# Technical Specifications - IFB

# Brownsville Navigation District

# Cargo Dock No. 3 Construction

HDR Project No. 10320226

*Port of Brownsville, Brownsville, Texas*
September 22, 2023

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## SEALS AND SIGNATURES

**The seal and signature below applies to the following Specifications divisions and sections of this Specifications Package:**

DIVISION 01 - GENERAL REQUIREMENTS
01 33 00 SUBMITTAL PROCEDURES

DIVISION 02 - EXISTING CONDITIONS
02 22 13 CONSTRUCTION VIBRATION MONITORING

DIVISION 03 - CONCRETE
03 31 30 MARINE CONCRETE
03 45 33 PRECAST STRUCTURAL CONCRETE

DIVISION 05 - METALS
05 50 14 STRUCTURAL METAL FABRICATIONS

DIVISION 09 - FINISHES
09 97 10.00 10 METALLIC COATINGS

DIVISION 31 - EARTHWORK
31 62 16.13 STEEL PIPE PILES

DIVISION 35 - WATERWAY AND MARINE CONSTRUCTION
35 59 13.16 MOLDED MARINE FENDERS


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**The seal and signature below applies to the following Specifications divisions and sections of this Specifications Package:**

DIVISION 31 - EARTHWORK
31 10 00 SITE CLEARING
31 11 00 CLEARING AND GRUBBING
31 23 00.00 20 EXCAVATION AND FILL

DIVISION 32 - EXTERIOR IMPROVEMENTS
32 12 13 BITUMINOUS TACK AND PRIME COATS
32 17 23 PAVEMENT MARKINGS

DIVISION 33 - UTILITIES
33 40 00 STORMWATER UTILITIES


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Engineer's seal and signature does not apply to the documents that comprise Division 00, Bidding and Contracting Requirements.

It is a violation of applicable laws and regulations governing professional licensing and registration for any person, unless acting under the direction of the licensed and registered design professional(s) indicated above, to alter in any way the Specifications in this project manual.

## END OF SEALS AND SIGNATURES

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SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.1 SUMMARY

1.1.1 Submittal Information

The Owner may request submittals in addition to those specified when deemed necessary to adequately describe the work covered in the respective sections. Each submittal is to be complete and in sufficient detail to allow ready determination of compliance with contract requirements.

Units of weights and measures used on all submittals are to be the same as those used in the contract drawings and as specified in respective specification sections.

Contractor is to check and approve all items before submittal and stamp, sign, and date indicating action taken. Proposed deviations from the contract requirements are to be clearly identified. Include within submittals items such as: Contractor's, manufacturer's, or fabricator's drawings; descriptive literature including (but not limited to) catalog cuts, diagrams, operating charts or curves; test reports; test cylinders; samples; O&M manuals (including parts list); certifications; warranties; and other such required submittals.

1.1.2 Submission of Submittals

Schedule and provide submittals requiring Owner approval before acquiring the material or equipment covered thereby. Pick up and dispose of samples not incorporated into the work in accordance with manufacturer's Safety Data Sheets (SDS) and in compliance with existing laws and regulations.

1.2 DEFINITIONS

1.2.1 Submittal Descriptions (SD)

Submittal requirements are specified in the technical sections. Examples and descriptions of submittals identified by the Submittal Description (SD) numbers and titles follow:

SD-01 Preconstruction Submittals

Submittals that are required prior to start of construction (work), issuance of contract notice to proceed by Owner, or commencing work on site.

Preconstruction Submittals include schedules and a tabular list of locations, features, and other pertinent information regarding products, materials, equipment, or components to be used in the work.

Certificates Of Insurance

Surety Bonds

List Of Proposed Subcontractors

List Of Proposed Products

Project Network Analysis Schedule (NAS)

Submittal Register

Schedule Of Prices

Health & Safety Plan

Work Plan

Quality Control (QC) plan

Environmental Protection Plan

SD-02 Shop Drawings

Drawings, diagrams and schedules specifically prepared to illustrate some portion of the work.

Diagrams and instructions from a manufacturer or fabricator for use in producing the product and as aids to the Contractor for integrating the product or system into the project.

Drawings prepared by or for the Contractor to show how multiple systems and interdisciplinary work will be coordinated.

SD-03 Product Data

Catalog cuts, illustrations, schedules, diagrams, performance charts, instructions and brochures illustrating size, physical appearance and other characteristics of materials, systems or equipment for some portion of the work.

Samples of warranty language when the contract requires extended product warranties.

SD-04 Samples

Fabricated or unfabricated physical examples of materials, equipment or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standards by which the work can be judged.

Color samples from the manufacturer's standard line (or custom color samples if specified) to be used for the project.

Field samples and mock-ups constructed on the project site establish standards ensuring work can be judged. Includes assemblies or portions of assemblies that are to be incorporated into the project and those that will be removed at conclusion of the work.

SD-05 Design Data

Design calculations, mix designs, analyses or other data pertaining to a part of work.

SD-06 Test Reports

Report signed by authorized official of testing laboratory that a material, product or system identical to the material, product or system to be provided has been tested in accord with specified requirements.

Report that includes findings of a test required to be performed on an actual portion of the work or prototype prepared for the project before shipment to job site.

Report that includes finding of a test made at the job site or on sample taken from the job site, on portion of work during or after installation.

Investigation reports

Daily logs and checklists

Final acceptance test and operational test procedure

SD-07 Certificates

Statements printed on the manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that the product, system, or material meets specification requirements. Must be dated after award of project contract and clearly name the project.

Document required of Contractor, or of a manufacturer, supplier, installer or Subcontractor through Contractor. The document purpose is to further promote the orderly progression of a portion of the work by documenting procedures, acceptability of methods, or personnel qualifications.

Confined space entry permits

Text of posted operating instructions

SD-08 Manufacturer's Instructions

Preprinted material describing installation of a product, system or material, including special notices and (SDS)concerning impedances, hazards and safety precautions.

SD-09 Manufacturer's Field Reports

Documentation of the testing and verification actions taken by manufacturer's representative at the job site, in the vicinity of the job site, or on a sample taken from the job site, on a portion of the work, during or after installation, to confirm compliance with manufacturer's standards or instructions. The documentation must be signed by an authorized official of a testing laboratory or agency and state the test results; and indicate whether the material, product, or system has passed or failed the test.

Factory test reports.

SD-10 Operation and Maintenance Data

Data provided by the manufacturer, or the system provider, including manufacturer's help and product line documentation, necessary to maintain and install equipment, for operating and maintenance use by facility personnel.

Data required by operating and maintenance personnel for the safe and efficient operation, maintenance and repair of the item.

Data incorporated in an operations and maintenance manual or control system.

SD-11 Closeout Submittals

Documentation to record compliance with technical or administrative requirements or to establish an administrative mechanism.

Special requirements necessary to properly close out a construction contract. For example, Record Drawings and as-built drawings.

