cutting of structural steel will be measured by the square inch (square millimeter) as determined by the multiplication of the length times the depth of the cut. Removal of rivets and removal of bolts will be measured by the number of each removed. Drilled holes for bolts on repair work will be measured by the number of drilled holes.

Jacking and supporting structural members will not be measured for payment.

711.73 Basis of Payment

The accepted quantities of structural steel shapes, fabricated steel, steel castings, iron castings, bolts, pins, rollers, rockers, anchor bolts, and threaded rods will be paid for at a contract lump sum price if the Schedule of Pay Items includes a lump sum pay item for structural steel. Changes from the estimated quantities shall be in accordance with 711.73(a). If the Schedule of Pay Items does not include a lump sum pay item for structural steel, the accepted quantities of structural steel will be paid for at the contract unit price per pound (kilogram) for structural steel. Such pay item will include all work listed above, complete in place. Payment will be in accordance with 711.73(b).

Stud shear connectors placed on existing structural steel will be paid for at the contract unit price per each, complete in place and accepted.

The accepted quantities of bronze plates will be paid for at the contract unit price per pound (kilogram). The accepted quantities of field structural steel cutting will be paid for at the contract unit price per square inch (square millimeter) for structural steel, field cut. The accepted quantities of rivet removal, bolt removal, and drilled holes will be paid for at the contract unit price per each for rivet, remove; per each for bolt, remove; and per each for drilled hole.

Jacking and supporting structural members, if specified as a pay item, will be paid for at the contract lump sum price for jacking and supporting the types of structural members shown in the Schedule of Pay Items.

Bolts, including anchor bolts and threaded rods, will be paid for as the full width (mass) computed on the basis of 490 lb/cu ft (7,849 kg/m^3), including nuts and washers, for the actual number of bolts in the structure.

If welding is shown on the plans, the weights (masses) of the structural steel parts will be computed as described above.

The weight (mass) of castings will be computed on the basis of 490 lb/cu ft (7,849 kg/m^3) for cast steel, and 450 lb/cu ft (7,208 kg/m^3) for cast iron, based on the net volume of the finished castings as shown on the plans, including fillets at angles. No deductions will be made for holes required to be drilled in castings or for rounding the corners of castings.

(a) Lump Sum Basis

An estimated weight (mass) of structural steel will be shown on the plans. Such weight (mass) will be computed by the same method as that used when computing the estimated weight (mass) when paid for on a unit price per pound (kilogram) basis

from semi-detailed plans. This weight (mass) will include all structural steel and miscellaneous metals unless otherwise included in specific pay items.

The weight (mass) of structural steel shown on the plans is approximate only. For a lump sum pay unit, the Contractor shall determine the weight (mass) on which the bid is based.

If there is a discrepancy between the plan weight (mass) and the actual weight (mass), no decrease or increase in the payment for the work will be made on account of such discrepancy.

If a change in the plans is made which will affect the weight (mass) of material to be furnished, payment for the addition or reduction of structural steel quantities required as a result of such change in plans will be made at a unit price per pound (kilogram) obtained by dividing the lump sum amount for structural steel by the total estimated weight (mass) of structural steel shown on the plans. Such unit price may be adjusted in consideration of the fabricating and connection cost. Changes in the plans involving classifications of structural steel may increase the pay quantities. Such additional quantities will be paid for on comparison of evidence of invoice prices.

(b) Unit Weight Basis

The weight (mass) of materials will be shown in the bill of materials on the plans when this information is included in such plans, or as computed from the fabricator's approved working drawings when this information is not included in the plans. In either case, such weight (mass) shall include all changes ordered.

For rolled sections, the gross weight (mass) of the steel will be considered. The weight (mass) will be figured on the basis of 490 lb/cu ft (7,849 kg/m^3). The weight (mass) of each piece will be the weight (mass) of the smallest regular shape from which the detail piece can be cut, not deducting cuts or holes. When so shown on the contract plans or on the approved working drawings, the weight (mass) of groups of 2 or more pieces shall be the weight (mass) of the smallest regular shape from which the given group of detail pieces may be cut by properly arranging the cuts.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Bolt, Remove	EACH
Bronze Plates	LBS (kg)
Drilled Hole	EACH
Jacking and Supporting _____ structural member type	LS
Rivet, Remove	EACH
Structural Steel	LS LBS (kg)

Structural Steel, Field Cut ..... SIN (mm2)
Stud Shear Connectors .....EACH

The cost of drilling holes for anchor bolts, elastomeric bearings, bridge bearing pads, fabrication, erecting falsework, welding material, Charpy V-Notch toughness tests, and necessary incidentals shall be included in the cost of the pay items in this section.

The cost of stud shear connectors placed on new structural steel will be included in the cost of structural steel.

No increase in pay weight will be permitted if diaphragm connections other than those shown on the plans are approved and used.

Shims between beams and top shoes of the thicknesses necessary to adjust the steel to planned elevations shall be furnished using either the plan datum or another datum as established. No adjustment will be made to the pay quantities as long as the total weight (mass) of shims required does not exceed that planned. No shim shall be less than 1/8 in. (3 mm) in thickness.

No allowance in weight (mass) will be made for work which is done at the option of the Contractor. No payment will be made for material used at the convenience of the Contractor in excess of the quantities shown on the plans.

SECTION 712 – TIMBER STRUCTURES

712.01 Description

This work shall consist of furnishing the materials for and the construction of timber structures, such parts of other structures which are of timber, and wood plank floors for structures in accordance with 105.03.

712.02 Materials

Materials shall be in accordance with the following:

Iron Castings..... 910.05(b)
Lumber and Timber (Treated) 911.02
Lumber and Timber (Untreated)..... 911.01
Malleable Iron Castings..... 910.05(d)
Preservatives..... 911.02(h)
Steel Castings ..... 910.05(a)
Structural Steel 910.02
Waterborne Finish Paint ..... 909.02(d)

Machine bolts, drift bolts, and dowels shall be medium steel. Machine bolts shall have square heads and nuts, unless otherwise specified. Nails shall be full-barbed, heavy, bright, flat-head, car nails. Lumber and timber shall be treated or

untreated. Rods, plates, bars, and shapes shall be structural steel. Castings shall be steel or iron. Washers may be cast O. G. or malleable castings or they may be cut from medium steel plates. Spikes shall be cut, wire, or boat spikes. Spikes, bolts, dowels, washers, and lag screws shall be black or galvanized.

CONSTRUCTION REQUIREMENTS

712.03 General Requirements

The ground underneath and in the immediate vicinity of all stored material shall be cleaned of weeds and rubbish and kept well drained. Lumber and timber at the site of the work shall be stored in piles. Untreated lumber shall be open stacked at least 12 in. (300 mm) above the ground surface, arranged to shed water and prevent warping, and protected by a weatherproof covering when so required. Creosoted timber and piling shall be closed-stacked so that warping is prevented and the tops of the stacks are covered. Treated timber shall be handled carefully without sudden dropping, breaking of outer fibers, bruising, or penetrating surfaces with tools. It shall be handled with rope slings. Canthooks, peaveys, spikes, or hooks shall not be used. Creosoted piling may be handled with chains.

Workmanship shall be 1st-class throughout. Competent bridge carpenters shall be employed. All framing shall be true and exact. Nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces will be considered evidence of poor workmanship and sufficient cause for the dismissal of a worker causing them.

In structures of untreated timber the ends, tops, and all contact surfaces of sills, caps, floor beams, stringers, end joints, contact surfaces of bracing, the back faces of bulkheads, and all timber which is to be in contact with earth, road material, or other timber shall be coated with 2 coats of hot creosote oil before being assembled. Countersinking shall be done where smooth faces are required. The recesses formed by countersinking shall be painted with hot creosote oil and filled with hot pitch after the bolt or screw is in place.

All cuts in treated piles or timber and all abrasions, after having been trimmed, shall be covered with 2 applications of a mixture of 60% creosote oil and 40% roofing pitch, or brush coated with at least 2 applications of hot creosote oil and covered with hot roofing pitch. Insofar as practicable, cutting, framing, and boring of timber to be treated, except pile cut-offs, shall be done before treatment.

All lumber and timber shall be cut accurately and framed to a close fit in such manner that joints will have even bearing over the entire contact surfaces. Mortises shall be true and even for their full depth and tenons shall fit snugly. Shimming will not be permitted in making joints nor will open joints be accepted. Timbers requiring an exact fit shall be matchmarked.

Holes for bolts, dowels, rods, and lag screws shall be bored as follows:

(a) machine bolts shall be the same diameter as the bolt;

(b) round drift bolts and dowels shall be 1/16 in. (2 mm) less in diameter than that of the bolt or dowel to be used;

(c) square drift bolts or dowels shall be equal to the least dimension of the bolt or dowel;

(d) rods shall be 1/16 in. (2 mm) larger than the rod; and

(e) lag screws shall be the screw diameter to the base of thread, and 1/2 the screw diameter to the point of the screw.

Before driving bolts, hot creosote oil shall be poured into all bolt holes so that the entire surface of the hole is coated. Any unfilled holes, after being treated with creosote oil, shall be plugged with creosoted plugs.

A washer of the size and type specified shall be used under each bolt head and under each nut which would otherwise come in contact with wood. Any portion of a bolt projecting more than 1/4 in. (6 mm) beyond the nut shall be cut off. The threads of each bolt shall be checked at the face of the nut after the nut has been finally tightened. The ends of bracing shall be bolted through the pile, post, or cap with bolts of no less than 5/8 in. (16 mm) in diameter. Intermediate intersections shall be bolted or spiked with wire or boat spikes as shown on the plans.

712.04 Caps

Timber caps shall have an even and uniform bearing over the tops of supporting posts or piles and shall have their ends evenly aligned. All caps shall be secured by drift bolts of no less than 3/4 in. (19 mm) in diameter extending at least 9 in. (230 mm) into the approximate center of posts or piles. Pile heads, after being cut to receive the caps and prior to placing the caps, shall be treated to prevent decay. The sawed surfaces of creosoted piles shall be covered with 3 applications of a mixture of 60% creosote oil and 40% roofing pitch or brush coated with 3 applications of hot creosote oil and covered with hot roofing pitch. A covering of medium weight roofing felt or galvanized iron shall be placed on this treatment, bent over the sides of the pile, and fastened securely. Edges shall be trimmed to present a satisfactory appearance. The sawed surfaces of untreated piles shall be brush coated with 2 applications of hot creosote oil.

712.05 Stringers

Stringers shall be sized at bearings and so placed in position that any knots at or near edges are in the top portion. Outside stringers may have butt joints with the ends cut on a taper. Interior stringers shall be lapped to take bearing over the full width of the floor beam or cap at each end. The lapped ends of untreated stringers shall be separated at least 1/2 in. (13 mm) for the circulation of air and shall be securely

fastened to the cap by drift bolting where specified. Where stringers are 2 panels in length, the joints shall be staggered. Cross-bridging between stringers shall be neatly and accurately framed and securely toenailed with at least 2 nails in each end.

712.06 Bents

Untreated timber, if used for mudsills shall be heart cedar, heart cypress, redwood, or other approved durable timber. Mudsills shall be embedded firmly and evenly to solid bearing and tamped in place. Concrete pedestals for the support of framed bents shall be carefully finished so that the posts or sills take even bearing on them. The sills or posts shall be anchored to pedestals with dowels and the dowels set when the pedestals are poured. They shall be no less than 3/4 in. (19 mm) in diameter and shall project at least 6 in. (150 mm) above the top of each pedestal. Sills shall have true and even bearing on mudsills, grillages, piles, or pedestals. They shall be drift-bolted to mudsills or piles with bolts no less than 3/4 in. (19 mm) in diameter and extend into the mudsills or piles at least 6 in. (150 mm). When feasible, all earth shall be removed from contact with sills to permit free circulation of air around them.

Posts shall be fastened to pedestals with dowels of no less than 3/4 in. (19 mm) in diameter extending at least 6 in. (150 mm) into the posts. Posts shall be fastened to sills, as shown on the plans, by means of drift bolts of not less than 3/4 in. (19 mm) in diameter driven diagonally through the base of the post, and extending at least 9 in. (230 mm) into the sill, or by means of dowels of no less than 3/4 in. (19 mm) in diameter extending at least 6 in. (150 mm) into posts and sills. Pile bents shall be driven in accordance with 701.

712.07 Wheel Guards and Railings

These shall be framed and erected true to line and grade. Wheel guards and rails shall be surfaced as shown on the plans. Wheel guards shall be laid in sections of no less than 12 ft (3.7 m) in length.

712.08 Painting

Paint shall be applied to untreated lumber and timber as shown on the plans or as otherwise specified. Lumber or timber treated with preservative shall not be painted, unless otherwise specified. The color shall be as specified.

Surface preparation shall be the removal of all contamination such as oil, grease, dirt, foreign matter, rust, mold, mildew, and sealers. Knots and pitch streaks shall be scraped or burned, and sanded. All nail holes or small openings shall be caulked with a general purpose caulking compound.

The surfaces shall be painted with 1 coat of waterborne finish paint. The paint shall be applied by brush or roller only and at the rate recommended by the manufacturer. All finishes shall be uniform in texture and color. If a painted surface is unsatisfactory, the paint shall be removed and the surface shall be cleaned and repainted or corrected as may be directed.

At the end of each work day, paint stains and splatters shall be removed from all surfaces not intended to receive the paint applied for that day.

712.09 Single-Ply Plank Floors

These floors shall consist of a single thickness of plank supported by stringers or joists. The planks shall be laid heartside down with 1/4 in. (6 mm) openings for seasoned material and with tight joints for unseasoned material. Each plank shall be fastened securely to each joist or stringer. The planks shall be carefully selected for thickness and laid so that a smooth riding surface is obtained.

712.10 Two-Ply Plank Floors

These floors shall consist of 2 layers of wood planks supported by stringers or joists. Both courses shall have been pressure treated with creosote oil. The top course shall be laid parallel to the roadway centerline with each piece fastened securely to the lower course. The lower course shall be fastened as provided above for single-ply. Joints shall be staggered at least 3 ft (0.9 m). Ends shall be fastened securely. If required, the outer ends of the top planks shall be beveled at each end of the bridge.

712.11 Method of Measurement

Structural timber and lumber, both treated and untreated, will be measured by the 1,000 board foot measure (cubic meter). Planks for floors will be measured by the square foot (square meter). Computation of the amount of lumber and timber will be based on full size for rough lumber and nominal size for dressed lumber on the shortest commercial lengths which may be used.

Metal parts, other than hardware, will be measured by the pound (kilogram) computed in accordance with 711.73(b). Bolts, dowels, washers, nails, spikes, and lag screws will be classed as hardware.

712.12 Basis of Payment

The accepted quantities of lumber and timber will be paid for at the contract unit price per 1,000 board foot measure (cubic meter) for lumber and timber, either treated or untreated as specified. Plank floors will be paid for at the contract unit price per square foot (square meter) for plank floors of the ply specified. Metal parts will be paid for at the contract unit price per pound (kilogram).

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Metal Parts	LBS (kg)
Plank Floors, ____ Ply	SFT (m2)
Lumber and Timber, Treated	MFBM (m3)
Lumber and Timber, Untreated	MFBM (m3)

The cost of preservative treatment, hardware, painting, and necessary incidentals shall be included in the cost of the pay items.

SECTION 713 – TEMPORARY BRIDGES AND APPROACHES

713.01 Description

This work shall consist of the construction and maintenance of temporary pile or timber trestle bridges and approaches in accordance with 105.03.

713.02 Materials

Materials shall be in accordance with the following:

Delineators	926.02
Delineator Posts	910.15
Fence	910.18
Piling	701

CONSTRUCTION REQUIREMENTS

713.03 General Requirements

Unless otherwise provided, the right-of-way will be furnished for temporary bridges and approaches.

Information indicating the details of the temporary bridge proposed to be built shall be submitted for approval. If this information is not in accordance with the plans, details of the proposed temporary bridge signed by and bearing the seal of a registered professional engineer shall be submitted. These details shall be supplied in triplicate or in such form that may be reproduced readily. Information or details, or both if required, regarding temporary bridges shall be submitted and approved before work is started.

Where it is necessary to remove existing fence, a temporary fence shall be erected along the temporary right-of-way line, if so directed. This fence shall be substantially as good as the existing fence. It shall be built and maintained satisfactorily.

713.04 Temporary Bridge

Unless otherwise provided, the temporary bridge shall have a clear roadway of no less than 28 ft (8.5 m) and be designed to carry an HS20 truck loading. The bridge shall be provided with substantial railings which shall be kept painted white. Backwalls shall be built at each end bent to hold the approach fills. Each bent shall have at least 4 piles or 4 substantial posts on an adequate mudsill. The temporary bridge shall be built to an elevation of not less than that shown on the plans. It shall have a clear length opening no less than shown or otherwise designated. Unless otherwise specified, all timber and piles may be treated or untreated.

713.05 Temporary Pipe

The minimum thickness required for the temporary pipe or pipe-arch shall be as follows:

(a) Corrugated Steel Circular Pipe

Thickness, in. (mm)	Pipe Diameter, in. (mm)
0.064 (1.63)	48 (1,200) or less
0.079 (2.01)	54 (1,350) or less
0.109 (2.77)	72 (1,800) or less
0.138 (3.51)	78 (1,950) or less
0.168 (4.27)	84 (2,100) or less

(b) Corrugated Steel Pipe-Arch, 3 in. by 1 in. (75 mm by 25 mm) Corrugations

Thickness, in. (mm)	Pipe-Arch Area, sq ft (m^2)
0.109 (2.77)	40 (3.71) or less
0.138 (3.51)	58 (5.39) or less

(c) Structural Plate Pipe-Arch 6 in. by 2 in. (150 mm by 50 mm) Corrugations

Thickness, in. (mm)	Pipe-Arch Area, sq ft (m^2)
0.111 (2.82)	38 (3.50) or less
0.140 (3.56)	71 (6.61) or less
0.170 (4.32)	122 (11.58) or less
9.188 (4.78)	131 (12.26) or less

For thicknesses, diameters, or areas not listed above, the Engineer shall be contacted for approval.

713.06 Temporary Approaches

Temporary approaches shall be constructed to a line and grade which will provide a reasonably convenient and safe connection between the temporary bridge and the existing road. The grade and crown elevation shall be as shown on the plans. The roadway and slopes shall be as shown on the plans. All necessary drainage shall be provided. Embankment shall be compacted in accordance with 203. If it becomes necessary to reconstruct the connection of the approaches with the existing roadway, either because of the operations or other cause, such adjustment shall be made as directed. HMA pavement for temporary approaches shall be in accordance with 402. Temporary pavement markings in accordance with 801.12 shall be placed as shown

on the plans. Delineators in accordance with 804 shall be placed as shown on the plans.

Guardrail and guardrail end treatment shall be provided at each corner of the temporary bridge as shown on the plans or as directed. The furnishing of materials and installation shall be provided in accordance with 601. After removal, the guardrail and guardrail end treatment will remain the property of the Contractor.

713.07 Maintenance

Unless otherwise provided, where a temporary bridge is required, traffic over the existing bridge shall not be prohibited until the temporary bridge and approaches are satisfactorily completed and opened to traffic. They shall be so maintained until the new structure is opened to traffic. The necessary material and labor shall be furnished to repair or replace any portion of the temporary bridge and approaches which may have deteriorated under traffic. During the winter months, salt or other equivalent materials shall be used as directed to prevent slippery conditions.

713.08 Removal

When the new work which made the temporary bridge and approaches necessary is opened to traffic, all the temporary work shall be removed and the temporary right-of-way shall be restored as nearly as possible to its original or satisfactorily altered state. All bents in the stream shall be removed entirely or down to the bed of the stream and all other bents either removed entirely or to 2 ft (0.6 m) below the ground surface, unless the property owner of the temporary right-of-way consents in writing to have them cut at the ground line. Temporary bituminous HMA pavement, when no longer required for maintenance of traffic, shall be removed and shall be disposed of in accordance with 203.10.

713.09 Method of Measurement

Temporary bridges, temporary pipes, and approaches will not be measured for payment unless otherwise specified. HMA mixtures for temporary pavement will be measured by the ton (megagram). Guardrail of the type specified will be measured by the linear foot (meter) along the top of rail. Guardrail end treatments will be measured per each of the type specified. Temporary pavement markings will be measured in accordance with 801.17. Seeding and sodding will be measured in accordance with 621.13. The removal and disposal of temporary HMA pavement will not be measured for payment.

713.10 Basis of Payment

The accepted quantities of temporary bridge and approaches, or temporary pipe and approaches will be paid for at the contract lump sum price for the work, complete in place and later removed as specified. HMA mixtures for temporary pavement will be paid for as the type of mixture specified, in accordance with 610.06, complete in place. Guardrail installed along approaches will be paid for at the contract unit price per linear foot (meter). Guardrail end treatment will be paid

for at the contract unit price per each for the type specified. Temporary pavement markings will be paid for in accordance with 801.18.

Seeding and sodding will be paid for in accordance with 621.14.

If adjustment of approach embankments is necessary, the additional excavation and borrow will be paid for in accordance with 203.28.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Guardrail End Treatment, ____, Temporary type Bridge Approaches	EACH
Guardrail, W-Beam, ____ ft.-____ in. (m) Spacing, Temporary Bridge Approaches	LFT (m)
Temporary Bridge	LS
Temporary Bridge and Approaches	LS
Temporary Pipe and Approaches	LS
Temporary Pipe	LS

The cost of excavation, embankment, backfill, removal and disposal of temporary HMA pavement, delineators, and temporary fence, shall be included in the cost of the pay items.

The cost of furnishing, installation, and removal of guardrail and guardrail end treatment shall be included in the cost of the pay items.

If the Contractor elects to build a longer bridge or approaches than specified, such work shall be done with no additional payment. If such work requires additional right-of-way, it shall be provided with no additional payment.

SECTION 714 – REINFORCED CONCRETE BOX STRUCTURES

714.01 Description

This work shall consist of the construction of a cast-in-place or precast reinforced concrete box structure and such parts of similar structures composed of concrete in accordance with these specifications and 105.03.

The Contractor will be allowed to substitute a three-sided structure in accordance with 723. The three-sided structure shall be of equivalent hydraulic capacity to that of the box structure shown on the plans. The structure shall be sumped as shown on the plans.

714.02 Materials

Materials shall be in accordance with the following:

Chemical Anchor System	901.05
Coarse Aggregates, Class A or Higher, Size No. 91	904
Concrete	702
Epoxy Coated Reinforcing Bars	910.01
Flowable Backfill	213
Geotextile	918.01 or 918.02
Hydrated Lime	913.04(a)
Joint Membrane System for Precast Reinforced Concrete Box Structure Sections	907.07
Masonry Cement	901.01(c)
Mortar Sand	904.02(e)
Natural Sand	904.02(a)
Pipe Joint Sealant	907.11
Portland Cement	901.01(b)
Precast Reinforced Concrete Headwalls, Wingwalls, Footings, and Spandrel Walls	907.06
Precast Reinforced Concrete Structure Sections	907.05
Reinforcing Bars	910.01
Riprap	904
Sealer	909.09 or 909.10
Steel Welded Wire Reinforcement, Smooth and Deformed	910.01
Structure Backfill	904.05

Cast-in-place concrete for a reinforced concrete box structure, or splices between an existing culvert structure and a precast reinforced concrete box structure section extension shall be class A or higher in accordance with 707.04(c). It shall have a 28-day minimum concrete compressive strength of 5,000 psi (34,500 kPa). Cast-in-place concrete for headwalls or wingwalls shall be class A or higher in accordance with 707.04(c). It shall have a 28-day minimum concrete compressive strength of 4,000 psi (27,600 kPa).

When the Contractor elects to provide a cast-in-place structure, acceptance of the structure will be based on tests for relative yield, air content, slump, water/cementitious ratio, and compressive strength. Relative yield and air content shall be in accordance with 702.05. The slump and concrete temperature shall be in accordance with 707.04(c). The amount of time from the introduction of mixing water to the cement and aggregates to the completion of the discharge of the concrete shall not exceed 90 min. The water/cementitious ratio shall be in accordance with 707.04(d). The 28-day compressive strength shall be equal to or greater than the specified concrete compressive strength and otherwise shall be in accordance with 707.04(c)3. The Contractor shall provide the necessary 6 in. diameter by 12 in. cylinder molds for the Department's use.

For plastic concrete sampling, acceptance testing procedures and casting cylinders will be in accordance with 505.01. Except for footings, concrete flexural strength or results from beam breaks will not be accepted in lieu of concrete compression cylinder test results.

Cast-in-place concrete used to seal existing culverts shall be class A. Cast-in-place concrete for footings shall be class B.

Unless otherwise specified herein, reinforcement may consist of either reinforcing bars or WWR. If specified to be coated, WWR shall be coated with either galvanized coating or epoxy coating, and reinforcing bars shall be coated with epoxy coating. Epoxy coated WWR shall be coated with Type I coating with Class A minimum coating thickness in accordance with ASTM A 884. Galvanized WWR shall be coated in accordance with ASTM A 123 and shall have a minimum coating grade of 35. For WWR, material with minimum yield strength of 65 ksi (448 MPa) shall be used.

CONSTRUCTION REQUIREMENTS

714.03 General Requirements

Unless otherwise specified, the applicable requirements of 702 and 703 shall apply to the construction of box structures, structure extensions, and concrete parts of similar structures. Excavation and disposal shall be in accordance with the applicable requirements of 206. Areas designated for waterproofing shall be waterproofed in accordance with 702.23. All underground drains encountered during excavation for the structure shall be perpetuated as dictated by field conditions. Drainage openings through masonry shall be in accordance with 702.16. Handling of box structures shall be in accordance with 907.05. Handling of wingwalls shall be in accordance with 907.06.

When riprap is specified, geotextile shall 1st be placed on the in-situ soil in accordance with 616.11. Riprap shall then be placed in accordance with 616.

714.04 Design Requirements

Where reinforcing bars are used, reinforcing bar splicing and spacing shall be in accordance with the AASHTO LRFD Bridge Design Specifications, except as modified herein.

(a) Box Structure

A box structure shall be designed in accordance with the methodology presented in ASTM C 1577 with the following exceptions.

The box structure shall be designed in accordance with the soil parameters shown in the contract documents.

Minimum structural reinforcement area shall be at least 0.002 of the gross concrete area A_g or 0.125 sq in./ft (265 mm^2/m), whichever is greater. The permissible variation in diameter of reinforcement shall be in accordance with the tolerances prescribed in the AASHTO specification for that type of reinforcement.

If coated reinforcement is specified, reinforcement, including support devices, in that structure shall be coated. In lieu of coating, the support device may be manufactured of a non-corrosive material.

(b) Concrete Headwalls, Wingwalls, and Footings

Headwalls, wingwalls, and footings may be precast or cast-in-place. Headwalls and wingwalls shall be designed based on a minimum equivalent fluid pressure of 40 lb/cu ft (6.3 kN/m^3). If flowable backfill is to be used, the Contractor shall consider the effects of hydrostatic pressure on the wingwalls. Weep holes shall be provided in all wingwalls. Horizontal pressures shall be increased for sloping backfill surfaces and live-load surcharge. Headwall connections and wingwall footings shall be checked for sliding and for overturning.

Wingwalls and wingwall footings shall be designed in accordance with the soil parameters shown in the contract documents.

A headwall with bridge railing mounted on top and the anchorage of the headwall to the box structure section shall be designed for the bridge railing test level shown on the plans.

Reinforcement in headwalls shall consist of reinforcing bars and shall be epoxy coated. Tension splices in circumferential reinforcement shall be made by means of lapping. Where reinforcing bars are used in wingwalls, the maximum spacing for wingwall reinforcing bars shall be 18 in. (450 mm) for horizontal bars and 12 in. (300 mm) for vertical bars.

Concrete cover for headwall and wingwall reinforcement shall be a minimum of 2 in. (50 mm). Concrete cover for footing reinforcement shall be 3 in. (75 mm) for the top and sides, and 4 in. (100 mm) for the bottom.

(c) Working Drawings

Working drawings shall be submitted in accordance with 105.02 for fabrication of a precast reinforced concrete box structure greater than 12 ft (3.6 m) span, a box structure of a size not described in ASTM C 1577, headwalls, wingwalls, and footings. Design calculations which show the effects of hydrostatic pressure on the structure shall also be submitted with the working drawings. Detailed plans for falsework and centering will not be required. Working drawings shall include all details, dimensions, and quantities necessary to construct the structure, headwalls, wingwalls, or footings and shall include, but not be limited to, the following information.

1. Structure span and rise.

2. Structure section details showing all concrete dimensions and reinforcement requirements.

3. Headwall details, showing all concrete dimensions, elevations, reinforcing bar sizes, reinforcing bar bending diagrams, lengths, spacings, and anchorage details. Headwall elevation and section views shall be provided.

4. Wingwall design calculations and details showing all concrete dimensions, elevations, reinforcement sizes, bending diagrams, lengths, spacings, and anchorage details. Wingwall plan, elevation, and section views shall be provided.

5. Wingwall backfill type and limits.

6. Footing details showing all concrete dimensions, elevations, reinforcing bar sizes, reinforcing bar bending diagrams, lengths, and spacings indicated. Footing plan and section views shall be provided. The actual soil bearing pressure shall be shown on the footing detail sheets.

7. Structure backfill type and limits for the structure and wingwalls.

8. Minimum concrete strength for all concrete portions of the structure.

714.05 Erection Requirements

The soils in the bottom of the excavation shall be compacted in accordance with 203.23.

Where a precast footing is utilized, a 4 in. (100 mm) layer of coarse aggregate No. 53 in accordance with 301 shall be placed under the full width of the footing. All cast-in-place footings shall be given a smooth float finish. The footing concrete shall reach a compressive strength of 2,000 psi (13,800 kPa) or flexural strength in accordance with 702.24(c) before placement of the wingwalls. The surface shall not vary more than 1/4 in. in 10 ft (6 mm in 3 m) if tested with a 10 ft (3 m) straightedge.

Structure backfill shall be placed and compacted in accordance with 211. Structure backfill shall be placed and compacted on each side of the structure to the fill line shown on the plans. During the backfill operation, the difference in elevations of the fill on each side of the structure shall not exceed 24 in. (610 mm).

Unless otherwise specified by the manufacturer on the working drawings, once the level of structure backfill reaches the top of the structure, 2 lifts shall be spread

and hand compacted over the structure without traversing the structure with heavy equipment. Compaction with heavy equipment will not be allowed until a minimum of 2 lifts have been placed, hand compacted, and accepted.

The operation of equipment over a structure shall be in accordance with the structure manufacturer's recommendations.

714.06 Precast Concrete Headwalls, Wingwalls, and Footings

(a) Headwall Reinforcement Placement Relative to Top of Structure

The vertical headwall reinforcement shall be attached to the top of the structure by either drilling holes or precasting holes. A chemical anchoring material, if used, shall be from the Department's List of Approved Chemical Anchoring Materials.

(b) Wingwall Placement

Each wingwall that is not precast as one unit with the footing shall be set on masonite or steel shims. A minimum gap of 1/2 in. (13 mm) shall be provided between the footing and the bottom of each wingwall. Once the wingwalls are placed, the space underneath the wingwall section to the top of the keyway sides shall be filled with prepackaged grout in accordance with ASTM C 1107, or conventional or self-consolidating fine grout in accordance with ASTM C 476, except as modified herein. If conventional fine grout is used, it shall be troweled into the keyway and mounded on one side of the wingwall. The mound of conventional fine grout shall be vibrated until it passes through to the other side of the wingwall. After completing this process on one side, if the conventional fine grout has not passed through to the other side, the process shall be repeated on the other side. Conventional or self-consolidating fine grout shall be from a prepackaged source or composed of one of the following mixtures.

1. 930 lb/cu yd (552 kg/m^3) Type I portland cement with No. 23 natural sand or mortar sand.

2. 930 lb/cu yd (552 kg/m^3) Type M masonry cement with No. 23 natural sand or mortar sand.

3. 828 lb/cu yd (491 kg/m^3) Type I portland cement and 75 lbs/cu yd (44 kg/m^3) hydrated lime with No. 23 natural sand or mortar sand.

The maximum water/cement ratio shall be 0.446 for both conventional and self-consolidating fine grout. An air entraining agent from the Department's list of approved PCC admixtures may be used. A type F or G chemical admixture from the Department's list of approved PCC admixtures shall be used in self-consolidating fine grout in order to achieve the slump flow and visual stability index requirements. Filling procedure B of ASTM C 1611 will be used for measuring slump flow. Appendix X1 of ASTM C 1611 will be used for determining the visual stability index value.

Acceptance of conventional fine grout will be based on an air content of 12% ± 4%. Acceptance of self-consolidating fine grout will be based on tests for air content, slump flow, and visual stability index. Air content shall be 12% ± 4%. Slump flow shall be 27 in. ± 3 in. (685 mm ± 75 mm). Visual stability index value shall not exceed 1.

Where prepackaged grout is used, a type C certification in accordance with 916 shall be provided.

Wingwalls shall be connected to the outside box structure sections with bolted steel plates.

(c) Sealing

Sealer shall be applied in accordance with 709 on the top surfaces of the structure section, headwalls and wingwalls. It shall extend 5 ft (1.5 m) vertically down the exterior of each section or 5 ft (1.5 m) vertically down both faces of each headwall or wingwall or to the bottom of each, whichever is less. Sealer material shall not be placed in keyway joints, if present. The sealer shall be provided for the full length of the structure. Surface preparation and application procedures shall be as recommended by the sealer manufacturer.

714.07 Rejection

Structure sections, headwalls, wingwalls, or footings will be rejected due to the following conditions:

(a) fractures or cracks passing through the section or wall, except for a single end crack which does not exceed one-half the thickness of the section or wall;

(b) defects which indicate proportioning, mixing, or molding which are not in accordance with this specification;

(c) honeycombed or open texture; or

(d) damaged section ends, where such damage prevents making a satisfactory joint.

714.08 Repairs

Structure sections, headwalls, wingwalls, and footings shall be repaired, if necessary, due to imperfections in manufacture, or damage caused by handling or construction. Repairs will be acceptable if it is determined that the repairs are sound, properly finished and cured, and if the repaired structure section, headwall, wingwall, or footing is in accordance with the requirements herein.

714.09 Extension of Existing Structure

All applicable requirements of this specification shall apply to the extension of an existing box structure, slab-top structure, or arch structure. Such portions of the existing structure designated for removal shall be removed. All portions of the existing structure which are to remain in place and are damaged shall be repaired or replaced as directed. Those portions left in place which are wholly or partially filled with debris shall be cleaned out. Material removed shall be disposed of in accordance with the applicable requirements of 202.02.

Before removing concrete from an existing structure with wingwalls, the Contractor shall saw around the perimeter of the removal area on the interior and exterior of the existing structure a depth of 1 in. (25 mm). All existing reinforcement in the top slab, bottom slab, and sidewalls exposed after concrete removal shall be cleaned and straightened in preparation for lapping with reinforcement from adjacent new work. Where existing reinforcement has deteriorated or been damaged during the removal operation, holes shall be drilled into the face of the existing structure to provide embedment for replacement reinforcing bars. The holes shall be of the diameter and depth required by the manufacturer of the approved chemical anchor system. The holes shall be cleaned prior to placing the approved chemical anchor system and the reinforcing bars.

No concrete shall be removed from an existing structure that has a headwall but no wingwalls. Reinforcing bars to tie the existing structure to the new structure section shall be installed by drilling holes into the face of the existing structure to provide embedment for reinforcing bars. The diameter and depth of the holes shall be according to the recommendations of the manufacturer of the approved chemical anchor system. The holes shall be cleaned prior to placing the approved chemical anchor system and the reinforcing bars.

An existing structure shall be extended by one of the following methods.

(a) Precast Reinforced Concrete Box Structure Extension

A cast-in-place concrete splice shall be constructed as a transition between the existing structure and the precast structure extension. The splice reinforcement in the precast structure extension section that will abut the existing structure shall be exposed 18 in. (450 mm) on the tongue end of the precast structure extension section. It shall be lapped 18 in. (450 mm) with either exposed existing structure reinforcement, in the case of an existing structure with wingwalls, or newly installed reinforcing bars in the existing structure, in the case of an existing structure with a headwall only as shown on the plans. Existing exposed structure reinforcement from an existing structure with wingwalls shall be cut off 1 in. (25 mm) from the face of the new precast extension.

If the existing tongue or groove joint end is acceptable and matches the mating joint on the new precast reinforced concrete box structure extension, the new extension may be installed using the mating joint of the existing box structure. No

cutting of the box structure or splicing of reinforcement is then required. The joint between the new precast box structure extension and the existing structure shall be sealed as directed below.

(b) Cast-In-Place Concrete Structure Extension

The reinforcement for the structure extension shall be lapped with the exposed reinforcement of the existing structure as shown on the plans.

714.10 Precast Reinforced-Concrete Box Structure Section Joints

Precast reinforced concrete box structure section joints shall be sealed as shown on the plans. Pipe joint sealant shall be applied once the concrete surface temperature is above 40°F (4°C) or above the minimum application temperature recommended by the pipe joint sealant manufacturer. The concrete surfaces shall be clean and dry prior to application of the pipe joint sealant. Heat may be applied to the concrete surfaces until they are in accordance with the temperature and dryness requirements. The pipe joint sealant shall be centered on both sides of the joint as it is being applied. After application, the geotextile or membrane material shall be rolled to avoid wrinkling. If the roll of geotextile or membrane material does not cover the full length of the joint, an overlap of at least 2 1/2 in. (64 mm) will be required to start the next roll of material. The manufacturer's application instructions shall apply in addition to the above requirements.

714.11 Method of Measurement

Precast reinforced concrete box structures or structure extensions, precast coated reinforced concrete box structures or structure extensions, precast headwalls, precast wingwalls, cast-in-place reinforced concrete box structures or structure extensions, cast-in-place coated reinforced concrete box structures or structure extensions, cast-in-place headwalls, and cast-in-place wingwalls will not be measured. The accepted quantities for payment will be the quantities shown on the plans.

Geotextile and riprap will be measured in accordance with 616.12. Structure backfill will be measured in accordance with 211.09. Flowable backfill will be measured in accordance with 213.08. Field drilled holes will be measured in accordance with 702.27.

Plain or coated reinforcement or WWR used in precast reinforced concrete box structures or structure extensions, precast headwalls, precast wingwalls, cast-in-place reinforced concrete box structures or structure extensions, cast-in-place headwalls, or cast-in-place wingwalls will not be measured for payment.

If the Contractor elects to provide a three-sided structure in lieu of the box structure shown on the plans, it will be measured in accordance with 723.17.

714.12 Basis of Payment

The accepted quantities of precast reinforced concrete box structures or structure extensions, precast coated reinforced concrete box structures or structure extensions,

cast-in-place reinforced concrete box structures or structure extensions, and cast-in-place coated reinforced concrete box structures or structure extensions of the size specified will be paid for at the contract unit price per linear foot (meter).

Geotextile or riprap will be paid for in accordance with 616.13. Structure backfill will be paid for in accordance with 211.10. Flowable backfill will be paid for in accordance with 213.09. Field drilled holes will be paid for in accordance with 702.28.

If the Contractor elects to provide a three-sided structure in lieu of the box structure shown on the plans, it will be paid for in accordance with 723.18. The Department will not incur additional cost for allowing the Contractor to substitute a three-sided structure for the box structure shown on the plans.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Structure Extension, Coated Reinforced Concrete, Box Sections, ____ ft (mm) x ____ ft (mm) span rise	LFT (m)
Structure Extension, Reinforced Concrete, Box Sections, ____ ft (mm) x ____ ft (mm) span rise	LFT (m)
Structure, Coated Reinforced Concrete, Box Sections, ____ ft (mm) x ____ ft (mm) span rise	LFT (m)
Structure, Reinforced Concrete, Box Sections, ____ ft (mm) x ____ ft (mm) span rise	LFT (m)

The cost of excavation except as provided in 206.11(a), expansion joint material, perpetuation of existing drains shown on the plans, removal of portions of existing structures, cleaning out old channels or structures, approved chemical anchor system, precast reinforced concrete structure joints, and necessary incidentals shall be included in the cost of the structure or structure extension.

The cost of precast concrete headwalls, precast concrete wingwalls, cast-in-place headwalls, or cast-in-place wingwalls shall be included in the cost of the structure or structure extension.

The cost of plain or coated reinforcement or WWR used in precast reinforced concrete box structures or structure extensions, precast headwalls, precast wingwalls, cast-in-place reinforced concrete box structures or structure extensions, cast-in-place headwalls, or cast-in-place wingwalls shall be included in the cost of the structure or structure extension.

The cost of concrete used in a cast-in-place splice shall be included in the cost of the structure extension.

The cost of designing a box structure, box structure extension, headwalls, and wingwalls shall be included in the cost of the structure or structure extension.

The costs of coring, testing, excavation, repairs, plugging core and handling holes, mortar, grout, sealer, cylinder molds, and necessary incidentals shall be included in the cost of the structure. The cost of wingwall footing and the aggregate base under such footing shall be included in the cost of the structure or structure extension.

No additional payment will be made for carrying an underground drain through a structure or structure extension. However, no deduction will be made for the volume of concrete occupied by the drain pipe in a cast-in-place structure or structure extension.

No additional payment will be made for the repair or replacement of existing concrete damaged by Contractor operations.

SECTION 715 – PIPE CULVERTS, AND STORM AND SANITARY SEWERS

715.01 Description

This work shall consist of the construction or reconstruction of pipe culverts, storm or sanitary sewers, slotted drain pipe, or slotted vane drain pipe in accordance with 105.03.

MATERIALS

715.02 Materials

Pipe materials, minimum thickness or strength classification, and protective treatments for pipes except underdrains and drain tile will be determined based on height of cover, required service life, site abrasiveness, and structure pH criteria shown on the plans. Pipe with material thickness, strength classification, or protective coatings in excess of the minimum required by the above noted criteria may be used.

Concrete used for anchors, collars, grated box end sections, encasements, and sealing existing pipes shall be class A. Corrugated polyethylene pipe, type S has a smooth interior liner with a corrugated outer wall. Type SP pipe is a type S pipe with perforations.

Materials shall be in accordance with the following:

B Borrow 211

Concrete 702
Flowable Backfill 213
Geotextiles..... 918.02
Pipe Joint Sealant 907.11
Reinforcing Bars..... 910.01
Rubber Type Gaskets 907.13
Straps, Hook Bolts, and Nuts..... 908.12
Structure Backfill 904

The maximum particle size of backfill material for corrugated pipe shall be less than 1/2 the corrugation depth.

(a) Type 1 Pipe

Type 1 pipe shall be used for culverts under mainline pavement and public road approaches and shall be in accordance with the following:

Clay Pipe, Extra Strength 907.08
Corrugated Aluminum Alloy Pipe and Pipe-Arches 908.04
Corrugated Polyethylene Pipe, Type S ..... *
Corrugated Steel Pipe and Pipe-Arches..... 908.02
Non-Reinforced Concrete Pipe, Class 3 ..... 907.01
Polymer Precoated Galvanized Corrugated Steel
Pipe and Pipe-Arches..... 908.08
Profile Wall Polyvinyl Chloride Pipe ..... *
Reinforced Concrete Horizontal Elliptical Pipe 907.03
Reinforced Concrete Pipe..... 907.02
Ribbed Polyethylene Pipe..... *
Smooth Wall Polyethylene Pipe ..... *
Smooth Wall Polyvinyl Chloride Pipe ..... *
Structural Plate Pipe and Pipe-Arches..... 908.09
* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

(b) Type 2 Pipe

Type 2 pipe shall be used for storm sewers and shall be in accordance with the following:

Clay Pipe, Extra Strength 907.08
Corrugated Polyethylene Pipe, Type S ..... *
Fully Bituminous Coated and Lined Corrugated Steel
Pipe and Pipe-Arches..... 908.13
Non-Reinforced Concrete Pipe, Class 3 ..... 907.01
Polymer Precoated Galvanized Corrugated Steel
Pipe and Pipe-Arches..... 908.08
Profile Wall Polyvinyl Chloride Pipe ..... *
Reinforced Concrete Horizontal Elliptical Pipe 907.03
Reinforced Concrete Pipe..... 907.02

Ribbed Polyethylene Pipe..... *
Smooth Wall Polyethylene Pipe ..... *
Smooth Wall Polyvinyl Chloride Pipe ..... *
* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

(c) Type 3 Pipe

Type 3 pipe shall be used for culverts under all drives and field entrances. All Type 1 pipe materials are acceptable.

(d) Type 4 Pipe

Type 4 pipe shall be used for drain tile and longitudinal underdrains and shall be in accordance with the following:

Clay Pipe** 907.08
Corrugated Polyethylene Drainage Tubing ..... *
Corrugated Polyethylene Pipe, Type S** ..... *
Corrugated Polyethylene Pipe, Type SP..... *
Drain Tile** 907.10
Non-Reinforced Concrete Pipe..... 907.01
Perforated Clay Pipe** 907.09
Perforated Polyvinyl Chloride Semicircular Pipe..... *
Profile Wall Polyvinyl Chloride Pipe ..... *
* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16
** These materials shall be used for drain tiles only.

(e) Type 5 Pipe

Type 5 pipe shall be used for broken-back pipe runs where coupled or jointed pipe is desirable and shall be in accordance with the following:

Corrugated Aluminum Alloy Pipe and Pipe-Arches 908.04
Corrugated Polyethylene Pipe, Type S ..... *
Corrugated Steel Pipe and Pipe-Arches..... 908.02
Fully Bituminous Coated and Lined Corrugated
Steel Pipe and Pipe-Arches..... 908.13
Polymer Precoated Galvanized Corrugated Steel
Pipe and Pipe-Arches..... 908.08
Profile Wall Polyvinyl Chloride Pipe ..... *
Ribbed Polyethylene Pipe..... *
Smooth Wall Polyethylene Pipe ..... *
Smooth Wall Polyvinyl Chloride Pipe ..... *
* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

(f) Slotted Drain Pipe

Slotted drain pipe shall be used to drain paved median and concrete gutter areas. Slotted drain pipe shall be in accordance with 908.14.

(g) Slotted Vane Drain Pipe

Slotted vane drain pipe shall be used to drain driveway areas. Slotted vane drain pipe shall be in accordance with 908.14.

(h) End Bent Drain Pipe

End bent drain pipe shall be perforated profile wall polyvinyl chloride pipe or perforated smooth wall polyvinyl chloride pipe from the Department's list of approved thermoplastic liner pipe in accordance with 907.16.

(i) Underdrain Outlet Pipe

Pipe shall be profile wall polyvinyl chloride pipe or smooth wall pipe for outlets from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16.

(j) Grated Box End Sections

Steel pipe and steel tubing for grating shall be in accordance with ASTM A 53, Type E or S, Grade B or ASTM A 501, electric-resistance welded or seamless. Such pipe and tubing shall be galvanized in accordance with ASTM A 123. All other related hardware shall be galvanized in accordance with ASTM A 153. Structural steel grates shall be ASTM A 36 (ASTM A 36M) for end sections having widths less than or equal to 3 ft (0.9 m) and shall be ASTM A 572 grade 50 (ASTM A 572M grade 345) for widths greater than 3 ft (0.9 m). Threaded inserts shall have a minimum pull-out capacity of 6,000 lb (27 kN). The 1/2 in. (M13) round bolts shall have hex heads, cut washers, and where necessary, shall be furnished with the grating. The aggregate leveling bed required for precast units shall be coarse aggregate No. 8 in accordance with 904.03. The hardware cloth used to cover the weep holes, may be plastic with 1/4 in. (6 mm) mesh or galvanized steel wire No. 4 mesh with a minimum wire diameter of 1/32 in. (0.8 mm). It shall be firmly anchored to the outside of the structure and shall be centered on the holes.

Pipe with a 4 in. (100 mm) outside diameter and in accordance with ASTM A 513, Type 5, may be used as an alternate to the 4 in. (100 mm) outside diameter pipe specified. The pipe used as an alternate shall have a minimum wall thickness of 5/16 in. (8 mm) and a minimum yield strength of 50,000 psi (345 MPa). Steel tube of 4 in. by 4 in. by 3/8 in. (100 mm by 100 mm by 9.5 mm), and in accordance with ASTM A 500, Grade B, will also be permitted as an alternate to the 4 in. (100 mm) outside diameter pipe specified.

Pipe furnished as an alternate as described herein shall be covered by a type B certification in accordance with 916. The results of the wall thickness measurement, outside diameter measurement, and the yield strength test shall be provided on the type B certification.

(k) Pipe End Sections

Metal pipe end sections shall be in accordance with 908.06. Precast concrete pipe end sections shall be in accordance with 905.06.

(l) Roadway Drain Casting Extensions

Pipe used for extending roadway drain castings located in a bridge deck shall be in accordance with 907.23, 907.28, or 908.10. Pipe support brackets and all hardware shall be galvanized in accordance with ASTM A 153, class D or AASHTO M 298, class 40, type I. A type C certification in accordance with 916 shall be provided for the pipe brackets.

(m) Drainage Pipe through Concrete Masonry

Pipe used as drainage pipe through concrete masonry as described in 702.16 shall be either profile wall or smooth wall polyvinyl chloride from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16, or steel in accordance with 908.11.

(n) Bridge Deck Drain System

Pipe and fittings used in an enclosed bridge deck drainage system shall be cast iron soil pipe in accordance with 908.10 or reinforced thermosetting resin pipe in accordance with 907.28.

CONSTRUCTION REQUIREMENTS

715.03 General Requirements

The construction requirements, method of measurement, basis of payment, and pay items described herein shall apply, except for the following, which are described in their respective sections.

Drain Tile 719
Structural Plate Pipe and Pipe-Arches 717
Underdrains 718

A pipe order shall be prepared and submitted prior to delivery of pipe to the project site. The order shall include the following:

(a) structure number and location;

(b) manhole, inlet, or catch basin type, if applicable;

(c) pipe length, as determined by construction engineering;

(d) pipe size, as shown on the plans;

(e) pipe material including all information required to verify conformance with cover and service life criteria; and

(f) number and type of end sections or quantity of concrete, A, structures.

When riprap is specified, geotextile shall 1st be placed on the in-situ soil in accordance with 616.11. Riprap shall then be placed in accordance with 616.

715.04 Excavation

Unless otherwise directed, the trench cross sectional dimensions shall be as shown on the plans. The trench bottom shall give full support to the pipe as shown on the plans. Recesses shall be cut to receive any projecting hubs or bells.

Where pipe is to be placed in fill sections, a portion of the fill shall be constructed prior to installation of the pipe as shown on the plans.

Where rock or boulder formation is encountered at or above the proposed trench bottom elevation, the trench shall be excavated at least 8 in. (200 mm) below the proposed grade, backfilled with structure backfill, and compacted in accordance with 211.04.

In case a firm foundation is not encountered at the required grade, the unstable material shall be removed to such depth that when replaced with suitable material, usually B borrow, compacted, and properly shaped, it will produce a uniform and stable foundation along the entire length of the pipe. A timber mat shall be placed to hold the pipe to line and grade if it is necessary.

All trenches shall be kept free from water until any joint filling material has hardened sufficiently not to be harmed.

715.05 Laying Pipe

Each section of pipe shall have a full firm bearing throughout its length, true to the line and grade given. All pipes which settle or which are not in alignment shall be taken up and re-laid. Pipe shall not be laid on a frozen trench bottom. Fully bituminous coated and lined corrugated steel pipe and pipe-arches shall only be placed when the ambient temperature is 35°F (2°C) or above.

Concrete and clay pipe shall be laid with hub upgrade, with the spigot end fully extended into the adjacent hub, and with all ends fitted together tightly.

Concrete pipe shall not be laid in muck or sulphate soils.

Except for circular concrete pipe, pipe joints designed to accommodate seals or pipe joints requiring seals shall be sealed with approved rubber type gaskets, caulking, pipe joint sealant, elastomeric material, or sealing compound. Circular concrete pipe joints shall utilize rubber type gaskets.

If the infiltration of water is a factor, each joint, regardless of the type used, shall be sealed with an approved compression type joint sealer in accordance with ASTM C 425 or ASTM C 443, whichever is applicable.

Joints and stub-tee connections for plastic pipe shall be in accordance with the requirements of the respective material specifications for each type of pipe.

Connections of plastic pipe to manholes, catch basins, and inlets shall be in accordance with the manufacturer's recommendations.

Prior to being lowered into the trench, corrugated metal pipe sections shall be examined closely and so fitted that they will form a true line of pipe when in place. Sections which do not fit together properly shall not be used.

At the time of acceptance, all pipe shall have been cleaned and be free from silt and other foreign matter.

Prior to constructing a pipe extension, the existing structure shall be cleaned of all foreign materials. Existing anchors, end sections, or headwalls shall be removed as shown on the plans or as directed. All existing pipes which are damaged by the removal operation shall be replaced. Removed materials shall be disposed of in accordance with 202.

715.06 Joining Pipe

Band couplers for AASHTO M 36 (M 36M) type I and type II corrugated steel pipe and pipe-arches shall have corrugations that mesh with the corrugations of the pipe sections being joined or the annular rerolled ends of those pipe sections. Band couplers with projections (dimples) may be used with pipe having either annular or helical corrugations only when corrugated band couplers will not provide a matching connection to both pipes. Band couplers for AASHTO M 36 (M 36M) type IA and IIA corrugated steel pipe and pipe-arches shall have corrugations that mesh with the corrugations of the pipe or shall be gasketed flat bands.

At the connection of a pipe extension to an existing structure where the extension is a different pipe material from that in place, or a satisfactory joint cannot be obtained, a concrete collar shall be constructed. Portions of the existing structure shall be removed as shown on the plans, or as necessary, to ensure proper fit of the extension to the existing pipe. If not shown on the plans, the collar shall have a width of at least 18 in. (450 mm) and a thickness of at least 6 in. (150 mm) around the entire joint.

If rigid pipe connections are of lesser strength than that of the main barrel of a pipe structure, these connections shall be encased with concrete at least 6 in. (150 mm) thick.

Any pipe which is damaged during installation shall be repaired or replaced as directed.

Slotted drain pipe or slotted vane drain pipe shall be constructed in 20 ft (6 m) sections with shop fabricated elbows. The upgrade end of slotted drain pipe shall be plugged with a metal cap before backfilling. The upgrade end of slotted vane drain pipe shall be plugged with class A concrete. Such concrete shall extend 6 in. (150 mm) inside the upgrade end of the pipe.

715.07 Tee and Stub-Tee Connections

At locations shown on the plans, or where directed, a stub-tee connection of the size specified shall be furnished and placed as a tee connection to corrugated metal pipe, corrugated metal pipe-arch, concrete pipe, reinforced concrete pipe, or reinforced concrete horizontal elliptical pipe.

The stub-tee connection to a corrugated metal pipe or pipe-arch shall be constructed of corrugated metal and the length of the stub shall be no less than that which readily accommodates the connecting band. It shall be made by shop welding a stub of corrugated metal pipe to the corrugated metal pipe or pipe-arch at the time of fabrication. Where field conditions warrant, stub-tee or other connections may be field connected by using shop fabricated saddle connectors. Welds, flame cut edges, and damaged spelter coating shall be regalvanized or painted with zinc dust-zinc oxide paint in accordance with Federal Specification TT-P641, type II or MIL-P-21035. Where applicable, damaged bituminous coating shall be repaired with asphalt mastic in accordance with AASHTO M 243. The pipe connection to the stub shall be made by means of connecting bands of required size or by means of concrete collars as directed.

The stub-tee connection to concrete pipe, reinforced concrete pipe, or reinforced concrete horizontal elliptical pipe may be field constructed or factory constructed. The concrete used in the stub shall be of the same proportions as that used in the construction of such pipe. The length of the concrete stub shall be no less than 6 in. (150 mm) nor more than 12 in. (300 mm). The pipe connection to the concrete stub shall be made by means of a cement mortar bead or concrete collar or as directed.

715.08 Blank

715.09 Backfilling

All pipes shall be backfilled with structure backfill or flowable backfill. Structure backfill shall be placed in accordance with 211. Flowable backfill shall be placed in accordance with 213.07 as shown on the plans or as directed.

Prior to placing flowable backfill, all standing water shall be removed from the trench. If the water cannot be removed from the trench, structure backfill shall be used in lieu of flowable backfill to an elevation 2 ft (0.6 m) above the groundwater. The remainder of the trench shall be backfilled as shown on the plans.

All pipes, except underdrains, will be visually inspected for acceptance a minimum of 30 days after the completion of backfill operations. Pipes that cannot be visually inspected shall be video inspected for acceptance in accordance with 718.07. The Engineer will determine the sections of pipe to be video inspected. A copy of the video inspection shall be provided in a format acceptable to the Engineer prior to performing the mandrel testing.

After the visual or video inspection, the Contractor shall check pipe deflection by performing a mandrel test for all pipes manufactured from materials listed in the following table or as otherwise directed.

PIPES REQUIRED TO BE MANDREL TESTED			
Pipe Material	Standard Specifications	AASHTO	ASTM
Corrugated Polyethylene Pipe	907.19	M 294	
Ribbed Polyethylene Pipe	907.20		F 894
Smooth Wall Polyethylene Pipe	907.21		F 714
Profile Wall Polyvinyl Chloride Pipe*	907.22	M 304	
Smooth Wall Polyvinyl Chloride Pipe	907.23	M 278	F 679

* Mandrel testing will not be required for profile wall polyvinyl chloride pipe in accordance with 907.22 that also is in accordance with ASTM F 949.

The mandrel shall have a minimum of 9 arms or prongs and a diameter that is 95% of the nominal pipe diameter. The Contractor shall provide a proving ring that is 95% of the nominal pipe diameter for each mandrel.

The Contractor shall pull the mandrel through the pipe by hand. If the mandrel does not pass through the pipe, the Contractor shall measure and report the minimum diameter of the deficient pipe to the Engineer.

If the minimum diameter of the deficient pipe is between 92.5% and 95.0% of the nominal pipe diameter, the Contractor shall provide an evaluation of the deficient pipe prepared by a professional engineer. The evaluation shall consider the severity of the deflection and its effects on structural integrity, environmental conditions, and the design service life of the pipe. A report summarizing the evaluation and including the professional engineer's recommendation for acceptance, remediation, or replacement of the pipe shall be submitted to the Engineer for final determination.

If the minimum diameter of the deficient pipe is equal to or less than 92.5% of the nominal pipe diameter, the deficient pipe shall either be replaced or a

remediation plan shall be prepared by a professional engineer and submitted to the Engineer for final determination.

The deficient pipe shall be replaced if the professional engineer's remediation plan recommends replacement of the pipe or if the pipe has been damaged.

Deficient pipe shall at a minimum be replaced between the nearest pipe joints or to the nearest structure. Replaced or remediated pipe sections shall be mandrel tested a minimum of 30 days after the completion of backfill operations.

Commercial and private drive pipes are excluded from the mandrel testing and video inspection requirements.

Where material other than structure backfill or flowable backfill is permitted and used for backfilling, it shall be of such nature that compacts readily. That portion around and for 6 in. (150 mm) above the top of the pipe shall be free from large stones. This material shall be placed in layers not to exceed 6 in. (150 mm), loose measurement, and each layer compacted thoroughly by means of mechanical tamps. Where coarse aggregate is used for structure backfill, geotextile shall be installed.

An adequate earth cover, as shown on the plans, shall be placed over the structure before heavy equipment is operated over it.

Backfill for slotted drain pipe and slotted vane drain pipe shall consist of class A concrete on both sides of the pipe. During the backfilling and paving operations, the slot shall be covered to prevent infiltration of material into the pipe.

715.10 Pipe End Sections, Anchors, Grated Box End Sections, and Safety Metal End Sections

Pipe end sections, anchors, grated box end sections, and safety metal end sections shall be constructed as shown on the plans or as directed.

Straps or hook bolts required for anchors shall be as shown on the plans. Anchor straps shall be placed at both the upstream and downstream end of each corrugated aluminum alloy, corrugated steel, or structural plate pipe or pipe-arch with a diameter or span of 42 in. (1.07 m) or greater. Hook bolts and anchor straps shall be placed at both the upstream and downstream end of each corrugated aluminum alloy, corrugated steel, or structural plate pipe or pipe-arch with a diameter or span of 84 in. (2.1 m) or greater.

A dimpled connection band shall be used for connecting pipe end sections and safety metal end sections to ends of corrugated metal pipe whose end corrugations are not perpendicular to the centerline of the pipe.

Grated box end sections shall be constructed according to the required pipe size and surface slope of the grated box end section specified at each location. Precast

units shall be cast as a single complete unit except for the toewall which shall be cast in place. They shall be set and leveled on a 6 in. (150 mm) thick bed of coarse aggregate. If precast units are used and the adjoining pipe is to be field connected directly to the precast unit, the connection shall be made using a class A concrete collar of 6 in. (150 mm) minimum longitudinal and radial thickness. Inserts for approved lifting devices may be cast in the bottom slab of the precast sections. The number and location of lifting devices needed for handling shall be determined by the fabricator. All reinforcement shall have a minimum cover of 1 1/2 in. (40 mm) and shall have a minimum lap of 21 in. (540 mm). The type A construction joint between the floor and the wall is optional for cast in place units.

715.11 Re-Laid Pipe

Where shown on the plans or as directed, existing pipe shall be taken up, re-laid, and if necessary, extended. Removal of the pipe shall be in accordance with 202.04 and the operations involved in its relaying shall be in accordance with similar operations contained herein for laying new pipe.

715.12 Pavement Replacement

Where a structure is to be placed under an existing pavement, the pavement removal and replacement shall be as shown on the plans.

The pavement replacement areas in asphalt pavements shall be filled with HMA for Structure Installation of the mixture type specified in the pay item in accordance with 402 except OG mixtures shall be in accordance with 401.05. A MAF in accordance with 402.05 will not apply. Mixtures will be accepted in accordance with 402.09. Each course shall be compacted by approved mechanical equipment in accordance with 409.03(d).

The pavement replacement areas in Portland Cement Concrete pavements shall be filled with PCCP in accordance with 502 except utilization of the Department provided spreadsheet is not required for the CMDS.

Partial loads of HMA or PCCP left over from structure installation processes shall not be incorporated into other work.

715.13 Method of Measurement

The accepted quantities of circular pipe, deformed pipe, slotted drain pipe, slotted vane drain pipe, end bent drain pipe, sanitary sewer pipe, and pipe extensions will be measured by the linear foot (meter), complete in place. The length of pipe to be measured for payment will be based on the net length of pipe used, which will be obtained by multiplying the nominal length of each pipe section by the number of sections used. If the pipe connects to manholes, inlets, or catch basins, the terminal sections will be field measured to the outside face of the structure. The length of beveled or skewed terminal sections of circular corrugated metal pipe to be measured for payment will be the average of the top and bottom centerline lengths for beveled

ends or of the sides for skewed ends. Measurement of deformed pipe will be made along the bottom centerline of the pipe.

Where used other than as a roadway drain extension pipe or as a bridge deck drain system, cast iron soil pipe will be measured by the pound (kilogram) based on the theoretical weight (mass) shown on the plans.

Roadway drain extension pipe will be measured per each drain extended.

Pipe used as drainage pipe through concrete masonry or pipe used for bridge deck drainage system will not be measured for payment.

Reinforcing bars, straps, and hook bolts used in anchors will not be measured for payment. Concrete used for backfill of slotted drain pipe and slotted vane drain pipe will not be measured for payment.

Excavation above the trench bottom elevation shown on the plans will not be measured for payment. Additional excavation below the proposed trench bottom elevation required to install the pipe at a lower elevation or to remove rock or unsuitable material will be measured in accordance with 203.27(b).

Pipe end sections, concrete anchors, and safety metal end sections will be measured by the number of units of each size installed. The size of the end section, concrete anchor, and safety metal end section will be considered as the nominal diameter of the pipe to which they are attached. A concrete anchor attached at one end of twin pipes will be measured as 2 concrete anchors. A concrete anchor attached at one end of triple pipes will be measured as 3 concrete anchors.

Tee, stub-tee, and wye branch connections will be measured along the centerline of the barrel. An additional allowance of 5 lft (1.5 m) of the smaller diameter pipe will be permitted for making such connection.

Elbow connections will be measured along the centerline of such connection. An additional 2 lft (0.6 m) of pipe of the same diameter as that of the elbow will be permitted for each such connection.

If increaser or reducer connections are made, measurement will be made on the basis of the larger diameter pipe for the full length of the section forming such connections.

Structure backfill will be measured in accordance with 211.09. Flowable backfill will be measured in accordance with 213.08.

Pavement replacement and subbase necessary due to structure placement under an existing pavement will be measured to the neat lines shown on the plans.

For structures for which the plans permit pipes of differing sizes for either smooth or corrugated interiors, and the corrugated interior alternate is installed, measurement of structure backfill or flowable backfill will be based on the neat line dimensions shown on the plans for the smooth interior alternate.

Grated box end sections will be measured per each for the specified type, surface slope, and pipe size.

Video inspection for pipe will be measured by the linear foot (meter) as determined by the electronic equipment.

Geotextile used to wrap backfill material will not be measured for payment.

715.14 Basis of Payment

The accepted quantities of pipe and pipe extensions will be paid for at the contract unit price per linear foot (meter) for pipe of the type, shape, and size specified, complete in place. Where used other than as a roadway drain casting extension pipe or as a bridge deck drain system, cast iron soil pipe will be paid for at the contract unit price per pound (kilogram) for the diameter specified.

Pipe end sections, concrete anchors, and safety metal end sections will be paid for at the contract unit price per each for the size specified, complete in place. A concrete anchor attached at one end of twin pipes will be paid for as 2 concrete anchors. A concrete anchor attached at one end of triple pipes will be paid for as 3 concrete anchors. Roadway drain casting extension pipe will be paid for at the contract unit price per each.

Pavement replacement necessary due to structure installation under an existing pavement will be paid for at the contract unit price per ton (megagram) of HMA for structure installation of the type specified and per square yard (square meter) for PCCP for structure installation. Subbase will be paid for in accordance with 302.09.

Structure backfill will be paid for in accordance with 211.10. Where used as a substitute for structure backfill, flowable backfill will be paid for as structure backfill. When specified for pipe backfill, flowable backfill will be paid for in accordance with 213.09.

If a pipe structure is lowered, relocated, or if unsuitable material is encountered so that additional excavation is necessary over and above that shown on the plans at the original location, such additional excavation will be paid for at 3 times the contract unit price for the class of excavation involved. If the contract does not include rock excavation or unclassified excavation, rock removal below the proposed trench bottom elevation will be paid for at 3 times the contract unit cost for common excavation. However, in each of the above cases, such excavation will not be paid for if the additional amount involved at such structure is 10 cu yd (8 m^3) or less.

For structures for which the plans permit pipes of differing sizes for entire smooth or corrugated interiors, and the corrugated interior alternate is installed, payment for pipe backfill will be made based on the neat line dimensions shown on the plans for the smooth interior alternate.

Grated box end sections will be paid for at the contract unit price per each for the specified type, surface slope, and pipe size.

Video inspections for pipe will be paid for at the contract unit price per linear foot (meter) completed.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Concrete Anchor, _____ in. (mm) (diameter)	EACH
Concrete Anchor, Min. Area ____ sq ft (m^2)	EACH
Grated Box End Section, ____, ____, _____ in. (mm) (type, slope, diameter)	EACH
Grated Box End Section, ____, ____, Min. Area ____ sq ft (m^2) (type, slope)	EACH
HMA for Structure Installation, Type _____ (mixture type)	TON (Mg)
PCCP for Structure Installation	SYS (m2)
Pipe End Section, _____ in. (mm) (diameter)	EACH
Pipe End Section, Min. Area ____ sq ft (m^2)	EACH
Pipe Extension, Circular, _____ in. (mm), _____ (diameter, material)	LFT (m)
Pipe Extension, Deformed, Min. Area ____ sq ft (m^2), _____ (material)	LFT (m)
Pipe, Bridge Deck Drain System	LS
Pipe, Drainage through Concrete Masonry	LS
Pipe, End Bent Drain, _____ in. (mm) (diameter)	LFT (m)
Pipe, Relaid, ____ in. (mm) x ____ in. (mm) (span, rise)	LFT (m)
Pipe, Relaid, _____ in. (mm) (diameter)	LFT (m)
Pipe, Roadway Drain Casting Extension	EACH
Pipe, Sanitary Sewer, _____ in. (mm) (diameter)	LFT (m)
Pipe, Slotted Drain, _____ in., (mm) _____ in. (mm) (diameter, thickness)	LFT (m)

Pipe, Slotted Vane Drain, _____ in. (mm) ..... LFT (m)
diameter
Pipe, Type ____, Circular, _____ in. (mm) ..... LFT (m)
diameter
Pipe, Type ____, Deformed, Min. Area ____ sq ft (m^2) ..... LFT (m)
Pipe, Underdrain Outlet, _____ in. (mm) ..... LFT (m)
diameter
Safety Metal End Section, ____, _____ in. (mm) ..... EACH
slope diameter
Safety Metal End Section, ____, Min. Area ____ sq ft (m^2) ..... EACH
slope
Soil Pipe, Cast Iron, _____ in. (mm) ..... LBS (kg)
diameter
Video Inspection for Pipe ..... LFT (m)

The cost of reinforcing bars, straps, and hook bolts used in anchors shall be included in the cost of the concrete anchor. The cost of the toe plate anchor and galvanized bolts required for pipe end sections and safety metal end sections shall be included in the cost of the pay items. The cost of pipe support brackets and all hardware used to attach the roadway drain casting extension pipe to the drain casting and the pipe support bracket to the structural member and to the drain extension pipe shall be included in the cost of the pay items. The cost of concrete backfill for slotted drain pipe and slotted vane drain pipe shall be included in the cost of the pay items.

B borrow obtained from planned excavation may be used to backfill culverts. No deduction will be made from the excavation or borrow quantities.

If existing concrete building foundations, concrete walls, concrete columns, or concrete steps not visible and not shown on the plans are encountered within the limits of the trench, the removal of such items, as required, will be paid for in accordance with 203.28.

The cost of sawing of pavement, excavation above the trench bottom elevation shown on plans, backfilling with material other than structure backfill or flowable backfill, dewatering, shoring, timber mats, class A concrete required for collar construction or sealing existing pipe, joint materials, replacing pipe which is damaged during installation or re-laying operations, sanitary sewer testing required by the local utility, and all other necessary incidentals shall be included in the cost of the pay items in this section. The cost of removal of pavement, existing pipe, end sections, anchors, or headwalls, concrete collars, encasements, and the disposal of surplus materials shall be included in the cost of the pay items.

The cost of concrete, grating, pipe tubing, reinforcing bars, aggregate leveling bed, hardware cloth, and necessary incidentals, for construction of grated box end sections will be included in the cost of the grated box end section.

Geotextile required for coarse aggregate structure backfill material will not be paid for separately. The cost of the geotextile shall be included in the cost of structure backfill.

The cost of providing video inspection equipment, technician, and a copy of the video inspection shall be included in the cost of video inspection for pipe.

No additional payment will be made for repair, remediation, or replacement of pipes, backfill, video inspection of the repaired, remediated, or replaced pipe, and all other work associated with the repair, remediation, or replacement of unacceptable pipes.

The cost of mandrel testing shall be included in the cost of the pipe.

SECTION 716 – TRENCHLESS PIPE INSTALLATION

716.01 Description

This work shall consist of installing pipes underground using construction techniques that eliminate open cutting of the pavement or of the ground in accordance with 105.03. This specification addresses auger boring, guided boring, horizontal directional drilling using a reamer diameter up to and including 24 in. (600 mm), pipe jacking, and pipe ramming, as defined below.

Installations by means of directional drilling which require a reamer larger than 24 in. (600 mm), microtunneling, or other tunneling methods, may be utilized if approved by the Engineer. The Contractor shall submit a detailed proposal prepared by a professional engineer for installations other than auger boring, guided boring, horizontal directional drilling using a reamer diameter less than 24 in. (600 mm), pipe jacking, and pipe ramming.

The following definitions apply to trenchless pipe installation.

(a) Auger Boring

Technique for forming a bore from a drive shaft to a reception shaft, by means of a rotating cutting head. Spoil is removed back to the drive shaft by helically wound auger flights rotating in a steel casing.

(b) Carrier Pipe

The tube which carries the product being transported and which may pass through casings at highway or railroad crossings. It may be made of steel, concrete, clay, plastic, ductile iron, or other materials.

(c) Casing Pipe

A pipe installed as external protection to a carrier pipe.

(d) Drive Shaft

Excavation from which trenchless technology equipment is launched. It may incorporate a thrust wall to spread reaction loads to the soil.

(e) Guided Boring

A trenchless tunneling method that utilizes small diameter pilot tubes that are installed and steered through the ground utilizing a slanted face at the cutting head containing a target with light emitting diodes, LEDs, and a camera mounted theodolite located in the shaft to achieve high accuracy in line and grade. The hole is enlarged to the same outside diameter of the final product pipe after the installation of the pilot tubes, which is then jacked into place.

(f) Horizontal Directional Drilling

A steerable system for the installation of pipes, conduits, or cables in a shallow arc using a surface launched drilling rig.

(g) Microtunneling

A remote controlled trenchless construction method that simultaneously installs pipes as the soil is excavated. This method provides continuous support of the excavation face with slurry pressure to balance groundwater and earth pressures.

(h) Pipe Jacking

A system of directly installing pipes behind a shield machine by means of hydraulic jacking from a drive shaft such that the pipes form a continuous string in the ground.

(i) Pipe Ramming

A non-steerable system of forming a bore by driving an open ended steel casing using a percussive hammer from a drive shaft. The soil may be removed from the casing by augering, jetting, or compressed air.

(j) Reception Shaft

Excavation into which trenchless technology equipment is driven and recovered following the installation of the pipe.

(k) Response Levels

Pre-established levels of instrument readings of settlement or of other monitored behavior such as lateral movement or vibrations, which trigger the implementation of mitigative measures. Response levels consist of the initial review level, at which mitigative measures must be implemented, and the alert level, at which construction must be halted and actions taken to ensure the alert level will not be exceeded in subsequent construction.

(l) Spoils

Earth, rock, or other materials displaced by a tunnel or casing, and removed as the tunnel or casing is installed.

MATERIALS

716.02 Materials

Materials shall be in accordance with the following:

Cellular Grout 725
Clay Pipe, Extra Strength 907.08
Polyvinyl Chloride Pipe ..... *
Reinforced Concrete Pipe 907.02
Smooth Wall Polyethylene Pipe ..... *
Steel Pipe 908.11
Water 913.01
* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

Concrete pipe shall be from the Department's Approved List for Certified Precast Concrete Producers.

Concrete pipe installed by means of pipe jacking shall be designed with sufficient concrete strength and steel reinforcement to resist jacking forces and shall have tongue and groove joints. All reinforced concrete pipes shall have steel reinforcement concentric with the pipe wall.

Steel pipe used as a carrier pipe shall have the following minimum wall thickness. Steel pipe used as a casing pipe, but not used as a carrier pipe, shall be selected by the Contractor to have minimum wall thickness sufficient to resist jacking forces. For installations where the casing is not used as a carrier but only as a casing for a carrier pipe, the thickness of the casing shall be determined by the Contractor.

Outside Diameter, in. (mm)	Wall Thickness, in. (mm)
18 (450) or less	1/4 (6)
19 – 20 (475 – 500)	5/16 (8)
21 – 26 (525 – 650)	3/8 (10)
27 – 30 (675 – 750)	1/2 (13)
31 – 42 (775 – 1,050)	1/2 (13)
43 – 48 (1,075 – 1,200)	9/16 (15)

CONSTRUCTION REQUIREMENTS

716.03 General Requirements

The Contractor shall submit a Quality Control Plan, QCP, in accordance with ITM 803. The QCP shall be submitted to the Engineer for review and acceptance, at least 15 days prior to the start of trenchless pipe installation operations.

Where ground water is known or anticipated, and where the technique selected for trenchless pipe installation does not provide positive support at the trenchless excavation face, such as by slurry support in microtunneling, then trenchless pipe installation shall not proceed without dewatering in advance of trenchless pipe installation. A dewatering system of sufficient capacity to handle the flow shall be maintained at the site until its operation can be safely halted. The dewatering system shall be equipped with screens or filter media sufficient to prevent the displacement of fines.

Where the use of explosives is necessary for performing the work, their use shall be in accordance with 107.13.

Bentonite or other suitable lubricants may be applied to the outside surface of the pipe to reduce frictional forces.

Joints in steel pipe shall be watertight. Where welded joints are utilized, they shall be welded in accordance with 711.32. Joints in concrete pipe or other jacking pipe materials including clay pipe shall be designed to withstand the additional forces that are created in the joints during the installation process. The joints in concrete pipe or other pipe jacking materials shall be protected with a resilient material around the circumference of the pipe. Resilient material shall also be used between the pipe and the thrust ring.

Pavement or ground surface heave or settlement resulting in damage to pavement, existing utilities, or structures above the installation will not be permitted. To confirm if heave or settlement is occurring, the Contractor shall undertake surface monitoring.

Installations shall have a bored hole essentially the same diameter as the outside of the installed pipe. If voids develop or if the bored diameter is greater than the outside diameter of the pipe by more than 1 in. (25 mm), grouting shall be used to fill such voids.

When the installation is 4 in. (100 mm) or larger and the casing is used as the carrier pipe, a visual or a video inspection shall be performed using a high resolution, high sensitivity color video camera and recording equipment. The pipe shall be cleaned of debris prior to the inspection. Cleaning shall be accomplished by means of water jetting or other approved methods.

The camera and recording equipment shall be specifically designed for continuous viewing and recording of detailed images of the interior wall of pipes and transitions of the specified sizes. The equipment shall include sufficient lighting to view the entire periphery of the pipe. The equipment shall have appropriate attachments to maintain a position in the center of the pipe and an electronic counter

to continuously record the location of the equipment in the pipe. A copy of the video inspection shall be submitted to the Engineer.

All sections of pipe found to be damaged or where joint failure is evident shall be repaired or replaced as approved by the Engineer.

If an obstruction is encountered during installation which stops the forward progress of the pipe, and it becomes evident that it is impossible to advance the pipe, the Engineer shall be notified. For installations utilizing tunnel shields or tunnel-boring machines or other methods that allow access to the face, the obstruction shall be removed in accordance with the QCP. For installations utilizing methods that do not allow access to the face, at the direction of the Engineer, the pipe shall be abandoned in place and filled with grout or other approved materials.

Where a gravity-flow carrier pipe is placed inside a casing pipe, the gravity-flow carrier pipe shall be shimmed to proper line, elevation, and grade and then the void between the 2 pipes shall be grouted with cellular grout.

Upon completion of the installation of the pipe, all excavated areas not occupied by the pipe shall be backfilled and compacted with suitable material in accordance with 203.

716.04 Method of Measurement

Pipe installed by means of trenchless installation methods will be measured by the linear foot (meter) along the center line of the pipe installed.

716.05 Basis of Payment

Pipe installed by means of trenchless installation methods will be paid for by the linear foot (meter) for pipe installation, trenchless, of the size specified, complete and in place including all incidentals.

Removal of boulders, concrete, or other obstructions will be paid in accordance with 104.03.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Pipe Installation, Trenchless, _____ size	LFT (m)

The cost of the QCP, excavating and backfilling of the drive shaft and reception shaft, video inspection, camera and recording equipment, bentonite or other lubricant, grout, and the casing if installed shall be included in the cost of pipe installation, trenchless.

If a partial installation has to be abandoned in place and filled with grout due to the encountering of an obstruction, the abandoned work will be paid for at 75% of the contract unit price of the pipe installed.

No payment will be made to repair or replace sections of pipe that have been damaged or show evidence of joint failure.

SECTION 717 – STRUCTURAL PLATE PIPE, PIPE-ARCHES, AND ARCHES

717.01 Description

This work shall consist of furnishing and placing structural plate pipe, pipe-arches, or arches in accordance with 105.03.

717.02 Materials

Materials shall be in accordance with the following:

Concrete, Class A	702
Flowable Backfill	213
Grouted Riprap	904
Pipe Joint Sealant	907.11
Reinforcing Bars	910.01
Structural Plate Arches	908.09
Structural Plate Pipe and Pipe-Arches	908.09
Structure Backfill	904.05

Structural plate pipe and pipe-arches are part of the pipe classification system described in 715.02. The minimum material thickness and required protective treatments will be determined in accordance with 715.02.

CONSTRUCTION REQUIREMENTS

717.03 General Requirements

Forming, punching, and assembling shall be in accordance with AASHTO LRFD Bridge Construction Specifications. The radius of the arc joining the top to the bottom shall be in accordance with 908.09(a)1. Excavation shall be in accordance with the applicable requirements of 715 for pipe and pipe-arches and 206 for arches. Concrete shall be placed in accordance with 702 and reinforcing bars shall be placed in accordance with 703.

Each side of an arch shall rest in a groove formed into the masonry or shall rest on a galvanized angle or channel securely anchored to or embedded in the structure. Where the span of the arch is greater than 14 ft (4.3 m), or the skew angle is more than 20°, a metal bearing surface having a width at least equal to the depth of the corrugations shall be provided.

Metal bearings may be either rolled structural or cold-formed galvanized angles or channels no less than 3/16 in. (5 mm) in thickness with the horizontal leg securely anchored to the substructure on 24 in. (610 mm) maximum centers. When the metal bearing is not embedded in a groove in the substructure, 1 vertical leg shall be punched to allow bolting to the bottom row of plates.

If shown on the plans, or otherwise required, the flowline of arches shall be paved with grouted riprap in accordance with 616.04 or paved with class A concrete.

If it is necessary to make a tee-connection to a structural plate pipe, pipe-arch, or arch, a stub-tee connection of the size and at the locations shown on the plans shall be furnished and placed, and its length shall be no less than 12 in. (300 mm) nor more than 24 in. (610 mm). The stub shall be connected in the field and the stub connection bituminous coated. The stub connection to the entering pipe shall be made by means of a connecting band of the required size or by means of concrete collars, as directed.

Structures on which the spelter coating has been bruised or broken either in the shop or in shipping, or which shows defective workmanship, shall be rejected unless it can be repaired satisfactorily. This requirement applies not only to the individual plates but to the shipment on any contract as a whole. Among others, the following defects are specified as constituting poor workmanship. The presence of defects in an individual culvert plate or in a shipment shall constitute sufficient cause for rejection.

(a) uneven laps;

(b) elliptical shaping, unless specified;

(c) variation from a straight centerline;

(d) ragged edges;

(e) loose, unevenly lined, or unevenly spaced bolts;

(f) illegible brand;

(g) bruised, scaled, or broken spelter coating;

(h) dents or bends in the metal itself; and

(i) twisted so that ends do not lay on bedding satisfactorily.

717.04 Backfill

All structural plate pipe and pipe arches shall be backfilled with structure backfill or flowable backfill. Arch backfill shall be structure backfill. The amount of camber on the invert of the pipe or pipe-arch shall be varied to suit the height of fill

and supporting soil, except the camber grade shall not be above level. Structure backfill shall be placed in accordance with 211. Flowable backfill shall be placed in accordance with 213.

An adequate earth cover shall be provided over the structure, as shown on the plans, before heavy construction equipment is operated over it. This earth cover shall be free of stones.

Where backfilling at arches before headwalls are placed, the material shall 1st be placed midway between the ends of the arch, forming as narrow a ramp as possible, until the top of the arch is reached. The ramp shall be built up evenly on both sides and the backfilling material compacted as it is placed. After both ramps have been built to the top of the arch, the remainder of the backfill shall be deposited in both directions from the center to the ends and evenly on both sides of the arch.

If the headwalls are built before the arch is backfilled, the backfill material shall 1st be placed adjacent to 1 headwall until the top of the arch is reached, after which the fill material shall be placed from the top of the arch towards the other headwall. The material shall be deposited evenly on both sides of the arch.

In multiple installations the above procedure shall be followed. The backfill shall be brought up evenly on both sides of each arch so that unequal pressures are avoided.

Compaction by saturation will not be permitted, except below the free water table, then the provisions of 203.23 do not apply.

717.05 Relaid Pipe and Pipe-Arch

When required, any existing structural plate pipe or pipe-arch shall be taken up, re-laid, and extended. Removal shall be in accordance with 202.04 and the operations involved in its relaying shall be in accordance with similar operations contained herein for new structural plate pipe or pipe-arch.

717.06 Blank

717.07 Concrete Paved Inverts

Structural plate pipe and pipe-arches with concrete field paved inverts shall be constructed in accordance with and at locations shown on the plans or where directed.

The paved inverts for these structures shall be reinforced with WWR and sealed with pipe joint sealant as shown on the plans. The concrete for paving the invert shall not be placed until such time as the backfilling and embankment procedures have been completed satisfactorily.

717.08 Method of Measurement

Structural plate pipe and pipe-arch, new, extended, and re-laid, will be measured in accordance with 715.13. Structural plate arches will be measured by the linear foot (meter), complete in place. Metal bearings and other hardware required to attach the structural plate arch to its substructure will not be measured for payment.

Concrete for headwalls and substructures will be measured in accordance with 702.27. Volumes occupied by a structural plate arch extending through the headwall will be deducted. Reinforcing bars used in substructures will be measured in accordance with 703.07. Concrete or grouted riprap paved flowline for structural plate arches will be measured by the square yard (square meter). Concrete anchors will be measured in accordance with 715.13. Reinforcing bars, straps, and hook bolts used in anchors will not be measured for payment.

Structural backfill will be measured in accordance with 211.09. Flowable backfill used for backfill will be measured in accordance with 213.08.

717.09 Basis of Payment

The accepted quantities of new, extended, or re-laid structural plate pipe, or pipe-arch will be paid for in accordance with 715.14. Structural plate arches will be paid for at the contract unit price for arch, structural plate, of the size specified. Concrete, A, structures will be paid for in accordance with 702.28. Reinforcing bars in substructures will be paid for in accordance with 703.08. Concrete or grouted riprap paved flowline placed in structural plate arch structures will be paid for at the contract unit price per square yard (square meter) for concrete paved flowline, arch, structural plate; or riprap, grouted. Concrete anchors will be paid for in accordance with 715.14.

If a pipe or pipe-arch is lowered or relocated, or if rock or unsuitable material is encountered which requires additional excavation, such excavation will be paid for in accordance with 715.14. Structure backfill will be paid for in accordance with 211.10. Where used as a substitute for structure backfill, flowable backfill will be paid for as structure backfill. Where specified for backfill, flowable backfill will be paid for in accordance with 213.09.

Stub-tee connections including the connecting bands, concrete collars, or cement mortar beads will be paid for in accordance with 715.14.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Arch, Structural Plate, Min. Area ____ sq ft (m^2)	LFT (m)
Concrete Paved Flowline, Arch, Structural Plate	SYS (m2)
Riprap, Grouted	SYS (m2)

The cost of excavation, concrete field paved inverts, disposal of surplus materials, reinforcing bars, straps, and hook bolts used in anchors, and necessary incidentals shall be included in the cost of the pay items.

The cost of metal bearings and other hardware needed to attach the structural plate arch to its substructure shall be included in the cost of the arch.

SECTION 718 – UNDERDRAINS

718.01 Description

This work shall consist of constructing underdrains using pipe, granular aggregates, outlet protectors, or geotextiles in accordance with 105.03.

MATERIALS

718.02 Materials

Materials shall be in accordance with the following:

Coarse Aggregate, Class E or Higher, Size No. 8 or 9	904
Concrete, Class A	702
Geotextile for Underdrains	918.03
Reinforcing Bars	910.01
Sod, including Nursery Sod	621
Structure Backfill	904.05
Underdrain Outlet Pipe	*
Underdrain Pipe	715.02(d)

* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

Transition pipes, 45° elbows, elbow connector pipes, and increasers shall be of the same material as the underdrain outlet pipe.

Rodent screens shall be woven stainless steel wire mesh or galvanized hardware cloth. Coarse aggregate No. 8 or 9 shall be used for 6 in. (150 mm) underdrain installations and for underdrains for MSE walls. Coarse aggregate No. 9 shall be used for 4 in. (100 mm) underdrain installations.

The mixture for HMA for underdrains shall be Intermediate OG19.0 mm in accordance with 401. An ESAL Category 5 in accordance with 401.04 and a PG Binder 76-22 shall be used. A MAF in accordance with 401.05 will not apply. Acceptance of the HMA for underdrains will be in accordance with 402.09.

CONSTRUCTION REQUIREMENTS

718.03 Pipe Installation

(a) Locations Outside MSE Wall Ground Reinforcement Limits

Trenches shall be excavated to the dimensions and grade shown on the plans. Each longitudinal underdrain trench shall be cut continuously across all twin outlet areas and all single outlet areas. Such pipeless portions of the trench shall be backfilled with aggregate for underdrains. Pipes shall be secured to ensure that the pipe's required grade and horizontal alignment are maintained. Perforated pipe shall be placed with the perforations down. The pipe sections shall be joined securely with the appropriate couplings, fittings, or bands. The pipe shall be installed in the underdrain trench such that a minimum clearance of 2 in. (50 mm) exists between the pipe and the trench walls. Aggregate for underdrains shall be placed in a manner which minimizes contamination. HMA for underdrains shall be placed and compacted separately from mainline mixtures. HMA for underdrains may be placed in 1 lift and shall be compacted with equipment in accordance with 409.03(d).

If plain end concrete pipe is being laid, no joint width shall not exceed 1/4 in. (6 mm).

(b) Underdrains Within MSE Wall Ground Reinforcement Limits

Underdrains for MSE walls shall be as shown on the plans. Coarse aggregate used as underdrains for MSE walls shall be compacted in accordance with 706.04.

718.04 Geotextile

Storage and handling of geotextiles shall be in accordance with the manufacturer's recommendations. Each geotextile roll shall be labeled or tagged. Damaged or defective geotextile shall be replaced as directed. The geotextile shall be placed loosely, but with no wrinkles or folds. The ends of subsequent rolls of geotextile shall be overlapped a minimum of 1 ft (0.3 m). The upstream geotextile shall overlap the downstream geotextile. Placement of aggregate shall proceed following placement of the geotextile. HMA for underdrains shall be placed and compacted separately from mainline mixtures. HMA for underdrains may be placed in one lift and shall be compacted with equipment in accordance with 409.03(d).

718.05 Underdrain Outlets

If the underdrain pipe and the outlet pipe are of different sizes, an increaser of the same material as the outlet pipe shall be installed between the transition pipe and the 45° elbow. If a single outlet pipe is to be skewed at 45°, a 2nd 45° elbow and an elbow-connector pipe are not required.

The outlet pipe or pipes shall be located as close as possible to the center of the outlet protector.

After the outlet pipe installation, the trench shall be backfilled as shown on the plans. Structure backfill shall not extend into the limits of the underdrain trench. The trench outside the limits of structure backfill shall be filled with materials suitable for growing vegetation. Aggregate and stabilized materials removed from an existing shoulder shall not be used as backfill and shall be disposed of in accordance with 206.07. At the time of installation, a rodent screen shall be placed on the outlet pipe or the ends of the underdrain pipe when located in inlets or catch basins.

718.06 Underdrain Outlet Protectors

Underdrain outlet protectors shall be constructed as shown on the plans.

718.07 Video Inspection

Underdrains and outlets shall be inspected using high resolution, high sensitivity, waterproof color video camera/recording equipment.

The camera/recording equipment shall be specifically designed for continuous viewing/recording of detailed images of the interior wall of pipes and transitions of the specified sizes. The equipment shall have the capability of viewing a minimum of 450 ft (140 m) into the pipes and shall be designed to include sufficient lighting to view the entire periphery of the pipe. The equipment shall have appropriate attachments to maintain a position in the center of the pipe and an electronic counter to continuously record the location of the equipment in the pipe. The recording equipment shall be a minimum 4 head industrial grade VHS recorder or a digital archiving and reviewing system. A color video printer shall be included in the equipment for printing observations during inspection.

The Engineer will determine the runs of the underdrain installations to be inspected. Video inspection shall be conducted after guardrail, lighting, sign installation, and final seeding or sodding operations are completed.

Damage discovered by the video inspection shall be repaired. Damage shall include but is not limited to; crushed or partially crushed pipe that impedes the progress of the camera, blockages, vertical pipe sags filled with water to a depth of d/2 or greater, 90° connections, connector separations, cracks or splits in the pipes. All repaired sections shall be video reinspected prior to acceptance. A copy of the video inspection shall be submitted to the Engineer.

718.08 Patching Underdrains

Underdrains that are disturbed shall be repaired such that the underdrain is perpetuated. This repair shall include the construction of new outlets where the existing configuration prior to the damage cannot be reinstalled. The repairs shall be as approved by the Department. Once the repairs are completed, a video inspection may be required by the Department to verify that the repairs have been successfully completed.

Geocomposite edge drains that are disturbed shall be outletted as approved and not perpetuated.

718.09 Method of Measurement

Underdrain and outlet pipe will be measured by the linear foot (meter), complete in place. If the pipe connects to structures such as manholes, inlets, or catch basins, the pipe will be field measured to the outside face of the structures. Outlet protectors will be measured by the number and type of units installed.

Measurement of outlet pipe will be made along the centerline of the pipe from the point of connection with the underdrain pipe to the downstream end of the outlet pipe and will include all transitions, elbows, and increaser or decreaser connections.

Structure backfill will be measured in accordance with 211.09. HMA for underdrains will be measured by the ton (megagram).

Aggregate for underdrains and underdrains for MSE walls will be measured by the cubic yard (cubic meter), complete in place. The pay limits will not extend beyond the neat lines shown on the plans.

Geotextiles will be measured by the square yard (square meter) based on the neat line limits shown on the plans.

Video inspections for underdrains will be measured by the linear foot (meter) as determined by the electronic equipment.

Patching of underdrains will not be measured.

Rodent screens and other incidentals will not be measured for payment.

Concrete, reinforcing bars, or sod for underdrain outlet protectors will not be measured for payment.

718.10 Basis of Payment

The accepted quantities of underdrains and underdrain outlet pipe will be paid for in accordance with 715.14. Aggregate for underdrains will be paid for at the contract unit price per cubic yard (cubic meter). Underdrains for MSE walls will be paid for as aggregate for underdrains. Geotextile for underdrains will be paid for at the contract unit price per square yard (square meter). Outlet protectors will be paid for at the contract unit price per each of the type of unit installed, complete in place. The accepted quantities of HMA for underdrains will be paid for at the contract unit price per ton (megagram).

Underdrain patching for structure installation will be paid for at the contract unit price per linear foot (meter) of underdrain, patching and shall be equal to the length of the theoretical pavement replacement as shown on the plans.

Structure backfill will be paid for in accordance with 211.10.

The final accepted quantity video inspection for underdrain will be paid for at the contract unit price per linear foot (meter).

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Aggregate for Underdrains	CYS (m3)
Geotextile for Underdrains	SYS (m2)
HMA for Underdrains	TON (Mg)
Outlet Protector, ____ type	EACH
Underdrain, Patching	LFT (m)
Video Inspection for Underdrain	LFT (m)

Geotextile for underdrains which has been rejected due to contamination or other reasons shall be replaced with no additional payment.

The cost of excavation, forming, reinforcing bars, concrete, curing materials, and sod shall be included in the cost of outlet protector.

The cost of providing the video inspection equipment, technician, videotapes, or computer disks shall be included in the cost of the underdrain video inspection. The cost of repair of underdrain pipes, aggregates, backfill, outlet protectors, geotextile fabric, providing video re-inspection of the repairs, etc. shall be included in the cost of the other pay items in this section.

Where underdrain repair for structure installation is required, the cost of underdrain pipe, aggregate for underdrains, geotextile for underdrains, HMA for underdrains, outlet protectors if required, video inspection for underdrains, and all other incidentals for underdrains shall be included in the cost of underdrain, patching. The cost of repairing underdrains damaged by activities other than for structure installation, or as defined above, shall be at the Contractor’s expense.

The cost of disposal of unsuitable excavated materials, installation of pipe end caps, rodent screens, and other incidentals shall be included in the cost of the pay items in this section.

SECTION 719 – TILE DRAINS

719.01 Description

This work shall consist of the installation of drain tile in accordance with 105.03.

MATERIALS

719.02 Materials

Materials shall be in accordance with the following:

Concrete, Class A	702
Drain Tile Terminal Pipe	907.24
Flowable Backfill	213
Reinforcing Bars	910.01
Riprap	616.02
Structure Backfill	904
Rodent Screen	718.02

Drain tile materials shall be in accordance with 715.02(d).

CONSTRUCTION REQUIREMENTS

719.03 Trench Excavation

The trench excavation shall begin at the outlet end and proceed towards the upper end, true to the required line and grade. The trench shall be as shown on the plans. If no trench details are shown on the pans, the trench shall be of sufficient width to provide ample working space on each side of the drain tile to permit compaction of the backfill around the tile. Recesses shall be cut into the trench bottom to accommodate any projecting hubs or bells.

If excavation is made too deep, proper bearing shall be secured by backfilling to the required elevation with sand, clay, or other approved material which shall be tamped into place and shaped properly.

If a firm foundation is not encountered at the required trench bottom grade, the unstable material shall be removed to such depth that provides ample support after being backfilled, compacted, and shaped to the required elevation or the drain tile shall be laid on planking which is not less than 1 in. (25 mm) thick, 10 in. (250 mm) wide, and 10 ft (3 m) long.

If rock is encountered at or above the required trench bottom grade, the trench shall be excavated at least 8 in. (200 mm) below the pipe and backfilled, compacted, and shaped as described above.

Where excavation is made for installing drain tile across private property, the topsoil and sod, if present, shall be kept in separate stockpiles. After completion of the backfill operation, the topsoil and sod shall be placed so that the area is restored as closely as possible to its original condition.

719.04 Laying Tile

Tile shall not be laid on a frozen or muddy trench bottom. It shall be laid true to line and grade, starting at the outlet end. Each tile shall have a firm bearing for its entire length and joints left as tight as practicable by turning the individual sections until the ends fit closely. A joint which does not close to within 1/4 in. (6 mm) shall be covered with pieces of broken tile. If laid on planking, the joints shall be covered with pieces of broken tile and then entirely covered with clay and tamped.

Drain tile installed on private property shall be perforated pipe in accordance with 715.02(d).

When an existing tile drain is encountered on permanent right-of-way, it shall be replaced in the following manner. If the tile is intercepted by a side ditch prior to crossing proposed pavement, it shall be replaced between the right-of-way line and the ditch with non-perforated drain tile and a 10 ft (3 m) long terminal pipe section of drain tile with a rodent screen. If the tile is to outlet into a storm sewer, it shall be replaced between the right-of-way line and the storm sewer with pipe in accordance with 715.02(b). If the tile is to outlet at a side ditch after crossing proposed pavement, it shall be replaced between the right-of-way line and the ditch with pipe in accordance with 715.02(a) with a rodent screen. If the tile is to be maintained across the right-of-way, it shall be replaced from right-of-way line to right-of-way line with pipe in accordance with 715.02(a).

719.05 Backfilling

Pipe replacing drain tile shall be backfilled in accordance with 715.09.

719.06 Blank

719.07 Method of Measurement

Drain tile and replacement pipe of the type and size specified will be measured in accordance with 715.13. Terminating pipe sections of the type and size specified will be measured per linear foot (meter). Structure backfill will be measured in accordance with 211.09. Flowable backfill will be measured in accordance with 213.08. Riprap will be measured in accordance with 616.12.

Tee or wye branch connections will be measured per each along the centerline of the barrel. An additional allowance of 5 lft (1.5 m) of the smaller diameter pipe will be made for making such connections.

Elbow connections will be measured along the centerline of such connection. An additional allowance of 2 lft (0.6 m) of pipe of the same diameter as that of the elbow will be made for each such connection.

Increaser and reducer connections will be measured by the linear foot (meter) as the larger diameter pipe over the length of the connection.

719.08 Basis of Payment

The accepted quantities of drain tile and replacement pipe will be paid for in accordance with 715.14. Terminating pipe sections will be paid for at the contract unit price per linear foot (meter) for pipe, drain tile terminal section, of the size specified, complete in place. Structure backfill will be paid for in accordance with 211.10. Flowable backfill will be paid for in accordance with 213.09. Riprap will be paid for in accordance with 616.13.

Tee and wye connections will be paid for by means of the allowance of an additional 5 lft (1.5 m) of the smaller pipe at the connection. Elbow connections will be paid for by means of the allowance of an additional 2 lft (0.6 m) of the pipe at the connection.

If increaser or reducer connections are made, payment will be made on the basis of the larger diameter of the connection for the full length of the section forming such connections.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Pipe, Drain Tile Terminal Section, _____ in. (mm) diameter	LFT (m)

The cost of excavating, backfilling with suitable excavated material, disposal, planking, removal of existing tile, and necessary incidentals shall be included in the cost of this work.

SECTION 720 – MANHOLES, INLETS, AND CATCH BASINS

720.01 Description

This work shall consist of the construction, reconstruction, or adjustment to grade of manholes, inlets, and catch basins in accordance with 105.03.

720.02 Materials

Materials shall be in accordance with the following:

Castings 910.05
Clay or Shale Brick 905.01

Clay Pipe 907.08
Concrete Brick..... 905.02
Concrete Masonry Blocks 905.03
Concrete 702
Hydrated Lime..... 913.04
Joint Filler..... 906.01
Joint Mortar 901.08, 907.12
Non-Reinforced Concrete Pipe..... 907.01
Precast Units..... 907.04
Reinforced Concrete Pipe..... 907.02
Reinforcing Bars..... 910.01
Water 913.01

CONSTRUCTION REQUIREMENTS

720.03 General Requirements

The construction of the items listed in this specification shall be in accordance with 203.14.

Excavation shall be to the established bottom of the foundations. The finished surface shall be firm and smooth. If soft or yielding spots are encountered at this elevation, they shall be removed, backfilled with suitable material, and tamped into place. If rock is encountered at the bottom elevation, the excavation shall be carried down 6 in. (150 mm) further and backfilled with approved material tamped to the required elevation.

Concrete construction shall be in accordance with the requirements for structural concrete. Masonry shall be in accordance with the requirements for the respective type. Exposed corners of concrete shall be rounded to a 1/4 in. (6 mm) radius. Air-entrained concrete will not be required in the precast portions of concrete manholes or catch basins.

Frames for castings and bearing plates for manholes shall be set in full mortar beds and secured as shown on the plans or as otherwise approved. The mortar shall be composed of 1 part cement to 2 parts No. 23 fine aggregate, by volume. Castings shall be set to the finished pavement elevation so that subsequent adjustments are not necessary.

Iron hood traps in catch basins shall be installed in walls as shown on the plans and so placed that a 6 in. (150 mm) seal is formed. Joints between hoods and walls shall be made gas tight.

Mortar for laying brick and masonry units shall be composed of 1 part masonry cement and 2 parts mortar sand. Mortar for plastering may be the same or it may be composed of 1 part of a combination of portland cement and hydrated lime and 2 parts mortar sand. The lime shall not exceed 10% of the cement. In any case,

proportioning shall be by volume. Ingredients, except water, shall be dry mixed, after which water shall be added to bring the mortar to a stiff paste and mixing continued until a uniform mixture results.

Required plaster coats on the inside and outside shall be at least 1/2 in. (13 mm) thick and shall be smooth, clean, and watertight.

Inlet and outlet pipes shall extend through walls a sufficient distance to allow for connections on the outside and the concrete or mortar carefully placed around them to prevent leakage around their outlet surfaces. Unless otherwise shown, the inside ends shall be flush with the inside walls. The pipe shall be of the same size and kind as that with which it connects on the outside.

Where castings are adjacent to or are surrounded by cement concrete construction, each casting shall be entirely separated from the concrete by a preformed joint filler not less than 3/8 in. (10 mm) thick. The cost of each joint, including the material, shall be included in the price for the structure. Grates shall be placed with the maximum dimension of the rectangular opening parallel to the direction of flow.

The surface of the grate shall be flush with the top edge of the frame, wingwall, and headwall. The frame shall be galvanized and anchored into concrete. The frame shall be factory assembled. All joints shall be fully welded.

Adjusting slots for curb boxes shall be of the dimensions shown on the plans. One slot shall be located at each end of the curb box, and 1 slot shall be located at the approximate centerline on the back of the curb box. Galvanized or stainless steel 3/8 in. UNC x 3 1/2 in. (M10 UNC x 90 mm) round head, square shoulder bolts with 1 flat washer, 1 lock washer, and 1 nut each shall be used in each slot to anchor the curb box to the frame such that the top of the curb box is flush with the top of the curb. Bolts shall be torqued to a minimum of 120 ft lb (160 Nm).

Steel grating type 12 shall be an approved, galvanized grating which shall be of sufficient strength to support a 12,000 lb (5,440 kg) wheel load with a maximum fiber stress of 20,000 lb/sq in (138 MPa). The grating shall seat firmly in, but shall not be secured to, the frame. The length and width of the grating shall be so as to leave not more than 3/8 in. (10 mm) clearance on each side when in place in the frame. The grating shall be cut such that all riveted or welded connections are left intact.

If a manhole is constructed within the pavement area or within an area that may be paved at some future date, the height of the casting used shall be based on the depth of pavement constructed or proposed and a bearing plate for such casting will also be required. Adjusting rings or steps of alternate types to those shown on the plans may be used subject to approval.

If a manhole is constructed outside the proposed pavement area and outside an area that may be paved at some future date, the height of the casting used shall be at least 7 in. (175 mm) and a bearing plate for such casing will not be required.

The manhole bottom shall be constructed of a precast bottom section, or of class A concrete formed in place. A precast cover shall be placed on a manhole in which headroom is limited.

Only competent masons shall be employed in laying units. Brick or other masonry units shall be laid in courses with full and close joints of mortar and finished properly as the work progresses. No joint shall exceed 3/8 in. (10 mm) in width. All units shall be wetted thoroughly immediately prior to being laid. Broken or chipped units will not be permitted in the face of the structure. No spalls or bats shall be used except for shaping around irregular openings or where necessary to finish out a course. As nearly as practicable, adjoining courses shall break joints at a 1/2 unit. Courses shall be level except where otherwise necessary. If brick is used, at least 1 course in each 7 shall be composed of headers.

The pipe used in pipe catch basins shall be of the bell-and-spigot type.

Reinforced concrete spring boxes shall be constructed of class A concrete to the dimensions and at locations shown on the plans or as otherwise specified.

If the completed structure is partially or completely under or at its nearest point is within 5 ft (1.5 m) of pavement, sidewalks, curbs, gutters, or similar miscellaneous existing or proposed structures, the excavated space not occupied by the newly completed structure shall be filled to the required subgrade elevation with material in accordance with 211.02. Placement of this material shall be in accordance with 211.04. If the completed structure is not located as set out above, the backfill shall be with approved material which, when compacted, shall meet the required subgrade density.

Material excavated for the structure shall, if suitable, be utilized as backfill. If, in excess for that purpose, the excess shall be used in embankment where locations are available or otherwise disposed of as directed. If the excavated material is unsuitable or is in excess for use in the work, it shall be disposed of in accordance with 201.03. When finally accepted, all structures shall be free from any accumulation of silt, debris, or other foreign matter.

The Contractor may precast inlets, catch basins, or manholes, subject to approval. If precast concrete inlets, catch basins, or manholes are used, a layer of structure backfill of minimum thickness of 4 in. (100 mm) shall be used under each unit for ease in positioning. If holes are formed or field cut in precast inlets or catch basins to receive the pipe structures, the pipes shall be connected directly to the precast unit, by means of a class A concrete collar of a minimum longitudinal and

radial thickness of 6 in. (150 mm). Holes formed or cut in the wrong place shall be plugged satisfactorily with a class A concrete mixture.

Horizontal joints may be used in the construction of precast catch basins. A sketch of the type, location, and sealing material planned for each joint shall be submitted for approval. No joints shall be closer than 3 in. (75 mm) above standing water for those catch basins requiring hoods.

Grade and location adjustments to precast inlets and catch basins caused by unforeseen conditions shall be handled as if the units were being cast in place. All additional adjustments required due to precasting will not be paid for directly, but the cost thereof shall be included in the cost of the inlet or catch basin.

720.04 Grade Adjustment of Existing Structures

When grade adjustment of existing structures is specified, the frames, covers, and gratings shall be removed and the walls reconstructed as required. The cleaned frames shall be reset at the required elevation. If so specified or if it is determined that the existing casting and supporting walls are in good condition, an approved device may be used to adjust the manhole casting cover to the correct grade without reconstructing the walls or resetting the frame. Upon completion, each structure shall be cleaned of any accumulations of silt, debris, or foreign matter of any kind and shall be kept clear of such accumulation until final acceptance of the work.

Excavation and backfill shall be done in accordance with 720.03.

If an existing casting is unfit for further use, a new casting shall be furnished with payment at the contract unit price per each for castings of the type specified, furnished, and adjusted to grade. This payment shall include and be full compensation for furnishing the new casting, placing and adjusting it to grade, including any necessary removal, construction, or reconstruction of not to exceed 12 in. (300 mm) average height of the upper portion of the masonry.

When catch basins and inlets are adjusted to grade and are to abut existing concrete construction, the castings shall be entirely separated from the adjacent concrete by a preformed expansion joint no less than 3/8 in. (10 mm) in thickness. The cost of furnishing and placing the preformed expansion joint material will not be paid for directly, but shall be included in the payment for reconstructed catch basin, or reconstructed inlet, or castings furnished and adjusted to grade. The preformed expansion joint material shall be in accordance with 906.01.

On resurface contracts the castings shall, unless otherwise permitted or directed, be adjusted to grade after the last binder course has been laid and before placing the surface course.

720.05 Capping Existing Structures

All structures directed to be capped shall be as shown on the plans or by filling the structure with class A concrete after the existing drainage has been maintained. The flow of water through pipes or underdrains in structures shall be perpetuated. Alternate methods for capping shall be submitted for approval before they may be used.

720.06 Method of Measurement

Manholes, inlets, spring boxes, and catch basins, both new and reconstructed as applicable, will be measured per each unit, complete in place.

Castings adjusted to grade and castings furnished and adjusted to grade will be measured per each unit complete in place, if the average adjustment height does not exceed 12 in. (300 mm). If corrections to the structure involve portions exceeding an average adjustment height of 12 in. (300 mm), the additional work will be measured by the linear foot (meter) for the type of structure involved.

The capping of existing structures will be measured by the number of structures capped.

720.07 Basis of Payment

The accepted quantities of manholes, inlets, spring boxes, catch basins, castings adjusted to grade not exceeding 12 in. (300 mm), and castings furnished and adjusted to grade not exceeding 12 in. (300 mm) will be paid for at the contract unit price per each, complete in place.

That portion of a reconstructed structure which exceeds 12 in. (300 mm) in average height will be paid for at the contract unit price per linear foot (meter), for structure, of the type specified, reconstruct, complete in place.

The capping of inlets and other structures will be paid for at the contract unit price per each for cap inlet.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Casting, ____, Adjust to Grade type	EACH
Casting, ____, Furnish and Adjust to Grade type	EACH
Catch Basin, ____ type	EACH
Inlet, ____ type	EACH
Inlet, type H, with Slotted Drains	EACH

Inlet, type HA, with Slotted Drains ..... EACH
Manhole, ____ ..... EACH
type
Pipe Catch Basin, ____ in. (mm) ..... EACH
size
Spring Box ..... EACH
Structure, ____, Reconstructed ..... LFT (m)
type

The cost of both inlets, the 12 in. (300 mm) pipe connecting the 2 inlets, the type 5 castings, the concrete filler between the barrier wall and the inlet, and other miscellaneous materials shall be included in the cost of the inlet, type H. The cost of the inlet, the type 5 casting, the concrete filler between the barrier wall and the inlet, and other miscellaneous materials shall be included in the cost of the inlet, type HA.

The cost of both inlets, the 12 in. (300 mm) pipe connecting the 2 inlets, the type 5 castings, the concrete filler between the barrier wall and the inlets, the slotted drain pipe, the concrete collar around the slotted drain pipe, and other miscellaneous materials shall be included in the cost of the inlet, type H, with slotted drains. The cost of the inlet, the type 5 casting, the concrete filler between the barrier wall and the inlet, the slotted drain pipe, the concrete collar around the slotted drain pipe, and other miscellaneous materials will be included in the cost of the inlet, type HA, with slotted drains.

The cost of excavation, backfill, reinforcing bars, structure backfill, concrete collar required for pipe connection to structures, removal, disposal and replacement of pavement, or surface material, casting removal, installation of concrete cap, HMA wedge, damage repair to pavement and shoulders, and necessary incidentals shall be included in the cost of the pay items.

SECTION 721 – AUTOMATIC DRAINAGE GATES

721.01 Description

This work shall consist of furnishing and placing cast-iron, automatic, hinged, flap-gate valves to the outlet ends of pipe or headwalls in accordance with 105.03.

721.02 Materials

The cast-iron flap and seat shall be machined accurately to ensure watertightness. They shall be in accordance with the applicable requirements of 910.05(b).

721.03 Construction Requirements

The gate shall be constructed to offer minimum resistance to water flowing through it. When the water elevation in the outlet stream is 1/2 in. (13 mm) or more above or below the bottom of the valve, the valve shall close or open, as the case may be. The valve shall be able to resist a head of at least 10 ft (3 m).

The end of the pipe, or headwall, to which the flange is attached shall be vertical and the flange attached thereto either with rivets, bolts, or other approved means.

721.04 Method of Measurement

Automatic drainage gates will be measured by the number of units installed.

721.05 Basis of Payment

The accepted quantities of this work will be paid for at the contract unit price per each for automatic drainage gate, of the size specified, complete in place.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Automatic Drainage Gate, _____ in. (mm) x _____ in. (mm)	EACH
width height	

If the gate is fastened to the end of a pipe, no additional payment will be allowed for that portion of pipe extending beyond the outside face of the headwall.

SECTION 722 – LATEX MODIFIED CONCRETE BRIDGE DECK OVERLAYS

722.01 Description

This work shall consist of the construction of a latex modified portland cement concrete overlay on an existing or new bridge deck, or it shall consist of patching an existing latex modified portland cement concrete overlay on a bridge deck in accordance with 105.03.

722.02 Materials

Materials shall be in accordance with the following:

Admixtures	912.03
Coarse Aggregate, Class A or Higher, Size No. 11*	904
Epoxy Penetrating Sealer	909.09
Epoxy Resin Adhesive	909.11
Fine Aggregate	904
Fly Ash	901.02
Latex Modifier	912.04
PCC Sealer/Healer	901.06
Portland Cement	901.01(b)
Water	913.01

* Crushed stone only

722.03 Storage and Handling of Materials

Fine and coarse aggregates shall be stored and handled avoiding contamination and maintaining uniform moisture content. Fine and coarse aggregates which are stored in piles or bins shall remain separated and shall be covered with a moisture proof material which prevents variations in moisture content of the aggregates. The maximum variation of moisture content in successive concrete batches shall be 0.5%.

Cement shall be stored in weatherproof enclosures which protect the cement from dampness. Cement shall not have developed lumps.

The latex modifier shall be stored in accordance with the manufacturer's recommendations. Latex modifier shall be strained to remove solid particles during transfer of the material from storage drums to the mobile mixer tank.

722.04 Proportioning

The amount of fine aggregate shall be 60% ± 5% by dry weight of the total aggregate and shall be considered as the amount of aggregate blend passing the No. 4 (4.75 mm) sieve. The coarse aggregate shall be No. 11, class A crushed stone. The cement content shall be a minimum of 658 lb/cu yd (391 kg/m^3) of concrete. The same brand of cement shall be used throughout a bridge structure. The amount of latex modifier shall be 3.5 gal. per 94 lb (13.3 L per 43 kg) of cement. The net water added shall produce a slump of 5 in. ± 1 in. (125 mm ± 25 mm) at 4 to 5 min after discharge from the mixer. The moisture content of the aggregates shall be controlled such that the slump is within the specified limits. The air content shall be a maximum of 6%, by volume, of the plastic mix.

The yield will be checked using the 1/4 cu yd (0.2 m^3) box method as follows. The chute shall be cleaned and the box shall be positioned to receive the discharged concrete. The mixer shall be operated until the cement counter indicates that 1/4 cu yd (0.2 m^3) of concrete has been produced. The contents of the box shall be consolidated and struck off. If the box is not essentially full, the gates shall be adjusted and the procedure shall be repeated until the actual and calculated volumes of concrete agree. Yield tests shall be run on the 1st load of each truck and every 3rd load per truck thereafter. Additional tests will be required after making any adjustments.

Slump and air content tests will be performed after each acceptable yield test. The slump test shall be in accordance with AASHTO T 119 and will be performed 4 to 5 min after the concrete is discharged from the mixer. The water flow meter reading will be recorded at the time the slump test is taken. The concrete shall not be disturbed during the waiting period for the slump test. The air content test shall be in accordance with 505. Any concrete mixture which is not properly proportioned or does not conform to the specified slump will be rejected.

Class F or class C fly ash may be used in the latex modified portland cement concrete. The maximum cement reduction shall be 15% and the minimum

replacement ratio by weight of fly ash to cement shall be 1.25:1. A concrete mix design shall be submitted in accordance with 702.05. If portland pozzolan cement, type IP is to be used in the concrete mix design, the cement content shall be increased by a multiplier of 1.06 times the specified cement content.

Bridge deck patching concrete shall be composed of the following:

(a) Fine aggregate shall be 35% to 45% of the total weight of aggregate used.

(b) The cement shall be 564 lbs/cu yd (335 kg/m^3) of portland cement type III or type IIIA, or 846 lbs/cu yd (503 kg/m^3) of portland cement type I or type IA.

(c) Air entraining admixture shall be added to produce 5% to 8% entrained air.

(d) The net water added shall produce a slump of no more than 4 in. (100 mm).

722.05 Preparation of the Bridge Floor

(a) Concrete Removal

1. Deck Surface

The top 1/4 in. (6 mm) of the entire bridge deck surface shall be removed if the overlay is to be placed on a bridge deck constructed under a previous contract. The surface removal operation shall be limited to that portion of the bridge deck that is closed to traffic at any 1 time. After this initial surface removal, an additional 1/4 in. (6 mm) of surface removal may be required on part or all of the bridge deck as directed.

Surface removal shall be performed with a power operated mechanical milling machine. The equipment shall uniformly remove the required depth of concrete surface in a satisfactory manner. Surface removal, which is in areas adjacent to the curb that are inaccessible to milling, shall be done by handchipping. All surface removal residue, including water, dust and concrete, shall be immediately removed.

2. Bridge Floor

Following the clean up from the surface removal operation, areas of unsound concrete to be removed will be marked. Removal of the unsound concrete shall be performed by handchipping or hydrodemolition. Handchipping tools may be hand or mechanically driven. Jack hammers shall not be heavier than nominal 45 lb (20.5 kg) class and chipping hammers shall not be heavier than nominal 15 lb (6.8 kg) class. Only chipping hammers shall be used when removing concrete within 1 in. (25 mm)

of reinforcing bars. Mechanically driven tools shall be operated at a maximum angle of 45° from the bridge floor surface.

The hydrodemolition machine shall utilize a high pressure water jet system and shall be approved prior to use. Hydrodemolition equipment shall be calibrated to remove only unsound concrete. The pressure of the water jet shall be calibrated for each structure prior to use. All water used in the hydrodemolition operation shall be potable, and stream or lake water will not be permitted. Precautions shall be taken, during the hydrodemolition operations, to prevent damage to surrounding property and traffic. Waste water shall not be discharged into a stream.

Regardless of the method of removal, the removal operation shall be stopped if it is determined that sound concrete is being removed. Appropriate recalibration, or changes in equipment and methods shall be performed prior to resuming the removal operation.

Where reinforcing bars have been exposed or the bond between the existing concrete and reinforcing bars has been destroyed, the concrete adjacent to the bars shall be removed to a minimum clearance of 1 in. (25 mm) around the entire periphery of the exposed bars. If the concrete is unsound down to the top layer of bottom reinforcing bars, all of the concrete within the marked area shall be removed and the cavity shall require full depth patching in accordance with 722.06(a). Prepared cavities which are deeper than the level of the adjacent prepared deck surface, but are not full depth, shall require partial depth patching in accordance with 722.06(b). Prepared partial depth cavities shall be made full depth when directed. Exposed reinforcing bars shall not be damaged by the removal operation. Any damaged reinforcing bars shall be repaired as directed with no additional payment.

The removal areas shall be thoroughly cleaned of all dirt, foreign materials and loose concrete to the extent necessary to produce a firm solid surface for adherence of the new concrete. A minimum 1 in. (25 mm) vertical surface shall remain, or be cut, 1 in. outside and around the entire periphery of each removal area after removal of all loose and unsound concrete.

(b) Cleaning

After the concrete removal operation is completed and just prior to placing the patches or the overlay, the entire deck shall be heavily sandblasted to expose fine and coarse aggregates and to remove unsound concrete or laitance layers from the surface. Exposed reinforcing bars and the concrete under and around the exposed bars shall be thoroughly cleaned by sandblasting. The surface shall be then cleaned free of all dust, chips, water, and foreign material to the extent necessary to produce a firm, solid surface for adherence of the new concrete. The air lines for sandblasting and air cleaning shall be equipped with oil traps.

722.06 Patching of the Bridge Floor

A vacuum device shall be used to remove all water from the prepared cavities.

(a) Full Depth Patching

The material used for full depth patching shall be either bridge deck patching concrete or latex modified concrete. Full depth patching shall be performed prior to the overlay operation unless otherwise permitted. The patching material shall be consolidated by internal vibration at the time of placement. Equipment shall not be operated on the repaired deck areas until the test beams indicate a minimum modulus of rupture of 550 psi (3,800 kPa). Curing of the patch shall be as directed.

1. Patching with Bridge Deck Patching Concrete

Epoxy resin adhesive shall be used to coat the surfaces of the prepared cavities and all the exposed reinforcement within the cavities. The epoxy coating shall be tacky at the time that the patching concrete is placed. If the epoxy coating has cured beyond the obvious tacky condition, it shall be re-applied prior to patching. The coated cavities shall then be filled with the patching concrete to the level of the adjacent deck surface.

2. Patching with Latex Modified Concrete

The surfaces of the prepared cavities shall be coated with a bond coat in accordance with 722.09. The cavities shall then be filled with the latex modified concrete to the level of the adjacent deck surface.

(b) Partial Depth Patching

The material used for partial depth patching shall be either bridge deck patching concrete or latex modified concrete. The patching material shall be consolidated by internal vibration at the time of placement. Curing of the patch shall be as directed.

1. Patching with Bridge Deck Patching Concrete

Partial depth patching with bridge deck patching concrete shall be in accordance with 722.06(a) and 722.06(a)1.

2. Patching with Latex Modified Concrete

The surfaces of the prepared cavities shall be coated with a bond coat in accordance with 722.09. The cavities shall then be filled with the latex modified concrete at the time that the overlay is placed.

722.07 Overlay Dam

An overlay dam shall consist of the removal of existing concrete from the bridge floor and replacing it with new concrete as shown on the plans or as otherwise directed. Overlay dam material shall be in accordance with 722.04.

The existing concrete shall be removed as required in accordance with 722.05(a). Exposed reinforcement shall not be cut or otherwise damaged.

Power driven hand tools for removal by handchipping will be permitted. Pneumatic hammers with a maximum weight of 69 lb (31 kg) may be used for the

tops of mudwalls. If, during the removal process, the tools or methods being used appear to cause damage such as cracks or spalling on the concrete which is to remain, the work shall cease immediately and shall not resume until the Engineer is assured the tools or methods being used will not cause further damage.

The surface to be repaired, the reinforcing bars, and the concrete under and around the bars shall be thoroughly cleaned in accordance with 722.05(b). The cavity shall be epoxy coated in accordance with 722.06(a)1 then filled with class A concrete in accordance with 702.

722.08 Mixing

Proportioning and mixing of the latex modified concrete shall be performed in a self-contained, self-propelled continuous mixer. The mixer shall be calibrated to accurately proportion the specified mix prior to starting the work. The calibration shall be in accordance with 722.12. Sufficient mixing capacity or mixers shall be provided to permit the intended pour to be placed without interruption. The mixer shall carry sufficient quantities of unmixed ingredients to produce at least 6 cu yd (4.6 m^3) of latex modified concrete at the site.

The mixer shall measure and control the flow of ingredients being introduced into the mix and shall record these quantities on an approved visible recording meter equipped with a ticket printer. Water flow shall be readily adjustable to compensate for minor variations in aggregate moisture content, and shall be displayed by an approved flow meter. The flow of the latex modifier shall also be displayed by an approved flow meter. The manufacturer's inspection plate shall clearly show the serial number, proper operating revolutions per minute, and the approximate number of counts on the cement meter to deliver 94 lb (43 kg) of cement.

The mixer shall automatically proportion and blend simultaneously all the ingredients of the specified mix on a continuous or intermittent basis as required by the finishing operation. The latex modified concrete shall be discharged through a conventional chute directly in front of the finishing machine. The surface ahead of the deposited mixture shall be kept damp by spraying it with water. If the water is applied by the mixer, it shall be dispensed ahead of the water flow meter.

722.09 Placing and Finishing

Existing expansion joints shall be maintained throughout the overlayment. A bulkhead, equal in thickness to the joint width, shall be installed to the required grade and profile prior to placing the overlay. Screed rails for the finishing machine shall be placed to the required profile, and stably anchored vertically and horizontally. Screed rails shall not be treated with a bond breaking compound.

The overlay shall not be placed unless the ambient temperature is 45°F (7°C) and rising, unless otherwise approved in writing. Placement may be required during early morning hours, at night, or during other limited work periods if the prevailing daytime temperature exceeds 85°F (29°C). The overlay shall not be placed if rain is

expected. Adequate precautions shall be taken to protect freshly placed overlay material from sudden or unexpected rain. Damaged material shall be removed and replaced with no additional payment. A construction dam or bulkhead shall be installed in case of a delay in placement of 1 h or more. During delays of less than 1 h, the end of the placed overlay material shall be protected from drying with layers of wet burlap.

After the surface has been cleaned, and immediately before placing the overlay material, the surface shall be thoroughly soaked for a period of 1 h. The surface shall not be allowed to dry before placing the overlay material and there shall be no standing water at the time of placement. The surface shall then be thoroughly and evenly coated with a brush applied bond coat of latex modified concrete. The progress of the bond coat application shall be controlled to ensure that the bond coat does not dry before the overlay is placed to the required grade. Aggregate segregated in the brush application of the bond coat shall be removed before the overlay is placed. Surface irregularities shall be filled to approximately 3/4 of their depth sufficiently ahead of the overlay operation to allow the material to stiffen and resist rolling back during the finishing.

Following the bond coat application and partial filling of any surface irregularities, the latex modified concrete overlay shall be placed to an elevation approximately 1/2 in. (13 mm) above final grade. The mix shall then be consolidated and machine finished to the required grade. The machine finishing shall be to within 12 in. (300 mm) of the curb line or coping line unless otherwise directed. Supplemental hand finishing with a wood float shall be performed as needed to produce the required tight, uniform surface.

The finishing machine shall be self-propelled and capable of positively controlled forward and reverse motion. The machine shall be equipped with at least 2 finishing devices. The 1st finishing device shall be a vibrating mechanism, such as a vibrating pan, for consolidating the deposited mix. The vibrating pan shall be metal and of sufficient dimensions to ensure proper consolidation. The 2nd finishing device shall be either a rotating cylindrical drum, at least 45 in. (1.1 m) in length, or a vibrating oscillating metal faced screed of 4 in. (100 mm) minimum in width. The vertical position of the finishing devices shall be positively controlled and the devices shall be raised clear of the finished surface when the machine is operated in the reverse direction. The vibration frequency of any vibrating finishing device shall be variable, with positive control between 3,000 and 6,000 vibrations per minute. Alternate finishing machines may be considered for approval subject to a written request.

Screed rails and construction dams shall be separated from the newly finished overlay by passing a pointing trowel along the rail-to-overlay and dam-to-overlay interfaces after the overlay has sufficiently set such that it does not flow back. This trowel cut shall be made for the entire length and depth of the rail or dam. The rails may be removed anytime after the overlay has initially set. Adequate precautions

shall be taken during and subsequent to the rail removal to protect the edge of the new overlay from damage. The finished surface shall be in accordance with 504.03.

722.10 Texturing

Immediately after the finishing is complete and before the surface film has formed, the surface of the overlay shall be textured by transverse grooving. The grooves may be formed by mechanized equipment using a vibrating beam roller, a series of discs or other approved device. Manual tools such as fluted floats, spring steel tined rakes, or finned floats with a single row of fins may be used. The grooves shall be relatively uniform and smooth and shall be formed without tearing the surface or bringing coarse aggregate to the top. The grooves shall be in accordance with 504.03. The grooves shall be terminated approximately 18 in. (450 mm) from vertical faces such as curbs and concrete railing.

All areas of hardened grooved overlay which do not conform to these requirements due to either a deficiency in the grooving or a rough open textured surface shall be corrected with no additional payment. Corrections shall be made by cutting transverse grooves in the hardened overlay with an approved cutting machine or by sealing with an approved mixture and retexturing to a satisfactory finish as directed.

722.11 Curing

When fly ash is used, the requirement for additional wet and/or dry curing time will be determined based on the relative initial, and final time of set and a comparison of strength versus age using control concrete strengths at conventional cure period ages as the reference. Unless otherwise directed, 702.22 shall apply except that the membrane forming curing compound shall not be used to cure the bridge deck overlay.

The minimum curing shall be 24 h of wet cure followed by 72 h of dry cure. An overlaid bridge deck may be opened to traffic during the minimum curing duration when the compressive strength of test cylinders is 4,000 psi (27,500 kPa) or greater. The strength requirements, and the making and curing of the cylinders, shall be in accordance with 702.24. After texturing, the plastic film which forms on the surface of the overlay shall be protected from shrinkage cracking with a single layer of well drained wet burlap. This layer of wet burlap shall be placed as soon as the overlay surface will support it without deformation. Approximately 1 h after placing the 1st layer of wet burlap, a 2nd layer shall be placed and the entire covering shall be maintained in a wet condition for a minimum of 24 h. Polyethylene film may be used in lieu of the 2nd layer of wet burlap. If the polyethylene film is used for the 2nd covering, then the burlap already in place shall be wetted just before placing the polyethylene film and shall be maintained in a wet condition. After the 24 h elapse, all layers of covering material shall be removed.

If the ambient temperature falls below 50°F (10°C) during either the wet or dry curing periods, the time that the temperature is below 50°F (10°C) shall not be

considered as part of the total 96 h curing period. If there is sufficient rain to wet the surface of the overlay for 1 h or more during the dry cure period, this number of hours shall not be considered as part of the 72 h dry cure period.

Immediately upon the start of the dry cure period, the surface shall be checked for cracks. If cracks exist, a thorough investigation will be conducted prior to sealing cracks. Cores may be required to determine the actual crack depth. Surface cracks not exceeding 3/8 in. (10 mm) in depth shall be sealed with an epoxy penetrating sealer followed by an application of an approved sand. The sealing and sand application shall be repeated as needed to ensure that the voids remain completely filled. Alternate methods of surface crack sealing may be used if approved. Cracks exceeding 3/8 in. (10 mm) in depth shall not be sealed at this time. Corrective procedures for repairing cracks exceeding 3/8 in. (10 mm) in depth will be determined after further investigation which may include additional cores. The method of repair shall be as directed in writing and may include removal and replacement or complete filling with an approved sealer/healer and a sand application on the surface. The Department will maintain a list of approved Sealer/Healers.

If it is determined by sounding or coring that adequate bonding between the overlay and the bridge deck has not been attained, the deficient areas shall be removed and replaced as directed.

722.12 Calibration of Continuous Mixers

(a) Frequency

A complete calibration shall be performed for each mixer prior to each pour unless the initial calibration was made within the previous 10 calendar days. A mixer that has been calibrated within the previous 10 calendar days may be approved for use providing that the mixer operator is in possession of the completed, signed, certified and dated Department calibration form for that mixer. A complete calibration of a mixer may be required at any time as directed. All mixers which are calibrated within the 10 day limit but are changing aggregate sources shall have an aggregate blend test performed.

(b) Equipment

All special equipment required for calibration shall be furnished. It shall include but not be limited to suitable material containers, buckets, stop watches and a set of balance beam platform scales graduated in at least 1/4 lb (0.10 kg) intervals with a minimum capacity of 500 lb (230 kg). Samples shall be obtained and handled by the Contractor. Normal testing equipment such as aggregate sieves and containers shall also be furnished.

(c) Pre-calibration

The aggregate bin shall be clean and the bin vibrators shall be in good working order. The mixer shall be equipped with a grounding strap. The cement meter feeder,

the fins and all pockets shall be clean and free of any accumulated cement. The aeration system shall be equipped with a gauge or indicator to verify that the system is operating. The main belts and the latex strainer shall be clean and free of any accumulated material.

(d) Calibration

1. Cement Meter

The mixer manufacturer's mix setting chart shall determine the specified operating revolutions per minute and the approximate number of counts required on the cement meter to deliver 94 lb (43 kg) of cement. At least 3,760 lb (1,700 kg) of cement shall be placed in the cement bin.

The mixing unit shall rest on a level surface. The engine throttle shall be adjusted to obtain the required revolutions per minute. The unit discharging the cement shall be operated until the belt has made 1 complete revolution. It shall then be stopped and the cement meter shall be reset to zero.

A suitable container shall be positioned to catch the cement and at least 90 lb (41 kg) of cement shall be discharged. The time required to discharge the cement shall be measured with a stop watch, the number of counts on the cement meter shall be recorded, and the weight of the discharged cement shall be determined. This process shall be repeated a total of 3 times. The cement counter shall be reset to zero before each repetition.

The following formulas shall be used to calculate the number of counts per 94 lb (43 kg) of cement and the time required to discharge 94 lb (43 kg) of cement.

$$94\ (43) \div \frac{A}{B} = \text{Counts per 94 lb (43 kg) of cement}$$

$$94\ (43) \div \frac{A}{C} = \text{Time in seconds per 94 lb (43 kg) of cement}$$

A = Total weight (mass) of cement in pounds (kilograms) for 3 trials
B = Total number of counts on the cement meter for 3 trials
C = Total time in seconds for 3 trials

2. Water Flow Meter

The accuracy of the water flow meter shall be verified by adjusting the flow to 2 gal. (7.6 L) per minute. With the equipment operating at the required revolutions per minute, the water discharged during a 1 minute interval shall be collected and weighed. The weight in pounds (mass in kilograms) of the discharged water shall be

divided by 8.33 (1) to determine the number of gallons (liters). This procedure shall be repeated with the flow meter adjusted to 3 gal. (11.4 L) per minute.

3. Aggregate Bin Gates

The gate opening shall be adjusted to provide the required amount of aggregate to produce a cubic yard (cubic meter) of the designated mix. The ratio of fine aggregate to total aggregate shall be verified by stopping the cement discharge and collecting the aggregate discharged in a container. A representative sample of the discharged aggregate shall be selected and separated on a No. 4 (4.75 mm) sieve. The fine aggregate will be considered as the amount passing the No. 4 (4.75 mm) sieve. The percentage shall be computed on a dry weight basis.

4. Latex Throttling Valve

The latex strainer shall be unobstructed. The latex throttling valve shall be adjusted to deliver the required amount of latex emulsion admixture for each 94 lb (43 kg) of cement. With the unit operating at the required revolutions per minute for the calculated time in seconds per 94 lb (43 kg) of cement, the latex shall be discharged into a container. The weight of the latex shall be determined and, if necessary, the valve shall be adjusted such that the amount of latex discharged is within 1/2 lb (0.23 kg) of the amount required for each 94 lb (43 kg) of cement. One verification shall be performed to check the accuracy of the valve setting.

5. Admixture Dispensers

This equipment shall be calibrated in accordance with the manufacturer's instructions for the specific materials and quantities involved.

722.13 Patching an Existing Bridge Deck Overlay

(a) Materials

Materials shall be in accordance with 722.02.

(b) Storage and Handling of Materials

Storage and handling of materials shall be in accordance with 722.03.

(c) Proportioning

Proportioning shall be in accordance with 722.04.

(d) Preparation of the Bridge Floor

Preparation of the bridge floor shall be in accordance with the applicable provisions of 722.05.

(e) Patching

Patching shall be in accordance with 722.06 except as modified herein. If no new overlay is planned, bridge deck patching concrete used in patching the bridge floor shall be placed to the level of the original deck. The remainder of each cavity shall be patched with the same material as the existing overlay.

(f) Mixing

Mixing shall be in accordance with the applicable provisions of 722.08.

(g) Placing and Finishing

Placing and finishing shall be in accordance with the applicable provisions of 722.09. Machine finishing shall be required when directed.

(h) Texturing

Texturing shall be in accordance with 722.10. In addition, the surface texturing shall match the pattern of the adjacent overlay.

(i) Curing

Curing shall be in accordance with 722.11.

(j) Calibration of Continuous Mixers

Calibration shall be in accordance with 722.12.

722.14 Method of Measurement

Surface milling will be measured by the square yard (square meter) for the initial 1/4 in. (6 mm) depth. Additional surface removal required below the initial 1/4 in. (6 mm) depth will be measured by the square yard (square meter) for each required 1/4 in. (6 mm) depth. Only the portion of the bridge deck which is to remain in place will be measured for payment. The undefined areas requiring full depth deck removal will be measured for payment. The areas of the bridge floor which are shown on the plans to be removed will not be measured for payment.

Full depth patching will be measured by the square foot (square meter). The patching material used in full depth patching will not be measured for payment.

Partial depth patching will be measured by the square foot (square meter). The measurement of bridge deck patching concrete used in partial depth patching will be based on a theoretical quantity determined by multiplying the area of the appropriate partial depth patches by an assumed average depth of 2 in. (50 mm) and converting the resulting volume into cubic yards (cubic meters). Overlay material used in partial depth patching will be measured by the cubic yard (cubic meter). The quantities of patching material used in partial depth patching will be included in the measurement of additional bridge deck overlay.

Overlay material used to fill surface irregularities will be measured by the cubic yard (cubic meter). Such quantity will be included in the measurement of additional bridge deck overlay.

Bridge deck overlay will be measured by the square yard (square meter) for the specified thickness. If there is no specified thickness shown on the plans, the specified thickness shall be 1 3/4 in. (45 mm).

Overlay dams and patching an existing overlay will be measured by the square foot (square meter).

Epoxy resin adhesive and bond coat will not be measured for payment. Blasting, cleaning, finishing, texturing, and curing will not be measured for payment.

722.15 Basis of Payment

Milling of the initial 1/4 in. (6 mm) depth of surface will be paid for at the contract unit price per square yard (square meter) for surface milling. Additional surface removal below the initial 1/4 in. (6 mm) depth will be paid for at the contract unit price per square yard (square meter) for surface milling for each required 1/4 in. (6 mm) depth.

Full depth patching will be paid for at the contract unit price per square foot (square meter) for bridge deck patching, full depth.

Partial depth patching will be paid for at the contract unit price per square foot (square meter) for bridge deck patching, partial depth.

Prepared partial depth cavities exceeding 2 in. (50 mm) in average depth, which are subsequently directed to be made full depth, will be paid for at the contract unit price per square foot (square meter) for bridge deck patching, partial depth. Additional payment will be made at 80% of the contract unit price per square foot (square meter) for bridge deck patching, full depth.

Prepared partial depth cavities of 2 in. (50 mm) or less in average depth, which are subsequently directed to be made full depth, will be paid for at the contract unit price per square foot (square meter) for bridge deck patching, full depth.

Patching material used for partial depth patching will be paid for at the contract unit price of $550 per cubic yard ($719 per cubic meter) for bridge deck overlay, additional.

Overlay material used to fill surface irregularities will be paid for at the contract unit price of $550 per cubic yard ($719 per cubic meter) for bridge deck overlay, additional.

Bridge deck overlay will be paid for at the contract unit price per square yard (square meter).

Patching an existing bridge deck overlay will be paid for at the contract unit price per square foot (square meter) for bridge deck overlay patching.

Overlay dam will be paid for at the contract unit price per square foot (square meter), complete in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Bridge Deck Overlay	SYS (m2)
Bridge Deck Overlay, Additional	CYS (m3)
Bridge Deck Overlay, Patching	SFT (m2)
Bridge Deck Patching, Full Depth	SFT (m2)
Bridge Deck Patching, Partial Depth	SFT (m2)
Overlay Dam	SFT (m2)
Surface Milling	SYS (m2)

The cost of milling, handchipping, removing debris and water, and necessary incidentals shall be included in the cost of surface milling.

The cost of removal of unsound concrete, preparation of cavity surfaces, furnishing and applying bond coat or epoxy resin adhesive as required, furnishing and placing patching material, and necessary incidentals shall be included in the cost of bridge deck patching, full depth, or bridge deck patching, partial depth.

The cost of patching material used for full depth patching shall be included in the cost of bridge deck patching, full depth.

The cost of furnishing and placing patching material and necessary incidentals shall be included in the cost of bridge deck overlay, additional.

The cost of removing the existing concrete; furnishing, hauling, and placing all materials including the epoxy; preparing the surface; and all necessary incidentals shall be included in the cost of overlay dam.

The cost of blasting, cleaning, furnishing, and applying epoxy resin adhesive or bond coat shall be included in the cost of other pay items.

Coring of the bridge deck, patching core holes, and all corrective measures required in accordance with 722.11 shall be performed with no additional payment.

The cost of bond coat, furnishing and placing the overlay material, and necessary incidentals shall be included in the cost of bridge deck overlay or bridge deck overlay patching.

SECTION 723 – REINFORCED CONCRETE THREE-SIDED STRUCTURES

723.01 Description

This work shall consist of constructing a reinforced concrete three-sided arch-topped structure or structure extension with headwalls and wingwalls, a reinforced concrete three-sided flat-topped structure or structure extension with headwalls and wingwalls, or a reinforced concrete true arch shape structure or structure extension with spandrel walls and wingwalls in accordance with 105.03. The reinforced concrete three-sided structure, structure extension, headwalls, wingwalls, footings, and spandrel walls may be precast or cast-in-place.

The Contractor will be allowed to substitute a box structure in accordance with 714. The box structure shall be of equivalent hydraulic capacity to that of the three-sided structure shown on the plans. The structure shall be sumped as shown on the plans.

MATERIALS

723.02 Materials

Materials shall be in accordance with the following:

Chemical Anchor System	901.05
Coarse Aggregates, Class A or Higher, Size No. 91	904
Concrete	702
Epoxy Coated Reinforcing Bars	910.01(b)9
Flowable Backfill	213
Geotextile	918.01, 918.02, or 918.03
Hydrated Lime	913.04(a)
Masonry Cement	901.01(c)
Mortar Sand	904.02(e)
Natural Sand	904.02(a)
Pipe Joint Sealant	907.11
Portland Cement	901.01(b)
Precast Reinforced Concrete Headwalls, Wingwalls, Footings, and Spandrel Walls	907.06
Precast Reinforced Concrete Structure Sections	907.05
Reinforcing Bars	910.01
Riprap	904
Sealer	909.09 or 909.10
Steel Welded Wire Reinforcement, Smooth and Deformed	910.01
Structure Backfill	904

Cast-in-place concrete for a reinforced concrete three-sided structure, or splices between an existing culvert structure and a precast reinforced concrete three-sided structure extension shall be class A or higher in accordance with 707.04(c). It shall

have a 28-day minimum concrete compressive strength of 5,000 psi (34,500 kPa). Cast-in-place concrete for headwalls, wingwalls, or spandrel walls shall be class A or higher in accordance with 707.04(c). It shall have a 28-day minimum concrete compressive strength of 4,000 psi (27,600 kPa).

When the Contractor elects to provide a cast-in-place structure, acceptance of the structure will be based on tests for relative yield, air content, slump, water cementitious ratio, and compressive strength. Relative yield and air content shall be in accordance with 702.05. The slump and concrete temperature shall be in accordance with 707.04(c). The amount of time from the introduction of mixing water to the cement and aggregates to the completion of the discharge of the concrete shall not exceed 90 minutes. The water cementitious ratio shall be in accordance with 707.04(d). The 28-day compressive strength shall be equal to or greater than the specified concrete compressive strength and otherwise shall be in accordance with 707.04(c)3. The Contractor shall provide the necessary 6 in. diameter by 12 in. cylinder molds for the Department's use.

For plastic concrete sampling, acceptance testing procedures and casting cylinders will be in accordance with 505.01. Except for footings, concrete flexural strength or results from beam breaks will not be accepted in lieu of concrete compression cylinder test results.

Cast-in-place concrete used to seal existing culverts shall be class A. Cast-in-place concrete for footings and base slabs shall be class B.

Unless otherwise specified herein, reinforcement may consist of either reinforcing bars or welded wire reinforcement, WWR. If specified to be coated, WWR shall be coated with either galvanized coating or epoxy coating, and reinforcing bars shall be coated with epoxy coating. Epoxy coated WWR shall be coated with Type I coating with Class A minimum coating thickness in accordance with ASTM A 884. Galvanized WWR shall be coated in accordance with ASTM A 123 and shall have a minimum coating grade of 35. For WWR, material with minimum yield strength of 65 ksi (448 MPa) shall be used.

Reinforcement in headwalls and pedestals shall consist of reinforcing bars and shall be epoxy coated. Reinforcement in spandrel walls shall be coated. If the structure is specified as requiring coated reinforcement, reinforcement, including support devices, in that structure shall be coated. In lieu of coating, the support device may be manufactured of a non-corrosive material.

Headwalls, wingwalls and spandrel walls shall be connected to the outside structure sections. Wingwalls shall be connected to the spandrel walls if the structure is a true arch shape structure. Precast headwalls, precast wingwalls, and precast spandrel walls shall be connected with bolted steel plates.

CONSTRUCTION REQUIREMENTS

723.03 General Requirements

Excavation and disposal shall be in accordance with the applicable requirements of 206. The areas designated for waterproofing shall be waterproofed in accordance with 702.23. All underground drains encountered during excavation for the structure shall be perpetuated as dictated by field conditions. Drainage openings through masonry shall be in accordance with 702.16. Handling of three-sided structures shall be in accordance with 907.05. Handling of wingwalls and spandrel walls shall be in accordance with 907.06.

723.04 Design Requirements

A three-sided structure shall be designed for HL-93 loading in accordance with AASHTO LRFD Bridge Design Specifications.

The three-sided structure, headwalls, wingwalls, footings, and spandrel walls shall be designed in accordance with the soil parameters shown in the contract documents.

Headwalls, wingwalls, and spandrel walls shall be designed based on a minimum equivalent fluid pressure of 40 lb/cu ft (6.3 kN/m^3). If flowable backfill is to be used, the Contractor shall consider the effects of hydrostatic pressure on the structure. Weep holes shall be provided in all wingwalls. Horizontal pressures shall be increased for sloping backfill surfaces and live load surcharge. Headwall connections, wingwall footings, and spandrel walls shall be checked for sliding and for overturning.

A headwall with bridge railing mounted on top and the anchorage of the headwall or spandrel wall to the structure section, shall be designed for the bridge railing test level shown on the plans.

Continuity shall be established between the structure footing and the wingwall footing.

(a) Placement of Reinforcement

For three-sided arch-topped or true arch shape structure sections, the concrete cover over the outside circumferential reinforcement shall be a minimum of 2 in. (50 mm). The cover over the inside circumferential reinforcement shall be a minimum of 1 1/2 in. (40 mm). The clear distance of the end circumferential reinforcement shall not be less than 1 in. (25 mm) nor more than 2 in. (50 mm) from the ends of the structure section. The ends of the longitudinal distribution reinforcement shall be not more than 3 in. (75 mm) from the ends of the structure section.

For flat-topped structure sections, the cover dimension over the top mat of reinforcement shall be a minimum of 2 in. (50 mm). The cover over the lower mat of reinforcement in the structure top shall be a minimum of 1 1/2 in. (40 mm). The

cover in the legs shall be a minimum of 2 in. (50 mm). The clear distance of the end circumferential reinforcement shall not be less than 1 in. (25 mm) nor more than 2 in. (50 mm) from the ends of the structure section. The ends of the longitudinal distribution reinforcement shall not be more than 2 in. (50 mm) from the ends of the structure section.

Cover for headwall, wingwall, spandrel wall, and pedestal reinforcement shall be a minimum of 2 in. (50 mm). Cover for footing and base slab reinforcement shall be 3 in. (75 mm) for the top and sides and 4 in. (100 mm) for the bottom.

(b) Splicing and Spacing of Reinforcement

Reinforcement splicing and spacing shall be in accordance with the AASHTO LRFD Bridge Design Specifications except as indicated herein. Tension splices in circumferential reinforcement shall be made by means of lapping. Where reinforcing bars are used for longitudinal distribution reinforcement, the reinforcing bars shall have a center to center spacing not to exceed 12 in. (300 mm) in flat-topped structure sections or 16 in. (400 mm) in arch-topped or true arch shape structure sections.

Where reinforcing bars are used in wingwalls, the maximum spacing for wingwall reinforcing bars shall be 18 in. (450 mm) for horizontal bars and 12 in. (300 mm) for vertical bars.

Exterior corner reinforcement for flat-topped structure sections shall be fully developed beyond the point where it is no longer required to resist flexure.

(c) Working Drawings

Working drawings shall be submitted in accordance with 105.02 for fabrication of a precast or cast-in-place reinforced concrete three-sided structure, precast or cast-in-place reinforced concrete three-sided structure extension, precast or cast-in-place headwalls, precast or cast-in-place wingwalls, and precast or cast-in-place spandrel walls. The working drawings shall include all details, dimensions, and quantities necessary to construct the structure, headwalls, wingwalls, or spandrel walls and shall include, but not be limited to, the following information.

1. Structure span and rise.

2. Structure section details showing all concrete dimensions and reinforcement requirements.

3. Headwall details showing all concrete dimensions, elevations, reinforcing bar sizes, reinforcing bar bending diagrams, lengths, spacings, and anchorage details. Headwall elevation and section views shall be provided.

4. Wingwall design calculations and details showing all concrete dimensions, elevations, reinforcement sizes, bending diagrams, lengths, spacings, and anchorage details. Wingwall plan, elevation, and section views shall be provided.

5. Spandrel wall details showing all concrete dimensions, elevations, reinforcement sizes, bending diagrams, lengths, spacings, and anchorage details. Spandrel wall elevation and section views shall be provided.

6. Footing design calculations and details showing all concrete dimensions, elevations, reinforcing bar sizes, reinforcing bar bending diagrams, lengths, and spacings indicated. Footing plan and section views shall be provided. If a pile footing is required, the pile layout shall be shown. The actual soil bearing pressure shall be shown on the footing detail sheets.

7. Design calculations and details for pedestals, if required.

8. Structure backfill type and limits for the structure and wingwalls.

9. Minimum concrete strength for all concrete portions of the structure.

723.05 Manufacture

The structure sections, headwalls, wingwalls, footings and spandrel walls shall be free of fractures. Headwalls, wingwalls, and spandrel walls shall be given a finish in accordance with 702.21.

The structure units shall not be stored in an upright position until the designated handling and storage compressive strength, as shown on the working drawings, has been achieved.

723.06 Rejection

Structure sections, wingwalls, footings, or spandrel walls will be rejected due to the following conditions.

(a) fractures or cracks passing through the section or wall, except for a single end crack which does not exceed one-half the thickness of the section or wall;

(b) defects which indicate proportioning, mixing, or molding which are not in accordance with this specification;

(c) honeycombed or open texture; or

(d) damaged section ends, where such damage prevents making a satisfactory joint.

723.07 Repairs

Structure sections, headwalls, wingwalls, footings or spandrel walls shall be repaired, if necessary, due to imperfections in manufacture, handling damage, or construction. Repairs will be acceptable if it is determined that the repairs are sound, properly finished and cured, and if the repaired structure section headwall, wingwall, footing, or spandrel wall is in accordance with the requirements herein.

723.08 Trench Compaction

The soils in the bottom of the excavation shall be compacted to 95% of the maximum dry density in accordance with 203.23. If 95% of the maximum dry density cannot be obtained in the bottom of the excavation or in other areas, the Office of Geotechnical Services shall be contacted for additional recommendations. If during construction, soft soils are encountered at depths that make removal impractical, the Office of Geotechnical Services shall be contacted for additional recommendations.

723.09 Footings

Where a precast footing is utilized, a 4 in. (100 mm) layer of coarse aggregate No. 53 in accordance with 301 shall be placed under the full width of the footing. All footings shall be given a smooth float finish. The footing concrete shall reach a compressive strength of 2,000 psi (13,800 kPa) or flexural strength in accordance with 702.24(c) before placement of the structure sections or wingwalls. The surface shall not vary more than 1/4 in. in 10 ft (6 mm in 3 m) when tested with 10 ft (3 m) straightedge.

723.10 Pedestals

Where a reinforced concrete pedestal is required between the base of the structure leg and the top of the footing, the Contractor shall have the option of providing a structure with extended legs or constructing the pedestals.

723.11 Placement of Structure Sections and Wingwalls

For three-sided arch-topped structures and three-sided flat-topped structures, the structure sections shall be set on masonite or steel shims. Each wingwall that is not precast as one unit with the footing shall be set on masonite or steel shims. A minimum gap of 0.5 in. (13 mm) shall be provided between the footing and the bottom of each section or wingwall. Once the wingwalls or structure sections are placed, the space underneath the wingwall or structure leg section to the top of the keyway sides shall be filled with prepackaged grout in accordance with ASTM C 1107, or conventional or self-consolidating fine grout in accordance with ASTM C 476, except as modified herein. If conventional fine grout is used, it shall be troweled into the keyway and mounded on one side of the leg or wingwall. The mound of conventional fine grout shall be vibrated until it passes through to the other side of the leg or wingwall. After completing this process on one side, if the conventional

fine grout has not passed through to the other side, the process shall be repeated on the other side. Conventional or self-consolidating fine grout shall be from a prepackaged source or composed of one of the following mixtures:

(a) 930 lb/cu yd (552 kg/m^3) Type I portland cement with No. 23 natural sand or mortar sand.

(b) 930 lb/cu yd (552 kg/m^3) Type M masonry cement with No. 23 natural sand or mortar sand.

(c) 828 lb/cu yd (491 kg/m^3) Type I portland cement and 75 lbs/cu yd (44 kg/m^3) hydrated lime with No. 23 natural sand or mortar sand.

The maximum water/cement ratio shall be 0.446 for both conventional and self-consolidating fine grout. An air entraining agent from the Department's list of approved PCC admixtures may be used. A type F or G chemical admixture from the Department's list of approved PCC admixtures shall be used in self-consolidating fine grout in order to achieve the slump flow and visual stability index requirements. Filling procedure B of ASTM C 1611 will be used for measuring slump flow. Appendix X1 of ASTM C 1611 will be used for determining the visual stability index value.

Acceptance of conventional fine grout will be based on an air content of 12% ± 4%. Acceptance of self-consolidating fine grout will be based on tests for air content, slump flow, and visual stability index. Air content shall be 12% ± 4%. Slump flow shall be 27 in. ± 3 in. (685 mm ± 75 mm). Visual stability index value shall not exceed 1.

Where prepackaged grout is used, a type C certification in accordance with 916 shall be provided.

True arch shape structures may have grout leveling pads poured in the footing keyways to ensure the correct seating of the true arch sections. Leveling pads shall be approximately 2 in. (50 mm) thick and 16 in. (400 mm) long to ensure that each true arch section is resting on approximately 8 in. (200 mm) of pad at each joint. The leveling pads shall be poured within 1/8 in. (3 mm) of the required elevation. No loads shall be placed on the grout leveling pads within 72 h of their placement. Masonite shims may also be used as leveling pads. Concrete blocks of 1 1/2 in. (40 mm) thickness, hardwood wedges, and steel or plastic shims shall be placed to retain the true arch sections in their proper positions until grout can be placed in the keyway. Grout shall be consolidated in the keyway to ensure that the entire area around the true arch section is completely filled. The grout used to construct the leveling pads and to fill the keyways shall be in accordance with this section. Grout shall not be placed if the air temperature is expected to be below 35°F (2°C) for a period of 72 h following grout placement.

723.12 Extension of Existing Structure

All applicable requirements of this specification shall apply to the extension of an existing three-sided arch-topped structure with headwalls and wingwalls, a three-sided flat-topped structure with headwalls and wingwalls, or a true arch shape structure with spandrel walls and wingwalls. Such portions of the existing structure designated for removal shall be removed. All portions of the existing structure which are to remain in place and are damaged shall be repaired or replaced as directed. Those portions left in place which are wholly or partially filled with debris shall be cleaned out. Material removed shall be disposed of in accordance with the applicable requirements of 202.02.

Before removing concrete from an existing structure with wingwalls, the Contractor shall saw around the perimeter of the removal area on the interior and exterior of the existing structure a depth of 1 in. (25 mm). All existing reinforcement in the top slab and sidewalls exposed after concrete removal shall be cleaned and straightened in preparation for lapping with reinforcement from adjacent new work. Where existing reinforcement has deteriorated or been damaged during the removal operation, holes shall be drilled into the face of the existing structure to provide embedment for replacement reinforcing bars. The holes shall be of the diameter and depth required by the approved chemical anchor system manufacturer. The holes shall be cleaned prior to placing the approved chemical anchor system and the reinforcing bars.

No concrete shall be removed from an existing structure that has a headwall but no wingwalls. Reinforcing bars to tie the existing structure to the new structure section shall be installed by drilling holes into the face of the existing structure to provide embedment for reinforcing bars. The diameter and depth of the holes shall be in accordance with the recommendations of the manufacturer of the approved chemical anchoring system. The holes shall be cleaned prior to placing the approved chemical anchor system and the reinforcing bars.

An existing structure shall be extended by means of one of the following methods.

(a) Precast Reinforced Concrete Three-Sided Structure Extension

A cast-in-place concrete splice shall be constructed as a transition between the existing structure and the precast structure extension. The splice reinforcement in the precast structure extension section that will abut the existing structure shall be exposed 18 in. (450 mm) on the tongue end of the precast structure extension section. It shall be lapped 18 in. (450 mm) with either exposed existing structure reinforcement, in the case of an existing structure with wingwalls, or newly installed reinforcing bars in the existing structure, in the case of an existing structure with a headwall only as shown on the plans. Existing exposed structure reinforcement from an existing structure with wingwalls shall be cut off 1 in. (25 mm) from the face of the new precast extension.

If the existing tongue or groove joint end is acceptable and matches the mating joint on the new precast reinforced concrete structure extension section, the new extension may be installed using the mating joint of the existing structure. No cutting of the structure or splicing of reinforcement is then required. The joint between the new precast structure extension and the existing structure shall be sealed as directed below.

(b) Cast-In-Place Concrete Three-Sided Structure Extension

The reinforcement for the structure extension shall be lapped with the exposed reinforcement of the existing structure as shown on the plans.

723.13 Sealing

Sealer shall be applied in accordance with 709 on the top surface of the structure section, headwalls, and wingwalls. It shall extend 5 ft (1.5 m) vertically down the exterior of each vertical leg or 5 ft (1.5 m) vertically down both faces of each headwall or wingwall or to the bottom of each, whichever is less. Sealer material shall not be placed in keyway joints, if present. The sealer shall be provided for the full length of the structure. Surface preparation and application procedures shall be as recommended by the sealer manufacturer.

723.14 Joints

Joints between structure sections for three-sided arch-topped structures and true arch shape structures, and for flat-topped structures with cover of 3 ft (0.9 m) or more, may be either butt joints or keyway joints.

The sections of flat-topped structures with less than 3 ft (0.9 m) of cover shall be produced with a minimum 4 in. (100 mm) depth by 1 1/2 in. (40 mm) width keyway joint. Non-shrink grout in accordance with 707.09 shall be placed in the keyway joint.

All butt joints between structure sections shall be covered with a joint wrap in accordance with ASTM C 877. The surface shall be free of dirt before the joint material is applied. The entire joint shall be continuously covered. Joints between structure sections and wingwalls, between wingwalls and spandrel walls, and between structure sections and headwalls or spandrel walls shall be covered with either the same wrap used between structure sections or with geotextile in accordance with 918.03.

The joint wrap shall be kept in its proper location over the joint. It shall not be damaged during the backfilling operation.

Joints in true arch shape structures shall be sealed with 1 1/2 in. (40 mm) diameter preformed pipe joint sealant before placement of the joint wrap.

723.15 Backfilling

Structure backfill shall be placed and compacted in accordance with 211. Structure backfill shall be placed and compacted on each side of the structure to the fill line shown on the plans. During the backfill operation, the difference in elevations of the fill on each side of the structure shall not exceed 24 in. (610 mm).

Unless otherwise specified by the manufacturer on the working drawings, once the level of structure backfill reaches the top of the structure, 2 lifts shall be spread and hand compacted over the structure without traversing the structure with heavy equipment. Compaction with heavy equipment will not be allowed until a minimum of 2 lifts have been placed, hand compacted, and accepted.

The operation of equipment over the structure shall be in accordance with the structure manufacturer's recommendations.

723.16 Scour Protection

When riprap is specified, geotextile shall 1st be placed on the in-situ soil in accordance with 616.11. Riprap shall then be placed in accordance with 616.

For concrete base slabs, concrete shall be placed in accordance with 702.

723.17 Method of Measurement

Precast reinforced concrete three-sided flat-topped structures or structure extensions, precast reinforced concrete three-sided arch-topped structures or structure extensions, precast reinforced concrete true arch structures or structure extensions, cast-in-place reinforced concrete three-sided flat-topped structures or structure extensions, cast-in-place reinforced concrete three-sided arch-topped structures or structure extensions, and cast-in-place reinforced concrete true arch structures or structure extensions will not be measured. The accepted quantities for payment will be the quantities shown on the plans.

Structure backfill will be measured in accordance with 211.09. Flowable backfill will be measured in accordance with 213.08. Geotextile and riprap will be measured in accordance with 616.12. Field drilled holes will be measured in accordance with 702.27.

Plain or coated reinforcement or WWR used in precast reinforced concrete three-sided flat-topped structures or structure extensions, precast reinforced concrete three-sided arch-topped structures or structure extensions, precast reinforced concrete true arch structures or structure extensions, precast headwalls, precast wingwalls, cast-in-place reinforced concrete three-sided flat-topped structures or structure extensions, cast-in-place reinforced concrete three-sided arch-topped structures or structure extensions, cast-in-place reinforced concrete true arch structures or structure extensions, cast-in-place headwalls, or cast-in-place wingwalls will not be measured for payment.

If the Contractor elects to provide a box structure in lieu of the three-sided structure shown on the plans, it will be measured in accordance with 714.11.

723.18 Basis of Payment

The accepted quantities of precast reinforced concrete three-sided flat-topped structures or structure extensions, precast reinforced concrete three-sided arch-topped structures or structure extensions, precast reinforced concrete true arch structures or structure extensions, cast-in-place reinforced concrete three-sided flat-topped structures or structure extensions, cast-in-place reinforced concrete three-sided arch-topped structures or structure extensions, and cast-in-place reinforced concrete true arch structures or structure extensions, of the size specified will be paid for at the contract unit price per linear foot (meter).

Structure backfill will be paid for in accordance with 211.10. Flowable backfill will be paid for in accordance with 213.09. Geotextile and riprap will be paid for in accordance with 616.13. Field drilled holes will be paid for in accordance with 702.28.

If the Contractor elects to provide a box structure in lieu of the three-sided structure shown on the plans, it will be paid for in accordance with 714.12. The Department will not incur additional cost for allowing the Contractor to substitute a box structure for the three-sided structure shown on the plans.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Structure Extension, Coated Reinforced Concrete, Three-Sided Sections, ____ in. (mm) x ____ in. (mm) span rise	LFT (m)
Structure Extension, Reinforced Concrete, Three-Sided Sections, ____ in. (mm) x ____ in. (mm) span rise	LFT (m)
Structure, Coated Reinforced Concrete, Three-Sided Sections, ____ in. (mm) x ____ in. (mm) span rise	LFT (m)
Structure, Reinforced Concrete, Three-Sided Sections, ____ in. (mm) x ____ in. (mm) span rise	LFT (m)

The cost of all design, coring, testing, pedestals or extended legs, excavation, repairs, plugging core and handling holes, mortar, grout, sealer, cylinder molds, and necessary incidentals shall be included in the cost of the structure or structure extension. The cost of spandrel walls, concrete base slab, footings, and aggregate base under precast footings shall be included in the cost of the structure or structure extension.

The cost of precast concrete headwalls, precast concrete wingwalls, cast-in-place headwalls, or cast-in-place wingwalls shall be included in the cost of the structure or structure extension.

The cost of plain or coated reinforcement or WWR used in precast reinforced concrete three-sided structures, precast reinforced concrete three-sided structure extensions, precast headwalls, precast wingwalls, cast-in-place reinforced concrete three-sided structures, cast-in-place reinforced concrete three-sided structure extensions, cast-in-place headwalls, or cast-in-place wingwalls shall be included in the cost of the structure or structure extension.

The cost of concrete used in a cast-in-place splice shall be included in the cost of the structure extension.

The cost of footings for wingwalls and aggregate base under the wingwall footings shall be included in the cost of the structure or structure extension.

The quantities for payment shall remain as shown on the plans whether the Contractor installs the three-sided arch-topped structure or structure extension, the three-sided flat-topped structure or structure extension, or the true arch shape structure or structure extension.

No additional payment will be made for carrying an underground drain through a structure or structure extension. However, no deduction will be made for the volume of concrete occupied by the drain pipe in a cast-in-place structure or structure extension.

No additional payment will be made for the repair or replacement of existing concrete damaged by Contractor operations.

SECTION 724 – STRUCTURAL EXPANSION JOINTS

724.01 Description

(a) Structural Expansion Joint

This work shall consist of furnishing and placing, for new construction, structural expansion joints of the type specified, in accordance with 105.03.

(b) Replacement of Existing Structural Expansion Joint

This work shall consist of the removal and replacement of an existing structural expansion joint with a joint of the type specified, in accordance with 105.03.

(c) Replacement of Existing Structural Expansion Joint Seal

This work shall consist of the replacement of the joint seal in an existing structural expansion joint of the type specified.

MATERIALS

724.02 Materials

Materials shall be in accordance with the following:

Concrete, Class C	702
Expansion Joint M	906.07(b)
Expansion Joint SS	906.07(a)
Inorganic Zinc Primer	909.02(a)1
Structural Steel	910.02

The joint manufacturer shall prepare and submit working drawings in accordance with 105.02. The working drawings shall include details of the assembly, installation details for where changes in the joint direction are required, manufacturer's specifications, and joint setting data.

(a) Expansion Joint SS

The joint assembly shall consist of one of the allowable alternates for this type of joint as shown on the plans. The strip seal shall be sized to accommodate a minimum of 4 in. (100 mm) of movement. The strip seal shall be furnished in 1 continuous length for the entire limits of the installed joint. Field splicing of the strip seal will not be allowed.

(b) Expansion Joint M

The joint assembly shall be manufactured in accordance with the details shown on the working drawings as prepared by the manufacturer of the joint assembly. The strip seals shall be furnished in 1 continuous length for the entire limits of the installed joint. Field splicing of the strip seals will not be allowed.

CONSTRUCTION REQUIREMENTS

724.03 General Requirements

All welding shall be in accordance with 711.32. All splice welds shall develop full strength. All welds which come in contact with the seals shall be ground smooth. All metal surfaces in direct contact with the seal shall be cleaned and properly treated in accordance with the manufacturer's recommendations. Lubricants and adhesives shall be used in accordance with the joint manufacturer's recommendations. All excess lubricant and adhesive shall be removed before it has set.

Final adjustment of the assembly shall be made as directed at the time of installation. All movements due to such factors as shrinkage, creep, and midslab deflection shall be accounted for prior to this final adjustment.

(a) Replacement of Existing Structural Expansion Joint

The existing joint and adjacent concrete shall be removed to the limits shown on the plans. Additional removal, as directed, may be required to encounter sound concrete adjacent to the joint area. The replacement joint shall be in accordance with the requirements contained herein for the specified type. Concrete shall be class C in accordance with 702.

(b) Replacement of Existing Structural Expansion Joint Seal

The existing seal shall be removed in its entirety. The new seal shall be installed in accordance with the requirements contained herein for the specified joint type.

724.04 Method of Measurement

Structural expansion joints will be measured by the linear foot (meter) along and parallel to the plane of the finished joint surface. Replacement of existing structural expansion joints will be measured by the linear foot (meter) along and parallel to the plane of the finished joint surface. Concrete removal and class C concrete required for the replacement of existing structural expansion joints will not be measured for payment. Sliding cover plates will not be measured for payment. Replacement of existing structural expansion joint seals will be measured by the linear foot (meter) along and parallel to the plane of the finished seal installation.

724.05 Basis of Payment

Structural expansion joint will be paid for at the contract unit price per linear foot (meter) of the type specified, complete in place. Replacement of existing structural expansion joint will be paid for at the contract unit price per linear foot (meter) for structural expansion joint, of the type specified, replace, complete in place. Replacement of existing structural expansion joint seals will be paid for at the contract unit price per linear foot (meter) for structural expansion joint seal, of the joint type specified, replace.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Structural Expansion Joint, ____ type	LFT (m)
Structural Expansion Joint, ____ type, Replace	LFT (m)
Structural Expansion Joint Seal, ____ type, Replace	LFT (m)

The cost of sliding cover plates shall be included in the cost of structural expansion joint or structural expansion joint, replace, as applicable. The cost of reinforcing bars, concrete removal and class C concrete for the replacement of existing structural expansion joint shall be included in the cost of structural expansion joint, replace.

SECTION 725 – SLIP LINING OF EXISTING PIPE

725.01 Description

This work shall include installing a thermoplastic liner pipe into an existing pipe and filling the space between the liner pipe and the existing pipe with cellular concrete grout all in accordance with 105.03. Existing circular pipe structures shall be lined with solid wall high density polyethylene, HDPE, liner pipe; profile wall HDPE liner pipe; or profile wall polyvinyl chloride, PVC, liner pipe. Existing deformed pipe structures shall be lined with solid wall HDPE liner pipe.

MATERIALS

725.02 Materials

Materials shall be in accordance with the following:

Admixture	*
Cellular Concrete Grout	ASTM C 796
Cement, Type I or Type III	901.01(b)
Concrete, A	702
Fine Aggregate**	904
Flowable Backfill	213
Foaming Agent	912.05
Profile Wall HDPE Liner Pipe	907.25(b)
Profile Wall PVC Liner Pipe	907.25(c)
Solid Wall HDPE Liner Pipe	907.25(a)
Water	913.01

* An admixture may be used as recommended by and in accordance with the foaming agent manufacturer's specifications.

** The supplier may elect to use gradations in accordance with 904.02(h) or may propose the use of alternate gradations.

The maximum number of joints and corresponding maximum length of each section of liner pipe used in each pipe structure to be lined shall be as shown on the plans. If the Contractor has obtained the necessary right-of-entry from all affected property owners, the Department will consider a written request by the Contractor to use liner pipe sections which exceed the maximum length shown on the plans. A corresponding reduction in the maximum allowable number of joints shall be included with the written proposal. The Contractor shall not install longer sections of liner pipe until written approval has been received from the Engineer. The liner pipe shall be chosen from those shown on the Department's list of approved Thermoplastic Liner Pipe.

The liner pipe must be approved by the Engineer prior to installation.

Proper care shall be taken to ensure that no damage is done to the liner pipe during the unloading process. All liner pipes shall be unloaded with straps and lifting equipment.

Liner pipe joints shall be bell and spigot, screw type, grooved press-on, butt fused, extrusion welded, or other joint as recommended by the liner pipe manufacturer and shall be installed according to the manufacturer's recommended methods.

CONSTRUCTION REQUIREMENTS

Where a deformed HDPE liner pipe is specified, the liner pipe shall be made deformed by using equipment specifically designed to take a circular liner pipe and deform it without causing damage to the liner pipe. The equipment and method used to the liner pipe shall be described in the QCP. Once the liner pipe has been deformed, it shall be structurally reinforced in the horizontal and vertical planes. Structural reinforcement shall be spaced at a maximum distance of 3 ft (0.9 m) on centers. Structural reinforcement shall not be removed until the installation of the liner pipe and cellular concrete grout at that structure has been completed.

725.03 Joining Liner Pipe

Each liner pipe joint shall be welded, fused, or joined according to the manufacturer's recommended methods. Welded liner pipe joints shall be welded with a continuous weld for the circumference of the liner pipe both inside and outside. Welded liner pipe joints shall have weld beads that are smooth and shall not project further than 3/8 in. into the inside of the liner pipe and shall not reduce the hydraulic capacity of the liner pipe. The ends of liner pipe that are to be welded or butt fused shall be at the same temperature ±5º F (±3º C).

A visual inspection will be conducted for acceptance of all liner pipe joined by methods other than by welding or fusing joints. All joints that do not pass visual inspection shall be removed, shall have a new joint fabricated, and will be re-inspected.

All liner pipe joints shall have sufficient mechanical strength to withstand the liner pipe installation and cellular concrete grouting operations.

(a) Welder, Butt Fuser, or Joiner Joint Testing

Welding, butt fusing, or joining shall be performed at all times by an operator trained and certified by either the manufacturer of the liner pipe or the manufacturer of the welding, butt fusing, or joining equipment. A copy of the operator's certification shall be provided to the Engineer prior to the start of work. Prior to fabricating a production joint on a liner pipe, each operator who is performing welding, butt fusing, or joining, shall demonstrate that they can produce a joint that will withstand a destructive test prior to being allowed to join liner pipe. This test shall be repeated as many times as necessary in order to produce a joint that will pass

the destructive test. One passing joint test is required per operator per contract. The method of joint testing shall be in accordance with section (b) or (c) below.

(b) Solid Wall HDPE Liner Pipe

Solid Wall HDPE liner pipe joined using butt fusion shall be in accordance with ASTM F 2620.

Solid wall HDPE liner pipe that is to have extrusion welded joints shall have destructive testing performed on a test section of liner pipe of the same material as the liner pipe being installed. The Contractor shall propose and describe in the QCP a destructive test, such as but not limited to a bend strap test, to demonstrate that an operator can produce an extrusion welded joint that will not fail. Once an extrusion welded joint is produced on a test section that passes the destructive test, each subsequent joint fabricated that same day by that operator will be visually inspected for acceptance. A destructive test in accordance with the approved QCP shall be conducted on the test section at the beginning of each day that solid wall HDPE liner pipe joining is being done.

(c) Profile Wall HDPE Liner Pipe

Profile Wall HDPE liner pipe joined using extrusion welding shall be in accordance with ASTM F 894. The Contractor shall propose and describe in the QCP a destructive test, such as but not limited to a bend strap test, to demonstrate that an operator can produce an extrusion welded joint that will not fail. Destructive testing shall be performed on 2 flat pieces of HDPE sheet stock that has been butt welded together to verify the extrusion gun is working properly and that the operator can produce an extrusion welded joint that will not fail. Once an extrusion welded joint is produced on a test section that passes the destructive test, each subsequent joint fabricated that same day by that operator will be visually inspected for acceptance. A destructive test in accordance with the approved QCP shall be conducted on the test section at the beginning of each day that profile wall HDPE liner pipe joining is being done.

725.04 Cellular Concrete Grout

The cellular concrete grout shall be designed in accordance with ASTM C 796 except as herein modified.

The admixtures, retarders, and plasticizers used in the grout shall be in accordance with the foam concentrate supplier's specifications.

The grout shall be made using the preformed foam process using foam generating equipment calibrated daily by the foam manufacturer to produce a precise and predictable volume of foam. The foam concentrate shall be certified by the manufacturer to have specific liquid/foam expansion ratio at a constant dilution ratio with water.

The specific job mix shall be submitted to the Engineer by either the foam concentrate supplier or the certified or licensed grouting contractor for approval prior to use on the contract. The mix shall have a minimum 28-day compressive strength of 150 psi (1,040 kPa). The mix shall be tested by a laboratory approved by the Department or shall be approved based on prior acceptable performance on Department contracts.

The cellular concrete grout pump gauges shall be calibrated a minimum of once per month in the presence of the Engineer by the method described in the QCP.

Grout mixed off site shall be delivered to the job site in a truck mixer in accordance with 702.09 filled to half its capacity. The foaming agent shall then be added to the cement mix in the truck and mixed to a uniform consistency.

Grout mixed on site shall be batched in a deck mate or similar device. Small batches of approximately 1 cu yd (1 m^3) shall be mixed and pumped in a continuous operation.

For each day worked or for each 100 cu yd (100 m^3) placed, 4 test cylinders measuring 3 in. by 6 in. (75 mm by 150 mm) shall be cast at the point of placement of the grout. Sampling, molding, curing, and compressive strength testing of the cylinders shall be in accordance with ASTM C 495, except as modified herein.

Initial curing shall be at a temperature of 70° ± 10°F (21.1° ± 5.5°C) and shall be from 2 to 5 days. After the initial curing, the test specimens shall be placed in a moist closet or moist room or stored in an enclosed curing tank above the water level. All specimens shall be kept in their molds in the moist storage for the remainder of the curing period. The specimens shall be tested at 28 days. At that time the specimens shall be prepared for testing in accordance with ASTM C 495 except the bearing surface may be ground or cut with a dry saw to meet surface tolerance. The specimens shall not be capped. Specimens shall be tested in compression as rapidly as possible to minimize drying. If more than 1 specimen is removed from the moist storage at the same time, these specimens shall be covered with a damp cloth until time of testing. The Contractor shall provide a Type A certification in accordance with 916 that provides the compressive strength results.

725.05 Right-of-Entry Areas

If the Contractor desires more working room than the right-of-way provides, the Contractor may elect to pursue rights-of-entry from all necessary adjacent property owners in accordance with 107.14. A temporary fence shall be installed as required to prevent encroachment of the public or livestock into the work area. Upon completion of the work, disturbed areas on private property shall be restored in accordance with 107.14.

725.06 Quality Control

A QCP shall be submitted in accordance with ITM 803. No work on the pipe lining operation shall begin until written notice has been received that the QCP has been accepted by the Engineer. Acceptance of the QCP in no way relieves the Contractor of the responsibility for installation procedures and testing requirements.

The QC representative shall be present at the jobsite for the initial testing of the 1st welding or fusing at each liner pipe installation location and for the joining, welding, or fusing of the liner pipe at each location.

725.07 Filling of Cavities Outside the Existing Pipe

All obvious cavities outside the existing pipe shall be filled with non-removable flowable backfill in accordance with 213 prior to the liner pipe installation or with cellular concrete grout placed in conjunction with the grouting operation after the liner pipe is installed.

725.08 Liner Pipe Installation

Prior to commencing the liner pipe installation, all jagged existing pipe edges or other deformities shall be repaired. All debris and foreign material shall be removed from the existing pipe. A visual walk-through inspection shall be performed after all debris and foreign material has been removed from the existing pipe in order to assess the current condition of the pipe. If visual inspection is not possible, a video inspection of the existing pipe shall be performed. A copy of the video inspection shall be provided to the Engineer. If, upon completion of the inspection of the existing pipe, the Contractor believes that they cannot proceed with the work as shown on the plans, the Engineer shall be notified.

The cross-sectional area of the liner pipe shall be as shown on the plans.

Prior to commencing the liner pipe installation operation, steps shall be taken to verify that a liner pipe meeting the required cross-sectional area can be successfully placed inside the existing pipe. If it is discovered prior to installation that a liner pipe with the required opening area cannot fit, the inside and outside diameters of a substitute liner pipe shall be submitted to the Engineer for approval. If this discovery is not made until after the liner pipe installation has begun, the partially installed liner pipe shall be removed. Inside and outside diameters for a substitute liner pipe shall then be submitted to the Engineer for approval.

After the liner pipe installation is complete and the liner pipe has cooled to the temperature of the existing pipe, the liner pipe shall be cut so that each end is 8 in. (200 mm) outside the end of the existing pipe.

The cellular concrete grout within the annular space between the existing pipe and the liner pipe shall be contained by bulkheads. The bulkheads shall be constructed at each end of the structure. Each bulkhead shall be constructed to withstand the pressure of the grouting operation. The bulkhead shall be free from

leaks and the exterior surface shall be given a smooth trowel finish. The bulkhead shall extend from the end of the existing pipe inward a minimum depth of 18 in. (450 mm).

Cellular concrete grout shall be injected into the annular space between the existing pipe and the liner pipe. The injection operation shall provide sufficient cellular concrete grout to fill all voids between the existing pipe and the liner pipe over the entire structure length, but shall also be performed in a manner that does not distort the liner pipe. Injection of the cellular concrete grout in lifts, use of spacers, or other safeguards shall be taken in order to keep the liner pipe in position and prevent the liner pipe from floating. The pressure developed in the annular space between the liner pipe and the existing pipe shall not exceed the liner pipe manufacturer's recommended maximum value.

All existing culverts, storm drains, underdrain pipes, drain tile, or other pipes that are directly connected to the lined structure shall be perpetuated. Cellular concrete grout shall not leak through the liner pipe at these connections.

725.09 Method of Measurement

All thermoplastic liner pipe will be measured by the linear foot (meter), for the shape and cross-sectional area of the liner pipe, complete in place. Perpetuation of existing pipes through the liner pipe will be measured by the number of existing pipes perpetuated.

No measurement will be made of liner pipe joints or the length of joint welding or fusing, or other incidentals necessary to join sections of liner pipe in accordance with the manufacturer's recommendations. The liner pipe or flat sheet stock used for destructive testing will not be measured for payment. No measurement will be made of a liner pipe meeting the required opening area that does not fit.

No measurement will be made for debris removal, filling existing voids, or trimming, cutting, jacking, or other corrective measures performed on jagged edges or other deformities of the existing pipe in order to facilitate installation of the liner pipe. No measurement will be made for visual or video inspection of the existing pipe.

No measurement will be made for the bulkhead.

725.10 Basis of Payment

The accepted quantities of thermoplastic liner pipe will be paid for at the contract unit price per linear foot (meter) for the shape and cross-sectional area of the liner pipe, complete in place. Perpetuation of existing pipes through the liner pipe will be paid for by the number of existing pipes perpetuated.

Payment will be made under:

Pay Item	Pay Unit Symbol
Liner Pipe, Thermoplastic, Circular, _____sq ft (m^2) cross-sectional area	LFT (m)
Liner Pipe, Thermoplastic, Deformed, _____ sq ft (m^2) cross-sectional area	LFT (m)
Perpetuation, Existing Pipe	EACH

The cost of repairing, trimming, or cutting jagged edges or deformities to existing pipe, filling cavities around the existing pipe with cellular concrete grout, acquisition and restoration of right-of-entry areas, erection, maintenance, and removal of temporary fence, removing debris and foreign material from the existing pipe, visual or video inspection of the existing pipe, deforming a circular liner pipe, supplying and constructing the bulkheads, grouting the annular space between the existing pipe and the liner pipe, and other incidentals will not be paid separately, but shall be included in the cost of the pay items in this section.