1.2.2 Approving Authority

Office or designated person authorized to approve the submittal.

1.2.3 Work

As used in this section, on-site and off-site construction required by contract documents, including labor necessary to produce submittals, construction, materials, products, equipment, and systems incorporated or to be incorporated in such construction. In exception, excludes work to produce SD-01 submittals.

1.3 SUBMITTALS

Submit the following in accordance with this section:

SD-01 Preconstruction Submittals

Submittal Register

1.4 SUBMITTAL CLASSIFICATION

1.5 PREPARATION

1.5.1 Transmittal Form

Transmit each submittal using the transmittal form prescribed by the Owner. Include all information prescribed by the transmittal form and required in paragraph IDENTIFYING SUBMITTALS. Use the submittal transmittal forms to record actions regarding samples.

1.5.2 Identifying Submittals

The Contractor must prepare, review and stamp submittals, including those provided by a subcontractor, before submittal to the Owner.

Identify submittals with the following information permanently adhered to or noted on each separate component of each submittal and noted on transmittal form. Mark each copy of each submittal identically, with the

following:

a. Project title and location

b. Construction contract number

c. Dates of the drawings and revisions

d. Name, address, and telephone number of Subcontractor, supplier, manufacturer, and any other Subcontractor associated with the submittal.

e. Section number of the specification by which submittal is required

f. Submittal description (SD) number of each component of submittal

g. For a resubmission, add alphabetic suffix on submittal description, for example, submittal 18 would become 18A, to indicate resubmission

h. Product identification and location in project.

1.5.3 Submittal Format

1.5.3.1 Format of SD-01 Preconstruction Submittals

When the submittal includes a document that is to be used in the project, or is to become part of the project record, other than as a submittal, do not apply the Contractor's approval stamp to the document itself, but to a separate sheet accompanying the document.

Provide data in the unit of measure used in the contract documents.

1.5.3.2 Format for SD-02 Shop Drawings

Provide shop drawings not less than 8 1/2 by 11 inches nor more than 30 by 42 inches, except for full-size patterns or templates. Prepare drawings to accurate size, with scale indicated, unless another form is required. Ensure drawings are suitable for reproduction and of a quality to produce clear, distinct lines and letters, with dark lines on a white background.

Dimension drawings, except diagrams and schematic drawings. Prepare drawings demonstrating interface with other trades to scale. Use the same unit of measure for shop drawings as indicated on the contract drawings. Identify materials and products for work shown.

Submit an electronic copy of drawings in PDF format in sets.

1.5.3.2.1 Drawing Identification

Include on each drawing the drawing title, number, date, and revision numbers and dates, in addition to information required in paragraph IDENTIFYING SUBMITTALS.

Number drawings in a logical sequence. Each drawing is to bear the number of the submittal in a uniform location next to the title block. Place the Owner contract number in the margin, immediately below the title block, for each drawing.

1.5.3.3 Format of SD-03 Product Data

Present product data submittals for each section as a complete, bound volume. Include a table of contents, listing the page and catalog item numbers for product data.

Indicate, by prominent notation, each product that is being submitted; indicate the specification section number and paragraph number to which it pertains.

1.5.3.3.1 Product Information

Supplement product data with material prepared for the project to satisfy the submittal requirements where product data does not exist. Identify this material as developed specifically for the project, with information and format as required for submission of SD-07 Certificates.

Provide product data in units used in the Contract documents. Where product data are included in preprinted catalogs with another unit, submit the dimensions in contract document units, on a separate sheet.

1.5.3.3.2 Standards

Where equipment or materials are specified to conform to industry or technical-society reference standards of such organizations as the American National Standards Institute (ANSI), ASTM International (ASTM), National Electrical Manufacturer's Association (NEMA), Underwriters Laboratories (UL), or Association of Edison Illuminating Companies (AEIC), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Owner. State on the certificate that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.5.3.3.3 Data Submission

Collect required data submittals for each specific material, product, unit of work, or system into a single submittal that is marked for choices, options, and portions applicable to the submittal. Mark each copy of the product data identically. Partial submittals will not be accepted for expedition of the construction effort.

Submit the manufacturer's instructions before installation.

1.5.3.4 Format of SD-04 Samples

1.5.3.4.1 Sample Characteristics

Furnish samples in the following sizes, unless otherwise specified or unless the manufacturer has prepackaged samples of approximately the same size as specified:

a. Sample of Equipment or Device: Full size.

b. Sample of Materials Less Than 2 by 3 inches: Built up to 8 1/2 by 11 inches.

c. Sample of Materials Exceeding 8 1/2 by 11 inches: Cut down to 8 1/2 by 11 inches and adequate to indicate color, texture, and material variations.

d. Sample of Linear Devices or Materials: 10 inch length or length to be supplied, if less than 10 inches. Examples of linear devices or materials are conduit and handrails.

e. Sample Volume of Nonsolid Materials: Pint. Examples of nonsolid materials are sand and paint.

f. Color Selection Samples: 2 by 4 inches. Where samples are specified for selection of color, finish, pattern, or texture, submit the full set of available choices for the material or product specified. Sizes and quantities of samples are to represent their respective standard unit.

g. Sample Panel: 4 by 4 feet.

h. Sample Installation: 100 square feet.

1.5.3.4.2 Sample Incorporation

Reusable Samples: Incorporate returned samples into work only if so specified or indicated. Incorporated samples are to be in undamaged condition at the time of use.

Recording of Sample Installation: Note and preserve the notation of any area constituting a sample installation, but remove the notation at the final clean-up of the project.

1.5.3.4.3 Comparison Sample

Samples Showing Range of Variation: Where variations in color, finish, pattern, or texture are unavoidable due to nature of the materials, submit sets of samples of not less than three units showing extremes and middle of range. Mark each unit to describe its relation to the range of the variation.

When color, texture, or pattern is specified by naming a particular manufacturer and style, include one sample of that manufacturer and style, for comparison.

1.5.3.5 Format of SD-05 Design Data

Provide design data and certificates on 8 1/2 by 11 inch paper. Provide a bound volume for submittals containing numerous pages.

1.5.3.6 Format of SD-06 Test Reports

Provide reports on 8 1/2 by 11 inch paper in a complete bound volume.

By prominent notation, indicate each report in the submittal. Indicate the specification number and paragraph number to which each report pertains.

1.5.3.7 Format of SD-07 Certificates

Provide design data and certificates on 8 1/2 by 11 inch paper. Provide a bound volume for submittals containing numerous pages.

1.5.3.8 Format of SD-08 Manufacturer's Instructions

Present manufacturer's instructions submittals for each section as a complete, bound volume. Include the manufacturer's name, trade name, place of manufacture, and catalog model or number on product data. Also include applicable federal, military, industry, and technical-society publication references. If supplemental information is needed to clarify the manufacturer's data, submit it as specified for SD-07 Certificates.