The cost of liner pipe joints other incidentals necessary to join sections of liner pipe in accordance with the manufacturer's recommendations, and all test sections of liner pipe and test sections of HDPE sheet stock shall be included in the cost of the pay items in this section. All costs associated with having the QC representative on site shall be included in the cost of the pay items in this section.

The cost of training and certifying an operator, destructive and non-destructive testing, liner pipe, and incidentals used in destructive testing, and all costs associated with the development of an acceptable QCP shall be included in the cost of the pay items in this section.

Any joint that does not pass the visual inspection and needs to be re-fused, re-welded, or re-joined shall be done at no additional cost to the Department.

In situations where the condition of the existing pipe requires that a substitute liner pipe be utilized, there will be no reduction in payment for the installation of the substitute liner pipe. There will be no additional payment for the additional cellular concrete grout required to fill the larger void between the existing pipe and the smaller liner pipe.

There will be no payment for the installation or removal of any liner pipe that cannot be successfully installed due to the condition of the existing pipe. There will be no payment for a liner pipe meeting the required cross-sectional area that does not fit.

If the existing pipe or any other object not designated for removal is damaged while performing this work, it shall be considered unauthorized work and repaired or replaced in accordance with 105.11.

SECTION 726 – BEARING ASSEMBLIES

726.01 Description

This work shall consist of furnishing and installing bearing assemblies in accordance with 105.03. Elastomeric bearings shall include plain bearings consisting of elastomer only, and laminated bearings consisting of layers of elastomer restrained at their interfaces by bonded laminates.

MATERIALS

726.02 Materials

The materials shall be in accordance with the following:

Anchor Bolts	910.02(g)
Elastomer	915.04
Grout	707.09
Polytetrafluoroethylene Sliding Surfaces	915.05
Side Retainers	910.02(a)
Shim and Fill Plates	910.02(a)
Threaded Studs and Hex Nuts	910.02(b)

CONSTRUCTION REQUIREMENTS

726.03 Construction Requirements

Elastomeric bearings without external load plates may be placed directly on a concrete or steel surface provided the surface is flat to within a tolerance of 0.005 of the nominal dimension for steel reinforced bearings or 0.01 of the nominal dimension for other types. Bearings shall be installed on surfaces that are horizontal and parallel between the top of the bearing and the underside of the girder.

The elastomer or the bond shall not be subjected to temperatures higher than 390ºF (200ºC).

Masonry plates for polytetrafluoroethylene, PTFE, bearings shall be perfectly level. The tolerance between the top face of the masonry plate and the bottom face of the top plate shall be a maximum of 1/16 in. (1.6 mm), measured at the ends of a diameter of the bottom plate of the bearing assembly. Other dimensional tolerances shall be as shown on the plans or in accordance with 915.04(d).

Immediately prior to setting bearings, the concrete and metal surfaces that are to be in contact shall be cleaned.

726.04 Method of Measurement

Elastomeric bearing pads will not be measured for payment. PTFE bearing devices will be measured by the number of devices placed.

726.05 Basis of Payment

Elastomeric bearing pads will not be paid for separately.

PTFE bearing devices will be paid for at the contract unit price per each device, complete and in place.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Bearing Assembly, PTFE	EACH

The cost of the pads, side retainers, anchor bolts, shim plates, and other incidentals shall be included in the cost of the structural member, or for PTFE bearing assemblies, the cost of the pay item.

SECTION 727 – STRUCTURAL CONCRETE REPAIR BY EPOXY INJECTION

727.01 Description

This work shall consist of structurally rebonding concrete cracks, fractures, or delaminations by means of an epoxy injection system in accordance with 105.03.

727.02 Materials

Materials shall be accordance with the following:

Epoxy Resin Additives 909.12

727.03 Approvals

The epoxy injection system proposed for use shall be subject to approval prior to the start of the repair work. One copy of preparation, mixing, and application instructions shall be furnished. Such instructions shall have been developed especially for use with the proposed epoxy injection system.

727.04 Construction Requirements

The location and extent of cracks to be repaired by epoxy injection will be determined.

The work shall be performed with 2-component automatic metering and mixing equipment.

Concrete surfaces adjacent to the cracks shall be cleaned to the extent necessary to achieve adequate bond of the surface seal material. Entry ports shall be provided along the crack at intervals determined in the field to ensure full depth penetration of the injection resin. Surface seal shall be applied between entry ports, and on both faces of through cracks when possible.

Epoxy injection shall begin at the lower entry port and continue until there is an appearance of epoxy at the adjacent entry port. Injection shall continue until all cracks are filled. If port to port travel is not apparent, the work shall be stopped immediately. The Engineer shall be notified.

Upon completion of the injection, the adhesive shall be permitted to cure for sufficient time to permit removal of surface seal without draining or runback of material from the cracks. Surface seal material and injection adhesive runs or spills shall be removed from concrete surfaces. The face of the crack shall be finished flush to the adjacent concrete. The face of the concrete shall show no indentations or protrusions caused by the placement of entry ports.

727.05 Method of Measurement

Furnishing equipment for epoxy injection will not be measured for payment. Crack preparation for epoxy injection will be measured by the linear foot (meter) of prepared crack. Epoxy material will be measured by the gallon (liter) placed.

727.06 Basis of Payment

This work will be paid for at the contract lump sum price for epoxy injection, furnishing equipment. Crack preparation will be paid for at the contract unit price per linear foot (meter) for epoxy injection, crack preparation. Epoxy resin adhesive will be paid for at the contract unit price per gallon (liter) for epoxy injection, epoxy material.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Epoxy Injection, Crack Preparation	LFT (m)
Epoxy Injection, Epoxy Material	GAL. (L)
Epoxy Injection, Furnishing Equipment	LS

SECTION 728 – BLANK

SECTION 729 – BLANK

SECTION 730 – BLANK

SECTION 731 – MECHANICALLY STABILIZED EARTH RETAINING WALLS

731.01 Description

This work shall consist of the design, furnishing materials, and placement of MSE retaining walls in accordance with 105.03.

731.02 General Design Requirements

An MSE retaining wall shall consist of a non-structural concrete leveling pad, concrete face panels, precast or cast-in-place concrete coping, ground reinforcement elements mechanically connected to each panel, a drainage system if required, and accommodations for appurtenances behind, in front of, under, mounted upon, or passing through the wall. Ground reinforcement shall have sufficient strength, frictional resistance, and quantity as required by design.

The MSE retaining wall system shall be selected from the Department's list of approved retaining wall systems. A retaining wall system manufacturer will be considered for inclusion on the Department's list by following ITM 806, Procedure J. The quantities shown in the Schedule of Pay Items will be the same for each MSE retaining wall system. The MSE retaining wall panels shall be constructed as shown on the panels' working drawings, based on the requirements herein.

If the wall manufacturer needs additional information to complete the design, the Contractor shall be responsible for obtaining such information.

All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other appurtenances shown on the plans, shall be accounted for in the design of the wall.

The wall design shall follow the general dimensions of the wall envelope shown on the plans. The working drawings shall show the location of the concrete leveling pad to be at or below the theoretical leveling pad elevation shown on the plans. The top of each face panel shall be at or above the panel elevation shown on the plans.

Where a coping or barrier is utilized, the wall face panel shall extend up into the coping or barrier a minimum of 2 in. (50 mm). The top of the face panels may be level or sloped to meet the top of the face panel line shown. Cast-in-place concrete will not be an acceptable replacement for panel areas indicated by the wall envelope.

Where walls or wall sections intersect with an included angle of 130° or less, a vertical corner element separate from the standard panel face shall abut and interact with the opposing panels. The corner element shall have ground reinforcement connected specifically to that panel.

Face panels shall be designed to accommodate a differential settlement of 1 linear unit in 100. Face panels of an area greater than 32 sq ft (3 m^2) through 64 sq ft (6 m^2) shall be designed to accommodate differential settlement of 1 linear unit in 200. Where shown on the plans, slip joints to accommodate excessive or differential settlement shall be included.

Only 1 typical face panel shape and architectural finish shall be used per contract.

731.03 Design Criteria

The internal stability shall be the responsibility of the Contractor. The design by the Engineer will consider the external stability of the wall mass including the applied bearing pressure, overturning, sliding, and stability of temporary construction slopes. The design for internal stability shall be in accordance with the AASHTO LRFD Bridge Design Specifications.

(a) Geotechnical Considerations

The theoretical failure plane within the soil mass shall be analyzed so that the soil-stabilizing component extends sufficiently beyond the failure plane to stabilize the material. External loads which affect the internal stability such as those applied through piling, bridge footings, traffic, crashwall, or slope surcharge, shall be accounted for in the design. The sizes of all structural elements shall be determined such that the design load stresses do not exceed the factored stresses shown in the AASHTO LRFD Bridge Design Specifications.

The φ, angle for the internal design of the reinforced backfill shall be assumed 34°. The φ angle of the backfill behind the reinforced portion of the MSE volume shall be assumed 30°. The φ angle for the internal design of the foundation soils shall be assumed 30°. For the external design parameters, such as but not limited to, bearing capacity, sliding, overturning, eccentricity, and global stability, the actual soil strength parameters used shall be obtained from the geotechnical report.

(b) Height of Wall

The wall limits shall be defined by the wall envelope shown on the plans. For design purposes, the height of wall, H, shall be measured from the theoretical top of the leveling pad to the top of the wall. For a wall with a level surcharge, the top of the wall shall be measured to the top of the coping or to the gutter line of the traffic barrier. The top of the wall shall be the theoretical top of the face panels only where a coping or barrier is not used. For a wall with a sloping surcharge, the top of the wall shall be measured at a point that is 0.3H back from the face where the design height is H and the actual wall height is H. For an abutment face, H shall be defined as the height measured from the top of the leveling pad to the top of the roadway surface.

(c) Ground Reinforcement

The ground reinforcement length shall be the controlling length resulting from the internal or external design.

The ground reinforcement shall be the same length from the bottom to the top of each wall section regardless of the type of ground reinforcement used. Differing ground reinforcement elements shall be marked for ease of construction. This element may be used individually or in a prefabricated grouping.

The ground reinforcement for the MSE volume shall be sized using the lesser of the factored loads for each specific connection and each specific reinforcing element.

The connection's applied factored load and effective pullout length shall be determined in accordance with the AASHTO LRFD Bridge Design Specifications.

For mats, grids, or strip steel, the minimum zinc coating thickness shall be 2 oz/sq ft (610 g/m^2). Such thickness shall be assumed to be 4 mils (90 µm) for purpose of calculation of reduced structural section.

The factored applied bearing pressures under the stabilized mass for each reinforcement unit's length shall be shown on the working drawings. It shall not exceed the maximum factored soil bearing resistance shown on the plans. Passive pressure in front of the wall mass shall be assumed to be zero for design purposes.

731.04 Submittals

The Contractor shall submit working drawings and design calculations in accordance with 105.02. Wall construction operations shall not begin until the Contractor receives written notice that the working drawings are approved.

(a) The working drawings shall include all details, dimensions, quantities and cross-sections necessary to construct the wall. They shall include, but shall not be limited to, the following:

1. Plan and elevation sheets.

2. A plan view of the wall that indicates the offsets from the construction centerline to the face of the wall at all changes in horizontal alignment. A plan view and elevation view which detail the placing position and connection of all ground reinforcement units in areas where piling, utility, or other structures are near the wall.

3. An elevation view of the wall which shall include the following:

   a. The elevation at the top of the wall at all horizontal and vertical break points at least every 50 ft (15 m) along the face of the wall.

   b. All steps in the leveling pad.

   c. The designation as to the type of wall unit.

   d. The length of ground reinforcement units.

4. All general notes required for constructing the wall.

(b) Panel details shall show all dimensions necessary to construct the element, all reinforcement in the element, and the location of ground reinforcement connection devices embedded in the panels.

(c) Details for construction of the wall around drainage facilities and the outletting of internal drainage from the MSE volume.

(d) Details of the architectural treatment.

(e) Details for diverting ground reinforcement around obstructions such as piles, catch basins, or utilities.

(f) Details for the connections between the concrete panel and the ground reinforcement.

(g) Determination of φ angle for reinforced materials and retained materials.

MATERIALS

731.05 Materials

Materials shall be in accordance with the following:

Admixtures for Concrete	912.03
Air Cooled Blast Furnace Slag	901.09
Alignment Pins	910.07(d)
B Borrow	211.02
Coarse Aggregate, Class A or Higher, Size No. 8 or 91	904
Components of MSE Retaining Walls	901.10
Concrete, Class A or Class C	702
Fine Aggregate, Size No. 23	904
Fly Ash	901.02
Joint Spacers and Joint Covering	901.10(b)
Portland Cement	901.01(b)
Rapid Setting Patch Materials	901.07
Reinforcing Bars	910.01
Steel Components	910.07
Steel Welded Wire Reinforcement, Smooth and Deformed	910.01(b)
Structure Backfill	211.03.1, 904.05
Underdrains for MSE Walls	718.03
Water	913.01

In the reinforced area of the MSE volume, backfill material shall be structure backfill, type 3, in accordance with 211 except that nominal size aggregate No. 30

shall not be used. The size of structure backfill selected for use in the reinforced area of the MSE volume shall remain the same for that wall volume.

Concrete for the leveling pad and coping shall be class A. Concrete used in openings to accommodate appurtenances behind, in front of, under, mounted upon, or passing through the wall shall be class C.

The Contractor shall supply the MSE retaining wall components listed above, including tie strips, fasteners, bearing pads, and all necessary incidentals, through a manufacturer listed on the Department's list of approved retaining wall systems.

CONSTRUCTION REQUIREMENTS

731.06 General Requirements

The wall manufacturer's representative shall provide technical instruction, guidance in preconstruction activities including the preconstruction conference, and on-site technical assistance to the Contractor during construction.

731.07 Foundation Preparation

The foundation for the structure shall be graded level for a width equal to or exceeding the length of the ground reinforcement or as shown on the plans. Prior to wall construction, the foundation, if not in rock, shall be compacted in accordance with 203. The base of the wall excavation shall be proofrolled with approved compacting equipment. If unsuitable foundation material is encountered, it shall be removed and replaced with B borrow in accordance with 211.02 and compacted in accordance with 211.04.

An unreinforced concrete leveling pad shall be provided at each foundation level as shown on the plans. The leveling pad shall be cured in accordance with 702.22 for a minimum of 12 h before placement of concrete face panels.

731.08 Retaining Wall Excavation

The Contractor shall notify the Engineer a minimum of 7 calendar days or other time as mutually agreed upon before beginning the excavation so that measurements can be taken of the undisturbed ground.

Prior to starting excavation operations at the wall site, clearing and grubbing shall be in accordance with 201.03. The area shall be cleared and grubbed to the excavation in accordance with the limits shown on the plans. All timber, stumps, or debris shall be disposed of in accordance with 201.03. Excavation shall include the construction and subsequent removal of all necessary bracing, shoring, sheeting, and cribbing. Excavation shall also include all pumping, bailing, and draining.

The excavation shall be shored or braced in accordance with State and local safety requirements. Excavation and related work shall be performed such that no portion of the wall is endangered by subsequent operations.

Where excavation for the wall requires shoring, sheeting, or bracing, the method shall be shown on the working drawings. Excavation operations shall not begin until the Contractor receives notice that the working drawings are approved

After the excavation for the wall has been performed, the Contractor shall notify the Engineer. The material beneath the leveling pad shall be compacted in accordance with 203. Concrete for the leveling pad shall not be placed until the Engineer has approved the depth of the excavation and the foundation material. The leveling pad shall be in accordance with 731.07.

731.09 Wall Erection

Concrete face panels shall be handled by means of a lifting device set into the upper edge of each panel. Panels shall be placed in successive horizontal lifts in the sequence shown on the plans as backfill placement proceeds. As backfill material is placed behind the panels, the panels shall be maintained in vertical position by means of temporary wooden wedges placed in the joint at the junction of the 2 adjacent panels on the external side of the wall. External bracing will be required for the initial lift.

Panels shall be stored on blocking to minimize contact with the ground or being covered by standing water. Panels placed in contact with the ground or covered by standing water shall have face discoloration removed by means of a chemical wash.

Plumb, vertical tolerances, and horizontal alignment tolerances shall not exceed 3/4 in. (19 mm) as measured with a 10 ft (3 m) straightedge. The maximum allowable offset in panel joints shall be 3/4 in. (19 mm). For a wall of over 10 ft (3 m) height, the overall plumb from top to bottom of the wall shall not exceed 0.05 in./ft (1.3 mm/m) of wall height.

For aesthetic considerations and to make differential settlement unnoticeable, the panels shall be erected such that the horizontal site line is discontinuous at every other panel. This shall be accomplished by starting erection with the lower panel level of each wall by alternating full-height and half-height panels. Panels above the lowest level shall be of a uniform size, except as required to top out the wall, to be in accordance with the plan elevations.

The Contractor shall perform the necessary work to verify that the foundation is at the correct elevation, that the wall is constructed to the correct alignment, and that the work is in accordance with the specified tolerances. The checking of alignments and tolerances shall include verifying that the plumb of the face panels is in accordance with 731.10 over the entire height of the wall. Alignment shall be checked at each layer of panels after the backfill behind the panels has been compacted, and the results shall be recorded.

The connections of the ground reinforcement to the panels shall be in 2 elevations for full height panels. The connections shall not be more than 30 in. (760 mm) vertically apart. To prevent out-of-plane rotation, full height face panels shall be connected to the ground reinforcement on at least 3 different points in 2 different planes. However, a preapproved system utilizing a horizontal stabilizing leg to prevent rotation shall require only ground reinforcement attachments in 1 plane. Partial size panels shall have 3 different connection points, but only 1 plane shall be attached to the ground reinforcement. Panels located at the top of the wall shall not be attached to the coping or traffic barrier.

Ground reinforcement shall be placed normal to the face of the wall, unless otherwise shown on the plans or as directed. Prior to placement of the ground reinforcement, backfill shall be compacted in accordance with 731.11.

731.10 Joint Spacers and Joint Covering for Wall Panels

Horizontal and vertical joint spacers shall be provided between adjacent face panels to prevent concrete-to-concrete contact and chipping if differential settlement occurs. Panels without an uninterrupted vertical joint shall have a minimum joint thickness of 3/4 in. (19 mm). Joint covering shall be provided and attached to the rear face of the panels.

731.11 Backfill Placement

Backfill placement shall follow erection of each course of panels and ground reinforcement. All sheeting and bracing shall be removed as the backfilling progresses. Backfill shall be placed so as to avoid damage or disturbance to the wall materials or misalignment of the concrete face panels. All material for backfill shall be subject to approval and shall be free from lumps, wood, or other undesirable material. Wall materials that become damaged or disturbed during backfill placement shall be removed and replaced or corrected as directed. All misalignment or distortion of the concrete face panels due to placement of backfill outside the limits described herein shall be corrected as directed.

The work shall also include B borrow backfilling above a theoretical 1:1 slope behind the ground reinforcement as shown on the plans.

B borrow and No. 4 size structure backfill shall be compacted to 95% of the maximum dry density in accordance with AASHTO T 99. Density of the B borrow and No. 4 size structure backfill will be determined in accordance with 203.24(b). Compaction equipment shall be in accordance with 409.03(d). For all other structure backfill material used, compaction shall consist of 4 passes with a vibratory roller and 1 pass with the same roller in static mode. The vibratory roller shall be equipped with a variable amplitude system and a speed control device. It shall have a minimum vibration frequency of 1,000 vibrations per min. A roller in accordance with 409.03(d)4 may be used. All displacement or rutting of the aggregate shall be repaired prior to placing subsequent material.

The maximum loose lift thickness shall not exceed 8 in. (200 mm). However, lifts within 3 ft (0.9 m) of the wall shall not exceed 5 in. (125 mm) in loose thickness. This lift thickness shall be decreased if necessary, to obtain the specified density.

Compaction within 3 ft (0.9 m) of the back face of the concrete face panels shall be achieved by means of a minimum of 5 passes with a lightweight mechanical tamper, roller, or an alternative vibratory system.

At the end of each day's operation, the last level of backfill shall be sloped away from the wall units. Surface runoff from adjacent areas shall not be permitted to enter the wall construction site.

Subsurface drainage for the pavement section shall be underdrains for MSE walls and shall be as shown on the plans.

Cutting or altering of the basic structural section of ground reinforcement at the site will be prohibited, unless the cutting is preplanned and detailed on the approved working drawings. Cutting shall be considered only if adequate additional ground reinforcement is provided to produce the required strength shown in the approved calculations. If the ground reinforcement is shortened in the field, the cut ends shall be covered with a galvanized paint or coal tar to prevent corrosion of the metal.

731.12 Method of Measurement

The measurement of concrete face panels and wall erection will be based on the square foot (square meter) of area contained within the neat line limits of the wall envelope shown on the plans and not that of the wall system supplier.

Concrete leveling pad will be measured by the linear foot (meter). Common excavation will be measured in accordance with 203.27. Structure backfill and B borrow will be measured in accordance with 211.09. Underdrains for MSE walls will be measured in accordance with 718.09. Unsuitable foundation materials, if found, will be measured in accordance with 211.09. Geotextile materials will not be measured.

Precast or cast-in-place concrete coping will not be measured. Drainage of the backfill including piping, aggregates, or geotextile materials will not be measured.

731.13 Basis of Payment

The accepted quantities of concrete face panels will be paid for at the contract unit price per square foot (square meter). Wall erection will be paid for at the contract unit price per square foot (square meter). Concrete leveling pad, complete and in place, will be paid for at the contract unit price per linear foot (meter) for leveling pad. Common excavation will be paid for in accordance with 203.28. Structure backfill and B borrow will be paid for in accordance with 211.10.

Underdrains for MSE walls will be paid for in accordance with 718.10. Unsuitable foundation materials will be paid for in accordance with 211.10.

Payment will be made under:

Pay Item	Pay Unit Symbol
Face Panels, Concrete	SFT (m2)
Leveling Pad, Concrete	LFT (m)
Wall Erection	SFT (m2)

The cost of designing the wall system, services including the testing laboratory, certified testing personnel, and the testing and inspection of the concrete panels shall be included in the cost of face panels, concrete.

The cost of all wall materials including concrete face panels, ground reinforcement, tie strips, fasteners, joint materials, precast or cast-in-place concrete coping, repair or replacement of face panels damaged or removed due to backfill placement, and incidentals shall be included in the cost of face panels, concrete.

The cost of all labor and materials required to prepare the wall foundation, place the ground reinforcement, and erect the concrete face panels shall be included in the cost of wall erection.

The cost of labor and materials required to provide for the drainage of the backfill including piping, aggregates, or geotextile materials shall be included in the cost of face panels, concrete.

The cost of refilling and refinishing of the core holes from verification coring shall be included in the cost of face panels, concrete.

The cost of performing the laboratory tests by an approved geotechnical laboratory for structure backfill or ACBF slag shall be included in the cost of the pay items in this section.

The cost of all labor and materials for required geotextile materials shall be included in the cost of the pay items in this section.

The cost of cutting, altering, or recoating the ground reinforcement at the site shall be included in the cost of wall erection.

SECTION 732 – BLANK

SECTION 733 – STEEL BIN-TYPE RETAINING WALL

733.01 Description

This work shall consist of furnishing materials and placement of steel bin-type retaining walls in accordance with 105.03.

MATERIALS

733.02 Materials

Materials shall be in accordance with the following:

Fasteners ..... 910.02(g)1
Steel Bin-Type Retaining Wall Units 910.08
Structure Backfill 211.03.1, 904.05

Backfill material used in the bin-wall sections shall be structure backfill, type 3, in accordance with 211.

CONSTRUCTION REQUIREMENTS

733.03 General

All units shall be fabricated such that units of the same nominal size shall be fully interchangeable. Drilling, punching, or drifting to correct defects in manufacture will not be permitted. Each unit with unauthorized holes shall be replaced. The ends of all stringers and spacers shall be bolted to corner columns by means of connecting channels.

The proper curvature for the face of a wall constructed on a curve shall be obtained through the use of shorter stringers in the front or rear panels of retaining walls as shown on the plans or as otherwise directed.

The wall height and depth may be varied. Two or more retaining wall designs may be incorporated in the same wall by the use of standard split columns to make the connection on the step back.

733.04 Foundation Preparation

The foundation for the structure shall be graded level or as shown on the plans. Prior to wall construction, the foundation, if not in rock, shall be compacted in accordance with 203. The base of the wall excavation shall be proofrolled with a vibratory roller weighing not less than 10 t (9 Mg), or with other approved compacting equipment. If unsuitable foundation material is encountered, it shall be removed and replaced with B borrow in accordance with 211.02 and compacted in accordance with 211.04.

733.05 Retaining Wall Excavation

Retaining wall excavation shall be in accordance with 731.08.

733.06 Backfill Placement

The fill material for the interior of the bin and behind the wall shall be structure backfill placed in layers not to exceed 6 in. (150 mm) in thickness. Backfilling behind the wall shall progress with the filling of the bins and shall not be carried ahead of the interior bins. Existing slopes, which are shaped so as to cause a wedge action in the backfill, shall be benched before backfilling.

The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer. Backfill material shall have placement moisture content between optimum and -3 percentage points of the optimum moisture content. Backfill material with placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniformly acceptable through the entire lift.

Compaction within 3 ft (0.9 m) of the back face of the bins shall be achieved by means of a minimum of 3 passes with a lightweight mechanical tamper, roller, or an alternative vibratory system.

Backfill placement shall otherwise be in accordance with 731.11.

733.07 Method of Measurement

The measurement of steel bin walls will be based on the square foot (square meter) of area contained within the neat line limits of the wall envelope shown on the plans and not that of the wall system supplier. Common excavation will be measured in accordance with 203.27. Structure backfill will be measured in accordance with 211.09. Unsuitable foundation materials, if found, will be measured in accordance with 211.09.

733.08 Basis of Payment

This work will be paid for at the contract unit price per square foot (square meter) for binwall, steel. Common excavation will be paid for in accordance with 203.28. Structure backfill will be paid for in accordance with 211.10. Unsuitable foundation materials will be paid for in accordance with 211.10.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Binwall, Steel	SFT (m2)

The cost of furnishing, handling, and installing the steel units, including all materials, bolts, and appurtenances; necessary excavation and structure backfill testing; and all labor, equipment, all necessary incidentals, or replacement of steel units with unauthorized holes, or those damaged and replaced during construction shall be included in the cost of the pay item.

SECTION 734 – PERMANENT EARTH RETENTION SYSTEM FOR CUT-WALL APPLICATION

734.01 Description

This work shall consist of designing and constructing a permanent earth retention system utilizing a cut-wall application in accordance with 105.03. Cut-wall applications refer to a class of earth retention systems in which construction of the system is performed from the top of the wall to the base utilizing either externally or internally stabilized elements or a combination of both. Geotechnical Engineering Circular No. 2 – Earth Retaining Systems, Report No. FHWA-SA-96-038 provides further discussion of cut-wall applications.

734.02 Contractor Design Requirements

The permanent earth retention system utilizing a cut-wall application shall be designed by a professional engineer having experience in the design of at least 3 completed permanent earth retention systems involving cut-wall applications. The permanent earth retention system shall be designed using the procedure described in the AASHTO LRFD Bridge Design Specifications, or in the FHWA report 0-IF-03-017, Soil Nail Walls. The required partial safety factors or allowable strength factors for Service Load Design, SLD, and load and resistance factors for LRFD, shall be in accordance with the above-referenced publications. The minimum factor of safety for SLD global stability or minimum required LRFD global stability shall be in accordance with the above-referenced publications, unless specified otherwise. Structural design of an individual wall element not addressed in the FHWA report shall be designed in accordance with the AASHTO specifications. Geometric data and design criteria including shear strength parameters and unit weights for soil and rock, corrosion protection, internal and external drainage requirements, horizontal and vertical alignment of the wall, and all known site and construction constraints, wall facing, and facing architectural requirements shall be as shown on the plans.

(a) Design Calculations

Design calculations shall include, but not be limited to, the following:

1. A written summary report which describes the overall design.

2. Applicable code requirements and design references.

3. Design cross-section geometry including soil and rock strata and location, magnitude and direction of design slope, external surcharge loads, and piezometric levels with the most critical slip surface shown along with the minimum calculated SLD factor of safety for global stability or minimum required LRFD global stability soil resistance to load ratio.

4. Design criteria including the undrained and drained shear strength parameters and unit weights for soil and rock.

5. Unit bond resistances for externally and internally stabilized elements.

6. Partial safety factors and strength factors for SLD or load and resistance factors for LRFD used in the design on the pullout resistance, surcharges, unit weights of soil and rock, and all materials proposed for the system including, but not limited to shotcrete, steel and concrete.

7. Seismic design acceleration coefficient.

8. Design calculation sheets with the contract number, designation number, wall location and designation, date of preparation, initials of designer and checker, page number shown on each page, and an index page.

9. Design notes including an explanation of all symbols and computer programs used in the design.

10. Structural design calculations for all temporary and permanent facing and facing connections, including consideration of flexural and shear strength of the facing and all externally stabilized elements, tensile strength of all headed studs, upper cantilever, minimum reinforcement ratio, mechanical splices, welds, built-up sections, and cover and splice requirements.

(b) Working Drawings

The limits of the wall and ground survey data shall be verified before preparing the drawings. Working drawings shall include all details, dimensions, quantities, ground profiles, cross sections necessary to construct the wall, and the following:

1. A plan view of the wall identifying the following:

   a. A reference centerline and elevation datum.

   b. The offset from the construction centerline to the finished face of the wall at its base and at all changes in horizontal alignment.

   c. Beginning and ending stations of the wall.

   d. Right-of-way and permanent or temporary construction easement limits, location of all known active and abandoned existing utilities, adjacent structures, or other potential interferences.

e. The centerline of each drainage structure or drainage pipe behind, passing through, or passing under the wall.

f. Limit of externally and internally stabilized elements.

g. Subsurface exploratory locations with appropriate reference base lines to fix the locations of the explorations relative to the wall.

2. An elevation view of the wall identifying the following:

a. The elevations at the top of the wall, at all horizontal and vertical break points, and at least every 30 ft (9 m) along the wall.

b. Elevations at the base and top of the wall for casting the facing.

c. Beginning and ending stations of the wall.

d. The distance along the face of the wall to all steps in the base of the wall.

e. All externally and internally stabilized elements as well as vertical and horizontal spacing.

f. The location of drainage elements and permanent facing expansion and contraction joints along the wall length.

g. Existing and finished grade profiles, both behind and in front of the wall.

3. Design parameters and applicable codes.

4. General notes for constructing the wall including sequencing and all special construction requirements, such as dewatering, if required.

5. Horizontal and vertical curve data affecting the wall and control points.

6. Match lines or other details to relate the wall stationing to centerline stationing.

7. A listing of the summary of quantities on the elevation drawing of each wall showing estimated square feet (square meters) of exposed wall face areas and other pay items.

8. Typical sections including staged excavation elevations, wall elements, and corrosion protection details.

9. Typical details of production and test anchors or nails defining the orientation and dimensional relationships of the unbonded and bonded lengths.

10. Details, dimensions, and schedules for all externally and internally stabilized elements, reinforcing bars, steel welded wire reinforcement, bearing plates, headed studs, and attachment devices for pneumatically placed mortar, cast-in-place, or prefabricated facings.

11. Details and dimensions for appurtenances such as barriers, coping, drainage gutters, and fences.

12. Details for constructing the wall around drainage facilities.

13. Details for terminating the wall and adjacent slope construction.

14. Facing finishes, color and architectural treatment requirements for permanent facing elements.

(c) Submittals

The Contractor shall submit working drawings and design calculations in accordance with 105.02.

At least 30 calendar days before the start of the wall construction, the Contractor shall submit a quality control plan, QCP, for approval. The QCP shall include, but not be limited to, personnel qualifications, wall construction procedures and sequencing, a verification testing program, and a performance monitoring program. Work shall not begin until written notice has been received from the Engineer that the QCP has been accepted.

1. Personnel Qualifications

The field superintendent or field foreman shall have supervised the construction of a minimum of 3 completed walls of the same type as that submitted by the Contractor.

2. Verification Testing Program

The program shall include a verification testing program of all production and test anchors and nails. The program shall identify the test locations, the type of test,

i.e., proof, performance, or pullout, testing procedures, acceptance criteria, and load and measuring devices to be used.

MATERIALS

734.03 Materials

Materials shall be in accordance with the following:

Geotextile Under Riprap	918.02
Pneumatically Placed Mortar	708
Reinforcing Bars	703
Steel H Piles	915.02
Steel Pipe Piles	915.01
Steel Sheet Piling	910.21
Steel Welded Wire Reinforcement, Smooth and Deformed	910.01
Structural Concrete	702
Structural Steel	910.02
Structure Backfill	904.05
Uncoated 7 Wire Strand	910.01(b)7

Drainage pipe shall be underdrain pipe in accordance with 715.02(d).

CONSTRUCTION REQUIREMENTS

734.04 General Requirements

Excavation and embankment shall be in accordance with 203.

Welding shall be in accordance with 711.32.

734.05 Performance Monitoring During Construction

The program shall identify points of monitoring interest, in accordance with Geotechnical Engineering Circular No. 2 – Earth Retaining Systems, Report No. FHWA-SA-96-038, and the frequency of monitoring during and following construction of the wall. The program shall also include a baseline survey for points of monitoring interest.

The Contractor shall notify the Engineer if indications of ground movement in the vicinity of the wall, increased size of old cracks, or separation of joints in structures, foundations, streets, or paved or unpaved surfaces are observed. The Contractor shall monitor the performance of the wall and movements of buildings, roads, or other facilities within a distance of 3 times the excavation depth for the wall. If the Engineer determines that the movements exceed those anticipated for construction, the Contractor shall take corrective actions necessary to arrest the movement, or make repairs.

Within 30 days after completion of the work, as-built drawings shall be submitted to the Engineer. Revised design calculations signed by the professional engineer shall be provided for all design changes made during the construction of the permanent earth retention system.

734.06 Performance Monitoring After Construction

Performance monitoring by the Contractor shall be done during construction and for a period of 1 year from the date the Contractor has been relieved of further maintenance, as set out in the final acceptance letter from the Department. The Contractor shall post a warranty bond for the performance monitoring that occurs after the Contractor has been relieved of further maintenance. The Contractor shall make evaluations of the test and monitoring data and performance of the wall at the frequency defined in the approved performance monitoring program. The Contractor, if necessary during the monitoring period or as directed, shall correct deficiencies in the capacities of individual elements or take other corrective measures which may be required to prevent damage or excessive movement of the wall and adjacent facilities. The Contractor shall submit all test and monitoring data to the Engineer on a weekly basis or as otherwise directed.

734.07 Method of Measurement

Cut wall will be measured by the square foot (square meter) of exposed face area of wall above finished grade as shown on the plans.

734.08 Basis of Payment

The accepted quantities of cut wall will be paid for at the contract unit price per square foot (square meter) for cut wall.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Cut-Wall, No. ____	SFT (m2)

The costs of all professional services, labor, excavation, structure backfill, equipment, materials, tests, QCP, and incidentals necessary to design, construct, and monitor the wall including all drainage required by the wall design and all temporary construction facing or permanent facing, if applicable, and correction required by the wall design of deficiencies which may be required to prevent damage or excessive movement of the wall shall be included in the cost of this work. No additional payment will be made for the costs of providing and taking corrective actions.

SECTION 735 – TEMPORARY WIRE-FACED MECHANICALLY STABILIZED EARTH RETAINING WALLS

735.01 Description

This work shall consist of the design, furnishing materials, and placement of temporary wire-faced mechanically stabilized earth retaining walls in accordance with 105.03.

735.02 General Design Requirements

A temporary wire-faced MSE wall shall consist of wire-facing elements, ground reinforcement elements mechanically connected to the wire-facing elements, and a drainage system if required. Concrete face panels will be required for the lower course of the wall if shown on the plans. Ground reinforcement shall have sufficient strength, frictional resistance, and quantity as required by the design.

A temporary wire-faced MSE wall shall be constructed in accordance with the approved plans and panels working drawings based on the requirements herein. The recommendations of the wall system supplier shall meet or exceed the minimum performance requirements included herein.

If appurtenances interfere with connecting ground reinforcement to face panels, back up panels shall be provided.

The top of the wire-facing elements shall be at or above the top of the wall envelope shown on the plans.

The maximum dimensions for wire-face panels shall be limited to 2 ft (0.6 m) vertical and 8 ft (2.5 m) horizontal.

735.03 Design Criteria

The design life of the wall shall be 36 months. The minimum allowable yield stress for reinforcement shall be 65 ksi (450 MPa). The maximum allowable stress in the reduced section after sacrificial steel has been removed at the end of the design life shall be 0.55Fy for WWR. The maximum allowable stress may be increased to 0.77Fy if the design life does not exceed 36 months. The reduced section of ground reinforcement shall be limited to the allowable stress shown above at the end of the 36-month design life.

The connections of the ground-reinforcing steel to the wire-facing shall not be more than 24 in. (600 mm) apart vertically.

The design shall otherwise be in accordance with 731.02 and 731.03.

735.04 Submittals

The Contractor shall submit working drawings and design calculations in accordance with 105.02. Wall construction operations shall not begin until the Contractor receives written notice that the working drawings are approved.

(a) The working drawings shall include all details, dimensions, quantities and cross sections necessary to construct the wall. They shall include, but shall not be limited to, that listed in 731.04(a) and (b).

(b) Wire-facing details shall show all dimensions necessary to construct the element, all wire in the element, and the location of ground-reinforcing-system devices attached to the wire-facing.

MATERIALS

735.05 Materials

Materials shall be in accordance with the following:

Admixtures for Use in Concrete	912.03
Air-Cooled Blast-Furnace Slag	901.09
Alignment Pins	910.07(d)
B Borrow	211.02
Coarse Aggregate, Class A or Higher, Size No. 8 or 91	904
Components of MSE Retaining Walls	901.10
Concrete, Class A	702
Fine Aggregate, Size No. 23	904
Fly Ash	901.02
Geotextile for Underdrains	918.03
Joint Spacers and Joint Covering	901.10(b)
PCC Components	901.10
Portland Cement	901.01(b)
Rapid Setting Patch Materials	901.07
Reinforcing Bars	910.01
Steel Components	910.07
Steel Welded Wire Reinforcement, Smooth	910.01(b)5
Water	913.01

Backfill material used in the temporary wire-faced MSE wall volume shall be structure backfill, type 3 in accordance with 211 with the exception that nominal size aggregate No. 30 shall not be used.

All retention fabric or filter cloth shall be geotextile for use with underdrains.

The Contractor shall supply the MSE retaining wall components described above, including wire-facing, concrete face panels, retaining strips or mesh, tie strips, fasteners, earth-retention materials, drainage system components, and all

necessary incidentals, through a manufacturer shown on the Department's list of approved retaining wall systems.

CONSTRUCTION REQUIREMENTS

735.06 General Requirements

Foundation preparation shall be in accordance with 731.07. Retaining-wall excavation shall be in accordance with 731.08.

735.07 Wall Erection

The wall system components shall be constructed in accordance with the wall system supplier's recommendations and construction manual.

The Contractor shall perform the necessary work to verify that the foundation is at the correct elevation, that the wall is constructed to the correct alignment, and that the work is in accordance with the specified tolerances.

Ground reinforcement shall be placed normal to the face of the wall, unless otherwise shown on the plans or as directed. Prior to placement of the ground reinforcement, backfill shall be placed and compacted in accordance with 731.11.

Where shown on the plans, backing mats shall be placed behind the wire-facing.

Where shown on the plans, galvanized screens with openings not exceeding 1/2 in. (13 mm) shall be placed behind the wire-facing to retain the earth.

735.08 Method of Measurement

The measurement of temporary wire-facing and temporary wall erection will be based on the square foot (square meter) of area contained within the neat line limits of the wall envelope shown on the plans and not that of the wall system supplier.

Common excavation will be measured in accordance with 203.27. Structure backfill and B borrow will be measured in accordance with 211.09. Unsuitable foundation materials, if found, will be measured in accordance with 211.09. Geotextile materials will not be measured.

Drainage of the backfill including piping, aggregates, and incidentals will not be measured.

735.09 Basis of Payment

The accepted quantities of temporary wire-facing and temporary wall erection will be paid for at the contract unit price per square foot (square meter). Common excavation will be paid for in accordance with 203.28. Structure backfill and B borrow will be paid for in accordance with 211.10. Unsuitable foundation materials will be paid for in accordance with 211.10.

Payment will be made under:

Pay Item	Pay Unit Symbol
Temporary Wire-Facing	SFT (m2)
Temporary Wall Erection	SFT (m2)

The cost of all MSE retaining wall components including wire-facing elements, concrete face panels, ground reinforcing, tie strips, fasteners, soil retention materials, repair or replacement of wire-facing elements damaged or removed due to backfill placement, and incidentals shall be included in the cost of temporary wire-facing.

The cost of all labor and materials required to prepare the wall foundation, to place the ground reinforcement, and to erect the concrete face panels shall be included in the cost of temporary wall erection.

The cost of labor and materials required to provide for the drainage of the backfill including piping, aggregates, or geotextile materials shall be included in the cost of temporary wire-facing.

The cost of performing the laboratory tests by an approved geotechnical laboratory for structure backfill or ACBF slag shall be included in the cost of the pay items in this section.

The cost of all labor and materials for geotextile materials used shall be included in the cost of the pay items in this section.

The cost of cutting, altering, and recoating of the ground reinforcement at the site shall be included in the cost of temporary wall erection.

SECTION 900 – MATERIALS DETAILS

SECTION 901 – PCC MATERIALS

901.01 Hydraulic Cement

(a) General

At the time cement is incorporated into the work, it shall meet the quality requirements of these specifications.

Cement which has been in storage may be tested prior to use, and if tests show that it does not meet the requirements specified, it will be rejected.

A means for storing and protecting the cement against dampness shall be provided. Cement which has become partially set or which contains lumps or caked cement will be rejected. Cement salvaged from discarded or used sacks shall not be used.

Different kinds or brands of cement, or cement of the same brand from different mills, even if tested and approved, shall not be mixed during use unless permitted, and then only as directed. They shall not be used alternately in any 1 pour for any structure, unless otherwise permitted.

(b) Portland Cement

Portland cement shall conform to the requirements of the following cited specifications except as noted.

1. Requirements

Cement	**Specifications**
Air-Entraining Portland Blast-Furnace Slag Cement	AASHTO M 240, Type ISA
Air-Entraining Portland Cement	AASHTO M 85, Type IA or IIIA
Air-Entraining Portland-Pozzolan Cement	AASHTO M 240, Type IP-A
Portland Blast-Furnace Slag Cement	AASHTO M 240, Type IS
Portland Cement	AASHTO M 85, Type I, II, or III
Portland-Pozzolan Cement	AASHTO M 240, Type IP
Slag Modified Portland Cement, Type ISM	AASHTO M 240

The exceptions to AASHTO M 240 are as follows:

a. The amount of pozzolan shall be limited to 20% ± 5% by weight of the portland-pozzolan cement for the types IP and IP-A.

b. The pozzolan in the portland-pozzolan cements, types IP and IP-A, shall be in accordance with ASTM C 618, class C or class F with the loss on ignition of the pozzolan limited to a maximum of 3%.

c. The pozzolan in the portland-pozzolan cements, types IP and IP-A, shall be interground with the portland cement clinker.

2. Acceptance Criteria

Portland cements and blended cements will be accepted based upon the manufacturer's or manufacturer/distributor's documented ability to consistently furnish these materials in accordance with the applicable AASHTO requirements.

a. General Requirements

Cements shall comply with the applicable requirements of 901 and will be accepted by certification from qualified manufacturers or manufacturer/distributor. The manufacturer is defined as the plant producing the cement. A manufacturer or manufacturer/distributor shall become qualified by establishing a history of satisfactory quality control of cement produced as evidenced by results of tests performed by a testing laboratory which is regularly inspected by the Cement and Concrete Reference Laboratory of the National Institute of Standards and Technology. Proof of such inspection shall be furnished upon request. All certifications shall be prepared by the manufacturer or distributor in accordance with the applicable requirements of 916. If a manufacturer or distributor elects to supply portland cement with a higher sulfur trioxide content in accordance with footnote B from Table 1 in AASHTO M 85, it shall supply all of the required supporting data to the Office of Materials Management prior to supplying such cement. A list of Qualified Manufacturers and Manufacturer/Distributors will be maintained by the Department.

The manufacturer or manufacturer/distributor shall conduct sufficient tests to ensure that adequate quality control is maintained and that cement furnished is in accordance with the specification requirements. Documentation pertaining to cement shipped on certification shall be maintained for a period of at least 3 years and shall be provided when requested.

Random samples of cement will be obtained at the concrete plant. If the sample is not in accordance with the specification requirements, an investigation will be conducted. A copy of the findings and conclusions resulting from the investigation will be furnished to the Contractor. Unless the investigation finds the Department is responsible for the failure to comply, the cost of the investigation plus any required corrective action will be assessed to the Contractor.

b. Requirements for Domestic Source Qualification

Cement manufacturers requesting to be qualified to supply cement shall provide the following:

(1) For the initial qualification, the manufacturer shall provide to the Office of Materials Management a QCP in accordance with the applicable requirements of ITM 806. The QCP shall also include the location and type of samples taken, and a monthly summary of mill test data for the previous years production. A current Material Safety Data Sheet shall be submitted as an integral part of the initial qualification package.

(2) To maintain qualification, a monthly average of mill test data shall be submitted to the Office of Materials Management. If a specific type of cement is not manufactured in a given month, the monthly submittal shall state "No type _____ cement was manufactured during the month of _____ 20____".

c. Requirements for Foreign Source Qualification

Foreign cement manufacturers or their domestic distributors requesting to be qualified to supply cement shall provide the following:

(1) For the initial qualifications, the manufacturer and distributor shall provide to the Office of Materials Management a QCP in accordance with the applicable requirements of ITM 806. The QCP shall also include the location and type of samples taken, and a summary of complete test results from the proposed cement source. A current Material Safety Data Sheet shall be submitted as an integral part of the initial qualification package. The QCP must explain the linkage between the cement being furnished and the manufacturer's/distributor's quality control data, relative to ship-loads, barge-loads, railroad car-loads, etc.

(2) Once the initial qualifications have been met, the manufacturer or distributor shall be required to furnish the cement test results for each shipment prior to Department cement usage for the first 5 cement shipments, which are intended for Department use. The test results for all 5 of these cement shipments must fully comply with the required material specifications. If not, this requirement will be continued for subsequent cement shipments until 5 consecutive cement shipment test results fully comply with

the required material specifications, or Department source approval is withdrawn due to the inability to consistently supply satisfactory cement.

(3) To maintain qualification after compliance with the previous requirements, a monthly submission of all cement shipment test results for cement which is intended for Department usage shall be submitted to the Office of Materials Management. If no cement shipments are received during a given month, the monthly submittal shall state "No cement was received during the month of _____, 20____".

d. Certification

Only qualified manufacturers and manufacturer/distributors as identified by the Department's list of Qualified Manufacturers and Manufacturer/Distributors may furnish cement on certification.

A sample certification form addressing all of the required information is included in ITM 804. Alternate procedures and forms will be considered when requested, and will be approved if there is a positive link between the cement furnished and the manufacturer's quality control data.

(c) Masonry Cement

Masonry cement shall be in accordance with ASTM C 91, except the air content test and the water retention test may be waived.

901.02 Fly Ash Used as a Pozzolan

(a) General

Fly ash is the finely divided residue that results from the combustion of ground or powered coal. In general, class F fly ash is produced from burning anthracite or bituminous coal and class C fly ash is produced from burning lignite or subbituminous coal.

Fly ash will be accepted from 1 of the sources on the Department's list of approved Fly Ash and Ground Granulated Blast Furnace Slag Sources. Fly ash from different sources or different types of fly ash shall not be mixed or used alternately in the same construction unless authorized in writing. Fly ash will be subject to random assurance sampling and testing by the Department. Failure of these random samples to meet the specified requirements will be cause for suspension of the fly ash source approval.

(b) Acceptance Criteria

Acceptance is based upon the supplier's documented ability to consistently furnish material in accordance with the specified requirements.

1. Requirements

The fly ash shall be in accordance with AASHTO M 295 for class C or class F, with the following exceptions:

Loss on Ignition (LOI), Maximum %.....3
Autoclave Expansion or Contraction, Maximum %.....0.5
Fineness: Amount retained when wet-sieved on No. 325
(45 µm) sieve, Maximum %.....30

On days when fly ash is being accumulated for use as a pozzolan, the supplier shall obtain a minimum of 1 sample per day and furnish test results for moisture content, loss on ignition, and No. 325 (45 µm) sieve residue for each sample.

For each 2,000 t (1,800 Mg) produced, a complete AASHTO M 295 analysis shall be performed on a sample composited randomly from the daily samples. The method of randomization shall be subject to approval by the Department.

2. Test and Calibration Procedure

The testing procedures followed shall be in accordance with ASTM C 311 or other methods approved in writing by the Department.

The minimum frequency for calibration of test equipment is:

a. The No. 325 (45 µm) sieve shall be calibrated every 100 determinations or every 6 months, whichever comes first.

b. The muffle furnace used for LOI determinations shall have a newly installed thermocouple every 6 months.

c. The analytical balances and scales shall be calibrated each year.

d. The concrete compression machine shall be calibrated annually.

e. The Blaine apparatus shall be calibrated annually.

f. All instrumentation used for rapid chemical analysis shall comply with applicable requirements of ASTM C 114 using NIST Fly Ash reference materials.

3. Documentation

Fly ash suppliers requesting approval shall supply the following:

a. For the initial approval, a current Materials Safety Data Sheet and a summary of results for all specified tests for 6

consecutive months shall be submitted. No test results shall be more than 1 year old at the time of request.

b. To maintain approval, a summary of results for all specified tests shall be submitted monthly. The results of the daily tests shall be available by telephone during normal working hours.

c. The fly ash suppliers shall furnish a QCP in accordance with the applicable requirements of ITM 806. The QCP shall ensure the Department of a continuous supply of fly ash complying with the requirements. This QCP will be reviewed to determine its adequacy.

d. Certification:

(1) For source approval, the supplier shall furnish a certification indicating the class of fly ash, the name, location, and unit of the generating plant. It shall state that all fly ash shipped for use on Department projects will be produced under appropriate quality control and shall be in accordance with the specified requirements. It shall further indicate that the power company will participate in appropriate inspection and assurance testing. A sample certification form is set out in ITM 804.

(2) For certification of test reports, the test results generated in accordance with 901.02(b)1 shall be summarized and submitted monthly. The reports shall state the name and location of the testing facility, and shall be signed by the chemist or technical manager. This certification shall also identify the concrete plants receiving fly ash represented by these results.

901.03 Ground Granulated Blast Furnace Slag Used As a Pozzolan

(a) General

Blast furnace slag shall consist of the non-metallic product, consisting essentially of silicates and aluminosilicates of calcium and other bases, that is developed in a molten condition simultaneously with iron in a blast furnace. A glassy granular material is formed when molten blast furnace slag is rapidly chilled by immersion in water. This material is then ground to cement fineness, producing ground granulated blast furnace slag.

Ground granulated blast furnace slag will be accepted from 1 of the sources on the Department’s list of approved Fly Ash and Ground Granulated Blast Furnace Slag Sources. Ground granulated blast furnace slag from different sources or

different grades of ground granulated blast furnace slag shall not be mixed or used alternately in the same construction unless approved in writing. Ground granulated blast furnace slag will be subject to random assurance sampling and testing by the Department. Failure of these random samples to be in accordance with the specified requirements will be cause for suspension of ground granulated blast furnace slag source approval.

(b) Acceptance Criteria

Ground granulated blast furnace slag will be accepted based on the manufacturer's or manufacturer/distributor's documented ability to consistently furnish these materials in accordance with the applicable ASTM and AASHTO requirements.

1. Requirements

The ground granulated blast furnace slag shall be in accordance with ASTM C 989 for grade 100 or 120.

For each 2,000 t (1,800 Mg) produced, a complete ASTM C 989 analysis shall be performed on a sample composited randomly from the daily samples. The method of randomization shall be subject to approval by the Department.

2. Test and Calibration Procedure

The testing procedures followed shall be in accordance with ASTM C 989 or other methods approved in writing by the Department.

The minimum frequency for calibration of test equipment is:

a. The No. 325 (45 µm) sieve shall be calibrated every 100 determinations or every 6 months, whichever comes first.

b. The analytical balances and scales shall be calibrated each year.

c. The concrete compression machine shall be calibrated annually.

d. The Blaine apparatus shall be calibrated annually.

e. All instrumentation used for rapid chemical analysis shall be in accordance with the applicable requirements of ASTM C 114 using NIST reference materials.

3. Documentation

Ground granulated blast furnace slag suppliers requesting approval shall supply the following:

a. For the initial approval, a current Materials Safety Data Sheet and a summary of results for all specified tests for 6 consecutive months shall be submitted. No test results shall be more than 1 year old at the time of request.

b. To maintain approval, a summary of results for all specified tests shall be submitted monthly. The results of the daily tests shall be available by telephone during normal working hours.

c. The ground granulated blast furnace slag suppliers shall furnish a QCP in accordance with the applicable requirements of ITM 806. The QCP shall ensure the Department of a continuous supply of ground granulated blast furnace slag which is in accordance with the requirements. This QCP will be reviewed to determine its adequacy.

d. Certification:

(1) For source approval, the supplier shall furnish a certification indicating the grade of ground granulated blast furnace slag, the name, location, and type of manufacturing facility. It shall state that the ground granulated blast furnace slag shipped for use on Department projects will be produced under appropriate quality control and shall be in accordance with the specified requirements. A sample certification form addressing all of the required information is included in ITM 804.

(2) For certification of test reports, the test results generated in accordance with 901.03(b) shall be summarized and submitted monthly. The reports shall state the name and location of the testing facility, and shall be signed by the chemist or technical manager. This certification shall also identify the concrete plants receiving ground granulated blast furnace slag represented by these results.

901.04 Silica Fume Used As a Pozzolanic Mineral Admixture

(a) General

Silica fume will be accepted from 1 of the suppliers on the Department's list of approved Pozzolanic Suppliers. Silica fume from more than 1 of these suppliers shall not be mixed or used alternatively in the same construction unless authorized in writing. Silica fume will be subject to random assurance sampling and testing by the Department. Failure of the random samples to meet the specified requirements will be cause for suspension of the silica fume supplier's approval.

(b) Acceptance Criteria

Acceptance of silica fume will be based on the manufacturer's documented ability to consistently furnish material in accordance with the specified requirements.

1. Requirements

The silica fume shall be in accordance with AASHTO M 307 with the following exceptions:

a. Reactivity with cement alkalies shall not be required.

b. The oversize, amount retained on the No 325 (45 µm) sieve, in accordance with ASTM C 1240, shall be conducted.

c. The oversize, amount retained on the No. 325 (45 µm) sieve, shall not be more than 10%.

d. Accelerated pozzolanic activity index, in accordance with ASTM C 1240, shall be conducted in lieu of strength activity index.

e. The accelerated pozzolanic activity index shall be a minimum of 85% at 7 days.

f. The increase of drying shrinkage of mortar bars at 28 days shall be conducted in accordance with ASTM C 1240.

g. The increase of drying shrinkage of mortar bars at 28 days shall be not more than 0.10%.

2. Frequency of Testing

a. The manufacturer shall obtain a minimum of 1 sample for each 400 t (400 Mg) of material produced. Test results for moisture content, and loss on ignition, shall be furnished for each sample.

b. For each 2,000 t (2,000 Mg) produced, a complete AASHTO M 307 analysis shall be performed on a sample composed randomly from daily samples. The method of randomization shall be subject to approval by the Department. The optional chemical requirements identified in AASHTO M 307 shall be reported in addition to the increase of drying shrinkage of mortar bars as well as the standard chemical and physical requirements.

3. Test and Calibration Procedure

The minimum frequencies for calibration of test equipment shall be as follows:

a. The analytical balances and scales shall be calibrated annually.

b. The concrete compression machine shall be calibrated annually.

c. The Blaine apparatus shall be calibrated annually.

d. All instrumentation used for rapid chemical analysis shall be in accordance with AASHTO T 105.

4. Documentation

Silica fume suppliers requesting approval shall supply the following to the Office of Materials Management:

a. For initial approval, a current Material Safety Data Sheet and a summary of results for all specified tests for 6 consecutive months shall be submitted. No test results shall be more than 1 year old at the time of the request.

b. To maintain approval, a summary of results for all specified tests shall be submitted monthly.

c. A QCP in accordance with the applicable requirements of ITM 806 shall be submitted. The QCP shall ensure the Department a continuous supply of silica fume complying with the material requirements and calibration procedures. This QCP will be reviewed by the Office of Materials Management to determine its adequacy.

d. Certification:

(1) For approval, the supplier shall furnish a certification indicating the name, location, and type of manufacturing facility, which includes the metallurgical process and furnace. It shall state that the silica fume shipped for use on Department projects will be produced under appropriate quality control and shall be in accordance with the specified requirements. A sample certification is set out in ITM 804.

(2) For certification of test reports, the results generated in accordance with 901.04(b) shall be summarized and submitted monthly. The reports shall state the name and

location of the testing facility, and shall be signed by the chemist or technical manager. This certification shall also identify the concrete plants receiving silica fume represented by these results.

901.05 Chemical Anchor System

Chemical anchor systems shall be furnished from the Department's list of approved Chemical Anchor Systems. Chemical anchor systems may be added to the approved list by completing the requirements of ITM 806, Procedure F and passing required laboratory testing.

(a) Requirements

Chemical anchor systems shall be in accordance with the following:

1. Chemical anchor systems shall be 2 part systems which are capable of anchoring deformed steel reinforcing bars and grouting load transfer dowels.

2. Chemically anchored steel reinforcing bars shall be capable of withstanding a tensile load equal to the yield strength of a #7 (#22), grade 60 (400), epoxy coated, deformed steel reinforcing bar.

3. Chemical anchor systems shall be capable of filling the entire annular space between the concrete and the steel reinforcing bar or dowel and remain in place until the chemical anchor is completely cured.

(b) Laboratory Testing

The Department will test chemical anchor systems in accordance with ITM 807.

901.06 PCC Sealer/Healers

PCC sealer/healers shall be furnished from the Department's list of approved PCC Sealer/Healers. PCC sealer/healers may be added to the approved list by completing the requirements in ITM 806, Procedure F and passing required laboratory testing.

(a) Requirements

PCC sealer/healers shall be in accordance with the following:

1. PCC sealer/healers shall be 2 part systems, capable of sealing and healing cracks in PC pavement.

2. PCC sealer/healers shall be capable of restoring the original integrity of a PCC beam broken in flexure.

3. All 4 beams used for testing sealer/healers shall break at a location different from the original break or with a flexural strength greater than or equal to 550 psi (3,800 kPa).

4. The viscosity of PCC sealer/healers shall be sufficient to penetrate a crack 1/32 in. (0.8 mm) wide and 6 in. (150 mm) in depth.

(b) Laboratory Testing

The Department will test PCC sealer/healers in accordance with ITM 808.

901.07 Rapid Setting Patch Materials

Rapid setting patch materials shall be selected from the Department's list of approved Rapid Setting Patch Materials. A rapid setting patch material may be added to the approved list by completing the requirements in ITM 806, Procedure F.

(a) Normal Weather Mixes

Normal weather rapid setting patch materials shall be used for ambient temperatures of 32 - 85°F (0 - 30°C).

(b) Hot Weather Mixes

Hot weather rapid setting patch materials shall be used for ambient temperatures above 85°F (30°C).

(c) Requirements

Rapid setting patch materials shall be capable of being utilized in patches ranging from 1 in. (25 mm) to full depth without bonding agents, no curing material shall be required, and shall be capable of being surface sealed with an epoxy sealer.

These products shall not contain soluble chlorides as an ingredient of manufacture nor shall they require chemical additives. The color shall be similar to PCC.

They shall be single packaged dry mix requiring only water just prior to mixing. They shall be packaged in 40 to 60 lb (18 to 27 kg) bags with a neat yield of approximately 0.40 cu yd (0.011 m^3) and shall allow at least a 50% extension, by weight (mass) with a 3/8 in. (10 mm) or a 1/2 in. (13 mm) round aggregate. The minimum shelf life shall be 12 months.

Mixing shall be conducted with small concrete mixers or with a drill or paddle mixer and shall be suitable for finishing with hand tools.

Rapid setting patch materials shall be in accordance with ASTM C 928 with the following exceptions.

Physical Test	Specification	Requirement
Setting Time	ASTM C 266	
Normal Weather		
	Initial at 72°F (22°C)	10 – 20 min
	Final at 72°F (22°C)	12 – 35 min
Hot Weather		
	Initial at 95°F (35°C)	10 – 20 min
	Final at 95°F (35°C)	12 – 35 min
Compressive Strength, Min*	ASTM C 109	72°F (22°C), Normal
1 h		2,000 psi (14 MPa)
2 h		3,000 psi (21 MPa)
24 h		5,000 psi (34.5 MPa)
28 day		8,000 psi (55 MPa)
Compressive Strength, Min*	ASTM C 109	95°F (35°C), Hot
3 h		3,000 psi (21 MPa)
24 h		5,000 psi (34.5 MPa)
28 days		8,000 psi (55 MPa)
Relative Dynamic Modulus	ASTM C 666	
Procedure B 300 cycles		95% Min.
Slant Shear Bond Strength, Min.	ASTM C 882	
28 days		2,500 psi (17 MPa)
Flexural Strength, 24 h	ASTM C 78	
mortar only		500 psi (3.5 MPa)
mortar – aggregate extension		600 psi (4.0 MPa)
Shrinkage, Max.	ASTM C 157	
28 days		0.03%
Scaling Resistance	ASTM C 157	
5 cycles		0 rating, No scale
25 cycles		0 rating, No scale
50+ cycles		1.5 rating, Lt. scale

* Material used shall be neat rapid setting patch material mixed in accordance with the manufacturer's installation instructions.

All rapid setting patch materials complying with the specified physical requirements will be subjected to a field performance demonstration. The field performance demonstration will take place as directed. Rapid setting patch materials shall be used to patch a designated site, typical of a standard repair. The site will be

evaluated after 1 year's exposure. Approval will be based on visible signs of distress, such as cracking, crazing, scaling, spalling, wearing, edge fraying, corner cracking, or debonding.

(d) Test Report

Testing shall be performed by a recognized laboratory in accordance with ITM 806. Test reports shall not be more than 5 years old on January 1st of the approval year.

901.08 Packaged, Dry, Combined Materials for Mortar and Concrete

These materials shall be in accordance with ASTM C 387. All packages shall be identified as conforming to ASTM C 387. The markings shall also show the kind and type of material, the net weight in each bag, the yield in cubic feet (cubic meters) or yield in square feet per inch (square meters per millimeter) of thickness, and the amount of water recommended for mixing to produce a 2 in. to 3 in. (50 mm to 75 mm) slump.

901.09 Air-Cooled Blast Furnace Slag for Retaining Walls

If ACBF or coarse aggregate is used, and soil, B borrow, structural backfill, or coarse aggregate is to be placed above the ACBF or coarse aggregate, a single layer of geotextile shall be placed on top of the ACBF or coarse aggregate in accordance with 616.11. A type C certification in accordance with 916 for the geotextile materials shall be furnished to the Engineer prior to use.

ACBF shall be in accordance with the pH, chlorides, sulfates, organic content, resistivity, and permeability requirements of structure backfill as listed in 211.07. It shall also be in accordance with ITM 212. Total sulfides shall also be determined in accordance with EPA 376.1, using the 100-mL pH water samples obtained during the ITM 212 test, and shall not exceed 400 ppm. The ACBF shall have a maximum corrosion rate as follows if tested in accordance with ASTM G 59.

(a) Zinc corrosion rate, first 2 years ..... 15 µm/yr/side
(b) Zinc corrosion rate, to depletion ..... 4 µm/yr/side
(c) Carbon-steel corrosion rate ..... 12 µm/yr/side

901.10 Components of MSE Retaining Walls

(a) PCC Components

1. Face Panels

Precast concrete face panels shall be produced from a source listed in the Department's List of Certified Precast Concrete Producers, in accordance with ITM 813. Concrete shall have a compressive strength equal to or greater than 4,000 psi (27.5 MPa) at 28 days.

The target water/cementitious ratio for the concrete mix design shall not exceed 0.435. The cement content and target water/cementitious ratio of the concrete mix design shall be sufficient to obtain the specified minimum 28-day compressive strength. Approved air entraining admixture and chemical admixture Type A, B, C, D, or E may be used.

Ground-reinforcement connection hardware and reinforcing bar lifting devices shall be set in place and secured prior to beginning casting, in accordance with the dimensions and tolerances shown on the working drawings.

a. Production Control Testing and Inspection

The manufacturer shall provide for all testing and inspection services during each day's production of the panels. The frequency of production control testing shall be based on a lot of 50 panels, or fraction thereof, for each day's production. Sampling and testing of the plastic concrete shall be in accordance with 505.01, or the ASTM equivalent. A minimum of 1 water/cementitious ratio, and slump, air content, and relative yield tests shall be run per production lot, per day. A minimum of two 6 in. by 12 in. (150 mm by 300 mm) cylinders shall be cast per day's production lot for compressive strength determination. Cylinders shall be cured in the same manner as the panels they represent. Relative yield, air content, and slump of the concrete shall be in accordance with 702.05. Compressive strength shall be determined in accordance with AASHTO T 22 or ASTM C 39, with lot acceptance based on the average of 2 cylinders tested at an age no greater than 28 days. Panels shall not be shipped until the compressive strength meets or exceeds the 28 day requirement.

If the cylinder-test results do not satisfy the requirements described herein, and additional cylinders for testing are not available, the manufacturer may core the panels. The wall manufacturer shall randomly select 2 panels from the lot for coring in accordance with AASHTO T 24 or ASTM C 42. The wall manufacturer shall obtain 1 core on the backside of each panel with a device that produces uniform test samples without coring completely through the panel. Coring shall not be located within 6 in. (150 mm) of the panel fasteners or the edges of the panels, and shall avoid the panel's reinforcing steel. The wall manufacturer shall fill the core holes with equivalent concrete materials or rapid setting patch materials, and trowel to produce a smooth finish. Excess material removed during troweling shall not be reused. If rapid setting patch material is used, mixing and curing shall be in accordance with the manufacturer's recommendations. Compressive strength testing shall be performed on the cores. If the average strength-test results from the cores satisfy or exceed the requirements described herein, the production lot panels may be shipped.

b. Casting

The panels shall be cast on a flat area, with the front face of the form at the bottom, and the back face at the upper part. Tie strip guides shall be set on the rear face. The concrete in each unit shall be placed without interruption and shall be

consolidated as necessary to prevent the formation of segregation or cleavage planes. Clear form oil from 1 manufacturer shall be used throughout the casting operation.

c. Curing

The panels shall be cured for a sufficient length of time such that the concrete develops the specified compressive strength.

d. Removal of Forms

The forms shall remain in place until they can be removed without damage to the unit.

e. Concrete Finish

The concrete surface for the front panel face shall have a surface finish produced from contact with the form. The rear face of the panel shall be screeded to eliminate open pockets of aggregate and surface distortions in excess of 1/4 in. (6 mm).

f. Tolerances

All panels shall be manufactured within the tolerances as follows:

(1) Panel Dimensions

Lateral position of tie strips shall be within 1 in. (25 mm). All other dimensions shall be within 3/16 in. (5 mm).

(2) Panel Squareness

Squareness, as determined by the difference between the 2 diagonals, shall not exceed 1/2 in. (13 mm).

(3) Panel-Surface Finish

Surface defects on smooth formed surfaces measured on a length of 5 ft (1.5 m) shall not exceed 1/8 in. (3 mm). Surface defects on textured finished surfaces measured on a length of 5 ft (1.5 m) shall not exceed 5/16 in. (5 mm).

g. Compressive Strength Verification

Verification of the panels' compressive strengths will be conducted by the Engineer. The frequency of verification testing will be 1 test for every 750 panels per manufacturer with a minimum of 1 test per contract. One panel will be randomly selected and 2 locations will be selected for coring. The Contractor shall obtain two 4 in. (100 mm) cores on the backside of the panel without coring completely through the panel, in the presence of the Engineer. The Contractor shall refill the core holes with rapid setting patch materials and trowel to produce a smooth finish. Excess material removed during troweling shall not be reused. Mixing and curing of the patching materials shall be in accordance with the manufacturer's recommendations.

The Engineer will test the cores in accordance with AASHTO T 24. The verification test results will be averaged and shall be in accordance with 901.10(a)1a. If the initial verification test results do not satisfy the requirements described herein,

the Engineer will randomly select 2 different panels for additional verification testing. If the additional verification tests satisfy the requirements described herein, no further action is required. If the test results still do not satisfy the requirements described herein, installation of panels shall cease and the Engineer will conduct an investigation. Panels manufactured on the same dates as the panels cored for verification tests that have already been installed will be considered and adjudicated as a failed material in accordance with 105.03. The Engineer will conduct verification testing until 3 consecutive dates of production satisfy the strength requirements described herein. The Contractor or wall manufacturer shall make arrangements so that panels from 3 consecutive dates of production are accessible for coring. Installation of panels may resume once acceptable verification testing results are achieved.

h. Rejection

Units shall be subject to rejection due to their failure to be in accordance with the requirements specified above. The following defects may result in rejection:

(1) Defects which indicate imperfect molding.

(2) Defects which indicate honeycombed or open texture concrete.

(3) Defects in the physical characteristics of the concrete, such as broken or chipped concrete, or color variations or dunnage marks on the front face due to excessive form oil or other reasons.

The Engineer will determine whether spalled, honeycombed, chipped, or otherwise defective concrete shall be repaired or be cause for rejection. Repair of concrete, if permitted, shall be completed in a manner which is acceptable to the Engineer. Repair to concrete surfaces that are to be exposed to view after completion of construction shall be subject to approval.

i. Marking

The place and date of manufacture, and production lot number shall be shown on the rear face of each panel.

j. Handling, Storage, and Shipping

All panels shall be handled, stored, and shipped so as to eliminate the danger of chipping, cracks, fractures, or excessive bending stresses. Panels in storage shall be supported on blocking located immediately adjacent to tie strips to avoid bending the tie strips.

2. Coping

The coping may be precast or cast-in-place.

(b) Joint Spacers and Joint Covering

The horizontal and vertical joint spacers shall include compression blocks, pins, or other manufacturer's recommended materials to provide a uniform joint.

The joint cover shall be either a non-woven needle-punch polyester geotextile or a woven monofilament polypropylene. The joint cover shall be attached to the rear face of the panels with a manufacturer's recommended adhesive.

A letter certifying that the joint spacers and joint cover adhesive material supplied is in accordance with the manufacturer's recommendations shall be provided prior to use of the materials.

SECTION 902 – ASPHALT MATERIALS

902.01 Asphalt

Asphalt is defined as a cementitious material obtained from petroleum processes. Asphalts shall be sampled and tested in accordance with the applicable requirements of 902.02.

(a) Performance Graded Asphalt Binders

Performance graded asphalt binders shall be supplied by an approved supplier in accordance with ITM 581.

Performance graded, PG asphalt binders shall be in accordance with the following:

GRADE	PG 58-28	PG 64-22	PG 64-28	PG 70-22	PG 70-28	PG 76-22
ORIGINAL BINDER						
Flash Point, minimum °C	230					
Viscosity, maximum, 3 Pa·s, Test Temp, °C	135					
DSR, G*/sin δ (delta), minimum, 1.00 kPa, Test Temp. @ 10 rad/s, °C	58	64	64	70	70	76
ROLLING THIN FILM OVER RESIDUE						
Mass Loss, maximum, %	1.00					
DSR, G*/sin δ (delta), minimum, 2.20 kPa, Test Temp. @ 10 rad/s, °C	58	64	64	70	70	76
PRESSURE AGING VESSEL (PAV) RESIDUE						
PAV Aging Temperature °C	100 (Note 1)					
DSR, G*sin δ (delta), maximum, 5,000 kPa, Test Temp. @ 10 rad/s, °C	19	25	22	28	25	31

Physical Hardening	Report (Note 2)					
Creep Stiffness, S, maximum, 300 MPa, m-value, minimum, 0.300 Test Temp. @ 60 s, °C	-18	-12	-18	-12	-18	-12

Notes:
1. Oven temperature tolerance shall be ± 0.5°C.
2. Physical Hardening is performed on a set of asphalt beams according to AASHTO T 313, Section 12.1, except the conditioning time is extended to 24 h ± 10 min at 10°C above the minimum performance temperature. The 24 h stiffness and m-value are reported for information purposes only.

A PG 58-28 or PG 64-22 binder may be modified by in-line blending with styrene butadiene rubber, SBR, polymer latex at the HMA plant in accordance with ITM 581. A PG 58-28 may be modified to a PG 64-28 and a PG 64-22 may be modified to a PG 70-22.

The SBR polymer latex shall be in accordance with the following:

SBR POLYMER LATEX	
Total Polymer Solids, % by weight	60 – 72
Butadiene, % by weight, minimum	68
Residual Styrene, % by weight, maximum	0.1
Ash, % of total polymer solids by weight, maximum	3.5
pH	9 – 11
Viscosity, Brookfield model RVF, Spindle No. 2 @ 20 rpm @ 25°C, maximum	2,000

A type A certification for the SBR polymer latex shall be furnished in accordance with 916.

The minimum SBR polymer latex content shall be 2.5 %. The SBR polymer latex content may be reduced below the minimum content provided, if the following requirements are met:

1. An AASHTO accredited laboratory shall blend the PG binder and SBR polymer latex at the proposed SBR polymer latex content and test and grade the modified PG binder in accordance with AASHTO M 320.

2. The laboratory test results verifying the blend and compliance with 902.01(a) shall be submitted to the Engineer for approval.

3. The source of the PG Binder or SBR polymer latex shall not be changed.

1. Lots and Sublots

A binder lot for each grade of PG binder will be 1 week of HMA production. Lots will be further subdivided into sublots for each calendar day that HMA is produced.

2. Sampling

An acceptance sample and backup sample shall be taken from the asphalt delivery system at the HMA plant. The 2 samples will represent a sublot. A copy of a load ticket identifying the binder source shall be submitted with the sublot samples. The Engineer will take immediate possession of the samples.

3. PG Binder Testing

The Department will randomly select 1 sublot from each lot in accordance with ITM 802 for either complete or partial testing in accordance with AASHTO M 320. Complete PG binder testing will consist of RTFO DSR and PAV BBR testing. Partial PG binder testing will consist of RTFO DSR testing. Rotational viscosity and flashpoint tests are not required. If the sublot selected is in accordance with the specifications, the lot will be accepted. If the selected sublot is not in accordance with the specifications, the material will be adjudicated as a failed material in accordance with 105.03.

4. Appeals

If the Contractor does not agree with the acceptance test results for the lot, a request may be made in writing for additional testing. The appeal shall be submitted within 15 calendar days of receipt of the Department's written results. The basis of the appeal shall include complete AASHTO M 320 test results for the specific sublot in question. The appeal results will replace all previous test results for acceptance of the lot.

(b) Asphalt Emulsions

Asphalt emulsions shall be composed of an intimate homogeneous suspension of a base asphalt, an emulsifying agent, and water. Asphalt emulsions may contain additives to improve handling and performance characteristics. Failure of an emulsion to perform satisfactorily in the field shall be cause for rejection, even though it passes laboratory tests. The grade used shall be in accordance with the table for asphalt emulsions as shown herein.

AE-90 is a medium breaking, low-penetration, high-asphalt content type, intended for hot and cold plant mixing, road mixing, and seal coats or as otherwise specified.

AE-90S is a rapid setting, anionic type emulsion for seal coat applications.

AE-150 is a medium breaking, moderately soft penetration type, intended for use in surface treating, tack coats, and coating open and dense graded aggregate, or as otherwise specified.

AE-150-L is a medium-breaking, relatively low-viscosity type. It may be specified in lieu of AE-T or AE-150 when a softer asphalt or greater aggregate penetration is desired. AE-150-L is suitable for sand seals.

AE-PL is a medium-slow-breaking, low-viscosity, low-asphalt content type, intended for use as a prime or as dust palative.

AE-T is a medium-breaking, comparatively low penetration type, intended for tack coats, seed mulching, or as otherwise specified.

HFRS-2 is a quick-breaking, high-viscosity, high-float, relatively high asphalt content type, intended for seal coats.

RS-2 is a quick-breaking, high-viscosity, relatively high-asphalt content type, intended for seal coats.

AE-PMP is a polymerized modified asphalt emulsion intended for use as a prime coat material.

AE-PMT is a polymerized modified asphalt emulsion intended for use as a tack coat material.

SS-1h is a slow setting, hard penetration type, intended for tack coats.

AE-F is a medium setting, hard penetration, diluted emulsion intended for fog sealing.

The requirements for asphalt emulsions shall be in accordance with the following:

Characteristic [1] [2]	AASHTO Test Method	RS-2	HFRS-2	AE-90	AE-90S	AE-T	AE-F	SS-1h	AE-150	AE-150L	AE-PL	AE-PMT [6]	AE-PMP [6]
Test on Emulsion													
Viscosity, Saybolt Furol at 25°C, min.	T 59			50				20	50				20+
Viscosity, Saybolt Furol at 25°C, max.	T 59					100	100	100		100	115	100	
Viscosity, Saybolt Furol at 50°C, min.	T 59	75	75		50				75				
Viscosity, Saybolt Furol at 50°C, max.	T 59	400	400						300				
Demulsibility w/35 mL, 0.02N CaC12, % min.	T 59	50	50		30		25						
Demulsibility w/50 mL, 0.10N CaC12, % min.	T 59			75		75						25+	25+
Oil Distillate by Distillation, mL/100 g Emul [3]	T 59	4.0	4.0	4.0	3.0	4.0	4.0	4.0	7.0	7.0	3.0	3.0	3.0
Residue by Distillation, % min.	T 59	68	68	68	65 [5]	54	27	57	68	60	30		
Residue by Distillation, % max.	T 59					62	35			65			
Sieve Test, % max.	T 59	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Penetrating Ability, mm, min.	902.02(w)										6		
Stone Coating Test, %	902.02(t)3a			90					90	90			
Settlement, % max.	T 59	5	5	5									
Storage Stability, % max.	T 59				1								
Asphalt Content by Distillation at 204°C, % min.												54	45
Asphalt Content by Distillation at 204°C, % max.												62	
Tests on Residue													
Penetration (0.1 mm) at 25°C, 100g, 5 s, min. [4]	T 49	100	100	100	90	50	40	40				50	300+
Penetration (0.1 mm) at 25°C, 100g, 5 s, max. [4]	T 49	200	200	200	150	200	90	90				200	
Penetration (0.1 mm) at 25°C, 50g, 5 s, min. [4]	T 49								100	100			
Penetration (0.1 mm) at 25°C, 50g, 5 s, max. [4]	T 49								300	300			
Ductility at 25°C, mm, min.	T 51	400	400	400		400		400					
Solubility in Org. Sol., % min.	T 44	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5
Float Test at 50°C, s, max. [4]	T 50												
Float Test at 60°C, s, min. [4]	T 50		1200	1200	1200	1200			1200	1200			
Force Ratio	T 300				0.3								

Elastic Recovery, at 4°C	T 301				58								
Polymer Content by Infrared												1.5+	1.5+

Notes:
(1) Broken samples or samples more than 10 days old will not be tested.
(2) Combined percentage of the residue and oil distillate by distillation shall be at least 70% (note the different units – ml for oil and % for residue).
(3) Oil distillate shall be in accordance with ASTM D 396, table 1, grade no. 1
(4) The Engineer may waive the test.
(5) Maximum temperature to be held for 15 min 200 ± 5°C.
(6) Asphalt shall be polymerized prior to emulsification.

(c) Cutback Asphalts

Cutback asphalts shall be composed of an intimate homogeneous mixture of an asphalt base and a suitable distillate designed for medium, or slow curing. Cutback asphalts may also contain an additive as an aid in uniformly coating wet, damp, or dry aggregates used in patching mixtures or HMA pavements. These asphalts shall not contain more than 0.3% water as determined by AASHTO T 55, shall not separate when allowed to stand, and shall not foam when heated to permissible temperatures. When an additive is used, it shall be incorporated homogeneously in the asphalt at the point of manufacture. The temperature of the cutback asphalt shall not be higher than shown for that grade in 902.03.

1. Medium Curing Asphalts With and Without Additives

Medium curing asphalts with and without additives shall be in accordance with the following:

Characteristics	Grades			
	MC-70 MCA-70	MC-250 MCA-250	MC-800 MCA-800	MC-3000 MCA-3000
Flash Point (Open Tag.), °C(4)	38+	66+	66+	66+
Kinematic Viscosity at 60°C (cSt)(2)	70-140	250-500	800-1600	3000-6000
Saybolt-Furol Viscosity at 50°C (s)	60-120			
Saybolt-Furol Viscosity at 60°C (s)		125-250		
Saybolt-Furol Viscosity at 83°C (s)			100-200	300-600
Distillation(1)				
Distillate (% of total distillate to 360°C MC-70 @ 225°C):				
to 225°C	0-20	0-10		
to 260°C	20-60	15-55	35+	15+
to 316°C	65-90	60-87	45-80	15-75
Residue from distillation to 360°C (volume % by difference)	55+	67+	75+	80+
Tests on Residue from Distillation(1)				
Penetration, 25°C, 100 g, 5 s, - (0.1 mm)				
(without additive)	120-250	120-250	120-250	120-250
(with additive)	120-300	120-300	120-300	120-300
Ductility, 25°C (10 mm)(3)	100+	100+	100+	100+
Solubility in organic solvents, %	99.5+	99.5+	99.5+	99.5+

(1) Test may be waived when approved.
(2) Viscosity may be determined by either the Saybolt-Furol or Kinematic test. In case of dispute, the Kinematic viscosity test shall prevail.
(3) If the ductility at 25°C is less than 100, the material will be acceptable if its ductility at 16°C is 100+.
(4) Flash point by Cleveland Open Cup may be used for products having a flash point greater than 80°C.

2. Slow Curing Asphalts With and Without Additives

Slow curing asphalts with and without additives shall be in accordance with the following:

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Characteristics	Grades			
	SC-70 SCA-70	SC-250 SCA-250	SC-800 SCA-800	SC-3000 SCA-3000
Flash Point (Cleveland Open Cup), °C	66+	79+	93+	107+
Kinematic Viscosity at 60°C (cSt)(2)	70-140	250-500	800-1600	3000-6000
Saybolt-Furol Viscosity at 50°C (s).....	60-120			
Saybolt-Furol Viscosity at 60°C (s).....		125-250		
Saybolt-Furol Viscosity at 83°C (s).....			100-200	300-600
Distillation(1)				
Total Distillate to 360°C (% by volume)	10-30	4-20	2-12	5
Float Test of Distillation Residue at 50°C (s).....	20-100	25-110	50-140	75-200
Ductility of Asphalt Residue at 25°C (10 mm)(1)	100+	100+	100+	100+
Solubility in organic solvents, %(1)	99.5+	99.5+	99.5+	99.5+

(1) Test may be waived when approved.
(2) Viscosity may be determined by either the Saybolt-Furol or Kinematic test. In case of dispute, the Kinematic viscosity test shall prevail.

(d) Utility Asphalt

The asphalts shall be uniform in character and shall not foam when heated to 350°F (177°C). Utility asphalts shall be in accordance with the following:

Characteristics/Grades	UA-I	UA-II	UA-III
Softening Point (Ring & Ball), °C	46-63	63-85	79.5-96
Penetration of Original Samples(1) (0.1 mm)			
at 4°C, 200 g, 60 s, Min.	10	10	10
at 25°C, 100 g, 5 s.....	50-100	25-45	15-35
at 46°C, 50 g, 5 s.....	100 Min.	130 Max.	90 Max.
Ductility @ 25°C, 50 mm/min, 10 mm, Min.(1)	30	10	2.5
Solubility in Organic Solvents, % Min.(1)	99.0	99.0	99.0
Flash Point (Cleveland Open Cup), °C, Min(1)	225	225	225
Penetration of Residue from Thin Film Oven Test, 25°C, 100 g, 5 s, (0.1 mm) Min.(1)	30	15	10

(1) Test will be performed when complete physical characteristics are needed or desired.

(e) Asphalt for Coating Corrugated Metal Pipe

Asphalt for coating corrugated metal pipe shall be in accordance with the following:

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Physical Properties	Minimum	Maximum
Softening Point (Ring & Ball), °C	93	110
Penetration of Original Samples (0.1 mm) at 4°C, 200 g, 60 s ..... at 25°C, 100 g, 5 s	 20 35(1)	
Solubility in Organic Solvents, %	99.0	
Flash Point (Cleveland Open Cup), °C	232	
Flow Test, mm		6.4
Shock Test	3 of 4 specimens shall pass	
(1) May be 30 minimum provided all 4 shock test specimens pass.		

902.02 Sampling and Testing Asphalt Materials
The tests and AASHTO references are as follows:

(a) Sampling Bituminous Materials ..... AASHTO T 40

The following exceptions to AASHTO T 40 shall apply:

1. Samples may be obtained at any time before material is incorporated into the work.

2. Samples for all grades of asphalt emulsion shall be a minimum of 1/2 gal. (1.9 L). The size of samples of other liquid material may be 1 qt (1 L).

3. Samples of liquid materials shall be obtained at 1 of the following:

   a. bulk storage tanks from sampling valves located in the tank or line and asphalt plant storage tanks from sampling valves located in the tank

   b. transports from sampling valves

   c. distributors from valves

   d. other storage or locations as approved

   e. sampling by other recognized devices may be approved

   f. sampling valves beyond the in-line blending location

(b) Water in petroleum products, except the solvent or carrier may be toluene ..... AASHTO T 55

(c) Density, Specific Gravity, or API Gravity of Crude Petroleum and Liquid Products by Hydrometer Method ..... AASHTO T 227

(d) Specific Gravity of Semi-Solid Bituminous Materials ..... AASHTO T 228

(e) Specific Gravity of Solid Pitch and Asphalt ..... AASHTO T 229

(f) Flash and Fire Points (Open Cup)

1. When the flash point is higher than 175°F (79°C), "Flash and Fire Points by Cleveland Open Cup" ..... AASHTO T 48

2. When the flash point is 175°F (79°C) or lower, "Flash Point with Tagliabue Open Cup"..... AASHTO T 79

(g) Softening Point of Bituminous Materials, Ring and Ball ..... AASHTO T 53

(h) Penetration of Bituminous Materials ..... AASHTO T 49

(i) Loss of Heating..... AASHTO T 47

(j) Solubility in Organic Solvents, except the solvent may be 1,1,1,-Trichloroethane ..... AASHTO T 44

(k) Inorganic Matter or Ash ..... AASHTO T 59

(l) Saybolt-Furol Viscosity ..... AASHTO T 72

(m) Ductility of Binder Material, except that the conditioning period of the specimens may be shortened, and that only 1 normal test will be required. Shortened conditioning period: The specimen shall be allowed to cool in air for at least 30 min. It shall then be trimmed and placed in the water bath for a period of 60 to 90 min before testing. In case of failure or dispute, 3 normal tests will be required and specimens shall be conditioned as in AASHTO T 51.

(n) Distillation of Cutback Asphaltic Products, except the length of condenser tube may be 400 mm ± 24 mm..... AASHTO T 78

(o) Float Test for Bituminous Materials..... AASHTO T 50

(p) Kinematic Viscosity of Asphalts ..... AASHTO T 201

(q) Absolute Viscosity of Asphalts ..... AASHTO T 202

(r) Effect of Heat and Air on Asphalt Materials,
Thin-Film Oven Test ..... AASHTO T 179

(s) Effect of Heat and Air on a Moving Film of
Asphalt, Rolling Thin Film Oven Test ..... AASHTO T 240

(t) Testing Asphalt Emulsions ..... AASHTO T 59
The following exceptions to T 59 shall apply:

1. For the Residue by Distillation test, the specified aluminum alloy still shall be the referee still.

2. When tests on the residue are not required, the percent of residue for emulsion grades RS-2, AE-60, AE-90, and AE-T only, may be determined by the Residue by Evaporation test of AASHTO T 59. The percent of residue shall be determined by the Residue of Distillation test in all cases of failure or dispute.

3. The stone coating test shall be performed as follows on a mixture of 465 ± 1 g of reference stone and 35.0 ± 0.1 g of asphalt emulsion:

   a. For AE-90 the mixture of stone and asphalt shall be mixed vigorously for 5 min. At the end of the mixing period, the mix shall be rinsed by running sufficient tap water at the side of the container to completely immerse the mix. The tap water shall then be poured off and the rinsing step repeated as necessary until the rinse water pours off essentially clear. The stone shall remain a minimum of 90% coated.

   b. For AE-150 and AE-150-L, the mixture of stone and asphalt shall be mixed vigorously for 5 min and then allowed to stand for 3 h. At the end of this time, the mixture shall again be mixed vigorously for 5 min. At the end of the mixing period, the mix shall be rinsed by running sufficient tap water at the side of the container to completely immerse the mix. The tap water shall then be poured off and the rinsing step repeated as necessary until the rinse water pours off essentially clear. The stone shall remain a minimum of 90% coated for AE-150 and AE-150-L.

4. For the Demulsibility test, normally only 1 test will be required. In case of failure or dispute, the specified procedure in AASHTO T 59 will be followed.

5. For oil portion from Residue by Distillation, report the number of milliliters of oil per 100 g of emulsion.

(u) For coating test for cutback asphalts with additive, 20 g of 20 to 30 mesh Ottawa sand shall be placed in a clean 2 oz (60 mL) wide-mouthed jar and covered with 25 g of distilled water at room temperature. One gram of the liquid asphalt to be tested shall be placed gently upon the surface of the water so that it floats and does not contact the sand. The lid shall then be placed on the jar and tightened securely. If the liquid asphalt to be tested is grade 70 or 250, the jar and contents shall be shaken vigorously for 30 s. If the grade is 800 or 3000, the jar and contents shall be immersed in a 115°F (46°C) water bath for 5 min to bring the contents of the jar to a temperature of approximately 100°F (38°C). The jar shall then be shaken vigorously for 30 s. After shaking, the asphalt coating on the sand shall be observed under a constant, strong light. Complete coating of the sand is required.

(v) Stripping tests for HMA mixtures using binder materials, with or without additives, shall be performed as follows:

1. Test 1. A sample of produced mixture, 500 g, minimum, shall be obtained for testing. The size of test specimen and the amount of distilled water shall be:

Approximate Size of Aggregate	Minimum Weight of Test Specimen	Amount of Distilled Water
Sand	100 g	400 mL
12	100 g	400 mL
11	150 g	600 mL
9	200 g	600 mL

Place the specimen in the boiling distilled water and stir with a glass rod at the rate of 1 revolution per second for 3 min. The aggregate shall retain a minimum of 90% of its asphalt film compared with the remainder of the sample, upon completion of this procedure.

2. Test 2. Approximately 500 g of produced mixture shall be heated to 250°F (121°C) in a laboratory oven for 2 h; stirred and cooled to 200°F (92.5°C). Then a portion of the mix shall be placed in boiling distilled

water, quantity of mix and quantity of boiling water shall be as specified in Test 1, and stirred with a glass rod at the rate of 1 revolution per second for 3 min. The aggregate shall retain a minimum of 90% of its asphalt film compared with the remainder of the sample, upon completion of this procedure.

Note: The purpose of these tests is to determine the relative compatibility of the aggregate and asphalt, and to detect tendency of Asphalt Emulsions to re-emulsify. Test 2 may be performed as a method of determining whether compatibility can be achieved, Test 1 having given unsatisfactory results.

(w) Penetrating Ability of AE-PL.

1. Apparatus and Equipment:

a. Sand mixture:

(1) Dry Ottawa Sand (AASHTO T 106) ..... 90 parts

(2) Dry Reference Limestone Dust, portion passing #50 (300 mm) sieve only. Reference Limestone Dust used by the Department is Limestone Calcium Carbonate manufactured by France Stone Co. The Department will furnish approximately 5 lb (2.3 kg) of Reference Limestone Dust upon request. ..... 10 parts

(3) Water ..... 3 parts

b. Container, 6 oz (170 g) ointment tin

c. Ruler or other measuring device

d. Timing device readable in seconds

e. Compacting Device. Rimac Spring Tester or other device suitable for compacting sand by applying a 20 psi (140 kPa) load. The compacting device shall include an adapter consisting of 2 metal discs slightly smaller in diameter than a 6 oz (170 g) ointment tin separated by a spacer 1 to 2 in. (25 to 50 mm). The 2.5 in. (65 mm) diameter discs used in determining weight of coating in AASHTO T 65 or ASTM A 90 are satisfactory.

f. Small, square ended spatula or putty knife

2. Procedure:

Thoroughly mix Standard Ottawa Sand, Reference Limestone Dust, and water. Weigh 190 ± 1 g of sand mixture into a 6 oz (170 g) ointment tin. Level surface of sand with a spatula. Place the compacting adapter on the sand surface and slowly, over a period of about 5 s, compact the sand until the 20 psi (140 kPa) load is achieved, which is approximately 100 lb (45 kg) on the Rimac Spring Tester. Remove the compacting device, avoiding disturbance to the sand surface. Quickly pour 12 g of the emulsion from a height of about 4 in. (100 mm) onto top of sand mixture. Start timer at start of pour. Stop timer when all emulsion penetrates into sand mixture. Delay 2 min then remove sand and mixture from 1 side of ointment tin, about 1/2 of mixture. Measure to determine average depth of penetration into sand mixture. Penetration time shall be 100 s or less; penetration depth shall be 1/4 in. (6 mm) or more.

(x) Flow Test for Asphalt for Coating Corrugated Metal Pipe..... AASHTO T 190

(y) Shock Test for Asphalt for Coating Corrugated Metal Pipe..... AASHTO T 190

(z) Viscosity Determinations of Unfilled Asphalts Using the Brookfield Thermosel Apparatus ..... AASHTO T 316

(aa) Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer..... AASHTO T 315

(bb) Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel..... AASHTO R 28

(cc) Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer ..... AASHTO T 313

902.03 Application Temperatures

Binder materials for the several applications indicated in the specifications shall be applied at temperatures not to exceed those shown in the following:

Type and Grade of Material	Maximum Application Temperature °F (°C)	
	Spray	Mix
MC-70, MCA-70	150 (66)	
MC-250, MCA-250	225 (107)	200 (93)
MC-800, MCA-800	250 (121)	225 (107)
MC-3000, MCA-3000	275 (135)	250 (121)
SC-70, SCA-70	200 (93)	
SC-250, SCA-250	225 (107)	225 (107)
SC-800-3000, SCA-800-3000	250 (121)	250 (121)
All Emulsions	160 (71)	180 (82)
All Penetration and Viscosity, Utility and Pipe Coating	350 (177)	325 (163)
PG Binders	(Note 1)	(Note 1)
Note 1: In accordance with manufacturer's recommendations.		

SECTION 903 – CLASSIFICATION OF SOILS

903.01 Definitions

All of the soils shall be tested and classified in accordance with AASHTO M 145, and in accordance with the grain-size classification procedure as follows:

Soil Classification	Definition
Boulders	Retained on 3 in. (75 mm) sieve
Gravel	3 in. (75 mm) to No. 10 (2.0 mm) sieve
Coarse Sand	No. 10 (2.0 mm) to No. 40 (425 µm) sieve
Fine Sand	No. 40 (425 µm) to No. 200 (75 µm) sieve
Silt	0.075 to 0.002 mm
Clay	Smaller than 0.002 mm
Colloids	Smaller than 0.001 mm

903.02 Soils Having 0% to 19% Retained on No. 10 (2.00 mm) Sieve

These soils shall be classified as follows:

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Classification	Sand and Gravel, %	Silt, %	Clay, %
Sand	80 – 100	0 – 20	0 – 20
Sandy Loam	50 – 80	0 – 50	0 – 20
Loam	30 – 50	30 – 50	0 – 20
Silty Loam	0 – 50	50 – 80	0 – 20
Silt	0 – 20	80 – 100	0 – 20
Sandy Clay Loam	50 – 80	0 – 30	20 – 30
Clay Loam	20 – 50	20 – 50	20 – 30
Silty Clay Loam	0 – 30	50 – 80	20 – 30
Sandy Clay	50 – 70	0 – 20	30 – 50
Silty Clay	0 –20	50 – 70	30 – 50
Clay	0 – 50	0 – 50	30 – 100

903.03 Soils Having 20% or More Retained on No 10 (2.00 mm) Sieve and More Than 20% Passing No. 200 (75 µm) Sieve

These soils shall be classified in accordance with 903.02, followed by a term describing the relative amount of gravel as follows:

20% to 35%:	"with some gravel"
36% to 50%:	"and gravel"

903.04 Soils Having 20% or More Retained on No. 10 (2.00 mm) Sieve and Less Than 20% Passing No. 200 (75 µm) Sieve

These soils shall be classified as follows:

	Gravel, %	Sand, %	Silt, %	Clay, %
Gravel	85 – 100	0 – 15	0 – 15	0 – 15
Sandy Gravel	40 – 85	15 – 40	0 – 20	0 – 20
Gravelly Sand	20 – 40	40 – 80	0 – 20	0 – 20
Sand & Gravel	20 – 50	20 – 50	0 – 20	0 - 20

If the gradation of a given sample is not in exact accordance with the requirements for a given classification, it shall be placed in the classification to which it comes the closest.

903.05 Organic Soils

The following classification system shall be used for organic soils in accordance with AASHTO T 267.

Classification	Percentage
With Trace Organic Matter	1 to 6
With Little Organic Matter	7 to 12
With Some Organic Matter	13 to 18
Organic Soil (A-8)	19 – 30
Peat (A-8)	More than 30

903.06 Marly Soils

The following classification system shall be used for marly soils with calcium and magnesium carbonate content.

Classification	Percentage
With Trace Marl	1 to 9
With Little Marl	10 to 17
With Some Marl	18 to 25
Marly Soil (A-8)	26 to 40
Marl (A-8)	More than 40

SECTION 904 – AGGREGATES

904.01 Aggregates

Aggregates shall consist of natural or manufactured materials produced from but not limited to limestone, dolomite, gravels, sandstones, steel furnace slag, SF, air-cooled blast furnace slag, ACBF, granulated blast furnace, GBF, wet bottom boiler slag, or other geologic rock types approved by the Engineer.

A source will not be considered for acceptance of material until a preliminary investigation has been made. As part of this investigation, samples will be obtained and tests conducted to determine the quality and classification of the aggregates in accordance with ITM 203.

Two types of samples are required for the preliminary investigation: ledge samples for crushed stone sources and production samples for crushed stone, natural sand and gravel, and slag sources.

Ledge samples will be obtained from bedrock units as they naturally occur in the proposed working face of the quarry. Ledges will be identified by their differences in color, texture, geological formation, etc.

Production samples will be obtained from stockpiles of finished materials.

Aggregates, except those used for precast concrete units or fine aggregates used for snow and ice abrasive, shall be supplied by a Certified Aggregate Producer in accordance with 917. Structure backfill may be obtained from a non-CAPP source in accordance with 211.02. SF for SMA mixtures shall also require the following.

(a) Specific gravity quality control tests shall be completed at a frequency of 1 test per 2,000 t (2,000 Mg) produced.

(b) Target bulk specific gravity shall be established using the average of the first 4 tests.

(c) Subsequent individual tests shall be within 0.050 of the target bulk specific gravity.

(d) Moving average of 4 consecutive tests shall be within 0.040 of the target bulk specific gravity.

(e) Tests outside these ranges shall require the material to be isolated from the approved stockpile until action has been taken to eliminate the cause of the non-conformity. Any non-conforming test shall be followed immediately by a corrective action. Corrective actions shall include, but are not limited to, investigation for assignable cause, correction of known assignable cause, and retesting.

(f) If it is determined that a new target is necessary, a request shall be made in writing to the District Testing Engineer to establish the new target.

Dolomite aggregates are defined as carbonate rock containing at least 10.3% elemental magnesium when tested in accordance with ITM 205.

Polish resistant aggregates are defined as those aggregates in accordance with ITM 214. Aggregates meeting these requirements will be maintained on the Department's list of approved Polish Resistant Aggregates.

Sandstone aggregates shall only be used in HMA surface or SMA surface mixtures. Sandstone aggregates are defined as a sedimentary rock composed of siliceous sandgrains containing quartz, chert, and quartzose rock fragments in a carbonate matrix or cemented with silica, calcite, or dolomite. The Office of Materials Management will determine identification of sandstone.

Steel furnace slag, SF, may be used in aggregate shoulders, HMA surface or SMA surface mixtures, dumped riprap, and snow and ice abrasives. SF slag coarse aggregate may be used in HMA base and HMA intermediate mixtures if the deleterious content is less than 4.0 % when tested in accordance with ITM 219. RAP with steel slag may be used in accordance with 401.06, 402.08 and 410.06.

Adjustments in weight (mass) shall be made to compensate for the difference in specific gravity of slag compared to natural aggregate when payment is on a weight (mass) basis. The following typical values for specific gravity will be used: natural aggregate both fine and coarse, 2.6; ACBF slag coarse aggregate, 2.3; ACBF slag fine aggregate, 2.6; GBF slag fine aggregate, 2.1; and SF slag both fine and coarse, 3.4. The contract quantity shall not be adjusted on any pay item less than 500 t (500 Mg).

When slag is furnished as an aggregate, the approximate quantity of tons (megagrams) to be supplied will be determined by multiplying the pay item quantity of tons (megagrams) by the specific gravity of slag divided by 2.6. The adjusted contract quantities will be determined by multiplying the accepted quantity of tons (megagrams) by 2.6 divided by the specific gravity of the slag.

At time of use, aggregates shall be free from lumps or crusts of hardened or frozen materials.

Composite stockpiling of natural sand fine aggregate from multiple sources into 1 stockpile will be allowed provided the fine aggregates are within a range of 0.10 for the bulk specific gravity (dry) and a range of 1.0% for the absorption. The range of bulk specific gravity (dry) and absorption values shall be the difference between the highest and lowest value, respectively, of the fine aggregate sources within the stockpile. A written request for the composite stockpiling shall be made to the Office of Materials Management.

904.02 Fine Aggregates

Fine aggregates are defined as 100% passing the 3/8 in. (9.5 mm) sieve and a minimum of 80% passing the No. 4 (4.75 mm) sieve. Characteristics of fine aggregates are as follows:

Characteristic	PCC	HMA	SMA
Physical			
Organic Impurities, AASHTO T 21 lighter than or equal to, Color Standard (Note 1).....	3		
Acid Insoluble, ITM 202.....		(Note 2)	
Soundness			
Freeze and Thaw, AASHTO T 103, Procedure A, % Max. (Note 3).....	10.0	10.0	10.0
Brine Freeze and Thaw, ITM 209, % max. (Note 3).....	12.0	12.0	12.0
Sodium Sulfate Soundness,.... AASHTO T 104, % max. (Note 3).....	10.0	10.0	10.0

Notes:
1. When subjected to the colormetric test for organic impurities and a color darker than the standard is produced, it shall be tested for effect of organic impurities on strength of mortar in accordance with AASHTO T 71. If the relative strength at 7 days is less than 95% it shall be rejected.
2. The fine aggregate, including blended fine aggregate, used in HMA Surface 4.75 mm mixtures shall have a minimum acid-insoluble content of 40%, except when using ACBF or GBF slag sands, the minimum acid-insoluble content shall be 25%. Acid-insoluble requirements shall not apply to crushed gravel, limestone, or dolomite sands.
3. AASHTO T 104 and ITM 209 may be run at the option of the Engineer, in-lieu of AASHTO T 103.

(a) For Portland Cement Concrete

Fine aggregate for use in PCCP or bridge decks shall be natural sand. Fine aggregate for other PCC shall be natural sand or crushed limestone, dolomite, gravel, or ACBF.

Natural sand which has been used as foundry sand when tested in accordance with ITM 215, and complying with IDEM Class III or Class IV in accordance with 329 IAC 10-7-4 may be used in precast concrete units or precast concrete pipe. When foundry sand is used, the precast concrete manufacturer shall maintain a copy of the Waste Classification issued by IDEM and an indemnification statement shall accompany the precast items to each contract.

(b) For HMA Mixtures

Fine aggregates for use in HMA shall be natural sand or crushed limestone, dolomite, gravel, sandstone, SF, or ACBF. SF sand may be used only in HMA surface mixtures. The amount of crushed limestone sand shall not exceed 20% of the total aggregate used in HMA surface mixtures with ESAL equal to or greater than 3,000,000, except limestone sands manufactured from aggregates on the Department's list of approved Polish Resistant Aggregates will not be limited. If

soundness testing cannot be conducted, the aggregate shall come from a Category I source in accordance with ITM 203.

The fine aggregate angularity value of the total blended aggregate material from the fine and coarse aggregates, and recycled materials shall meet or exceed the minimum values for the appropriate ESAL category and position within the pavement structure as follows:

FINE AGGREGATE ANGULARITY		
TRAFFIC ESAL	DEPTH FROM SURFACE	
	≤ 100 mm	> 100 mm
< 300,000		
300,000 to < 3,000,000	40	40
3,000,000 to < 10,000,000	45	40
10,000,000 to < 30,000,000	45	40
≥ 30,000,000	45	45

Fine Aggregate Angularity, Method A ..... AASHTO T 304

The fine aggregate angularity value shall not apply to OG mixtures.

The clay content of the blended aggregate material from the fine and coarse aggregates shall meet or exceed the minimum values for the appropriate ESAL category as follows:

CLAY CONTENT	
TRAFFIC ESAL	SAND EQUIVALENT, MINIMUM
< 300,000	40
300,000 to < 3,000,000	40
3,000,000 to < 10,000,000	45
10,000,000 to < 30,000,000	45
≥ 30,000,000	50

Clay Content, Sand Equivalency ..... AASHTO T 176

(c) For SMA Mixtures

Fine aggregate for SMA shall be limestone, dolomite, crushed gravel, SF, or ACBF. Crushed gravels shall have a minimum fine aggregate angularity of 45 in accordance with AASHTO T 304 Method A. Fine aggregates shall be non-plastic in accordance with AASHTO T 90.

(d) For Pneumatically Placed Mortar

Fine aggregate shall be natural sand suitable for use with a pneumatic cement gun. Fine aggregate shall be size No. 15, or size PP in accordance with 904.02(h), or an approved gradation from a CAPP source.

(e) Mortar Sand

Fine aggregate for mortar shall consist of uniformly graded natural sand in accordance with gradation requirements of 904.02(h) for size No. 15 or an approved gradation from a CAPP source.

(f) Mineral Filler for SMA

Mineral filler shall consist of dust produced by crushing stone, portland cement, or other inert mineral matter having similar characteristics. Mineral filler shall be in accordance with the gradation requirements of 904.02(h) for size No. 16. Mineral filler shall be in accordance with ITM 203 or from an ABF slag source. The sieve analysis of mineral filler shall be conducted in accordance with AASHTO T 37 except as noted in 904.06. Mineral filler shall be non-plastic in accordance with AASHTO T 90.

(g) Snow and Ice Abrasives

Snow and ice abrasives shall be fine aggregates or cinders in accordance with the gradation requirements of 904.02(h) for size S&I.

When steel slag is used for snow and ice abrasives, and payment is on a tonnage basis, the pay quantity shall be adjusted in accordance with 904.01.

(h) Sizes of Fine Aggregates

SIZES (PERCENT PASSING)						
Sieve Sizes	23	24	15	16	PP	S&I
3/8 in. (9.5 mm)	100	100				100
No. 4 (4.75 mm)	95-100	95-100			100	
No. 6 (3.35 mm)			100			
No. 8 (2.36 mm)	80-100	70-100	90-100		85-95	
No. 16 (1.18 mm)	50-85	40-80				
No. 30 (600 µm)	25-60	20-60	50-75	100	50-65	
No. 50 (300 µm)	5-30	7-40	15-40		15-25	0-30
No. 80 (180 µm)				95-100		
No. 100 (150 µm)	0-10	1-20	0-10		0-10	
No. 200 (75 µm)	0-3	0-6	0-3	65-100		0-7

(i) Sampling and Testing

Sampling and testing shall be conducted in accordance with the following AASHTO and ITMs.

Acid Insoluble Content ..... ITM 202
*Amount of Material Finer than
No. 200 (75 µm) Sieve ..... AASHTO T 11
Brine Freeze and Thaw Soundness ..... ITM 209
Control Procedures for Classification of Aggregates ..... ITM 203
Determining the Plastic Limit and Plasticity Index of
Soils ..... AASHTO T 90

Mortar Strength ..... AASHTO T 71
Organic Impurities..... AASHTO T 21
Sampling Aggregates..... AASHTO T 2
Sampling Stockpiled Aggregates..... ITM 207
*Sieve Analysis of Aggregate ..... AASHTO T 27
*Sieve Analysis of Mineral Filler..... AASHTO T 37
*Soundness.....AASHTO T 103, T 104
Specific Gravity and Absorption, Fine Aggregate..... AASHTO T 84

* Except as noted in 904.06.

904.03 Coarse Aggregates

Course aggregates are defined as having a minimum of 20% retained on the No. 4 (4.75 mm) sieve. Coarse aggregates shall not contain adherent fines that are detrimental to the end product as defined in ITM 211.

The coarse aggregate shall comply with the quality requirements and the additional requirements in accordance with 904.03(a). However, coarse aggregate may be rejected based on previous performance service records. Class AP is defined as the highest classification and Class F the lowest. Blending of material for compliance with gradation or crushed particle requirements may be permitted when requested in writing. Blending of aggregate products to improve the quality classification of the finished product will not be permitted.

210 **(a) Classification of Aggregates**

Characteristic Classes	AP	AS	A	B	C	D	E	F
Quality Requirements:								
Freeze and Thaw Beam Expansion, % Max. (Note 1) ...	.060							
Los Angeles Abrasion, % Max. (Note 2)	40.0	30.0	40.0	40.0	45.0	45.0	50.0	
Freeze and Thaw, AASHTO T 103, Procedure A, % Max. (Note 3)	12.0	12.0	12.0	12.0	16.0	16.0	20.0	25.0
Sodium Sulfate Soundness, % Max. (Note 3)	12.0	12.0	12.0	12.0	16.0	16.0	20.0	25.0
Brine Freeze and Thaw Soundness, % Max. (Note 3) ...	30	30	30	30	40	40	50	60
Absorption, % Max. (Note 4)	5.0	5.0	5.0	5.0	5.0			
Additional Requirements:								
Deleterious, % Max.								
Clay Lumps and Friable Particles	1.0	1.0	1.0	1.0	2.0	4.0		
Non-Durable (Note 5)	4.0	2.0	4.0	4.0	6.0	8.0		
Coke					(See Note 6)			
Iron					(See Note 6)			
Chert (Note 7)	3.0	3.0	3.0	5.0	8.0	10.0		
Weight per Cubic Foot for Slag, lbs, Min.	75.0		75.0	75.0	70.0	70.0	70.0	
(Mass per Cubic Meter for Slag, (kg))	(1,200)		(1,200)	(1,200)	(1,120)	(1,120)	(1,120)	
Crushed Particles, % Min. (Note 8)								
Asphalt Seal Coats			70.0	70.0				
Compacted Aggregates			20.0	20.0	20.0	20.0		
Additional SMA Requirements:								
Micro-Deval Abrasion, %, Max. (Note 9)		18.0						
Aggregate Degradation, %, Max. (Note 10)		3.0						

Notes:

1. Freeze and thaw beam expansion shall be tested and re-tested in accordance with ITM 210.
2. Los Angeles abrasion requirements shall not apply to BF.
3. Aggregates may, at the option of the Engineer, be accepted by the Sodium Sulfate Soundness or Brine Freeze and Thaw Soundness requirements.
4. Absorption requirements apply only to aggregates used in PCC and HMA mixtures except they shall not apply to BF. When crushed stone coarse aggregates from Category I sources consist of production from ledges whose absorptions differ by more than 2 percentage points, the absorption test will be performed every 3 months on each size of material proposed for use in PCC or HMA mixtures. Materials having absorption values between 5.0 and 6.0 that pass AP testing may be used in PCC. If variations in absorption preclude satisfactory production of PCC or HMA mixtures, independent stockpiles of materials will be sampled, tested, and approved prior to use.
5. Non-durable particles include soft particles as determined by ITM 206 and other particles which are structurally weak, such as soft sandstone, shale, limonite concretions, coal, weathered schist, cemented gravel, ocher, shells, wood, or other objectionable material. Determination of non-durable particles shall be made from the total weight (mass) of material retained on the 3/8 in. (9.5 mm) sieve. Scratch Hardness Test shall not apply to crushed stone coarse aggregate.
6. ACBF and SF coarse aggregate shall be free of objectionable amounts of coke, iron, and lime agglomerates.
7. The bulk specific gravity of chert shall be based on the saturated surface dry condition. The amount of chert less than 2.45 bulk specific gravity shall be determined on the total weight (mass) of material retained on the 3/8 in. (9.5 mm) sieve for sizes 2 through 8, 43, 53, and 73 and on the total weight (mass) of material retained on the No. 4 (4.75 mm) sieve for sizes 9, 11, 12, and 91.
8. Crushed particle requirements apply to gravel coarse aggregates used in compacted aggregates, and seal coats except seal coats used on shoulders. Determination of crushed particles shall be made from the weight (mass) of material retained on the No. 4 (4.75 mm) sieve in accordance with ASTM D 5821.
9. Micro-Deval abrasion requirements shall apply to each coarse aggregate. A blend of coarse aggregates shall have the abrasion loss value determined in accordance with ITM 220.
10. Aggregate degradation shall be determined in accordance with ITM 220.

(b) Coarse Aggregate Angularity for HMA and SMA

The coarse aggregate angularity (CAA) of the total blended aggregate, including recycled materials, shall meet or exceed the minimum values for the appropriate ESAL category and position within the pavement structure as follows.

COARSE AGGREGATE ANGULARITY		
TRAFFIC, ESAL	DEPTH FROM SURFACE	
	≤ 4 in. (100 mm)	> 4 in. (100 mm)
< 300,000	55	
300,000 to < 3,000,000	75	50
3,000,000 to < 10,000,000	85/80*	60
10,000,000 to < 30,000,000	95/90*	80/75*
≥ 30,000,000	100/100*	100/100*
* Denotes 2 faced crush requirements.		

For SMA mixtures, the total blended aggregate shall be 100% 1 face and 95% 2 face crushed.

Coarse Aggregate Angularity ..... ASTM D 5821

Coarse aggregate angularity requirements do not apply to 4.75 mm HMA mixture designation.

(c) Flat and Elongated

The coarse aggregate shall contain 10% or less flat and elongated particles. A flat and elongated piece is defined as a particle having a ratio of length to thickness greater than 5. Determination of flat and elongated particles shall be made from the weight (mass) of material retained on the 3/8 in. (9.5 mm) sieve and each sieve size greater than the 3/8 in. (9.5 mm) sieve.

Flat and Elongated ..... ASTM D 4791

Flat and elongated requirements do not apply to 4.75 mm HMA mixture designation.

(d) Surface Aggregate Requirements

The surface mixture aggregates selection shall be based on the ESAL category as follows.

1. HMA Coarse Aggregate

Coarse Aggregate Type	Traffic ESALs		
	< 3,000,000	< 10,000,000	≥ 10,000,000
Air-Cooled Blast Furnace Slag	Yes	Yes	Yes
Steel Furnace Slag	Yes	Yes	Yes
Sandstone	Yes	Yes	Yes
Crushed Dolomite	Yes	Yes	(Note 1)
Polish Resistant Aggregates	Yes	Yes	(Note 1)
Crushed Stone	Yes	No	No
Gravel	Yes	No	No

Note 1. Polish resistant aggregates or crushed dolomite may be used when blended with ACBF or sandstone but cannot exceed 50% of the coarse aggregate by weight (mass), or cannot exceed 40% of the coarse aggregate by weight (mass) when blended with steel furnace slag.

2. SMA Coarse Aggregate

Coarse Aggregate Type	Traffic ESALs		
	< 3,000,000	< 10,000,000	≥ 10,000,000
Air-Cooled Blast Furnace Slag	No	No	No
Steel Furnace Slag	(Note 1)	(Note 1)	Yes
Sandstone	(Note 1)	(Note 1)	Yes
Crushed Dolomite	(Note 1)	(Note 1)	(Note 2)
Polish Resistant Aggregates	(Note 1)	(Note 1)	(Note 2)
Crushed Stone	No	No	No
Gravel	No	No	No

Notes:
1. Steel furnace slag, sandstone, crushed dolomite, polish resistant aggregates or any blend of these aggregates may be used provided the aggregates are in accordance with 904.03(a).
2. Polish resistant aggregates or crushed dolomite may be used when blended with sandstone but shall not exceed 50% of the coarse aggregate by weight (mass), or shall not exceed 40% of the coarse aggregate by weight (mass) when blended with steel furnace slag. The aggregates shall be in accordance with 904.03(a).

250 **(e) Sizes of Coarse Aggregates**

Sieve Sizes	COARSE AGGREGATE SIZES (PERCENT PASSING)									
	COARSE GRADED								DENSE GRADED	
	2	5	8	9	11	12	43[1]	91	53[1]	73[1]
4 in. (100 mm)										
3 1/2 in. (90 mm)										
2 1/2 in. (63 mm)	100									
2 in. (50 mm)	80-100									
1 1/2 in. (37.5 mm)		100					100		100	
1 in. (25 mm)	0-25	85-98	100				70-90	100	80-100	100
3/4 in. (19 mm)	0-10	60-85	75-95	100			50-70		70-90	90-100
1/2 in. (12.5 mm)	0-7	30-60	40-70	60-85	100	100	35-50		55-80	60-90
3/8 in. (9.5 mm)		15-45	20-50	30-60	75-95	95-100				
No. 4 (4.75 mm)		0-15	0-15	0-15	10-30	50-80	20-40		35-60	35-60
No. 8 (2.36 mm)		0-10	0-10	0-10	0-10	0-35	15-35		25-50	
No. 30 (600 µm)						0-4	5-20		12-30	12-30
No. 200 (75 µm)[2]							0-6.0		5.0-10.0[4]	5.0-12.0
Decant (PCC)[3]		0-1.5	0-1.5	0-1.5	0-1.5	0-1.5		0-1.5		
Decant (Non-PCC)	0-2.5	0-2.5	0-3.0	0-2.5	0-2.5	0-2.0		0-2.5		

Notes:
1. The liquid limit shall not exceed 25 (35 if slag) and the plasticity index shall not exceed 5. The liquid limit shall be determined in accordance with AASHTO T 89 and the plasticity index in accordance with AASHTO T 90.
2. Includes the total amount passing the No. 200 (75 µm) sieve as determined by AASHTO T 11 and T 27.
3. Decant may be 0-2.5 for stone and slag.
4. When slag is used for separation layers as defined in 302.01, the total amount passing the No. 200 (75 µm) sieve shall be 10.0 to 12.0.

(f) Sampling and Testing

Sampling and testing will be in accordance with the following AASHTO, ASTM, and ITMs.

*Amount of Material finer than No. 200 (75 µm) Sieve ..... AASHTO T 11
Brine Freeze and Thaw Soundness..... ITM 209
Clay Lumps and Friable Particles..... AASHTO T 112
Control Procedures for Classification of Aggregates ..... ITM 203
Crushed Particles.....ASTM D 5821
Dolomite Aggregates..... ITM 205
Flat and Elongated Particles .....ASTM D 4791
Freeze and Thaw Beam Expansion ..... ITM 210
*Lightweight Pieces in Aggregates ..... AASHTO T 113
Los Angeles Abrasion ..... AASHTO T 96
Micro-Deval Abrasion..... AASHTO T 327
Polished Resistant Aggregates..... ITM 214
*Sampling Aggregates..... AASHTO T 2
Sampling Stockpiled Aggregates..... ITM 207
Scratch Hardness ..... ITM 206
*Sieve Analysis ..... AASHTO T 27
*Soundness.....AASHTO T 103, T 104
*Specific Gravity and Absorption ..... AASHTO T 85
Unit Weight and Voids in Aggregates..... AASHTO T 19

*Except as noted in 904.06

904.04 Riprap

Riprap shall consist of SF for dumped riprap only, sound stone, stone masonry, or other approved material, free from structural defects and of approved quality. Stone containing shale, unsound sandstone, or other material that will disintegrate readily, shall not be used.

(a) Dumped Riprap

Dumped riprap shall be broken concrete, masonry, or stone removed from an old structure; broken pieces removed from concrete pavement, base, or monolithic brick pavement; or broken rock from class X, class Y, unclassified excavation, or solid rock excavation. Material provided from sources outside the right-of-way shall be coarse aggregate, Class F or higher.

(b) Grouted Riprap

Grouted riprap material shall be in accordance with dumped riprap or revetment riprap.

(c) Revetment, Class 1, and Class 2 Riprap

The material shall be coarse aggregate, Class F or higher. Gradation shall be in accordance with 904.04(f).

(d) Uniform Riprap

The material shall be coarse aggregate, Class F or higher in accordance with 904.03(a). Gradation shall be in accordance with 904.04(f). Either type A or type B may be utilized.

(e) Precast Concrete Riprap

Precast concrete riprap shall consist of unreinforced concrete units of the thickness specified and shall be in accordance with the details shown on the plans. The precast concrete units shall be in accordance with ASTM C 139 except the fine aggregates shall be in accordance with 904.02(a) and the coarse aggregates, class A or higher, shall be in accordance with 904.03. The minimum compressive strength shall be 2,500 psi (17 MPa) for an average of 3 units and 2,300 psi (16 MPa) for individual units. The maximum water absorption shall be 12 lb/cu ft (190 kg/m^3) for an average of 3 units.

(f) Sizes of Riprap

GRADATION REQUIREMENTS					
Percent Smaller					
Size, in. (mm)	Revetment	Class 1	Class 2	Uniform A	Uniform B
30 (750)			100		
24 (600)		100	85-100		
18 (450)	100	85-100	60-80		
12 (300)	90-100	35-50	20-40		
8 (200)				100	
6 (150)	20-40	10-30	0-20	35-80	95-100
3 (75)	0-10	0-10	0-10		35-80
1 (25)				0-20	0-20
Depth of Riprap, minimum	18 in. (450 mm)	24 in. (600 mm)	30 in. (750 mm)		

The maximum dimension of individual pieces shall not be greater than 3 times the minimum dimension. The riprap will be visually inspected for size, shape, and consistency.

904.05 Structure Backfill

The material shall be of acceptable quality, free from large or frozen lumps, wood, or other extraneous matter. It shall consist of suitable sand, gravel, crushed stone, ACBF, or GBF. Structure backfill shall be in accordance with 1 of the gradations shown in the table below, or coarse aggregate No. 5, No. 8, No. 9, No. 11, No. 12, No. 53, or No. 73 in accordance with the gradation requirements of 904.03(e). Coarse aggregate No. 5, No. 8, No. 9, No. 11, No. 12, No. 53, or No. 73 shall be crushed stone or ACBF, class D or higher.

Sieve Sizes	NOMINAL SIZES AND PERCENTS PASSING					
	2 in. (50 mm)	1 1/2 in. (37.5 mm)	1 in. (25.0 mm)	1/2 in. (12.5 mm)	No. 4 (4.75 mm)	No. 30 (600 µm)
2 1/2 in. (63 mm)	100					
2 in. (50 mm)	90-100	100				
1 1/2 in. (37.5 mm)	70-100	90-100	100	100		
1 in. (25.0 mm)	55-95	70-100	85-100			
3/4 in. (19.0 mm)	45-90	55-95	70-100			
1/2 in. (12.5 mm)	35-85	40-90	55-95	85-100	100	100
No. 4 (4.75 mm)	20-65	20-70	25-75	45-85	90-100	
No. 8 (2.36 mm)	10-50	10-55	15-60	25-75	75-100	
No. 30 (600 µm)	3-35	3-35	3-35	5-45	15-70	70-100
No 200 (75 µm)	0-8	0-8	0-8	0-8	0-8	0-8

904.06 Exceptions to AASHTO Standard Methods

(a) Exceptions to AASHTO T 2

Stockpile sampling shall be in accordance with ITM 207, unless otherwise permitted.

(b) Exceptions to AASHTO T 11, T 27, and T 37

1. When tests are performed in the field where ovens are not available, test samples may be dried in suitable containers over open flame or electric hot plates with sufficient stirring to prevent overheating, then cooled to constant weight (mass).

2. The balance shall be a Class G2 general purpose balance in accordance with AASHTO M 231.

(c) Exceptions to AASHTO T 27 for Coarse Aggregates

The size of test samples for coarse aggregate shall be as follows:

Aggregate Size	**Minimum Weight (Mass) of Test Sample**
No. 2	25 lb (11.3 kg)
No 5, 8, 43, 53, 73, and 91	13-18 lb (6-8 kg)
No. 9	9-13 lb (4-6 kg)
Structure Backfill	
2 in. (50 mm)	25 lb (11.3 kg)
1 1/2 in. (37.5 mm) and 1 in. (25.0 mm)	13-18 lb (6-8 kg)
1/2 in. (12.5 mm)	9-13 lb (4-6 kg)
No. 4 (4.75 mm) and No. 30 (600 µm)	10 oz (300 g)

(d) Exceptions to AASHTO T 85

The in-water weight (mass) shall be determined following the 15 h soaking period prior to determining the SSD weight (mass).

(e) Exceptions to AASHTO T 103 and 104

1. Counting the number of individual particles coarser than the 3/4 in. (19.0 mm) sieve will not be required.

2. For testing ledge rock, the ledge samples shall be crushed to obtain test samples for the designated increments passing the 1 1/2 in. (37.5 mm) sieve and retained on the No. 4 (4.75 mm) sieve. The factors used to calculate the weighted average loss are 30%, 40%, and 30% of the 1 1/2 in. (37.5 mm) - 3/4 in. (19 mm), 3/4 in. (19.0 mm) - 3/8 in. (9.5 mm), and 3/8 in. (9.5 mm) - No. 4 (4.75 mm) increments, respectively.

3. In the case of ledge rock, modify sections 3.3 and 6.2 of AASHTO T 103 and AASHTO T 104 respectively. When the sample received is deficient in material of a component size of any test portion, that material will be supplemented with the available component size to provide the test portion.

4. Modify section 8 of AASHTO T 103 and section 10 of AASHTO T 104. For materials designated as a coarse aggregate, the weighted loss will be calculated considering the material retained on the No. 4 (4.75 mm) sieve as 100% of the sample, and only the total weighted loss reported. In AASHTO T 104 sections 10.1.3.2 and 10.1.3.3 shall not apply, and unless otherwise noted only new solution will be used.

SECTION 905 – MASONRY UNITS

905.01 Clay or Shale Brick

Brick shall be in accordance with the following specifications.

(a) Sewer Brick

Sewer brick shall be in accordance with AASHTO M 91, Grade SS.

(b) Manhole Brick

Manhole brick shall be in accordance with AASHTO M 91, Grade MS.

(c) Building Brick

Building brick shall be in accordance with AASHTO M 114, Grade SW.

905.02 Concrete Brick

Concrete brick intended for use in construction of manholes, catch basins, and similar structures, or as building bricks, shall be in accordance with ASTM C 55, Grade S.

905.03 Concrete Masonry Blocks

Concrete masonry blocks may be rectangular or segmented and, when specified, shall have ends shaped to provide interlock at vertical joints. Solid masonry units shall be in accordance with ASTM C 139. Hollow load-bearing masonry units shall be in accordance with ASTM C 90, Grade N-II.

905.04 Precast Concrete Curbing

Precast concrete curbing shall consist of precast portland cement concrete curb units constructed to the length, shapes, and other details shown on the plans. These units shall be reinforced with steel reinforcement when shown on the plans. Steel reinforcement shall be in accordance with 910.01.

When required for driveways, crossings, closures, or for other reasons a depressed or modified section of curb is indicated, curbing with the required modification shall be furnished.

905.05 Detectable Warning Elements

The detectable warning surface in concrete curb ramps shall be constructed using materials from the Departments approved list of Detectable Warning Elements, which is maintained by the Office of Materials Management. An element manufacturer wishing to add a product to the approved list shall comply with Procedure L of ITM 806.

(a) Brick detectable warning elements shall consist of clay, shale, or similarly naturally occurring earthy substance, subjected to heat treatment at elevated temperatures to form bricks or pavers. The dimensions of the element shall be 8 in. in length, 4 in. in width including any spacing lugs. The thickness of the element shall be 2 in., excluding dome height and edge chamfers. The truncated domes on the surface shall be formed integral with the main body of the detectable warning element and be present on the element prior to heat treatment. The size and physical requirements of the elements shall be in accordance with ASTM C 902 for weather and traffic environment classifications Class SX, Type II, respectively. The truncated domes may be ground off to meet the cap thickness requirement for compressive strength testing.

(b) Brick detectable warning elements shall be predominantly red-brown in color and shall be uniform throughout the element. The color will be determined from the average of 5 color readings for detectable warning elements when measured at the top surface between the raised truncated

domes and determined in accordance with ASTM E 1349, CIE Illuminant D65, 10° Standard Observer, using instrument geometry of 45°/0°, and the CIE L*a*b* color system. The tested elements shall be within the limits as follows:

	Minimum	Maximum
L*	35.0	50.0
a*	6.0	36.0
b*	0.0	30.0

The value of a* shall not be less than 90% of the value of b*. The color difference of any installed element after 1 year of exposure or of an individual detectable warning element from the average color for any product or model from a manufacturer shall not be greater than 5.0 ΔE* units. The color shall be uniform throughout the detectable warning elements.

(c) Cast iron detectable warning elements shall be manufactured from gray iron in accordance with AASHTO M 105, Class 30A as a minimum. The truncated domes shall be as shown on the plans. The tops of the domes and the space between domes shall have a non-slip textured surface. The minimum thickness of the casting shall be 0.300 in. The minimum thickness shall not be measured within the area of integral reinforcing ribs or bracing, domes or the textured surface.

(d) The height tolerance of the truncated domes shall be within 0.18 to 0.26 (3.50 to 6.50 mm). The base diameter, dome top diameter and dome spacing shall be within ± 1/16 in. (± 1.5 mm) of the design value. The design values shall be within the ranges identified in the Standard Drawings. No more than 2 truncated domes per element may be out of tolerance for dimensions.

(e) Detectable warning elements that are not classified as brick in accordance with 905.05(a) or cast iron in accordance with 905.05(c) will be considered. The detectable warning elements shall meet the color requirements of 905.05(b) and the truncated dome requirements of 905.05(d).

905.06 Precast Concrete Units Not Otherwise Covered

These units shall be cast in substantial permanent steel forms. Structural concrete shall attain a minimum 28 day compressive strength of 3,000 psi (20.7 MPa) as determined in accordance with AASHTO T 22. When air entrained concrete is specified, it shall have an air content of from 5% to 8% by volume. The precast units shall be cured in accordance with AASHTO M 170. Water absorption of individual cores taken from such units shall not exceed 9%. Additional reinforcement shall be provided as needed to handle the precast units.

SECTION 906 – JOINT MATERIALS

906.01 Joint Fillers

Joint fillers shall be preformed materials intended to be used in PCCP and bridge joints or as otherwise specified. Joint fillers shall be in accordance with AASHTO M 213.

906.02 Joint Sealing Materials

(a) Joint Sealers

Joint sealers shall consist of materials which are intended to be used in sealing joints and cracks in pavements and structures.

1. Silicone Joint Sealants

a. Physical Requirements

Silicone joint sealants shall be in accordance with ASTM D 5893.

b. Field Evaluation

All silicone joint sealants complying with the physical requirements will be subjected to a field evaluation before approval for general use is granted. The Department will maintain a list of approved Joint Sealant materials, which comply with the physical requirements and field evaluation.

c. Specific Requirements for Installation of Silicone Joint Sealant

The sealant shall be stored in the original unopened container at or below 90°F (32°C). The sealant shall be placed when the ambient temperature is above 40°F (4°C). The equipment used shall be adequate for the placement of the sealant and shall meet the sealant manufacturer's recommendations. Air compressors used for the placement of this sealant shall be equipped with traps which remove moisture and oil from the air.

The approved sealants which are self leveling shall be identified as such on the Department's list of approved Joint Sealant materials, and will not require tooling. Sealants not identified as self leveling on the approved list shall be tooled or applied in such a manner which causes them to wet the joint faces. Such sealants which are not formulated for self leveling will not position properly in the joint under its own weight (mass). A backer rod as set out herein shall be used to control sealant configuration and facilitate tooling. Applicable joint configurations shall be as shown on the plans. After a joint has been sealed, all surplus joint sealer on the pavement surfaces shall be promptly removed. Traffic shall not be permitted over sealed joints until the sealer is tack free.

The sealant shall be delivered in containers plainly marked with manufacturer's name or trade mark.

2. Hot Poured Joint Sealant

a. General Requirements

The sealant shall be in accordance with AASHTO M 324, Type II. The material shall be tested in accordance with ASTM D 5329 except that after blotting, the surface of the blocks shall be blown dry with compressed air.

b. Packaging and Marking

The sealing compound shall be delivered in the manufacturer's original sealed container. Each container shall be legibly marked with the name of the manufacturer, the trade name of the sealer, the manufacturing batch number or lot, the pouring temperature, and the safe heating temperature.

c. Requirements for Installation

The sealant shall be used in accordance with the manufacturer's recommendations. A backer rod as set out herein shall be used to provide the joint configuration in accordance with the standard drawings.

d. Sampling and Testing

Samples may be taken prior to delivery provided the plant or warehouse is located in the geographical area serviced by the Department's inspectors. If not sampled prior to delivery, it will be sampled at the job site. Scheduling shall provide 2 weeks after delivery to the Office of Materials Management for testing. The basis for use will be the applicable laboratory number.

3. Preformed Elastomeric Joint Seals

This joint shall be in accordance with AASHTO M 220. Joint seals furnished under this specification shall be covered by a type A certification in accordance with 916.03(b).

4. Polychloroprene Joint Membrane and Adhesive

Polychloropene joint membrane shall be general purpose, heavy duty polychloropene sheeting with nylon fabric reinforcement. The sheeting shall be in accordance with the following:

Property	Test Method	Requirement
Thickness	ASTM D 751	0.094 in. ± 0.01 in. (2.39 mm ± 0.25 mm)
Breaking Strength, Grab Test, minimum	ASTM D 751	700 lbf x 700 lbf (3,114 N x 3,114 N) (Longitudinal x transverse)
Adhesive Strip, 1 in. by 2 in. (25 mm by 50 mm)	ASTM D 751	9 lbf (40 N) (minimum)
Burst Strength	ASTM D 751	1,400 psi (9.65 MPa) (minimum)
Heat Aging, 70 h, 212°F (100°C)	ASTM D 2136	180° bend with no cracking of coating
Low Temp. Bend Test, 1h, 40°F (-4.4°C)	ASTM D 751	Bend around a 1/4 in. (6 mm) mandrel with no cracking of coating

Polychloroprene joint membrane shall be covered by a type B certification in accordance with 916.

The adhesive used to attach the polychloroprene joint membrane to concrete shall be a black styrene-butadiene rubber base material compatible with both concrete and polychloroprene. The adhesive shall be in accordance with the following:

Property	Test Method	Minimum	Maximum
Viscosity, cps	ASTM D 2196, RVF #6 sp @ 20 rpm	7,500	18,000
Solids, %	ASTM D 1259	28	35
Weight per gal., lb (Mass per L, kg)	ASTM D 1875	6.6 (0.79)	7.0 (0.84)

The adhesive shall be covered by a type C certification in accordance with 916.

(b) Backer Rod

The rod is to act as a bond breaker, to control the thickness of the bead, and to provide support for any required tooling of the sealant.

1. Requirements

When hot poured material is used, compatibility of the backer rod with the hot sealant shall be verified before use. The backer rod shall be a closed cell expanded polyethylene foam or an isomeric polymer foam rod. Diameter and placement shall be as shown on the plans.

2. Certification

Backer rod furnished under this specification shall be covered by a type C certification in accordance with 916.

906.03 Blank

906.04 Blank

906.05 Blank

906.06 Blank

906.07 Bridge Expansion Joints

Joints, including anchor assemblies, shall be shop fabricated, delivered and installed as a continuous unit for lengths up to 46 ft (14 m). Joints longer than 46 ft (14 m) shall be furnished in continuous units or in appropriate shorter sections as shown on the working drawings and approved by the Engineer. Joints used in stage construction shall be furnished in sections appropriate to accommodate the work. All joints furnished in sections shall be spliced with welds, with ends prepared for welding in the shop. All welds shall be in accordance with 711.32.

The profile of the joint in the roadway area shall conform to the roadway cross section. Where changes in direction are required, such as at curbs or concrete rails, the sections shall be cut to the bevel required to produce the same cross section on each piece being joined. Slider plates shall be provided at curbs, walkways, and concrete rails as part of the completed joint assembly. The slider plate shall be the same material as the extrusion and shall be galvanized in accordance with ASTM A 123.

All welds in contact with the elastomeric seals shall be ground smooth. Metal surfaces in direct contact with the elastomeric seal shall be cleaned and treated in accordance with the manufacturer's recommendations to provide a high strength bond between the elastomeric seal and mating metal surfaces. The elastomeric seals shall be clean and free of foreign materials. All exposed structural steel surfaces, except stainless steel or polytetrafluoroethylene coated, shall be shop painted in accordance with 619.

(a) Type SS

Structural steel shall be in accordance with ASTM A 36 (A 36M), A 588 (A 588M), A 1011 (A 1011M), A 242 (A 242M), or Merchant Quality 1010, 1020.

Sealant and grouts shall be in accordance with the manufacturer's recommendation.

The elastomer shall be neoprene in accordance with ASTM D 5973 except that the physical requirements in Table 1 for low temperature recovery, high temperature recovery, and compression-deflection properties will not apply.

The strip seal shall be furnished in 1 continuous length for the entire limits of the installed joint. Field splicing of the strip seal will not be permitted. Miter cut,

vulcanized shop splices will be required in the strip seal. The shop vulcanization of the strip seal splice may be either a hot or cold process so long as the process produces a splice of equal or greater strength than the elastomer.

The structural steel and polyurethane sealant shall be covered by a type C certification, and the elastomer shall be covered by a type B certification, both in accordance with 916.

(b) Type M

This joint shall consist of prefabricated multiple elastomeric seals, separator beams, and support bars. The structural design of the joint shall be in accordance with AASHTO LRFD Bridge Construction Specifications and shall be for the same design loading as the bridge structure at which it is to be installed, but not less than HS 20-44 truck loading and impact. The joint shall be designed to accommodate the movement shown on the plans.

The joint assembly shall be preset by the manufacturer in accordance with the approved working drawings, joint setting data and specifications. The assembly shall be properly secured for shipping and contain provision for final field adjustment at the time of installation. The manufacturer shall furnish a copy of the installation instructions prior to the placement of these joints.

Structural steel shall be in accordance with ASTM A 36 (A 36M), A 1011 (A 1011M), A 242 (A 242M), A 588 (A 588M), or Merchant Quality 1010, 1020 in accordance with ASTM A 576.

Sealant and grout shall be in accordance with the joint manufacturer's recommendation.

Elastomer shall be neoprene in accordance with ASTM D 3542.

The structural steel and sealant shall be covered by a type C certification and the elastomer by a type B certification, both in accordance with 916.

Bearings above and below the support bar shall be a nylon or urethane compound with polytetrafluorethylene riding surfaces. All components of the system shall be accessible to periodic inspection and component replacement if necessary.

The elastomer seals shall be in accordance with the requirements as follows:

1. be held in place by compressive forces throughout the normal limits of joint movement,
2. be supplied and installed in 1 piece;
3. have corner locked edges for a watertight fit;
4. not be any part of the load bearing riding surface;

5. be installed using seal lubricant-adhesive or be mechanically clamped in position to produce a watertight seal;
6. have a shape which promotes self removal of foreign material during normal joint operation;
7. be recessed 1/2 in. (13 mm) below the riding surface throughout the normal limits of joint movement;
8. be held in position by the separator beams;
9. have a hollow box shape for joints utilizing urethane equilibrium control spacers or a strip seal configuration for joints using a mechanical linkage to maintain equidistant separator beam spacing. The joint shall have a maximum opening of 3 in. (75 mm) per seal.

The separator beams shall be in accordance with the requirements as follows:

1. provide the riding surface across the joint;
2. have an extruded or machined shape suitable to hold the seals;
3. be stable against tipping, tilting, or lifting during application of traffic loads by use of a suitable shape and connection to the support bar;
4. be supported individually on their own independent support bars;
5. maintain equidistant spacing through use of suitable urethane equilibrium type control spacers to counter the compressive forces of the seals or through a positive horizontal mechanical linkage or proportioning bar.

The support bars shall be in accordance with the requirements as follows:

1. incorporate stainless steel sliding surfaces to minimize resistance to joint movements;
2. be supported above, below, and laterally as required to prevent lifting, to transmit bearing loads, and to maintain positioning of the bar.

All support bar boxes and joint housings shall have top, bottom, and sides made of steel plate with 1/2 in. (13 mm) minimum thickness. Anchorages shall consist of looped No. 5 reinforcing bars welded to 1/2 in. (13 mm) steel plates spaced at 9 in. (230 mm) centers. Non-welded steel to steel contact will not be permitted.

906.08 High Density Bearing Strip

The strip shall be nontoxic multipolymer plastic in accordance with the following requirements:

Property	Test Method	Requirement
Compressive Strength	ASTM D 695	8,000 to 9,000 psi (55.2 to 62.1 MPa)
Coefficient of Linear Expansion	ASTM D 696	7.62×10^{-4} mm/mm/ºC to 1.27×10^{-3} mm/mm /ºC

The high density bearing strip shall be covered by a type B certification in accordance with 916.

SECTION 907 – CONCRETE, CLAY, AND PLASTIC DRAINAGE COMPONENTS

907.01 Non-Reinforced Concrete Pipe

This pipe shall be in accordance with AASHTO M 86 (M 86M) for the specified diameter and strength classes. When used for underdrain, each section of pipe shall not exceed 3 ft (0.9 m) in length.

907.02 Reinforced Concrete Pipe

This pipe shall be in accordance with AASHTO M 170 (M 170M) for the specified diameters and strength classes. Precast concrete units shall be from a source listed in the Department's List of Certified Precast Concrete Producers, in accordance with ITM 813. Unless otherwise specified, pipe wall design and use of elliptical reinforcement in circular pipe are optional.

The pipe provided shall be in accordance with the class and D-load rating shown in the plans.

When the pipe listed below is specified or permitted, it shall be in accordance with the class noted.

Extra Strength Reinforced Concrete Pipe.....Class IV
Heavy Duty Reinforced Concrete Pipe.....Class V
Reinforced Concrete Pipe.....Class III
Reinforced Concrete Sewer Pipe.....Class II

Precast reinforced concrete end sections shall be in accordance with the cited specifications to the extent to which they apply.

The manufacturer of the steel reinforcement shall furnish to the pipe manufacturer a mill test report. The pipe manufacturer shall certify, on furnished forms that:

(a) The placement of the steel reinforcement is in accordance with the Standard Specifications.

(b) The area of steel reinforcement per linear foot (meter) of pipe is in accordance with or exceeds the specification requirements.

(c) Based on the steel reinforcement manufacturer's mill test report, the steel used in the pipe is in accordance with the specification requirements.

(d) Copies of the steel reinforcement manufacturer's mill test reports shall be on file and available to review for 5 years.

907.03 Reinforced Concrete Horizontal Elliptical Pipe

This pipe shall be in accordance with AASHTO M 207 (M 207M). Certification shall be in accordance with 907.02.

907.04 Precast Concrete Manholes, Inlets, and Catch Basins

These units shall be in accordance with AASHTO M 199 (M 199M). References to diameter are applicable to corresponding dimensions in other than circular sections. Absorption tests will not be required for flat top or base slabs. Certification shall be in accordance with 907.02.

No more than 3 holes shall be cast or drilled in each section for the purpose of handling.

In addition to the requirements of AASHTO M 199 (M 199M), the manhole steps shall be permanently marked with the specific step designation, and the manufacturer's identification. This marking shall remain exposed after installation.

Steps shall be selected from the list of approved Manhole Steps. Requests for adding steps to the list shall be accompanied by: a certified test report demonstrating compliance with AASHTO M 199 (M 199M); instruction for proper installation; complete product description including the ancillary equipment required for installation; and a sample step. The Department may perform a laboratory evaluation of specific steps and may not add steps to the list which are not furnished with ancillary installation equipment.

907.05 Precast Reinforced Concrete Structure Sections

Precast reinforced concrete structure sections shall be from a source listed in the Department's List of Certified Precast Concrete Producers, in accordance with ITM 813. A water-reducing admixture from the Department's list of approved Water-Reducing Admixtures may be used.

Handling devices or holes will be permitted in each structure section. Holes for handling shall be filled with material in accordance with 901.07, 901.08, or with precast concrete plugs which shall be secured with portland cement mortar or other approved adhesive before backfilling. Drilled handling holes shall be filled with

portland cement mortar. Prior to backfilling the structure, all holes shall be covered with joint wrap material with a minimum width of 9 in. (225 mm).

The section ends shall be of such design and shall be so formed that when the structure sections are erected, they shall make a continuous line of structure with a smooth interior free of irregularities. The ends of the structure sections shall be normal to the walls and centerline, except where beveled ends are specified. The surface of the structure sections shall be cast from a smooth steel form or troweled surface. Trapped air pockets causing surface defects shall be considered as part of a smooth steel form finish.

(a) Box

Box structure sections shall be in accordance with ASTM C 1577 and the exceptions to ASTM C 1577 listed in 714.04. Not more than 4 holes may be cast, drilled, or otherwise made in each box section for the purpose of handling or laying.

(b) Three-Sided

Three-sided structure sections shall be in accordance with ASTM C 1504 and the exceptions to ASTM C 1504 listed in 723.04. Not more than 6 holes shall be cast, drilled, or otherwise made in each section for the purpose of handling or laying.

907.06 Precast Reinforced Concrete Headwalls, Wingwalls, Footings and Spandrel Walls

Precast concrete units shall be from a source listed in the Department's List of Certified Precast Concrete Producers, in accordance with ITM 813. A water-reducing admixture from the Department's list of approved Water-Reducing Admixtures may be used.

Handling devices or holes will be permitted in each wingwall and spandrel wall section. Not more than 4 holes shall be cast or drilled in each section for the purpose of handling or setting. Weep holes shall be provided in all wingwalls. Headwalls, wingwalls, and spandrel walls shall be free of fractures and shall be given a finish in accordance with 702.21.

The concrete compressive strength for headwalls, wingwalls, and spandrel walls shall have a minimum 28 day compressive strength of 4,000 psi (27,600 kPa), as determined by compressive strength testing of concrete cylinders. The concrete compressive strength for footings shall have a minimum 28-day compressive strength of 2,000 psi (13,800 kPa), as determined by compressive strength testing of concrete cylinders.

Structural steel used in bolted connections of headwalls or wingwalls to a box-structure section, or of wingwalls to a three-sided-structure section or spandrel wall, shall be in accordance with 910.02(a), and zinc coated after fabrication in accordance with ASTM A 153.

Bolts and studs shall be hot dipped in accordance with 910.02(g)1. Nuts shall be in accordance with ASTM A 563, Grade A, Hex style; unless specified otherwise. Washers shall be in accordance ASTM F 844, unless specified otherwise. Bolts, nuts and washers shall be hot dip zinc coated.

907.07 Joint Membrane System for Precast Reinforced Concrete Box Structure Sections

The Contractor may elect to use an approved self-adhering membrane system in lieu of the detail shown on the plans.

Joint membrane systems shall be in accordance with the following requirements.

PROPERTY	TEST METHOD	REQUIREMENTS
Thickness	ASTM D 3767 Procedure A	59 mil (1.5 mm) Min.
Tensile Strength	Grab Tensile Strength, ASTM D 4632	650 N Min.
Elongation	Grab Tensile Strength, ASTM D 4632	20% Min.
Bursting Strength	Mullen Burst, ASTM D 3786	290 psi (2,000 kPA) Min.
Peel Strength	ASTM D 903	850 N/m Min.
Permeance	ASTM E 96, Water Method	1.05 Perm (60 ng/Pa s m^2) Max.

The membrane system shall be supplied in roll widths of at least 12 in. (300 mm). The membrane shall be a composite sheet material composed of a non-woven fabric and a polymer membrane material. The membrane shall be protected by a release paper.

Material furnished under this specification shall be covered by a type B certification in accordance with 916.

907.08 Clay Pipe

This pipe shall be in accordance with ASTM C 700 for the specified diameters and strength classes for circular non-perforated pipe. When specified, the bell shall have integral spacer lugs to provide for an annular opening and self centering feature. The pipe may be glazed or unglazed, unless otherwise specified.

907.09 Perforated Clay Pipe

This pipe shall be in accordance with ASTM C 700 for the specified dimensions and strength classes. It may be glazed or unglazed, unless otherwise specified. Where vitrified clay culvert pipe is furnished, a pipe end section compatible to that as required for concrete or metal pipe shall be used.

907.10 Drain Tile

This pipe shall be in accordance with AASHTO M 178 (M 178M) for concrete or ASTM C 4 for clay for the specified material, diameters, and quality classes. Standard quality drain tile shall not be used. When specified, the pipe spigot shall have integral spacer lugs to provide for an annular opening and self centering feature. Material furnished under this specification shall be covered by a type C certification in accordance with 916.

907.11 Pipe Joint Sealant

Material for sealing the joints of bell and spigot or tongue and groove concrete or clay pipe or culverts furnished under this specification shall not contain asbestos fibers, shall be covered by a type B certification in accordance with 916, and shall be in accordance with one of the following:

(a) Preformed Flexible Joint Sealants

Joint sealants shall be either bitumen or butyl rubber in accordance with ASTM C 990. The results of the following tests shall be shown on the type B certification.

Property	Test Method
Hydrocarbon Blends	ASTM D 4 (bitumen) or D 297 (butyl)
Ash-Inert Mineral Matter	AASHTO T 111
Volatile Matter	ASTM D 6
Specific Gravity @ 77°F	ASTM D 71
Ductility @ 77°F	AASHTO T 51 or ASTM D 113
Flash Point	ASTM D 92
Fire Point	ASTM D 92
Softening Point	ASTM D 36
Compression Index@ 77°F & 32°F	ASTM C 972
Cone Penetration @ 77°F & 32°F, 150 g, 5 s, mm/10	ASTM D 217
Chemical Resistance	ASTM C 990

(b) Bituminous Mastic Sealant

A cold applied, mineral filled, bituminous joint sealing compound that can be applied to the joints with a trowel when the air temperature is between 20° and 100° F (-7° and 38° C). The bituminous material shall adhere to the concrete or clay pipe so as to make a watertight seal and shall not flow, crack, or become brittle when exposed to the atmosphere.

The mastic shall also be in accordance with the following. The results of the tests shall be shown on the type B certification.

Property	Minimum	Maximum
Grease cone penetration unworked, 77°F (25°C), 150 g, 5 sec., ASTM D 217, mm/10	125	275
Non-Volatile, 10 g., 220°-230°F (105°C-110°C), 24 hr	75%	
Loss on Heating, 325°F (163°C), 5 hr., 50 g		20%
Inorganic Content [complete burn, 1200° to 1400°F (645° to 760°C)]	15%	45%
Flash Point, ASTM D 92 or D 1310	100°F (38°C)	
Fire Point, ASTM D 92 or D 1310	150°F (66°C)	
High Temperature Resistance to Flow	No sag	
Cold Temperature Flexibility	No cracks	

The test for high temperature resistance to flow shall be as follows: trowel joint mastic approximately 1/2 in. (12.5 mm) thick on a porous concrete slab or piece of concrete block. Place in oven at 140°F (60°C) for 10 h.

The test for cold temperature flexibility shall be as follows: trowel joint mastic approximately 1/4 in. (6 mm) on heavy kraft paper or very light gage sheet metal. Condition in a freezer at 10°F (-12°C) for 3 h. Bend the sample over a 1 in. (25 mm) diameter pin or mandrel.

907.12 Joint Mortar

Pipe joint mortar shall consist of 1 part portland cement and 2 parts sand with water as necessary to obtain the required consistency. Mortar shall be used within 30 min after its preparation.

907.13 Rubber Type Gaskets

Ring gaskets for pipe shall be in accordance with ASTM C 1619, class C. Material furnished under this specification shall be covered by a type B certification in accordance with 916. The results of the following tests shall be provided on the type B certification.

Property	Test Method
Tensile Strength and Elongation	ASTM D 412
Hardness	ASTM D 2240
Oven-age tensile reduction, of original	ASTM D 573 and D 412
Oven-age elongation reduction, of original	ASTM D 573 and D 412
Compression Set	ASTM D 395
Water Absorption	ASTM D 471
Ozone resistance	ASTM D 1149
Splice Strength Classification	ASTM D 2527

907.14 Blank

907.15 Blank

907.16 Thermoplastic Pipe Requirements

A list of approved thermoplastic pipe and liner pipe will be maintained by the Department. The list will specify the manufacturer and thermoplastic pipe designation. All of these materials shall comply with the applicable AASHTO or ASTM requirements listed in the following table and will only be accepted from qualified manufacturers. The manufacturer is defined as the plant which produces the thermoplastic pipe. The manufacturer shall become qualified by establishing a history of satisfactory quality control of these materials as evidenced by the test results performed by the manufacturer's testing laboratory.

SUMMARY OF THERMOPLASTIC PIPE SPECIFICATION REQUIREMENTS				
Pipe Material	Standard Specifications	AASHTO	ASTM	Manufacturer Requirements
Corrugated Polyethylene Drainage Tubing	907.17	M 252		ITM 806, Procedure A
Perforated Polyvinyl Chloride Semicircular Pipe	907.18		D 3034	ITM 806, Procedure A
Corrugated Polyethylene Pipe	907.19	M 294		ITM 806, Procedure O
Ribbed Polyethylene Pipe	907.20		F 894	ITM 806, Procedure A
Smooth Wall Polyethylene Pipe	907.21		F 714	ITM 806, Procedure A
Profile Wall Polyvinyl Chloride Pipe	907.22	M 304	F 949	ITM 806, Procedure A
Smooth Wall Polyvinyl Chloride Pipe	907.23	M 278	F 679	ITM 806, Procedure A
Type PSM Polyvinyl Chloride Pipe and Fittings	907.24(a)		D 3034	ITM 806, Procedure A
Schedule 40 Polyvinyl Chloride Pipe	907.24(b)		D 1785	916, Type C Cert.

907.17 Corrugated Polyethylene Drainage Tubing

Tubing and fittings shall be in accordance with AASHTO M 252. Perforations shall be required for tubing used as a longitudinal underdrain. Qualification

requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

907.18 Perforated Polyvinyl Chloride Semicircular Pipe

Perforated polyvinyl chloride semicircular pipe may be used as an alternate to 6 in. (150 mm) or less diameter pipe or tile. Pipe shall be in accordance with ASTM D 3034, SDR 35. This semicircular pipe shall have a smooth top and a smooth, semicircular bottom, nominally 4 5/8 in. (118 mm) in diameter, with perforations uniformly distributed along the top of the bottom section in accordance with AASHTO M 252 perforation requirements. The top section shall extend a minimum of 1/2 in. (13 mm) beyond the top of the semicircular section. The top section shall be approximately 6 3/8 in. (162 mm) wide including the sloping overhangs on each side. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

907.19 Corrugated Polyethylene Pipe

Pipe and fittings shall be in accordance with AASHTO M 294. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure O.

907.20 Ribbed Polyethylene Pipe

Pipe and fittings shall be in accordance with ASTM F 894. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

907.21 Smooth Wall Polyethylene Pipe

Pipe shall be in accordance with ASTM F 714 for nominal diameters of 39 in. (1,000 mm) or less. Fittings shall be in accordance with ASTM F 1055. The pipe sizes shall be in accordance with ISO sizing system. The pipe dimension ratio shall be 26 or less. The resin used in manufacturing this type of pipe shall have a minimum cell classification of 335434C in accordance with ASTM D 3350 or a minimum grade of PE4710 in accordance with ASTM F 714. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

907.22 Profile Wall Polyvinyl Chloride Pipe

Pipe and fittings shall be in accordance with AASHTO M 304 or ASTM F 949. Perforations shall be required when used as a longitudinal underdrain or end bent drain pipe. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

907.23 Smooth Wall Polyvinyl Chloride Pipe

Pipe and fittings shall be in accordance with AASHTO M 278 for pipe sizes 4 in. through 15 in. (100 mm through 375 mm), and ASTM F 679 for pipe sizes 18 in. through 27 in. (450 mm through 675 mm). Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

907.24 Smooth Wall Pipe for Outlets

Pipe and pipe fittings shall be smooth wall, non-perforated plastic pipe. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

(a) Type PSM Polyvinyl Chloride Pipe and Fittings

Pipe and fittings shall be in accordance with ASTM D 3034, SDR 23.5.

(b) Schedule 40 Polyvinyl Chloride Pipe

Pipe shall be in accordance with ASTM D 1785 and shall have a minimum pipe stiffness of 150 psi (1,030 kPa) at 5% deflection when determined in accordance with ASTM D 2412. Material furnished under this specification shall be covered by a type C certification in accordance with 916 and shall reference ASTM D 1785 in the product printline.

907.25 Thermoplastic Liner Pipe

Thermoplastic liner pipe shall be high density polyethylene or polyvinyl chloride pipe with sufficient rigidity to withstand the installation operation and shall exhibit a minimum amount of distortion. The liner pipe shall be free from visible cracks, holes, foreign inclusions, or other defects.

(a) Solid Wall HDPE Liner Pipe

Solid wall HDPE liner pipe shall be in accordance with ASTM F 714. The maximum standard dimension ratio, SDR, for the liner pipe as defined in ASTM F 412 shall be 32.5. The resin used in the manufacture of the liner pipe shall have a minimum cell classification of 345464C in accordance with ASTM D 3350 or a minimum grade of PE4710 in accordance with ASTM F 714. A 12 in. (300 mm) section of the liner pipe shall show no evidence of splitting, cracking, or breaking when compressed between parallel plates to 40% of its outside diameter within 2 to 5 min. Thermoplastic liner pipe may be added to the Department's approved list by completing the requirements of ITM 806, Procedure Q.

(b) Profile Wall HDPE Liner Pipe

Profile wall HDPE liner pipe shall be in accordance with ASTM F 894. The minimum liner ring stiffness constant, RSC, shall be 100. Thermoplastic liner pipe may be added to the Department's approved list by completing the requirements of ITM 806, Procedure A.

(c) Profile Wall PVC Liner Pipe

Profile wall PVC liner pipe shall be in accordance with ASTM F 949. Thermoplastic liner pipe may be added to the Department's approved list by completing the requirements of ITM 806, Procedure A.

907.26 Solvent Cements for Polyvinyl Chloride Pipe and Pipe Fittings

Solvent cement for polyvinyl chloride pipe and fittings shall be in accordance with ASTM D 2564. Material furnished under this specification shall be covered by a type C certification in accordance with 916.

907.27 Elastomeric Seals

Elastomeric seals for joining plastic pipe shall be in accordance with ASTM F 477. Material furnished under this specification shall be covered by a type B certification in accordance with 916. The results of the following tests shall be provided on the type B certification.

Test	ASTM
Tensile Strength	D 412 or D 1414
Ultimate Elongation	D 412 or D 1414
100% Modulus	D 412 or D 1414
Hardness (Durometer)	D 2240 or D 1414
Low-Temperature Hardness	D 2240 or D 1414
Compression Set	D 395 Method B, or D 1414
Accelerated Aging	D 573
Water Immersion	D 471
Ozone Resistance	D 1149
Elastomer Compound Effect on Pipe	F 477
Force Decay (Stress Relaxation)	F 913

907.28 Reinforced Thermosetting Resin Pipe and Pipe Fittings

Reinforced thermosetting resin pipe and accompanying fittings shall be in accordance with ASTM D 2996 for the specified sizes. The short-term rupture strength hoop tensile stress shall be a minimum of 30,000 psi (207 MPa). All pipes shall be pigmented resin throughout the wall thickness. The color of the pipe shall be gray. Painting, gel-coating, or exterior coating of the pipe to obtain the specified color shall not be done. Material furnished shall be covered by a type A certification in accordance with 916. The results of the following tests shall be provided on the type A certification.

Test	ASTM
Wall Thickness & Diameter	D 3567
Short-Term Hydrostatic Failure Strength	D 1599
Longitudinal Tensile Properties	D 2105 or D 638
Stiffness Factor	D 2412, based on 5% deflection

SECTION 908 – METAL PIPE

908.01 Blank

908.02 Corrugated Steel Pipe and Pipe-Arches

Corrugated steel pipe and pipe-arches shall be type I, IA, II, or IIA in accordance with AASHTO M 36 (M 36M).

Corrugated steel pipe, pipe-arches, and coupling bands shall be zinc coated steel or aluminum coated steel in accordance with AASHTO M 36 (M 36M), except as noted herein. They may be fabricated with circumferential corrugations and riveted lap joint construction or with helical corrugations with continuous lock or welded seam extending from end to end of each length of pipe. Reforming the ends of helical corrugated pipe to form circumferential corrugations will be permitted to allow use of circumferential corrugated coupling bands. The reforming shall be limited to the length required to accommodate the coupling bands and in such a manner that there is not appreciable slippage of the seam nor a plane of weakness created.

Polymer precoated galvanized corrugated steel pipe type IA and pipe-arch type IIA have an outer shell of corrugated sheet with helical corrugations and an inner liner of smooth sheet attached to the shell with a helical lock seam.

Fittings, including stub-tee connections and saddle connectors specified in 715.06, shall be shop fabricated. Damage to the coating on fittings shall be repaired in accordance with AASHTO M 36.

If the pipe or pipe-arch invert is to be paved, it shall 1st be coated over half its circumference in accordance with 908.07. The paved invert shall then be constructed in accordance with 908.07.

Sheet metal used to fabricate pipe shall be the same brand from the same manufacturer in any 1 length of finished pipe.

The manufacturer shall furnish to the fabricator a certified mill report for materials shipped to the fabricator. This certified mill report shall list the kind of base metal, actual test results of the chemical analysis and mechanical tests of each heat, the thickness, the weight (mass) of coating, and shall certify that the material complies with specified requirements for the type of metal furnished.

The fabricator shall certify, on furnished forms that:

(a) the fabricated structure has been manufactured in accordance with these Standard Specifications;

(b) based on the sheet manufacturer's certified mill report, the materials used in fabricating the structure were tested and the test results are in accordance with the specified requirements; and

(c) copies of the sheet manufacturer's certified mill report shall be on file and available to review for 5 years.

908.03 Blank

908.04 Corrugated Aluminum Alloy Pipe and Pipe-Arches

Pipes, pipe-arches, and coupling bands shall be in accordance with AASHTO M 196 (M 196M). The pipe shall be type I, IA, II, or IIA. If the pipe invert is to be paved, it shall be in accordance with 908.07.

The sheet manufacturer's certified mill report and the fabricator's certification shall be in accordance with 908.02, except the documents shall be in accordance with the applicable requirements of AASHTO M 196 (M 196M).

Where aluminum alloy pipe culvert is furnished, aluminum alloy end sections shall also be furnished. All component parts shall be aluminum alloy.

908.05 Blank

908.06 Metal End Sections

The end section's metal shall be in accordance with AASHTO M 36 (M 36M) or M 196 (M 196M), whichever is applicable. The sheet metal manufacturer's certified mill report and the fabricator's certification shall be in accordance with 908.02 or 908.04, whichever is applicable.

End sections consisting of multiple panels shall have lap seams which shall be tightly jointed with 3/8 in. (M10) galvanized rivets or bolts.

All steel pipe end sections shall have a toe plate anchor constructed of 0.138 in. (3.5 mm) thick galvanized steel. The toe plate anchor shall be match punched to fit holes in the skirt lip, and shall be supplied loose, and complete with 3/8 in. (M10) diameter galvanized bolts.

Straps for pipe end sections shall be either galvanized No. 6 (20M) reinforcing bars or zinc coated 3/8 in. (10 mm) diameter aircraft cable.

908.07 Fully Bituminous Coated Corrugated and Lined Steel Pipe and Pipe-Arches

The material, fabrication, the manufacturer's certified mill report, and fabricator's certification shall be in accordance with the applicable requirements of 908.02. Coupling bands shall be fully bituminous coated.

After fabrication, the pipe or pipe-arch shall be fully bituminous coated.

Connecting or coupling bands shall be of the 2-piece type when used with coated pipe of 36 in. (900 mm) diameter or larger.

The asphalt material for coating shall be in accordance with 902.01(e). Samples of the asphalt material will be obtained from the working tank prior to or during coating of the pipe, or from strippings off the pipe after coating. When applied to the pipe, the asphalt material shall be free from impurities. The metal shall be free from grease, dust, or moisture. Either process set out below may be used for application.

(a) When the pipe is not preheated, the temperature of the asphalt at the time of immersion shall be 400°F ± 5°F (204°C ± 3°C). The duration of the immersion in the asphalt shall be in accordance with the following:

Thickness	0.052 in. (1.32 mm)	0.064 in. (1.63 mm)	0.079 in. (2.01 mm)	0.109 in. (2.77 mm)	0.138 in. (3.51 mm)	0.168 in. (4.27 mm)
Minimum Immersion Time for 1st Dip (min)	2.0	2.5	3.0	5.0	6.5	8.0

(b) When the pipe is preheated it shall be brought to a temperature of 300°F (149°C) and the asphalt shall be heated to a temperature of 380°F ± 5°F (193°C ± 3°C) before the pipe is dipped.

In either process, the pipe shall be dipped a 2nd time or more if necessary, to give a minimum thickness of 0.05 in. (1.3 mm).

If paved invert is specified, the pipe or pipe-arch shall 1st be fully coated as required. Additional bituminous material shall be applied in the bottom section to form a smooth pavement. Except where the upper edges intersect the corrugations, the pavement shall have a minimum thickness of 1/8 in. (3 mm) above the crests of the corrugations. The pavement shall be applied to the lower quarter of the circumference.

The manufacturer of the asphalt material shall furnish to the pipe fabricator the type of certification specified in the Frequency Manual and in accordance with 916 for each shipment or lot of asphalt material. The pipe fabricator shall keep these certifications on file and available to review for 5 years. In addition, samples from the working tank will be obtained for verification of requirements.

908.08 Polymer Precoated Galvanized Corrugated Steel Culvert Pipe and Pipe-Arches

The pipe or pipe-arch and coupling bands shall be in accordance with AASHTO M 245 (M 245M) with additions in accordance with 908.02. The polymer precoated galvanized steel sheets shall be in accordance with AASHTO M 246 (M 246M), Grade 10/10 (250/250).

908.09 Structural Plate Pipe, Pipe-Arches, and Arches

(a) Steel

Steel structural plate pipe, pipe-arches, and arches shall be constructed from individually galvanized corrugated steel plates as described herein. For pipes and pipe-arches having a thickness less than 0.280 in. (7.11 mm), the bottom plates shall be of the next greater thickness than that specified for the top and side plates, not including corner plates for pipe-arches. The individual plates shall be in accordance with AASHTO M 167 (M 167M) and AASHTO LRFD Bridge Construction Specifications.

The materials and fabrication shall be as follows:

1. The minimum corner plate radius of the arc joining the top and bottom plates of pipe-arches shall be 18 in. (457 mm) for openings up to and including 131 sq ft (12.2 m^2) and 31 in. (787 mm) for openings over 131 sq ft (12.2 m^2). The minimum radius of the arc shall be 31 in. (787 mm) for openings from 98 sq ft (9.1 m^2) up to and including 214 sq ft (19.8 m^2).

2. Assembly bolts shall be in accordance with AASHTO M 164 (M 164M), ASTM A 325 (A 325M), or ASTM A 449. Nuts shall be in accordance with ASTM A 563 (A 563M), grade C (class 8S); AASTHO M 164 (M 164M); or ASTM A 325 (A 325M). Assembly bolts, nuts, and washers shall be galvanized in accordance with ASTM A 153, or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

3. The sheet manufacturer's certified mill report and the fabricator's certification shall be furnished in accordance with 908.02, except the documents shall be in accordance with the applicable requirements of AASHTO M 167 (M 167M).

(b) Aluminum Alloy

Aluminum alloy structural plate pipe, pipe-arches, and arches shall be in accordance with AASHTO M 219 (M 219M). The sheet manufacturer's certified mill report and the fabricator's certification shall be furnished in accordance with 908.02.

908.10 Cast Iron Soil Pipe

This pipe shall be in accordance with ASTM A 74. Markings shall be in accordance with ASTM A 74 or ANSI A 40.1.

908.11 Steel Pipe

This item shall be electric-fusion, arc-welded steel pipe in accordance with ASTM A 139, grade B, or electric-resistance welded pipe in accordance with ASTM A 53, Type E, Grade B, as applicable. Material furnished under this specification shall be covered by a type C certification in accordance with 916.

908.12 Straps, Hook Bolts and Nuts Used in Anchors

Straps shall be of the type and size shown on the plans. Reinforcing bars used for straps shall meet the applicable requirements of 910.01 and shall be galvanized in accordance with ASTM A 767 (A 767M), class I. Aircraft cable used for straps shall be made of zinc coated steel wire, 3/8 in. (9.5 mm) nominal diameter, consisting of seven 19 wire flexible steel strands, with a minimum breaking strength of 14,000 lb (62.3 kN). The cable shall be in accordance with Military Specification MIL-W-83420D.

Hook bolts and nuts shall be of the size shown on the plans, shall be in accordance with ASTM A 307, and shall be galvanized in accordance with ASTM A 153. Threads shall be American Standard Coarse Thread Series Class 2 fit. Threads shall be cleaned after galvanizing to provide a free running fit. Maximum oversizing of the nut threads shall be 1/64 in. (0.4 mm).

908.13 Blank

908.14 Slotted Drain or Slotted Vane Drain Pipe

Slotted drains shall be manufactured from helically corrugated steel pipe in accordance with AASHTO M 36 (M 36M). At the end of the pipe there shall be 2 annular corrugations to permit the corrugated band to fully mesh with the pipe.

The grated assembly shall be made of structural steel in accordance with AASHTO M 183 (M 183M), Grade 36. The assembly shall be suitably welded to the pipe and galvanized after assembly in accordance with AASHTO M 111. The grate shall be of the size and spacing shown on the plans and shall be welded on both sides to each bearing bar with a 3/16 in. (5 mm) fillet weld.

The size and thickness of the corrugated steel slotted drain pipe shall be as shown on the plans.

Slotted vane drain pipe shall be smooth wall polyvinyl chloride in accordance with 907.23, and shall be of the diameter specified. The casting shall be in accordance with 910.05(b). The finish shall be standard black asphalt emulsion. Individual units shall have a minimum weight (mass) of 155 lb (70 kg).

SECTION 909 – PAINT AND LIQUID EPOXY

909.01 General Requirements

All necessary facilities for inspection of materials and manufacture of coatings, paints, and ingredients shall be granted. Free access to all parts of the premises where any or all of these products are being prepared shall be allowed. Material Safety Data Sheets shall be provided.

Paints and coatings shall be furnished ready for use without modification and shall not settle, cake, curdle, liver, gel, or develop excessive change in viscosity between time of manufacture and time of use. It shall remain capable of being readily dispersed with a paddle, or other approved methods, to a consistency appropriate for the intended use. Paints and coatings may be sampled and tested at any time prior to use. If, for any reason, re-sampling and re-testing following initial or prior approval is indicated, the latest test results shall prevail over all previous tests for material that has not been used. Previously approved paint or coating that are stored for future use may be re-sampled and re-tested.

Paints and coatings shall be delivered in new containers of such strength, durability, design, fabrication, and material that the paint shall be suitably protected in transit and in storage against any change in characteristics which would cause rejection on the basis of laboratory or field evaluation. Each container shall bear a label which shows the name and address of the manufacturer, kind of paint or coating, formula identification, date of manufacture, and lot or batch number. The weight per gallon (mass per volume) lb per gal. (kg/L) of the paint shall be accurately determined at 77°F (25°C). The container shall be so filled that the net weight (mass) of the material in the container shall be the product of the weight per gallon (mass per volume) at 77°F (25°C) and the stated number of gallons (liters) in the container.

All containers shall be labeled in accordance with the OSHA requirements for labeling of hazardous chemicals as described in the Hazardous Communications Standard.

909.02 For Metal

Paints for metal surfaces shall be in accordance with the requirements shown below.

(a) Zinc Primers

1. Multi-Component Inorganic Zinc Silicate Primer

These primers shall be of the self-cure type which, when mixed and applied in accordance with these specifications, shall cure without the use of a separate curing solution. The multi-component inorganic zinc silicate primers shall have a maximum of 3 components. The components of each primer shall be packaged in such

proportions that when the full quantity of each component is mixed together, the specified mixed primer shall be yielded.

These inorganic primers shall be in accordance with AASHTO M 300.

Inorganic zinc primer for use on faying surfaces at all slip-critical structural bolted connections using ASTM A 325 or ASTM A 490 high-strength bolts in primary members shall meet class B slip coefficient in accordance with Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints as adopted by the Research Council on Structural Connections.

2. Organic Zinc Primer

Organic zinc primer shall be a self-curing type primer. It shall be in accordance with SSPC paint specification No. 20 type II with exceptions as follows.

Table I, total zinc dust, percent by weight (mass) of pigment requirement shall be a minimum of 84% metallic zinc. Table I, total zinc dust, percent by weight (mass) of total solids requirement shall be a minimum of 72% metallic zinc. The viscosity variation in Kreb Units in Section 6.2 shall be ± 10.

The organic zinc primer shall also be in accordance with the requirements as follows.

a. The viscosity shall be 70 to 100 Kreb units.

b. The weight per gallon (mass per volume) shall be a minimum of 17.0 lb/gal. (2.04 kg/L).

c. The dry time shall be a maximum of 1 h set-to-touch and 24 h dry hard when applied at 6 mil (150 µm) blade clearance to a tin coated steel panel at 25°C and 60% ± 5% relative humidity.

d. The infrared spectrum of the vehicle shall match the infrared spectrum of the vehicle of the sample submitted for formulation approval.

e. The organic zinc primer shall not exceed 3.5 lb/gal. (0.419 kg/L) volatile organic compounds. The cured film shall not contain toxic heavy metals above the regulatory levels of 40 CFR 261.24.

f. The organic zinc primer shall be compatible with inorganic zinc and finish coat paints already on the bridge. The color shall be able to produce a distinct contract with blast cleaned metal surface and the finish coat. The cured organic zinc film

shall be compatible with a top coating of waterborne finish coat paint.

Organic zinc primer for use on faying surfaces at all slip-critical structural bolted connections using ASTM A 325 or ASTM A 490 high-strength bolts in primary members shall meet class B slip coefficient in accordance with Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints as adopted by the Research Council on Structural Connections.

3. Approval of Formulation

The manufacturer shall obtain approval of the formulation prior to furnishing the primers. Only zinc primers from the Department's list of approved Coating Formulations shall be used. Zinc primers will be placed and maintained on the Department's list of approved Coating Formulations in accordance with ITM 606.

(b) Epoxy Intermediate Paint

Epoxy intermediate paint shall be a 2 component coating consisting of an epoxy resin and a curing agent, together with prime and filler pigments, colorants, gellant, leveling agents and solvents. When mixed, this coating shall be suitable for application over inorganic and organic zinc primers and shall be compatible with a polyurethane finish coat. The color of this coating shall contrast significantly from the other coatings within the coating system.

The mixed paint shall be in accordance with the requirements as follows.

Volatile organic compounds, ASTM D 3960, Max. ..... 336 g/L
Volume solids, ASTM D 2697, Min. 60%
Set-to-touch, ASTM D 1640, 6 mils (150 µm) wet film thickness,
25 ± 1°C, Max. .....4 h
Potlife, 25 ± 1°C, Min. .....6 h
Weight (mass)/volume variance from the initially approved
batch, ASTM D 1475, 25°C, Max. ..... 0.060 kg/L
Total solids variance from the initially approved batch,
ASTM D 2369, Max. 3.0%

The infrared spectra of each component and of the mixed coating shall essentially match the spectrums of the initially approved batch.

(c) Polyurethane Finish Coat

Polyurethane finish coat shall be a 2 component polyester or acrylic aliphatic polyurethane suitable for use as a finish coat over epoxy intermediate paint.

The mixed paint shall be in accordance with the requirements as follows.

Volatile organic compounds, ASTM D 3960, Max. ..... 336 g/L
Volume solids, ASTM D 2697, Min. 60%

Set-to-touch, ASTM D 1640, 5 mils (127 µm) wet film thickness,
25 ± 1°C, 50 ± 10% relative humidity, Min. .....30 min
Total solids ASTM D 2369, Min. 70%
Specular gloss, 60°, ASTM D 523, Min. 75
Viscosity, ASTM D 562, Kreb Units, Max. 100
Contrast ratio, ASTM D 2805, 5 ± 0.5 mils (127 ± 13 µm)
wet film thickness, dried 24 h @ 25 ± 2°C on Leneta Form 2A
or 2C, Min. 0.95
Dry hard, ASTM D 1640, 5 mils (127 µm) wet film thickness,
25 ± 1°C, 50 ± 10% relative humidity, Max. .....24 h

The infrared spectra of each component and of the mixed coating shall essentially match the sprectrums of the initially approved batch.

The color of the dried paint film shall match the color number of Federal Standard 595 as follows.

Color No.	Color
14260	Green
15450	Light Blue
17886	White
13538	Yellow
13711	Buff
17038	Black

(d) Waterborne Finish Paint

The waterborne finish coating shall be a single package, high build acrylic emulsion for use as a finish coat over inorganic and organic zinc primers. It shall be compatible with and adhere to the cured zinc primers.

1. Vehicle Component

The vehicle shall consist of an acrylic emulsion together with the necessary antifoamers, cosolvents, coalescing agent, preservatives, and antifreeze in order to produce a coating in accordance with this specification.

2. Pigment Component

The active pigment shall consist of titanium dioxide in accordance with ASTM D 476, type IV, and non-reactive color retentive tinting pigments. The pigment shall contain extenders and additives as required for proper application.

3. Mixed Paint Properties

The mixed paint shall be in accordance with the requirements as follows:

Viscosity, ASTM D 562, Kreb Units.....80 – 100
Weight (mass)/volume, ASTM D 1475, deviation from
approval formulation, Max. .....0.2 lb/gal. (0.024 kg/L)

Pigment grind, ASTM D 1210, Hegman, Min. 5
Total solids, % by weight (mass), ASTM D 2369, Min. 48
Vehicle solids, % of vehicle by weight (mass), Min. 37.5
Dry time, ASTM D 1640, 3 mils (75 µm) wet film thickness on a tin
coated steel panel @ 25 ± 1°C and 50 ± 5% relative humidity, Max:
Set-to-touch, h 1
Dry hard, h 24
Contrast ratio, ASTM D 2805, 5 ± 0.5 mils (125 ± 13 µm)
wet film thickness dried 24 h @ 25 ± 2°C on Leneta
Form 2A or 2C, Min. 0.97
Specular gloss, 60°, 10 mils ± 0.5 mils (250 ± 13 µm) wet film thickness
on a tin coated steel panel, dried 48 h @ 25°C and 50 ± 5% relative
humidity, ASTM D 523, Max.....30
pH, ASTM E 70.....7.0 – 9.0
Volatile organic compounds, ASTM D 3960,
Max.....1.50 lb/gal. (0.180 kg/L)

The infrared spectrum of the vehicle when extracted from the mixed paint in accordance with ASTM D 3168 shall match the infrared spectrum of the sample submitted for formulation approval.

The mixed paint shall be in accordance with the requirements of Sections 5.4 through 5.17 of SSPC paint specification No. 24.

The cured waterborne finish paint shall not contain toxic heavy metals above the regulatory levels of 40 CFR 261.24.

4. Color

The color of the dried paint film shall match the color number of Federal Standard 595 as follows.

Color No.	Color
24227	Green
24466	Light Green
25526	Light Blue
27780	White
23538	Yellow
23717	Buff
27038	Black

5. Approval of Formulation

The manufacturer shall obtain approval of the formulation prior to furnishing the waterborne finish paint. Only waterborne finish paint from the Department's list of approved Coating Formulations shall be used. Waterborne finish paint formulations will be placed and maintained on the list of approved Coating Formulations in accordance with ITM 606.

(e) Finish Coat for Weathering Steel

The finish coat shall be an aliphatic polyurethane or a waterborne acrylic paint. It shall be suitable for use as a finish coat over epoxy intermediate paint. The mixed paint shall be in accordance with the requirements as follows.

Specular gloss, 60°, ASTM D 523, Max. 25.0
Weight (mass)/volume variance from the initially approved
batch, ASTM D 1475, 25°C, Max. ..... 0.048 kg/L
Total solids variance from the initially approved
batch, ASTM D 2369, Max. 2.0%
Volatile Organic Compounds, ASTM D 3960, Max. ..... 336 g/L

The dried paint film shall match color number 20045 of Federal Standard 595.

909.03 Structural Steel Coating System

This coating system shall consist of an inorganic zinc primer, an epoxy intermediate paint, and a polyurethane finish coat for the painting of steel bridges and other structural steel. All of the coatings within any coating system shall be manufactured by the same manufacturer and shall be compatible with 1 another. All coatings shall be in accordance with 909.02.

(a) Toxicity

The cured film of each coating within the structural steel coating system shall not contain any toxic heavy metals above the limits of the regulatory levels of 40 CFR 261.24, table 1, when tested in accordance with EPA TCLP, or contain any other material which will require characterization as a hazardous waste for the disposal of the dried film.

(b) Resistance

The coating system shall be tested in accordance with the requirements of NEPCOAT, Specification Criteria For Protective Coatings, dated June 6, 1996. The coating system shall be in accordance with all of the acceptance criteria and shall maintain a specular gloss retention of 60% relative of the initial gloss and a maximum color change of 15 ΔE for Test No. 3, Weathering Resistance.