Submit the manufacturer's instructions before installation.

1.5.3.8.1 Standards

Where equipment or materials are specified to conform to industry or technical-society reference standards of such organizations as the American National Standards Institute (ANSI), ASTM International (ASTM), National Electrical Manufacturer's Association (NEMA), Underwriters Laboratories (UL), or Association of Edison Illuminating Companies (AEIC), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Owner. State on the certificate that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.5.3.9 Format of SD-09 Manufacturer's Field Reports

Provide reports on 8 1/2 by 11 inch paper in a complete bound volume.

By prominent notation, indicate each report in the submittal. Indicate the specification number and paragraph number to which each report pertains.

1.5.3.10 Format of SD-11 Closeout Submittals

When the submittal includes a document that is to be used in the project or is to become part of the project record, other than as a submittal, do not apply the Contractor's approval stamp to the document itself, but to a separate sheet accompanying the document.

Provide data in the unit of measure used in the contract documents.

1.5.4 Source Drawings for Shop Drawings

1.5.4.1 Source Drawings

The entire set of source drawing files (DWG) will not be provided to the Contractor. Request the specific Drawing Number for the preparation of shop drawings. Only those drawings requested to prepare shop drawings will be provided. These drawings are provided only after award.

1.5.4.2 Terms and Conditions

Data contained on these electronic files must not be used for any purpose other than as a convenience in the preparation of construction data for the referenced project. Any other use or reuse is at the sole risk of the Contractor and without liability or legal exposure to the Owner. The Contractor must make no claim, and waives to the fullest extent permitted by law any claim or cause of action of any nature against the Owner,

Engineer, or any of Owner's subconsultants that may arise out of or in connection with the use of these electronic files. The Contractor must, to the fullest extent permitted by law, indemnify and hold the Owner harmless against all damages, liabilities, or costs, including reasonable attorney's fees and defense costs, arising out of or resulting from the use of these electronic files.

These electronic source drawing files are not construction documents. Differences may exist between the source drawing files and the corresponding construction documents. The Owner makes no representation regarding the accuracy or completeness of the electronic source drawing files, nor does it make representation to the compatibility of these files with the Contractor hardware or software. The Contractor is responsible for determining if any conflict exists. In the event that a conflict arises between the signed and sealed construction documents and the furnished source drawing files, the signed and sealed construction documents govern. Use of these source drawing files does not relieve the Contractor of the duty to fully comply with the contract documents, including and without limitation the need to check, confirm and coordinate the work of all contractors for the project. If the Contractor uses, duplicates or modifies these electronic source drawing files for use in producing construction data related to this contract, remove all previous indication of ownership (seals, logos, signatures, initials and dates).

### 1.5.5 Electronic File Format

Provide submittals in electronic format, with the exception of material samples required for SD-04 Samples items. Compile the submittal file as a single, complete document, to include the Transmittal Form described herein. Name the electronic submittal file specifically according to its contents, and coordinate the file naming convention with the Owner. Electronic files must be of sufficient quality that all information is legible. Use PDF as the electronic format. Generate PDF files from original documents with bookmarks so that the text included in the PDF file is searchable and can be copied. Index and bookmark files exceeding 30 pages to allow efficient navigation of the file. When required, the electronic file must include a valid electronic signature or a scan of a signature.

## 1.6 INFORMATION ONLY SUBMITTALS

Normally submittals for information only will not be returned. Response from the Owner is not required on information only submittals. The Owner reserves the right to require the Contractor to resubmit any item found not to comply with the contract. This does not relieve the Contractor from the obligation to furnish material conforming to the plans and specifications.

## 1.7 PROJECT SUBMITTAL REGISTER AND DATABASE

Prepare and maintain submittal register, as the work progresses. A submittal register showing items of equipment and materials for which submittals are required by the specifications is provided as an attachment. This list may not be all inclusive and additional submittals may be required. Contractor is responsible to ensure all submittal identified in each specification section are accounted for in the submittal register for the project.

The Contractor is to track all submittals by maintaining a complete list, including completion of all data columns, including dates on which submittals are received and returned by the Owner.

The Contractor is required to complete the submittal register and submit it to the Owner for review within 30 calendar days after Notice to Proceed. The approved submittal register will serve as a scheduling document for submittals and will be used to control submittal actions throughout the contract period. Coordinate the submit dates and need dates with dates in the Contractor prepared progress schedule. Submit monthly or until all submittals have been satisfactorily completed, updates to the submittal register showing the Contractor action codes and actual dates with Owner action codes. Revise the submittal register when the progress schedule is revised and submit both for review by Owner.

1.7.1 Action Codes

Entries for columns (j) and (o) are to be used as follows (others may be prescribed by the Transmittal Form):

"A" - "NO EXCEPTION TAKEN"

"B" - "MAKE CORRECTIONS NOTED"

"C" - "REVISE AND RESUBMIT"

"D" - "REJECTED"

"E" - "NO ACTION REQUIRED BY OWNER

1.7.2 Delivery of Copies

Submit an updated electronic copy of the submittal register to the Owner with each invoice request. Provide an updated Submittal Register monthly regardless of whether an invoice is submitted.

1.8 VARIATIONS

Variations from contract requirements require Owner approval.

1.8.1 Considering Variations

Discussion of variations with the Owner before submission will help ensure that functional and quality requirements are met and minimize rejections and resubmittals. For variations that include design changes or some material or product substitutions, the Owner may require an evaluation and analysis by a licensed professional engineer hired by the contractor.

Specifically point out variations from contract requirements in a transmittal letter. Failure to point out variations may cause the Owner to require rejection and removal of such work at no additional cost to the Owner.

1.8.2 Proposing Variations

When proposing variation, deliver a submittal, clearly marked as a "VARIATION" to the Owner, with documentation illustrating the nature and features of the variation including any necessary technical submittals and why the variation is desirable and beneficial to Owner. If lower cost is a benefit, also include an estimate of the cost savings. In addition to documentation required for variation, include the submittals required for the item. Clearly mark the proposed variation in all documentation.

Specifically point out variations from contract requirements in a transmittal letter. Failure to point out variations may cause the Owner to require rejection and removal of such work at no additional cost to the Owner.

1.8.3 Warranting that Variations are Compatible

When delivering a variation for approval, the Contractor warrants that this contract has been reviewed to establish that the variation, if incorporated, will be compatible with other elements of work.

1.8.4 Review Schedule Extension

In addition to the normal submittal review period, a period of 14 calendar working days will be allowed for the Owner to consider submittals with variations.