(c) Approval of Structural Steel Coating System

The manufacturer shall obtain approval of each structural steel coating system prior to furnishing any of these coatings. Only structural steel coating systems from the Department's list of approved Structural Steel Coating Systems shall be used. Structural steel coating systems will be placed and maintained on the Department's list of approved Structural Steel Coating Systems in accordance with ITM 606.

909.04 Field Paint for Wood or Metal

The primers for field paint shall be formulated for minimal surface preparation, provide adhesion to the substrate and be compatible with the finish coat. The primers

shall not contain lead, chromium, or other heavy metals which would require classification as a hazardous waste upon removal. The primers shall comply with the current IDEM VOC regulations and shall be used as follows.

a. For unpainted galvanized steel and other ferrous metals, use 1 coat of a zinc dust-zinc oxide pigmented primer.

b. For non-ferrous metals, use 1 coat of primer formulated for use on non-ferrous metals.

The field paint finish coat shall be an exterior type coating. It shall be chalk resistant, gloss retentive, and suitable for application by brush, roller, or spray. This coating shall comply with the current IDEM VOC regulations and shall not contain lead, chromium, or other heavy metals which would require classification as a hazardous waste upon removal. The color of this coating shall be as specified.

909.05 White and Yellow Traffic Paint

(a) Blank

(b) Fast Dry Traffic Paint

1. General Requirements

The general requirements specified in 909.01 shall apply except as modified herein.

White and yellow traffic paint shall be used on pavements for centerlines, lane lines, or as otherwise specified. In addition to its other requirements, when glass beads are applied, it shall be such that it shows capillary action in the interstices and voids existing between the beads sufficient to cause the level of the paint to be raised approximately 2/3 the diameter of the beads to provide anchorage and refraction. The capillary action shall be such that it does not cause complete envelopment. The paint, as furnished, shall contain no glass beads.

The paint shall be ground to a uniform consistency, and it shall permit satisfactory application by the pressure spray type of painting machine. This painting equipment is designed to apply reflectorized lines, using a pressurized bead application method, 4 to 6 in. (100 to 150 mm) wide, at a wet film thickness of 0.015 in. (380 µm) on clean dry pavement, with the material being heated at a maintained temperature from ambient air temperature to a maximum of 180°F (82°C), at the atomized spray gun, at a minimum ambient temperature of 40°F (4°C). The material shall be capable of being applied under these conditions at speeds of 10 to 15 mph (16 to 24 km/h). The material shall have physical characteristics which permit it to be pumped at a minimum temperature of 40°F (4°C) through pumps from the shipping container into the paint tank on the paint machine, and then by pumps

through the paint machine plumbing system to and through the heat exchanger and to the spray gun at the proper pressure and temperature.

2. Specific Requirements

The paint shall dry to a no tracking condition in no more than 60 s. The no tracking condition shall be determined by actual application on the pavement at a wet film thickness of 15 mils (380 µm) with white or yellow paint covered with glass beads at a rate of 6 lb/gal. (0.7 kg/L). The paint lines for this test shall be applied with the specialized striping equipment operated so as to have the paint at temperatures up to 180°F (82°C) at the spray orifice. This maximum no tracking time shall not be exceeded when the pavement temperature varies from 35 to 120°F (2 to 49°C), and under all humidity conditions providing that the pavement is dry. The no tracking time shall be determined by passing over the paint line 60 s after paint application, in a simulated passing maneuver at a constant speed of 30 to 40 mph (48 to 64 km/h) with a passenger car. A line showing no visual deposition of the paint to the pavement surface when viewed from a distance of approximately 50 ft (15 m) from the point where the test vehicle has crossed the line shall be considered as showing no tracking and conforming to the requirement for field drying conditions. This field dry time test shall be used for production samples only.

In addition to the above, the paint shall meet the following requirements:

	Min.	Max.
Pigment, Federal Standard 141A, Method 4022, percent by weight (mass)	54	60
Titanium Dioxide, ASTM D 476, Types II, III, and IV, white only, lb/gal. (g/L) of paint	0.8 (96)	-
Medium Chrome Yellow, ASTM D 211, Type III, yellow only, lb/gal. (g/L) of paint	1.2 (144)	-

Other pigments may be used, provided the amount of pigment is such that there will be a minimum of 1.04 lb/gal. (0.125 kg/L) of pure lead chromate per gallon of paint.

Vehicle Solids, percent of vehicle by weight (mass), Federal Standard 141A, Method 4053	35	-
Total Non-Volatiles, Federal Standard 141A, Method 4042, percent by weight (mass)	72	-
Viscosity @ 77°F (25°C), ASTM D 562, Krebs Units	80	100
C.I.E. illuminant C, 2° standard observer, ASTM E 1349, % White	84	-

Yellow	50	-
Color, yellow only, x-y C.I.E. coordinates for green limit, FHWA color chart of June 1965 C.I.E. illuminant C, 2° standard observer	Match the green limit ± 8%	
Contrast ratio, ASTM D 2805, wet film 15 ± 1 mil (380 ± 25 µm) black – white chart paper, air dried at least 16 h	0.96	-
Uncombined (free) Water, Federal Standard 141A, Method 4081, %	-	1.0

(c) White and Yellow Waterborne Traffic Paint

White and yellow waterborne traffic paints shall consist of an emulsion of pigmented binder.

When glass beads are induced into the paint lines, the paint shall provide capillary action in the interstices and voids between the glass beads sufficient to cause the level of paint to raise approximately 2/3 the diameter of the glass beads. This capillary action shall not cause complete envelopment of the glass beads. The paint as furnished shall not contain glass beads. The paint shall be ground to a uniform consistency, and it shall permit satisfactory application by the pressure-spray type of painting equipment. The painting equipment shall use a pressurized bead application method that is designed to apply 4 to 6 in. (100 to 150 mm) reflectorized paint lines at paint temperature up to 150°F (65°C). The paint shall be capable of being applied at speeds of 10 to 15 mph (16 to 24 km/h).

The paint shall not darken under the heating conditions of application, or show appreciable discoloration due to sunlight exposure and aging of the paint lines. The paint shall be furnished ready for use without thinning, screening, or other modifications and shall not settle, cake, curdle, liver, gel, or have an excessive change in viscosity in the container during a period of 1 year after manufacture. The paint shall be capable of being stirred to a uniform consistency. The paint shall be able to withstand variations of temperatures when stored outside in the containers as delivered, and in an environment above 40°F (5°C). All paint furnished under these specifications will be rejected if it contains skins, thickened or jelly-like layers, lumps, coarse particles, dirt, or other foreign materials which prevent the proper application of the paint, or produces a non-uniform paint line. All paint which cannot be transferred by pumps on the paint equipment from the shipping containers and through the paint equipment due to excessive clogging of screens, filters, or paint guns will be rejected.

The paint shall dry to a no-tracking condition in less than 60 s. The no tracking condition shall be determined by actual application of the paint on the pavement at a wet film thickness of 15 mils (380 µm) with glass beads at a rate of 6 lb/gal.

(0.7 kg/L). The paint lines for the determination of no-tracking condition shall be applied with the specialized painting equipment operated so as to have the paint at application temperatures up to 140°F (60°C) at the spray guns. This maximum no tracking time shall not be exceeded when the pavement temperature varies from 50 to 120°F (10 to 50°C), and with all relative humidity conditions providing that the pavement is dry. The no tracking time shall be determined by passing over the paint line 60 s after the paint application, in a simulated passing maneuver at a constant speed of 30 to 40 mph (48 to 64 km/h) with a passenger car. A paint line with no visual deposition of the paint to the pavement surface when viewed from a distance of approximately 50 ft (15 m) from the point where the vehicle crossed the paint line shall be considered as showing a condition of no tracking and being in accordance with the requirement.

1. Composition Requirements

The exact composition of the waterborne traffic paint shall be left to the discretion of the manufacturer, provided that the finished product is in accordance with all of the specification requirements.

The pigment portion of these paints shall be a combination of prime and extender pigments as required to produce either white or yellow waterborne traffic paint in accordance with the color and other requirements of the finished product. The yellow waterborne traffic paint pigment shall contain pigment yellow Colour Index Number 65 and/or 74 and/or 75. The white waterborne traffic paint pigment shall contain titanium dioxide in accordance with ASTM D 476. The non-volatile portion of the vehicle shall be composed of a 100% acrylic polymer.

The cured film of waterborne traffic paint shall not contain toxic heavy metals above the limits of the regulatory levels of 40 CFR 261.24 Table 1 when tested in accordance with EPA Toxicity Characteristics Leaching Procedure Test Method 1311 in Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, EPA publication SW-846. It shall not contain other hazardous materials which would require characterization as a hazardous waste for the disposal of the dried film.

2. Specific Requirements

	Minimum	**Maximum**
Volume solids, ASTM D 2697, %	58.0	--
Total solids by mass, ASTM D 3723, %	73.0	--
Pigment by mass, ASTM D 3723, %	45.0	57.0
Vehicle solids by mass of the vehicle, %	44.0	--
Viscosity, ASTM D 562, Kreb Units	75	95

Unit mass @ 77°F (25°C), ASTM D 1475, lb/gal. (kg/L)	12.50 (1.498)	--
Unit mass @ 77°F (25°C), variation between manufacturer's production batches, ASTM D 1475, lb/gal. (g/L)	--	0.20 (24)
Dry time, ASTM D 711, 15 mils (380 µm) wet film thickness, at 77°F (25°C), 50% ± 5% relative humidity, airflow of less than 50 cu ft/min (1.4 m^3/min), without glass beads	--	10 min
Reflectance Factor, Y, C.I.E. illuminant, C, 2° standard observer, ASTM E 1349, 15 mils (380 µm) wet film thickness, air dried a minimum of 16 h, %		
White	84	--
Yellow	50	57
Color, yellow only, by & y C.I.E. Coordinates for the strong limits of FHWA color chart PR1, 15 mils (380 µm) wet film thickness, air dried a minimum of 16 h, measured on white background, C.I.E. illuminant, C, 2° standard observer, % deviation	Match the strong limits	± 6.00
Coarse material retained on a No. 30 (600 µm) sieve, ASTM D 185, %	--	0.05
Bleeding ratio, Federal Specifications TT-P-1952B, except asphalt saturated felt paper shall be in accordance with ASTM D 226, Type I	0.97	--
Contrast ratio, ASTM D 2805, 10 mils (254 µm) wet film thickness on Leneta Form 2A or 2C, air dried a minimum of 16 h	0.96	--
Volatile organic compounds, ASTM D 3960, lb/gal. (g/L)	--	1.25 (150)

Abrasion resistance, Federal Specifications TT-P-1952B, L	190	--
Freeze-thaw stability, Federal Specifications TT-P-1952B, change in consistency, Kreb Units	--	10
Heat stability, Federal Specifications TT-P-1952B, change in consistency, Kreb Units	--	10
Scrub resistance, ASTM D 2486, with abrasive medium and shims, cycles	300	--
Water resistance, Federal Specification TT-P-1952B	Film shall not soften, blister, wrinkle, or lose adhesion	
Flexibility, Federal Specifications TT-P-1952B	No cracking or flaking of film	
Infrared spectrum of the vehicle ASTM D 3168	Shall match spectrum of manufacturer's previously submitted samples	

Dilution test shall be capable of dilution with water at all levels without curdling or precipitation such that wet paint can be cleaned up with water only.

3. Formulation Approval

The manufacturer shall obtain approval of the waterborne traffic paint formulation prior to furnishing the paints. Only waterborne traffic paints from the Department's list of approved Coating Formulations shall be used. Waterborne traffic paint formulations will be placed and maintained on the Department's list of approved Coating Formulations in accordance with ITM 606.

909.06 Blank

909.07 Blank

909.08 Blank

909.09 Epoxy Penetrating Sealers

(a) Polysulfide Type

The material shall be a system composed of a mixture of equal parts by volume of components A and B. Component A shall be a solution of totally reactive epoxy resin, which may be cut back with a reactive diluent, such as cresyl glycidyl ether. Component B shall be a solution of the specified liquid polysulfide polymer and an amine curing agent compatible with the epoxy resin. The use of butyl glycidyl in either compound shall be prohibited.

Neither component shall contain a residual constituent which is unreactive with the epoxy resin. An amount of liquid polysulfide polymer sufficient to comply with the mercaptan content, total sulfur, and total sulfur/mercaptan ratio requirements given below shall be contained within the component B.

Non-volatile, or non-reactive extenders will not be permitted in either component. Each component shall have a usable shelf life of at least 6 months from the date of delivery.

The epoxy resin shall be manufactured from epichlorohydrin and bisphenol A, shall contain no more than trace amounts of hydrolyzable chlorine, and may contain sufficient reactive diluent, such as cresyl glycidyl ether, to conform to the specific requirements of 909.09(c).

(b) Unmodified Type

The material shall be a system composed of a mixture of equal parts by volume of components A and B. Component A shall be a solution of a totally reactive epoxy resin, and component B shall be a solution of an amine curing agent compatible with the epoxy resin. The use of butyl glydicyl ether in either component shall be prohibited.

Neither component shall contain a residual constituent which is unreactive with the epoxy resin. Non-volatile extenders will not be permitted in either component. Each component shall have a usable shelf life of at least 6 months from the date of delivery.

The epoxy resin shall be manufactured from epichlorohydrin and bisphenol A, shall contain no more than trace amounts of hydrolyzable chlorine, shall contain no reactive diluents, and shall be in accordance with 909.09(c).

(c) Specific Requirements

Specific requirements for each type of sealer shall be as shown in the table.

Property	Polysulfide Type	Unmodified Type	Test Method
RESIN			
Epoxide Equivalent	180 – 195	180 – 195	ASTM D 1652
Viscosity @ 77°F (25°C), Poises	5 – 7	100 – 180	ASTM D 2196, Method A
Color (Gardner) Max.	5	5	ASTM D 1544
COMPONENT A			
Viscosity @ 77°F (25°C), cps, Max.	40	40	ASTM D 2196, Method A
Weight (mass) per Epoxy Equivalent	180 – 195	180 – 195	ASTM D 1652 Corrected to 100% Solids Basis
Color	Clear Amber	Clear Amber	Visual
Infrared Spectrum	Shall Essentially Match Std. Spectrum	Shall Essentially Match Std. Spectrum	AASHTO T 237
COMPONENT B			
Viscosity @ 77°F (25°C), cps, Max.	40	40	ASTM D 2196, Method A
Color	Clear Amber	Clear Amber	Visual
Infrared Spectrum	Shall Essentially Match Std. Spectrum	Shall Essentially Match Std. Spectrum	AASHTO T 237
Total Sulfur, % Min. Corrected to 100% Solid Basis	11.0		ASTM E 443, or other Approved Method
Mercaptan, % Min.	1.8		ITM 602
Ratio of Total Sulfur % to Mercaptan %	6.2 – 8.0		
1/1 VOLUME MIXTURE OF A AND B			
Viscosity @ 77°F (25°C), cps, Max.	40	40	ASTM D 2196, Method A
Total Solid, %, Min	50	50	ASTM D 1644 (Note 1)
Ash %, Max	0.5	0.5	ASTM D 482
Flexibility	No Breaking or Cracking of Film	No Breaking or Cracking of Film	ITM 604
Moisture Permeability, %, Max	0.8	0.8	ITM 605
Color	Clear Amber	Clear Amber	Visual (Note 2)
Set to Touch, Hrs., Max.	4 (Note 3)	4 (Note 3)	FED. Test Method Std. 141 (Note 4)

(Note 1) Method A, except sample size shall be 3.0 grams ± 0.1 gram.
(Note 2) Poured on glass plate, and cured 48 h @ 70 to 80°F (21 to 27°C).
(Note 3) Applied to tin coated steel panel, approximately 20 ga., previously warmed to 90°F ± 2°F (32°C ± 1°C).
(Note 4) Method 4061.1, applied at mixture temperature of 90°F ± 2°F (32°C ± 1°C).

The polysulfide polymer used in formulation of polysulfide sealer shall be a difunctional mercaptan made from 98 mole percent of bis, 2-chlorethyl, formal and 2 mole percent of trichloropropane, and shall be in accordance with the following requirements.

Property	Requirements	Test Method
Specific Gravity @ 20/20°C	1.24 – 1.30	ASTM D 1963
Viscosity at 25°C, Poises	7 – 12	ASTM D 2196, Method A
pH, Water Extract	6.0 – 8.0	AASHTO T 200
Moisture Content, %	0.1 Max.	Fed Test Method Std. 141A Method 4082
Pour Point, °C	-26.8 Max.	ASTM D 97
Molecular Mass Av.	1000 Max.	Empirical Formula
Flash Point, (Cleveland), °C	200 Min.	AASHTO T 48
Sulfur, %	36 – 40	ASTM D 1552
Color, Hellige	9 – 12	Fed Test Method Std. 141A Method 4242

(d) Low Temperature Epoxy Penetrating Sealer

A low temperature epoxy penetrating sealer shall consist of a system composed of a mixture of equal parts by volume of a totally reactive epoxy resin solution, and a solution of an amine curing agent. The epoxy materials shall be in accordance with 909.09(a) or 909.09(b). The material, when mixed in accordance with the manufacturer's recommendations, shall be capable of complete curing when applied to a concrete surface at a temperature of 35°F (2°C) or above, and with an ambient air temperature of 35°F (2°C) or above. The material shall be in accordance with 909.09(c), except the set-to-touch shall be determined at 20° ± 2°F (-7° ± 1°C) when applied to a tin coated steel panel at a mixture temperature of 77° ± 2°F (25° ± 1°C).

(e) Packaging and Marking

Each component shall be packaged in clean steel containers. Containers for component B shall be lined with a material inert to chemical reaction with the contents.

Each container shall be clearly marked with the product's identification, component designation (A or B), manufacturer's name, date of manufacture, formulation number, batch number, mixing directions, and such warning information as may be appropriate or required by law. A batch shall consist of a single charge of all ingredients in a mixing vessel and is not to be confused with the formulation number.

(f) Approval of Formulation

Prior to furnishing any material, the manufacturer shall obtain approval of formulation. Only epoxy penetrating sealers from the Department's list of approved

Coating Formulations shall be used. Epoxy penetrating sealers will be placed and maintained on the Department's list of approved Coating Formulations in accordance with ITM 606.

909.10 Proprietary PCC Sealers

Proprietary PCC sealers shall be selected from the Department's list of approved Other Concrete Sealers. A proprietary PCC sealer may be added to the approved list by completing the requirements in accordance with ITM 806, Approved List Procedure C.

(a) Properties

The proprietary PCC sealer shall be in accordance with NCHRP 244, Series IV, Southern Climate Weathering Test and possess the following properties.

Property	Requirement
Reduction of Chloride Ion Content	90% of the Control
Active Ingredients, Minimum	
Silane Based	20%
Siloxane Based	15%
Others	10%

(b) Test Report

The testing shall be performed by a recognized laboratory in accordance with ITM 806.

The proprietary PCC sealers shall be delivered to the jobsite in unopened containers with the manufacturer's numbered seal intact.

909.11 Epoxy-Resin-Base System for Bonding Plastic Concrete to Hardened Concrete

Two-component, epoxy-resin bonding systems for use in bonding freshly mixed concrete to hardened concrete shall be in accordance with ASTM C 881 for type II, grade 2, and the class consistent with the ambient temperature as follows. Class A for use below 40°F (4°C); class B for use between 40°F (4°C) and 60°F (16°C); and class C for use above 60°F (16°C). Material furnished under this specification shall be covered by a type C certification in accordance with 916.

909.12 Epoxy Resin Additives for Injection into Concrete

The epoxy resin adhesive shall be of low enough viscosity such that it flows to the next open port in the surface seal material. The adhesive shall be capable of penetrating crack widths down to 0.005 in. (125 µm). The adhesive shall be capable of bonding to dry or damp surfaces. The adhesive shall exhibit a slant shear strength exceeding the concrete strength when tested fully cured in accordance with AASHTO T 237.

The surface seal material shall have adequate strength to hold injection fittings in place and to resist injection pressures adequately to prevent leakage during injection.

The epoxy resin adhesive for injection shall be covered by a type C certification in accordance with 916.

SECTION 910 – METAL MATERIALS

910.01 Reinforcing Bars and Dowel Bars

(a) General

Unless otherwise specified, bars for concrete reinforcement shall be deformed billet steel, grade 60 (420). Tie bar assemblies used in lieu of bent tie bars shall be in accordance with the minimum total ultimate strength and minimum total yield strength requirements specified for bent tie bars; bend test and elongation will not be required.

Reinforcement used in precast or precast prestressed concrete structural members, including deck panels, shall be in accordance with ASTM A 615 grade 60 (A 615M, grade 420) or ASTM A 706 grade 60 (A 706M grade 420).

Reinforcing bars shall be furnished by selecting bars made by a manufacturer on the list of Certified Uncoated Reinforcing Bar Manufacturers and in accordance with ITM 301. When shipped to the project site, the reinforcing bars shall be accompanied by the type of certifications specified in ITM 301 and in accordance with 916.

(b) Specific Requirements

1. Billet Steel Bars

Billet steel bars shall be in accordance with ASTM A 615 (A 615M).

2. Threaded Tie Bar Assembly

The threaded tie bar assembly shall be deformed billet steel, grade 60 (420) or higher, in accordance with 910.01(b)1 and a coupling device. The minimum strength of the tie bar assembly shall be 125% of the designated yield strength of the bar from which it is manufactured. Where epoxy coated threaded tie bar assemblies are specified, an epoxy coating with a minimum film thickness of 6 mils (150 µm) shall be applied to the coupling device and epoxy coated reinforcing bars shall be provided in accordance with 910.01(b)9 with the exception that the epoxy coated bar is not required to be furnished from the list of Certified Reinforcing Bar Epoxy Coaters.

3. Splicing Systems

Reinforcing bar splicing systems shall be selected from the list of approved Reinforcing Bar Splicing Systems. A manufacturer may request to have a splicing system added to the list by submitting 3 randomly selected epoxy coated bars of each bar designation to be included as an approved splicing system on the list. The samples furnished shall be assembled. The splicing system will be tested for tensile strength in accordance with ASTM A 370 and shall reach 150% of the specified yield on all 3 samples for each bar size submitted. Splicing systems demonstrating consistent, repeatable, and passing test results will be added to the list. Approved bar designations will be noted on the list.

4. Blank

5. Steel Welded Wire Reinforcement, Smooth

Smooth steel welded wire reinforcement shall be in accordance with ASTM A 185, except as follows.

a. The wire used in manufacturing the welded wire reinforcement shall be as drawn, not galvanized, unless otherwise specified.

b. The welded wire reinforcement shall be furnished in flat sheets unless otherwise permitted or specified.

c. Weld shear tests of welded wire reinforcement shall be performed by the manufacturer on the test specimens obtained for testing tensile properties in accordance with the Frequency Manual. If there is weld shear failure, additional test specimens shall be tested in accordance with ASTM A 185.

6. Steel Welded Wire Reinforcement, Deformed

Deformed steel welded wire reinforcement shall be in accordance with ASTM A 497, except as follows.

a. The wire used in manufacturing the welded wire reinforcement shall be in accordance with ASTM A 496.

b. The welded wire reinforcement shall be furnished in flat sheets unless otherwise specified or permitted.

c. Weld shear tests of welded wire reinforcement shall be performed by the manufacturer on the test specimens obtained for testing tensile properties in accordance with the Frequency Manual. If there is shear failure, additional test specimens shall be tested in accordance with ASTM A 497.

7. Uncoated 7 Wire Strand

Uncoated 7 wire strand shall be in accordance with ASTM A 416. The strand shall have the minimum tensile strength and initial tension shown on the plans.

Uncoated 7 wire strand shall be covered by a type A certification in accordance with 916. The certification shall include the lot number, size, cross-sectional area, yield strength, breaking strength, strand composition, modulus of elasticity, and a load-elongation curve for each size of strand supplied.

8. Steel Spiral Reinforcement

Steel spiral reinforcement shall be either:

a. deformed billet steel, ASTM A 615, grade 60 (A 615M, grade 420); or

b. cold drawn steel wire, ASTM A 82.

9. Epoxy Coated Reinforcing Bars

Epoxy coated reinforcing bars shall be furnished by selecting bars coated from an applicator's plant on the list of Certified Reinforcing Bar Epoxy Coaters and in accordance with ITM 301. The epoxy coating material shall be selected from the list of approved Epoxy Coating for Steel.

Epoxy coated reinforcing bars shall be in accordance with ASTM A 775 (A 775M), except as follows.

a. the bars shall be in accordance with 910.01(b)1;

b. the coating color shall contrast with the color of iron oxide;

c. tensile and bend tests shall be performed on the bars. If an examination of the bend test specimen suggests the need, the adhesion of the coating shall be checked by subjecting additional specimens to the 120° bend test. Hairline cracks without bond loss will be acceptable provided there are not more than 2 and the length of either crack does not exceed 1/4 in. (6 mm). The average coating thickness shall be 9 to 14 mils (225 to 350 µm) after cure. The thickness measurements shall be made in accordance with ASTM G 12. The coating thickness shall be an average based on 12 individual readings. No specific correction for the base preparation process shall be applied to the thickness measurements.

d. epoxy coated reinforcing bars furnished by coaters on the list of approved Certified Reinforcing Bar Epoxy Coaters shall be

accompanied by the types of certifications specified in ITM 301 and in accordance with 916.

e. repair and handling procedures shall be in accordance with 703.04. The patching material shall be in accordance with the Annex to ASTM D 3963 (D 3963M).

Epoxy coated support devices for epoxy coated reinforcing bars shall be in accordance with ASTM A 775 (A 775M), except as follows.

a. the steel shall be in accordance with 910.01(b)1;

b. the coating color shall contrast with the color of iron oxide;

c. the coating thickness shall be 6 to 20 mils (150 to 500 µm) after cure. The thickness measurements shall be made in accordance with ASTM G 12.

10. Dowel Bars

Dowel bars shall be in accordance with AASHTO M 254 and the metal core in accordance with AASHTO M 255, grade 60 (420). The dowel bar area and weight (mass) for the nominal bar diameter shall be as follows.

Nominal Bar Diameter, in. (mm)	Cross Sectional Area, sq in. (mm^2)	Weight (Mass) lb/ft (kg/m)
1 (25)	0.79 (510)	2.670 (3.973)
1 1/4 (32)	1.23 (794)	4.172 (6.209)
1 5/16 (33)	1.35 (871)	4.600 (6.846)
1 1/2 (38)	1.77 (1142)	6.008 (8.941)

Dowel bars shall be coated with an epoxy coating material selected from the list of approved Epoxy Coating for Steel. The coating thickness after cure shall be a minimum of 7 mils (175µm). Dowel bars shall not have burring or other deformation restricting slippage in concrete. Dowel bar ends shall be saw cut. Chips from the cutting operation shall be removed from coated bars.

Dowel bars shall be furnished by selecting bars made by a coater and manufacturer on the list of approved Certified Reinforcing Bar Epoxy Coaters and in accordance with ITM 301. When shipped to the project site, the dowel bars shall be accompanied by the types of certifications specified in ITM 301 and in accordance with 916.

(c) Inspection, Sampling, and Testing

All reinforcing bars may be inspected, sampled, and tested after delivery to the project.

910.02 Structural Steel

(a) Structural Steel

Unless otherwise specified, structural steel shall be in accordance with ASTM A 709, grade 36 (A 709M, grade 250).

(b) Weathering Steel

Steel in accordance with ASTM A 709 that has an atmospheric corrosion resistance index that meets or exceeds the index value shown in ASTM A 709.

(c) High Strength Structural Steel

This steel, when specified, shall be in accordance with ASTM A 709, grade 100 (A 709M, grade 690); ASTM A 709, grade 50 (A 709M, grade 345); or ASTM A 709, grade 50W (A 709M, grade 345W).

The corrosion resistance of ASTM A 709, grade 50W (A 709M, grade 345W) steel shall be at least 4 times that of structural carbon steel. The steel fabricator, when placing the order, shall state that the steel is for bridge use, and that the steel shall be used in the bare, unpainted condition.

All fasteners used in conjunction with ASTM A 709, grade 50W (A 709M, grade 345W) steel shall be friction type high-strength steel bolts in accordance with ASTM A 325 (A 325M) type III. Certification and a sample shall be submitted to the Engineer prior to start of erection.

All plates and bars produced from ASTM A 572 (A 572M) steel over 3/4 in. (19 mm) in thickness shall be “killed fine grain practice”.

(d) High Performance Steel

High performance steel, HPS, shall be in accordance with ASTM A 709 (A 709M). In addition to the conditions listed in Section 6.7 of ASTM A 709 (A 709M), high performance steel may be furnished as hybrid/mixed design structural components using high performance steel plates in combination with high strength, low alloy steel plates and shapes, for welded or bolted applications in bridge construction.

The impact testing requirements for HPS in accordance with 10.1 and 10.2 of ASTM A 709 (A 709M) shall meet temperature zone 2.

(e) Charpy V-Notch Toughness Tests

Structural steel, except members exempted below, shall meet the longitudinal Charpy V-Notch test requirement as specified in the following table for the type or types of steel specified or furnished. Sampling and testing procedures shall be in accordance with ASTM A 673 (A 673M). The H frequency of heat testing shall be

used. Charpy V-Notch test data shall be included on the mill test reports for structural steel specified in 711.08 and 916.

ASTM Designation	Thickness – in. (mm)	Foot-Pounds Joule (J) @ 40°F (4°C)
A 709 grade 36 (A 709M grade 250)		15 (20.3)
A 709 grade 50* (A 709M grade 345)*	Up to 4 in. (100 mm) mechanically fastened Up to 2 in. (50 mm) welded	15 (20.3) 15 (20.3)
A 709 grade 50W* (A 709M grade 345W)*	Up to 4 in. (100 mm) mechanically fastened Up to 2 in. (50 mm) welded Over 2 in. to 4 in. (50 to 100 mm) welded	15 (20.3) 15 (20.3) 20 (27.1)
* If the yield point of the material exceeds 65,000 psi (450 MPa), the temperature for the CVN value for acceptability shall be reduced by 15°F (-10°C) for each increment of 10,000 psi (69 MPa) above 65,000 psi (450 MPa).		

This test requirement shall apply to all structural steel members and/or components except diaphragms, cross frames, stiffeners, lateral bracing, railroad ballast retainers and components, shoe assemblies, expansion joints, and compression members of trusses.

(f) Mill Test Reports

Mill test reports for structural steel shall be in accordance with 711.08 and 916 and shall include Charpy-Impact test data as set out in 910.02(e).

(g) High Strength Bolts, Nuts, and Washers

1. General Use

High strength bolts shall be in accordance with ASTM A 325 (A 325M). Type 3 bolts will be required if the structural steel is to remain unpainted. High strength nuts shall be of the grade and finish specified in ASTM A 325 (A 325M) and in accordance with ASTM A 563 (A 563M) or ASTM A 194 (A 194M). High strength washers shall be of the type specified in ASTM A 325 (A 325M) and in accordance with ASTM F 436. The bolts, washers, and nuts shall be coated after fabrication in accordance with ASTM A 153, class C or AASHTO M 298, class 55.

2. Assembly of Structural Steel in Bridges

High strength bolts, nuts, and washers used in the assembly of structural steel in bridges, excluding shoes and bearing assemblies, shall be provided in accordance with 910.02(f)1 and the following additional requirements.

a. Bolts

The maximum tensile strength shall be 150,000 psi (1,034 MPa) for bolts 1 in. (25 mm) or less in diameter. The maximum tensile strength shall be 120,000 psi (827 MPa) for bolts greater than 1 in. (25 mm) in diameter. The maximum hardness shall be 33 Rc.

b. Nuts

The nuts shall be in accordance with ASTM A 563 (A 563M), grade DH; or ASTM A 194 (A 194M), grade 2H.

c. Tests

(1) Rotational Capacity

High strength fasteners shall be subjected to the rotational capacity test in accordance with ASTM A 325, Section 6.3. The fastener shall complete 2 times the required number of turns from snug tight conditions in accordance with AASHTO LRFD Bridge Construction Specifications, in a Skidmore-Wilhelm calibrator or equivalent tension measuring device without stripping or failure. During this test, the maximum recorded tension shall be at least 1.15 times the required fastener tension indicated in AASHTO LRFD Bridge Construction Specifications. The measured torque required to produce the required fastener tension shall not exceed the value obtained by the following equation.

$$\text{Torque} = 0.25\ PD$$

where:

Torque	=	Measured Torque, (foot-pounds) (newton meters)
P	=	Measured Bolt Tension, (pounds) (newtons)
D	=	Nominal Diameter (feet) (meters)

(2) Proof Loads

Proof load tests for bolts shall be conducted in accordance with ASTM F 606, Section 3.2.3. Proof load test for nuts shall be conducted in accordance with ASTM F 606, Section 4.2.

(3) Wedge Tension Test

The wedge tests of full size bolts shall be conducted in accordance with ASTM F 606, Section 3.5.

d. Certification

The supplier shall provide a certification of compliance with all requirements for high strength bolts, nuts, and washers used in the assembly of structural steel in bridges. The certification, in addition to complying with the applicable requirements of 916, shall include the lot number on the shipping package and indicate when or where all testing was performed.

(h) Bolts other than High Strength Bolts

1. General

Bolts shall be unfinished, turned, or ribbed bolts conforming to the requirements for Grade A bolts of specification for low carbon steel externally and internally

threaded fasteners, ASTM A 307. Bolts shall have single, self-locking nuts or double nuts unless otherwise shown on the plans or in the special provisions. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

Bolts, washers, and nuts utilized in the U channel steel post splice as shown on the plans shall be in accordance with ASTM A 449, SAE J429-G7.9, or ASTM A 325 (A 325M) and shall be galvanized.

2. Unfinished Bolts

Unfinished bolts shall be furnished unless other types are specified.

3. Turned Bolts

The surface of the body of turned bolts shall meet the ANSI roughness rating value of 125. Heads and nuts shall be hexagonal and standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed. Bolts furnished shall provide for a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

4. Ribbed Bolts

The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 in. (2 mm) greater than the nominal diameter specified for the bolts. Ribbed bolts shall be furnished with round heads conforming to requirements of ANSI B 18.5 unless otherwise specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The hardness of the ribs shall be such that the ribs do not mash down enough to permit the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an over sized bolt used as a replacement.

910.03 Permanent Metal Forms

Metal bridge deck forms and supports shall be fabricated from steel in accordance with ASTM A 653 (A 653M) for grades A through E having a coating class of G165.

Material furnished under this specification shall be covered by the type of certification specified in the Frequency Manual and in accordance with 916. The certification shall list the yield tensile stresses, the ultimate tensile stresses, the ultimate tensile elongations, the base metal thicknesses, the weights (masses) of the galvanized coating, and shall certify that the material complies with the specified material requirements. The properties and parameters shall be listed for each gage (thickness) of material used in the panels and the hardware necessary to erect them. The materials will be sampled at the work site and shall include a representative

portion of a panel of each gage (thickness) to be used and a representative portion of each type and size of hardware necessary to erect the panels, excluding the fasteners.

910.04 Steel Forgings and Steel Shafting

(a) Carbon Steel Forgings

Steel forgings shall be in accordance with ASTM A 668 for carbon steel forgings for general industrial use. Class F forgings shall be furnished unless otherwise specified.

(b) Cold Finished Carbon Steel Shafting

Shafting shall be in accordance with ASTM A 108 for cold finished carbon steel bars and shafting. Grade designation 1016-1030, inclusive, shall be furnished unless otherwise specified.

(c) Alloy Steel Forgings

Alloy steel forgings shall be in accordance with ASTM A 668 for alloy steel forgings for general industrial use. Class G forgings shall be furnished unless otherwise specified.

(d) Certification

Steel forgings and steel shafting shall be covered by a mill certification reporting the test results of:

1. chemical analysis;
2. heat treatment, not required for shafting;
3. tensile strength, yield strength, and elongation.

Elongation is not required for shafting.

910.05 Castings

The casting design shall be proof loaded to 40,000 (178 kN) in accordance with Federal Specification FF-F-621. Castings shall be in accordance with the plan dimensions and to the following requirements for the designated materials. A certified inspection report shall be submitted by the manufacturer with each shipment of castings, except as otherwise provided herein. Inspection and testing shall be done by the manufacturer. The certified inspection report shall list the casting date, casting number, and the type of material, such as gray iron, ductile iron, etc. It shall state that inspection and testing has been performed, that all parts shipped meet the pertinent specification requirements, and that all component parts fit. The supporting test results, including proof load data, shall be retained and be available on request for a period of 7 years. All castings shall have the manufacturer's identification and the date of manufacture cast on an exposed surface. Acceptance of castings will be based on the certified inspection report, visual inspection, and check measurements.

(a) Steel Castings

Chromium alloy steel castings shall be in accordance with ASTM A 743 (A 743M). Grade CA 15 shall be furnished unless otherwise specified.

(b) Iron Castings

Iron casting shall be gray iron castings in accordance with ASTM A 48, class No. 35B, unless otherwise specified. Tension tests will be required for all castings including drainage castings.

Castings shall be true to pattern in form and dimensions. A tolerance of ± 1/8 in. (± 3 mm) in general dimensions as shown on the plans will be permitted with the exception that the tolerance in the dimensions of grates or covers and the openings into which they fit shall be limited to ± 1/16 in. (2 mm). All castings shall weigh at least 95% of the specified weight (mass) of that type cast to the exact dimensions shown on the plans. They shall be free from sponginess, cracks, blowholes, warping, sand inclusions, cold shots, cold shuts, chilled iron shrinks, or any defects which would affect the strength and value for the intended purpose. The castings shall completely fill the molds and shall not be removed until properly cooled. The casting date and a casting code number shall be cast on each casting.

All corners of the castings shall be filleted and outside corners and edges shall be rounded to a radius of not less than 1/8 in. (3 mm). All contact surfaces between different castings shall present a firm and even bearing without rattling or rocking. The lid frame bearing surfaces on all round castings shall be machine milled to provide true bearings around the entire circumference. All other contact surfaces shall be ground.

All castings shall be cleaned of molding or core sand, rust, scale, and foreign material just prior to shipment. Iron castings shall be delivered unpainted.

(c) Ductile Iron Castings

These castings shall be in accordance with ASTM A 536. Grade 65-45-12 shall be furnished unless otherwise specified. In addition, they shall be in accordance with all requirements of 910.05(b), except the first paragraph.

(d) Malleable Castings

These castings shall be in accordance with ASTM A 47 (A 47M). Grade No. 32510 or 35018 shall be furnished unless otherwise specified. In addition, they shall be in accordance with all requirements of 910.05(b), except the first paragraph.

(e) Carbon Steel Castings

These castings shall be in accordance with ASTM A 27 (A 27M). The grade shall be 60-30, 65-35, or 70-36.

Castings shall be true to pattern in form and dimensions and free from pouring faults, sponginess, cracks, blowholes, and any defects in positions affecting their strength and value for the service intended.

Blowholes appearing on finished castings shall be located so that a straight line laid in any direction does not cut a total length of cavity greater than 1 in. (25 mm) in any 1 ft (0.3 m) nor shall any single hole exceed 1 in. (25 mm) in any dimension or have an area greater then 1/2 sq in. (323 mm^2). Blowholes shall not be deep enough to affect the strength of the casting adversely.

Minor defects which do not impair strength may, with approval, be welded by an approved process. Defects shall be removed in solid metal by chipping, drilling, or other satisfactory methods and, after welding, the castings shall be annealed if required. Castings which have been welded without permission will be rejected. No sharp unfilleted angles or corners will be allowed.

910.06 Bronze and Copper Alloy

(a) Bronze Castings

Bronze castings shall be in accordance with ASTM B 22, alloys 911 or 913. Material furnished under this specification shall be covered by a type A certification in accordance with 916.

(b) Copper Alloy Plates

Copper alloy plates shall be in accordance with ASTM B 100. Material furnished under this specification shall be covered by a type A certification in accordance with 916.

910.07 Steel Components of MSE Retaining Walls

(a) Backing Mats, Clevis Connector, Connector Bar, and Wire-Facing

1. Backing Mats

Backing mats shall be smooth steel welded wire reinforcement in accordance with 910.01(b)5. Galvanization, if required, shall be in accordance with ASTM A 123, coating grade 55, or ASTM B 695, class 55. The Engineer will test samples in accordance with ASTM A 185.

2. Clevis Connector

Clevis connectors, if used, shall be attached to the alignment templates using the bars provided with the forms. The vertical and horizontal alignment of the connectors shall be ±1/8 in. (±3 mm). The holes inside the loops shall be free of all concrete and debris, loose or otherwise.

The clevis connector shall be fabricated of cold-drawn steel wire in accordance with ASTM A 82, and welded in accordance with ASTM A 884. Loops shall be

galvanized in accordance with ASTM A 153 class B-3, ASTM A 123, coating grade 55, or ASTM B 695 class 55.

A type A certification in accordance with 916 shall be furnished for the clevis connector. The results of the tension, bend, and coating adhesion tests, and measurements of coating thickness and average weight of the coating, shall be included on the certification for the clevis connector.

3. Connector Bar

The connector bar, if used, shall be fabricated of cold-drawn steel wire in accordance with ASTM A 884, and galvanized, if so shown on the plans, in accordance with ASTM A 123, coating grade 55, or ASTM B 695 class 55.

A type A certification in accordance with 916 shall be furnished for the connector bars. The results of the coating adhesion test and the measurements of coating thickness, average weight of the coating, and coating flexibility, shall be included on the certification for the connector bar.

4. Wire-Facing

Wire-facing shall be smooth steel WWR in accordance with 910.01(b)5. Galvanization, if required, shall be in accordance with ASTM A 123, coating grade 55, or ASTM B 695, class 55. All wire-facing shall be handled, stored, and shipped so as to eliminate the danger of excessive bending stresses. The Engineer will test samples in accordance with ASTM A 185.

(b) Ground Reinforcement

The ground reinforcement shall be either a deformed steel strip or a welded-wire grid. The grid or strip used shall be consistent with that used in the pullout test and shall be consistent throughout the project.

The grid shall consist of not less than 2 longitudinal wires, perpendicular to the wall, welded to equally-spaced cross ribs capable of developing passive pressure with the fill. The deformed strip shall be of constant width. The strip thickness shall vary only from the undeformed section to the deformed section as required to produce the pullout resistance.

The face-panel edges shall be configured to conceal the joints. All horizontal and vertical joints shall be covered with a joint cover to prevent backfill leakage while passing water.

Ground-reinforcement units shall be hot rolled from bars to the required shape and dimensions. Physical and mechanical properties of the units shall be in accordance with ASTM A 572 Grade 65 (A 572M Grade 450). Tie strips shall be shop fabricated with hot-rolled steel in accordance with the minimum requirements of ASTM A 1011 Grade 50. Galvanization for ground-reinforcing units and tie strips shall be in accordance with ASTM A 123, coating grade 85 or ASTM B 695 class

80. All ground-reinforcement units and tie strips will be inspected to ensure that they are true to size and free from defects which can impair their strength and durability.

A type A certification in accordance with 916 shall be furnished for ground reinforcement prior to use of the materials. The results of the yield strength, coating thickness, and coating adhesion tests shall be shown on the certification.

(c) Fasteners

Fasteners shall consist of 1/2 in. (13 mm) diameter, bolts, nuts, and washers and shall otherwise be in accordance with 910.02(g)1 with the exception that the hardware shall be coated in accordance with ASTM A 153, class C or ASTM B 695, class 55.

The supplier shall provide a certificate of compliance with all requirements for high strength bolts, nuts, and washers used in the assembly of MSE retaining walls. The certification, in addition to complying with the applicable requirements of 916, shall include the lot number and heat number on the shipping package and indicate when or where all testing was performed.

(d) Alignment Pins

The rods used to align the face panels during construction shall be 3/4 in. (19 mm) diameter and 12 in. (300 mm) in length. The rods shall be mild steel, polyvinyl chloride, or fiberglass. A type C certification in accordance with 916 shall be furnished for the alignment pins.

910.08 Steel Bin-Type Retaining Wall Units

Wall units shall consist of adjoining closed-face cells filled with structure backfill to form a gravity-type retaining structure. The cells shall be constructed of members in accordance with AASHTO M 218 (M 218M) that are bolted together. The necessary bolts and appurtenances shall be furnished for complete assembly of the units into a continuous closed-face wall of connected bins.

Working drawings shall be submitted in accordance with 105.02.

The units shall present a uniform workmanlike appearance once assembled. The base metal shall be not less than 16 gage (1.6 mm).

The steel sheets shall be galvanized on both sides in accordance with ASTM A 123, coating grade 85. All sheets will be inspected to ensure that they are true to size and free from defects, which may impair their strength and durability.

A type A certification in accordance with 916 for the bin-wall sheets shall be furnished prior to use. The results of the steel yield strength and coating adhesion tests, and measurement of the coating thickness, shall be shown on the certification.

910.09 Guardrail

Guardrail of the same type shall be interchangeable regardless of the source. Guardrail shall be supplied by a Certified Guardrail Supplier selected from the Department's list of Approved Certified Guardrail Suppliers.

Steel beam rail shall be galvanized, corrugated sheet steel beams in accordance with AASHTO M 180 as modified herein. The rails, including terminal sections, shall be either class A, base metal nominal thickness of 0.105 in. (2.67 mm), 12 gage, or class B, base metal nominal thickness or 0.135 in. (3.43 mm), 10 gage. They shall be type 2, zinc coated with 3.60 oz/sq ft (1.1 kg/m^2) minimum single spot and 4.00 oz/sq ft (1.22 kg/m^2) minimum triple spot. Tests for adherence of the coating may be made including the test specified in ASTM A 123, when deemed necessary.

Where beam rail is set on a curve of 150 ft (45.7 m) radius or less, the rail plate shall be shop curved with its traffic face concave or convex as required. The radii of curvature shall be in increments of 10 ft (3 m) from a radius of 150 to 50 ft (45.7 to 15.2 m) inclusive and in increments of 5 ft (1.5 mm) from a radius of 50 ft (15.2 m) to and including 20 ft (6.1 m).

The steel channels specified on the plans shall be standard 5 in. (127 mm) channels weighing 6.7 lb/ft (10.0 kg/m). The material shall be in accordance with ASTM A 36 (A 36M). The channel shall be galvanized in accordance with ASTM A 123 after fabrication. The weight (mass) of zinc coating per area of actual surface shall average not less than 2.0 oz/sq ft (610 g/m^2) for any individual piece of channel.

Construction details for the rails and channels shall be as shown on the plans. Whenever field fabrication, as approved, requires cutting or drilling, the cut or drilled member shall be coated with a high zinc dust-zinc oxide paint in accordance with Federal Specification TT-P-641, type II, or Military Specifications DOD-P-21035. When spray paints are used, 2 coats shall be applied.

910.10 Guardrail Posts

Guardrail posts shall be either steel or wood as specified and shall be in accordance with the following requirements.

(a) Steel Guardrail Posts

The dimensions of the steel guardrail posts shall be as shown on the plans. The material shall be in accordance with ASTM A 36 (A 36M). The posts shall be galvanized in accordance with ASTM A 123 after fabrication. However, the weight (mass) of zinc coating per square foot (square meter) of actual surface shall not average less than 2.0 oz (610 g) for an individual post.

The weight (mass) of the W6 x 15 post, after fabrication and coating, shall not be less than 14.60 nor more than 16.00 lb/ft (21.73 nor more than 23.81 kg/m).

Construction details shall be as shown on the plans. Whenever field fabrication, as approved, requires cutting or drilling, the cut or drilled member shall be coated with a high zinc dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P-641, or Military Specifications DOD-P-21035.When spray paints are used, 2 coats shall be applied.

(b) Wood Guardrail Posts

The wood guardrail posts shall be in accordance with 911.02(d). Dimensions and construction details shall be as shown on the plans.

910.11 Guardrail Accessories, Fittings, and Hardware

These items consist of brackets, splice plates and bars, post anchors, diaphragms, clamps and clamp bars, end caps, connections, anchor rod assemblies, deadmen, bolts, screws, nuts, washers and blockouts of the type, dimensions, and design shown on the plans. They shall be in accordance with the requirements set out below. Items of the same type shall be interchangeable regardless of the source.

(a) For Steel Beam Guardrail

1. Post brackets, bars, plates and shapes for bridge railing brackets, and plate washers shall be in accordance with ASTM A 36 (A 36M). Post brackets, bars, and plates and shapes for bridge railing brackets shall be galvanized in accordance with 910.10(a). Plate washers shall be galvanized after fabrication in accordance with ASTM A 153. The weight (mass) of the W6 x 15 post bracket shall be in accordance with 910.10.

2. Splice plates and rail portion of bridge railing brackets shall be class B, type 2, in accordance with the first paragraph of 910.09(a).

3. Bolts and nuts of the sizes specified on the plans shall be in accordance with ASTM A 307. Cut washers and lock washers shall be standard round steel washers of the sizes specified on the plans. The diameter of cut washers shall be 1 3/4 in. (44 mm) for 5/8 in. (16 mm) bolts and 2 in. (50 mm) for 3/4 in. (19 mm) bolts with a thickness of 0.134 in. (3.4 mm) ± 0.026 in. (0.66 mm) measured at the hole. The bolts, washers, and nuts shall be coated after fabrication in accordance with ASTM A 153, or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements for class C of ASTM A 153.

4. Whenever approved field fabrication requires cutting or drilling, the cut or drilled members shall be coated with a high zinc dust-zinc oxide paint conforming to Federal Specification TT-P-641, type II, or Military Specifications DOD-P21035. When spray paints are used, 2 coats shall be applied.

5. Pipe spacers of the size specified on the plans shall be galvanized after fabrication in accordance with ASTM A 153, class C. The weight (mass) of coating per square foot (square meter) of actual surface shall average no less than 1.25 oz (381 g) for the specimen tested and shall be no less than 1 oz (305 g) for any individual specimen.

6. For breakaway cable terminal, and cable terminal anchor system, the rail element, standard bolts, nuts, and washers shall be in accordance with 910.09 and requirements 1 and 3 of 910.11(a).

7. For cable terminal anchor system, the anchor bracket, end plate, soil plate, bearing plate, strut and yoke shall be in accordance with AASHTO M 270 grade 250. They shall be zinc coated after fabrication in accordance with AASHTO M 111. The steel tube shall be in accordance with ASTM D 500 grade B and zinc coated in accordance with AASHTO M 111. The post sleeve shall be in accordance with ASTM A 53 grade B and zinc coated in accordance with AASHTO M 111. The stud shall be in accordance with ASTM F 568 class 8.8, and zinc coated in accordance with AASHTO M 111. The threads shall be in accordance with ANSI B1.13M and shall be M24 by 3 class 6g pitch. The swaged fitting shall be in accordance with ASTM A 576 grade 1035, zinc coated in accordance with AASHTO M 111, and shall be annealed for cold swaging. A lock pin hole to accommodate a 1/4 in. (6 mm) plated spring-steel pin shall be drilled through the head of the swaged fitting.

8. Timber blockouts shall be in accordance with 911.02(f). Alternate material blockouts shall be in accordance with 926.03.

High strength bolts shall be in accordance with ASTM A 325 (A 325M) or ASTM A 449. High strength nuts shall be in accordance with ASTM A 563 (A 563M), Grade B or better. Galvanizing shall be in accordance with ASTM A 153 or mechanically galvanized and conform to the coating thickness, adherence, and quality requirements for class C of ASTM A 153. Foundation plates and bearing plates shall be in accordance with ASTM A 36 (A 36M), and shall be galvanized after fabrication in accordance with ASTM A 123, except the weight (mass) of zinc coating per square foot (square meter) of actual surface shall average no less than 2.0 oz (610 g) and shall be no less than 1.8 oz (549 g) for any individual specimen. Welding shall be in accordance with AWS D1.1.

Terminal posts shall be fabricated from tubing meeting ASTM A 500, Grade B, or ASTM A 501 and from plates meeting ASTM A 36 (A 36M). Welding shall be in accordance with AWS D1.1. They shall be galvanized after fabrication in accordance

with ASTM A 123, except the weight (mass) of zinc coating per square yard (square meter) of actual surface shall average no less than 2.0 oz (610 g). The average for any component part, including paddle plate, tubing, or base plate, shall be no less than 1.8 oz (549 g).

The steel pipe in the type 5 anchor and the steel spacer tube in the transition type WGB shall be Schedule 40.

Tapered washers may be of steel or malleable iron, and galvanized in accordance with ASTM A 153.

The wire rope used in the cable assemblies shall be in accordance with AASHTO M 30 and shall be 3/4 in. (19 mm) preformed, 6 by 19, wire strand core or independent wire rope core (IWRC), galvanized, right regular lay, manufactured of improved plow steel, with a minimum specified breaking strength of 42,800 lbf (190 kN). The swaged fitting, stud, and nut shall develop the breaking strength of the wire rope. The fitting shall be galvanized in accordance with ASTM A 123 before swaging. After galvanizing, the head and nut may be tapped 0.023 in. (0.6 mm) over the ANSI B1.1, class 2B tolerance.

(b) For Steel Tube Guardrail

1. Channels and bars for connections, splice bars, and diaphragms shall be in accordance with ASTM A 36 (A 36M).

2. Cap screws shall be stainless steel in accordance with ASTM A 276, type 304 or 430.

3. Rail end caps shall be malleable iron castings in accordance with ASTM A 47 (A 47M), grade 35018, or steel castings in accordance with ASTM A 27 (A 27M), grade 70-36.

4. Cut washers and lock washers shall be standard round steel washers. The diameter of cut washers shall be 1 1/2 in. (37.5 mm) and 1/8 in. (3.2 mm) thick measured at the hole. Washers shall be coated after fabrication in accordance with requirement 3 of 909.11(a).

5. All materials other than cap screws and washers shall be galvanized after fabrication in accordance with ASTM A 123.

6. When field fabrication, as approved, requires cutting or drilling, the cut or drilled members shall be coated with a high zinc dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P-641 type II or Military Specifications DOD-P-21035. When spray paint is used, 2 coats shall be applied.

910.12 Certification of Guardrail Suppliers

Suppliers desiring to be on certification status will be approved upon request and added to the Department's list of approved Certified Guardrail Suppliers. The written request shall be submitted to the Office of Materials Management. An approval number will be assigned to each supplier to be used for identification acceptable of material.

The supplier shall perform testing or shall obtain documentation to ensure the quality of the material incorporated into the work.

The supplier shall prepare each month a type D certification in accordance with 916.02(e). Such certification shall contain the contract number; supplier's name; supplier's approval number; month of installation; rail manufacturer; bolt manufacturer; quantities of rail, channel, posts, block, and paddle posts incorporated into the work; quantities of sawed timber posts and blocks for thrie-beam and W-beam guardrail incorporated into the work; and a statement that the materials furnished are in accordance with 910.09 through 910.12.

The Department will inspect the steel beam guardrail on a randomly selected contract for compliance with specifications for a minimum of 1 time per year per supplier.

Selected contracts with failing results will be adjudicated as a failed material in accordance with normal Department practice.

If the supplier shows negligence or the inability to ensure the delivery of specified materials, the supplier may be removed from the approved list.

910.13 Steel Fence Posts

Tubular steel fence posts and line posts shall meet the following specifications and the requirements as shown on the plans.

(a) Line Posts

Line posts shall be in accordance with AASHTO M 281 and galvanized in accordance with AASHTO M 111, Coating grade 65.

Line posts for farm field fence shall be furnished with anchor plates. End, corner, pull, and gate posts for farm field type fence shall be furnished with braces and all fittings and details required to make a complete installation as shown on the plans.

(b) Tubular Steel Fence Posts

Two groups of tubular steel fence posts are included in these specifications. Tubular section posts shall have heavy malleable iron caps or pressed galvanized steel caps. Such caps shall be made to provide a drive fit over the outside of the

section to exclude moisture. The weight (mass) per foot (meter) for tubular posts and braces shall be no less than 90% of the weight (mass) specified. Unless specified otherwise, the tubular steel fence post shall be group 1.

1. Group 1

Tubular steel fence posts for group 1 shall be hot-dipped zinc-coated and shall be in accordance with ASTM F 1083 except tests shall be conducted on sample posts selected as being representative of the posts furnished. The weight (mass) per foot (meter) will be acceptable provided it is at least 90% of the specified weight (mass).

2. Group 2

Tubular steel fence posts for group 2 shall have a minimum 50 ksi (345 MPa) yield strength and be in accordance with AASHTO M 181, except that the inner pipe surface may be galvanized in lieu of a zinc rich coating or hot dipped aluminum coated, Type 2, meeting the chemical requirements of AASHTO M 274. The aluminum coated, Type 2, steel fence posts shall be manufactured by roll forming aluminum coated, Type 2, steel strip and electric resistance welding it into tubular form. The outside of the weld area shall be metallized with commercially pure aluminum to a thickness sufficient to provide resistance to corrosion equal to that of the remainder of the outside of the post. The aluminum coating weight (mass) shall be a minimum of 0.75 oz/sq ft (229 g/m^2) average, and 0.70 oz/sq ft (214 g/m^2) for an individual test specimen, as measured in accordance with ASTM A 428. Specimens for determining weight of coating shall be obtained in accordance with ASTM F 1083.

(c) Fence Fastenings

When fastenings are necessary for attaching the farm field fence to the posts, they shall be either galvanized or aluminum coated No. 9 (3.8 mm) wire, or galvanized or aluminum coated clamps of the manufacturer's standard design. The coating weights shall be a minimum of 0.60 oz/sq ft and 0.30 oz/sq ft (183 g/m^2 and 92 g/m^2) for galvanized and aluminum coated, respectively. A sufficient quantity of individual tie wires or clamps shall be furnished to provide for 5 attachments of the fencing to each line post and 1 tie wire for each strand of barbed or tension wire.

Line posts for chain link type fence shall be furnished with the necessary tie wires or fabric bands for fastening the fabric to the posts. These fastenings shall be made of aluminum strip or wire of approved gage and design or of galvanized steel wire and may be in accordance with the manufacturer's standard design. If galvanized steel wire ties are furnished, the wire shall be no smaller than No. 9 gage (3.8 mm). A sufficient quantity of individual ties or bands shall be furnished to provide for attaching the fabric to each line post each 1 ft (0.3 m) or as called for on the plans.

910.14 Sign Posts

(a) Steel, Flanged, Channel Posts

1. General Requirements

Posts shall be made from open hearth, basic oxygen, or electric furnace steel rolled from standard tee rails or new billets. The steel used in the posts shall conform to the physical properties of ASTM A 499, grade 60, and to the chemical compositions of ASTM A 1 for 91 lb/yd (45 kg/m) or larger steel rails.

Posts fabricated from other steels will be acceptable providing that the following criteria are met. A notarized copy of a dynamic crash test report shall be furnished substantiating that the posts manufactured from this material, when double mounted in a 7 ft (2.1 m) span, conform to the breakaway requirements of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, except that the maximum change in velocity shall not exceed 16 ft/s (4.9 m/s). For 2 posts in a 7 ft (2.1 m) path, impact performance may be estimated by multiplying the vehicle energy loss observed in a single post crash test by 2. This estimated double post energy loss may then be used to calculate an estimated impact velocity change and momentum change for a double post sign design. The minimum yield strength shall be 60,000 psi (414 MPa) and the minimum tensile strength shall be 90,000 psi (621 MPa).

The tensile strength shall be determined by either the standard Rockwell Hardness test, Brinnel Hardness test, or by actual tensile test. The Rockwell Hardness shall be a minimum of B 91. The yield strength shall be determined by the manufacturer by actual test. Tensile and yield strengths and chemical composition shall be determined by the average from the 3 latest test results the manufacturer has available at the time of shipment. These test results need not be made on the materials from which the posts were made. However, the tests must have been made within 90 days of shipment. Posts, except those used for temporary construction signs, temporary traffic signs, and temporary panel signs, shall be certified by a type B certification in accordance with 916. The certification shall include the above 3 test results and the elastic section modulus value in accordance with 910.14(a)3.

Posts shall be of uniform flanged channel or U section such that the area of contact between the post and the sign is symmetrical about the vertical axis of both sign and post. The back of each post shall be formed in a manner to ensure a solid bearing surface over the entire length of the post when mounted back to back. The bearing surface on the back of the post shall be flat. The length shall be as specified with a tolerance of ± 1 in. (± 25 mm). Sign posts shall be punched with 58 holes which shall be 3/8 in. (9.5 mm) in diameter located on the center-line and spaced on 1 in. (25 mm) centers beginning 1 in. (25 mm) from the top. The remainder of the post shall be punched with 3/8 in. (9.5 mm) holes on 1 in. (25 mm) or 2 in. (50 mm) centers.

The finished posts shall be machine straightened and have a smooth uniform finish free from cracks, flaws, injurious seams, laps, blisters, and edges which are ragged, sharp, and imperfect, or other defects affecting their strength, durability, or appearance. The maximum variation in straightness shall be no more than 1/4 in. in any 5 ft (6 mm in any 1.5 m) of length, or exceed in inches (millimeters) 1/4 times the number of feet (meter) of length divided by 5. Bolt holes of the diameter specified shall be accurately spaced vertically and centered horizontally so that holes will register for back to back application. All holes and sheared ends shall be commercially free from burrs.

The steel sign posts shall be galvanized in accordance with ASTM A 123.

Galvanizing shall be the final process after all fabrication and punching has been completed. Posts saw cut after galvanizing shall have the cut surface treated with a zinc-based solder in rod form which complies with ASTM A 780. The cut surface shall not be treated until the fuse plate is installed and all bolts are tightened. The top of the fuse plate shall be 1 in. (25 mm) below the bottom of the sign.

Posts saw cut before galvanizing shall have temporary fasteners provided with sufficient strength to prevent warping or deforming of the post during the galvanization process. The surface under the temporary fasteners shall be treated with an approved zinc solder meeting the above mentioned specifications. The surface shall be treated before the fuse plate is installed. The break-away stubs shall be galvanized a minimum of 8 in. (200 mm) below the top of the concrete foundation.

Steel posts shall be wired or strapped securely in bundles of not more than 2,000 lb (907 kg). They shall be nested in rows with the edges intermeshed so as to form a rectangular bundle and shall be fastened in such a manner that they do not slip or rub against each other and cause damage to the finish. Care shall be taken during shipment to prevent the bundles from rubbing against each other and causing damage. Excessive damage to the finish during shipment will be cause for rejection of the damaged posts.

2. Deflection Test Requirements

Posts will be tested as a simple beam with the flange in compression on non-restricting supports 24 in. (610 mm) apart. Test specimens shall be 28 in. ± 1/4 in. (711 mm ± 6.3 mm) long. A load of 1500, 3500, or 4600 lb (6672, 15569, or 20462 N), depending on the type of post, shall be applied at the center of the span with a mandrel of not less than 1 in. (25 mm) in diameter. Application of the load shall be at a speed of not to exceed 0.03 in. (8 mm) per min. Deflection of the post upon application of the total load shall not exceed 0.16 in. (4 mm). The load shall then be removed. Deflection of the post 1 minute after removal of the load shall not exceed 0.01 in. (0.25 mm).

3. Type of Posts

Posts shall conform to the following table and to deflection tests required in 910.14(a)2.

Type	Minimum Elastic Section Modulus	Loading
A	.200	1,500 lb (6,672 N)
B	.400	3,500 lb (15,569 N)
C	.560	4,600 lb (20,462 N)
Abb*	.670	**
Bbb*	1.190	**

* Back to Back
** Back to Back post shall be tested singly for deflection prior to assembly.
Note: The elastic section modulus values shall be included in the type B certification.

(b) Wide Flange Posts

Structural steel members for the support of signs shall be in accordance with AASHTO M 183 and ASTM A 709 grade 36 (A 709M grade 250). These members shall be galvanized in accordance with ASTM A 123. Base plates and stiffeners shall be in accordance with the requirements of ASTM A 709 grade 36 (A709M grade 250). Fuse plates shall be in accordance with the requirements of ASTM A 36 (A 36M) and shall be galvanized in accordance with ASTM A 123. All bolts, nuts, and washers shall be high strength and be in accordance with AASHTO M 164 and ASTM A 325.

All holes shall be drilled. All cutting shall preferably be saw cuts however flame cuts as specified in 711.13 may be allowed. Metal projecting beyond the plane of the plate face will not be allowed.

(c) Structural Steel Posts

Steel members for the support of signs shall be standard shapes as specified and shall be in accordance with 910.02(a). These members shall be galvanized in accordance with ASTM A 123. Material furnished under this specification, except those used for temporary construction signs, temporary traffic signs, and temporary panel signs, shall be covered by a type C certification in accordance with 916.

(d) Structural Aluminum Posts

These posts shall be standard shapes as specified and shall be aluminum in accordance with ASTM B 221 (B 221M) alloy 6061-T6. Material furnished under this specification, except those used for temporary construction signs, temporary traffic signs, and temporary panel signs, shall be covered by a type C certification in accordance with 916.

(e) Square Steel Posts

Square steel sign post, except those used for temporary construction signs, temporary traffic signs, and temporary panel signs, shall be covered by the type of certification specified in the Frequency Manual and in accordance with 916.

1. Steel

Square steel posts shall be roll formed and in accordance with one of the following:

a. ASTM A 1011, hot rolled carbon sheet steel in either 0.105 in. (2.66 mm) or 0.075 in. (1.90 mm) with a minimum yield strength of 60,000 psi (414 MPa). The ultimate tensile strength shall not exceed 79,800 psi (550 MPa) or have an elongation measured over 2 in. (50 mm) greater than 20%.

b. ASTM A 1008, cold rolled high strength steel, 0.075 in. (1.90 mm) with a minimum yield strength of 60,000 psi (414 MPa). This shall apply to the 2 in. by 2 in. (50 mm by 50 mm) size posts only.

c. ASTM A 653, cold rolled high strength steel, 0.075 in. (1.90 mm) with minimum yield strength of 60,000 psi (414 MPa). The ultimate tensile strength shall not exceed 79,800 psi (550 MPa) or have an elongation measured over 2 in. (50 mm) greater than 20%. This requirement shall apply to the 2 in. by 2 in. (50 mm by 50 mm) size posts only.

Yield strengths and chemical composition shall be determined from the 3 latest test results performed by the steel manufacturer. These test results may not be determined on materials from which the delivered posts were made. However, the tests shall have been performed within 90 days of shipment. The certification shall include the range of test results and the section modulus value in accordance with 910.14(a)3.

2. Fabrication

The posts shall be corner welded and scarfed as necessary to allow sections to telescope within each other. The finished posts shall be machine straightened and have a smooth uniform finish free from cracks, flaws, injurious seams, laps, blisters, and edges which are ragged, sharp, and imperfect, or other defects affecting their strength, durability, or appearance. The maximum variation in straightness shall be no more than 1/4 in. in any 5 ft (6.3 mm in any 1.52 m) of length. Cut holes or knockout holes of 7/16 in. (11 mm) diameter shall be spaced on 1 in. (25 mm) centers, on the centerlines of all 4 sides in true alignment, and opposite to each other for back to back applications. All holes and sheared ends shall be free from burrs.

3. Protective Coating

The protective coating shall be applied using one of the following:

a. Before fabrication, both sides of the rolled sheet steel shall be galvanized in accordance with ASTM A 653, coating designation G 90. (A 653M, coating designation Z 275).

b. After fabrication, a triple coating system on the outside of the posts consisting of galvanizing with zinc which is in accordance with AASHTO M 120 weighing 0.60 ± 0.15 oz/sq ft (183 ± 46 g/m^2) followed by a chromatic conversion coating weighing 15 ± 5 micrograms, µg/sq in. (0.02 ± 0.006 g/m^2) and a clear organic exterior coating with a dry film thickness of 0.2 ± 0.1 mil (5 ± 2.5 µm). The interior surface of the posts shall receive a double in-line application of a zinc rich organic coating with a total dry film thickness of 1.2 ± 0.6 mil (30 ± 15 µm). The dried zinc rich organic coating film shall contain a minimum of 77% total zinc. Samples from the posts which use these protective coatings shall be exposed to salt fog testing in accordance with ASTM B 117 for a total of 500 h. The samples shall be examined at both 100 and 500 h of salt fog testing and rated for corrosion. At 100 h the corrosion rating shall be a minimum of 9 and at 500 h the corrosion rating shall be a minimum of 6 when determined in accordance with ASTM D 1654.

(f) Portable Construction Sign Trailer

The portable construction sign trailer, not including the signs and lights, shall weigh no more than 300 lb (140 kg) and shall not be fabricated with heavier than 3 by 3 in. (75 by 75 mm) angles, 2 1/2 in. (63 mm) pipe, or 3 by 2 in. (75 by 50 mm) rectangular tubing. The rim size of the wheels shall not exceed 12 in. (300 mm). Axle assemblies with differential housings shall not be used.

910.15 Delineator Posts

Posts shall be in accordance with 910.14(a)1.

Physical requirements for the finished delineator posts shall be:

Width of flange face .....2 to 2 3/8 in. (50 to 60 mm)
Width of back .....3/4 to 7/8 in. (19 to 22 mm)
Depth from face of flange to back .....7/8 to 1 1/8 in. (22 to 29 mm)
Length..... 7.0 ft ± 1 in. (2.1 m ± 25 mm)
Weight (Mass) ..... 1.0 to 1.5 lb/ft (1.5 to 2.2 kg/m)

Delineator posts shall be punched with a minimum of twenty-four 1/4 in. (6 mm) holes on the centerline spaced on 1 in. (25 mm) centers beginning 1 in. (25 mm) from the top.

910.16 Copper Flashing

Copper flashing shall be soft copper and shall be in accordance with ASTM B 370, except the minimum copper content shall be 99.5%. The weight (mass) per square foot (square meter) will be determined by weighing individual samples. If the 1st sample is not in accordance with the tolerances for 16 oz (450 g) sheet, 2 additional samples shall be tested and both shall comply with the specified tolerances. The sample shall withstand being cold bent through an angle of 180° flat upon itself, without failure of the outside of the bent portion. The type of certification for copper flashing will be covered by the Frequency Manual and shall be in accordance with 916.

910.17 Bronze or Copper Alloy Plates

Bronze or copper alloy to be used for self lubricating bearing plates shall conform to 1 of the following requirements based on the design unit loading set out on the plans.

Design Unit Loading not over	Shall Conform to ASTM
A. 3,000 psi (20,684,271 Pa)	B 22, Alloy C86300
B. 2,500 psi (17,236,894 Pa)	B 100, Alloy C51000
C. 2,000 psi (13,789,514 Pa)	B 22, Alloy C91100
D. 1,000 psi (6,894,757 Pa)	B 22, Alloy C90500*
* Up to 2.5% lead allowed	

The sliding surfaces of the plates shall be provided with cylindrical recesses with a depth necessary to provide proper containment of the lubricant. The recesses shall be arranged in a geometric pattern so that each successive row will overlap in the direction of motion. The total area of the recesses shall comprise no less than 25% and no more than 35% of the total area of the plate.

The surface finish of bearing areas shall be in accordance with ANSI B46.1 #125. The lay of tool marks shall be in the direction of expansion or contraction of the structure. If the surface is ground, grinding knurls may be omni-directional. Flat bearing surfaces shall be flat to a tolerance of ± 0.0005 in. (0.0125mm). Curved bearing surfaces shall be machined to a tolerance of ± 0.0005 in. (0.0125 mm) in each 1 in. (25 mm) of length perpendicular to the circular section. The radius of curved bearing surfaces shall have the following tolerances.

	Positive Tolerance	Negative Tolerance
Concave Surface	0.010 in. (0.25 mm)	0.000 in. (0.000 mm)
Convex Surface	0.000 in. (0.000 mm)	0.010 in. (0.25 mm)

The lubricant shall be of the solid type. It shall consist of graphite and metallic substances having lubricating properties with a lubricating binder. The lubricant shall be free of any material that causes abrasive or corrosive action on the metal surfaces. It shall withstand the atmospheric elements. The lubricant shall be compressed into

the recesses of the bearing plate by hydraulic pressure to form a dense non-plastic lubricating insert.

At the time of assembly in place, the steel surfaces which bear on the self lubricating bearing plate shall be lubricated with additional lubricant furnished by the manufacturer. White lead, tallow, or other coating shall be removed before the application of the lubricant.

The coefficient of friction between the self lubricating plate and the steel plates in contact with them shall not exceed 0.10 when subjected to twice the designed loading.

Material furnished under this specification shall be covered by a type C certification in accordance with 916.

910.18 Fence, Fittings, and Gates

(a) Farm Field or Woven Wire Fence

This fence shall be in accordance with ASTM A 116. The wire shall be No. 9 gage (3.8 mm). The design shall be 1047-6-9. The coating shall be class 3. The method of securing the vertical stays to the horizontal wires may be either of those shown on the plans. Diagonal braces shall be in accordance with 910.18(b)3.

(b) Steel Fabric Chain Link Fence

This fence shall be in accordance with ASTM A 392 for galvanized steel fabric or ASTM A 491 for aluminum coated steel fabric. The height of the fabric shall be 48 in. (1.22 m) unless otherwise specified. It shall be of No. 9 gage (3.8 mm) wire woven in 2 in. (50 mm) mesh. The fabric shall be knuckled at the top and bottom selvages when the height is less than 72 in. (1,830 mm). Fabric of 72 in. (1,830 mm) in height or higher shall be knuckled at the top and shall have the twisted and barbed finish at the bottom. For galvanized fabric, coating shall be done after weaving and shall be class II, average of 2 or more specimens no less than 2.0 oz/sq ft (610 g/m^2) and no less than 1.8 oz/sq ft (549 g/m^2) for any individual specimen. For aluminum coated fabric, coating shall be class II, 0.40 oz/sq ft (122 g/m^2) minimum.

The fabric shall be furnished with ties required for fastening it to the top and bottom tension wires. These fastenings may be of aluminum wire or strip of approved gage and design, or of galvanized steel wire in accordance with the manufacturer's standard design. If galvanized steel wire ties are furnished, the wire shall be no smaller than No. 12 gage (2.7 mm). Sufficient ties shall be furnished to provide for attaching to the top and bottom tension wires each 24 in. (600 mm). Fittings necessary to make complete installation shall be pressed or rolled steel, forged steel, cast steel, or malleable iron.

Steel fabric chain link fence shall be as shown on the plans and as set out above.

1. Tension Wire

Tension wire intended for use on the top or bottom of steel chain link fence or on the bottom of farm field fence when specified shall be spring coil or crimped steel wire with an initial diameter of 0.177 ± 0.005 of an in. (4.5 ± 0.1 mm), a minimum breaking load of 1,950 lb (8.67 kN), and a coating of either zinc or aluminum. The minimum weight (mass) of coating shall be 0.80 oz/sq ft (244 g/m^2) for galvanized wire and 0.40 oz/sq ft (122 g/m^2) for aluminum coated steel wire. The weight (mass) of aluminum coating shall be determined in accordance with ASTM A 428.

2. Stretcher Bars, Truss Rods, and Turnbuckles

Stretcher bars shall be 3/16 by 3/4 in. (4.8 by 19.0 mm) flat bars. These bars, truss rods, turnbuckles, and necessary fittings shall be of good commercial quality steel, malleable iron, or wrought iron. They shall be galvanized in accordance with ASTM A 153 after fabrication. The turnbuckles shall be made from drop forged malleable iron. They shall have a minimum take up of 4 in. (100 mm). The fittings may be pressed or rolled steel, forged steel, cast steel, or malleable iron.

3. Braces

Braces shall be made of steel pipe with bolted steel couplings or connections. Steel pipe shall be in accordance with ASTM F 1083. They shall be galvanized as set out therein. Fabrication or manipulation that causes minor damage to the galvanized coating shall be corrected by approved application of a high zinc dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P-641 type II or Military Specifications DOD-P-21035. When spray paints are used, 2 coats shall be applied. Damaged braces will be rejected.

4. Barbed Wire

Barbed wire used at the top and bottom of farm field fence, or as otherwise specified, and in accordance with 603 shall be in accordance with applicable provisions of ASTM A 121. It shall be composed of No. 12 1/2 gage (2.5 mm) galvanized or aluminum coated steel wire with 4 round 14 gage (2.0 mm) barbs at approximately 5 in. (125 mm) spacing. The galvanized coating shall be in accordance with class 3 in Table 2. The minimum aluminum coating shall be in accordance with class 60 for the line wire and class 20 for the barb wire. The weight (mass) of coating shall be determined in accordance with ASTM A 428. The use of aluminum barbs, in accordance with ASTM B 211 (B 211M), alloy 5052-H38, nominal diameter No. 14 gage (2.03 mm), will be permitted.

The use of barbed wire with No. 15 1/2 gage (1.70 mm), high tensile strength line wires, and No. 16 1/2 gage (1.47 mm) barbs will be permitted. The barbs shall be round with 4 points and spaced at approximately 5 in. (125 mm) intervals. The barbed wire shall be in accordance with ASTM A 121. The galvanized coating shall be in accordance with class 3 in Table 2.

(c) Aluminum Fabric Chain Link Fence

This fence shall be in accordance with the applicable requirements of 910.18(b) except for composition of materials. Requirements for the various component parts of aluminum fence shall be as shown in Table 1.

TABLE 1

ITEM	ASTM REFERENCE	ALLOY	ADDITIONAL INFORMATION
Fabric	B 211 (B 211M)	Alclad 5056 or 6061-T94	
Barbed Wire - Line	B 211 (B 211M)	5062-0, H38, or 6061-T89	2-strand dia. 0.110 in. (2.8 mm) 4-pt barb. dia. 0.080 in. (2.0 mm) 5 in. (127.0 mm) space
Barbs	B 211 (B 211M)	5052-H38	
Tension Wire	B 211 (B 211M)	Alclad 5056 or 6061-T94	Dia. 0.192 in. (4.9 mm); Note 1
Hog Ring Fasteners	B 211 (B 211M)	6061-T94	Dia. 0.110 in. (2.8 mm)
Wire Ties	B 211 (B 211M)	1100-H18	Dia. 0.148 in. (3.8 mm)
Flat band ties	B 211 (B 211M)	3003-H14	1.2 in. (12.7 mm) wide; 0.06 in. (1.5 mm) thick
Stretcher Bars	B 211 (B 211M)	6063-T6	3/4 in. (19.0 mm) by 1/4 in. (6.4 mm); square edges
Truss and Brace Rods	B 211 (B 211M) or B 221 (B 221M)	6061-T6	Dia. 3/8 in. (9.5 mm)
Turn Buckles	B 26 (B 26M) (cast parts), B 211 (B 211M) (wrought)	356.0-T6 6061-T6	
Bands	B 221 (B 221M)	6063-T6	1/8 in. (3.2 mm) by 1 in. (25 mm) beveled edge
Bolts	B 211 (B 211M) or B 221 (B 221M)	2024-T4	ASA B 18.2 hexagon threads class 2, 2A, or 2B
Nuts	B 211 (B 211M) or B 221 (B 221M)	6061-T6	
Expansion Sleeves	B 210 (B 210M)	3003-H18	1.695 in. (43.1 mm) ID by 0.078 in. (1.98 mm); wall drawn type. 6 in. (152 mm) long; self centering
Post Tops, Rails And Brace Ends	B 26 (B 26M) or B 108	356.0T6	Fabricated in permanent molds or sand castings
Top and Brace Rails	B 241 (B 241M) and B429	6063-T6	1 1/4 in. (31.8 mm) pipe; Note 2
Barbed Wire Extension Arms	B 26 (B 26M) or B 108	356.0T6	Fabricated as for post tops; sheet castings
Line Posts	B 241 (B 241M) and B 429	6063-T6	2 in. (50 mm) pipe; Note 2
Corner Posts	B 241 (B 241M) and B 429	6063-T6	2 1/2 in. (63 mm) pipe; Note 2
Note 1: Aluminum coated steel wire in accordance with 910.18(b) may be used. Note 2: ANSI schedule 40 pipe, plain ends.			

(d) Gates

Gate posts sizes shall be as follows:

ANSI Nominal Pipe Size	Swing Gate Opening, (inclusive)	
	Single Gate	Double Gate
2 1/2 in. (64 mm)	Up to 6 ft (1.83 m)	Up to 12 ft (3.66 mm)
3 1/2 in. (89 mm)	7 to 13 ft (2.13 to 3.96 m)	13 to 26 ft (3.96 to 7.92 m)
6 in. (152 mm)	14 to 18 ft (4.27 to 5.49 m)	27 to 36 ft (8.23 to 11.28 m)
8 in. (203 mm)	19 to 32 ft (5.79 to 9.75 m)	37 to 64 ft (11.27 to 19.51 m)

1. Steel Gates

Steel gate posts shall be standard weight (mass), galvanized, steel pipe in accordance with ASTM F 1083 and furnished with all necessary fittings. Post sizes shall be as set out above. The gate frames shall be of standard weight (mass), galvanized, steel pipe in accordance with ASTM A 53; of 1 1/2 in. (38.1 mm) nominal size; and shall have welded joint or riveted construction using galvanized pressed steel or malleable fittings. Areas welded after galvanizing shall be coated with a material conforming to the requirements of Federal Specification TT-P-641, type II or Military Specifications DOD-P-21035. When spray paints are used, 2 coats shall be applied. Fabric coverings for gates shall be in accordance with 910.18(a) or 910.18(b). These gates shall be furnished with necessary fastenings, hinges, center stops, and locking devices galvanized after fabrication in accordance with ASTM A 153.

2. Aluminum Gates

Aluminum gate post sizes shall be in accordance with 910.18(d). They shall be ANSI schedule 40 pipe and in accordance with ASTM B 241 (B 241M) or B 429, alloy 6063-T6. Gate frames shall consist of 1 1/2 in. (38 mm) schedule 40 pipe assembled by welding and/or with fittings. Pipe shall be in accordance with ASTM B 241 (B 241M) or B 429, alloy 6063-T6. Welding material and procedures shall be in accordance with the applicable AWS provisions. Formed sheet fittings shall be in accordance with ASTM B 209 (B 209M), alloy 6061-T6. Gate hinges may be offset type wrought aluminum, ASTM B 209 (B 209M), alloy 6061-T6, or galvanized malleable iron. Fabric shall be in accordance with 910.18(c).

(e) Control Procedures for Furnishing Fence and Accessories

1. General Requirements

All fence and accessory materials shall be subject to the control procedures set out herein. The control procedure methods which may be used are as follows.

a. Suppliers qualified to furnish pretested approved stockpiled material;

b. Suppliers not qualified or not desiring to furnish pretested approved stockpiled material.

2. Suppliers of Pretested Approved Stockpiled Material

Suppliers desiring to furnish pretested approved stockpiled material shall contact the District Testing Engineer. A written request will not be required.

The requirements set out in the General Procedures for Controlling Materials Approved Prior to Delivery to the Project will apply with the following additions, modifications, or clarifications.

a. Posts, braces, or similar pieces shall be bundled before or after sampling, but prior to approval.

b. All tests will be performed at the Office of Materials Management.

c. Basis of acceptance will be a car seal attached to each roll of fence, barbed wire or tension wire, and each bundle of posts. Acceptance numbers will not be issued for accessories such as post caps, brackets, or tie wires.

d. If a complete roll or bundle is not shipped, the car seal shall be retained with the unused portion. The number shall be supplied to the Engineer for the material acceptance.

3. Suppliers Not Furnishing Pretested Approved Stockpiled Material

Suppliers not desiring to retain status or who lose status to furnish pretested stockpiled material will have their material inspected at the project site after delivery. No material may be used until it has been tested and approved.

910.19 Overhead Sign Structures

The complete structure with signs in place shall be able to withstand wind pressure in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. The structure shall be designed to resist fatigue of the material in accordance with the AASHTO specifications.

All prefabricated structural units shall be packed so that there is no injury or defacement during transportation to the point of destination.

All bolts, nuts, and washers for bridge bracket assemblies shall be stainless steel in accordance with ASTM F 738M.

Strain poles for cable span signs shall be in accordance with 922.05(a). Each strain pole shall include 3 band type attachments for span wire clamps. Such attachments shall be galvanized in accordance with ASTM A 153. Cable shall be in accordance with 922.06(b). Each cable shall include 3 wire rope clips at each end. Anchor bolts shall be in accordance with 922.05(c)6. All sign mounting hardware except for the extruded aluminum bar shall be galvanized in accordance with ASTM A 153.

Material furnished under this specification shall be covered by a type C certification in accordance with 916.

(a) Aluminum Overhead Sign Structures, Box Truss and Bridge Attached

Extruded tubes shall be of aluminum in accordance with ASTM B 221 (B 221M), B 241 (B 241M), or B 429, alloy 6061-T6. All other castings shall be of aluminum in accordance with ASTM B 26 (B 26M), alloy 356.0-T6. Plates shall be of aluminum in accordance with ASTM B 209 (B 209M), alloy 6061-T6. Plates shall be free of sharp edges and irregularities.

Welding material and procedures shall be in accordance with 803 and applicable AWS provisions.

Bolts, nuts, screws, and flat washers shall be passivated type 304 stainless steel. Bolts and screws shall be in accordance with ASTM A 193 (A 193M), grade B8. Hexagon nuts and washers shall be in accordance with ASTM A 194 (A 194M), grade 8. High strength bolts, nuts and washers for chord splice connections, shall be in accordance with 910.02(g) and shall be galvanized in accordance with AASHTO M 232.

The J hook shall consist of one 3/8-in. (10-mm) steel bar in accordance with ASTM A 307. It shall be spot welded to the inside of the end-support member. The J hook shall be hot-dip galvanized prior to welding or in the final assembly with the support column.

Neoprene pads shall be ultraviolet rated.

The safety cable shall be in accordance with 922.06(b).

Anchor bolts, nuts and washers shall be in accordance with ASTM F 1554, Grade 36. A hexagon nut, leveling nut, and flat washer shall be furnished with each anchor bolt. Top ends of anchor bolts and associated hardware as shown on the plans, shall be coated in accordance with ASTM A 153 or be mechanically

galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

Certified proof of the qualifications for a minimum of 2 welders shall be presented after the contract is awarded and before fabrication is started. This certification shall be from a commercial or public testing laboratory and qualifications shall be based on welding of aluminum alloy, 6061-T6 with consumable electrode type welding using aluminum alloy ER5356 filler material. Welders shall qualify by passing the requirements of "Procedure and Performance Tests of Qualification Standard for Welding Procedures, Welders, and Welding Operations", latest edition, formulated by the Boiler and Pressure Vessel Committee of the American Society of Mechanical Engineers.

Welding shall be checked carefully by visual inspection. Poor welding workmanship as noted by visual inspection shall be sufficient cause for rejection.

Each complete structure shall be warranted that it is free from any misfits or structural deficiencies prior to shipment.

(b) Steel Overhead Sign Structures, Box Truss, Cantilever, Monotube, and Bridge Attached

Steel sections used for upright members, cross beams, or horizontal members shall be either tapered or constant cross section tubular members as specified herein. The tubular members may be either circular or multi-sided.

Box truss and bridge attached structures shall be fabricated from constant cross section tubular steel in accordance with ASTM A 53, type E or S, grade B (minimum yield strength of 35,000 psi). Constant cross section tubular steel with greater yield strength may be used, with written approval. However, structural dimensions must remain as shown on the plans. Structures shall be galvanized after fabrication in accordance with ASTM A 123.

Tri-chord truss, cantilever, and monotube structures shall be made of tapered tubular members in accordance with either ASTM A 595 or ASTM A 572, grade 50 (A 572M, grade 345), or of constant cross section tubular members in accordance with API High Test Line Pipe, grade X-52. Members shall have a minimum yield strength of 50,000 psi (345 MPa). Structures shall be galvanized after fabrication in accordance with ASTM A 123.

Strain poles shall be anchor bolt type complete with hand-holes and pole top or cap. They shall meet the requirements set out above for cantilever sign structures. Each pole is to include 3 band type attachments for span wire clamps. The band shall be from material in accordance with ASTM A 572, grade 50 (A 572M, grade 345); ASTM A 606; or approved equal. The bands shall not be of the U-bolt type. The poles shall have maximum deflections as shown below when loaded 18 in. (450 mm) from the top with a 100 lb (445 N) load.

Pole Size	Deflection
15 in. by 30 in. (380 mm by 910 mm)	0.16 in. (4.1 mm)
14 in. by 26 in. (356 mm by 790 mm)	0.12 in. (3.0 mm)

The steel flanges at the center of the cross beam and at the ends of the horizontal arms shall be fastened to the tapered or straight sections by means of 2 circumferential welds. One of the circumferential welds shall weld the outside of the flange firmly to the tube. The flange connection shall develop fully the strength of the tubular sections being joined together by means of the flange connections.

Gusset, flange, and base plates shall be in accordance with ASTM A 36 (A 36M) and shall be galvanized after fabrication in accordance with ASTM A 123. Base plates for upright poles shall develop the full strength of the poles. Castings for the vertical pole top and horizontal arm and cap shall be in accordance with ASTM A 126 and shall be galvanized with a minimum coating of 2 oz/sq ft (610 g/m^2). Bolts and nuts, except anchor bolts, shall be in accordance with ASTM A 325, Type 1. Two nuts for use in plumbing upright poles shall be furnished with each anchor bolt. Anchor bolts for overhead steel structures shall be in accordance with 910.19(a). Steel bolts, nuts, washers, and the top ends of anchor bolts shall be coated in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153, class C. Welding shall be in accordance with 711.32.

Beam clamp details and sign support assemblies shall be galvanized in accordance with ASTM A 153. Clamps shall be fabricated of high strength, low alloy steel in accordance with ASTM A 242 (A 242M), ASTM A 606, or approved equal. Stainless steel U-bolts may be used in lieu of the clamps for the attachment of the sign hangers to the arms of double arm cantilevers. The U-bolts shall be in accordance with 910.19(a) for stainless steel hardware.

910.20 Steel Bridge Railing Components

Materials for steel bridge railing components shall be in accordance with the following.

(a) Railing tubing shall be in accordance with ASTM A 500, Grade B.

(b) Posts, connection plates, splice bars, base plates, and anchor channel bars shall be in accordance with ASTM A 36 (A 36M).

(c) Steel bolts, nuts, and cap screws shall be in accordance with ASTM A 307.

(d) Railing end caps shall be steel castings in accordance with ASTM A 27, grade 70-36 (A 27M, grade 485-250).

(e) Threaded rods, nuts, and washers shall be in accordance with AASHTO M 164.

(f) Steel washers shall be standard round cut or lock washers, as shown on the plans.

(g) Cap screws shall be stainless steel in accordance with ASTM A 276, type 304, 305, or 430.

(h) Anchor bolts shall be stainless steel in accordance with ASTM A 276, type 305 or 430. However, they shall have a minimum ultimate strength of 100 ksi (690 MPa). Threads may be cut or rolled.

(i) Railing tubing, posts, connection plates, splice bars, base plates, anchor channel bars, and railing end caps shall be galvanized after fabrication in accordance with AASHTO M 111.

Bolts, nuts, cap screws, washers, and lock washers shall be galvanized after fabrication in accordance with AASHTO M 232.

(j) Anchor bolts furnished under this specification shall be covered by a type A certification in accordance with 916. All other components furnished under this specification shall be covered by a type C certification in accordance with 916.

910.21 Steel Sheet Piling

Steel sheet piling shall be in accordance with ASTM A 328 (A 328M), ASTM A 1011 (A 1011M), or ASTM A 525 (A 525M).

SECTION 911 – WOOD MATERIALS

911.01 Untreated Lumber

(a) General

Untreated limber is a saw mill product which is not further manufactured than by sawing, resawing, passing lengthwise through a standard planning machine, drying, cross cutting to length, and machining but is not treated with preservatives.

All lumber to be used without preservative treatment shall have the heart center completely boxed in pieces 6 in. (150 mm) and over in thickness. Pieces not large enough to box the center shall be cut outside the heart. Stringers, floor beams, and flooring shall have no less than 80% of heart on any girth. Caps, sills, and posts shall have no less than 60% of heart on each of the 4 sides measured across the side.

Bracing, struts, rails, and such shall have no less than 80% on both sides measured across the side. If plans or purchase order are marked “Square Edge”, no wane will be permitted.

1. Boards

Yard lumber less than 2 in. (50 mm) thick and more than 1 in. (25 mm) wide is a board.

2. Dimension Lumber

Lumber from 2 in. (50 mm) to but not including 5 in. (125 mm) thick and 2 in. (50 mm) or more wide is dimension lumber.

3. Structural Lumber

Lumber that is 2 in. (50 mm) or more thick and 4 in. (100 mm) or more wide intended for use where working stresses are required is structural lumber. The grading of structural lumber is based on the strength and use of the entire piece. Joists and planks shall be structural lumber. Dimensions and grade of lumber shall be as shown on the plans or as otherwise specified.

4. Sawn Timbers

Lumber of 5 in. (125 mm) or more in the least dimension is timber. Timbers may be classified as beams, stringers, posts, caps, sills, girders, purlins, etc. Timber for structural purposes shall be no less than 6 in. (150 mm) in width or thickness. Dimensions and grade of lumber shall be as shown on the plans or as otherwise specified.

5. Timbers, Round

These timbers are used in the original round form, such as poles, posts, and mine timbers. Round timbers, such as posts and poles, shall be entirely peeled. All limbs and knots shall be trimmed flush. Unless otherwise permitted or shown on the plans, no minus tolerances will be permitted on the specified diameter.

6. Yard Lumber

Lumber of all sizes and patterns that is intended for general building purposes is yard lumber. The grading of yard lumber is based on the intended use of the particular grade and is applied to each piece with reference to its size and length when graded without consideration to further manufacture.

7. Surfaced or Dressed Lumber

This is lumber that is dressed by running it through a planer.

8. Rough Sawn Lumber

This is lumber that has been sawn, edged, and trimmed, but not dressed.

(b) Species and Grade

Only coast region douglas fir, red oak group, redwood, long or short leaf southern yellow pine, and white oak group will be permitted, except as set out elsewhere herein. Redwood lumber shall not be used in bridges where it is a permanent part of the structure.

Except as otherwise provided, all lumber furnished under these specifications shall be of the species and grades specified.

Softwood lumber shall be graded in accordance with grade rules which conform with the basic provisions of the American Softwood Lumber Standard PS20-70. It shall be grade marked and shall be in accordance with the applicable grading rules or specifications of the following agencies for the species indicated.

Coastal Region Douglas Fir – West Coast Lumber Inspection Bureau

Southern Yellow Pine – Southern Pine Inspection Bureau

Redwood – Redwood Inspection Service

Red and White Oak Group, Hardwood Lumber, shall be grade marked and shall be in accordance with the applicable grading rules of the National Hardwood Lumber Association.

If lumber is not to be graded as provided above, it may be green or seasoned, but shall be sound, free from excessive wane, unsound loose or hollow knots, knot holes, shakes, or other defects which would impair strength or durability for the use intended. Pin holes, shot holes, or occasional grub holes in oak are not classified as defects. If approved and if the proposed use of the material is stated on the purchase order, grade markings may not be required on native red or white oak groups furnished from local sources or on emergency orders or small orders of douglas fir and southern yellow pine.

Lumber for temporary bridges or other temporary structures may be of any species and grade which meets approval.

(c) Inspection

All lumber regardless of grade markings may be inspected for grades and quality at the point of origin or final destination. If, during inspection of a lot of lumber, it becomes apparent that the quantity of rejections exceed 20% , the entire lot may be rejected.

(d) Tolerances

Tolerances for rough sawed, or dressed lumber shall be in accordance with the following table.

Nominal Dimensions		Rough Lumber Tolerances*		Surfaced Lumber Tolerances (SIS and S2S to S4S)	
Thickness, in. (mm)	Width, in. (mm)	Thickness, in. (mm)	Width, in. (mm)	Thickness, in. (mm)	Width, in. (mm)
1 (25)	Under 8 (200)	1/8 (3)	1/4 (6)	1/4 (6)	3/8 (10)
	8 (200) and over	1/8 (3)	3/8 (10)	1/4 (6)	1/2 (13)
2 (50)	Under 8 (200)	1/4 (6)	1/4 (6)	3/8 (10)	3/8 (10)
	8 (200) and over	1/4 (6)	3/8 (10)	3/8 (10)	1/2 (13)
Over 2 (50) but Less than 8 (200)	Under 8 (200)	1/4 (6)	1/4 (6)	3/8 (10)	3/8 (10)
	8 (200) and over	1/4 (6)	3/8 (10)	3/8 (10)	1/2 (13)
8 (200) and over	8 (200) and over	3/8 (10)	3/8 (10)	1/2 (13)	1/2 (13)
* If full size rough lumber is specified, no minus tolerances will be permitted.					

(e) Untreated Piling

Untreated piles shall be in accordance with ASTM D 25 and the following. All piling shall be cut from white or red oak, dense southern yellow pine, fir, or cypress, preferred in the order listed. They may be of other species, subject to approval, which can withstand driving without showing excessive brooming or splitting.

All piling shall have been cut from sound, solid, live trees. All pile containing defects, or combination of defects, which impair the strength of the pile shall not be used. Piles shall be free from reverse bends. The butts and tips shall be sawed square with the axis of the pile. Alternatively, the tips may be tapered to a point of not less than 16 sq in. (10,300 mm^2) with the tip so formed that the centerline of the pile passes through the tip.

Unless otherwise specified, all piles shall be clean-peeled before driving. No strip of the inner bark remaining on the pile shall be more than 3/4 in. (19 mm) wide There shall be at least 1 in. (25 mm) of barkfree surface between 2 such strips. Not less than 80% of the surface on 1 circumference shall be clean wood. All knots shall be trimmed flush with the body of the pile.

After peeling, piles shall have diameters as indicated below unless otherwise approved or required.

	Diameter – Inches (mm)		
Length of Pile	Tip Minimum	3 in. (0.9 m) from Butt, Minimum	Butt Maximum
Less than 20 ft (6.1 m)	8 (200)	11 (280)	20 (510)
20 ft (6.1 m) and less than 40 ft (12.2 m)	8 (200)	12 (305)	20 (510)
40 ft (12.2 m) and less than 60 ft (18.3 m)	7 (180)	13 (330)	20 (510)
60 ft (18.3 m) and more	6 (150)	13 (330)	20 (510)

Piles shall be strapped with at least 3 straps: 1 approximately 18 in. (450 mm) from the butt, 1 approximately 24 in. (600 mm) from the butt, and 1 approximately 12 in. (300 mm) from the tip. Additional straps shall be provided at approximately 15 ft (4.5 m) centers between the butt and tip. Strapping shall encircle the pile once and be tensioned as tightly as possible. Straps shall be 1 1/4 in. (32 mm) wide, 0.31 in. (8 mm) thick, cold rolled, fully heat treated, high tensile strapping, painted, and waxed, with an ultimate tensile strength of 5,100 psi (35.2 MPa). The strap shall encircle the pile once and shall be crimped with a notch type sealer to furnish a joint yielding 80% of the strap tensile strength. Treated timber piles shall be strapped after treatment.

911.02 Treated Lumber

(a) General

Treated lumber shall be lumber which is preservative treated by pressure processes in accordance with the AWPA Standards. AWPA Standard C1 specifies general requirements for all wood products. Other AWPA Standards applying to specific items are set out in 911.02(b), 911.02(c), 911.02(d), and 911.02(e) and 911.02(g). Lumber to be treated shall be in accordance with 911.01, except as modified in 911.02(b), 911.02(c), 911.02(d), and 911.02(e). The lumber may be inspected at the treating plant. Preservatives shall be in accordance with 911.02(f). Wherever ammoniacal copper quat type B preservative is utilized, stainless steel fasteners shall be used.

(b) Bridge Lumber

This shall be southern yellow pine or coast region douglas fir. There shall be no heartwood requirements and the amount of sapwood shall not be limited. Wane will not be permitted on any treated plank for flooring and may be excluded elsewhere when so specified. In other lumber, wane shall not exceed 1/8 of the width of any face and 1/4 of the length of the piece on any 1 corner. Both the outer and inner bark shall be removed from any area where wane is permitted. Lumber for bridges shall be treated with a preservative in accordance with applicable provisions of Standards C14 and C2 of the AWPA Standards.

(c) Piling

Wood piling, before treatment, shall be in accordance with 911.01(e) except piles shall be southern yellow pine, red oak, or coast region douglas fir. The outer and inner bark shall be removed before treatment. Unless otherwise specified, piling shall be treated with a preservative in accordance with the applicable requirements of AWPA of Standards U1 and T1.

(d) Guardrail Posts, Braces, and Battens

Wood for these items shall be cut from live, dense southern yellow pine, coast region douglas fir, red oak, or other species if so designated in the proposal or purchase order. Posts shall be rough sawed unless otherwise specified. Dimensions shall be as shown on the plans. There shall be a length tolerance of plus 2 in.

(50 mm) for posts. The bottoms shall be sawed square and the tops roofed as shown on the plans. Wane shall not extend more than 2 ft (0.6 m) from the bottom end. Knots shall be closely trimmed, but hollow knots extending in close to the center of the post, loose knots, and knot clusters will not be permitted. Posts shall be practically straight and no post with a crook exceeding 1 in. (25 mm) between top and butt will be accepted.

Posts listed above shall be sound posts. No sapwood rot will be permitted. Ring shake will not be permitted and oak posts shall be free from pecks or excessive grub holes. Grub holes in the butt, 1/2 in. (13 mm) or less in diameter, are not considered defects. Posts containing ant holes will not be accepted. Any post which contains any defect which is detrimental to the post will be rejected.

Wood braces and battens shall be of the same general species and specifications as required for the posts and shall be of the dimensions shown on the plans.

Wood guardrail posts, and wood parts in connection with guardrails, shall be treated with a preservative in accordance with the applicable provisions of Standards C14 and C2 of the AWPA Standards.

(e) Sign Posts

Wood sign posts shall be cut from live catalpa; northern white cedar; native red cedar; southern red cedar; black locust; yellow locust; mulberry; red, black, and white oak group; osage orange; dense southern yellow pine; redwood; sassafras; coast region douglas fir, or other species as specified. Posts shall be surfaced 4 sides.

Dimensions shall be in accordance with the plans. There shall be a length tolerance of 2 in. (50 mm). Both butt and top ends shall be sawed square. All outer and inner bark shall be removed. One way sweep, not exceeding 1 in. (25 mm) between the top and butt, will be acceptable. Short crooks will not be permitted.

The posts shall be sound timber. No splits, shakes, excessive cracks, loose decayed or hollow knots will be permitted. Occasional pin, shot, or grub holes in oak, or bird pecks in other timbers, will not be considered defects. All posts shall be entirely treated with preservatives in accordance with all applicable provisions of Standards C14 and C2 of the AWPA Standards. The oil carrier shall be a heavy petroleum solvent in accordance with the applicable provisions of Standard P9 of the AWPA Standards and shall be of such characteristics that the posts will be suitable for painting with an oil base paint.

(f) Sawed Timber Posts and Blocks for Thrie-Beam and W-Beam Guardrail

The requirements for posts and blocks prior to treatment shall be as shown below.

1. Species and Grades

Wood posts shall be of the species listed, and shall be in accordance with the grading requirements specified in Table A. Wood blocks shall be of the species listed, and shall be in accordance with the grading requirements specified in Table B. Wood posts and blocks shall have a nominal cross section and dimensions as shown on the plans.

TABLE A

SPECIAL AND GRADING REQUIREMENTS FOR SAWED TIMBER GUARDRAIL POSTS		
SPECIES	POSTS & TIMBERS GRADE	GRADING RULES AGENCIES[a]
HARDWOODS		
Red Oak (Northern Red, Black, Pin, Laurel, Cherry-Bark, Scarlet, Water and Willow Oaks)[b], Hard Maple (Black & Sugar) and Red Maple, White Ash, White-Heartwood Beech, Yellow Birch, Hickory (Mockernut, Pignut, Shagbark, and Shellbark Hickories)	Grade GRP	Department
SOFTWOODS		
Douglas Fir, Douglas Fir-Larch	No. 1 or better	WWPA or WCLIB
Southern Pine	No. 1 or better	SPIB
Jack Pine 8 in. by 8 in. (200 mm by 200 mm)	No. 1 or better	NHPMA

[a] NHPMA (Northern Hardwood and Pine Manufacturers Assoc.); WWPA (Western Wood Products Assoc.); WCLIB (West Coast Lumber Inspection Bureau); and SPIB (Southern Pine Inspection Bureau).

[b] Southern Red Oak will not be permitted.

Posts and blocks shall be graded in accordance with grading rules based on principles and methods specified in ASTM D 245. Where there is a conflict between AWPA and ASTM standards, AWPA will prevail. Where there is a conflict between either AWPA or ASTM standards and this specification, this specification will prevail.

All material shall show the approved grading agency stamp indicating mill origin, species, and grade.

TABLE B

SPECIES AND GRADING REQUIREMENTS FOR SAWED TIMBER GUARDRAIL BLOCKS		
SPECIES	POSTS & TIMBERS GRADE	GRADING RULES AGENCIES[a]
HARDWOODS		
Red Oak (Northern Red, Black, Pin, Laurel, Cherry-Bark, Scarlet, Water and Willow Oaks)[b], Hard Maple (Black & Sugar) and Red Maple, White Ash, White-Heartwood Beech, Yellow Birch, Hickory (Mockernut, Pignut, Shagbark, and Shellbark Hickories)	Grade GRP	Department
SOFTWOODS		
Douglas Fir, Douglas Fir-Larch	No. 2 or better	WWPA or WCLIB
Southern Pine Species	No. 2 or better	SPIB
Jack Pine, Red Pine, and Eastern White Pine (Northern White Pine)	No. 1 or better	NHPMA

[a] NHPMA (Northern Hardwood and Pine Manufacturers Assoc.); WWPA (Western Wood Products Assoc.); WCLIB (West Coast Lumber Inspection Bureau); and SPIB (Southern Pine Inspection Bureau).
[b] Southern Red Oak will not be permitted.

2. Department Grade GRP

The requirements for posts to be in accordance with the Department's Grade GRP, Guardrail Posts, will be as follows.

a. Splits

Splits in the plane of the bolt hole shall not exceed 3 in. (75 mm). At other locations, splits shall not exceed 6 in. (150 mm).

b. Checks

Single checks shall not be greater than 3 in. (75 mm) deep. Checks opposite each other shall not total more than 3 in. (75 mm) deep, as measured with a probe that is not more than 1/16 in. (1.6 mm) in thickness or in diameter.

Single checks of 1/4 in. (6 mm) wide, or wider, measured at the widest point, shall not extend more than 1/3 of the length of the post. Single checks, measured at the widest point, shall not exceed 3/8 in. (10 mm) in width.

c. Shakes

Shakes, measured in the least dimension, shall not exceed 2 in. (50 mm).

Splits, checks, and shakes shall not be in combinations which may cause the post to separate into several pieces.

d. Stains

Stained heartwood, not caused by decay, shall not exceed 15% of the piece.

e. Slope of Grain

Slope of the grain shall not exceed 1 in 10.

f. Wane

Wane shall be less than 1/4 of each face.

g. Knots

Knots shall be sound and tight. The sum of the least dimensions of all knots in a 6 in. (150 mm) length of post, all faces, shall be less than 5 in. (125 mm). Grain distortion caused by knot clusters shall not exceed 2 1/2 in. (63 mm). Knots will be permitted on all faces, but knots shall not exceed 2 1/2 in. (63 mm) in the least dimension.

3. Department Grade GRB

The requirements for blocks to be in accordance with the Department's Grade GRB, Guardrail Blocks, will be as follows.

a. Splits

Splits in the plane of the bolt hole shall not exceed 3 in. (75 mm). At other locations, splits shall not exceed 5 in. (125 mm).

b. Checks

Checks shall be in accordance with 911.02(f)2b.

c. Shakes

Shakes, measured in the least dimension, shall not exceed 3 in. (75 mm). Shakes shall not extend beyond 1/2 the standard grading length of the piece.

Splits, checks, and shakes shall not be in combinations which may cause the post to separate into several pieces.

d. Stains

Stained heartwood, not caused by decay, shall not exceed 25% of the piece.

e. Wane

Wane shall be less than 1/3 of each face.

f. Knots

Grain distortion caused by knot clusters shall not exceed 4 in. (100 mm). Knots will be permitted on all faces, but knots shall not exceed 4 in. (100 mm) in the least dimension.

4. General Requirements

Posts and blocks shall be in accordance with the following general requirements.

a. Decay

Posts and blocks shall be free from decay before treatment.

b. Unsound Wood

Posts containing unsound wood will be rejected. Blocks may contain small spots of unsound wood provided they are well scattered.

c. Crook or Bow

Crook or bow shall not exceed 1 in. per 10 ft (25 mm per 3 m) length.

d. Dimensional Tolerances

Posts and blocks shall be sawed square to within -1/2 in. (-13 mm) of the specified cross-sectional dimensions. A tolerance of -2 in. (-50 mm) will be permitted on the specific length of the posts. A tolerance of -1/2 in. (-13 mm) will be permitted on the specified length of the blocks.

5. Pressure Treating Posts and Blocks

Pressure treating posts and blocks shall be in accordance with the following requirements.

a. Machining

Posts and blocks shall be sawed to their final shape and holes bored prior to treatment.

b. Blank

c. Inspection Before Treatment

The treater shall be responsible for ensuring that the material has the required approved grading agency stamp before treatment is commenced. The stamp or marking shall be applied on a wide face at the trimmed end. The stamp shall be applied such that it remains readable after treating. Material that has been air dried or kiln dried shall be inspected for moisture content as specified below, in accordance with AWPA Standard M2. Tests of representative pieces shall be conducted. The minimum number of tests shall be the lesser of 5% or 50 pieces out of a charge.

d. Test for Moisture Content

The test shall be made with an electrical resistance type moisture meter with insulated needles of 1 1/2 in. (38 mm) in length. The readings shall be corrected for species and temperature readings in accordance with the meter instructions. The readings shall be taken on 1 surface at mid-length with needles driven to their full length. The lot will be considered acceptable when the average moisture content does not exceed 19%. Individual pieces exceeding 23% moisture content will be rejected. Such pieces shall be removed from the lot.

e. Preservative Treatment

All posts and blocks shall be treated with a preservative as specified herein.

f. Material for Preservative Treatments

The preservative used for treating posts and blocks shall be in accordance with the appropriate AWPA standards listed in Table C.

TABLE C

MATERIAL	AWPA Standard
Ammoniacal Copper Arsenate (ACA)	P5
Ammoniacal Copper Zinc Arsenate (ACZA)	P5
Chromated Copper Arsenate (CCA)	P5

g. Treatment Methods

Wood for guardrail posts and blocks shall be treated to be in accordance with AWPA Standards C1 and C2, ASTM D 1760, and the requirements specified herein.

h. Sorting and Spacing

The material in a charge shall consist of the same species or consist of species within 1 group shown in Table D. The material shall have similar moisture content and be of similar form and size. Blocks and posts may be treated in the same charge.

Pieces in the charge shall be separated by horizontal stickers so that preservative and steam, if used, shall contact all horizontal surfaces.

TABLE D

SPECIES GROUPINGS FOR TREATMENT IN SAME CHARGE	
GROUP	SPECIES
A	Southern Pine
B	Douglas Fir
C	Jack Pine*
D	Hardwoods
* Also Red Pine and Eastern White Pine Blocks	

i. Conditioning

Material may be conditioned by means of air seasoning, kiln drying, Boulton drying, vapor drying, steaming, or heating in preservative except as limited herein. Material which is air seasoned or kiln dried shall have an average moisture content not exceeding 19% before treatment. When steam conditioning, the maximum temperature shown in Table E shall not be reached in less than 1 h. If a vacuum is applied after steaming, it shall be a minimum of 22 in. (560 mm) of mercury. In addition, when using CCA, ACA, or ACZA, material shall be removed from the cylinder and permitted to cool to 120°F (49°C), or below, after steaming and before the preservative is applied. When treating southern pine, jack pine, and red pine with

CCA, ACA, or ACZA, steaming will only be permitted to thaw frozen or ice coated material.

When conditioning by heating in preservative, the solution shall cover the material. Maximum temperatures permitted shall be those shown in Table E. Conditioning by means of heating in water-borne preservatives CCA, ACA, or ACZA will not be permitted.

TABLE E

CONDITIONING METHODS PERMITTED AND TEMPERATURE REQUIREMENTS FOR METHOD USED					
		HEATING IN			
		STEAMING		PRESERVATIVE	
SPECIES	CONDITIONING METHODS PERMITTED	Max. Temp, °F (°C)	Max. Duration, Hrs.	Max. Temp, °F (°C)	Max. Duration, Hrs.
Hard Maple	Air drying only				
Other Hardwoods(1)	No Steaming			220 (104)	No Limit
Southern Pine	All	245 (118)	17	220 (104)	No Limit
Eastern White Pine	All	240 (116)	4 1/2	210 (99)	6 (3)
Other Softwoods(2)	All	240 (116)	6	210 (99)	6 (3)

(1) Red Oak, White Ash, White-heartwood beech, Yellow Birch, Hickory, and Red Maple
(2) Jack Pine, Douglas Fir, and Red Pine
(3) If seasoned material is used, otherwise, no limits

j. Blank

k. Inspection During Treatment

The treater shall determine that the preservatives used are in accordance with the requirements herein. The minimum frequency of the preservation analysis shall be each charge for the occasional single charge inspected. The minimum frequency for consecutive treatments from the same working tank shall be the 1st and at least 1 of every 5 additional charges, selected at random. Preservative samples shall be taken as appropriate so as to be representative of the solution in the treating cylinder.

l. Retentions

The minimum retentions in lb/cu ft (kg/m^3) for the outer 0.6 in. (15 mm) of guardrail posts and blocks shall be those listed in Table F. Retentions shall be determined by chemical assay with samples taken after treatment in accordance with the inspection after treatment requirements shown below and the AWPA Standards listed in Table F.

TABLE F

MINIMUM REQUIREMENTS FOR RETENTION OF PRESERVATIVE			
PRESERVATIVE	RETENTION lb/cu ft (kg/m^3)		AWPA STANDARD
	POSTS	BLOCKS	
CCA, ACA, or ACZA	0.60 (9.61)	0.40 (6.41)	A11

If blocks are treated along with posts, retention of the charge shall be determined by assay of borings from posts.

m. Penetration

The penetration requirements for heartwood and sapwood shall be as specified in Table G. Samples to determine penetration shall be taken after treatment in accordance with the inspection after treatment requirements shown below.

TABLE G

PENETRATION REQUIREMENTS FOR POSTS AND BLOCKS		
SPECIES	MINIMUM PENETRATION	
	HEARTWOOD	SAPWOOD
Permitted Species*	0.3 in. (8 mm)	0.6 in. (15 mm) or 90%, whichever is greater
* For Red Oak, 65% of the total annual rings shall be penetrated. If this is not possible, properly conditioned wood may be treated to refusal.		

n. Inspection After Treatment

Following treatment, the charge shall be examined by the treater for cleanliness; mechanical damage to individual pieces; treatment damage such as severe checking, splitting, or honeycombing; and for untreated areas resulting from air pockets, floating material, or insufficient height of preservative. All such material shall be removed from the remaining acceptable material before shipment.

Sampling and testing for preservative retention and penetration will be done by the Department.

o. Branding

All post and blocks shall be burn branded clearly and permanently on 1 of the wide faces. The brand shall be within 12 in. (300 mm) of the top of the post. The brand shall show the treater's identification, the plant designation, and the year of treatment. The month may also be included. The brand shall also show the species or group code designation shown in Table H, the preservative type, and retention, all in accordance with AWPA Standard M6.

p. Conformance

The treating plant supplying the material shall be responsible for and will be required to supply a certificate indicating the species, grade, preservative type, retention, year, and name of treater.

TABLE H

GROUP CODING AS AN ALTERNATE TO SPECIES CODING*	
GROUP	CODE
Hardwoods	MH
Jack Pine	J
Other Softwoods	MS
* Species designated in Tables A and B	

q. Records

Copies of treating records, analysis records, and other records which may be necessary to determine accordance with specifications shall be made available to Department personnel or their designated representatives upon their request. Required information shall be that which is listed in Part 7.2 of AWPA Standard M2. These records shall be retained by the treating plant for 5 years from the date of material shipment.

r. Independent Inspections

The Department may inspect the material or call for a non-Departmental inspection to verify that it is in accordance with all specifications.

6. Field Treatment of Posts and Blocks

Cuts, holes, or injuries to the surface of posts and blocks which occur after pressure treatment shall be field-treated by brushing, spraying, dipping, soaking, or coating. The Contractor shall ensure that all injuries, such as abrasions and nail and spike holes, are thoroughly saturated with the field-treating solution. Holes bored in pressure-treated materials shall be poured full of preservative. Horizontal holes may be filled by pouring the preservative into the holes with a bent funnel after temporarily plugging the other end of the hole.

The solution used for field treatment shall be a 20% solution of copper naphthenate.

7. Rejection for Degrade After Treatment

Guardrail posts or blocks developing the following degrade prior to installation will be rejected regardless of prior approvals.

a. single checks greater than 3 in. (75 mm) deep or checks opposite each other totaling more than 3 in. (75 mm) deep, measured with a probe not more than 1/16 in. (2 mm) thick;

b. single checks 1/4 in. (6 mm) wide or wider measured at the widest point, and extending more than 1/3 of the length of the post or block;

c. single checks greater than 3/8 in. (10 mm) wide measured at the widest point;

d. splits greater than 3 in. (75 mm) long which are in the plane of the bolt hole;

e. crooks or bows exceeding 1 in. (25 mm) per 10 ft (3 m) length; and all twists;

f. combinations of checks, splits, or shakes which are otherwise in accordance with the specifications but which may cause the post or block to separate into several pieces.

(g) Recreational Applications

Lumber that will be used where human contact will occur, such as handrails and picnic tables, will be treated with ammoniacal copper quat, type B in accordance with AWPA Standards C-14 and P-5. The treater shall perform inspection and marking in accordance with AASHTO M 133. Material furnished under this specification shall be covered by a type C certification in accordance with 916.

(h) Preservatives

Preservatives shall be in accordance with AASHTO M 133 as modified by EPA regulation.

Waterborne preservatives shall be in accordance with AWPA-P5, and shall be Acid Copper Chromate, Ammoniacal Copper Arsenate, or Chromated Copper Arsenate.

SECTION 912 – CONCRETE CURING MATERIALS AND ADMIXTURES

912.01 Curing Materials

Curing materials shall be in accordance with the following requirements.

(a) Burlap Cloth made from Jute or Kenaf

This material shall be new, or reclaimed and thoroughly vacuum cleaned burlap. Burlap from sugar, salt, or fertilizer bags shall not be used. The burlap shall weigh no less than 10 oz/sq yd (0.34 kg/m^2) and shall be in strips of not less than 40 in. (1 m) nor more than 120 in. (3 m) wide and no less than 2 ft (0.6 m) longer than the width of the pavement being cured.

(b) Waterproof Paper Blankets

These blankets shall be in accordance with AASHTO M 171.

(c) White Polyethylene Sheeting, Film

The sheeting shall be in accordance with AASHTO M 171.

(d) White Burlap Polyethylene Sheet

These sheets shall be in accordance with AASHTO M 171.

(e) Liquid Membrane Forming Compounds

These compounds shall be in accordance with AASHTO M 148, type 2, except the drying time requirement will be determined on a glass surface.

(f) Polyethylene Film

The sheeting shall be in accordance with AASHTO M 171.

912.02 Curing-Sealing Materials

Curing-sealing materials are single application curing and sealing products for portland cement concrete.

A list of approved Curing-Sealing Materials will be maintained by the Department. The list will identify pre-approved products, specify the manufacturer and product designation, and include application instructions.

In order to have a product added to the list of approved Curing-Sealing Materials, the manufacturer shall furnish to the Office of Materials Management a type A certification in accordance with 916. Such certification shall state that the product is in accordance with the requirements of NCHRP 244 Series IV Southern Climate Weathering Test, and AASHTO M 148 Type 1.

(a) The certification shall be in accordance with the applicable requirements of 916, and shall include a dated test report. The test report shall substantiate full compliance with the specifications and establish when the testing was started. Test reports older than 7 years on January 1st of the approval year will not be accepted.

(b) If irregularities are found in the results required for such certification, copies of the original data may be required prior to reconsideration of the certification.

(c) Tests must be conducted by a state highway agency testing laboratory or a testing laboratory regularly inspected by CCRL. Proof of such inspection shall be furnished with the test report.

After a product has been approved, it will be added to the list of approved and/or Prequalified Materials. The product will remain on the list until test results on file are 7 years old, provided that there are no changes in raw materials, formulation, or procedures for manufacture. Results more than 7 years old or products in which there

has been a change in raw materials, formulation, or procedures for manufacture shall be recertified in order to remain on the list.

A curing-sealing material that performs unsatisfactorily in the field will be removed from the approved list.

912.03 Admixtures for Use in Concrete

Admixtures for use in PCC shall be selected from the Department's list of approved Admixtures for PCC. An admixture may be added to the approved list by completing the requirements in ITM 806, Procedure D. Admixtures containing chloride added as an ingredient of manufacture are unacceptable.

(a) Air Entraining Admixtures

Air entraining admixtures are materials to be added to PCC mixtures at the mixer for the purpose of entraining air.

(b) Chemical Admixtures for Concrete

Chemical admixtures are materials to be added to PCC mixtures at the mixer for the purpose or purposes indicated below.

1. Type A

Type A is a water reducing admixture that reduces the quantity of mixing water required to produce concrete of a given consistency.

2. Type B

Type B is a retarding admixture that retards the setting of concrete.

3. Type C

Type C is an accelerating admixture that accelerates the setting and early strength development of concrete.

4. Type D

Type D is a water reducing and retarding admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and retards the setting of concrete.

5. Type E

Type E is a water reducing and accelerating admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and accelerates the setting and early strength development of concrete.

6. Type F

Type F is a high range water reducing admixture, HRWR, that reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater.

7. Type G

Type G is a high range water reducing and retarding admixture, HRWRR, that reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater, and retards the setting of concrete.

8. High Range Water Reducing Admixture System

HRWR admixture system is a combination of admixtures that act as a type F mixture within a concrete mixture. The system consists of chemical admixtures and an air entraining admixture. One of the components shall be a type F admixture. Components shall be in accordance with 912.03 for their respective types.

9. High Range Water Reducing and Retarding Admixture System

HRWRR admixture system is a combination of admixtures that act as a type G admixture within a concrete mixture. The system consists of chemical admixtures and an air entraining admixture. One of the components shall be a type F or a type G admixture. One of the components shall retard the setting of the concrete. Components shall be in accordance with 912.03 for their respective types.

(c) Test Report

Testing shall be performed by a recognized laboratory in accordance with ITM 806.

1. Air entraining admixtures shall be in accordance with AASHTO M 154.

2. Chemical admixtures shall be in accordance with AASHTO M 194 for their respective types.

3. Test reports shall not be more than 5 years old on January 1st of the approval year. New submittals of test reports more than 5 years old will be accepted, if all subsequent 5 year limited retest reports, are submitted. Subsequent limited retest results shall comply with the dating and age requirements specified above and shall include the following tests as a minimum requirement for compliance.

    a. infrared analysis, residue by oven drying, and specific gravity;

    b. water content and time of setting;

    c. flexural strength at 3, 7, and 28 days;

    d. relative durability.

912.04 Latex Modifiers

The latex modifiers are an admixture to be added to the concrete mixture at the continuous mixer. The latex shall be 1 of the latex modifiers in the list of approved Admixtures for Portland Cement Concrete.

The formulated latex admixture shall be a non-toxic, film forming, polymeric emulsion in water to which all stabilizers have been added at the point of manufacture and shall be homogeneous and uniform in composition. A type B certification shall be furnished in accordance with 916.

Physical properties of the latex modifier shall be in accordance with the following:

Polymer Type	Styrene Butadiene
Stabilizers	Anionic and Nonionic Surfactants
Anitfoaming Agent	Polydimethyl Siloxane
Percent Solids, % by Mass	46.0 Minimum
Mass Per Gallon (Liter)	8.4 lb (1.0 kg) at Minimum
pH (as shipped)	9.0-11.0
Freeze/Thaw Stability	5 Cycles, -15° to 25°C
Shelf Life	2 Years, Minimum
Color	White

912.05 Foaming Agent

Foaming agents used in making preformed foam for cellular concrete grout shall be in accordance with ASTM C 869. A type C certification shall be furnished in accordance with 916.

SECTION 913 – SOIL TREATMENT MATERIALS

913.01 Water

Water used in mixing or curing shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substance injurious to the finished product. Water will be tested in accordance with AASHTO T 26. Water shall be in accordance with the requirements as follows.

(a) pH	6 to 8
(b) Chloride Ions	less than 300 ppm
(c) Sulphate (SO_4)	less than 500 ppm
(d) Total Solids	less than 1500 ppm

In addition, water containing algae will be unacceptable for use in concrete. Water known to be of potable quality may be used without test. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

913.02 Calcium Chloride

Calcium chloride shall be in accordance with AASHTO M 144 and shall be:

(a) Type S, grade 1, class A

(b) Type S, grade 3, class A or B

(c) Type L

913.03 Sodium Chloride

Sodium chloride shall be in accordance with AASHTO M 143. Rock salt shall be used for de-icing purposes. Either rock salt or evaporated salt may be used for stabilization.

913.04 Lime

Lime shall be a hydrated lime when used in masonry or a hydrated lime, quicklime, or lime by-product when used for soil modification.

(a) Hydrated Lime for Masonry

Hydrated lime used in masonry shall be in accordance with ASTM C 207, Type N.

(b) Lime for Soil Modification

Hydrated lime, quicklime, or lime by-product used for soil modification shall be approved in accordance with ITM 806, Procedure P and shall meet the following requirements.

1. Hydrated Lime and Quicklime

Hydrated lime and quicklime shall be in accordance with AASHTO M 216.

2. Lime By-Products

Lime by-products shall be hydrated lime or quicklime by-products in accordance with ASTM C 25 having the following requirements.

a. The lime by-products shall contain a minimum of 60% total calcium and magnesium oxides (non-volatile basis).

b. Available calcium hydroxide plus magnesium oxide calculated as calcium hydroxide shall be a minimum of 30%.

c. Sieve analysis shall be performed in accordance with ASTM C 110. The lime by-products gradation shall be as follows:

Sieve	% Retained (Max)
No. 4 (4.75 mm)	5

No. 30 (600 µm)	10
No. 100 (150 µm)	25

913.05 Cement By-Products

Cement by-products used for soil modification shall be approved in accordance with ITM 806, Procedure P and shall meet the following requirements:

(a) The cement by-product shall contain a minimum of 50% calcium oxide as reported.

(b) Available free lime (CaO) shall be a minimum of 5%.

(c) Loss on ignition shall be a maximum of 30%.

Sieve analysis shall be performed in accordance with ASTM C 110. The cement by-products gradation shall be as follows:

Sieve	% Retained (Max)
No.4 (4.75 mm)	5
No. 30 (600 µm)	10
No. 100 (150 µm)	25

913.06 Bentonite Grout

Bentonite grout shall be untreated, sodium bentonite, finely ground with not more than 5% retained on the No. 200 (75 µm) sieve. It shall be free of lumps and materials that can prevent mixing into a fluid free of lumps of unmixed bentonite. Calcium bentonite will not be accepted.

The grout shall be proportioned at 2 lbs (0.24 kg) of pure bentonite powder per gal. (L) of potable water. Deviations from these proportions shall be subject to approval.

SECTION 914 – ROADSIDE DEVELOPMENT MATERIALS

914.01 Special Topsoil for Roadside Development

This topsoil shall consist of loose friable soil, free of refuse, stumps, large roots, rocks over 2 in. (50 mm) in diameter, brush, weeds, or other material which would be detrimental to the proper development of vegetative growth. It shall be capable of supporting normal vegetation as demonstrated by the growth of healthy vegetation on it. It shall not be taken from a source known to contain any of the noxious weeds defined as such in the Indiana State Seed Law, IC 15-4-1.

Topsoil shall have a pH value of 6.2 to 7.4. Testing for pH value shall be performed in accordance with AASHTO T 289. Agricultural limestone may be added to topsoil in order to raise the pH to meet specification requirements. The

addition of agriculture limestone shall be determined based on tests performed by a laboratory approved by the Office of Geotechnical Services. Topsoil shall not be incorporated into the work until it is approved.

914.02 Temporary Seed

Temporary seed will be approved for use by visual inspection of the Engineer. Temporary seed may be purchased from any commercial source provided the seed's package is clearly marked and labeled by the manufacturer as to its content and weight.

914.03 Fertilizer

Fertilizer shall be standard commercial fertilizer with an analysis of 12-12-12.

Tests will not be required, but fertilizer standards shall be governed by the rulings of the Indiana State Seed Commissioner.

914.04 Grass and Legume Seed

Grass and legume seed in the quantities and varieties required shall be furnished full-tagged and delivered in properly designated packages or bags as directed. Seeds shall be in accordance with the following requirements.

Seed of warm season grasses, forbs, or aquatic species shall be delivered to the project site individually packaged by species. Warm season grass and forb seed shall be purchased from lots for which test results are provided. Testing will not be required for aquatic species. When normal germination testing is not practical for forb species, a tetrazolium test shall be conducted to determine seed viability.

Seeds shall contain none of the noxious weeds listed herein nor any that are listed in the Acts of the General Assembly of the State. Noxious weeds are Canada Thistle, Field Bindweed, Johnson Grass, Perennial Peppergrass, Perennial Sowthistle, Quack Grass, Russian Knapweed, and Wild Garlic.

Clover shall be free from dodder with no tolerance allowed. Lespedza will be allowed no more than 90 dodder/lb (200 dodder/kg) and 45 giant foxtail per lb (20 giant foxtail per kg).

Requirements noted above are minimum and trade allowances will not be permitted.

Seed shall be purchased from sources of supply that have been sampled, tested, and reported by the State Seed Commissioner, Purdue University, West Lafayette, Indiana, and found to be satisfactory. Seed of warm season grasses shall be tested by the State Seed Commissioner or an independent laboratory. Seed of forbs shall be tested by an independent laboratory. Test results by independent laboratories shall be signed by a Registered Seed Technologist. Test results shall be submitted to the State Seed Commissioner, and a copy to the Office of Materials Management. This report

is required before seed is sown. Such test report shall be no more than 9 months old at the time seed is used and the use of the seed shall be subject to approval.

Seed which has been tested by the State Seed Commissioner may be used without further testing provided each bag of seed bears a tag showing the seed meets the requirements of the Standard Specifications.

Seed which meets the weed seed tolerance, but does not comply with the purity or germination requirements, or both, may be used provided the percentage of purity or the percentage of germination is not more than 10% below the minimum specified and that the result obtained from the following formulae does not exceed the maximum percent of weed seeds permitted.

$$W \times P \times G = M \text{ or less}$$

$$P = \frac{\text{Minimum Specified Purity}}{\text{Actual Purity}}$$

$$G = \frac{\text{Minimum Specified Germination}}{\text{Actual Germination}}$$

W = Actual percent of weed seeds
P = Purity Factor
G = Germination Factor
M = Maximum percent of weed seeds permitted

If such seeds are selected for use, the amount to be used shall be increased in accordance with the following formula except the amount used shall not be less than that specified.

Amount to be used = Amount specified x P x G

VARIETY		Percentages of Weed Seed Content (Not more than)
Alfalfa	Medicago sativa	0.5
Alsike Clover	Trifolium hybridum	0.5
Alta Fescue or Ky. 31 Fescue	Festuca elatior (var. arundinacea)	0.75
Birdsfoot Trefoil	Lotus corniculatus	0.5
Chewings Fescue	Festuca rubra (var. fallax)	0.5
English Perennial Rye	Lolium perfenne	0.5
Kentucky Bluegrass	Poa prateusis	0.5
Korean Lespedeza	Lespedeza stipulacea	0.75
Sericea Lespedeza	Lespedeza sericea	0.75

Ladino Clover	Trifolium repens (var. latum)	0.5
Lemons Alkali Grass	Puccinellia airoides (Lemons)	0.5
Orchard Grass	Dactylis glomerata	0.5
Red Clover	Trifolium pratense	0.5
Red Fescue	Festuca rubra	0.5
Red Top	Agrostis alba	0.75
Rough Stalked Meadowgrass	Poa trivialis	0.5
Rye, Agricultural	Secale cereale	0.5
Rye, Annual	Lolium multiforum	0.5
Sheeps Fescue	Festuca orina	0.5
Smooth Brome Grass	Bromus inermis	0.95
Sweet Clover-white (Scarified)	Melilotus alba	0.5
Sweet Clover-yellow (Scarified)	Melilotus officinalis	0.5
Timothy	Phleum pratense	0.5
White Clover	Trifolium repens	0.75

VARIETY		Percentages of Purity (Not less than)
Alfalfa	Medicago sativa	99
Alsike Clover	Trifolium hybridum	97
Alta Fescue or Ky. 31 Fescue	Festuca elatior (var. arundinacea)	98
Birdsfoot Trefoil	Lotus corniculatus	98
Chewings Fescue	Festuca rubra (var. fallax)	97
English Perennial Rye	Lolium perfenne	95
Kentucky Bluegrass	Poa prateusis	85
Korean Lespedeza	Lespedeza stipulacea	98
Sericea Lespedeza	Lespedeza sericea	98
Ladino Clover	Trifolium repens (var. latum)	98
Lemons Alkali Grass	Puccinellia airoides (Lemons)	85
Orchard Grass	Dactylis glomerata	85
Red Clover	Trifolium pratense	98
Red Fescue	Festuca rubra	95
Red Top	Agrostis alba	90
Rough Stalked Meadowgrass	Poa trivialis	85
Rye, Agricultural	Secale cereale	99
Rye, Annual	Lolium multiforum	95
Sheeps Fescue	Festuca orina	97
Smooth Brome Grass	Bromus inermis	85
Sweet Clover-white (Scarified)	Melilotus alba	98
Sweet Clover-yellow		

(Scarified)	Melilotus officinalis	98
Timothy	Phleum pratense	90
White Clover	Trifolium repens	97

VARIETY		Percentages Actual Germination (Not less than)
Alfalfa	Medicago sativa	85*
Alsike Clover	Trifolium hybridum	85*
Alta Fescue or Ky. 31 Fescue	Festuca elatior (var. arundinacea)	85
Birdsfoot Trefoil	Lotus corniculatus	80*
Chewings Fescue	Festuca rubra (var. fallax)	75
English Perennial Rye	Lolium perfenne	90
Kentucky Bluegrass	Poa prateusis	80
Korean Lespedeza	Lespedeza stipulacea	80*
Sericea Lespedeza	Lespedeza sericea	80*
Ladino Clover	Trifolium repens (var. latum)	85*
Lemons Alkali Grass	Puccinellia airoides (Lemons)	80
Orchard Grass	Dactylis glomerata	80
Red Clover	Trifolium pratense	90*
Red Fescue	Festuca rubra	85
Red Top	Agrostis alba	80
Rough Stalked Meadowgrass	Poa trivialis	75
Rye, Agricultural	Secale cereale	80
Rye, Annual	Lolium multiforum	90
Sheeps Fescue	Festuca orina	75
Smooth Brome Grass	Bromus inermis	80
Sweet Clover-white (Scarified)	Melilotus alba	85*
Sweet Clover-yellow (Scarified)	Melilotus officinalis	85*
Timothy	Phleum pratense	85
White Clover	Trifolium repens	90*

* including not more than 25% hard seeds

914.05 Mulch

(a) Mulch for Seeding

Mulch for seeding may consist of straw; excelsior mulch; wood cellulose fiber mulch; excelsior blanket; paper mat; or straw mat. All mulch shall be reasonably free from primary noxious weeds in accordance with 914.04.

1. Excelsior Mulch

Excelsior mulch shall consist of wood fibers cut from sound green timber. The average length of the fibers shall be 4 in. to 6 in. (100 mm to 150 mm). The cut shall be made in such a manner as to provide maximum strength of fiber, but at a slight angle to the natural grain of the wood so as to cause splintering of the fibers when weathering in order to provide adherence to each other and to the soil.

2. Wood Cellulose Fiber

Wood cellulose fiber mulch shall be made from wood chip particles manufactured articularly for discharging uniformly on the ground surface when disbursed by a hydraulic water sprayer. It shall remain in uniform suspension in water under agitation and blend with grass seed, and fertilizer when permitted, to form a homogeneous slurry. The mulch fibers shall intertwine physically to form a strong moisture holding mat on the ground surface. The mulch shall be heat processed so as to contain no germination or growth inhibiting factors. It shall be non-toxic and colored green. The percent of moisture content shall be determined in accordance with 621.14(c), except material containing more than 15% will be rejected. The ash content shall not exceed 1.5%. One hundred grams of oven dried material saturated in water, drained, and weighed shall hold a minimum of 1,000 grams of water.

3. Excelsior Blanket

Excelsior blanket shall consist of a machine produced mat of wood excelsior with 80% of the fibers to be 6 in. (150 mm) or longer. The wood from which the excelsior is cut shall be properly cured to achieve curled and barbed fibers. The blanket shall have a consistent thickness, with the fibers evenly distributed over the entire area of the blanket. The excelsior blanket shall be covered on the top side with a 3 by 1 in. (75 by 25 mm) leno weave, twisted kraft paper yarn netting having a high wet strength, or a biodegradable extruded plastic mesh netting having an approximate minimum opening of 5/8 by 5/8 in. (16 mm by 16 mm) to an approximate maximum opening of 2 in. by 1 in. (50 by 25 mm). The netting shall be entwined with the excelsior mat for maximum strength and ease of handling. The minimum roll width shall be 4 ft (1.2 m). The mass of the material shall be not less than 0.7 lb/sq yd (0.4 kg/m^2), constant mass, air dry. The rolls shall be packaged with suitable protection for outdoor storage on the project site in a manner which protects them from biodegradation prior to use.

4. Paper Mat

Paper mat shall consist of a knitted construction of photodegradable, polypropylene yarn with uniform openings interwoven with strips of biodegradable paper. The rolls shall be packaged with suitable protection for outdoor storage at a construction site in a manner which protects them from biodegradation prior to use. The mass of the paper shall be a minimum of 0.125 lb/sq yd (0.069 kg/m^2). Roll sizes shall have a minimum width of 5 ft (1.5 m).

5. Straw Mat

Straw mat shall consist of a machine produced mat consisting of at least 90% of the total dry mass being clean straw from agricultural crops, with the exception that up to 30% of the total dry mass may be coconut fibers in lieu of an equal percentage of straw. Paper or paper related products shall not be permitted as component in the straw mat. The straw shall be evenly distributed throughout the mat to form a thickness of 1/2 in. ± 1/8 in. (13 mm ± 3 mm). The top side of the mat shall be covered with a photodegradable/biodegradable plastic mesh which shall be substantially adhered to the straw by a knitting process using photodegradable/biodegradable thread. The rolls shall be packaged with suitable protection for outdoor storage at a construction site in a manner which protects them from biodegradation prior to use. The average dry mass of the straw shall not be less than 0.7 lb/sq yd (0.4 kg/m^2). The minimum roll width shall be 6 ft (1.8 m).

(b) Mulch for Plants

Mulch for plants shall consist of broken corncobs, wood chips, chopped bark, size No. 5 gravel, or crushed stone in accordance with 904.02(e), except 0% to 5% may pass the No. 200 (75 µm) sieve, or other approved materials. The particles of wood chips, chopped bark, and corncobs shall contain no more than 10% passing the 1/2 in. (12.5 mm) screen and 100% shall pass the 3 in. (75 mm) screen. Wood chips shall be from green, hardened, deciduous trees. Broken corncobs shall be no longer than 4 in. (100 mm).

914.06 Leguminous Inoculants

The inoculants for treating leguminous seeds shall be standard pure culture of nitrogen fixing bacteria. They shall be no more than 1 year old at the time of use and shall be subject to approval. Directions of the manufacturer on containers of inoculants shall be followed when inoculating seed.

914.07 Sod

Sod shall consist of fibrous, well rooted, bluegrass, fescue, or other approved grass cut to a height of 2 to 3 in. (50 to 75 mm). Edges of sod shall be cut cleanly, either by hand or machine, to a uniform minimum thickness of 3/4 in. (19 mm) or more. The roots shall be exposed in the sod strip to allow the sod to be handled without undue tearing or breaking. The sod strip shall be of a uniform width of no less than 16 in. (406 mm) and no less than 2 ft (6.1 m) in length. Sod shall be free from all primary noxious weeds in accordance with 914.04. Acceptance in the field before cutting shall not preclude rejection when delivered to the work if such contamination is found.

Nursery sod shall meet applicable requirements as set out above and shall be a variety or blend of Kentucky bluegrass or fescue. It shall comply with nursery inspections and plant quarantine regulations of the states of origin and destination as well as with Federal regulations governing interstate movement of nursery stock. Material furnished under this specification shall be covered by a type C certification in accordance with 916.

914.08 Plant Materials

If the plant material is shown on the Schedule of Pay Items as plant, the Contractor shall submit its source of supply for each plant material for approval prior to delivery to the project site. This plant list shall include the name of the source of supply and the location where the plants were grown. A certification that the plants are available at this source, that the plants were grown at the prescribed location, and that there is a firm commitment for their purchase at the time of certification shall be provided. These procedures shall be followed for approval of alternate sources when the originally approved source is unable to furnish plants at the time when needed. Plants shall be in accordance with the requirements set out herein. Unless otherwise specified, all plant material shall be acquired from zones 4, 5, or 6. However, plant material shall be acquired from zones no further than 1/2 zone south of the zone in which the project is located. Hardiness zones shall be determined from the Plant Hardiness Zone Map, Miscellaneous Publications No. 1475, Agricultural Research Service, United States Department of Agriculture, published by the U. S. Government Printing Office, Washington, D.C. The Contractor shall have a copy of this map.

If the plant material is shown on the Schedule of Pay Items as seedlings, the Contractor shall choose a source which is shown on the approved list of sources that is maintained by the Department. This list will specify the sources that are currently on an immediate use basis. If the source is not on the list, then the same procedure shall be followed as stated above for plants to obtain approval.

(a) Quality of Plant Material

All plants shall be 1st class and representative of the normal species or varieties, true to type, and standard form. Unless otherwise specified, all plants shall be nursery grown stock that had been transplanted or rootpruned 2 or more times according to the kind and size of plant. The root system shall be vigorous and well developed. The branch system shall be developed normally. All plants shall be free from disfiguring knots, sun-scald, injuries, abrasions of the bark, dead or dry wood, broken terminal growth, or other objectionable disfigurements.

(b) Plant Names

Plants shall be true to name, following standard botanical and common nomenclature as adopted by the American Joint Committee on Horticultural Nomenclature given in the current edition of Standardized Plant Names. All trees delivered shall be tagged legibly with the names and sizes of the trees.

All delivered shrubs shall be tagged legibly with the name and size of the shrub when “Tag Each” is indicated on the summary list. Otherwise, each bundle shall be tagged. If shrubs are separated individually when delivered, 20% of each species shall be tagged. A tag with the name and size of the shrub printed thereon shall be used for each species. A 1 in. (25 mm) band of non-toxic paint shall be applied to the

stem of seedlings or “whips”, prior to delivery, in lieu of tags. If tags are required, they shall remain attached to shrubs for the duration of the contract.

(c) Substitutions

Substitutions of plants in size and kind shall be made only after proper execution of a change order in accordance with 109.05 and then only when sufficient evidence has been shown that the specified stock could not be secured.

(d) Grading Standards

Grading of plants shall be in accordance with the American Association of Nursery Horticultural Standards of the current ASNS, ANSI Z 60.1 as revised herein and on the plans.

(e) Nursery Inspection and Plant Quarantine

All plants shall be free from plant diseases and insect pests. Shipments of plants shall be in accordance with nursery inspection and plant quarantine regulations of the states of origin and destination as well as with Federal regulations governing interstate movement of nursery stock. A valid copy of the certification of inspection shall accompany each package, box, bale, or carload shipped or otherwise delivered.

(f) Balled and Burlapped Plants

Balled and burlapped plants shall be dug so as to retain as many fibrous roots as possible and shall come from soil which forms a firm ball. The soil in the ball shall be the original and undisturbed soil in which the plant was grown and shall be free of noxious weeds and weed seeds. The plant shall be dug, wrapped, transported, and handled in such a manner that the soil in the ball will not be loosened enough to cause stripping of the small and fine feeding roots or cause the soil to drop away from such roots. Any indication of manufactured earth balls or mishandling of the plant will be cause for rejection. The shape and size of the ball shall be as specified in the ASNS as revised herein and shown on the plans.

(g) Container Grown Plants

Plants which are furnished in containers shall be well rooted and established in the container in which they were shipped. An established container grown plant shall be a plant transplanted into a container and grown in that container sufficiently long for the new fibrous roots to have developed so that the root mass retains its shape and holds together when removed from the container.

(h) Bare Rooted Plants

The minimum root system of bare rooted trees or shrubs shall be in accordance with the standards stated in the ASNS. Bare rooted plants shall be dug only when the air temperature exceeds 35°F (2°C). Particular attention shall be given to the fibrous roots. The maximum time lapse between loading for shipment and delivery to the work or approved storage site shall be 4 days unless other shipping arrangements are approved.

(i) Collected Plants

Collected plants, when specified in connection with any species or variety, shall not be nursery grown, but shall have been grown under natural conditions at the location from which they were procured. They may be balled and burlapped or bare roots as specified in the plant list on the plans. In either case, the collected material shall be in accordance with the applicable requirements given in the current issue of ASNS for quality, size, ball, and grade.

(j) Forms, Shapes, and Condition of Plants

Vines and groundcover plants shall be in accordance with grades and specifications shown in the ASNS unless otherwise specified.

Plants which have been cut back from larger grades to meet specifications will not be acceptable. Plants designated on the plans as street trees, specimen, extra heavy, clump, or of other like import shall be in accordance with the standards as given in the ASNS for the special type specified.

Trees shall have straight trunks, be well branched, and have symmetrical tops. There shall be no cuts of limbs over 3/4 in. (19 mm) in diameter which have not completely healed over. Each tree shall have the top and root characteristics of its variety and growth that are typical of such trees in this region. Deciduous trees, unless otherwise specified, shall have branching between 1/4 and 1/2 of the distance of their height from the ground. Street trees, if so specified, shall be of uniform branching height. Bush form, when specified, shall be branching at the base of the plant or within 12 in. (300 mm) of the base. Clumps, when specified, shall have 3 or more main leaders or trunks starting at the ground. At least 2 of these shall be of the caliber specified.

(k) Inspection

Plant materials shall be subject to inspection at any time during the life of the contract. Such inspection shall not be construed as final acceptance of the plants involved. Any stock which is not in accordance with these specifications will be rejected and shall be removed from the project.

Balled and burlapped plants may have the ball opened for inspection, at the option of the Department, to determine if the root system is sufficient to ensure plant growth. If after breaking open, the ball is found to be acceptable, payment for the destroyed plant will be made at 50% of the contract price for the plant involved.

Nursery stock may by inspected at the nursery before digging or shipping and sealed with Department seals. If not inspected and sealed at the nursery, it shall be done at a final collecting point at or adjacent to the project and prior to planting, unless otherwise specified in writing. Notification shall be made a minimum of 3 days in advance of delivery of unsealed plants. Large quantities of small plant material such as shrubs, seedlings, vines, groundcovers, etc., shall be sealed in a satisfactory manner. Sealing of plants shall not be considered as final acceptance and

shall not waive the responsibility to furnish, plant, and maintain material that complies with the specifications.

(l) Shipment

All precautions that are customary in good trade practice shall be taken to ensure the arrival of the plants in good condition. Plants shall be packed or covered in such a manner as to ensure adequate protection against damage while in transit. The roots of bare root plants shall be protected with wet straw or other suitable material to ensure the arrival at destination with the roots in a moist condition. When shipment is made in an enclosed vehicle, the vehicle shall be adequately ventilated to prevent over heating of the plants in transit.

(m) Certification

Certifications from all plant supply sources shall be furnished certifying that all plants furnished are in accordance with 914.08. These certifications shall be submitted monthly and shall contain the information as indicated on the suggested form in ITM 804.

914.09 Miscellaneous Material

(a) Water

Water used in the planting or care of vegetation shall be free from oil, acids, alkalis, salts, or any substance injurious to plant life. Water from streams, lakes, ponds, or similar sources shall not be used unless approved.

(b) Stakes for Bracing and Anchoring

Wood stakes for bracing or supporting trees shall be of rough cypress, cedar, locust, oak, or other approved wood free from knots, rot, cross grain, or other defects that would impair the strength of the stake for which it is to be used. Wood stakes shall be a minimum of 2 in. by 2 in. (50 mm by 50 mm) square in cross section and of adequate length. The wood bracing stakes shall be painted or stained dark green. Delineator posts in accordance with 910.15 may be used except they shall be painted dark green.

An alternate staking and bracing method using a solid rubber support cord with metal hooks and stakes, and plastic stake disk system, may be used.

(c) Tree Wound Dressing

Dressing for treating tree wounds or cuts shall be either:

1. an approved black asphaltum base antiseptic paint;

2. an approved black paint consisting of Bordeaux Mixture, raw linseed oil, and lampblack; or

3. an approved black paint consisting of zinc oxide, raw linseed oil, and lampblack.

(d) Porous Material

Porous material for tree root protection may be gravel, crushed stone, slag, or other porous material varying in size from 1 to 3 in. (25 to 75 mm) and shall be approved before being used.

(e) Pipe

Pipe for underdrains shall be in accordance with 907 or 908. The size and type shall be as specified.

(f) Staples

Staples shall be made from No. 11 gage (3 mm) or heavier wire, 1 or 2 in. (25 or 50 mm) wide at the throat and 6 in. (150 mm) from top to bottom after bending. The staples shall be packaged in cartons.

(g) Plastic Net

Plastic net shall consist of photodegradable, longchain synthetic polymer plastic yarn, either extruded oriented or woven into a net with the yarns fixed at each intersection such that they retain their relative positions with respect to each other. The plastic net shall have a square mesh opening of approximately 3/4 in. by 3/4 in. (19 mm by 19 mm). The plastic net shall have a minimum tensile strength of 20 lb (89 N) over a 3 in. (75 mm) width in the machine direction and 15 lb (67 N) over a 3 in. (75 mm) width in the transverse direction. The plastic net shall have a nominal mass of 2.8 ± 0.4 lb per 1,000 sq ft (15.6 ± 2.2 g per m^2). The plastic net shall be furnished in rolls which can be easily handled and the rolls shall be packaged in a suitable protection for outdoor storage at a construction site, which protects the material from degradation prior to use. Roll sizes shall have a minimum width of 6 ft (1.8 m).

Material furnished under this specification shall be covered by a type C certification in accordance with 916.

SECTION 915 – BRIDGE PILES AND BEARINGS

915.01 Steel Pipe Piles and Epoxy Coated Steel Pipe Piles

(a) General Requirements

Steel pipe piles and epoxy coated steel pipe piles, as designated herein, shall consist of fluted steel, or rounded straight seamed, spiral seamed, or seamless steel pipes which, after being driven are filled with class A concrete. The steel pipe shall be uncoated unless an epoxy coating, in accordance with 915.01(d) is specified.

Pipe piles shall be of the diameter and minimum wall thickness shown on the plans. All sections shall be 1 cylindrical integral piece except as otherwise required

for end sections of the outside diameter specified. All pipe piles shall be of sufficient strength to withstand driving to the required penetration depth and nominal driving resistance.

If necessary to facilitate handling, pipe piles may be furnished in sections to be welded in the field to form the final integral lengths required.

The manufacturer shall provide a mill certification showing heat numbers and test results for the specified tests. Each pipe pile shall be stenciled to show the diameter, wall thickness, and heat numbers for the verification of the certifications. The certifications shall be delivered before the pipe piles are driven.

The end of pipe piles shall be equipped with conical pile tips or flat end plates. The welding used to attach the conical pile tips or flat end plates to the end of pipe piles shall be done by a welder qualified in accordance with 711.32.

1. End Plates

If end plates are used, they shall be flat, non-reinforced and a minimum thickness of 3/4 in. (19 mm) for pipe piles 12 in. (305 mm) outside diameter or smaller, and 1 in. (25 mm) thick for pipe piles greater than 12 in. (305 mm) outside diameter up to and including 14 in. (355 mm). For pipe piles larger than 14 in. (355 mm) outside diameter, the end plates shall be designed to complement the size of the pipe pile. End plates shall have a diameter approximately 1/2 in. (13 mm) greater than the outside diameter of the pipe pile and be fillet welded to the pipe pile, using 2 passes or beads.

2. Conical Pile Tips

Conical pile tips shall be of sufficient dimensions to ensure adequate joint and driving strength. The end of the pipe pile shall have full bearing on the face of the pile tip or against a shoulder inside the pile tip. Unless otherwise permitted, the pile tip shall be conical with a 60 to 90° angle between faces. The pile tip shall be substantially of the same diameter as the end of the pipe pile and butt welded to the end of the lowest section.

(b) Fluted Steel Pipe Piles

Fluted steel pipe piles shall have a minimum tensile strength of 50,000 psi (345 MPa) when tested in accordance with ASTM A 370. Test specimens for determination of tensile strength shall be taken longitudinally adjacent to the crest of the flute. The diameter of fluted steel pipe piles shall be measured from crest to crest of flutes.

A sufficient taper will be allowed to permit no less than 6 in. (150 mm) telescoping at the joints. The lowest section shall taper approximately 1 in. in 4 ft (25 mm in 1.2 m) from an 8 in. (203 mm) tip to the specified diameter of the upper end. Flutted steel pile piles with a taper of 1 in. in 7 ft (25 mm in 2.1 m) on the

lowest section of long piles may be used provided a minimum of approximately 5 ft (1.5 m) of the top of the pile below cutoff elevation is the full diameter as shown on the plans.

(c) Rounded Steel Pipe Piles

Rounded steel pipe piles, except for end finish, shall be in accordance with ASTM A 252, grade 3. Welded pipe may be welded with straight or spiral seams.

(d) Epoxy Coating for Piles

Only powdered epoxy resin from the Department's list of approved Coating Materials shall be used for the epoxy coating of steel pipe piles and steel H piles.

The patching or repair material shall be compatible with the coating and shall be made available by the coating manufacturer. The material shall be suitable for repairs made to coated areas damaged during fabrication or handling.

The coating color shall contrast with the color of iron oxide. All coated piles furnished for a structure shall be the same color. The patching or repair material shall also be the same color as the original coating material.

1. Prequalification of Organic Coatings for Steel Piles

The coating product shall be a 100% solids, heat curable, thermosetting, dry powdered epoxy coating. Coating manufacturers who request to have their product added to the Department's list of approved Epoxy Coatings for steel shall supply the information as follows.

a. Product Data Sheet

A product data sheet which shall specify the method of surface preparation, the thermal treatments before and after coating application, the coating application procedure, and the product name and description of the patching material shall be provided.

b. Fingerprint

The fingerprint shall include the method of test, such as infrared spectroscopy or thermal analysis, and a generic description of the product.

c. Materials Safety Data Sheet

Current materials safety data sheets shall be supplied for the product and the patching material.

d. Laboratory Report

A dated laboratory report shall be provided which substantiates full compliance with the following test requirements.

(1) Tensile Strength and Elongation

The tensile strength and elongation of the coating material shall be tested in accordance with ASTM D 2370 with a rate of elongation of 10% to 20% min. The minimum tensile strength shall be 8,000 psi (56 MPa). The minimum elongation shall be 5%.

(2) Impact Resistance

The impact resistance of the coating shall be tested in accordance with ASTM G 14 using a 5/8 in. (16 mm) diameter tip, and a 12 mil (30 µm) minimum coating thickness of a 1/8 in. (3.2 mm) thick panel at 73°F (23°C). Three tests shall be performed. The minimum acceptable value shall be 80 Lbf·in. (9.0 N·m) of impact with no visible breaks in the coating.

(3) Abrasion Resistance

The abrasion resistance of the coating shall be tested in accordance with the Annex to ASTM A 972.

(4) Salt Fog

The weathering resistance of the coating shall be tested by means of a salt spray cabinet following ASTM B 117 for 1,000 h. The coating shall not blister or exhibit corrosion, discoloration, or loss of adhesion away from the scribed area.

2. Application

The application of the epoxy coating shall be at an enclosed plant, equipped with environmental controls and automated blasting equipment. This equipment shall facilitate surface preparation and coating application in accordance with the manufacturer's recommendations and in accordance with additional requirements set out herein. The application process shall be performed by a continuous, balanced system where cleaning of the surface and application of the coating are performed at the same rate.

a. Surface Preparation

The pile surface shall be blast cleaned in conformance with SSPC-SP-10, Near White Metal Blast. The cleaning media shall produce an anchor pattern profile of 2 mils (50 µm) minimum. All raised slivers, scabs, laminations or bristles of steel remaining on the newly cleaned surface shall be removed by means of abrasive sanders. All traces of grit and dust from the blasting shall be removed.

b. Coating Application

The coating shall be applied immediately to the cleaned surface and before visible oxidation of the surface occurs. The coating shall be applied in accordance with the manufacturer's recommendations. The recommendations shall address the equipment required for proper application, the number of coats of epoxy, cure time between coats, cure time before placing in service, and all other information needed by the Department to ensure proper performance of the material.

(1) Thickness

Thickness of the cured coating shall be measured on a representative number of piles from each production lot by the same method required by ASTM G 12 for measurement of film thickness of pipeline coatings on steel. The minimum coating thickness for fusion bonded epoxy shall be 8.0 mils (200 µm) for individual measurements and 12 mils (300 µm) for the average.

(2) Cure

The coating film shall be cured and post cured in accordance with the manufacturer's recommendations. A representative proportion of each production lot shall be checked by the coating applicator using a method found most effective for measuring cure to ensure that the entire production lot is in a fully cured condition.

(3) Continuity of Coating

After cure, the epoxy coating shall be checked by the applicator for continuity of coating and shall be free from holes, voids, contamination, cracks, and damaged areas. There shall not be more than 2 holidays, which are pinholes not visually discernable, in any linear foot (0.3 m) of the coated pile. A holiday detector in accordance with ASTM A 972 shall be used in accordance with the manufacturer's instructions to check the coatings for holidays.

3. Certification

Material furnished under this specification shall be covered by a type C certification in accordance with 916. In addition, a certificate of compliance prepared by the applicator shall be furnished for each shipment of coated piles. The certificate of compliance shall state that the piles have been coated in accordance with the manufacturer's requirements; that thickness, continuity, and flexibility tests of the coating have been performed; and that the test results are in accordance with the requirements outlined herein. Test results shall be retained by the applicator and made available for inspection upon request for a period of 7 years.

915.02 Steel H Piles and Epoxy Coated Steel H Piles

Steel H piles and epoxy coated steel H piles shall be of the shape and dimensions shown on the plans or as otherwise specified. The steel shall be in accordance with ASTM A 572, grade 50. Steel H piling shall be handled in the same manner as required in 711.56. The piles shall be uncoated unless an epoxy coating, in accordance with 915.01(d), is specified.

The manufacturer shall provide a mill certification showing heat numbers and test results for the specified tests. Each H pile shall be stenciled to show the manufacturer's name, the specifications, size and mass of section, and heat numbers for verification of the certification. The certification shall be submitted at the time of delivery of the piles.

915.03 Wood Piles

Wood piles shall be in accordance with 911.01(e) or 911.02(c) as specified.

915.03.1 Pile Shoes

Steel H pile shoes furnished shall be covered by a type C certification in accordance with 916. Pile shoes shall be cast-in-one-piece steel in accordance with ASTM A 148 Grade 80-50 (grade 550-345) and shall be fastened to the piles by welding in accordance with the manufacturer's recommendations. They shall have sufficient flange and continuous web vertical back-ups to assure proper alignment and fitting to the pile. Either the pile shoe or the outside of each flange of the pile shall be beveled 45°. E70XX welding rods shall be used. All welds shall be made in the flat position and the welder shall be qualified in accordance with 711.32.

Timber pile shoes furnished shall be covered by a type C certification in accordance with 916. Pile shoes shall be cast-in-one-piece steel in accordance with ASTM A 27 Grade 65-35 (450-240) Class 2 or Grade 70-36 (485-250) Class 2 and shall be fastened to the piles in accordance with the manufacturer's recommendations.

The soil or rock bearing surfaces of the shoes shall be sloped downward towards the web a minimum of 15° but not to exceed 45° to the horizontal under the flanges. The sloped surfaces of the shoes shall terminate so as to form a flat surface not exceeding 1/3 of the flange width. The surfaces may have individual or continuous cutting teeth.

915.04 Elastomeric Bearings

(a) Description

Elastomeric bearings as herein specified shall include plain bearings, consisting of elastomer only, and laminated bearings, consisting of layers of elastomer restrained at their interfaces by bonded laminates. The bearing type shall be as shown on the plans.

(b) Materials

1. Elastomer

Elastomeric bearing pads shall be made from elastomeric materials and shall be steel reinforced as shown on the plans. They shall be in accordance with Articles 18.1 and 18.2 of the AASHTO LRFD Bridge Construction Specifications and AASHTO M 251 with the exception that Table X1 is not applicable. The elastomer portion of the elastomeric compound shall be 100% virgin natural polyisoprene known as natural rubber, or 100% virgin polychloroprene known as neoprene. The cured compound shall be in accordance with Table A for natural rubber, or Table B for neoprene, depending on which type is furnished.

TABLE A

240 **POLYISOPRENE, OR NATURAL RUBBER, QUALITY CONTROL TESTS**

PHYSICAL PROPERTIES		
ASTM D 2240	Hardness (Shore A Durometer)	55 ± 5
ASTM D 412	Tensile Strength, Min., ksi (MPa)	2.25 (15.5)
	Ultimate Elongation, Min. %	425
HEAT RESISTANCE		
ASTM D 573, 70 h, @ 158ºF (70ºC)	Change in Durometer Hardness, Max. Points	10
	Change in Tensile Strength, Max. %	-25
	Change in Ultimate Elongation, Max. %	-25
COMPRESSION SET		
ASTM D 395, Method B	22 h @ 158ºF (70ºC), Max. %	25
OZONE		
ASTM D 1149	25 ppm ozone in air by volume, 20% strain, 100ºF ± 2ºF (38ºC ± 1ºC), 48 h mounting procedure, D 518, Procedure A	No Cracks
LOW-TEMPERATURE BRITTLENESS		
ASTM D 746, Procedure B	Grades 0 & 2	
	Grade 3, Brittleness @ -40ºF (-40ºC)	No Failure
INSTANTANEOUS THERMAL STIFFENING		
ASTM D 1043	Grades 0 & 2, Tested @ -32ºC	Stiffness at test temperature shall not exceed 4 times the stiffness measured at 74ºF (23ºC).
	Grade 3, Tested @ -40ºF (-40ºC)	
LOW-TEMPERATURE CRYSTALLIZATION		
Quad Shear Test as Described	Grade 3, 14 Days @ -15ºF (-26ºC)	Stiffness at test time and temperature shall not exceed 4 times the stiffness measured at 74ºF (23ºC) with no time delay. The stiffness shall be measured with a quad shear test rig in an enclosed freezer unit. The test specimens shall be taken from a randomly selected bearing. A ±25% strain cycle shall be used. A complete cycle of strain shall be applied within a period of 100 s. The first 0.75 cycle of strain shall be discarded. The stiffness shall be determined by the slope of the force deflection curve for the next 0.50 cycle of loading.

TABLE B
POLYCHLOROPRENE, OR NEOPRENE, QUALITY CONTROL TESTS

PHYSICAL PROPERTIES		
ASTM D 2240	Hardness (Shore A Durometer)	55 ± 5
ASTM D 412	Tensile Strength, Min., ksi (MPa)	2.25 (15.5)
	Ultimate Elongation, Min. %	375
HEAT RESISTANCE		
ASTM D 573, 70 h, @ 212ºF (100ºC)	Change in Durometer Hardness, Max. Points	15
	Change in Tensile Strength, Max. %	-15
	Change in Ultimate Elongation, Max. %	-40
COMPRESSION SET		
ASTM D 395, Method B	22 h @ 212ºF (100ºC), Max.%	35
OZONE		
ASTM D 1149	25 ppm ozone in air by volume, 20% strain, 100ºF ± 2ºF (38ºC ± 1ºC), 48 h mounting procedure, D 518, Procedure A	No Cracks
LOW-TEMPERATURE BRITTLENESS		
ASTM D 746, Procedure B	Grade 3, Brittleness @ -40ºF (-40ºC)	No Failure
INSTANTANEOUS THERMAL STIFFENING		
ASTM D 1043	Grade 3, Tested @ -40ºF (-40ºC)	Stiffness at test temperature shall not exceed 4 times the stiffness measured at 74ºF (23ºC).
LOW-TEMPERATURE CRYSTALLIZATION		
Quad Shear Test as Described	Grade 3, 14 Days @ -15ºF (-26ºC)	Stiffness at test time and temperature shall not exceed 4 times the stiffness measured at 74ºF (23ºC) with no time delay. The stiffness shall be measured with a quad shear test rig in an enclosed freezer unit. The test specimens shall be taken from a randomly selected bearing. A ±25% strain cycle shall be used. A complete cycle of strain shall be applied within a period of 100 s. The first 0.75 cycle of strain shall be discarded. The stiffness shall be determined by the slope of the force deflection curve for the next 0.50 cycle of loading.

The bond strength, determined in accordance with ASTM D 429 Method B, shall be at least 40 lb/in. (7 N/mm).

The adhesion failure, determined in accordance with ASTM D 429 Method B, shall be at least R-80. The adhesion-failure requirement will be waived if the bond strength is at least 80 lb/in. (14 N/mm).

2. Structural Steel

Structural steel spacer plates and other steel components, including anchor bolts, shall be galvanized in accordance with AASHTO M 111.

3. Internal Steel Shims

Internal steel shims shall be rolled hot and cold steel and shall be in accordance with AISI 1015 through 1025, ASTM A 1008 (A 1008M), or ASTM A 1011 (A 1011M) grade 36 or higher.

4. Threaded Stud

Threaded studs, where required, shall be in accordance with ASTM A 307 (A 307M) and mechanically zinc coated in accordance with AASHTO M 298, class 50.

5. Side Retainer

Side retainers shall be made from plates or rolled mild steel in accordance with ASTM A 36 (ASTM A 36M).

(c) Manufacturing Requirements

Plain bearings may be molded individually, cut from previously molded strips or slabs, or extruded and cut to length. Cut edges shall be at least as smooth as ANSI B 46.1 No. 250 finish. Unless otherwise shown on the plans, all components of a laminated bearing shall be molded together into an integral unit. Air bubbles within the elastomeric material shall be cause for rejection.

Laminated elastomeric bearings shall be individually molded to the required size. Corners and edges may be rounded with a radius at the corners not exceeding 3/8 in. (10 mm) and a radius at the edges not exceeding 1/4 in. (6 mm).

Steel shims shall be sandblasted and cleaned and protected against contaminants until fabrication is completed.

Bearings designed as a single unit shall be built as a single unit.

Each reinforced bearing shall be marked with indelible ink or flexible paint. The marking shall consist of the orientation, the order number, lot number, bearing identification number, and elastomer type and grade number. Unless otherwise specified, the marking shall be on a face that is visible after erection of the bridge.

(d) Appearance and Dimensions

The edges of the embedded steel laminates, including around holes, shall be covered with 1/8 to 1/4 in. (3 to 6 mm) of elastomer. All other dimension tolerances shall be in accordance with AASHTO M 251.

(e) Quality Assurance

The mechanical properties of the materials and of the finished bearing shall be in accordance with the AASHTO LRFD Bridge Construction Specifications, Article 18.2.5, and AASHTO M 251, with the exception that the tables in 915.04(b)1 shall be used.

1. Compressive strain of any layer of an elastomeric bearing shall not exceed 7% at 800 psi (5.5 MPa) average unit pressure or at the design dead load plus live load pressure if so indicated on the plans.

2. The shear resistance of the bearing shall not exceed 40 psi (276 kPa) for 55 durometer, Table A compounds; nor 75 psi (517 kPa) for 55 durometer, Table B compounds at 25% strain of the total effective rubber thickness after an extended 4 day ambient temperature of -20°F (-29°C).

(f) Certification

Material furnished under this specification shall be covered by a type B certification in accordance with 916. The results of the following tests shall be provided on the type B certification.

Test	ASTM, or INDOT Std. Spec.
Ultimate Tensile Strength	D 412
Ultimate Elongation	D 412
Hardness (Durometer)	D 2240
Tensile Strength and Elongation on Oven-aged Material	D 573 and D 412
Hardness on Oven-aged Material	D 573 and D 2240
Compression Set	D 395, Method B
Ozone Resistance	D 1149
Adhesion	D 429, Method B
Brittleness	D 746, Procedure B
Compressive Strain	915.04(e)1
Shear Resistance	915.04(e)2

In addition, 1 bearing pad from each type to be furnished for the structure will be required for laboratory testing. However, if shapes A and B of a given type are required, only shape A need be furnished for testing. The material may be sampled prior to shipment to the project, provided suitable arrangements can be made through the Office of Materials Management. Materials not previously sampled and approved

for use shall be sampled after delivery to the project site. Samples shall be furnished at least 30 days before date of use.

915.05 Bearing Assemblies with Polytetrafluoroethylene, PTFE, Sliding Surfaces

A copy of the manufacturer's design manual shall be submitted for approval when directed.

All steel components shall be in accordance with ASTM A 709 Grade 36 (ASTM A 709M Grade 250) unless otherwise shown on the plans. Where these assemblies are to be used in conjunction with a self-weathering steel bridges, the steel components shall be in accordance with ASTM A 709 Grade 50W (ASTM A 709M Grade 345W). Stainless steel mating surfaces shall be 14 gage minimum ASTM A 240 type 304 sheets with a maximum surface roughness of 20 Rms.

The PTFE shall be 100% virgin unfilled polymer or 15% glass filled and etched on the bonding side. The properties of the PTFE shall be in accordance with the following:

REQUIREMENT	TEST METHOD	VALUE
Tensile Strength, minimum	ASTM D 638	2,500 psi (17.24 MPa)
Elongation, min. percent	ASTM D 638	200
Specific Gravity	ASTM D 792	2.1 to 2.3

PTFE, where required, shall be bonded to grit blasted steel. The PTFE guides shall be bonded and mechanically fixed into place. The bonding compound used to bond PTFE or elastomeric pads to steel plates shall be in accordance with ASTM D 429, Method B.

All steel surfaces exposed to the environment shall be zinc metallized and shall be 7 mils (175 µm) thick in accordance with CSA G-189, or painted with structural primer in accordance with 909.02(a). The finish coat for painted steel shall be in accordance with 909.02(d). The color shall be in accordance with Federal Color Standard 595, color No. 30045.

All required materials shall be covered by a type B certification in accordance with 916.

SECTION 916 – MATERIALS CERTIFICATIONS

916.01 General

Materials certifications will be required for certain materials in accordance with various sections of these specifications and other contract documents. Unless otherwise specified or directed, 1 copy of each certification shall be submitted prior to use of the material. All certifications shall be signed by a person having legal authority to bind the company preparing the certification.

The contract number, name of the Contractor, destination to which the material covered by the certification is consigned, and name and quantity of material represented shall be shown on all copies of the certification. Identifying information such as alloy, grade, type, class, or other similar designation shall also be shown when applicable.

Any material received on the project for which certification has been furnished may be sampled and tested. If the results of the tests are in disagreement with the certification, the test results shall prevail and further acceptance by certification from the manufacturer of the material concerned may be suspended.

916.02 Types of Certifications

Certifications shall be type A, type B, type C, type D, or as required under other types. When specified, the type of certification provided for a material shall be in accordance with the Frequency Manual except as otherwise specified. Specific information and test results required in type A, type B, and other types of certifications will be listed in the material specifications. Sample forms for type A, type B, type C, and type D certifications are shown in 916.03. Sample forms for other type certifications are shown in 916.03 or ITM 804.

(a) Type A

Type A certification shall be prepared by the manufacturer. It shall consist of a certified copy of a laboratory report which lists results of the specified tests and shall certify that the materials furnished comply with the specifications. The applicable specification shall be referred to in the certification. The tests may be conducted in the laboratory of the manufacturer or in another qualified laboratory. Such tests shall have been conducted on samples obtained from the lot or lots of material in the shipment.

(b) Type B

Type B certification shall be prepared by the manufacturer. It shall show the limits of test values for the specified tests and shall certify that the materials furnished comply with the specifications. The applicable specification shall be referred to in the certification. The tests may be conducted in the laboratory of the manufacturer or in another qualified laboratory.

(c) Type C

Type C certification shall be prepared by the manufacturer and shall certify that the materials furnished are in accordance with the specifications. The applicable specification shall be referred to in the certification.

(d) Type D

Type D certification shall be prepared by the Contractor and shall certify that the materials furnished are in accordance with the specifications. The applicable specification shall be referred to in the certification. A type D certification shall be used for product identification. It may be required to certify that the material is in accordance with minimum trade standards.

(e) Other Types

Types of certifications other than type A, B, C, and D are specified for selected materials. The requirements for a certification are described in the material's specification.

(f) Requirements for Small Quantities of Materials

Where circumstances warrant and previously approved material is not available, small quantities may be accepted either by a type D certification or by an affidavit from the supplier stating that the material offered is equal to that specified.

(g) Buy America Requirement

All steel and cast iron materials and products used in the contract shall be certified to be in accordance with 106.01(c).

916.03 Sample Forms

(a) For Buy America Requirement

BUY AMERICA CERTIFICATION

In accordance with Indiana Department of Transportation Specification 106.01(c), I hereby certify that all steel and cast iron materials and products incorporated in Contract No. _____ were produced and manufactured in the United States of America or territories subject to its jurisdiction.

_____ _____

Date CONTRACTOR

_____

SIGNATURE

(b) Sample Type A Certification Form

INDIANA DEPARTMENT OF TRANSPORTATION

TYPE A CERTIFICATION OF COMPLIANCE

CONTRACTOR NUMBER _____

PROJECT NUMBER _____

CONTRACTOR'S NAME _____

MANUFACTURER'S NAME _____

B/L or INVOICE NUMBER _____

MATERIAL DESTINATION _____

This is to certify that for the contract described above, the materials supplied are as follows:

**Material Name	Quantity
_____	_____
_____	_____

***Conform to: _____

The materials listed above comply with the following Test Methods and are within the acceptable limits of said Test Methods:

TEST METHOD	LIMITS OF TEST VALUE	ACTUAL TEST RESULTS
_____	_____	_____
_____	_____	_____
_____	_____	_____

_____ _____

Date Company of Manufacture

_____

*Signature of Company Official/Title

* This Certification shall be prepared by the manufacturer of the material being supplied for this contract.

** Identifying information such as Alloy, Grade, Type, Class, or other similar designation shall also be shown when appropriate.

*** Applicable material specification reference shall be listed.

(c) Sample Type B Certification Form

INDIANA DEPARTMENT OF TRANSPORTATION

TYPE B CERTIFICATE OF COMPLIANCE

CONTRACT NUMBER _____

PROJECT NUMBER _____

CONTRACTOR'S NAME _____

MANUFACTURER'S NAME _____

B/L or INVOICE NUMBER _____

MATERIAL DESTINATION _____

This is to certify that for the contract described above, the materials supplied are as follows:

**Material Name	Quantity
_____	_____
_____	_____

***Conform to: _____

The materials listed above comply with the following Test Methods and are within the acceptable limits of said Test Methods.

TEST METHOD	LIMITS OF TEST VALUE
_____	_____
_____	_____

_____ _____

Date Company of Manufacture

_____

*Signature of Company Official/Title

* This Certification shall be prepared by the manufacturer of the material being supplied for this contract.

** Identifying information such as Alloy, Grade, Type, Class, or other similar designation shall also be shown when appropriate.

*** Applicable material specification reference shall be listed.

(d) Sample Type C Certification Form

CONTRACT NUMBER _____

PROJECT NUMBER _____

CONTRACTOR'S NAME _____

MANUFACTURER'S NAME _____

B/L or INVOICE NUMBER _____

MATERIAL DESTINATION _____

This is to certify that for the contract described above, the materials supplied are as follows:

**Material Name Quantity

_____ _____

_____ _____

***Conform to: _____

_____ _____

Date Company of Manufacture

_____

*Signature of Company Official/Title

* This Certification shall be prepared by the manufacturer of the material being supplied for this contract.

** Identifying information such as Alloy, Grade, Type, Class, or other similar designation shall also be shown when appropriate.

*** Applicable material specification reference shall be listed.

(e) Sample Type D Certification Form

CONTRACT NUMBER _____

PROJECT NUMBER _____

MANUFACTURER'S NAME _____

MATERIAL DESTINATION _____

This is to certify that for the contract described above, the materials supplied are as follows:

**Material Name	Quantity
_____	_____
_____	_____

***Is in accordance with: _____

_____ _____
Date Contractor

_____
*Signature of Contractor Official/Title

* This Certification shall be prepared by the Contractor.

** Identifying information such as Alloy, Grade, Type, Class, or other similar designation shall also be shown when appropriate.

*** Applicable material specification reference shall be listed. Otherwise, a statement shall be provided that the material supplied is in accordance with minimum trade standards.

(f) Sample Asbestos Exclusion Letter

Prior to acceptance of work and final payment, the Contractor shall submit to the Engineer for each building or bridge, on the Contractor's letterhead, a signed, dated copy of the following letter. The Engineer will be responsible for the distribution of the letter.

ASBESTOS EXCLUSION LETTER

_____
Date

_____
work address of Engineer for Indiana Department of Transportation

ATT: _____
Name, Project Engineer/Supervisor

Re: Asbestos Exclusion
Location/Description ..... _____
Contract Number ..... _____
Bridge Structure Number..... _____
Contractor's Name..... _____

Dear Engineer:

I hereby certify that to the best of my knowledge no asbestos containing material was used as a building material in this project.

Very truly yours,

_____
Signature of Contractor official

_____
Title of Contractor official

cc: District Bridge Inspection Engineer
Environment, Planning and Engineering Division Chief
Project File

SECTION 917 – QUALITY ASSURANCE AGGREGATE CERTIFICATION

917.01 General Requirements

An aggregate source will be authorized to ship products in the status of a Certified Aggregate Producer who is in accordance with the required standards of ITM 211. This will consist of a program which will require the aggregate source to make a commitment to product quality management. Approval to participate in the program will be based on the following criteria.

(a) existence of suitable materials in the deposit being mined;

(b) facilities capable of consistently processing uniform materials in accordance with the specification requirements; and

(c) a source Quality Control Plan which will ensure that the mineral aggregates have a 95% assurance of being in accordance with the Department's quality and uniformity requirements.

Specific details of this program are contained in ITM 211. Sampling and testing details are found in the Inspection and Sampling Procedures for Fine and Coarse Aggregates manual. A Certified Aggregate Producer shall operate in accordance with the requirements of both publications.

917.02 Quality Control Plan

An aggregate source will not be approved as a Certified Aggregate Producer until it has prepared a Quality Control Plan and the plan has been approved. The plan shall encompass all details of production starting with the extraction of the indigenous raw materials and concluding with material shipped from the plant. The Quality Control Plan shall be prepared in accordance with the requirements of ITM 211.

917.03 Source Approval Requirements

The Office of Materials Management shall be notified in writing that the aggregate source wants to become a Certified Aggregate Producer. The aggregate source shall identify the specific products for which approval is sought. Such list shall include all of the products to be produced at the source regardless of whether the products are for Department or other uses.

An aggregate source may not be considered for entry into the certification program until the preliminary source investigation has been completed in accordance with Indiana Test Method 203.

The following procedure will be used to establish an aggregate source as a Certified Aggregate Producer.

(a) Step 1

The source shall enter the coordinated testing phase of ITM 211. Coordinated testing shall be performed in accordance with ITM 211. During this phase, the producer shall be required to develop a Quality Control Plan to establish demonstrated mean test values and standard deviations.

(b) Step 2

The aggregate source shall enter the trial phase. The producer shall also operate in accordance with ITM 211 and the Quality Control Plan. The Quality Control Plan shall be refined as may be necessary.

(c) Step 3

The aggregate source will become an approved Certified Aggregate Producer following satisfactory performance during the trial phase. Achieving such status shall be accompanied by the inherent responsibility to operate within the tenets of ITM 211. The Certified Aggregate Producer shall produce material at a compliance requirement of effectively 95% of the appropriate specifications. The Department will monitor such compliance through the use of periodic in-depth inspections of the production site. Continuing approval is contingent upon the effectiveness of the

producer's Quality Control Plan as evidenced by the quality and uniformity of the products which are prepared in accordance with the appropriated specifications and ITM 211.

917.04 Removal from Certified Producer Status

The Office of Materials Management will be responsible for the review and removal of an aggregate source from being an approved Certified Aggregate Producer. A Certified Aggregate Producer shall operate so as to avoid a need for the Department to exercise this action. However, removal from Certified Aggregate Producer status may be necessary for situations such as:

(a) the statistical probability of the product compliance has fallen below 90%;

(b) the product has a 90% to 95% probability of compliance but the producer has failed to take corrective action to restore 95% probability;

(c) the Certified Aggregate Producer has failed to take immediate corrective action relative to deficiencies in the performance of the approved Quality Control Plan;

(d) evaluation of data has demonstrated an inability of the Certified Aggregate Producer to consistently be in accordance with Department requirements;

(e) the Certified Aggregate Producer has deliberately shipped aggregate material which is not in accordance with the specifications, or has falsified records; or

(f) the production site has not been operated in accordance with the Summary of Production or Ledge Quality Results letter.

Notice of removal from Certified status will be in written form, will be issued by the Office of Materials Management, and will identify the reasons for the removal. Effective immediately upon receipt of such notification, no further aggregate shipments shall be made on a certified basis.

917.05 Appeals

The producer shall have the right to appeal removal from Certified Producer status to the Engineer. The appeal shall be in written form, shall state the reason or reasons on which the appeal is based, and shall be received within 14 calendar days of receipt of the removal notice.

SECTION 918 – SOIL FABRICS

918.01 Fabric for Waterproofing

Fabric for waterproofing shall be treated cotton in accordance with AASHTO M 117, woven glass in accordance with ASTM D 1668, or glass fiber mat in accordance with ASTM D 2178. Material furnished under this specification shall be covered by a type C certification in accordance with 916.