1.9 SCHEDULING

Schedule and submit concurrently product data and shop drawings covering component items forming a system or items that are interrelated. Submit pertinent certifications at the same time. No delay damages or time extensions will be allowed for time lost in late submittals.

a. Coordinate scheduling, sequencing, preparing, and processing of submittals with performance of work so that work will not be delayed by submittal processing. The Contractor is responsible for additional time required for Owner reviews resulting from required resubmittals. The review period for each resubmittal is the same as for the initial submittal.

b. Submittals required by the contract documents are listed on the submittal register. If a submittal is listed in the submittal register but does not pertain to the contract work, the Contractor is to include the submittal in the register and annotate it "N/A" with a brief explanation. Review by the Owner does not relieve the Contractor of supplying submittals required by the contract documents but that have been omitted from the register or marked "N/A."

c. Resubmit the submittal register and annotate it monthly with actual submission and review dates. When all items on the register have been fully reviewed, no further resubmittal is required.

Owner review will be completed within 14 calendar working days after the date of submission.

1.9.1 Reviewing, Certifying, and Approving Authority

The Contractor is responsible for checking and reviewing and certifying that submittals are in compliance with contract requirements.

1.9.2 Constraints

Conform to provisions of this section, unless explicitly stated otherwise for submittals listed or specified in this contract.

Submit complete submittals for each definable feature of the work. At the same time, submit components of definable features that are interrelated as

a system.

When acceptability of a submittal is dependent on conditions, items, or materials included in separate subsequent submittals, the submittal will be returned without review.

Review of a separate material, product, or component does not imply review of the assembly in which the item functions.

1.9.3 Contractor Responsibilities

a. Review submittals for conformance with project design concepts and compliance with contract documents.

b. Ensure that material is clearly legible.

c. Stamp each sheet of each submittal with a certifying statement or an approving statement, except that data submitted in a bound volume or on one sheet printed on two sides may be stamped on the front of the first sheet only.

   Contractor will certify submittals forwarded to the Owner with the following certifying statement:

   "I hereby certify that the (equipment) (material) (article) shown and marked in this submittal is that proposed to be incorporated with Contract Number _____ is in compliance with the contract drawings and specification, can be installed in the allocated spaces, and is submitted for Owner review.

   Certified by Contractor _____, Date _____
   (Signature when applicable)

d. Update the submittal register as submittal actions occur, and maintain the submittal register at the project site until final acceptance of all work by the Owner.

e. Retain a copy of completed submittals at project site, including CONTRACTOR's copy of samples.

1.10 REVIEW NOTATIONS

Submittals will be returned to the Contractor with the following notations:

a. Submittals marked "A" - "NO EXCEPTION TAKEN" authorize proceeding with the work covered.

b. Submittals marked "B" - "MAKE CORRECTIONS NOTED" authorize proceeding with the work covered provided that the Contractor makes the noted corrections.

c. Submittals marked "C" - "REVISE AND RESUBMIT" indicate noncompliance with the contract requirements or design concept, or that submittal is incomplete. Resubmit with appropriate changes. No work shall proceed for this item until resubmittal is reviewed by owner.

d. Submittals marked "D" - "REJECTED" indicate incomplete submittal or noncompliance with the contract requirements or design concept. Resubmit with appropriate changes. Do not proceed with work for this

item until the resubmittal is reviewed by the Owner.

e. Submittals marked "E" - "NO ACTION REQUIRED BY OWNER" indicate that submittals have been received by Owner and is for information-only and for Owner's records.

1.11 REJECTED SUBMITTALS

Make corrections required by the Owner. If corrections are made to shop drawings, corrections shall be noted by clouding all corrections or changes. It will be assumed that, if not clouded, no revisions have been made and no "acceptance" is given to unclouded revisions.

If changes are necessary to submittals, make such revisions and resubmit in accordance with the procedures above. No item of work requiring a submittal change is to be accomplished until the changed submittals are reviewed by Owner.

1.12 REVIEWED SUBMITTALS

The Owner's review of submittals is not to be construed as a complete check, and indicates only that the general method of construction, materials, detailing, and other information are satisfactory and meet the requirements of contract drawings and specifications.

Owner's review of a submittal does not relieve the Contractor of the responsibility for meeting the contract requirements or for any error that may exist, because under the Quality Control (QC) requirements of this contract, the Contractor is responsible for ensuring information contained with in each submittal accurately conforms with the requirements of the contract documents.

After submittals have been reviewed by the Owner, no resubmittal for the purpose of substituting materials or equipment will be considered unless accompanied by an explanation of why a substitution is necessary.

1.13 REVIEWED SAMPLES

Review of a sample is only for the characteristics or use named in such review and is not be construed to change or modify any contract requirements. Before submitting samples, provide assurance that the materials or equipment will be available in quantities required in the project. No change or substitution will be permitted after a sample has been reviewed.

Match the reviewed samples for materials and equipment incorporated in the work. If requested, reviewed samples, including those that may be damaged in testing, will be returned to the Contractor, at its expense, upon completion of the contract. Samples not meeting contract requirements will also be returned to the Contractor at its expense, if so requested.

Failure of any materials to pass the specified tests will be sufficient cause for refusal to consider, under this contract, any further samples of the same brand or make as that material. The Owner reserves the right to disapprove any material or equipment that has previously proved unsatisfactory in service.

Samples of various materials or equipment delivered on the site or in place may be taken by the Owner for testing. Samples failing to meet contract

requirements will automatically void previously reviewed samples. Replace such materials or equipment to meet contract requirements.

1.14 PROGRESS SCHEDULE

1.14.1 Bar Chart

a. Submit the progress chart, for review by Owner, at the Preconstruction Conference in one reproducible and 10 copies.

b. Prepare the progress chart in the form of a bar chart utilizing form "Construction Progress Chart" or comparable format acceptable to the Owner.

c. Include no less than the following information on the progress chart:

(1) Break out by major headings for primary work activity.

(2) A line item break out under each major heading sufficient to track the progress of the work.

(3) A line item showing contract finalization task which includes punch list, clean-up and demolition, and final construction drawings.

(4) A materials bar and a separate labor bar for each line item. Both bars will show the scheduled percentage complete for any given date within the contract performance period. Labor bar will also show the number of men (man-load) expected to be working on any given date within the contract performance period.

(5) The estimated cost and percentage weight of total contract cost for each materials and labor bar on the chart.

(6) Separate line items for mobilization and drawing submittal and approval. (These items are to show no associated costs.)

d. Update the progress schedule in one reproduction and 10 copies every 30 calendar days throughout the contract performance period. Alternatively, Contractor has the option of submitting the project schedule electronically.

1.14.2 Project Network Analysis Schedule

Submit the initial progress schedule within 21 calendar days of notice to proceed. Schedule is to be updated and resubmitted monthly beginning 7 calendar days after return of the reviewed initial schedule. Updating to entail complete revision of the graphic and data displays incorporating changes in scheduled dates and performance periods. Redlined updates will only be acceptable for use as weekly status reviews.

Contractor to provide a single point contact from his on-site organization as his Schedule Specialist. Schedule Specialist is to have the responsibility of updating and coordinating the schedule with actual job conditions. Schedule Specialist to participate in weekly status meetings and present current information on the status of purchase orders, shop drawings, off-site fabrication, materials deliveries, Subcontractor activities, anticipated needs for Owner furnished equipment, and any problem which may impact the contract performance period.