918.02 Geotextile for Use Under Riprap

The material used shall consist of a non-woven geotextile consisting of strong, rot resistant, chemically stable long-chain synthetic polymer material dimensionally stable with distinct and measurable openings. The plastic yarn or fibers used in the geotextile, shall consist of any long-chain synthetic polymer composed of at least 85% by weight of polyolefins, polyesters, or polyamides, and shall contain stabilizers and inhibitors added to the base plastic to make the filaments resistant to deterioration due to ultraviolet and heat exposure. The geotextile shall be calendared or otherwise finished so that the yarns or fibers will retain their relative position with respect to each other. Silt film geotextiles will not be permitted unless approved.

The geotextile shall meet the following physical requirements.

GEOTEXTILE MATERIAL PROPERTIES

TEST	METHOD	REQUIREMENTS*
Tensile Strength	Grab Tensile Strength, ASTM D 4632	200 lb (890 N)
Elongation	Grab Tensile Strength, ASTM D 4632	15%
Seam Strength	Grab Tensile Strength, ASTM D 4632	180 lb (800 N)
Puncture Strength	ASTM D 4833	80 lb (356 N)
Trapezoid Tear	ASTM C 4533	50 lb (225 N)
Ultraviolet Degradation at 150 h	ASTM D 4355	70% strength retained
Apparent Opening Size (AOS)	ASTM D 4751	AOS shall be No. 50 (300 µm) standard sieve or filter
Permeability**	ASTM D 4491 (Permittivity)	0.01 cm/sec or >

* Use value in weaker principal direction. All numerical values represent minimum average roll value and test results from any sampled roll in a lot shall meet or exceed the minimum values in the table. Lots shall be sampled according to ASTM D 4354.

** The nominal coefficient of permeability shall be determined by multiplying permittivity value by nominal thickness. The nominal thickness is measured under a normal load of 280 psi (1.93 MPa).

The geotextiles to be used will be selected from the list of approved Geotextiles for Use Under Riprap.

A manufacturer requesting that a geotextile be added to the approved list shall provide a certification documenting compliance with the above requirements and a sample to the Office of Materials Management. The certification shall be prepared by the manufacturer which addresses all the required information as shown on a sample certification form in ITM 804. No relabeled materials will be considered for approval. A specified material on the approved list will not be listed under more than 1 name.

When it is determined the material is acceptable, it will be added to the list of approved Geotextiles for Use Under Riprap and it may be used upon publication of the list.

918.03 Geotextile for Use With Underdrains

This material shall consist of a non-woven needle punched or heat bonded geotextile consisting of strong, rot resistant, chemically stable long-chain synthetic polymer materials, which are dimensionally stable relative to each other including selvedges. The plastic yarn or fibers used in the geotextile shall consist of at least 85% by weight of polyolefins, polyesters, or polyamides. The plastic yarn or fibers shall have stabilizers and inhibitors added to the base plastic to make the filaments resistant to deterioration due to ultraviolet and heat exposure.

The geotextile shall be in accordance with the physical requirements as follows:

TEST	METHOD	REQUIREMENTS[2]
Grab Strength	ASTM D 4632	80 lb (355.8 N)
Seam Strength[1]	ASTM D 4632	70 lb (311.4 N)
Puncture Strength	ASTM D 4833	25 lb (111.2 N)
Trapezoid Tear	ASTM D 4533	25 lb (111.2 kg)
Apparent Opening Size (AOS)	ASTM D 4751	Sieve No. 50 or smaller opening
Permeability	ASTM D 4491	0.1 mm/sec
Ultraviolet Degradation at 150 h	ASTM D 4355	70% strength retained

1 Values will apply to both filed and manufactured seams.
2 The value in the weaker principal direction shall be used. All numerical values will represent the minimum average roll value. Test results from a sampled roll in a lot shall be in accordance with or shall exceed the minimum values shown in the table. Lots shall be sampled in accordance with ASTM D 4354.

The geotextiles to be used shall be selected from the list of approved Geotextiles for Use With Underdrains.

A manufacturer requesting that a geotextile be added to the approved list shall provide a certification documenting compliance with the above requirements and a sample to the Office of Materials Management. The certification shall be prepared by the manufacturer in accordance with 916. No relabeled materials will be considered for approval. A specified material on the approved list will not be listed under more than 1 name. When it is determined the material is acceptable, it will be added to the

list of approved Geotextiles for Use with Underdrains and it may be used upon publication of the list.

918.04 Geotextile for Silt Fence

The silt fence fabric shall consist of a woven or non-woven geotextile consisting of strong, rot resistant, chemically stable long-chain synthetic polymer materials, which are dimensionally stable relative to each other including selvedges. The plastic yarn or fibers used in the geotextile shall consist of at least 85% by weight of polyolefins, polyesters, or polyamides. The plastic yarn or fibers shall have stabilizers and inhibitors added to the base plastic to make the filaments resistant to deterioration due to ultraviolet and heat exposure.

The geotextile shall be in accordance with the guidelines of AASHTO-AGC-ARTBA, Task Force 25 and AASHTO M 288.

The geotextile shall be in accordance with the physical requirements as follows.

TEST	METHOD	REQUIREMENTS[1]	
		Wire Fence Supported	Self Supported
Grab Strength	ASTM D 4632	90 lb (41 kg)	90 lb (41 kg)
Elongation at 45 lb (20 kg)	ASTM D 4632		50% Max.
Apparent Opening Size[2]	ASTM D 4751	No. 20 (0.84 mm)	No. 20 (0.84 mm)
Permittivity[2]	ASTM D 4491	0.01 sec^{-1}	0.01 sec^{-1}
Ultraviolet Degradation at 500 h	ASTM D 4355	70% strength retained	70% strength retained

1. The value in the weaker principal direction shall be used. All numerical values will represent the minimum average roll value. Test results from a sampled roll in a lot shall be in accordance with or shall exceed the minimum values shown in the above table. The stated values are for non-critical, non-severe conditions. Lots shall be sampled in accordance with ASTM D 4354.
2. The values reflect the minimum criteria currently used. Performance tests may be used to evaluate silt fence performance if deemed necessary by the Engineer.

Material furnished under this specification shall be covered by the type of certification specified in the Frequency Manual and in accordance with 916.

918.05 Geogrid

Geogrid shall be on a regular network of integrally connected polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding material. The geogrid structure shall be dimensionally stable and shall be able to retain its geometry under construction stresses. The geogrid structure shall have a resistance to damage during construction, ultraviolet degradation, and all forms of chemical and biological degradation encountered in the soil being placed on.

Geogrid shall be in accordance with the property requirements as specified in the Geosynthetic Research Institute Standard Test Methods GG1, GG3, GG4, and ASTM D 5262.

During periods of shipment and storage, the geogrid shall be protected from temperatures greater than 140°F (60°C), mud, dirt, dust, and debris. Each geogrid roll shall be labeled or tagged to provide product identification. The manufacturer's recommendations shall be followed with regard to protection from direct sunlight. At the time of installation, the geogrid will be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. All damaged portions of geogrid for the entire width shall be replaced.

Only geogrids selected from the Department's list of approved Geogrids shall be used. Geogrids will be placed and maintained on the Department's list in accordance with ITM 806, procedure C. No relabeled materials will be considered for approval. A specified material shown on the approved list will not be listed under more than 1 name.

The geogrid shall be in accordance with the property requirements for the type specified as follows.

(a) Type I

PROPERTY	TEST METHOD	UNIT	VALUE, Min.
Aperture	Calibered	in. (mm)	0.5 by 0.5 (13 by 13)
Open Area	COE, CWO2215	percent	> 50.0, ≤ 80.0
Tensile Modulus, machine direction cross machine direction	ASTM D 6637[1,2,3]	 lb/ft (N/m) lb/ft (N/m)	 10,000 (146,000) 10,000 (146,000)
Ultimate Strength, machine direction cross machine direction	ASTM D 6637[2,3]	 lb/ft (N/m) lb/ft (N/m)	 800 (11,670) 800 (11,670)

1. Secant modulus at 5% elongation.
2. Results for machine direction, MD, and cross machine direction, CMD, are required.
3. Minimum average roll values shall be in accordance with ASTM D 4759.

(b) Type II

PROPERTY	TEST METHOD	UNIT	VALUE, Min.
Open Area	COE, CWO2215	percent	> 50.0, ≤ 80.0
Tensile Modulus, machine direction	ASTM D 6637[1,2]	lb/ft (N/m)	49,300 (720,000)
Creep Limited Strength, machine direction at 5% strain	ASTM D 5262	lb/ft (N/m)	1,090 (16,000)

1. Secant modulus at 2% elongation.
2. Minimum average roll values shall be in accordance with ASTM D 4759.

SECTION 919 – TRAFFIC SIGNS

919.01 Traffic Signs

Traffic signs shall be in accordance with the MUTCD.

Panel sign fabrication shall not utilize overlapping or butt splicing of reflective sheeting. Roll splices, as supplied on the roll of sheeting by the sheeting manufacturer, are permitted subject to the following conditions.

(a) a maximum of 1 roll splice per panel, and

(b) a maximum of 3 roll splices per sign.

Exit panels are considered a part of the signs to which they are attached when fabricated under the same contract. If the exit panels are made for separate installation, only 1 roll splice is permitted on the entire sign.

Overlap splices on sheet signs will be permitted only because of insufficient sheeting width on signs whose smaller dimension exceeds 48 in. (1,220 mm). The overlap splice shall be installed in a shingle type manner using a horizontal lap. The lap width shall be a minimum of 1/4 in. (6 mm). Butt splices shall not be used. Roll splices are permitted on sheet signs but shall not exceed 1 splice per sign.

All signs shall be packed for shipment and handled during construction in accordance with the manufacturer's recommendations. All sign or sign face damaged prior to acceptance shall be replaced or repaired. Damaged sheet signs shall be replaced in their entirety. Damaged panel signs shall have the affected panels replaced or repaired in accordance with the manufacturer's recommendations.

Repaired areas on panel signs shall not be larger than 3 in. by 3 in. (75 mm by 75 mm). Repaired areas 1 in. by 1 in. (25 mm by 25 mm) or less shall be limited to a maximum of 3 per panel and a maximum of 6 per panel sign. Repaired areas larger than 1 in. by 1 in. (25 mm by 25 mm) shall be limited to 1 per panel and a maximum of 3 per panel sign. The maximum number of repaired areas shall be 3 on a panel or 6 on a panel sign. No more than 20% of the total number of panel signs may be patched. Panels with sheeting cracked at the bend around the panel edge shall be replaced.

A sign with the metal face damaged greater than superficial deformation shall be replaced.

(a) Backing Material

Fabrication, including cutting and punching of holes but excluding holes for demountable copy, shall be completed prior to surface treatment. Material shall be

cut to size and shape and shall be free from buckles, warp, dents, cockles, burrs, and defects resulting from fabrication. The surface shall be a plane surface.

Metal sign base material shall be cleaned and prepared to receive the sheeting material in accordance with the sheeting manufacturer's recommendation.

1. Sheet Signs

The backing material for permanent sheet signs shall be sheet aluminum in accordance with ASTM B 209 (B 209M), alloy 5052H38, or alloy 6061-T6.

The minimum thickness of the sheet shall be as shown for the appropriate sign width.

Width, in. (mm)	Thickness, in. (mm)
Up to 30 (750)	0.080 (2.00)
31 to 60 (775 to 1,500)	0.100 (2.50)
61 (1,525) and Over	0.125 (3.20)

Backing material for temporary ground mounted signs shall be aluminum, steel, fiberglass, reinforced plastic, or plywood, unless otherwise approved.

2. Panel Signs

Extruded aluminum panels shall be in accordance with ASTM B 221 (B 221M), alloy 6063-T6, and be 12 in. (300 mm) in width. Extruded aluminum panels shall be flat and straight within tolerances established by the aluminum industry. The weight (mass) for panels shall be 2.48 lb/ft (3.70 kg/m).

Trim molding shall be of the same material and thickness as the panels to which it is attached.

Panel bolts, flat washers, and lock-nuts shall be in accordance with ASTM B 211 (B 211M), alloy 2024-T4. Panel bolts shall be 3/8 in. by 3/4 in. (10 mm by 19 mm) standard hex head. Lock-nuts shall be standard hex head.

3. Demountable Letters, Numbers, and Symbols

Backing material for letters, numbers, and symbols shall be 0.040 in. (1 mm) thick aluminum sheets in accordance with ASTM B 209 (B 209M), alloy 3003-H14. Borders shall be 0.032 in. (0.8 mm) thick aluminum sheet in accordance with ASTM B 209 (B 209M), alloy 6061-T6.

(b) Sheeting Material

Only sheeting materials from the Department's list of approved Sign Sheeting Materials shall be used. Type IV or higher sheeting shall be used for highway signs. The sheeting type for the sign copy and border shall be the same type or higher than the sheeting type used for the background. Sheeting materials will be placed and maintained on the Department's approved list in accordance with ITM 930.

1. Reflective Sheeting

Reflective sheeting used for signs, channelizing and delineation devices shall be in accordance with AASHTO M 268. Type V reflective sheeting may be used on delineators. Reboundable reflective sheeting shall be used on plastic drums, flexible delineator posts, and other flexible channelizers.

The reflective sheeting shall include an adhesive backing Class 1 or Class 2 in accordance with AASHTO M 268.

2. Non-reflective Sheeting

Non-reflective sheeting shall be in accordance with AASHTO M 268 except that the sheeting shall not incorporate optical elements. The color shall be black in accordance with Federal Standard 595, Color No. 17038.

3. Transparent Sheeting

Transparent sheeting shall be a material recommended by the background sheeting manufacturer.

(c) Letters, Numbers, Symbols, and Accessories

Letters, numbers, symbols, and accessories shall be demountable.

The reflective sheeting shall be of the same type as used on the background and mechanically applied to the properly prepared aluminum in a manner prescribed by the sheeting manufacturer.

Each demountable legend unit, supplemental panel, and border frame shall be supplied with mounting holes and shall be secured to the sign face with aluminum rivets with aluminum mandrels. Adhesives that, when removed, may damage the sign face, legend unit, or border shall not be used to hold the unit in place.

Completed demountable units shall be dipped coated with a high gloss clear finish coat as specified by the sheeting manufacturer. The finished units shall be clean cut, sharp, and have essentially a plane surface.

(d) Fasteners

1. Sheet Signs

The bolts, steel flat washers, and lock-nuts used to attach sheet signs to posts shall be stainless steel in accordance with ASTM A 276, or type 304 carbon steel in accordance with ASTM A 307, grade A. Carbon steel hardware shall be galvanized in accordance with ASTM A 153. Lock washers and hex nuts shall be used in lieu of the lock-nuts when carbon steel hardware is furnished.

The bolts shall be 5/16 in. by 3 in. (8 mm by 75 mm) hex head, full threaded. The steel flat washers shall be size no. 1/4, 0.738 in. (19 mm) outside diameter,

0.317 in. (8.1 mm) inside diameter, and 0.051 to 0.08 in. (1.2 to 2.0 mm) thick and in accordance with Military Specifications MS 15795-811. Nylon flat washers shall be 7/8 in. (22 mm) outside diameter, 0.317 in. (8.1 mm) inside diameter, and shall be 0.032 in. (0.81 mm) thick.

2. Panel Signs and Temporary Panel Signs

The aluminum post clips shall be in accordance with ASTM B 26 (B 26M) or ASTM B 108 (B 108M), alloy 356.0-T6 and as shown on the plans. Aluminum post clip bolts shall be as shown on the plans and in accordance with ASTM B 211 (B 211M), alloy 2024-T4. Lock-nuts shall be in accordance with ASTM B 211 (B 211M), alloy 2017-T4. Flat washers shall be in accordance with ASTM B 209 (B 209M), alloy Alclad 2024-T4.

3. Aluminum Rivets

Aluminum rivets shall be determined by character size and shape but shall not be more than 8 in. (200 mm) on center. All rivets shall be color matched to the legend or supplemental panel being installed.

(e) Basis for Use

Materials furnished under this specification, except those used for temporary construction signs, temporary traffic signs, and temporary panel signs, shall be covered by a type C certification in accordance with 916.

SECTION 920 – HIGHWAY ILLUMINATION MATERIALS

920.01 Highway Illumination Materials

All luminaires, lamps, fuse kits, wire and cable, and major equipment shall be approved new material bearing the UL seal of approval or meet their standards.

Descriptive and technical literature shall be furnished for approval on all equipment prior to purchase and incorporation into the work.

Warranties for all major equipment shall be in accordance with 807.02.

(a) Lighting Standards and Mast Arms, under 80 ft (24.4 m)

1. General Requirements

Conventional lighting standards shall be aluminum or steel and shall be in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

For conventional light standards, design wind velocity shall be 80 mph (129 km/h). The maximum horizontal deflection of the pole under maximum loading conditions shall not exceed a deflection angle of 1° 10" from the vertical axis of the pole for any 1 ft (0.3 m) section of the pole along the entire length of the pole. The maximum stress shall be 80% of the AASHTO Standard Specifications for Group I-

DL loads. Vibration dampers shall be furnished as recommended by the manufacturer. The manufacturer may use drag coefficients based on actual wind tunnel tests; otherwise, they shall use the drag coefficients in Table 1.2.5c of Group I loads.

Conventional light standards shall be designed to support a 53 lb (24 kg) luminaire with an effective area of 2.4 sq ft (0.22 m^2). When larger luminaires are specified, the light standards shall be designed to support the larger luminaires and this shall be shown on the light standard working drawings.

Conventional poles shall have a 4 in. by 8 in. (100 mm by 200 mm) reinforced handhole centered 18 in. (460 mm) above the base of the pole and a cover attached with a minimum of 2 stainless steel hex head bolts. The pole shall have a removable pole cap and a wire support hook to support the vertical drop of the wire by a service drop clamp attached to the cable. A wiring hole with a 1 in. (25 mm) inside diameter grommet shall be provided where the arm is attached. Pole bases shall be designed for mounting on anchor bolts equally spaced on an 11 1/2 in. (292 mm) or 14 1/2 in. (368 mm) diameter anchor bolt circle. Anchor bolt covers shall be furnished.

Hardware shall be type 304 or 305 stainless steel in accordance with ASTM A 276, except where otherwise specified.

For conventional poles, a 1/2 in. (13 mm) by 13 UNC threaded grounding nut or other approved method shall be provided near the bottom of and shall be accessible through the handhole for attaching the ground wire. The ground wire shall be No. 6 AWG soft-drawn, solid copper in accordance with ASTM B 3.

Mast arms less than 8 ft (2.4 m) in length shall either be single member or truss type, except that mast arms on bridge deck light standards shall be truss type. Single member arms shall be a tapered tube oval shaped at the pole end with the long dimension in the vertical plane, welded to a pole plate and bolted or clamped to the shaft with a minimum of four 1/2 in. (13 mm) bolts. Mast arms 8 ft (2.4 m) and over in length shall be truss type. The upper member shall be a tapered tube oval shaped at the pole with the long dimension in the horizontal plane. The lower member may be standard pipe. Both members shall be welded to a pole plate and bolted or clamped to the pole. A minimum of four 1/2 in. (13 mm) bolts at the upper member and a minimum of two 3/8 in. (10 mm) bolts at the lower member shall be used if a pole plate configuration is used to attach the mast arm to the pole. Mast arms that are clamped to the pole shall have a minimum of four 1/2 in. (13 mm) bolts per clamp. Mast arms shall provide an enclosed raceway for the wiring and shall be free of burrs and rough edges. Each arm shall be furnished with a 2 in. (50 mm) nominal pipe size slipfitter. The maximum rise of the truss style arm shall be as set out in the table and shall be measured vertically from the centerline of the free end of the truss to a plane through the centerline of the upper arm bracket after loading.

MAST ARM LENGTH ft (m)	MAXIMUM RISE ft (m)
9 (27) or less	4 (1.2)
10 to 14 (3 to 4.3)	5 (1.5)
15 to 19 (4.5 to 5.8)	5.5 (1.7)
20 to 25 (6.1 to 7.6)	6 (1.8)
26 to 30 (7.9 to 9.1)	8 (2.4)

Light standards shall be constructed to provide a nominal luminaire mounting height above the roadway pavement as shown on the drawings. The elevations of foundations above or below the edge of the pavement shall be controlled by existing roadside conditions. The proper shaft length shall be determined by field measurement prior to placing an order for the poles.

A variation in the nominal mounting height of ± 1 ft (0.3 m) is permitted so that the "Effective Mounting Height", foundation to luminaire, of the light standards may be supplied for 40 ft (12.2 m) nominal mounting height.

Elevation of Foundation Top with Respect to the Near Road Edge ft (m)	Effective Mounting Height, Foundation to Luminaire ft (m)
+7.00 to +5.01 (2.13 to 1.53)	34 (10.4)
+5.00 to +3.01 (1.52 to 0.92)	36 (11.0)
+3.00 to +1.01 (0.91 to 0.031)	38 (11.6)
+1.00 to -1.00 (+0.30 to -0.30)	40 (12.2)
-1.01 to -3.0 (-0.31 to -0.91)	42 (12.8)
-3.01 to -5.00 (-0.92 to -1.52)	44 (13.4)
-5.01 to -7.00 (-1.53 to -2.13)	46 (14.0)

The effective mounting heights for other nominal mounting heights deviate from the table by the difference in the nominal heights.

2. Aluminum Lighting Standards

a. Round Seamless

The pole and mast arm shall be in accordance with ASTM B 241 (B 241M), alloy 6063-T4, and of sufficient diameter and wall thickness to withstand the design loads. The pole shall be tapered full length or tapered in the middle with the top and/or bottom approximately 1/3 of the pole of constant cross section. The minimum wall thickness for poles on breakaway couplings and steel slip bases shall be 0.219 in. (5.6 mm). Poles on transformer bases or shoe anchor bases installed without breakaway devices are exempted from this minimum wall thickness requirement. An inner tube extension, or sleeve, fitted inside the main tube shaft, is permissible to increase the wall thickness of the shaft starting at the bottom of the shoe base and extending upward towards the top of the pole. The sleeve or tube

extension shall be no less than 3 ft (0.9 m) in length, fabricated from aluminum alloy 6063-T4 and heat treated to produce a T6 temper after placing in the shaft. The minimum wall thickness of the combination of shaft and sleeve shall be 0.219 in. (5.6 mm). Attaching plates or clamps for aluminum mast arms shall be in accordance with ASTM B 241 (B 241M), alloys 6061-T6, 6063-T6, 356.0-T6, or 5052-H32. The bottom end of the shaft shall be welded to a 1 piece cast aluminum shoe anchor base of 356.0-T6 aluminum alloy in accordance with ASTM B 26 (B 26M) for sand castings or ASTM B 108 for permanent mold castings or equal and provided with 4 slotted holes for anchor bolts and the shaft's full length shall be heat treated to produce a T6 temper. The top of the shaft shall be provided with a removable aluminum pole cap. The shaft shall have no longitudinal welds. After fabrication, the shaft shall be cleaned to a satin finish and wrapped for protection during shipping and handling.

b. Single Longitudinal Welded

The material for these lighting standards shall be round, tapered structural marine aluminum sheet in accordance with ASTM B 209 (B 209M), alloy 5086-H34, and of sufficient diameter and wall thickness to withstand the design loads. The minimum wall thickness for poles on breakaway couplings and steel slip bases shall be 0.219 in. (5.6 mm). Poles on transformer bases or shoe anchor bases installed with no breakaway devices are exempted from the minimum wall thickness requirement. The anchor base shall be 1 piece cast aluminum in accordance with ASTM B 26 (B 26M), alloy 356.0-T6. The base casting for the formed and welded shaft shall be designed to be inserted a minimum of 12 in. (300 mm) into the shaft and bonded to the shaft with a weatherproof structural epoxy adhesive that fully develops the required strength as specified by the design criteria. After fabrication, the shaft shall be cleaned to a satin finish and wrapped for protection during shipping and handling.

3. Stainless Steel Lighting Standards

Stainless steel lighting standards shall be fabricated from stainless steel in accordance with ASTM A 666, type 201, that has a minimum yield point of 68,000 psi (469 MPa). Welds other than spot welds shall be performed with conventional welding equipment and with stainless steel welding rods. Welds shall be free of cracks and pores. The wall thickness and diameter of the pole shall be sufficient to withstand designed loads. Exposed surfaces of the standard shall be smooth and free from marks or imperfections. During shipment, the poles and mast arms shall be protected with a non-staining protective material to preserve the finish.

4. Galvanized Steel Lighting Standards

The pole and base plate shall be fabricated from steel in accordance with ASTM A 572 (A 572M) A 595, or A 1011 with a minimum yield strength of 50,000 psi (345 MPa). Single member mast arms and the upper members of truss type mast arms shall be fabricated from steel in accordance with ASTM A 572 (A 572M) or A 595 with a minimum yield strength of 50,000 psi (345 MPa). The lower member of truss type arms may be fabricated from standard steel pipe in accordance with ASTM A 53 with a minimum yield strength of 36,000 psi (250 MPa). After

fabrication, the pole and mast arm shall be thoroughly cleaned and galvanized in accordance with ASTM A 123.

Steel standards shall be tapered 0.14 in./ft (11.67 mm/m) and shall be round, octagonal, or dodecagonal. The design load shall be used to determine the pole diameter and wall thickness. The pole shall have 1 longitudinal electrically welded joint. A steel base plate shall be welded to each pole and provided with 4 slotted holes for the anchor bolts.

All welds on steel standards shall be performed at the factory. Base plate welds shall be 100% penetration. Circumferential welds shall be backed-up welds with 100% penetration. Longitudinal welds shall be a minimum of 60% penetration. The 100% penetration welds shall be ultrasonically inspected and all other welds shall be inspected by magnetic particle. Welding shall be performed in accordance with 711.32.

5. Wood Pole Lighting Standards

Wood poles for highway lighting standards shall be in accordance with 922.05(b).

6. Frangible Breakaway Bases

All light standards, except high mast towers and those protected by bridge end bents or retaining walls, shall be installed on breakaway devices. All breakaway devices on a contract shall be of the same type and manufacturer.

Breakaway devices shall be in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals as modified in 920.01(a)1.

A certification from the manufacturer shall be furnished with the shop drawings stating the breakaway devices conform to the breakaway criteria of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

a. Cast Aluminum Transformer Base

The anchor bolts for transformer bases shall be in accordance with 920.01(a)7. The anchor bolt circle for transformer bases shall be 15 in. (381 mm). The bolt holes in the transformer base may be slotted. The pole shall be bolted to the transformer base with four 1 in. (25 mm) diameter galvanized steel bolts.

An approved handhole in the transformer base may be substituted for the 4 in. by 8 in. (100 mm by 200 mm) handhole specified in 920.01(a)1.

b. Breakaway Coupling

Breakaway couplings may be used with aluminum poles with mounting heights up to 50 ft (15 m) and with steel poles that weigh 600 lb (272 kg) or less. The

couplings shall be furnished with necessary hardware including a 2 piece cover. Couplings shall be installed in accordance with the manufacturer's instructions and recommended clearance between the top of the foundation and the bottom of the breakaway coupling.

7. Anchor Bolts

Anchor bolts shall be 1 in. (25 mm) with 8NC rolled threads in accordance with ASTM A 307. The minimum length of threads shall be 6 in. (150 mm). Mean diameter of rod stock shall be 0.918 in. ± 0.011 in. (23.32 mm ± 0.28 mm) and out-of-round tolerance shall be ± 0.012 in. (0.3 mm). The top 10 in. (254 mm) of the bolt shall be galvanized in accordance with ASTM A 153. Anchor bolts shall be in accordance with 910.19(b). The bolts shall be a minimum of 36 in. (914 mm) in length for poles 8 in. (200 mm) outside diameter or less and 48 in. (1,219 mm) in length for poles 9 in. (230 mm) or 10 in. (254 mm) outside diameter. In addition to the minimum length, the bolt shall have a 4 in. (100 mm) right angle bend at the unthreaded end. The anchor bolts in bridge structures shall be as shown on the plans.

(b) High Mast Standards of 80 ft (24.5 m) and Over

The high mast pole, base, anchor bolts, lowering device, installed fixtures, and associated appurtenances shall be designed to withstand a minimum wind speed of 90 mph (145 km/h), gust of 117 mph (188 km/h), using applicable design criteria in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. Minimum design criteria for each fixture shall be an effective projected area of 2.8 sq ft (0.26 m^2) and a weight of 85 lb (38.6 kg). If larger fixtures are used, the actual size and weight shall be used in the design of the pole.

The Contractor shall be responsible for the accuracy of the dimensions and the proper fit of all material and equipment furnished with the pole. The Contractor shall provide all applicable manufacturer's warranties for material and workmanship. External lowering devices shall be designed to attach to the pole as shown on the plans. The pole shall include the mounting accommodations as shown on the plans.

1. High Mast Poles

The poles shall be tapered shafts having poly-sided or circular cross sections. The pole shaft sections shall be slip fitted and shall provide at least 1 in. (25 mm) radial clearance from all interior devices.

All tower shaft components shall be fabricated from high strength, low alloy, steel in accordance with AASHTO M 270; ASTM A 595, Grade A or B; ASTM A 572, Grade 55; ASTM A 1011 (A 1011M); ASTM A 606, or ASTM A 808 (A 808M), with a minimum yield strength of 50,000 psi (345 MPa).

Sections which are slip fitted shall have slip joints with a minimum overlap of 1.5 times the diameter of the bottom of the upper section at the slip joint. Towers having slip joint construction shall be match marked at the factory and shall be

shipped disassembled for assembly at the work site. Slip joints shall be marked to ensure that the 1.5 times diameter insertion is provided.

All steel used in the base plate and shaft shall meet an impact property of 15 ft·lbs (20.3 J) at 40°F (4°C) in the longitudinal direction using the Charpy V-Notch test. This shall be an average of 3 tests per mill heat with no test below 10 ft·lbs (13.6 J). A copy of the certified mill test reports for this steel and the Charpy V-Notch test results shall be submitted. Sufficient information shall be furnished to demonstrate that this material is traceable to the mill heat number shown on the test report.

All tower shaft hardware including hardware for the handhole door, and the latch mechanism shall be stainless steel in accordance with ASTM A 276, type 304 or 305, except where otherwise specified.

After fabrication, the pole shall be cleaned and galvanized. Galvanized steel towers, including the handhole, handhole door, base plate, mounting plate, and all other elements welded to the shaft shall be hot-dip galvanized in accordance with AASHTO M 111.

2. Welding

The welding symbols and all information regarding location, type, size, welding sequence, and welding procedure specifications shall be shown on the shop drawings.

Welds shall be smooth and cleaned of flux and spatter in accordance with AWS procedure. Minimum preheats for welds shall be 100°F (38°C) for seams, and 225°F (107°C) for circumferential welds.

All welds shall be performed at the factory. Circumferential welds shall be backed-up welds with 100% penetration. Longitudinal welds shall have a minimum of 60% penetration except within 2 ft (0.6 m) of either side of the circumferential joint, the welds shall be backed-up and of 100% penetration. Base plate welds shall be 100% penetration. Circumferential welds and 100% penetration longitudinal welds shall be 100% ultrasonically inspected. The 60% penetration longitudinal welds shall be 100% ultrasonically or radiographically inspected for soundness. Welding shall be performed in accordance with AWS D1.5 and 711.32. Weld filler shall provide Charpy V Notch equal to or greater than 20 ft·lbs (27.1 J) at 0° F (-18°C).

a. Inspection

The manufacturer shall provide quality control, QC, inspection. The inspector shall be an AWS certified welding inspector, CWI, in accordance with AWS D1.5. The NDT inspector shall be an independent non-destructive-testing inspector, certified as level II in RT, UT, or MT, or all as applicable. Copies of the inspection reports and NDT reports shall be provided to the Engineer.

The method for testing full penetration and partial penetration welds by the independent welding inspector shall be the same as specified above.

b. Blank

3. Handholes

Openings for handholes shall be reinforced to maintain the design strength of the pole. The handhole shall have a weatherproof gasket made of neoprene or silicone rubber. The gasket shall be formed for a forced fit around the handhole or be attached by mechanical means. Samples of the gaskets shall be furnished for approval. The door and hinges shall be the same type steel as the poles. The hinge pins and other securing hardware shall be stainless steel and tamperproof. The door shall be fabricated to allow for a padlock, which is not included in the hardware. The hasp used for padlocking shall be fabricated from stainless steel. Provisions shall be made to bolt the door securely shut. The door shall include a bugproof and weatherproof aperture with a minimum opening of 4 sq in (2,580 mm^2). Nylon or non-corrosive screens, or other approved methods of bugproofing shall be furnished. Two bonding plates shall be furnished which are accessible through the pole handhole for connecting the ground wires. A connection shall be furnished for an additional ground wire on the outside of the pole near the base plate.

4. Luminaire Ring Assembly

The ring shall be fabricated from ASTM A 666 Type 201 or 304 stainless steel and shall have a removable raceway cover. The ring shall be fabricated as an enclosed wire raceway to provide for the symmetrical mounting of the luminaires. All structural connections shall be made with bolts and nuts.

The luminaire ring shall be supported by means of stainless steel aircraft cables of 7 strands with 19 wires per strand with a minimum breaking strength of 3,900 lb (17,350 N).

5. Head Frame Assembly

The head frame shall be made of ASTM A 666 Type 201 or 304 stainless steel. All required pulleys, rollers, or sheaves and shafts shall be constructed from non-corrosive metallic materials. No component shall be used in the lowering device in excess of its rating or in violation of the component manufacturer's recommendation. This requirement shall be applicable, but not limited to, the compatibility of the cables and sheaves. There shall be 3 supports for the suspension cables. A roller system or 1 compatible sheave for the power cable shall be located mid-point between 2 of the suspension supports. To prevent the cables from riding out of the grooves, cable guides shall be provided. The suspension cable sheaves shall have a minimum pitch diameter of 3 1/2 in. (90 mm) and the power cable sheave or individual rollers in a roller assembly shall have a minimum pitch diameter of 18 1/2 in. (470 mm) and shall be grooved to fit the power cable.

All components at the top of the pole shall be protected from the weather by a dome fabricated from steel in accordance with 920.01(b)1, fiberglass, or spun aluminum.

The dome shall be secured to the head frame assembly with at least eight fasteners around the perimeter of the dome. The dome shall be reinforced at the points of attachment and it shall be fitted to the head frame assembly so that no visible distortion occurs to the dome when it is properly installed. The dome attachment shall be designed to withstand pole vibration, other pole movement, and the design windload. The fiberglass dome shall be made of material that is not subject to cracking or other deterioration because of aging.

6. Winch Assembly

The winch cable shall be 5/16 in. (8 mm) diameter galvanized steel aircraft cable of 7 strands with 19 wires each strand with a minimum breaking strength of 9,800 lb (43,600 N).

The winch shall have a drum with a minimum diameter of 4 in. (100 mm) and drum flanges with a minimum diameter of 8 in. (200 mm). The drum shall be supported at each end by a rigidly mounted permanently lubricated bearing capable of carrying the design load. The winch drum shall be designed to allow the cable to lay in even consecutive layers.

The winch shall be driven by a self locking, worm gear reducer. The gear reducer shall be permanently lubricated and totally enclosed in a cast aluminum or cast iron housing. The winch assembly shall be powered by an external drive system.

7. External Drive System

The external drive system shall be powered by a heavy duty reversing NEMA frame motor with an electromagnetic friction breaking mechanism rated at a minimum of 6 ft·lb (8.15 J) of torque per motor horsepower (746 W). The brake shall be actuated each time the power to the motor is interrupted. The breaking mechanism shall be an integral part of the motor housing. The motor operated drive shall have a factory set torque limiter or clutch. This clutch assembly shall be calibrated to position the ring at the top of the pole and not exceed 80% of yield strength of the cable.

The external drive system shall operate with the 240/480 AC volt power available at the pole or incorporate a transformer into the system. The external drive system may use either the luminaire power plug or a separate outlet with a 600 volt, 30 ampere rating. The external drive system shall be operated from a minimum distance of 25 ft (7.6 m) from the pole. The control voltage for any hand-held control equipment shall not exceed 120 volts. The hand-held control equipment shall be shock proof.

The external drive system shall be capable of operating all high mast pole installations. Working drawings shall be furnished in accordance with 105.02 and shall include the dimensions and the wiring diagram of the standard connections of the external drive system. The external drive system shall be mounted on a 2 wheel cart with wheels at least 12 in. (300 mm) in diameter and the weight shall be distributed so that it presents a balance load.

8. Cable Terminator

The 3 luminaire ring support cables shall be attached to 3 stainless steel helical compression springs incorporated into the cable terminating device. These springs shall be designed to compensate for inequalities in the cable lengths and to maintain adequate tension on the support cables through pole and cable thermal expansion and contraction.

The cable terminator shall incorporate a separate eye bolt on the bottom of the device for the attachment of a cable or chain to hold the luminaire ring in a raised position while the winch cable or winch assembly is being inspected or repaired. The cable terminating device shall be designed to prevent the device from catching on the slip joint of the structure.

9. Lightening Rod Assembly and Grounding System

The lightening rod, air terminal, shall shield the head frame assembly cover and the outer edge of the luminaires within a 45° electrostatic shielded cone. The grounding system shall include bonding plates, grounding clamps, four 5/8 in. (16 mm) diameter by 12 ft (3.7 m) copperweld grounding rods, a grounding conductor with a minimum size of 28 strands of 14 gage bare copper wire in rope lay configuration, 9/16 in. (14 mm) diameter with a weight of copper of 375 lb per 1,000 ft (136 kg per 306 m), air terminal, lightening rod and other incidental connectors. All hardware shall be stainless steel, brass, copper, copper alloy, or equally corrosion-resistant metal.

Bonding plates, with a minimum contact surface area of 8 sq in. (5,160 mm^2), shall be installed at locations shown on the plans. The bonding plates shall be welded to the tower shaft during the time of manufacturing. The grounding conductor shall be secured to the bonding plates by a 2 bolt pressure plate clamp connector having a minimum of 4 in. (100 mm) of contact with the copper wire. At the point of termination the grounding conductor shall extend beyond the bonding plate a minimum of 3 in. (75 mm).

Each ground rod clamp shall have a minimum of 1 1/2 in. (38 mm) of contact between the grounding conductor and the ground rod. The grounding conductor shall be continuous between the bonding plates inside the tower shaft handhole and the grounding rod termination point.

Bends of conductors shall form an angle of 90° or more. Unsupported conductors shall have a radius of bend 8 in. (200 mm) or greater.

10. Anchor Bolts

Anchor bolts for high mast poles shall be furnished in a pre-clustered form and shall be a hooked deformed reinforcing bar or a hooked smooth bar. The bolts shall be in accordance with ASTM A 615 (A 615M) modified to a minimum yield strength of 75,000 psi (517 MPa). The top 12 in. (300 mm) of each anchor bolt, nut, and washer shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

(c) Wire and Cable

Lighting circuit cables for direct burial shall be enclosed in polyethylene conduit.

1. Polyethylene Conduit

This conduit shall be in accordance with ASTM D 3485 either medium density type II, class C or high density type III, class C smooth wall, coilable polyethylene conduit for preassembled wire and cable.

The size of the conduit for different cable conductor sizes shall be as follows.

Cable Conductor Size	Conduit Size
3-1/C No. 4	1 1/4 in. (32 mm)
3-1/C No. 2	1 1/2 in. (38 mm)
3-1/C No. 1/0	2 in. (50 mm)
3-1/C No. 3/0	2 in. (50 mm)

2. Conductors in Cable-Duct

The cable shall consist of 3 separate electrically insulated conductors installed in the duct so any 1 conductor may be easily removed without damage to the other 2. The conductors shall not be cabled or twisted together. The conductors shall be stranded copper of the AWG size specified. Conductor sizes No. 8 AWG and larger shall be stranded in accordance with ASTM B 8, class B.

Each conductor shall be insulated with crosslinked polyethylene manufactured in accordance with Insulated Power Cable Engineer Association publication S66-524. Each conductor shall have the following characteristics: a 600 volt rating; UL listed; an XHHW conductor temperature rating not to exceed 90°C in dry locations; and not to exceed 75°C in wet locations.

Each of the 3 conductors shall be imprinted at regular intervals with the following description: Type XHHW; 600 volt; UL; the conductor's AWG size and metal or alloy; the manufacturer's name, trademark, or other distinctive marking by which the product can be readily identified.

Identification coding of the conductors shall be accomplished by complete color coding or by ribbing of the insulation. Color coding of the insulation shall be homogeneous throughout the entire depth and length of the jacket. The colors shall include 1 black, 1 white, and 1 red. Ribbing shall consist of 1 non-ribbed conductor, 1 single ribbed conductor, and 1 double ribbed conductor. The same method of conductor identification coding shall be used throughout the project.

3. Lighting Standard Circuit Wiring

This wiring shall consist of two 1/C No. 10 AWG, 600 volt, THWH or MTW insulation, stranded copper wire.

4. Sign and Underpass Wiring

The wiring from the switch box to the last luminaire shall be 3/C copper stranded No. 10 AWG conductors and shall have imprinted at regular intervals along the length of the insulation jacket the following designation: No. 10 AWG, type MTW or THHN or THWN or Gasoline and Oil Resistant II or AWM, 600 volt, UL. The conductor classifications shall be UL listed and have the following minimum temperature ratings: MTW 90°C; THHN 90°C; THWN 75°C; and AWM 105°C. It shall be installed in 3/4 in. (19 mm) conduit between the breaker box and luminaires.

5. Aerial Cable

This cable shall be triplex secondary distribution cable consisting of 2 insulated conductors and a steel reinforced bare copper messenger neutral. The insulated conductor shall be No 6 AWG stranded copper with 600 volt, XHHW-XLP type insulation.

6. High Mast Tower Luminaire Ring Conductors

The wiring from the terminal box on the ring through the last luminaire shall be in accordance with 920.01(c)4.

7. Power Cable-High Mast Poles

The power cable shall be a 4/C No. 10 AWG copper insulated electrical cable type “SO” modified for a repetitive reeling operation. It shall be in accordance with ASTM B 3, ASMT B 173, and IPCEA S-19-83. Conductor insulation shall be in accordance with ASMT D 169 and IPCEA S-19-81, Paragraph 3.12. The sheath or jacket shall meet or exceed IPCEA S-19-81, Paragraph 7.6.20.1.1. Conductors shall be color coded.

The power cable shall have a heavy-duty 600 volt, AC 30 amp rated electrical plug capable of disconnection in a safe manner under load conditions. The electrical plug shall be moisture resistant and waterproof at both transition points.

8. Electrical Connectors

Connectors shall be a compression type of the proper size with only 1 conductor per groove in the fitting. They shall be designed specifically for use on aluminum and copper conductors, prefilled with an oxide inhibitor and installed with a

hydraulic tool according to the manufacturer's specifications. After installation, the connectors shall be fully insulated and weatherproofed. The connectors installed in underground handhole shall be taped and then waterproofed as shown on the plans.

(d) Luminaires

1. General Requirements

Lamps supplied for luminaires shall be electrically compatible with the luminaires. Luminaires shall include the lamp ballast. The ballast shall be integrally built in and of the constant wattage regulator type of sufficient size to operate the designated lamp at the required voltage. The ballast shall provide satisfactory lamp performance to 20°F (-7°C) with an input voltage variation of ± 10% of the rated operating voltage specified.

Luminaires shall include vandal shields when installed on an underpass or signs on bridge brackets and when otherwise specified. The vandal shield shall be made of a tough durable plastic, such as Lexan, mounted in a rugged galvanized steel or aluminum frame, and shall withstand severe impact without being damaged or allowing the refractor to be damaged. It shall be fastened securely to the luminaire so it can not be removed from the outside and shall not interfere with the light distribution pattern. It shall protect the face of the refractor and if ventilation is necessary, the ventilating apertures shall be arranged so that they do not admit a probe of a diameter greater than 1/4 in. (6 mm).

2. Roadway Lighting Luminaires

Roadway lighting luminaires shall have a precision-cast aluminum housing and refractor holder with weatherproof finish. They shall have a strong, easily operated, positive latch on the street side of the refractor holder and a hinge with a safety catch that prevents accidental unhinging on the house side of the refractor holder. They shall include a slipfitter capable of adapting to a 2 in. (50 mm) mounting bracket; an easily detachable highly specular aluminum reflector; and an easily adjustable socket in both horizontal and vertical directions capable of producing lighting patterns to meet all the requirements of the American Standard Practice for Roadway Lighting as sponsored by the Illumination Engineering Society and as shown on the plans. They shall have a high impact, heat-resistant, glass, prismatic refractor; and include gasketing that will completely seal out dust, moisture, and insects from the interior of the optical assembly and retard the formation of an undesirable film from gaseous vapors on the interior of the optical assembly.

3. Sign Luminaires

Luminaires shall be 250W mercury vapor unless otherwise specified. Sign luminaires shall have the same requirements as roadway luminaires plus a shield that blocks the view of the refractor from an approaching motorist. This shall be accomplished by the design of the housing or by a shield fabricated from sheet aluminum, approximately 0.05 in. (1.3 mm) thick, and of sufficient size to be

fastened onto the horizontal edge of the refractor holder with self tapping screws and placed between the refractor and approaching traffic.

Aluminum and steel structural members for luminaire supports shall include aluminum conduit, conduit clamps, fittings, and stainless steel screws.

4. Underpass Luminaires

Underpass luminaires shall have the same requirements as roadway luminaires except they shall have vandal shields and the ballast shall meet the same requirements except it may be mounted separately near the luminaire as shown on the plans.

5. High Mast Luminaires

The luminaires shall be in accordance with the American Standard Practice for Roadway Lighting by the Illumination Engineering Society and shall produce lighting patterns as shown on the plans. The lamp in the high mast luminaire shall be supported at both ends with mechanical spring grips or other means to hold the lamp secure against vibration. The socket shall be mogul sized and porcelain enclosed. The luminaire housing shall be an enclosed aluminum unit with a reflector and borsillicate glass refractor. It shall include gasketing that will completely seal out dust, moisture, and insects from the interior of the optical assembly and retard the formation of an undesirable film from gaseous vapors on the optical assembly.

(e) Circuit Breakers and Enclosure

All circuit breaker enclosures shall be NEMA 4/5.

1. Circuit Breakers for Type II Service Point

The cabinet and hardware shall be weatherproof and rain tight. The enclosure shall have provisions for pad locking. The fastener and mounting hardware shall be plated brass, stainless steel, or aluminum. The enclosure shall be made of 14 gage aluminum or 14 or 16 gage (1.5 mm) stainless steel. The circuit breaker operating handles for manual tripping shall be concealed inside the enclosure. Computation of branch circuits shall be based on the National Electrical Code Standard Limitation of loading breakers to 80% of their rated current. Additional details shall be as shown on the plans.

2. Circuit Breakers for Sign and Underpass Circuits

Sign and underpass circuit protection shall be provided by 2 single pole, 240 volt AC, 120 volt for 120/240 volt service, circuit breakers with ampere rating of 200% of the normal load. The circuit breakers shall have provisions for padlocking externally. The circuit breaker operating handles for manual tripping shall be concealed inside the enclosure. The enclosure shall be made of aluminum or stainless steel. Additional details shall be as shown on the plans.

3. Circuit Breakers for High Mast Poles

The enclosure shall be furnished with 2 single pole, 30 ampere, 480 volt AC circuit breakers with a minimum symmetrical RMS interrupting capacity of 14,000 amperes. The breakers shall be accessible through the pole handhole. The circuit breaker operating handles for manual tripping shall be external to the enclosure. The enclosure shall be made of aluminum or stainless steel. Additional details shall be as shown on the plans.

4. E-Series Magnetic Circuit Breakers

These breakers shall have the following features.

a. capable of 10,000 on-off operations;

b. interrupting capacity of 7,500 amperes;

c. temperature stable so as not to be adversely affected by temperature changes over their operating environment of -40°F (-40°C) to 185°F (85°C);

d. lug range 1/0 - 14 copper and 1/0 - 12 aluminum; and

e. trip on overload, even when handle is forcibly held in the ON position.

(f) Multiple Relay Switches with Photocell Receptacles

Multiple relay switches with photocell receptacles shall have a 2 pole relay for connection to a 120/240 or 240/480 volt, 3 wire, single phase, 60 hz power supply. The relay switch components shall match the service voltage being supplied. The unit shall contain 2 single pole circuit breakers with a minimum rated capacity to withstand 100% of the rated ampere load. The circuit breakers shall trip at not less than 125% of the rated load capacity. Control circuit arresters for lighting protection and a manual control selector switch shall be included within the unit. The enclosure shall be a cast aluminum weatherproof case, with a hinged cover, having provisions for padlocking and a hanger for pole or wall mounting.

(g) Materials Certification

Unless otherwise specified, materials furnished under this specification require a type C certification in accordance with 916.

(h) Junction Box

The junction box shall be polymer concrete, of concrete-gray color, with a cover rating of 20,000 lb (9,072 kg).

SECTION 921 – PAVEMENT MARKING MATERIALS

921.01 Blank

921.02 Durable Marking Material

Durable marking material shall be thermoplastic, preformed plastic or multi-component pavement markings. The materials shall not contain any toxic heavy metals above the limits of the regulatory levels of 40 CFR 261.24, table 1, when tested in accordance with EPA TCLP, or contain any other material which will require characterization as a hazardous waste when removed from the pavement surface.

(a) Thermoplastic

This material shall be in solid form in accordance with AASHTO M 249 or supplied in a preformed state and shall not contain lead chromate pigments.

Heat bonded preformed thermoplastic shall be in accordance with AASHTO M 249 with the exception of the application properties outlined in section 5 of AASTHO M 249 shall not apply. Drying time and short term and long term flowability requirements are not applicable at time of installation. The material shall be capable of fusing to itself and previously applied thermoplastic pavement markings when heated. The material shall contain a minimum of 30% beads by weight. The beads must be homogeneously blended throughout the material. The marking thickness throughout its width, before the material is heated up, shall be supplied at a minimum average thickness of 90 mils (2.3 mm).

(b) Preformed Plastic and Extended Warranty Preformed Plastic

This material shall consist of a homogeneous preformed plastic film with a width as specified. Dimensional requirements shall meet one of the following:

1. Preformed plastic material shall have a smooth plane surface, with a minimum thickness of 60 mils (1.5 mm) throughout the entire cross section, or

2. Preformed plastic material shall have an embossed patterned surface with 35% to 65% of the surface area raised. The edges of the raised areas shall present a near vertical face to traffic from any direction. The minimum thickness of the raised area shall be 60 mils (1.5 mm). The area between the raised areas shall be a minimum of 20 mils (0.5 mm) measured at the thinnest section of the cross section.

The material shall have a precoated adhesive. The adhesive shall allow the preformed plastic material to be repositioned on the pavement surface to which it is applied before permanently fixing it in its final position with downward pressure.

The material shall be capable of being affixed to either HMA or PCCP by means of the precoated adhesive and, following the initial application of pressure, shall mold itself to pavement contours, breaks, and faults by traffic action at normal pavement temperatures.

The near vertical faces of patterned preformed plastic shall be coated with a layer of beads.

A type C certification in accordance with 916 shall be furnished for the marking materials except materials used for temporary pavement markings.

1. Packaging

Each package shall be marked to indicate the color of the material, specific symbol or word message, the batch number, the manufacturer's name, address, and the date of manufacture.

2. Basis For Use

A type C certification in accordance with 916 shall be furnished for the preformed plastic material except materials used for temporary pavement markings.

(c) Multi-Component

The material shall be for use on both HMA and PCC pavements. The material shall consist of a pigmented resin system of epoxy. The multi-component pavement markings shall be ultra-violet light resistant and shall not darken during the heating conditions of application, chalk, crack, show appreciable degradation or discoloration due to sunlight exposure and aging of the markings. The cured multi-component pavement markings shall be impervious to salts, grease, oil, fuels, acids, alkalies and other common chemicals that may be found in or on HMA and PCC pavements. The pigment in the white material shall contain titanium dioxide in accordance with ASTM D 476.

The material shall be provided in containers, which are in accordance with current Federal DOT regulations. Each container shall be labeled in accordance with 29 CFR 1910.1200 and include the trade name or trade mark, formulation or product identification, date of manufacturer, color, batch or lot number, component identification and mixing instructions.

Multi-component pavement marking material furnished under this specification shall be covered by a type C certification in accordance with 916.

(d) Snowplowable Raised Pavement Marker and Cast Metal Base

Snowplowable raised pavement marker shall consist of a cast metal base to which is attached a replaceable prismatic reflector for reflecting light longitudinally along the pavement from a single or from opposite directions. Both ends of the casting shall be shaped to deflect a snowplow blade upward.

The prismatic reflectors and cast metal bases shall be in accordance with ASTM D 4383. Only prismatic reflectors and cast metal bases from the Department's list of approved snowplowable pavement markers shall be used.

A type B certification in accordance with 916 shall be furnished for the epoxy material.

1. Epoxy Adhesive

The epoxy adhesive shall be in accordance with AASHTO M 237, type IV, Table 3 with respect to composition and performance. A type B certification in accordance with 916 shall be furnished for the epoxy material.

2. Blank

(e) Pavement Marking Beads

A type C certification in accordance with 916 shall be furnished for the beads.

1. Standard Beads

Beads shall be glass in accordance with AASHTO M 247, Type I. The beads shall have a moisture resistant coating.

2. Modified Standard Beads

The modified standard beads shall be glass in accordance with AASHTO M 247, Type IM. These beads shall have a moisture resistant coating and may a have an adhesion promoting coating.

3. Supplemental Beads

The supplemental beads shall be glass in accordance with AASHTO M 247 except the beads shall have a minimum roundness of 80 percent by weight and the gradation shall be as follows:

Sieve Size	Percent Passing by Weight
No. 10 (2.0 mm)	100
No. 12 (1.7 mm)	95 – 100
No. 14 (1.4 mm)	80 – 95
No. 16 (1.18 mm)	10 – 40
No. 18 (1.0 mm)	0 – 5
No. 20 (850 µm)	0 – 2

These beads shall a have a moisture resistant coating and may have an adhesion promoting coating.

4. Supplemental Elements

These shall be for color, skid resistance, or wet weather retro-reflectivity and may be used provided they do not exhibit a characteristic of toxicity referenced in

AASHTO M 247. A type D certification in accordance with 916 shall be furnished for the supplemental elements.

SECTION 922 – TRAFFIC SIGNALS

922.01 Traffic Signal Controller and Cabinet

(a) Model Approval

Each model of controller and its cabinet will be tested, evaluated, and approved prior to use. Testing, evaluation, and approval will require a minimum of 6 months to perform. The period of evaluation will commence when the Department receives the preliminary product evaluation form accompanied by the product brochure, operational manual, maintenance manual, and documented theory of operation. The Logistical Support Center will advise the manufacturer or vendor, in writing, of the date to deliver the controller and cabinet, for which model approval is requested, to the Logistical Support Center. Certification in accordance with 922.01(f)6b, shall be received at the Logistical Support Center a minimum of 2 weeks prior to the date of delivery of the controller and cabinet. Certifications in accordance with 922.01(f)6a, schematics for the controller and cabinet, operational manuals, theory of operation and parts list shall be furnished with the controller when it is submitted to the Logistical Support Center for evaluation and testing. The controller and cabinet will undergo the bench test in accordance with 922.01(d). A controller or control unit that fails the bench test procedure 3 times will be rejected and will not be placed upon the approved products list, nor will it be considered for future evaluation without documented changes to design. A list of approved Models will be maintained by the Department. Only models from the approved list of Control Equipment in effect as of the date of letting, or as otherwise specified, shall be used in the contract. Continued failure and repeated malfunctions of an approved controller or control equipment shall be cause to remove that model from the Department's list of approved Products.

A design change to an approved model of controller will require a resubmittal of the model for testing, evaluation, and approval. Permanent addition or removal of component parts or wires will be considered to be a design change.

(b) Controllers or Control Units Furnished and Installed by the Contractor

A controller with all components of equipment, necessary for an operating signal, wired into a cabinet will be a control unit. The Contractor shall prepare 3 packets for each control unit and provide these packets to the Engineer. Packet 1 shall consist of 1 complete set of wiring and schematic diagrams for the control unit and its appurtenances and a listing of model name/number and serial number of the removable equipment that can be readily exchanged or replaced, such as controller enclosure, controller modules, load switches, conflict monitor, detectors, and flashers. Packets 2 and 3 shall each consist of the same items as in Packet 1 plus a descriptive parts list and instruction and maintenance manuals that include the

manufacturer's data sheets on each different type of I.C. chip being used, connection diagrams, voltage checks and the theory of operation. Each packet shall be labeled with the name of the intersection, the Contract Number, the Commission Number and the date of installation. Packet 1 will be forwarded to the Logistical Support Center, packet 2 will be retained in the controller cabinet, and Packet 3 will be retained by the District Traffic Office.

The Contractor shall be responsible for all costs associated with vendor or manufacturer warranty service until acceptance of the contract, or acceptance of that portion of the contract where the traffic control equipment is installed.

(c) Blank

(d) Bench Testing

The Department's Traffic Signal Control Bench Test Procedures, which are used for bench testing of traffic signal controllers, cabinets, and related equipment are on file and available upon request.

During bench testing a control unit will be considered as failed if 1 of the following conditions are encountered during the physical or operational test procedure.

a. The controller unit skips intervals, or phases, places false calls, presents false indicator lights, does not follow the prescribed sequence or exhibits changes in timing beyond the tolerances of the specifications.

b. The load switches produce incorrect signal indications.

c. The conflict monitor fails to perform in accordance with the specifications of the requisition or contract.

d. Auxiliary equipment such as pre-emptors, coordinators, or detectors do not operate in accordance with the specifications.

e. The wiring for the interface of any items set out above is defective or incorrect.

If the control unit fails the bench test procedure, the control unit shall be removed from the Logistical Support Center for repairs and returned to the Traffic Support Center for retesting. The cover letter for the resubmittal of the control unit for retesting shall include an explanation of why the unit failed and what specific repairs were made.

A written test report will be provided for each control unit tested. A representative of the manufacturer or vendor may be present during the bench testing procedure.

(e) Pretimed Solid State Digital Controller

The following requirements are the minimum for the design and operation of a pretimed solid state digital, keyboard entry or keyboard entry backlit liquid crystal display menu-driven display type controller. The controller shall be capable of operating as a master or secondary control unit having 4 cycles, 3 offsets and 4 splits per cycle, and a minimum of 4 signal plans with individual control of 24 signal circuits, with an option of a total of 40 signal circuits, in each of 24 intervals. Controller, cabinet, and component parts shall be in accordance with NEMA Standards TS-1, all provisions contained herein, and the Department's traffic signal control bench test procedures. The requirements herein and the test procedures shall govern over NEMA standards.

1. General

The controller shall have a keyboard entry or keyboard entry backlit liquid crystal display menu-driven type with internal pre-emption, time base coordination, telemetry, printer, and interconnect modules. The controller unit shall contain a printer interface module, which permits a hard copy printout of all keyboard settings. The unit shall employ circuit designs, consistent with the latest techniques, using a microprocessor to implement the control logic.

The keystroke buttons shall be clearly marked as to function. The controller shall be programmable to permit initialization in any interval after a defined power interruption or reset by the conflict monitor.

All data entry display windows shall be liquid crystal design. The display shall be a high resolution type display such that the display shall be readable on a plane located 2 ft (0.6 m) in front of, and parallel to, the display window. As a minimum, the display shall be readable throughout a vertical 60° angle that contains a minus 15° angle to a plus 30° angle measured from the horizontal line that is perpendicular to the center of the display window. Also, the display shall be readable throughout a horizontal 60° angle that contains a minus 15° angle to a plus 30° angle measured from the vertical line that is perpendicular to the center of the display window. The backlit liquid crystal display shall have a diffusion type lens or membrane to reduce its surface glare. All menu driven, data entry displays shall be backlit. The display for the menu driven controller shall be a minimum of 4 lines with 40 characters per line. All programming buttons and indicators pertinent to the operation of a phase shall be on the front of the controller. The display windows shall be capable of displaying the cycle length, offset, split, and any other variable functions or controller settings.

Materials, conductors and component identification for all printed circuit boards shall be in accordance with NEMA Standards TS-1-14.2.3. Where practical, components shall be individually soldered directly to the printed circuit boards except for the memory elements, such as ROM, RAM, and PROM, which shall be socket mounted.

All volatile memory chips and modules shall have battery back-up to protect any operator programmed data for a period of at least 60 days without 115 volt, 60 hertz AC input to the controller unit. Battery back-up may be achieved with either a rechargeable battery maintained in a charged state through a trickle charge or a non-rechargeable battery with a minimum shelf life of 10 years. Batteries shall be capable of being disconnected for shelf storage of the controller unit. An indicator shall be provided on the front of the controller to indicate that the battery is connected and operating properly. If a non-rechargeable battery is supplied, an indicator shall also be provided to show a low battery charge. The memory module, when removed from the mainframe, shall maintain all programmed data for at least 48 h.

Any external battery within the controller unit shall be turned off or disconnected during shipment and storage.

All electrical components such as integrated circuit chips, transistors, diodes, triac, and capacitors shall be of such quality that they function properly under the environmental conditions experienced in field operation. All printed circuit boards shall be protected with a rosin coating. Fusing shall be on the front panel of the controller and shall provide protection to the controller from internal and external overload.

The motherboard in the mainframe shall be capable of accepting all plug-in modules, including additional modules to provide for 40 signal circuits, necessary for the operation of the controller. All plug-in modules shall be equipped for easy removal or installation without the use of tools. All plug-in circuit boards shall be readily accessible for maintenance. Extender boards may be used for this purpose. As a minimum, all circuit boards shall be edge labeled with the 1st and last number, the 1st and last letter, and the 1st and last double letter if applicable, corresponding to the pin connector position. All modules shall each be removable without removing any other module. All hinges used shall have stainless steel pins.

The controller unit shall be able to operate as a master controller or a secondary controller without requiring any changes in the unit itself. When used as a master controller, it shall not be required to program the unit's offsets to zero. The controller unit shall be capable of operating in an existing pretimed interconnected system, which may have an electromechanical interrupter utilizing 115 volts, 60 hertz, AC. Cycle, offset, and split selectability shall be either by application of 115 volts, 60 hertz AC to the fuse panel or manually from the keyboard. Use of 115 volts AC Interconnect to a 24 volts DC logic interface is acceptable. As a minimum, the controller shall be capable of accepting 9 conductors for interconnect, 2 conductors for cycle 1-4 selection, 3 conductors for reset 1-3 selection, 2 conductors for split 1-4 selection, and 1 conductor each for flash and common.

With each controller unit and cabinet there shall be furnished 3 complete sets of wiring and schematic diagrams, 2 descriptive parts lists, 2 instruction and

maintenance manuals that include the manufacturer's data sheets on each different type of integrated circuit chip being used that has not been previously submitted to and on file at the Logistical Support Center, connection diagrams, voltage checks and the Theory of Operation. The instructions manual shall contain explicit programming procedures for all required features and any additional features incorporated in the controller's design. All schematics shall also include numbered test points, where applicable, with operating voltages.

Serial number and model numbers shall be permanently applied on the face or front of all removable components of the controller where it is easily readable, without removing or disconnecting the component. Serial number and model number of the main frame shall be permanently applied near the front panel.

2. Controller Requirements

The controller shall be capable of providing 4 cycle lengths with a minimum time setability from 10 to 255 s in increments of 1 s. Transfer from 1 cycle to another cycle shall occur at the end of the interval in effect at the time of request for transfer if that interval is programmed for transfer. Cycle selection of any of the 4 cycles, from a remote location, shall be accomplished by use of no more than 3 conductors.

The unit shall be capable of providing 3 individually programmable offsets for each cycle with a minimum time setability from 0 to 250 s in 1 s increments. The offset to be in effect shall be selected by activation of 1 of the 3 reset inputs of the controller. Energization of a reset input shall place that offset in effect independent of timing plan selection. Momentary de-energization, for a period of 3 to 5 s, of a reset input shall define the system reference or synchronization.

The controller shall have program selected capabilities of a minimum of 2 methods of offset seeking transfer, shortway or dwell.

Shortway offset transfer is the transfer from 1 offset to another by shortening or lengthening the permitted intervals of the signal plan so that no offset change may exceed 25% of the cycle length in 1 cycle. The new offset shall never be more than 50% away from the existing offset. The permitted intervals, whose duration may be varied, shall be specified in the signal plan. During shortway offset seeking, no interval shall time less than the minimum programmed, in the signal plan, for that interval.

Dwell offset transfer is the transfer from 1 offset to another by holding in a programmed interval up to a maximum programmed duration. The controller shall be capable of programming the maximum dwell time between 1 and 250 s in 1 s increments. Only 1 maximum dwell interval shall be timed between transitions of reset input lines. The unit shall be capable of accepting interrupter pulses.

The controller shall provide the capabilities of 4 splits for each programmed cycle. Each split for each cycle shall consist of a programmed number of intervals,

variable up to a maximum of 24. If split transfer is programmable, transfer from 1 split to another shall occur in the intervals programmed to allow split transfer. If split transfer is not programmable, transfer shall occur at the zero point of the cycle. Split selection of any of the 4 splits, from a remote location, shall be accomplished by the use of no more than 3 conductors.

A minimum of 24 signal intervals shall be provided for each combination of cycle and split. The intervals shall be individually programmable minimum time setability, selectable from 0 to 12.7 s in increments of 0.1 s or from 0 to 127 s in increments of 1 s for each cycle and split. The controller shall be capable of copying the timing values for any cycle and split into any other cycle and split in 1 operation.

If the controller can indicate time settings greater than required, the greater time settings shall be active when entered into the controller.

The controller shall be capable of implementing any 1 of up to 4 different signal plan sequences. The signal plan shall be either externally selectable by placing logic ground to the input terminal or manually selectable through the keyboard. During any controller cycle, it shall be possible to operate in any of the 4 signal plans, if the signal plans are compatible. Signal plan transfer shall occur in the next interval programmed for signal plan transfer. Each signal plan shall have at least 1 interval to enable safe transfer between signal plans. The controller unit shall operate in accordance with the programmed values for the selected cycle, offset and split, regardless of the signal plan in effect. Signal plan PROM programming shall effect the On-Off-Flash condition of the signal circuits, and minimum and backup timing of each interval.

The unit shall provide the capabilities for a minimum of 2 detector inputs which can be programmed for Lock, Non-Lock, or Recall modes. The detector inputs shall provide a means to enter vehicle or pedestrian demand. When activated, these inputs may add intervals up to a total of 24 intervals to the cycle.

The unit shall provide the capabilities for a minimum of 2 preempt inputs. These inputs, either of which is activated, shall cause initialization of the selected preemption sequence which shall remain in effect until the input is removed.

The controller unit shall have an internal time clock with capabilities of programming for time-of-day, day-of-week, and week-of-year. The time clock shall allow selection of cycles, splits, and offsets through the time clock, the hardwire interconnect, the communication module, manual selection through keyboard entry, or a combination of these functions.

The controller shall have internal communication and telemetry with at least FSK 1200 Baud rate capable of transmitting on Bell 3002 four wire conductor with 600 ohm line impedance.

The controller unit shall provide capabilities for the following inputs: Stop Timing, External Start, Start-up Flash, Interval Advance, Manual Control Enable, Remote Flash, and System or Computer Control.

Stop timing shall cause all timings to be discontinued. When stop timing is removed, timing shall resume from the point of interruption.

External start shall cause the controller to assume its programmed initialization conditions and commence normal operations upon removal of the input.

Interval advance shall cause the controller to advance to the next interval in sequence, provided the manual control enable input is not energized. The actual advance shall occur on the trailing edge of the actuation. The duration of any interval shall be capable of being shortened without regard to the programmed minimum for the interval with the interval advance input active.

Manual control enable shall cause the controller to operate in the manual mode of operation. The transfer from automatic to manual mode operation and back to automatic operation shall occur immediately upon activation or de-activation of manual control enable.

When operating in the manual mode, the same color sequence, as provided in automatic control, shall be displayed. Duration of all programmed variable intervals shall be controlled by operation of the interval advance input. Duration of programmed non-variable intervals shall not be less than the minimum time specified in the signal plan for such intervals. Operation of the interval advance input shall not advance the controller out of these intervals.

Synchronization with the system shall be maintained during manual mode operation. When transferring back to automatic operation, the controller shall resume timing of the interval at the point in the selected timing plan that corresponds to the beginning of the interval being displayed when the transfer occurs.

Remote flash shall cause the controller to transfer to flashing operation when an AC+ signal is applied to the unit's fuse panel by an external source. The police panel switch shall cause the controller to go to immediate flash. Synchronization with the system master shall be maintained during flashing operation, if applicable. Upon de-activation of remote flash, transfer to cyclic operation shall be immediate and the unit shall display the interval that was programmed for exit from flash.

System or computer control, when activated, shall control the duration of the programmed variable intervals, except when pedestrian or vehicle calls are not placed on the detector inputs.

3. Spare Modules

All spare modules shall be in accordance with the appropriate sections of this specification.

4. Controller Enclosure

The enclosure shall be of adequate physical strength to protect the components during normal physical handling. Fusing, keypad, liquid crystal display, and input-output connectors required for the operation and standard field adjustments shall be mounted on the front panels.

The main frame shall be completely equipped and wired as a complete pretimed controller so that no additional hardware or wiring is required. The front panel of the controller shall be positively fastened to the frame. Special tools shall not be required to remove or replace modules or plug-connected printed circuit boards.

5. Power Requirements

The controller shall operate in accordance with NEMA Standard TS-1-2.

6. Certification of Traffic Control Units

Certification of traffic control units shall be in accordance with 922.01(f)6.

7. Warranty

The warranty for traffic control units shall be in accordance with 922.01(f)7.

(f) Traffic Actuated Solid State Digital Controller

The following requirements are the minimum for the design and operation of an 8 phase fully-actuated solid state, digital, menu-driven with backlit liquid crystal display controller. Controller, cabinet, and component parts shall meet NEMA Standards TS-1, all provisions contained herein, and the Department traffic signal control bench test procedures. The requirements herein and the test procedures shall govern over NEMA standards.

1. General

The controller shall be keyboard entry, menu-driven with liquid crystal type display. The controller shall have internal preemption, time base coordination, telemetry, printer and interconnect modules. The microprocessor shall utilize non-volatile memory devices. If “0” Powered Ram is utilized, the shelf life, with load, shall be a minimum of 10 years. Time base coordination shall use battery backed RAM to maintain the system clock and power outage. Any external battery within the controller unit shall be turned off or disconnected during storage and shipment. With each controller unit and cabinet, there shall be furnished 3 complete sets of wiring and schematic diagrams, 2 descriptive parts lists, 2 instruction and maintenance manuals that include the manufacturer’s data sheets on each different type of integrated circuit chips used that has not been previously submitted to and on file at the Logistical Support Center, connection diagrams, voltage checks, and the Theory of Operation. The instruction manual shall contain explicit programming

procedures for all required NEMA features and any additional features of which are incorporated into the controller design. All schematics shall also include numbered test points, where applicable, with operating voltages.

Serial number and model numbers shall be permanently applied on the face or front of all removable components of the controller where it is easily readable, without removing or disconnecting the component. Serial number and model number of the main frame shall be permanently applied externally near the front panel.

2. Controller Requirements

The time settings shall be in accordance with NEMA Standards TS-1-14. If the controller can indicate time settings greater than required, the greater time settings shall be active when entered into the controller. A minimum of 2 maximum timing parameters shall be supplied on all phases of the controller and shall function when activated.

The controller shall be capable of 2 through 8 phase programming and shall be capable of accepting an interrupter pulse on any coordinated phase.

Pedestrian timing shall be provided on all phases of a controller.

The backlit liquid crystal display window shall consist of a minimum of 4 lines with 40 characters per line. The display shall be a high resolution type display such that the display shall be readable on a plane located 2 ft (0.6 m) in front of, and parallel to, the display window. As a minimum, the display shall be readable throughout a vertical 60° angle that contains a minus 15° angle to a plus 30° angle measured from the horizontal line that is perpendicular to the center of the display window. Also, the display shall be readable throughout a horizontal 60° angle that contains a minus 15° angle to a plus 30° angle measured from the vertical line that is perpendicular to the center of the display window. The backlit liquid crystal display shall have a diffusion type lens or membrane to reduce its surface glare.

The Time Base Coordinator shall operate such that the line function has the capability to provide output for a minimum of 4 time of day functions during the same event time.

Controllers shall be capable of servicing eight phases. The control unit, when delivered, shall be programmed to initialize in phase 2 and phase 6 green. The controller shall be keyboard programmable to permit initialization in any phase after a defined power interruption or reset by the conflict monitor. The following recall functions shall be a minimum and shall show functional status on the liquid crystal display.

(1) lock detection
(2) maximum recall
(3) minimum recall

(4) non-lock detection
(5) pedestrian recall

Keystroke buttons shall be clearly marked as to function.

All indicators shall be liquid crystal design. All programming buttons and indicators pertinent to the operation of a phase shall be on the front of the controller. The controller shall have complete phase skipping capabilities. Dual ring, eight phase controllers shall have single entry operation.

Controllers shall have keyboard programmable overlaps in accordance with NEMA Standards TS-1-14.3.7. All inputs and outputs from the controller shall be in accordance with NEMA Standards TS-1-13 and shall be accessible within the cabinet at the output terminal facility.

All electrical components such as integrated circuit chips, transistors, diodes, triac, and capacitors shall be of such quality that they function properly under the environmental conditions experienced in field operation. All printed circuit boards shall be protected with a rosin coating. As a minimum, all plug-in circuit boards shall be edge labeled with the 1st and last number, the 1st and last letter, and the 1st and last double letter if applicable, corresponding to the pin connector position. Input-output pin connectors and MS connectors shall be as specified in NEMA Standards TS-1. Fusing shall be on the front panel of the controller and shall provide protection to the controller from internal and external overload.

3. Spare Modules

All spare modules shall be in accordance with the appropriate sections of this specification.

4. Controller Enclosure

The enclosure shall be of adequate physical strength to protect the components during normal physical handling. Fusing, keypad, liquid crystal display and input-output connectors required for the operation and standard field adjustments shall be mounted on the front panels.

The main frame shall be completely equipped and wired as a complete 8 phase NEMA controller so that no additional hardware or wiring is required. The front panel of the controller shall be positively fastened to the frame such that no special tools shall be required to remove or replace modules or plug-connected printed circuit boards.

5. Power Requirements

The controller shall operate in accordance with NEMA Standards TS-1-2.

6. Certification of Traffic Control Units

The following certifications shall be furnished in accordance with the applicable provisions of 916.

a. Certification of a Production Run Model

A certification for a model of control unit shall be on file with the Department. A production run model shall be tested in accordance with, and comply with, all requirements of the NEMA Standards TS-1, Part 2, including shock and vibration. A certification of a production run model will be valid for a maximum period of 4 years from the date of testing or unless a significant change is made in the controller. If a significant change is made a new certification shall be submitted. A significant change shall be the addition or deletion of any function or feature in the control unit, or any major change to the circuitry in the control unit.

b. Certification of Environmental Testing

A certification shall be furnished with each control unit approval indicating it has been tested and is in accordance with the following tests from NEMA Standards TS-1-2.

TS1-2.2.03- Test Procedure – Transients, Temperature, Voltage, and Humidity.
TS1-2.2.04- Cabinet ventilation tests.
TS1-2.2.07- Power interruption test.
TS1-2.2.08- Timing accuracy tests.
TS1-2.2.09- Signal conflict monitoring tests.

The cabinet requirements in 922.01(g) shall be applicable during the appropriate tests.

The certification shall specify the model and serial number of the following components: cabinet, controller main frame, phase modules, ring modules, conflict monitor, load switches, flasher, and all specified auxiliary control equipment.

A complete log of each test for every controller shall be maintained. The log shall show which, if any, controller component failed during the test, when it failed, and what steps were taken to repair the controller. The log shall include the date of testing, name and title of person conducting the tests, a record of conditions throughout the tests, and a temperature and humidity vs time chart. The maximum revolution of any chart shall be 24 h. The chart shall be from a recording machine used to monitor the status of the environmental chamber during testing.

7. Warranty

A standard manufacturer's warranty shall be furnished for each traffic signal control unit which is furnished and installed. The effective date for the beginning of the warranty shall be the turn-on date shown on form IC 636A. The warranty shall be provided prior to final acceptance.

Each traffic signal control unit purchased by the Department shall have a minimum 2 year operational warranty or the manufacturer's standard warranty, whichever is longer. The 2 year warranty shall begin on the date the control unit is

received at the Logistical Support Center. The vendor or manufacturer shall be responsible, during the warranty period, for transportation costs to and from the Logistical Support Center for items requiring warranty service.

Continued failure and repeated malfunctions of an approved model of controller shall be cause to remove that model from the Department's list of approved Models.

(g) Cabinet Requirements for Traffic Signal Controllers

1. General

The cabinet and the shelf, if needed, shall be fabricated of aluminum. The cabinet shall be 1/8 in. (3 mm) minimum thickness sheet aluminum or 1/4 in. (6 mm) minimum thickness die-cast aluminum. The cabinet exterior and interior including shelves, shall have a sandblasted, roughened, or chemically etched finish that reduces gloss, reflection, and glare.

The main cabinet door shall use a Corbin Lock No. 2 and the lock shall be furnished with 2 No. 2 keys. The door shall be capable of being opened and stopped in at least the following 2 ranges of degree opening as measured from the face of the cabinet door on the hinged side, 80° to 100°, and 150° to 180°. The door shall be hinged on the left or right side of the cabinet.

The cabinet shall have a police door within the main door. The police door shall use a standard Corbin Police panel lock. The police door shall be weathertight. Two keys shall be furnished for the police door.

In a cabinet used for a pretimed controller, the police door shall contain 3 separate switches for controller operation, 1 for automatic or manual, 1 for signal or flash, and 1 for signal on or off. A 1/4 in. (6 mm) phone jack receptacle shall be connected to the proper circuits for manual control of any signal interval. The switches shall be protected from water when the door is opened.

In a cabinet used for actuated controllers, the police door shall contain 2 separate switches, 1 switch for master power cut-off and 1 switch to change automatic signal control to flashing control, or vice-versa. The switches shall be protected from water when the door is opened.

The cabinet shall contain 1 duplex convenience outlet and a switch controlled lamp receptacle. The convenience outlet shall be duplex, 3 prong, NEMA Type 5-15R grounding outlet in accordance with NEMA WD-6, with ground-fault circuit interruption as defined by the National Electrical Code. These units shall be protected with a 15 amp cartridge fuse wired ahead of the multi-breakers.

The cabinet shall contain a thermostatically controlled ventilating fan and a vent with a commercially classified uniform 1 in. (25 mm) thick filter. The vent size and filter size will be according to the provisions for the type of cabinet. The thermostat shall be manually adjustable from 70°F to 100°F (21°C to 38°C). The fan shall be

mounted internally at the top and toward the front of the cabinet to exhaust out the front top lip of the controller. The fan shall be rated at a minimum of 100 cu ft (2.83 m^3) per minute. The thermostat shall be located within 6 in. (150 mm) of the fan.

The cabinet shall contain a surge arrestor. The surge arrestor shall be wired behind the multi-breaker, in parallel with the 35 amp circuit breaker signal buss and in series with the 10 amp circuit breaker for the solid state electronic equipment such as controller, conflict monitor and detectors. The surge arrestor shall have a maximum clamp voltage of 350 volts at a peak current of 20,000 amps for a minimum of 20 occurrences. The surge arrestor will operate between -30°F to 165°F (-34°C to 74°C). The dimensions of the unit shall not exceed 3 1/4 in. (80 mm) wide by 6 in. (150 mm) long by 2 1/2 in. (64 mm) deep.

Each inductive device, including the fan, shall have a separate power surge protection.

The terminals for AC + and - input to the cabinet shall be capable of accepting a No. 6 wire.

Test inputs A and B shall not be used for any purpose that will prevent interchangeability of controllers manufactured in accordance with these specifications.

The manual flashing switch shall be wired to let the controller operate when the signals are flashing.

The cabinet shall contain a jack mounted type 3 solid state flasher in accordance with NEMA Standards TS1-8 or approved non-repairable unit in accordance with the NEMA Standards TS1-8 electrical and physical dimensions. Repairable flashers shall consist of opto or photo isolated solid state power relays.

Remote flashing shall be provided for all signal circuits. Phases that the controller is to initialize in green, shall be wired to flash yellow. All other phases shall be wired to flash red. Flashing for signal circuits shall be as evenly balanced as possible on the circuits of the flasher controller.

The cabinet shall be wired to activate the pedestrian timing, including load switches and all other necessary components. The pedestrian load switch and the signal load switch shall be a triple signal load switch in accordance with NEMA Standards TS1-5 or approved non-repairable units in accordance with NEMA Standards TS1-5 electrical and physical dimension requirements. Repairable load switches shall consist of opto or photo isolated solid state power relays. The repairable load switch shall not use a printed circuit board to transmit the 115 volts AC line - in input or signal buss output. Each load switch shall have an indicator for each circuit indicating the status of the input to the load switch.

The load switch signal outputs shall be brought to a separate terminal strip for hook-up of the signal displays. Load switches shall be capable of being programmed for flash, overlap, vehicular, or pedestrian phases with the use of a standard slotted or Phillips screw driver or standard nut driver. Programming of the load switches shall be accomplished on the front of the cabinet terminal facilities by installing or removing electrical conductors.

The cabinet for a pretimed secondary controller used in a hardwired interconnect system shall contain a fuse block with a 2 amp fuse for the remote selection of each of the following inputs: Reset 1, Reset 2, Reset 3, Cycle 2, Cycle 3, Split 2, Split 3, and Flash. For an actuated controller, an additional input shall be provided for system or free operation. The fuse block shall have a 150 volt, 10 amp metal oxide varistor on the controller side of the fuse, connected to ground.

The cabinet for a pretimed master controller used in a hardwired interconnect system shall contain a fuse block with a 6 amp fuse for the output selection of each of the following inputs: Reset 1, Reset 2, Reset 3, Cycle 2, Cycle 3, Split 2, Split 3, and Flash. For an actuated controller, an additional output shall be provided for system or free operation. The fuse block shall have a 150 volt, 10 amp metal oxide varistors for each of the output selections, on the controller side of the fuse, connected to ground. The fuse block shall also have a 1K ohms, 30 watt resistor for each of the output selections, on the interconnect side of the fuse, connected to ground.

The cabinet shall contain a main backpanel and supplementary backpanels, as needed. The model number of the main backpanel shall be permanently applied to the front of the backpanel, where it is easily readable, without removing or disconnecting the backpanel. Each controller input and output circuit shall terminate on the main backpanel or on a supplementary backpanel.

The cabinet shall contain auxiliary control devices such as conflict monitor, vehicle detectors, or other items specified. All terminal facilities and fusing within the cabinet shall be readily accessible for field connection without removing the controller or associated equipment. All equipment and terminals shall be readily accessible for maintenance in the cabinet. The backpanel shall be attached to the cabinet such that access to the backside of the backpanel, for maintenance purposes, shall be accomplished without the use of special tools or removal of auxiliary panels or other cabinet appurtenances.

2. G Cabinet

The G cabinet shall be pedestal mounted or pole mounted. The bottom of the cabinet shall be reinforced to ensure a secure pedestal mounting. The G cabinet shall have dimensions of 25 in. (635 mm) wide, 38 in. (965 mm) high, 18 in. (460 mm) deep with a tolerance of + 4 in. (100 mm) in all dimensions.

A cabinet slipfitter shall be used to attach the cabinet to the pedestal. The slipfitter shall fit a 4 1/2 in. (114 mm) outside diameter pipe and shall have a minimum of 3 set screws equally spaced around the slipfitter.

A vent of adequate size shall be provided. The size of the vent and the filter requirements shall be in accordance with the manufacturer's recommendations.

a. Cast Aluminum Pedestal Base

A pedestal mounted G cabinet shall have a cast aluminum pedestal base. The cabinet and pedestal base shall be ground mounted on a concrete type A foundation at locations and dimensions as shown on the plans.

The cast aluminum base shall be made of aluminum in accordance with ASTM B 179, alloy ANSI 319.1 or 319.2, or in accordance with ASTM B 26 (B 26M), alloy ANSI 356.0-T6. The square base shall include an access door and anchor bolts with nuts and washers. The base shall be 13 3/8 in. (8,630 mm) square and 15 in. (380 mm) in height ± 1 1/4 in. (32 mm). The weight shall be 22 lb ± 5% (10 kg ± 2.2 kg).

The base shall be designed to support a 150 lb (68 kg) axial load and 11 sq ft (1 m^2) of signal head area rigidly mounted. For design purposes, the distance from the bottom of the base to the center of the signal head area is 18 ft (5.5 m). In addition to the dead load, the base shall be designed to withstand wind load and ice loads on the specified signal head area and on all surfaces of the support, in accordance with the AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. Wind speeds used for design shall be based on a 10 year mean recurrence interval and a wind drag coefficient of 1.2 or as shown on the plans. The base shall contain an access door, which is 8 in. by 8 1/4 in. ± 1/4 in. (200 mm by 210 mm ± 6 mm) with a stainless steel hex head bolt for attaching the door.

The base shall be attached to a foundation by 4 anchor bolts, with an anchor bolt circle of 12 3/4 in. (324 mm). Slotted lugs shall be integrally cast into the 4 corners of the base for attachment of the anchor bolts. The anchor bolts shall be steel in accordance with ASTM A 36 (A 36M). The diameter of the anchor bolt shall be 3/4 in. (19 mm) with a minimum length of 18 in. ± 1/2 in. (460 mm ± 13 mm), plus 2 1/2 to 3 in. (64 to 75 mm) right angle hook on the unthreaded end. The top 4 in. (100 mm) of the bolt shall be threaded with 10 NC threads. The threads, plus 3 in. (75 mm), shall be coated after fabrication in accordance with ASTM A 153 or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C. Each anchor bolt shall be provided with 2 hex head nuts in accordance with ASTM A 325 (A 325M) and 3 washers. Two of the washers shall have a minimum 2 in. (50 mm) and maximum 2 1/8 in. (54 mm) outside diameter and be in accordance to ANSI B 27, Type B regular series and 1 shall be a nominal 3/4 in. (19 mm) series W washer, in accordance with ASTM F 436 (F 436M).

The cast aluminum pedestal base shall be in accordance with the dimensions and requirements shown on the plans. The casting shall be true to pattern in form and dimensions; free from pouring faults, sponginess, cracks, and blowholes; and free from other defects in positions affecting the strength and value of the intended use for the casting. The base shall not have sharp unfilleted angles or corners. The surface shall have a workmanlike finish.

The door and bolt for the door shall be interchangeable on cast bases from the same manufacturer.

b. Pedestal Pole

The top of the base shall accommodate a pole having a 4 1/2 in. (114 mm) outside diameter. The threads inside the top of the base shall be 4 in. (100 mm) national standard pipe threads. The pole shall be either a steel pedestal pole or an aluminum pedestal pole.

A steel pedestal pole shall be a seamless schedule 40 carbon steel pipe in accordance with ASTM A 53, grade B. The pole shall have an outside diameter of 4 1/2 in. (114 mm). The pole shall weigh approximately 10.8 lb/ft (16 kg/m). The length of the pole shall be as shown on the plans. The pole shall have full depth national standard pipe threads on 1 end of the pole. The length of threads shall be 2 1/2 in. (64 mm). The pole shall be galvanized, after threading, in accordance with ASTM A 123. The threads shall be cleaned of all excess galvanizing and protected by a suitable shield.

An aluminum pedestal pole shall be in accordance with ASTM B 241 (B 241M) for seamless aluminum alloy, schedule 40, 6061-T6. The outside diameter of the pole shall be 4 1/2 in. (114 mm). The length of the pole shall be as shown on the plans. The pole shall weigh approximately 3.7 lb/ft (5.5 kg/m). The pole shall have full depth national standard pipe threads on 1 end of the pole. The length of threads shall be 2 1/2 in. (64 mm) and protected by a suitable shield. The pole shall have a spun finish.

c. Pole Cap

A pole cap shall be supplied for the top of the pole if the pole is used for the mounting of pedestrian signal faces or side mounted signal control cabinets. The pole cap shall be either a cast pole cap of aluminum or a pole cap of spun aluminum.

A cast pole cap shall be made of aluminum, in accordance with ASTM B 179, alloy ANSI 319.1 or 319.2. The cap shall fit freely on the 4 1/2 in. (114 mm) outside diameter of the pole. A set screw using a 3/4 in. (19 mm) No. 12 hex head machine screw shall be supplied to hold the cap on the pole. A standard foundry draft will be allowed on the casting.

A pole cap made from spun aluminum shall be in accordance with ASTM B 209 (B 209M), alloy 1100-0. The cap shall fit tightly when placed on the end of the pole.

3. M Cabinet

The M cabinet shall be ground mounted on a concrete foundation at locations and dimensions shown on the plans.

The M cabinet shall have dimensions of 30 in. (762 mm) wide, 48 in. (1,219 mm) high, and 16 in. (406 mm) deep with a tolerance of ± 2 in. (50 mm) in any or all dimensions.

Anchor bolts shall be steel in accordance with ASTM A 36 (A 36M). Diameter of the bolt shall be 1/2 in. (13 mm) or 5/8 in. (16 mm) and the minimum length shall be 15 in. (381 mm) plus a 3 in. (75 mm) right angle hook on the unthreaded end. The top 6 in. (150 mm) of the bolt shall be threaded with 13 NC threads on 1/2 in. (13 mm) bolts and 11 NC threads on 5/8 in. (16 mm) bolts. The hexagon nut, the flat washer, and the threaded end of the bolt shall be galvanized in accordance with ASTM A 153, or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

If an interrupter is shelf mounted, a shelf shall be located a minimum of 12 in. (305 mm) from the top of the cabinet but shall have adequate room to easily install or remove the interrupter.

The vent shall have a uniform 1 in. (25 mm) thick filter which may be of any of the following sizes: 20 in. by 10 in. (510 by 255 mm); 16 by 10 in. (405 by 255 mm); or 16 by 8 in. (405 by 200 mm).

The cabinet shall contain solid state load switches with incandescent lamp load rating of 1200 watts with nominal 120 volts 60 hertz which meet NEMA Standards TS1-5. Cabinets for pretimed controllers shall contain a type 6 conflict monitor and cabinets for actuated controllers shall contain a type 12 conflict monitor. Conflict monitors shall be in accordance with NEMA Standards TS1-6. The conflict monitor upon sensing conflicting signal indications or unsatisfactory operating voltage shall transfer the signals to a flashing indication and the controller shall be wired to provide flash transfer if the conflict monitor is removed from service. Each channel of the conflict monitor shall have an indicator to show the channel’s on or off status.

A red failure indicator shall be provided, exclusively labeled red failure, and shall be continuously illuminated when red failure has occurred. The conflict monitor shall indicate the channel where red failure occurred by means of the channel indicator.

The phase arrangement of the controller shall coincide with the channel arrangement of the load switches and conflict monitor.

The cabinet shall contain a multi-breaker with one 10 amp circuit breaker to provide overload protection to the controller, conflict monitor, and detectors and 1

35 amp circuit breaker to provide overload protection to the signal and flash buss load. When both circuit breakers are in the off or tripped position, the signal output, the conflict monitor, and the controller shall be turned off. The signal shall be capable of operating in the flashing mode with the 10 amp circuit breaker OFF and the 35 amp circuit breaker ON. The controller, the conflict monitor, and the detectors shall be capable of operating with the 10 amp circuit breaker ON and the 35 amp circuit breaker OFF.