Include the following in the project network analysis:

a. Graphically display with the standard network or arrow diagram capable of illustrating the required data. Drafting to be computer generated on standard 24 by 36 inch (nominal size) drafting sheets or on small 11 by 17 inch minimum sheets with separate overview and detail breakouts. Provide a project network analysis that is legible with a clear, consistent method for continuations and detail referencing. Clearly delineate the critical path on the display. Clearly indicate the contract milestone date on the project network analysis graphic display.

b. Data is to be presented as a separate printout on paper or, where feasible, may be printed on the same sheet as the graphic display. Data is to be organized in a logical coherent display capable of periodic updating.

c. Include within the data verbal activity descriptions with a numerical ordering system cross referenced to the graphic display. Additionally, costs (broken down into separate materials and costs), duration, early start date, early finish date, late start date, late finish date, and float are to be detailed for each activity. A running total of the percent completion based on completed activity costs versus total contract cost is to be indicated. A system for indicating scheduled versus actual activity dates and durations is also to be provided.

d. Sufficient detail to facilitate the Contractor's control of the job and to allow the Owner to readily follow progress for portions of the work should be shown within the schedule.

1.15 STATUS REPORT ON MATERIALS ORDERS

Within 20 calendar days after notice to proceed, submit, for review by the Owner, an initial material status report on all materials orders. This report will be updated and re-submitted every 30 calendar days as the status on material orders changes.

Report to include list, in chronological order by need date, materials orders necessary for completion of the contract. The following information will be required for each material order listed:

a. Material name, supplier, and invoice number.

b. Bar chart line item or CPM activity number affected by the order.

c. Delivery date needed to allow directly and indirectly related work to be completed within the contract performance period.

d. Current delivery date agreed on by supplier.

e. When item d exceeds item c, the effect that delayed delivery date will have on contract completion date.

f. When item d exceeds item c, a summary of efforts made by the Contractor to expedite the delayed delivery date to bring it in line with the needed delivery date, including efforts made to place the order (or subcontract) with other suppliers.

-- End of Section --

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# SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
BND CD3 Phase 1 - Construction Package

CONTRACTOR

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SECTION 02 22 13

CONSTRUCTION VIBRATION MONITORING

PART 1 GENERAL

1.1 DESCRIPTION

This Section includes: the furnishing of all labor, materials, equipment, supervision, and every other thing necessary to develop a construction monitoring program and to perform the related vibration monitoring as described herein.

1.1.1 Scope

Contractor shall complete the following Work:

a. Employ the services of a qualified seismologist to supervise Contractor's Vibration Monitoring Program and vibration assessment submittals.

b. Develop and submit a Vibration Monitoring Plan for approval.

c. Conduct a Pre-construction Structures Condition Survey of the project site prior to commencing work.

d. Conduct a vibration assessment for proposed equipment prior to commencing work.

e. Install vibration monitoring equipment and monitor during construction.

f. Conduct a Post-construction Structures Condition Survey of the project site.

Vibration monitoring shall be conducted before, during and after any anticipated vibration producing activities such as, but not limited to:

a. Demolition.

b. Site preparation and excavation activities.

c. Pile driving installation.

d. Pile extraction by use of vibratory hammer, if needed.

e. Operation of construction equipment, construction traffic and other activities related to construction.

Existing structures/features which may be susceptible to vibrations effects at the project site include but are not limited to:

a. The United States Customs and Harbor Master Building.

b. Above and below-ground utilities.

c. The International Seafarer Center Building.

d. Range Tower across Windhaus Road.

e. Any other features, including other nearby structures or earthen sloped banks, etc.

The Contractor shall prepare a vibration management plan. The vibration management plan should include at a minimum:

a. The qualifications of the personnel preparing and executing the plan, including sub-contractors.

b. Identifying reasonable and appropriate vibration impact thresholds for human and building response to vibration.

c. Review of geotechnical information to assess subsurface conditions and the general propagation characteristics of soil in the project area.

d. Identifying equipment and activities with potential to cause or contribute to ground-borne vibration levels of concern.

e. A determination of the potential zone of influence through execution of an appropriate screening process.

f. An inventory and ranking of buildings and non-building structures within that zone of influence based on potential sensitivity to construction-induced ground-borne vibration.

g. Windshield (drive-through) survey and site visits to enhance the inventory and ranking.

h. A determination of where pre- and post-construction site inspections should occur for photo and video inspections and potential installation of strain gauges and/or vibration monitoring equipment.

i. The types of monitoring equipment, feedback systems, and reporting requirements that are appropriate.

1.1.2 REQUIRED SUB-CONTRACTORS AND THEIR ROLES

1.1.2.1 Seismologist

The seismologist shall collect and analyze data during the pre-construction stage of the project, and in conjunction with the Brownsville Navigation District (Owner) and Contractor use that information to:

a. Develop the monitoring Drawings for the existing structures/features.

b. Evaluate expected levels of construction-related vibrations on the existing structures.

c. Assess means and methods for reducing potential vibrations at the existing structures/features.

The data collected shall include baseline ground motions caused by non-construction vibration sources near the structures/features shown in the monitoring plan.

The seismologist shall supervise the monitoring and recording of vibration by the vibration monitoring contractor, and shall also be required to

recommend values for maximum peak particle velocities (PPV) thresholds and geographic limits of zones of influence for the existing structures/features that are identified in the monitoring plan.

The seismologist shall prepare and submit a final report to the Owner at the completion of construction.

1.1.2.2 Vibration Monitoring Contractor

The vibration monitoring contractor shall install monitoring equipment, routinely observe vibrations during construction, keep records of the activities that create the vibrations, and regularly update or inform the seismologist and Contractor of the findings.

1.1.2.3 Specialty Design Consultant

The Specialty Design Consultant shall perform conditions surveys of the existing structures/features prior to the Contractor's mobilization and document any existing damage to the structures/features that are identified in the monitoring plan. The Specialty Design Consultant shall prepare and submit a report to the Owner of the findings prior to start of construction.

During construction, the seismologist may require that the Specialty Design Consultant check specific structures/features that are identified in the monitoring plan for deformations such as cracks and settlement in real time based on information provided by the vibration monitoring contractor.

The Specialty Design Consultant shall also perform post-condition surveys of the structures/features that are identified in the monitoring plan at the completion of all construction-related activities to record any changes to the conditions of the structures/features.

1.1.2.4 Land Surveyor

The land surveyor shall establish the existing topographic, layout, and as-built surveys of the existing structures/features that are shown on the monitoring plan prior to any construction-related activities. The land surveyor shall also maintain monitoring as defined by monitoring plan and conduct a final survey at the end of the construction project to document any changes to these structures/features or topography that may be the result of the vibration-related work.

1.2 QUALITY ASSURANCE

1.2.1 Sub-Contractor Qualifications

The Contractor shall employ the services of a qualified seismologist with verifiable previous experience of a minimum of three projects within the last five years in the installation of vibration monitoring equipment, planning, supervising or performing the required vibration-monitoring operations and interpretation of vibration data.

The Contractor shall employ the services of an independent third party qualified vibration monitoring contractor with verifiable previous experience of a minimum of three projects within the last five years in performing the required vibration-monitoring field operations during construction.

The Contractor shall employ the services of a Specialty Design Consultant

who shall be a Professional Engineer registered in the State of Texas and is a qualified structural inspector with the competence to observe and inspect materials and existing structural systems. The Specialty Design Consultant shall have verifiable previous experience of a minimum of three similar projects within the last five years.

The Contractor shall employ the services of a Registered Professional Land Surveyor in the State of Texas with verifiable previous experience of a minimum of three projects within the last five years in performing land surveying.

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Vibration Management Plan

Pre-Construction Report

Mitigation Measures

Pre-Construction Survey

SD-03 Product Data

PPV Measurement Data

Vibration Monitoring Notifications

Changes in the Physical Features

Photographic Updates

SD-06 Test Reports

Vibration Monitoring Report

SD-07 Certificates

Qualifications of The Seismologist

Qualifications of The Vibration-Monitoring Contractor

Qualifications of The Specialty Design Consultant

Qualifications of The Land Surveyor

SD-09 Manufacturer's Field Reports

Deviations from the Vibration Monitoring Plan

SD-11 Closeout Submittals

Vibration monitoring final report

1.3.1 Pre-Construction Submittals

The Contractor shall submit the following:

a. A vibration management plan that includes

(1) Qualifications of the seismologist

(2) Qualifications of the vibration-monitoring Contractor

(3) Qualifications of the Specialty Design Consultant

(4) Qualifications of the land surveyor

b. A general notice prepared by the seismologist for at least one (1) public pre-construction consultation with property owners and occupants within the zone of influence advising of the possibility of construction -induced vibrations.

c. A pre-construction report that shall include the following:

(1) Results of the pre-construction condition survey including all records, reports, video, photographs, and recommendations for maximum peak particle velocity (PPV) threshold limits and warning limits in any of the three mutually perpendicular components of particle velocity for all structures/features surveyed that might be affected by construction-induced vibrations. A threshold limit should be recommended for each structure/feature in the zone of influence that shall meet the Federal, State, or local codes and regulations, or be more stringent where needed.

(2) A vibration-monitoring plan prepared by the seismologist which includes the locations and types of the seismic monitoring sensors and equipment.

(3) Pre-construction topographical survey of all structures/features within the specified zone of influence and along the project limits, as determined by the seismologist.

d. The Contractor shall identify and submit for review by the Owner mitigation measures to reduce the effects of construction related vibrations within the zone of influence. The Contractor shall submit for review by the Owner a remedial action plan for the structures/features that are likely to be so affected.

1.3.2 During Construction Submittals

The Contractor shall submit the following:

a. Records of PPV measurement data of the monitoring activities, as required by Monitoring Plan, to the Owner at the end of each month when vibration inducing activities are conducted.

b. A report summarizing when vibration monitoring notifications were sent to Contractor.

c. Changes in the physical features of the structures that are identified in the monitoring plan throughout the entire project duration and as determined by the seismologist. Include photographic updates.

d. A monthly report that documents any deviations from the vibration monitoring plan, and explains the reasons for the deviations, and consequences and outcomes of those deviations.

1.3.3 Post-Construction Submittals

The Contractor shall submit a vibration monitoring final report that shall include the following:

a. All vibration monitoring data associated with the specific construction activities that were observed in the field.

b. Results of the post-construction condition surveys including all records, reports, video, and photographs for items that may have been affected by construction-induced vibrations and narratives on comparative pre-construction condition survey information.

c. Post-construction topographical survey data of all structures/features potentially impacted by the construction and that were recommended by the seismologist, and written statements of how this data compare to the pre-construction topographic survey data.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 VIBRATION MONITORING

3.1.1 Pre-Construction Requirements

The Contractor, through the seismologist shall perform a documented pre-construction condition survey as part of determining vibration or settlement effects on any existing structures/features within the influence zone of the proposed constructions activities.

The seismologist shall determine the predicted and maximum allowable PPV threshold values for the structures/features defined in the vibration monitoring plan based on the analysis of data gathered during the pre-construction condition survey.

The seismologist shall establish the vibration zone of influence. A vibration zone of influence or influence zone is defined as the area of land within or adjacent to a construction site, including any structures/features, that potentially may be affected by vibrations emanating from a construction activity where the PPV at the location where measured, is equal to or greater than the limiting PPV threshold value as defined by the seismologist.

3.1.1.1 Pre-Construction Survey

The Contractor, through the seismologist shall perform a documented pre-construction condition survey as part of determining vibration or settlement effects on any existing structures/features within the influence zone of the proposed construction activities.

The pre-construction condition survey shall include videos with audio

recordings, still photography, and legible sketches with proper labeling and notes as needed to fully describe the existing condition of each structure/feature potentially affected by any construction induced vibrations, including the interior and exterior of any building structures. Crack gauges may be used to document existing cracks. Sizes (length and width) of existing cracks in structures/features shall be recorded and documented.

The Contractor, through the seismologist shall use site-specific information about on-site and sub-surface soils to perform a screening assessment that shall be used to determine the distances from the vibration sources to target features within the influence zones. This pre-construction condition survey shall be completed at least 30 days prior to the start of onsite activities and a pre-condition survey report shall be submitted to the Owner within seven (7) days after completion.

The Contractor must perform pre-construction surveys of critical physical features of all structures within the specified zones of vibration influence and of any other structures that are located along the project limits at the direction of the seismologist.

A report shall be prepared for each feature identified by the seismologist. The report shall include all of the recorded observations.

3.1.1.2 Baseline Ground Motions (Existing, Pre-construction ground borne vibration levels)

The data that is collected shall include baseline ground motions caused by non-construction vibration sources near structures/features that are shown in the monitoring plan.

Where predicted PPVs are anticipated to exceed the determined threshold, the seismologist shall establish protocols for the structures/features that are expected to be negatively affected by the construction-related vibrations as shown in the monitoring plan.