Two 1.0 microfarad 600 volts + 10% capacitors shall be installed on the output field terminal strip for left turn phases which are normally phases 1 and 3. One capacitor shall be connected from the green output terminal to AC negative terminal on each phase and the other capacitor shall be connected from the yellow output terminal to AC negative terminal on each phase.

The cabinet shall contain a type 3 solid state flasher in accordance with NEMA Standards TS1, Part 8. The flashing output circuits carrying the signal load shall consist of opto or photo isolated solid state power delays. Programmable flash shall be provided for on the cabinet terminal facilities. No special tools shall be required to program flash. Flashing for even numbered phases shall be placed on 1 circuit and flashing for odd numbered phases shall be placed on the other circuit.

The cabinet shall contain all terminal blocks, solid state load switch blocks, and harnesses necessary for the operation of the controller. It shall have 2 adjustable shelves with the 1st shelf located 15 in. ± 1 in. (380 mm ± 25 mm) below the top of the cabinet and the 2nd shelf located 7 in. (178 mm) below the 1st shelf. The cabinet shall contain 30 spare terminals. The spares shall be in 1 location and easily accessible in the cabinet. If vehicle detection is required for a controller, the spare terminals may be used for this purpose.

Terminal strips shall be consecutively numbered and shall be in accordance with the schematic diagram. Numbering for terminal strips shall be neat and legible, silk screen type painting. All harnesses shall be of sufficient length to allow for the placement of the controller and conflict monitor at any location within the upper half of the cabinet. The shelf of the cabinet connector harnesses shall be grounded. All relays and conflict monitors shall be encased in a protective covering to reduce the potential of electrical shock.

The police panel shall contain 2 separate switches. One switch for master power cut-off and 1 switch to change operation from automatic signal control to flashing control, or vice-versa. The switches shall be protected from water when the door is in the open position.

4. P-1 Cabinet

The P-1 cabinet shall be ground mounted on a concrete foundation at locations and dimensions as shown on the plans with anchor bolts in accordance with 922.01(g)3. The P-1 cabinet shall house an 8 phase traffic actuated solid state digital

controller and shall have 2 adjustable shelves with the 1st shelf located 20 in. (508 mm) below the top of the cabinet and the 2nd located 7 in. (178 mm) below the 1st shelf. The cabinet shall be 44 in. (1118 mm) wide, 52 in. (1321 mm) high, and 24 in. (610 mm) deep with a tolerance of ± 3 in. (75 mm) in all dimensions. Maximum exterior dimensions shall be 34 in. (864 mm) deep, 47 in. (1194 mm) wide, and 63 in. (1,600 mm) high.

The cabinet shall be in accordance with applicable provisions of 922.01(g)1 and 922.01(g)4. It shall have 1 type 12 conflict monitor which shall be in accordance with NEMA Standards TS-1, Part 6.

Two 1.0 microfarad 600 volt, 10% capacitors shall be installed on the output field terminal strip for the left turn phases which are normally phases 1, 3, 5, and 7. One capacitor shall be connected from the green output terminal to AC negative terminal on each phase, and the other capacitor shall be connected from the yellow output terminal to AC negative terminal on each phase.

The cabinet shall have a vent with a uniform 1 in. (25 mm) thick filter which may be of any of the following sizes: 16 by 25 in. (405 by 635 mm); 15 by 20 in. (380 by 510 mm); or 16 by 20 in. (405 by 510 mm). It shall contain 40 spare terminals.

(h) Two Circuit Alternating Flasher

Two circuit alternating flasher shall be solid state.

1. General

The solid state flasher shall periodically interrupt a source of alternating current line power. Solid state shall mean electrical circuits, the active components of which are semi-conductors, to the exclusion of electromechanical devices or tubes.

The flasher shall be a type 3 solid state flasher conforming to Section 8 of the NEMA Standards Publication TS 1-1983. The flasher output circuit carrying the signal load shall consist of opto or photo isolated solid state power relays and shall be hard wired to the flasher connector.

Three schematic diagrams and 3 descriptive parts lists shall be furnished with each flasher.

Two circuit alternating flashers shall be plug-in design. The flasher design shall not permit the unit to be inserted improperly into the plug-in base. The flasher shall have heavy-duty plugs and jacks capable of handling the rated load current. The rate of flash shall be 50 to 60 flashes per minute.

The flasher shall operate between 95 volts and 135 volts AC 60 Hertz. No degradation of performance shall be experienced in environmental changes from -20°F to 165°F (-29°C to 74°C) and 0 to 90% relative humidity.

2. Cabinet Requirements

The cabinet shall be weatherproof and fabricated from cast aluminum or aluminum sheeting with a minimum thickness of 0.125 in. (3.18 mm). The cabinet door shall be the entire front of the cabinet and shall be hinged on the right or left side of the cabinet. A Corbin No. 2 lock and two No. 2 keys shall be furnished. The lock shall be located near the center of the door on the side opposite the hinge.

Minimum dimensions for the cabinet shall be 12 in. (305 mm) deep, 12 in. (305 mm) wide, and 12 in. (305 mm) high. The maximum dimensions shall be 18 in. (460 mm) deep, 15 in. (380 mm) wide, and 18 in. (460 mm) high.

The cabinet shall have 2 pole plates for stainless steel band mounting of the cabinet on a pole with a minimum diameter of 4 in. (100 mm) and a maximum diameter of 18 in. (460 mm). Two hub plates for 1 in. (25 mm) diameter conduit shall be provided with gaskets, eight bolts at 4 bolts per plate, nuts, and washers for attaching the hub plates to the cabinet. The cabinet shall be drilled for the mounting of the pole plates or hub plates as shown on the plans.

It shall have a screened vent in the bottom with a minimum size of 1 3/4 sq in (1,129 mm^2). A fan and thermostat shall be located in the top of the cabinet. The fan shall have separate power surge protection. The thermostat shall be located within 6 in. (150 mm) of the fan and shall be adjustable between 70°F and 110°F (21°C and 43°C).

The panel in the cabinet shall be capable of being removed and reinstalled with simple hand tools. A 25 amp radio interference filter and surge arrestor in accordance with 922.01(g)1 wired ahead of a 15 amp circuit breaker shall be mounted on the panel. A terminal block capable of the following electrical connections shall be mounted on the panel.

Circuit 1 -	for connection of field signals
Circuit 2 -	for connection of field signals
AC plus -	can be attached to breaker if circuit breaker can accept a No. 6 wire
AC minus lug -	capable of accepting a No. 6 wire
Neutral lug -	capable of accepting a No. 6 wire
Fan Circuit -	adequately fused separately from circuit breaker with a fuse rating less than 15 amps

922.02 Interconnection Equipment

(a) Hardwire Interconnection

1. Electro-Mechanical Dial Coordination Unit

a. General

The coordinating unit shall operate and be compatible with a 2 phase, 4 phase, and 8 phase controller in accordance with 922.01(f). It shall function in an interconnect system containing 3 dial electro-mechanical controllers and actuated controllers and shall contain 3 background cycles that are programmable in length of time and percentage split.

The dial coordinating unit shall generate a continuous background cycle. With an absence of vehicle actuation, recall operation, or pedestrian actuations, the traffic signal controller shall continue to rest in the coordinated phase. During periods of heavy vehicular demands, the coordinating unit shall not permit transfer of right-of-way to non-coordinated phase or pedestrian until the background cycle is in the predetermined position. When there is insufficient vehicular demand to extend the phase to the force-off limit the unit shall allow an early return to the coordinated phase.

The interface between the coordinating unit and the actuated controller shall provide a yield/force-off type of coordination. The coordinated phase or phases shall yield and the remaining phases shall be forced off. The coordination unit shall operate in a coordinated system with the number of controller phases specified. The interface between the coordinator and the controller shall provide for Max I timing during coordinated operation. During non-coordinated, free run, operation, Max II timings shall be in effect.

The coordinating unit shall operate on 115 volt AC, 60 Hertz. It shall be shelf mounted and enclosed in a case with maximum dimensions of 19 in. (483 mm) wide, 7 1/2 in. (191 mm) high, and 8 in. (200 mm) deep. Three sets of wiring and schematic diagrams, 3 descriptive parts lists, and 2 instruction and maintenance manuals shall be furnished with each coordinating unit.

b. Additional Requirements for Master Locations

A master control unit shall include a dial coordinating unit interrupter and a dial coordinating unit master both compatible and able to function in an interconnected system containing 3 dial electro-mechanical controllers and actuated controllers.

The master control unit shall be capable of the following output selections: Reset 1, Reset 2, Reset 3, Dial 2, Dial 3, Flash, and coordinating free. The dial coordinating unit master and the dial coordinating unit interrupter shall have the following 5 cycle length gears for each dial.

Dial 1	60-80-90-100-110 sec
Dial 2 & 3	70-75-85-95-110 sec

A master control unit shall contain a fuse block with a 6 amp fuse for the output selection of each of the following: Reset 1, Reset 2, Reset 3, Dial 2, Dial 3, Flash, Split 2, and Split 3. The fuse block shall have 10 amp metal oxide varistors for each

of the output selections on the controller side of the fuse, connected to ground. The fuse block shall have 1,000 ohm, 30 watt resistors for each of the output selections on the interconnect side of the fuse, connected to ground.

c. Additional Requirements for Secondary Locations

A secondary control unit shall contain a secondary dial coordinating unit compatible and able to function in an interconnect system containing 3 dial electro-mechanical and actuated controllers. The location shall be capable of the following input selections form a remote location: Reset 1, Reset 2, Reset 3, Dial 2, Dial 3, Flash, and coordinating free. Two switches within the secondary control unit shall be provided to manually select the following operations and labeled to show which operation is in effect. One switch shall select Dial 1, Dial 2, Dial 3, Time Clock, or System. The other switch shall select Coordination or Free Run. Secondary dial coordinating unit shall have the same 5 cycle length gears for each of the 3 dials as required by the master and interrupter dial coordinating units.

922.03 Blank

922.04 Signal Head Components

(a) Vehicle Signal Face

Vehicle signal faces shall be as shown on the plans. The components shall be in accordance with the latest standard of the Institute of Transportation Engineers for Adjustable Face Vehicular Traffic Control Signal Heads.

1. General

The signal faces shall be sectional in construction, requiring 1 section for each lens and furnished in the nominal size of 12 in. (305 mm). Each section of a face shall have a rectangular silhouette when viewed from the front or the rear.

2. Housing, Door, and Visor

The top and bottom of each housing shall have an integral locking ring with 72 serrations to permit rotation of the signal housing in 5° increments. Hub openings in the top and bottom of the signal housing shall accommodate standard 1 1/2 in. (38 mm) bracket arms. The thickness of the hub at the top and bottom of the housing shall be a maximum of 1 in. (25 mm) and a minimum of 3/8 in. (10 mm). The 12 in. (305 mm) door shall have 2 simple locking devices. The door on the hinged side shall be attached with hinge pins. Each lens shall have the standard cap type visor. All screws, latching bolts, locking devices, and hinge pins shall be stainless steel.

3. Lens

The lens shall be made of plastic and shall be in accordance with ASTM D 788, grade 8; or ASTM D 3935. The index of refraction shall be between 1.48 and 1.59. The lens shall be uniformly colored throughout the body of the material, true to size and form, and free from any streaks, wrinkles, chips, or bubbles. The values of luminous transmission for the signal lens and the limits of chromaticity for the lens

colors shall be in accordance with the latest standard of the Institute of Transportation Engineers for Adjustable Face Vehicular Traffic Control Signal Heads. The lens hole with the lens gasket in place shall be of sufficient size to accommodate a 12 in. (305 mm) diameter lens.

4. Reflector Assembly

The reflector shall be made of Specular Alzak Aluminum. The reflector assembly shall be designed so that it is pivoted and can be swung out of the housing and easily removed without the use of tools. A neoprene gasket shall be provided between and completely around the reflector and the reflector frame and shall be reusable. The reflector frame shall be aluminum or plastic.

5. Lamp Receptacle and Wiring

The lamp receptacle shall be fixed focus type, positioning the lamp filament at the correct focal point with respect to the reflector. The assembly shall be designed so the lamp socket can be rotated through 360° into positions of adjustment for proper positioning of the lamp filament after relamping. The lamp socket shall be equipped with color coded wire either red, yellow, or green depending upon the lens color of the section. The socket wires shall be a minimum of 26 in. (660 mm) long, fixture wire No. 18 AWG or larger, 600 volts, with insulation designed to withstand 221°F (105°C). The conductor size, insulation type letter designation, and temperature rating shall be marked on the insulation or a material certification of compliance shall accompany each signal head combination. The wiring leads shall be terminated with screw spade lug type or female type connectors for ease of connection to the terminal block. The socket shall be equipped with a gasket to insure a dust tight fit between the socket and reflector.

6. Section Coupling

Any method to connect 2 or more sections together may be used, if the following requirements are met.

a. Two or more sections, when joined together, shall maintain structural integrity when loaded to Institute of Transportation Engineers Standards.

b. The opening between joined sections shall accommodate 2 1/2 in. (13 mm) cables.

c. The maximum length of bolts used to connect sections together shall be 4 in. (100 mm).

Nuts, bolts, or lock washers shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and be in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

7. Terminal Block

The yellow section of the 3 section signal head shall be equipped with a 5 position terminal block for termination of field wiring. Each section shall have provisions for addition of an 8 position terminal block or two 5 position terminal blocks or one 5 position and one 3 position terminal block. The terminal block shall have a minimum spacing between screw connections of 1/2 in. (13 mm). The height of the insulating ridge between screw connections shall be a minimum of 19/32 in. (15 mm) from the base of the terminal blocks.

8. Material Requirements

a. Polycarbonate Signal Head

The housing, door, and visor of the section shall be made of ultraviolet and heat stabilized polycarbonate. The color shall be permanently molded into the components except the inside surface of the visor shall be painted non-reflecting flat black. The color shall be yellow in accordance with 909.02(d)4.

b. Die-Cast Aluminum Signal Head

The housing, door, and visor of the section shall be made of a die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B 85. All surfaces of the housing, doors, and visor shall receive a prime coat of zinc chromate paint in accordance with 909.02(a) or shall be anodized with a chromate aluminum oxide coating process. The finish shall be highway yellow enamel, 2 coats, oven baked and in accordance with 909.02(b) except the inside surface of the visor shall be painted non-reflecting flat black.

9. Certification

A material certification in accordance with the applicable provisions of 916 shall accompany each order certifying that a signal head from a normal production run within the past 12 months, passed the Institute of Transportation Engineers criteria for breaking strength and deflection. Deflection testing is not required in the certification for polycarbonate signal heads.

(b) Pedestrian Signal Head

A pedestrian signal shall be 1 section and rectangular in shape. The dimensions of each side may vary from 18 to 19 in. (460 to 485 mm), including the visor and the hinges. The signal shall contain 2 figures with 2 different colored messages. The left figure shall transmit an upraised hand symbol message, and the right figure shall transmit a walking person symbol message. The pedestrian signal shall be in accordance with the standard of the Institute of Transportation Engineers for Pedestrian Traffic Control Signal Indications.

1. Housing, Door, and Visor

The housing shall be equipped with mounting device hardware, such as clamshell, and round openings at top and bottom for mounting with brackets made of iron pipe standard, to fit the 1 1/2 in. (38 mm) pipe. The openings shall have a

common vertical centerline through the housing to permit 360° rotation after it is mounted. The openings shall have a serrated ring which permits locking of the housing in 5° increments throughout the entire 360° of rotation. The brackets or the clamshell shall serve as the electrical conduit for the pedestrian signal. The housing shall be made of die cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B 85.

The door on the front of the housing may be hinged from any side. The door shall be gasketed to maintain a weather-tight enclosure when secured to the housing. The door and the visor shall be made of the same material as the housing or of polycarbonate. All materials shall be clean, smooth, and free from flaws, cracks, blowholes, or other imperfections.

The exterior of the housing shall be Federal yellow in color. The polycarbonate components shall be black in color impregnated throughout. The metal components shall be painted with enamel in accordance with 909.02(b).

Each signal shall be provided with a visor. The visor shall consist of a minimum of 20 horizontal and 20 diagonal equally spaced louvers. Every other formed louver shall be reversed to provide diamond shaped cells each having a minimum area of 1 sq in. (650 mm^2). The louvers shall be made of impregnated black polycarbonate plastic processed with a flat finish on both sides, to eliminate sun phantom. The door and visor assembly shall be attached to the housing by means of stainless steel screws and nuts.

2. Optical Unit

The optical unit shall consist of the redirecting lens, the lamp, a reflector, a filter, and other optical elements necessary for proper operation. The optical unit shall be designed to minimize the return of the outside light rays entering the unit, such as sun phantom. The optical unit shall be designed and assembled so that no light escapes from 1 message unit to the other.

The values of luminous transmission for pedestrian signal lenses and the limits of chromaticity for pedestrian signal colors shall be in accordance with the standard of the Institute of Transportation Engineers for Pedestrian Traffic Control Signal Indications.

3. Lens

The lens shall be made of plastic. The lens shall be in accordance with ASTM D 788, grade 8; or ASTM D 3935. However, the index of refraction shall be between 1.48 and 1.53. As required by the type of pedestrian signal, the lens shall be uniformly clear or colored throughout the body of the material, true to size and form and free from any streaks, wrinkles, chips, or bubbles.

4. Message

When illuminated, the upraised hand symbol shall be in Portland Orange on the left surface of the signal indications. The walking person symbol shall appear in white on the right surface of the signal indication when illuminated. The upraised hand and walking person symbols shall each be a minimum of 11 in. (280 mm) in height. The width of the upraised hand symbol shall be a minimum of 7 in. (178 mm). The width of the walking person symbol shall be a minimum of 6 in. (150 mm). Message configuration, color, and size shall be in accordance with the standard of the Institute of Traffic Engineers for Pedestrian Traffic Control Indications.

5. Reflector Assembly

The reflector shall be a double parabolic type, made of textured polycarbonate plastic sheet coated with aluminum, or made of specular Alzak Aluminum with bead or flange on the outer edge to stiffen the reflector and ensure the true shape. The reflecting surface shall be free of flaws, scratches, defacements, or mechanical distortion.

The 2 sections of the reflector shall be divided by a full depth divider which properly mates with the message lens to effectively prevent light spillage from 1 section to the other.

6. Light Distribution

The illuminated signal shall be uniformly illuminated over the entire message surface without shadows when viewed from usual angles encountered in service. The upraised hand and walking person symbols shall not appear to be illuminated portions of the lens. When not illuminated, the upraised hand and walking person symbols shall not appear to be illuminated by external light sources when viewed from the far end of the crosswalk. The pedestrian indication shall be visible to the pedestrian at all times at all distances from 10 ft (3 m) to the full width of the street to be crossed.

7. Electrical

The signal shall be equipped with a lamp and a socket for each of the 2 sections of the double parabolic reflector. The lamp receptacle shall be of heat resisting material. The lamp receptacle shall be provided with a grip to prevent the receptacle from working loose due to vibration. Each lamp shall be traffic signal lamp type A 21. The metal portion of the lamp receptacle shall be compatible with brass or copper.

Each pedestrian signal shall be completely wired internally, and ready for connection of the field wiring. A suitable terminal block for connection of the internal wiring and the incoming field wires to the pedestrian signal head shall be provided in the signal housing.

The light source shall be designed and constructed so that if an electrical or mechanical failure occurs, the upraised hand and walking person symbols shall also remain dark.

(c) Disconnect Hanger Junction Box

Traffic signal disconnect hanger junction boxes shall consist of a span hanger, a balance adjuster, a disconnect hanger clevis, and a housing with a hinged door with a positive latching device. The span hanger balance adjuster, and all related hardware shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153. The housing shall be made of a die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B 85. The balance adjuster fitting shall be made of ferrous or non-ferrous metal. When made of ferrous metal it shall be galvanized in accordance with the requirements for the components and related hardware as set out above.

The disconnect hanger shall be designed so that the maximum allowable space or play between the span hanger and the eye-bolt of the balance adjuster and between the balance adjuster and the disconnect hanger clevis, at points where they are attached to each other by rivet or hex head bolts and nuts with lock washers, shall be 0.062 in. (1.6 mm). The span hanger bolt where the eye-bolt or the balance adjuster is attached shall be 5/8 in. (16 mm) diameter.

When serrated locking rings are not integrally cast in the components, the component and locking ring shall be designed so that when the locking ring is placed flush against the component, the component and locking ring shall not rotate or slide when torque is applied. The serrated components shall have 72 serrations to permit rotation of the disconnect hanger clevis, hub plate, or signal head in 5° increments. There shall be no thread in contact with a wearing surface. Locking rings shall have a minimum thickness of 3/16 in. (4.8 mm) and a maximum thickness of 1/4 in. (6.4 mm) from the base of the ring to the serration peaks. The inside diameter shall be 2 in. (50 mm) and the outside diameter shall be 2 7/8 in. (73 mm).

The terminal block shall have an 18 point terminal block permanently engraved or etched with sequential numbers indicating the circuits. The terminal block shall not have a method of connection which allows a screw point to damage wires when the wires are securely connected. Each point of connection shall accommodate a minimum of four No. 14 gage (2.0 mm) wires.

The disconnect hanger shall have 2 side entrance holes on opposite sides capable of receiving a 1 1/2 in. (38 mm) plastic or rubber insert to reduce water infiltration. It shall be capable of supporting signal faces in the ambient temperature range of -30°F to 120°F (-35°C to 49°C) without failure.

The balance adjuster shall have hex head bolts, lock washers, and nuts for securing the main body of the balance adjuster firmly onto and around the eye-bolt to

prevent any twisting or turning of the head suspended below it. The span hanger shall have 2 J-bolts, lock washers, and hex head nuts adequate in size to securely fasten the hanger to a messenger cable up to 1/2 in. (13 mm) in diameter.

A type C certification in accordance with 916 shall be provided.

(d) Signal Bulbs

The minimum design requirements for light bulbs to be used in a traffic signal face shall be in accordance with the Institute of Transportation Engineers standard for Traffic Signal Bulbs and as follows.

1. Bulbs shall be 67 watt, 116 watt, or 150 watt for different kinds of indications, as specified below.

INDICATION	WATTAGE
9 in. (230 mm) pedestrian	67
12 in. (305 mm) and 18 in. (455 mm) pedestrian	116
8 in. (200 mm) red, yellow, and green	67
12 in. (305 mm) red	150
12 in. (305 mm) yellow and green	116
12 in. (305 mm) yellow and green arrows	150
optically programmed heads	150

2. All bulbs shall have medium size, brass bases.

3. Bulbs shall be designed for use in a horizontal position or a base down position.

4. The light center length shall be 2 7/16 in. (62 mm) for 67 watt bulbs and 3 in. (75 mm) for 116 watt and 150 watt bulbs.

5. The filament shall be C9 design with a minimum of 7 supports. The 2 voltage supply leads may be counted as 2 of the 7 supports.

6. The maximum, overall bulb length for 67 watt and 116 watt bulbs shall be 4 3/8 in. (111 mm) and for 150 watt bulbs shall be 4 3/4 in. (120 mm).

7. All bulbs shall be clear and shall be 130 volt.

8. The 150 watt bulb shall be P25 or A21 size and shape.

9. The 67 watt and 116 watt bulbs shall be A21 size and shape.

10. All bulbs shall have 6,000 h minimum burning life.

(e) Free Swinging Signal Support Assemblies

The maximum allowable space or play between the hanger assembly and the eyebolt of the balance adjuster and between the balance adjuster and the weatherhead clevis, at points where they are attached to each other by rivet pins or hex head bolts and nuts with lock washers, shall be 0.062 in. (1.6 mm). No bushings or shims will be allowed in this assembly.

The balance adjuster shall consist of a hex head bolt, a lock washer, and nuts for securing the main body of the balance adjuster onto and around the threads of the eye-bolt to prevent any twisting or turning of the adjuster.

The span hanger, balance adjuster, weatherhead, and all related hardware shall be made of non-corrosive metal or shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153. The weatherhead shall have a minimum of 2 1/2 in. (64 mm) of exposed threads. The weatherhead shall have 2 set screws to fasten the nipple to the weatherhead. If the weatherhead and threaded pipe has a slipin connection, the locking device shall be a double nut assembly. If the weatherhead and threaded pipe has a screw-in connection, the locking device shall be a double set screw assembly.

The span hanger shall be furnished with 2 each of J-bolts, lock washers, and hex head nuts. The J-bolt shall be a minimum of 1/4 in. (6.4 mm) diameter and shall have sufficient threads to be able to secure the hanger to a 1/4 in. (6.4 mm) or a 1/2 in. (13 mm) messenger cable. The multiple pipe arm assembly shall consist of a span hanger assembly, a balance adjuster, a signal weatherhead, a 2, 3, or 4 way pipe arm, 1 1/2 in. (38 mm) pipe, a lower arm assembly, and all related hardware necessary for a complete assembly.

The 2, 3, or 4 way pipe arms shall have a minimum of 2 in. (50 mm) of exposed thread. Each arm of the pipe arm shall be furnished with two 72 serration locking rings. One locking ring shall have a 3 in. (75 mm) outside diameter and 1 locking ring shall have a 2 3/8 in. (60 mm) outside diameter.

ASSEMBLY	MAXIMUM ALLOWABLE WEIGHT
2 Way	19 lb (8.6 kg)
3 Way	25 lb (11.3 kg)
4 Way	28 lb (12.7 kg)

(f) Mid-Mast Arm Mount Signal Bracket

The bracket shall permit the following 4 adjustments.

1. rotational adjustment about bracket axis;

2. vertical adjustment;

3. rotational adjustment about mast arm; and

4. rotational adjustment right and left from vertical plane

The bracket shall be fastened to the supporting arm or structure with stainless steel bands. The bracket shall adjust to fit all sizes of round, octagonal, elliptical, or other shape structure without special tools or equipment.

The bracket shall attach to the signal by clamping the signal head both top and bottom and shall be designed to accommodate the specified signal configuration. Each bracket shall be complete with all necessary hardware to attach the traffic signal to the bracket and the bracket to the support.

All electrical wiring shall be concealed within the bracket, except that which runs from the bracket to the mast arm.

Upper and lower arms shall be cast from aluminum in accordance with ASTM B 26 (B 26M), alloy 713.0-T5 or 356.0-T6. The vertical support tube shall be extruded from aluminum in accordance with ASTM B 241 (B 241M), alloy 6063-T6 or 6061-T6, and the strapping to attach the bracket to the arm shall be stainless steel. All steel or malleable iron parts shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153.

(g) Pedestal Mounted Control Cabinets or Pedestrian Signal Heads

The pedestal base used for mounting pedestrian signal heads or control cabinets shall be in accordance with 922.01(g)2a. The length of the pedestal pole shall be as shown on the plans.

922.05 Signal Support

(a) Steel Strain Pole

The steel strain pole shall be an anchor base type pole and shall include a handhole and a pole top or cap. The poles shall be furnished in lengths specified.

The pole shall have a reinforced handhole within 18 in. (460 mm) of the base. The minimum size shall be 5 in. (130 mm) by 8 in. (200 mm) with a cover and latching device. The pole shall have a top or cap with a set screw that can be removed with small hand tools.

The pole material shall be in accordance with ASTM A 595 or A 572 with a minimum yield strength of 50,000 psi (345 MPa). The pole shall be galvanized after fabrication in accordance with ASTM A 123.

All hardware, handhole cover and latching device, band type steel pole bands, steel bolts, nuts, and washers shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153. All nuts and bolts, except anchor bolts, shall be in accordance with ASTM A 307. If a cast pole top or cap is used it shall be in accordance with ASTM A 126 and shall be galvanized with a minimum coating of 2 oz/sq ft (0.610 kg/m^2).

The pole bands shall fit the pole as planned. The wire rope shall not be in contact with any 90° edges or with any threads on the band. The pole band material shall be in accordance with ASTM A 572, grade 50 (A 572M, grade 345); ASTM A 606; or ASTM A 36 (A 36M) with a minimum yield of 50,000 psi (345 MPa). The minimum width of the bands shall be 3 in. (75 mm) and the bands shall be capable of supporting the pole design load. Each half of the band shall be stamped with the corresponding size number.

All welding shall be in accordance with 711.32. Welds shall generate the full strength of the shaft. Only longitudinal continuous welding shall be permitted on the pole shaft. Contacting joint surfaces shall be thoroughly cleaned before fabrication then completely sealed by means of welding. Shop drawings shall be submitted in accordance with 922.05(c)9.

The pipe coupling for the weatherhead and base plate shall be installed prior to galvanizing. The threads shall be cleaned of all excess galvanizing. An internal J-hook shall be installed near the top of the pole for wire support.

The steel strain pole shall be capable of supporting an 8,000 lb (35.6 kN) load applied horizontally 18 in. (460 mm) below the top of the pole with a maximum allowable deflection of 0.16 in. (4.1 mm) per 100 lb (445 N) of load. The pole shall be tapered 0.14 in./ft (12 mm/m) of length.

A 1 piece base plate shall be secured to the base of the pole and shall develop the full strength of the pole. The base plate material shall be in accordance with ASTM A 36 (A 36M), A 572 (A 572M), or A 588 (A 588M). The base plate shall have 4 holes of adequate size to accommodate 2 1/4 in. (57 mm) anchor bolts. The bolt circle shall have a 22 in. (560 mm) diameter and bolt square of 15 1/2 in. (394 mm).

Four high strength steel anchor bolts, 2 1/4 in. (57 mm) diameter and 96 in. (2,400 mm) long, including the hook, shall be furnished with each pole. Each bolt shall have 2 hex nuts and 2 washers in accordance with ASTM A 307, grade A. The anchor bolt material shall be in accordance with ASTM A 576 or ASTM A 675 (A 675M) with a minimum yield strength of 55,000 psi (379 MPa) or ASTM A 36 (A 36M), special quality, modified to 55,000 psi (379 MPa) or approved equal. The threaded end of the anchor bolt shall have 12 in. (305 mm) of 4 1/2 NC threads and shall be galvanized the length of the threads, plus 3 in. (75 mm). The threaded end

shall be coated after fabrication in accordance with ASTM A 153 or be mechanically galvanized and be in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C. The unthreaded end of the anchor bolt shall have a standard L bend for a distance of 9 in. (230 mm) from the centerline of the anchor bolt to the end of the L. In lieu of the standard bend, a steel plate 4 1/2 in.^{2} (2900 mm^2) and 1 1/4 in. (32 mm) thick may be welded to the embedded end of the anchor bolt.

(b) Wood Strain Pole

Wood strain poles shall be made from southern yellow pine and shall be in accordance with the current ANSI Specifications and Dimensions for Wood Poles No. 05.1. They shall be of the length and class specified.

All poles shall be full length pressure treated by the full cell process in accordance with current specifications as set forth in the AWPA Standards C1 and C4, using preservative as outlined in standard P5 and set forth in 911.02(h).

Treatment, handling, and storage methods shall be in accordance with the current AWPA Standards.

(c) Signal Cantilever Structures

1. General

A signal cantilever structure shall be designed in accordance with the latest AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, except where modified herein.

Where the manufacturer has wind tunnel test data, he may use drag coefficients based on actual tests. Otherwise, the manufacturer shall use the drag coefficients in Table 1.2.5c.

2. Signal Support

The traffic signal pole and mast arm shall be designed to support the loads in accordance with the plans in an 80 mph (129 km/h) wind with gusts to 104 mph (167 km/h). Loading shall assume diecast aluminum heads.

The traffic signal pole and mast arm shall be designed to provide a 17 ft (5.3 m) minimum clearance at all signals. Clearance shall be the vertical distance from the lowest point of the signal combination to a horizontal plane 3 in. (75 mm) below the base of the mast arm pole or from the lowest point of the signal combination to the pavement surface below the signal combination, whichever governs. Adjustment of the clearance at the installation site shall be by raising or lowering the mast arm along the upper length of the pole. After the pole is anchored to the foundation, the pole design shall permit the mast arm to be rotated 90° in either direction and secured. The cable inlet shall not be obstructed when a field rotation or vertical adjustment of the mast arm is made.

There shall be no threads in the wearing surface plane at the point of connection between the clevis clamp and the signal face assembly. The clevis clamp shall have a 11/16 in. (18 mm) diameter bolt hole to receive the signal face assembly.

3. Combination Signal-Luminaire Support

All requirements for a signal support shall apply to a combination signal-luminaire support.

The minimum design load of the luminaire shall be 53 lb (24 kg) with a projected surface area subject to wind loading of 2.4 sq ft (0.223 m^2). If heavier or larger luminaires are used, their actual values shall be used. The required luminaire mounting height shall be in accordance with the plans. Mounting height shall be defined as the vertical distance from the lowest point of the luminaire to the horizontal plane which passes through the base of the pole.

The maximum percentage of allowable stress shall be 80% of the AASHTO Standard Specifications for Group 1 loads. Vibration dampers shall be furnished as recommended by the manufacturer.

4. Pole Requirements

a. General

The pole shall be a round or multi-sided tapered tube, except the upper 4 to 6 ft (1.2 to 1.8 m) of a signal support pole may be non-tapered. The signal support pole shall have a reinforced handhole 4 in. (100 mm) by 6 in. (150 mm) minimum complete with cover and latching device located 18 in. (460 mm) above the base. A 1/2 in. (13 mm) 13 NC threaded grounding nut or approved equivalent shall be provided and be accessible through the handhole. The pole cap shall be secured in place with set screws. The combination signal-luminaire pole shall have a reinforced handhole 4 in. (100 mm) by 8 in. (200 mm) minimum complete with cover and latching device, located 18 in. (460 mm) above the base. The combination signal-luminaire pole shall be provided with a removable pole cap and integral wire support hook for the luminaire electrical cable. The cable shall be attached to the hook by a service drop clamp. A wiring hole with a 1 in. (25 mm) to 1 1/2 in. (38 mm) inside diameter grommet shall be provided where the luminaire mast arm attaches to the pole.

b. Deflection

The maximum allowable horizontal deflection of the pole under maximum loading conditions shall not exceed a deflection angle of 1° 10" from the vertical axis of the pole for any 1 ft (305 mm) section of the pole along the entire length of the pole.

c. Materials

The signal pole and the combination signal-luminaire pole shall be steel or aluminum. Steel poles shall be in accordance with ASTM A 595 or A 572 with a minimum yield strength of 50,000 psi (345 MPa) and shall be galvanized in accordance with ASTM A 123. Aluminum poles shall be in accordance with ASTM B 221 (B 221M) alloy 6063-T6 or 6005-T5, or ASTM B 241 (B 241M), alloy 6063-T6.

d. Hardware

All hardware for steel poles except bolts for the mast arm clamps and anchor bolts shall be in accordance with ASTM A 307 and shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153, class C. A cast pole cap shall be in accordance with ASTM A 126 and shall be galvanized with a minimum coating of 2 oz/sq ft (0.610 kg/m^2).

All hardware for aluminum poles shall be stainless steel in accordance with ASTM A 276, type 304 or type 305.

e. Anchor Base

A 1 piece anchor base shall be secured to the lower end of the pole and shall develop the full strength of the pole. The base shall be provided with 4 holes of adequate size to accommodate 1 1/4 in. (32 mm) anchor bolts equally spaced on a bolt circle of 15 in. (380 mm) diameter and shall have 4 tapped holes for attaching the bolt covers. Four removable bolt covers shall be provided with each base and each cover shall attach to the upright portion of the body of the base by means of 1 hex head cap screw. The steel for the anchor base shall be in accordance with ASTM A 36 (A 36M), A 572 (A 572M), or A 588 (A 588M). Aluminum for the anchor base shall be in accordance with ASTM B 26, alloy 356.0-T6 or 356.0-T7 or ASTM B 209, alloy 6061-T6.

5. Arm Requirements

a. Signal Cantilever Arm

A signal cantilever arm shall be attached to the pole by circular clamps. 1-half of the clamp shall be welded to the cantilever arm. The single member arm or the upper tapered member of the truss style arm shall have a cable inlet adjacent to the clamp complete with grommet. The cable inlet shall be a 1 3/4 in. (44 mm) diameter hole with a 1 1/2 in. (38 mm) inside diameter rubber grommet. The 20, 25, and 30 ft (6.1, 7.6, and 9.2 m) cantilever arms shall have 1 intermediate cable inlet with grommet located 12 ft (3.7 m) from the free end of the arm. The 35 and 40 ft (10.7 and 12.2 m) cantilever arm shall have 2 intermediate cable inlets with grommets located 12 ft (3.7 m) and 24 ft (7.3 m) respectively from the free end of the arm. The intermediate cable inlet shall be a 1 in. (25 mm) diameter hole with a 3/4 in. (19 mm) inside diameter rubber grommet.

The maximum rise of the single member arm shall be 1/2 in. (13 mm) per 1 ft (305 mm) of arm after loading. The maximum rise of the truss style arm shall be as set out in the table. The rise shall be measured vertically from the centerline of the free end of the truss to a plane through the centerline of the upper arm bracket after loading.

Mast Arm Length ft (m)	Total Rise ft - in. (m)	Tolerance in. (mm)
12 - 20 (3.7 - 6.1)	4 - 0 (1.2)	± 1 (± 25)
25 (7.6)	4 - 3 (1.3)	± 1 (± 25)
30 - 40 (9.2 - 12.2)	4 - 7 (1.4)	± 1 (± 25)

The end signals on the truss style arms shall be suspended and the intermediate signals shall be rigidly attached. All signals on the single member arms shall be rigidly attached as shown on the plans. The cantilever arms shall be used as an enclosed raceway for wiring and shall be free of burrs and rough edges.

Both parts of the clamp for the single member arms shall be stamped with the arm length prior to galvanizing.

b. Luminaire Mast Arm for Combination Support

The luminaire mast arm shall be in accordance with 920.01(a)1.

c. Materials

The signal mast arm shall be of the same material as the pole. The luminaire mast arm shall be of the same material as the pole except that a truss type arm shall be in accordance with 920.01(a). Bolts for the mast arm clamp shall be stainless steel in accordance with ASTM A 276, type 304 or 305.

6. Anchor Bolts

Four steel anchor bolts, each fitted with 2 hex nuts and 2 flat washers, shall be furnished with each pole. The anchor bolt shall be 1 1/4 in. (32 mm) diameter with a minimum of 10 in. (254 mm) of 7 NC threads on the upper end. The threads, nuts, and washers shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153. The anchor bolt shall be 48 in. (1220 mm) long with a 4 in. (100 mm) right angle bend on the lower end or a square steel washer, 6 in. by 6 in. by 1/2 in. (150 mm by 150 mm by 13 mm), with a hex nut welded onto the lower end. The steel for the bolt shall be in accordance with ASTM A 576, or ASTM A 675 (A 675M), with a minimum yield strength of 55,000 psi (379 MPa), or ASTM A 36 (A 36M), special quality, modified to 55,000 psi (379 MPa) or approved equal.

7. Finish

All steel material shall be fully galvanized. Galvanizing shall take place after all welding is accomplished. Aluminum poles shall be provided with a satin finish

accomplished by mechanical rotary grinding and aluminum mast arms shall be provided with a satin etched finish.

8. Certification

Unless otherwise specified, all materials covered herein shall be covered by a type C certification in accordance with 916.

9. Shop Drawings

Five sets of shop drawings and a set of design calculations shall be submitted to the Design Division for approval. A copy of the transmittal letter shall be sent to the Engineer. The approved drawings will be distributed by the Design Division.

(d) Downguys, Anchors, Rods, and Guards

Pole anchors shall be 8 way expanding with a minimum area of 135 sq in. (87,100 mm^2) when expanded or a 10 in. (250 mm) diameter screw anchor. They shall have a minimum holding strength of 10,000 lb (44.5 kN). They shall be painted and in accordance with ASTM A 1011 (A 1011M). Anchor rods for expanded anchors shall be 3/4 in. (19 mm) diameter steel and for screw anchors shall be 1 1/4 in. (32 mm) diameter steel, 8 ft (2.4 m) long, in accordance with ASTM A 659 (A 659M), and be galvanized in accordance with ASTM A 153.

Guy guards shall be made of 18 gage galvanized steel, polyethylene, polyvinylchloride, or melamine phenolic, and shall be 7 ft (2.1 m) long. The steel guy guard shall have a tight gripping, non-scarring hook for quick attachment to the guy wire. The bottom shall have a clamp that fits over the anchor rod and securely grips by tightening the bolt. Steel guy guards shall be in accordance with ASTM A 659 (A 659M). The non-metallic guy guard shall be a helical pigtail which shall resist upward movement, a lock strap to secure the lower end, and a guy guard sleeve. Non-metallic guy guards shall be gray or yellow.

922.06 Traffic Cable

(a) Messenger Cable

Messenger cable shall be zinc-coated steel wire strand, contain 7 wires, and have a nominal diameter of 3/8 in. (10 mm). The cable shall be in accordance with ASTM A 475, Siemens-Martin Grade.

(b) Span, Catenary, and Downguy Cable

Span, catenary, and downguy cable shall be aircraft cable for non-aircraft use, and shall be 3/8 in. (10 mm) nominal diameter, made of stainless steel wire, and consist of 7, 19 wire steel strands. The 3/8 in. (10 mm) cable shall have a minimum breaking strength of 12,000 lb (53.4 kN). It shall be in accordance with Military Specifications MIL-W-1511.

(c) Tether and Support Cable

Tether and support cable shall be aircraft cable, for non-aircraft use, and shall be 1/8 in. (3 mm) nominal diameter, made of stainless steel wire, and consist of 7, 7 wire flexible steel strands. The 1/8 in. (3 mm) cable shall have a minimum breaking strength of 1,700 lb (7,560 N). It shall be in accordance with Military Specifications MIL-W-1511.

(d) Cable Hardware

1. Messenger Hangers

Messenger hangers shall be either a 3 bolt clamp or a 3/8 in. (10 mm) by 1 3/4 in. (44 mm) steel hanger with a 90° bend extending from the pole 3 3/4 in. (95 mm). The hanger shall have a curved groove and clamp capable of receiving a 5/16 in. to 1/2 in. (8 mm to 13 mm) cable.

The messenger shall be clamped by two 1/2 in. (13 mm) high carbon steel bolts. The angle hanger shall be mounted with a 5/8 in. (16 mm) through bolt and a 1/2 in. (13 mm) lag screw. The 3 bolt clamp shall be mounted with a 5/8 in. (16 mm) through bolt. The angle hanger shall be in accordance with ASTM A 575. The bolts shall be in accordance with NEMA PH 23.

2. Cable Ring

Cable rings shall be galvanized steel in accordance with IMSA 51-1.

3. Clamps

Clamps shall be made of 3/8 in. (10 mm) steel and in accordance with ASTM A 575.

Two bolt clamps shall be a minimum of 3 3/4 in. (95 mm) long and 1 1/4 in. (32 mm) wide with two 1/2 in. (13 mm) bolts which shall clamp cable of 1/8 to 1/2 in. (3 to 13 mm) diameter.

Three bolt clamps shall be a minimum of 6 in. (150 mm) long and 1 5/8 in. (42 mm) wide with three 5/8 in. (16 mm) bolts which shall clamp cable of 5/16 to 1/2 in. (8 to 13 mm) diameter.

The bolt heads shall be large enough to provide maximum clamping area and shall have oval shoulders to prevent the bolts from turning while tightening. The bolts shall be in accordance with NEMA PH 23.

4. Servi-Sleeves

Servi-sleeves shall be 1 1/4 in. to 2 1/4 in. (32 mm to 57 mm) in length and shall hold the size of the cable specified. The sleeves shall be in accordance with ASTM A 659 (A 659M).

5. Straight Eye-Bolts

Straight eye-bolts shall be 3/4 in. (19 mm) diameter drop forged steel, a minimum of 14 in. (356 mm) long, and have 6 in. (150 mm) of thread. The steel washers shall be 2 1/4 in. (57 mm) by 2 1/4 in. (57 mm) by 3/16 in. (5 mm) in size with 13/16 in. (21 mm) hole in the center. All parts shall be in accordance with ASTM A 575 and shall be galvanized in accordance with ASTM A 123.

6. Hub-Eyes

Hub-eyes shall be made of drop forged steel and in accordance with ASTM A 575. They shall receive a 3/4 in. (19 mm) mounting bolt and have a full rounded thimble eye for protection of the guy cable.

(e) Signal Cable

1. Hook-up Wire

Signal hook-up wire shall be stranded 1 conductor wire, type THW 7 strand No. 14 AWG, with a thermoplastic sheath 3/64 in. (1.19 mm) thick and a 600 volt rating. Insulation shall be color coded, as required, and labeled with gage, voltage rating, and insulation type.

2. Signal Control Cable

Signal control cable shall be in accordance with IMSA 19-1 or 20-1 and shall be stranded No. 14 AWG wire.

3. Integral Messenger Interconnect Cable

Integral aerial interconnect cable shall be figure “8” self-supporting type cable consisting of a messenger cable and 7 conductors No. 14 AWG signal cable in accordance with IMSA 20-3.

4. 6 Pair/19 Telemetry Cable

6 pair telemetry cable shall contain 6 twisted pairs of 19 gage conductors and shall be in accordance with IMSA Specification 40-2 for underground application and IMSA Specification 40-4, integral messenger, for aerial application.

5. Fiber Optic Interconnect Cable

Fiber optic cable shall contain 4 stranded multimode, graded index, optic fibers with a minimum of 1 non-metallic central strength member. The cable shall be loose tube, all dielectric construction, suitable for outdoor use in conduit or on aerial supports. Each individual fiber shall be 62.5/125 µm diameter, core/clad, and each fiber shall be individually encased in its own gel-filled color coded buffer. The fiber optic cable shall be constructed with Kevlar braid and outer polyethylene jackets as a minimum. If an inner jacket is used it shall be PVC. Maximum attenuation of the cable shall be 4.0 dB/km nominal, measured at room temperature at 850 nm. The bandwidth shall not be less than 160 MHz/km, also at 850 nm. Each fiber shall be continuous with no factory splices except for joining standard length cables to form longer, continuous jacketed cable to fit installation requirements. The cable shall

have standard nylon rip cords. Kevlar rip cords will not be accepted. The cable shall be in accordance with the generic requirements for optical fiber and optical fiber cable per Bellcore Technical Reference TR-TSY-000020.

The exterior of the polyethylene outer cable jacket shall be stenciled so that every fifth meter on each reel is marked with a number. The fifth meter of each reel shall be marked with a 5, the tenth meter marked with a 10, and so on until the end of the reel. The stencil shall be applied to the outer jacket using permanent ink and shall be permanently engraved into the jacket to provide long lasting readability.

6. Service Cable

Traffic signal service cable shall be color coded, stranded copper No. 8 AWG wire, 3 conductor cable, type THWN.

7. Detection Wire and Sealant

a. Loop Detector Lead-In Cable

Loop detector lead-in cable shall be in accordance with IMSA 50-2 and shall be stranded 2 conductor No. 16 AWG, 19 strands of No. 29 wire.

The nominal capacitance between conductors shall be 57 pF/ft (187 pF/m) and 98 pF/ft (322 pF/m) between 1 conductor and the other conductor connected to the shield.

b. Roadway Loop Wire

Roadway loop wire shall be 14 AWG gage IMSA 51-7 duct-loop wire with polyvinyl chloride or polyethylene outer jacket of 1/4 in. (6.3 mm) diameter.

c. Sealant

Prior to installing roadway loop wire in the roadway saw cuts, the saw cuts shall be cleaned in accordance with the requirements for the joint sealant to be used. After proper cleaning and installation of the loop wire, the saw cut shall be sealed with a joint sealant material in accordance with 906.02(a)1 or 906.02(a)2. The joint sealant material to be used shall be compatible with the roadway materials. If polyethylene duct loop wire is used, only sealant in accordance with 906.02(a)1 shall be used. The joint sealant material shall be installed in accordance with the applicable sealant specification. However, the joint configuration shall not apply. A copy of the sealant manufacturer's written application instructions shall be submitted to the Engineer prior to any sealant operations. If the Contractor elects to use a sealant complying with 906.02(a)2, the sealant material shall be heated in a kettle or melter constructed as a double boiler with the space between the inner and outer shells filled with oil or other heat-transfer medium. This melter shall have a positive temperature control and a mechanical agitator. A backer rod shall be used for both cold applied sealants and hot poured sealants. The sealant material shall fill the saw cut as shown on the plans. All significant or objectionable surplus joint sealant on the pavement surfaces shall be promptly removed.

8. Ground Wire

The ground wire shall be copper wire No. 6, AWG soft-drawn, solid copper in accordance with ASTM B 3.

9. Splicing Kit

Splicing kits shall contain a 2 piece, transparent snap-together mold body and include an epoxy and sealing compound contained in a unipak. It shall be capable of insulating and splicing non-shielded cables rated up to 5 kilovolts and multi-conductor cables rated up to 600 volts.

922.07 Ground Rod and Connections

Ground rods shall be 1/2 in. (13 mm) in diameter by 8 ft (2.4 m) long with a machined point and chamfered top. They shall be made of steel with a molecularly bonded outer layer of electrolytically applied copper. The finished rod shall be cold-drawn and shall have the following minimum physical properties.

PHYSICAL PROPERTY	MINIMUM
Tensile strength	97,000 psi (668 MPa)
Yield strength, 0.2% offset	85,000 psi (586 MPa)
% of elongation	13 psi (90 kPa)

The ground rod and wire connection shall be made by a thermo weld process or approved equal. The welding material shall cover and secure the conductor to the rod and shall be porous free.

An acceptable alternate shall be a ground grid connection properly sized and shall consist of a shear head bolt, a “C” shaped body, nest, and wedge. The connector components shall be fabricated from an aluminum-bronze alloy, silicone-bronze alloy, and copper.

922.08 Castings for Handholes

The ring and cover for handholes shall be in accordance with 910.05(b).

922.09 Entrance Switch

The entrance switch shall be a single pole, 50 amp, 120 volt circuit breaker in a NEMA type 3R enclosure. The minimum dimensions of the enclosure shall be: 5 in. (127 mm) wide, 3 3/4 in. (95 mm) deep, and 9 1/4 in. (235 mm) high. A 1 in. (25 mm) rain-tight detachable hub shall be supplied in the top of the enclosure. The enclosure shall have knockouts on the sides, bottom and back with diameters of 7/8 in. (22 mm) to 1 3/4 in. (44 mm). The enclosure shall contain the circuit breaker, an insulated solid bar for connection of AC Neutral, a separate lug for attachment of earthground, have provisions for a padlock, and shall be surface mounted.

The enclosure shall be made of galvanized steel with a rust inhibiting treatment, and finished in the manufacturer’s standard color of baked enamel.

922.10 Conduit and Fittings

(a) Steel Conduit

Steel conduit, couplings, and elbows shall be galvanized rigid steel conduit in accordance with UL 6. The conduit shall be galvanized by the hot dip method on the interior and exterior surfaces. Conduit threads shall be cut after galvanizing. The conduit shall be supplied with a threaded coupling attached to 1 end and the other threaded end protected by a suitable shield.

The various conduit fittings such as bands, bodies, straps, lock nuts, and threadless connectors, shall be in accordance with Federal Specifications A-A-50553 and shall be galvanized if not stainless steel. Conduit straps shall be 2 hole straps with a minimum thickness of 1/8 in. (3 mm). Conduit lock nuts 3/8 in. to 1 1/2 in. (10 mm to 38 mm) in size shall be made of steel. Other sizes shall be made of either steel or malleable iron. All conduit lock nuts shall be galvanized. Other nuts shall be either stainless steel or galvanized steel.

(b) Polyvinyl Chloride Conduit

PVC conduit shall be in accordance with ASTM D 1785, schedule 40. The PVC conduit fittings shall be in accordance with ASTM D 2466. Each length of pipe shall include a coupling.

922.11 Detector Housing

The entire housing casing shall be made from aluminum alloy in accordance with ANSI 320.

922.12 Certification

Unless otherwise specified, all materials covered herein shall have a type C certification in accordance with 916.

SECTION 923 – TEMPORARY TRAFFIC CONTROL DEVICES

923.01 Temporary Pavement Marking Tape

Temporary pavement marking tape shall be furnished in 2 colors and 2 types. It shall consist of a white or yellow reflecting film on a conformable backing which is a minimum of 4 in. (100 mm) wide, and is designed for marking either asphalt or concrete pavements.

The white or yellow reflective film on the tape shall be in accordance with highway colors. The tape shall have an average thickness, as determined by 5 micrometer readings, of no less than 20 mils (0.50 mm). The type I reflective film shall have glass beads uniformly distributed throughout the reflective film. Type I and type II reflective film shall have a reflective layer of glass beads bonded to the surface.

The tape shall be supplied in rolls ready for application and have a precoated, pressure sensitive adhesive on the backing which shall not require activation procedures. There shall be no more than 3 splices per 50 yds (46 m) of length. It shall be shipped in standard commercial containers so constructed as to ensure acceptance by the carrier and prevent damage during shipment and storage. It shall be capable of being stored at temperatures up to 100°F (38°C) for periods of 1 year without deterioration.

When the tape is applied in accordance with the manufacturer's recommended procedures, it shall be weather and traffic resistant and show no appreciable fading, lifting, or shrinkage during the useful life of the line. The material shall be of good appearance, free from cracks, and edges shall be true, straight, and unbroken. The material shall be capable of performing satisfactory for a minimum of 1 year.

Type I tape shall be selected from the Department's list of approved Temporary Pavement Marking Tape, Type I. Temporary pavement marking tape type I will be placed and maintained on the Department's approved list in accordance with ITM 806.

Type I tape furnished under this specification shall be covered by a type C certification in accordance with 916.

The minimum reflective intensity values expressed as 0.12 Candlepower/sq ft/foot candle (0.12 Candela/m^2/lux) when tested in accordance with ASTM D 4061 shall be in accordance with the following table.

SPECIFIC LUMINANCE USING ENTRANCE ANGLE 86 DEGREE

Observation Angle	White		Yellow	
	0.2°	0.5°	0.2°	0.5°
Specific Luminance, Type I	1770	1270	1310	820
Specific Luminance, Type II	1000	760	820	510

923.02 Temporary Raised Pavement Marker

Temporary pavement markers shall be designed to be affixed with adhesive to the pavement surface and shall be in accordance with ASTM D 4280. Adhesive shall be in accordance with the manufacturer's recommendations.

Markers shall be selected from the Department's list of approved Temporary Raised Pavement Markers. Temporary raised pavement markers will be placed and maintained on the approved list in accordance with ITM 806.

923.03 Construction Warning Lights

Construction warning lights shall be self-illuminated by means of an electric lamp behind the lens. Types A and C shall also be externally illuminated by reflex-reflective elements built into the lens to enable it to be seen by the light from the headlights of oncoming traffic.

The batteries shall be entirely enclosed in a case. The case shall be secured by a locking device which can be opened with a special tool.

(a) Flash Requirements

1. Flash Rate

The light from types A and B shall have a flash rate of 65 ± 10 pulsations per minute from -20°F (-29°C) to 150°F (66°C).

2. On-Time

On-time is defined as the period of the flash when instantaneous intensity is equal to or greater than the effective intensity as specified in 923.03(b)1.

a. Type A

The light shall have an on-time of no less than 10% of the flash cycle.

b. Type B

The light shall have an on-time of no less than 8% of the flash cycle.

(b) Optical Requirements

1. Effective Intensity

The light beam projected upon a surface perpendicular to the axis of the light beam shall produce a lighted area within the solid angle bounded by the 2 vertical planes 9° from the vertical plane through the axis of the optical system and 2 planes 5° above and below the horizontal plane through the optical axis of the system.

For type A, the effective intensity shall not drop below 4.0 candles (4.0 cd) within the area specified herein during the first 336 h of continuous flashing.

For type B, the effective intensity shall not drop below 35 candles (35 cd) within the area specified herein during the first 168 h of continuous flashing.

For type C, the effective intensity shall not drop below 2.0 candles (2.0 cd) within the area specified herein during the first 168 h of continuous burning.

2. Lens Illumination

The illuminated lens shall be uniformly bright in appearance over its entire illuminated surface when viewed from any point within the angle defined in 923.03(b).

3. Reflex-Reflective Performance

For types A and C the specific intensity of the lens when acting as a reflex-reflector at an observation angle of 0.2 of a degree shall be no less than the following.

Entrance Angle (degrees)	Specific Intensity Candles per Footcandle (Candelas per lux)
0	18 (1.67)
10	14 (1.40)
20	7 (0.65)

4. Testing Procedure

The effective intensity of types A and B lights shall be calculated using the Guide for Calculating the Effective Intensity of Flashing Signal Lights as approved by the Illuminating Engineering Society, June, 1961. The intensity of the type C light shall be tested in accordance with SAE Standard J 575d, Lighting Equipment and Photometric Tests. Reflex-reflection shall be tested in accordance with SAE Standard J 594d.

(c) Lens Requirements

1. Size of Lens

The lens shall be no less than 7 in. (175 mm) in diameter including for a reflex-reflector ring of 1/2 in. (13 mm) minimum width around the periphery for types A and C.

2. Directional Lenses

Unless otherwise directed, types A, B, and C shall have uni-directional lenses.

3. Lens Chromaticity

If the light uses an incandescent lamp, the chromaticity of the lens color shall be defined by the tri-stimulus coordinates of the Commission International d'Eclairage Standards. When tested with illuminants from 2856 K to 2366 K, the lens color shall fall within the area of the chromaticity diagram in accordance with the 1931 Commission International d'Eclairage Standard Observer as defined by the following coordinates.

X	Y	Z
0.543	0.452	0.005
0.548	0.452	0.000
0.584	0.411	0.005
0.589	0.411	0.000

If the light uses other than an incandescent lamp, the light output shall be in the same range as the light obtained with the incandescent lamp and the specific lens.

4. Lens Luminous Transmittance

The minimum relative luminous transmittance of the lens with illuminant at 2856 K shall be 0.440.

5. Lens Material

The lens shall be plastic of 1 piece construction and shall meet the test requirements in accordance with SAE J 576b, except that the exposure time and condition, paragraph 3.4.3, for the purposes of this standard shall be 1 year.

(d) Head and Case

1. Swivel Head

If swivel capabilities as described herein are not incorporated in the device used to mount a type A or C light on a barricade or sign, the head shall be mounted on the housing in a manner permitting it to be swiveled through a minimum 90° arc in a horizontal plane. If swiveling is accomplished by rotation of the head, construction shall be such that the head rotation shall not damage the wiring.

2. Case

The case shall be so constructed and closed as to exclude moisture that would affect the specified operation of the light. The case shall have a weephole to allow the escape of moisture from condensation.

(e) Photoelectric Controls

Photoelectric controls, if provided on types A or C lights, shall keep the light operating whenever the ambient light falls below 20 footcandles (215 lux).

923.04 Flashing Arrow Sign

The flashing arrow sign shall be an all weather, self-contained, flashing sign designed to display the required flashing messages continuously for a minimum of 24 h without servicing. A reserve storage battery shall be provided to automatically operate the flashing arrow sign for a minimum period of 8 h if there is a power failure of the primary source.

The flashing arrow sign shall have a control unit which incorporates a photo-controlled transfer relay for automatic lamp intensity settings. The highest photo-controlled setting shall be full intensity for daylight operation. The lowest photo-controlled setting shall be for night-time operation and shall be 50% of full intensity when the ambient light level drops below 5 footcandles (54 lux). A minimum of 2 interim photo-controlled settings shall automatically increase or decrease the lamp intensity in direct proportion to the ambient light level.

The flashing arrow sign shall have a manual control unit for adjusting lamp intensity when automatic operation becomes unsatisfactory. The manual control shall be fully adjustable between the minimum limit of 30% of full lamp voltage and maximum limit of full lamp voltage.

An indicator light shall be provided on the back of the sign to provide confirmation that the flashing arrow sign is operating. The indicator light shall be visible for 500 ft (150 m).

(a) Solar Powered

Solar power assisted units shall incorporate a target sight device and leveling mechanism to aid the user for positioning of the unit prior to use. The device shall be attached to the elevated portion of the flashing arrow sign and not to the fixed support frame.

The lamps shall be electronically operated by means of a solid state controller. An automatic lamp intensity regulator shall hold the lamp output constant with varying battery voltage. The control system shall incorporate a full time tracking system designed to track ambient light for 24 h a day. The control system shall adjust lamp intensity to provide maximum system efficiency. The controller shall be in a weatherproof, ventilated, lockable enclosure.

The lamps shall provide amber beams with a minimum of 20° horizontal and 6° vertical field of view. The minimum effective luminance within the required beam shall not be less than 1 half the effective luminance at the beam center.

The battery bank shall consist of 12 v, deep cycle, batteries. The battery bank shall be of sufficient capacity to power the unit for 15 days with no assistance from the sun. A battery condition indicator and a test switch shall be provided to monitor the system's battery charge. The batteries shall be secured in a well ventilated, weatherproof lockable housing. A low battery charge indicator which shall be visible to maintenance personnel driving past the sign shall be provided to indicate the need to recharge the batteries. The battery bank shall be at full charge when delivered to the project site.

The unit shall be equipped with a sign/solar panel lifting mechanism. The lifting mechanism shall be designed to safely carry the capacity of the sign's load. The lifting mechanism shall incorporate a positive locking device to secure the panel in a raised or lowered position.

Solar power assisted flashing arrow signs to be used shall be selected from the Department's list of approved Solar Power Traffic Control Devices.

(b) Diesel Powered

Flashing arrow sign shall be fueled by diesel fuel only.

(c) AC Powered

When connected to an AC electrical power source, provisions shall be made to prevent electrocution.

FLASHING ARROW SIGN GENERAL SPECIFICATIONS

	TYPE A	TYPE B	TYPE C	SOLAR POWER ASSISTED
Minimum Board Size	2 ft (0.6 m) high by 4 ft (1.2 m) wide**	See Note Below	4 ft (1.2 m) high by 8 ft (2.4 m) wide	4 ft (1.2 m) high by 8 ft (2.4 m) wide
Minimum No. of Lamps Flashing Arrow Flashing Double Arrow Sequential Chevron (3 Heads Minimum)	 5 in head, 5 in shaft* 5 in head, 4 in shaft* 5 in head		Same as Type A	 5 in head, 5 in shaft* 5 in head, 3 in shaft* 7 in shaft
Lamp Type	Sealed Beam - 12.8 v, not to exceed 3 A Ave. rated life - 300 h. Min. Candlepower - 1000 candles (1000 cd) Min. 9700 candles (9700 cd) Max.		Same as Type A	Sealed Beam - 12.8 v, not to exceed 3 A Average rated life - 300 h Min. Candlepower - 600 candles (600 cd) at normal voltage and > 250 candles (250 cd) at low voltage
Lens Color	Amber		Amber	Amber
Board Color	Flat Black		Flat Black	Flat Black
Flashing Rate	30-50 F.P.M. (50% on time)		30-50 F.P.M. (50% on time)	25-40 F.P.M. (50% on time)
Message (Left or Right)	Flashing Arrow, Flashing Double Arrow, or Sequential Chevron		Flashing Arrow, Flashing Double Arrow	Flashing Arrow, Flashing Double Arrow, or Warning Bar
Minimum mounting height (to bottom of board)	7 ft (2.1 m)		7 ft (2.1 m)	7 ft (2.1 m)
Where Permitted	Where normal speed limit is less than 40 mph		All rural & urban locations	Stationary Operations Tangent Sections (See 801.15(a)
Required Minimum Visibility	0.5 mi (0.8 km)		1 mi (1.6 km)	1 mi (1.6 km)

* When flashing a single or double arrow(s), the lamp(s) nearest the arrow points shall not be illuminated.
** Either rectangular or arrow shaped black background sign will be permitted.
Note: General specifications for a type B flashing arrow sign are shown in the MUTCD.

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923.05 Temporary Worksite Speed Limit Sign Assembly

The temporary worksite speed limit sign assembly shall be an all weather, self-contained unit designed to display speed limit signs in accordance with the MUTCD and as shown on the plans. The signs shall be installed on frangible posts or mounted on movable stands or trailers in accordance with 910.14(f). The power source shall be capable of operating the strobe lights, without service, for the period which the sign is in effect. An on/off switch will be required.

923.06 Tubular Marker

The vertically placed portion of this device shall consist of high density polyethylene plastic in accordance with ASTM D 5203. The base material shall be butyl rubber in accordance with ASTM D 5900 or high impact polystyrene in accordance with ASTM D 4549. Epoxy material used to attach the base to the roadway surface shall be in accordance with the manufacturer's recommendations. The tubular portion shall be reflectorized with high intensity reflective sheeting in accordance with 919.01(b)1 as shown on the plans.

923.07 Acceptance of Temporary Traffic Control Devices

Temporary traffic control devices will be accepted by visual inspection unless otherwise indicated.

SECTION 924 – WELDING SUPPLIES

924.01 Welding Supplies

(a) Aluminum Alloy Base Metals

1. Bare Wire Electrodes and Welding Rods

Bare wire electrodes for use with the gas metal arc welding process and welding rods for use with the gas tungsten-arc welding process shall be in accordance with AWS A5.10. Tungsten electrodes for the gas tungsten-arc welding process shall be in accordance with the Specifications for Tungsten-Arc Welding Electrodes, ASTM B 297 or AWS A5.12.

2. Filler Metal

Filler metals to be used with particular base metals shall be as shown in the table below. Other filler metals may be used if approved.

Base Metal	Filler Metal
3003 to 3003	ER1100
3004 to 3004	ER4043
5052 to 5052	ER5356*
5083 to 5083	ER5183
5086 to 5086	ER5356*
5456 to 5456	ER5556
6061 to 6061	ER5356*

6063 to 6063	ER5356*
356.0 to 6061	ER4043
356.0 to 6063	ER4043

*ER5183, ER5356, and ER5556 may be used interchangeably for these base metals.

Filler metals shall be kept covered and stored in a dry place at relatively uniform temperatures. Original rod and wire containers shall not be opened until time to be used. Rod and wire shall be free of moisture, lubricant, or other contaminants. Spools of wire temporarily left unused on the welding machine shall be kept covered to avoid contamination by dirt and grease collecting on the wire. If a spool of wire is to be unused for more than a short length of time, it shall be returned to the carton and the carton tightly sealed.

3. Shielding Gases

Shielding gases shall be welding grade or better. Shielding gas for gas metal-arc welding shall be argon, helium, or an approximate 75% helium and 25% argon mixture. Shielding gas for gas tungsten-arc welding done with alternating current shall be argon. Shielding gas for gas tungsten-arc welding done with direct current, straight-polarity, shall be helium.

Hose used for shielding gases shall be made of synthetic rubber or plastic. Hose which has been previously used for acetylene or other gases shall not be used.

SECTION 925 – ITS CONTROLLER CABINET

925.01 General Requirements

ITS controller cabinets shall be constructed such that it has a NEMA 3R rating. The cabinet shall be a rainproof cabinet with dimensions of 66 in. by 24 in. by 30 in. (1670 mm by 610 mm by 762 mm) in depth. The cabinet top shall be crowned or slanted to the sides to prevent standing water.

The cabinet, sunshields, doors, and all panels shall be fabricated of 1/8 in. (3 mm) minimum thickness aluminum. The only exception to this aluminum thickness is the detector rack, which shall be fabricated of 0.090 in. (2.3 mm) thickness aluminum. All exterior seams for the cabinets and doors shall be continuously welded. All exterior welds shall be ground smooth. All edges shall be filed to a radius of 5/16 in. (8 mm) minimum.

The cabinet, sunshields, doors, and all panels shall be fabricated from aluminum sheet in accordance with ASTM B 209 (ASTM B 209M), 5052-H32 aluminum sheet.

Welding on aluminum shall be done by the gas metal arc welding process using bare aluminum welding electrodes. Electrodes shall be in accordance with AWS A5.10 for ER5356 aluminum alloy bare welding electrodes.

Procedures, welders, and welding operators for welding on aluminum shall be qualified in accordance with the requirements of AWS B3.0, “Welding Procedure and Performance Qualification”, and to the practices in accordance with AWS C5.6.

Each aluminum surface shall be finished in accordance with Military Specification MIL-A-8625F(1), “Anodic Coatings for Aluminum and Aluminum Alloys”, type II, class I coating, except that the anodic coating shall have a minimum thickness of 0.0008 in. (0.02033 mm) and a minimum coating weight of 0.04 mg/mm^2. The anodic coating shall be sealed in a 5% aqueous solution of nickel acetate (pH 5.0 to 6.5) for 15 min at 206°F (97°C). The anodized coating shall be silver in color. Prior to applying the anodic coating, the cabinets shall be cleaned and etched as follows:

(a) Clean by immersion in inhibited alkaline cleaner such as Oakite 61A or Diversey 909, or equivalent, 45 to 60 grams per liter, 160°F (71°C) for 5 min.
(b) Rinse in cold water.
(c) Etch in a solution of 11 g of sodium fluoride, plus 30 to 45 g of sodium hydroxide per liter of distilled water at 140 to 150°F (60 to 65°C) for 5 min.
(d) Rinse in cold water.
(e) Dissolve in a 50% by volume nitric acid solution at room temperature for 2 min.
(f) Rinse in cold water.

The cabinet shall have single front and rear doors equipped with a lock. The doors shall use a Corbin lock No. 2, and each cabinet shall be equipped with 2 No. 2 keys. When each door is closed and latched, the door shall be locked. Keys shall be removable in both the locked and unlocked positions. The door handles shall have provision for padlocking in the closed position. The handle shall have a minimum length of 7 in. (180 mm) and shall be provided with a 5/8 in. (16 mm), minimum, steel shank. The handle shall be fabricated of cast aluminum or stainless steel. The cabinet door frame shall be designed so that the latching mechanism shall hold tension on and form a firm seal between the door gasket and the door frame.

The cabinet shall not include a police door nor have provisions for a police door.

The latching mechanism shall be a 3-point cabinet latch with nylon rollers. The center catch and pushrods shall be zinc-plated or cadmium-platted steel. Pushrods shall be turned edgewise at the outer supports and shall be 1/4 by 3/4 in. (6 by 19 mm), minimum. The nylon rollers shall have a minimum diameter of 3/4 in. (19 mm) and shall be equipped with ball bearings.

All cadmium plating shall be in accordance with the Society of Automotive Engineers, SAE-AMS-QQ-P-416, “Plating, Cadmium (Electrodeposited)”. All zinc

plating shall be in accordance with ASTM B 633-98E1, “Electrodeposited Coatings of Zinc on Iron and Steel”.

The door’s hinging shall be 3 or 4 bolt butt hinges. Each hinge shall have a fixed pin. Doors larger than 22 in. (60 mm) in width or 6 sq ft (0.5574 m^2) in area shall be provided with catches to hold the door open at both 90° and 180°, ± 10°. The catches shall be 1/3 in. (8 mm) diameter, minimum, plated steel rods. The catches shall be capable of holding the door open at 90° in a 56 mi/h (90 km/h) wind at an angle perpendicular to the plane of the door. Door hinges, pins, and bolts shall be made of stainless steel. The hinges shall be bolted to the cabinet. The hinge pins and bolts shall not be accessible when the door is closed.

Door gaskets shall be provided on all door openings and shall be dust tight. Gaskets shall be permanently bonded to the metal. The mating surface of the gasket shall be covered with a silicone lubricant to prevent sticking to the mating surface.

Both cabinet doors shall have louvered openings and shall provide ventilation. A filter shall be provided over the louvers and shall include an aluminum filter cover secured with a spring loaded latch as shown on the plans. The filter shall be 12 by 16 by 1 in. (300 by 400 by 25 mm). Two spare filters shall be provided with each cabinet.

The cabinet shall be provided with 2 metal lifting eyes to be used when placing the cabinet on the foundation. Each eye shall have a minimum diameter of 3/4 in. (19 mm) and shall be capable of lifting 990 lbs (450 kg).

Machine screws and bolts shall not protrude beyond the outside wall of the cabinet.

925.02 Model Approval

Each cabinet model shall be approved prior to use. A period of evaluation will commence when the Department receives a preliminary product evaluation form accompanied by the product brochure, detailed electrical schematics, and cabinet assembly drawings. The Operations Support Division will advise the manufacturer or vendor, in writing, of the date and location to deliver the cabinet for which model approval is requested. Electrical schematics for the cabinet, cabinet assembly drawings, and parts lists shall be furnished with the controller when it is submitted to the Operations Support Division for evaluation and testing.

A list of approved models will be maintained by the Department. Only models from the Department’s list of approved ITS Controller Cabinets in effect as of the date of letting, or as otherwise specified, shall be used on the contract. Continued failure and repeated malfunctions of an approved controller or control equipment shall be cause to remove that model from the Department’s list of approved products. A design change to an approved model or cabinet will require re-submittal of the

model for testing, evaluation, and approval. Permanent addition or removal of component parts or wires will be considered to be a design change.

925.03 Warranty

The cabinet, sunshields, doors, and all other exterior surfaces shall carry a 5 year warranty against all material imperfections. All other electrical components and wiring shall carry a 3 year warranty against all imperfections in workmanship or materials.

925.04 Cabinet Accessories

The following accessories shall be furnished and installed with each ITS cabinet.

(a) Rack Frame Assembly

The cabinet shall come equipped with standard Electronic Industries Alliance 19 in. (480 mm) rack frame assembly. The rack frame assembly shall have standard Electronic Industries Alliance vertically spaced threaded holes for attachment of equipment, mounting angles, and shelves. Frame mounting of equipment and shelves shall be available on both door sides of the cabinet.

(b) Equipment Shelves

The equipment rack shall be furnished with 2 adjustable equipment shelves. A 3 in. (75 mm) hole shall be provided in each shelf. The hole shall be fitted with a nylon snap bushing liner with an outside diameter of 3.16 in. (80 mm), inside diameter of 2 1/2 in. (63 mm) and a height of 0.72 in. (18 mm). The shelves shall be constructed of an aluminum screen tack welded between the shelf bottom and upper ribs. The shelves shall be capable of being moved in any location.

(c) Sunshield

An aluminum panel sunshield shall be mounted on standoffs on the top and each side of each cabinet.

(d) Side Panels

Two aluminum side panels shall be provided and mounted on the Electronic Industries Alliance rack parallel to the cabinet sides. One panel shall be designated as the “power distribution panel” and the other panel shall be designated the “heater panel”.

(e) Data Pocket

The data pocket is to be large enough to hold several drawings, a maintenance log notebook, and several pieces of reference material but not so large as to contact any of the installed equipment.

(f) Equipment Labels

The labels shall have a non-reflective, exterior grade, low glare matte surface finish applied to flexible ABS plastic. The labels shall be black with white lettering

and have an engraving depth of 0.002 to 0.003 in. (0.0508 to 0.0762 mm). Labels shall conform to the designations on the cabinet diagrams.

(g) Primary Power Terminal Block

A power distribution terminal block shall be mounted on the power distribution panel. The power distribution block shall be a mechanical 3 pole connector. The connectors for the incoming power shall be able to accept wire sizes between 12 AWG and 2/0 AWG. The load side connectors shall be able to accept wire sizes between 14 AWG and 4 AWG. The rating of the connector shall be 195 amps per pole. The connector elements shall be made from a tin plated, high conductivity aluminum alloy and insulated with high strength thermoplastic housing with a relative temperature index of 260°F (125°C). It shall be rated 600 volt, AL9CU. The dimensions shall be 4 by 5.2 by 3.23 in. (100 by 132 by 82 mm) high. The block shall come with 1 polycarbonate safety cover per pole. Mounting screws shall be No. 10, 0.19 in. (4.83 mm) diameter. The block shall be UL Listed. The terminal block shall be a Burndy Model BDB-11-2/0-3.

(h) Ground Lug

The ground lug mounted on the power distribution panel shall be a heavy-duty 1-hole ground lug, manufactured from electrolytic copper tubing and strip stock. UL Listed and CSA certified for stranded CU wire and for 600 volts. Wire range: 6 AWG to 14 AWG. Bolt size: #10. Tang length shall be 1/2 in. (13 mm). Width shall be 5/16 in. (8 mm). The lug shall be an Ilsco Model SLUH-35.

(i) Ground Bus

Rated to 600 volts. 12 taps per ground bar suitable for wire ranging from 6 AWG to 14 AWG. Main ground connection wire range from 4 AWG to 14 AWG. The ground bar shall be 5 15/16 in. by 3/4 in. by 11/32 in. (150 mm by 19 mm by 9 mm). It shall be UL Listed. The ground bus shall be an Ilsco Model D167-12.

(j) Transient Voltage Surge Suppression

The transient voltage surge suppression, TVSS, shall have individually fused suppression modes, thermal cutout, operational indictors (LED) to indicate loss of protection or circuit fully operational, including neutral-to-ground, AC tracking filter with EMI/RFI filtering up to -50dB from 100 kHz to 100 MHz, and a short circuit current rating of 200,000 rms symmetrical amperes. Surge suppression shall be provided for each mode (L-N or L-L, L-G, N-G). The TVSS shall be UL 1449 Second Edition Listed and UL 1283 Recognized. The TVSS shall have 120/240 volt split phase service voltage and dry contacts for each phase providing a summary alarm. The contacts are terminated in a DB-9 connector.

The surge capacity shall be 80 kA/phase. The response time shall be less than 1/2 nanosecond. The unit shall withstand 5000 category C3 impulses with less than 10% drift. It shall be suitable for use under non-condensing relative humidity range of 0 - 95%. The suppressed voltage rating shall be 330 volts L-N, L-G, N-G and 700 volts L-L. Operating frequency: 47 - 63 Hz. Operating temperature: -40°F to 140°F

(-40°C to +60°C). External mount NEMA 1 standard enclosure. Standard size: 6 in. by 6 in. by 4 in. (150 mm by 150 mm by 100 mm) depth. Weight: 8 lbs (3.63 kg). The TVSS shall be UL 1449 Second Edition Listed, 1283 Recognized and CUL. The unit shall be an Advanced Protection Technologies Model TE/1XF.

(k) Load Center Main Breaker

The load center main breaker shall be enclosed 2 pole, 240/240 volt AC, 60 amp. It shall have a 10,000 rms symmetrical ampere short circuit current rating. The circuit breaker enclosure shall be a Square D, Model QO2TR.

(l) Load Center Panelboard

The panelboard shall be a 120/240 volt AC, 600 volt, 8 pole panelboard. The panelboard shall have a neutral bus bar with 3 10 amp breakers, four 15 amp breakers and 1 spare. The load center shall be main lug only Square D, Model QO. The circuit breakers shall be Square D, Model QO.

(m) GFI Duplex Receptacle

The convenience receptacle shall be a duplex, 3-prong, NEMA type 5-15R grounding type outlet and shall be in accordance with UL Standard 943.

(n) Duplex Receptacle

A standard 3-prong, NEMA type 5-15R grounding type outlet shall be mounted on the power distribution panel.

(o) Terminal Strip Surge Protector

One 48 in. (1,220 mm) surge protected terminal strip with ten 15A outlets shall be furnished and installed.

The terminal strip shall have a low profile aluminum housing measuring 1 1/2 by 1 3/16 in. (38 by 30 mm) and have a 14/3 SJT cord and a NEMA 5-15P plug. The spacing between the outlets shall be 4 in. (100 mm) and the grounding pin shall be positioned so that it is oriented toward the bottom of the cabinet. The unit shall be in accordance with UL Standard 1449 with a 330 volt clamping level. The unit shall be a Wiremold Model 4810BCS with a 6 ft (1.8 m) cord.

(p) Door Open Switches

Four dry-contact, 1-pole-form-C (single-pole, double throw), switches shall be provided and installed. Switch poles are to be electrically isolated. One set of switches shall be rated for 5 amp at 120 volt AC to be used to automatically turn the lights off when both cabinet doors are closed. The other set shall be rated for 1 amp at 5 volt DC and are to be used to send a door open alarm. The switches shall be Omron part No. Z-15GQ-B.

(q) Light Switch

A toggle switch 20 amp, DPDT with 1/8 in. (3 mm) diameter hole in solder lugs shall be provided and installed that will manually switch on the lights regardless of

the door switch position. The switch shall be McGill Mfg. Co., part No. 0121-7013 or Eaton part No. 7803K13.

(r) Lamp Holders

Each cabinet shall be furnished with 2 lamp holders. The UL Listed device shall have a medium phenolic base measuring 1.9 by 1.9 by 1.5 in. (48 by 48 by 38 mm) and rating 660 watt and 250 volt. The lampholder shall be a Leviton Model 9063.

(s) Lamps

Each lamb holder shall be provided with a 100 watt rugged service incandescent bulb.

(t) Circulating Fans

Three 110 cu ft/min (3 m^3/min), 4.7 by 4.7 by 1.5 in. (120 by 120 by 38 mm) cooling fans shall be installed within the cabinet to circulate internal air. The fans shall have an allowable ambient temperature range of 14°F to 158°F (- 10°C to +70°C) and a voltage rating of 115 volt. The fan casings shall be aluminum alloy. The impeller shall be UL94V-O reinforced plastic. The fans shall have ball bearings and an impedance protected, shaded pole induction motor. The fans shall not be exposed or routed to the external environment. The environmental controller shall control fan operation. The fans shall activate at 80°F (27°C). The fans shall be NMB Model 4715FS-12T-B50-D00.

(u) Enclosure Heaters

Two 250 watt ceramic insulated strip heaters shall be furnished and installed in the cabinet to protect against condensation damage and to keep the electronic components above freezing in the winter. The strip heaters shall have a seamless stainless steel sheath with ceramic element support and magnesium oxide packing. The environmental controller shall control enclosure heater operation. Heating strips shall not be installed on either door. The heaters shall be 8 in. (200 mm) long by 1 1/2 in. (38 mm) wide and shall have 2 wire terminals. The strip heaters shall be UL Recognized. The heaters shall be Hotwatt Model CS-8.

(v) Heater Relays

Two solid state SPST-NO heater relays shall be installed on the power distribution side panel. Load current range 0.04 to 25 amp, 1-cycle surge 250 amp peak. Rated for 120 volt AC and UL Recognized.

(w) Thermostats

The cabinet shall be furnished with 2 thermostats installed. One thermostat shall activate the enclosure heaters and circulating fan with the internal cabinet temperature goes below 35°F (2°C). The other thermostat shall activate the 2 circulating fans at the top of the cabinet when the internal cabinet temperature goes above 80°F (27°C). The thermostats shall be Thermodisc, Type AL-1.

(x) Detector Card DIN Rail Terminal Blocks

Double-deck compression clamp DIN rail terminal blocks shall be hard wired to the Canoga Card Racks. A total of 64 terminal blocks shall be mounted to an aluminum panel that is secured to the Electronic Industries Alliance rack. The terminal blocks shall allow wires between 24 AWG and 10 AWG. Each measures 2.5 in. by 0.2 in. (65 mm by 6 mm). The terminal blocks shall be the Entretec part number 011527122 type M 4/6 D2.

(y) I/O Module

An isolated 8-Bit digital input module shall be provided and installed. It shall have 6 fully isolated inputs and 2 share common ground inputs. High voltage inputs. Logic levels: LOW +1.0 volt DC max, HIGH +3.5 to +30 volt DC. Input impedance: 3 kohm. Input isolation: 3000 vrms. Power consumption: 0.4 watt. Operating temperature: 14°F to 158°F (-10°C to 70°C). The I/O module shall be a Measurement Computing, Model CB-7052.

(z) Detector Card Rack

The detector card rack shall be as shown on the plans.

(aa) Padlocks

Padlocks shall be classified as a high security padlock with hardened shackles, laminated body, a minimum 4 pin cylinder, and come complete with a weather cover to protect the lock body and cylinder from sand, dirt, water, and ice. A wafer cylinder shall not be used. Keys shall not be provided with each padlock supplied. All padlocks shall be keyed alike and shall be keyed identical to the keys currently in use by the Department. The main body width of the padlock shall not exceed 3 in. (75 mm) and shall have a shackle length of 2 1/4 to 3 3/4 in. (56 to 94 mm) and a shackle diameter of 5/16 in. (8 mm). For padlock information, contact the ITS Operations Engineer.

(bb) Other Cabinet Equipment

In addition to the equipment specified above, the cabinet shall be furnished with all ancillary equipment, brackets, wiring ducts, hardware, etc, as is necessary to provide a neat and finished appearance. These items along with all associated cables, connectors, wiring, etc. shall be labeled on the required submittal drawings.

925.05 Cabinet Wiring

All conductors used in ITS cabinet wiring shall be in accordance with the following color-code requirements.

(a) The AC neutral conductor of a circuit shall be identified by a continuous white or natural gray color.

(b) The equipment grounding conductor shall be identified by a continuous green color or by a continuous green color with 1 or more yellow stripes.

(c) The ungrounded conductors shall be identified by any color not specified in a or b above.

All wire shall be type THHN with color and gage as shown on the plans with the exception of the microloop card rack wiring which will be 2-pair twisted with a shield and plentium rated.

Connectors used for interconnecting various portions of circuits together shall be designed and constructed for the application involved. Connectors shall be designed to provide positive connection of all circuits, and easy insertion and removal of mating contacts. Connections shall be permanently keyed to prevent improper connection of circuits.

925.06 Drawings

The Contractor shall provide 3 sets of cabinet wiring diagrams. The diagrams shall be non-proprietary and shall identify all circuits, as installed, in such a manner as to be readily interpreted. In addition, 3 cabinet drawings shall be provided with each cabinet to show the component layout in elevation views from the front and rear. An elevation of both aluminum side panels shall also be shown. Elevation views are to be detailed down to the level showing mounting brackets and wiring ducts. All other mounting hardware and cable ties need not be shown. All cables and connectors shall be clearly labeled. Any data sheets for internal cabinet components that have been made available by the manufacturer shall also be provided. One set of the wiring diagram and cabinet drawing shall be placed in a heavy-duty side-opening clear plastic pouch and inserted into the data pocket. The pouch shall be of such design and material that it provides adequate storage and access to the drawings. The other 2 sets of drawings shall be delivered to the attention of the ITS Field Engineer.

SECTION 926 – MISCELLANEOUS MATERIALS

926.01 Flexible Delineator Posts

Flexible delineator posts shall be made of high density polyethylene plastic in accordance with ASTM D 5203. The post shall be straight along its center line and have a smooth surface free from cracks, flaws, seams, laps, blisters, and edges affecting the strength, durability, or appearance. The cross section width shall not exceed 6 in. (150 mm).

The reflective sheeting on the post shall be in accordance with 919.01(b) and shall have minimum dimensions of 3 by 8 in. (75 by 200 mm). Reflective sheeting shall be applied directly to the post and protected in a manner that minimizes damage to the sheeting upon impact.

The color of the post and the reflective sheeting shall match the color of the adjacent edgeline.

When installed, the flexible post shall withstand, without damage, 5 vehicle impacts at ambient air temperatures of 32°F (0°C) and at 85°F (30°C) each. The vehicle impacts shall include both bumper and tire impacts. It shall be able to bend to an angle of 85° from vertical and right itself to within 10° of the vertical immediately and stand erect within 4 h within the same ambient air temperature range.

Only flexible delineator posts from the Department's list of approved Flexible Delineator Posts shall be used. Flexible delineator posts will be placed and maintained on the Department's approved list in accordance with ITM 806, procedure G.

926.02 Delineators

(a) Acrylic Plastic Delineators

Acrylic plastic delineators shall consist of a hermetically sealed optical system with a circular plastic face and prismatic molded rear surface. The optical system shall have a minimum diameter of 3 in. (75 mm) with a minimum area of approximately 7 sq in. (4,520 mm^2). The trademark of the manufacturer shall be molded legibly into the face of the lens. Color shall be clear, red, or yellow in daylight as well as when viewed by reflected light at night. Photometric or optical requirements shall equal or exceed the following minimum values.

Observation Angle Degrees	Entrance Angle Degrees	Specific Intensity Candle Power/Footcandle (Candelas/lux)		
		Clear	Yellow	Red
0.1	0	119 (11.1)	79 (7.3)	28 (2.6)
0.1	20	47 (4.4)	28 (2.6)	11 (1.0)
Note: The observation angle is the angle at reflector between the observer's line of sight and direction of light incident on reflector. The entrance angle is the angle at the reflector between the direction of light incident on it and the direction of reflector axis. The specific intensity is the candlepower returned at the chosen observation angle by a reflector or reflective surface for each footcandle (lux) of illumination at the reflector.				

The opaque backing shall be made from aluminum sheet having a minimum thickness of 0.02 in. (0.5 mm). The backing shall form an integral part of the delineator and shall retain the optical system securely. A single aluminum grommeted hole in the center of the reflector shall be provided for mounting. The inside diameter of the grommet hole shall be 3/16 in. (5 mm).

Only acrylic plastic delineator models and colors from the Department's list of approved Delineators shall be used. Acrylic plastic delineators will be placed and maintained on the Department's approved list in accordance with ITM 806, procedure G.

(b) Reflective Sheeting Delineators

Reflective sheeting delineators shall consist of reflective sheeting affixed to an aluminum backing material. The white delineator shall be 3 by 8 in. ± 1/8 in. (75 by 200 mm ± 3 mm). The yellow delineator shall be 5 by 5 in. ± 1/8 in. (125 by 125 mm ± 3 mm). The backing material shall be in accordance with 919.01(a) except the minimum thickness shall be 0.064 in. (1.6 mm). Reflective sheeting shall be in accordance with 919.01(b).

There shall be 2 mounting holes, 3/16 in. (5 mm) in diameter, with one at the top and one at the bottom. The holes shall be 6 in. ± 1/16 in. (150 mm ± 2 mm) center to center and in the corners of the square units. Completed delineators shall be dip coated with a high gloss clear finish coat as specified and supplied by the sheeting manufacturer. The finished units shall be clean cut, sharp, and have essentially a plane surface.

Material furnished under this specification shall be covered by a type C certification in accordance with 916.

(c) Barrier Delineators

The delineators shall consist of a transparent acrylic plastic face, herein referred to as the lens, and an opaque back fused to the lens under heat and pressure around the entire perimeter to form a unit permanently sealed against dust, water, and water vapor. The reflector lens shall be colorless.

The lens shall consist of a smooth front surface free from projection or indentations other than for purposes of identification or orientation of the reflector. The rear surface shall have a prismatic configuration such that it will effect total internal reflection of light. The manufacturer's trademark shall be molded legibly into the face of the lens.

The reflector lens, having a minimum effective reflex area of 6.5 sq in. (4,194 mm^2), shall be methyl methacrylate in accordance with Federal Specification LP-380C, type 1, Class 3. Photometric or optical requirements shall equal or exceed the minimum values in 926.02(a).

Only barrier delineator models and colors from the Department's list of approved Delineators shall be used. Barrier delineators will be placed and maintained on the Department's approved list in accordance with ITM 806, procedure G.

(d) Temporary Barrier Delineator

Temporary barrier delineators shall consist of a type III sheeting in accordance with 919.01(b)1 affixed to a reboundable substrate. The delineator shall be 8 by 12 in. (200 by 300 mm) vertically mounted. The mounting bracket used to affix the delineator to the barrier shall not be more than 3 in. (75 mm) vertical.

926.03 Alternate Material Guardrail Blocks

Non-timber blockouts shall be dimensioned as tested and shall be used with the type of guardrail as tested in accordance with NCHRP 350. Blockouts shall be accompanied by a certification from the manufacturer stating the blockouts furnished have the same chemistry, mechanical properties, and geometry as those certified to have passed the NCHRP 350 crash test and have been certified by the FHWA to be acceptable for use on NHS facilities.

Alternate material blockouts meeting the criteria may be used interchangeably with timber blockouts as long as the line and grade of the face of the guardrail is true to that shown on the plans.