3.1.1.3 Specifications for Proposed Vibration Monitoring Equipment

Equipment for measuring construction-induced ground-borne vibration shall at a minimum measure peak particle velocity, be tri-axial 3-channel (3 seismic channels) units capable of digitally storing collected data and sending out warning and stop work notifications via text message. Equipment shall be capable of printing ground motion time histories and summaries of peak motion intensities, frequencies and USBM R18507 PPV-frequency plots. Printed report records must also include date, time of recording, operator name, instrument number and date of last calibration. Other required system features:

a. Instruments must have certifications of factory- or equivalent calibrations within the past 12 months.

b. Instruments shall have a flat frequency response between 2 and 250 Hz for particle velocity.

c. The digitizing sampling rate for peak particle velocity measurements shall be at least 1,024 samples per second.

d. Seismographs shall be capable of performing a self-test of velocity transducers and printed event records shall indicate whether or not the

sensor test was successful.

e. Seismographs used for compliance monitoring shall be capable of recording particle velocity from 0.01 to 5.0 in/sec.

f. Systems shall be capable of providing printed event reports that include all peak measurements, frequencies and complete waveform plots. At a minimum, the monitors shall employ a two-tiered text messaging notification system so work can be paused or stopped before measured levels reach damage thresholds.

g. Seismographs shall have adequate memory to digitally record the entire duration of the construction-induced motion. The minimum event recording time shall be three seconds.

h. All seismograph software systems-shall be capable of saving back-up copies of all event files on USB flash drives or portable hard drives or provided on a cloud accessible network and copies shall be furnished to the Owner.

i. The Contractor shall provide the seismograph reporting software to the Owner with the first submittal of the vibration measurement records.

3.1.2 During Construction Requirements

3.1.2.1 Vibration Monitoring

Maintaining ground vibration within the limits imposed under this contract is critical to the success of this project. To assure satisfactory results for data acquisition, the collection of these data must be conducted under the supervision of a qualified seismologist.

Vibrations shall be monitored at appropriate locations throughout the project. Vibration measured in peak particle velocity in inches per second shall be recorded at the monitoring locations. Monitoring locations shall be determined by the seismologist and approved by the Owner. Each monitoring location shall be a secure, marked and surveyed position and shall remain at the same position. The Contractor may elect at the Contractor's expense to provide additional instrumentation at additional monitoring locations for any purpose.

Vibration monitors shall run continuously during the duration of the project's activities at the site, and readings on each seismograph shall be checked at the intervals recommended by the seismologist. If equipment allows, this data may be downloaded and checked remotely.

The Contractor shall provide and maintain temporary weather protection and remote power and communication capabilities as necessary for all vibration monitoring activity.

Monitor ground crack and install monitors to monitor crack width and changes during construction (i.e. crack growth) and notify Owner.

3.1.2.2 Vibration Control

The seismologist shall place at least two (2) seismographs at structures/features of concern (or as recommended and approved by the Owner) to measure and record ground movements during construction. The seismologist shall provide qualified personnel capable of setting up

instruments at designated locations to accurately record data, deploy the instruments, and operate, gather, and analyze the vibration data. The seismologist shall use the collected data to control future vibration so as not to exceed the limits established. The instrumentation shall record three orthogonal components (vertical, radial and transverse) of particle velocity direction. The PPV for compliance purposes is the highest measurement made in any of the three measured directions. The instrument records shall consist of instrument readings identified by instrument number; the location of instruments; the date, time and location of the measurements; and the peak particle velocity and dominant frequency it occurred in.

Construction activities shall be controlled in such a manner that the intensity of ground motion at the nearest existing structures/feature shall be limited to a peak particle velocity as set out by seismologist.

3.1.2.3 Immediate Threshold Adherence

The Owner shall be notified immediately when the intensity of measured ground motions (PPV) exceed specified warning levels. When the PPV threshold limit is exceeded one time or warning levels are exceeded more than three times at any type of structure/feature, the Contractor shall submit a revised construction plan to the Owner that outlines specific measures that will be applied to bring ground motion levels into compliance within specified limits. The Contractor shall submit a printed copy of the monitoring records showing PPV values. A digital copy of the monitoring event records on a CD-ROM disk or provided on a cloud accessible network shall also be submitted.

3.1.2.4 Reporting

The Contractor shall provide results of the testing to the Owner at the end of each month when vibration inducing activities are conducted.

The Owner shall be notified of any movements detected and the Contractor shall immediately take any remedial measures required to prevent damage to the existing structures/features.

3.1.2.5 Damages

The Contractor shall make every effort to avoid damage to the existing utilities, appurtenances, other structures or features within the influence of any construction-induced vibrations including the use of site access routes.

The Contractor is responsible for all construction related damages caused by, but not limited to, vibration or soil settlement slope or ground instability, and structural damage. Any damage caused by the Contractor's operations shall be repaired by the Contractor, to the satisfaction of the Owner, at no additional cost to the Owner.

Upon the discovery of any damage, operations shall cease until the Contractor has the damage repaired to the satisfaction of the Owner or has agreed with the Owner on an acceptable timeline by which the damage shall be satisfactorily repaired and provides suitable measures to control future disturbance.

3.1.3 POST-CONSTRUCTION REQUIREMENTS

3.1.3.1 Vibration Monitoring Report

A report will be prepared for each structure/feature previously identified with a summary that documents any changes from the pre-condition survey and whether any of the changes noted were a direct result of the construction activities. The qualified seismologist shall attend the post-construction survey to provide input. Changes in the condition of any structure/feature impacted shall be documented with video, still photographs, and sketches and a detailed narration or explanation.

3.1.3.2 Site Restoration

Any areas or items disturbed by the Contractor's operations shall be restored to pre-construction conditions or replaced by the Contractor at no additional cost to the Owner. The costs for any site restoration or replacement of items damaged as a result of the Contractor's work shall be paid for by the Contractor.

3.2 PROTECTION OF SITE

3.2.1 Existing Structures

When the Drawings or construction activities require excavation, piling or other foundation installation operations in proximity to existing structures, the Contractor shall take precautions to prevent damage to such structures. The requirements described herein apply to all types of structures (within or outside of project limits) that may be adversely affected by construction operations (including phased construction) due to vibrations. At least 48 hours prior to any excavation, piling or other foundation installation operations, the Contractor shall notify the Texas one Call (811) and all known utility owners within the work area. The Contractor shall protect utilities as required.

When pile driving or excavating, the Contractor is responsible for evaluating the need for, design of, and providing any necessary precautionary activities to protect adjacent structures/features from damage, including, but not limited to, selecting methods and procedures that will prevent damaging caving of the excavation and monitoring and controlling the vibrations from construction activities, including driving of any piles, and their removal (if applicable).

The Contractor shall survey and monitor structures for settlement in a manner approved by the Owner, recording elevations to 0.01 foot. The Contractor shall employ a qualified Specialty Design Consultant to inspect and document the condition of structures prior to and after completion of all pile installations, excavations and other related foundation installation activities, and to inspect and monitor the structures within the influence zones.

The Contractor shall obtain the Owner's approval of the number and location of monitoring points and shall record survey elevations:

a. Before beginning construction

b. Daily during the driving of any piling, or extraction of piling (if applicable)

c. Weekly for two weeks after stopping pile driving

d. During excavation

e. As directed by the Owner

The Contractor shall notify the Owner of any movements detected and immediately take any remedial measures required to prevent damage to the existing structures.

The Owner will make the necessary arrangements to provide right of way entry to the existing structures.

3.2.2 Concrete

The seismologist shall provide vibration limits to ensure that concrete whose age is less than 7 days is not subjected to vibrations from pile driving, and/or other construction activities located within 100 feet from the nearest outside edge of said concrete to the vibration source.

3.2.3 Miscellaneous

Upon detecting settlement, heave, or other slope movements, or vibration levels near threshold values, or damage to structures/features, immediately stop the source of vibrations or disturbance, backfill any open excavations, and contact the Owner for instructions.

-- End of Section --

SECTION 03 31 30

MARINE CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

| | |
|---|---|
| AASHTO M 182 | (2005; R 2017) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats |

AMERICAN CONCRETE INSTITUTE (ACI)

| | |
|---|---|
| ACI 117 | (2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary |
| ACI 121R | (2008) Guide for Concrete Construction Quality Systems in Conformance with ISO 9001 |
| ACI 201.2R | (2016) Guide to Durable Concrete |
| ACI 211.1 | (1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete |
| ACI 214R | (2011) Evaluation of Strength Test Results of Concrete |
| ACI 301 | (2016) Specifications for Structural Concrete |
| ACI 304.2R | (2017) Guide to Placing Concrete by Pumping Methods |
| ACI 304R | (2000; R 2009) Guide for Measuring, Mixing, Transporting, and Placing Concrete |
| ACI 305R | (2020) Guide to Hot Weather Concreting |
| ACI 306R | (2016) Guide to Cold Weather Concreting |
| ACI 308.1 | (2011) Specification for Curing Concrete |
| ACI 309R | (2005) Guide for Consolidation of Concrete |
| ACI 347R | (2014; Errata 1 2017) Guide to Formwork for Concrete |

| | |
|---|---|
| ACI SP-2 | (2007; Abstract: 10th Edition) ACI Manual of Concrete Inspection |
| ACI SP-15 | (2011) Field Reference Manual: Standard Specifications for Structural Concrete ACI 301-05 with Selected ACI References |
| ACI SP-66 | (2004) ACI Detailing Manual |

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

| | |
|---|---|
| APA PS 1 | (2009) Structural Plywood (with Typical APA Trademarks) |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A416/A416M | (2018) Standard Specification for Low-Relaxation, Seven-Wire for Prestressed Concrete |
| ASTM A615/A615M | (2020) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement |
| ASTM A1064/A1064M | (2017) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete |
| ASTM C31/C31M | (2021a) Standard Practice for Making and Curing Concrete Test Specimens in the Field |
| ASTM C33/C33M | (2018) Standard Specification for Concrete Aggregates |
| ASTM C39/C39M | (2021) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens |
| ASTM C42/C42M | (2020) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete |
| ASTM C78/C78M | (2021) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading) |
| ASTM C94/C94M | (2021a) Standard Specification for Ready-Mixed Concrete |
| ASTM C138/C138M | (2017a) Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete |
| ASTM C143/C143M | (2020) Standard Test Method for Slump of Hydraulic-Cement Concrete |
| ASTM C150/C150M | (2021) Standard Specification for Portland Cement |

| | |
|---|---|
| ASTM C157/C157M | (2017) Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete |
| ASTM C171 | (2020) Standard Specification for Sheet Materials for Curing Concrete |
| ASTM C172/C172M | (2017) Standard Practice for Sampling Freshly Mixed Concrete |
| ASTM C192/C192M | (2019) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory |
| ASTM C260/C260M | (2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete |
| ASTM C294 | (2012; R 2017) Standard Descriptive Nomenclature for Constituents of Concrete Aggregates |
| ASTM C295/C295M | (2019) Standard Guide for Petrographic Examination of Aggregates for Concrete |
| ASTM C311/C311M | (2018) Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete |
| ASTM C494/C494M | (2019) Standard Specification for Chemical Admixtures for Concrete |
| ASTM C595/C595M | (2021) Standard Specification for Blended Hydraulic Cements |
| ASTM C618 | (2019) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete |
| ASTM C805/C805M | (2018) Standard Test Method for Rebound Number of Hardened Concrete |
| ASTM C920 | (2018) Standard Specification for Elastomeric Joint Sealants |
| ASTM C1017/C1017M | (2013; E 2015) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete |
| ASTM C1064/C1064M | (2017) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete |
| ASTM C1077 | (2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation |
| ASTM C1107/C1107M | (2020) Standard Specification for Packaged |

| | |
|---|---|
| | Dry, Hydraulic-Cement Grout (Nonshrink) |
| ASTM C1152/C1152M | (2020) Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete |
| ASTM C1231/C1231M | (2015) Standard Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders |
| ASTM C1260 | (2021) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) |
| ASTM C1567 | (2021) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method) |
| ASTM C1602/C1602M | (2018) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete |
| ASTM C1611/C1611M | (2021) Standard Test Method for Slump Flow of Self-Consolidating Concrete |
| ASTM D75/D75M | (2019) Standard Practice for Sampling Aggregates |
| ASTM D512 | (2012) Chloride Ion in Water |
| ASTM D516 | (2016) Standard Test Method for Sulfate Ion in Water |
| ASTM D1179 | (2016) Standard Test Methods for Fluoride Ion in Water |
| ASTM D1751 | (2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types) |
| ASTM D1752 | (2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction |
| ASTM D3867 | (2016)Standard Test Methods for Nitrite-Nitrate in Water |
| ASTM D6690 | (2015) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements |
| ASTM E329 | (2021) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection |

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

| | |
|---|---|
| CRSI 10MSP | (2018) Manual of Standard Practice |

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

| | |
|---|---|
| FS SS-S-200 | (Rev E; Am 1; Notice 1) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement |

1.2 DEFINITIONS

a. "Cementitious material" as used herein shall include portland cement and fly ash.

b. "Concrete System" is the term describing a structural element comprised of concrete, reinforcing steel and concrete cover.

c. "Design strength" (f'c) is the specified compressive strength of concrete at the end of 28 days to meet structural design criteria.

d. "Field test strength" (fcr) is the required compressive strength of concrete to meet structural and durability criteria. Determine (fcr) during mixture proportioning process.

e. "Marine concrete" is all concrete that will be in contact with seawater or brackish water, tidal variations, splash, or spray from water in navigable waterways.

f. "Mixture proportioning" is the process of designing concrete mixture proportions to enable it to meet the strength, durability and constructability requirements and of the project while minimizing the initial and life-cycle cost.

g. "Mixture proportions" are the masses or volumes of individual ingredients used to make a unit measure (cubic yard or meter) of concrete.

h. "Pozzolan" is a siliceous or siliceous and aluminous material, which in itself possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

i. "Process control sampling" is sampling and testing conducted by the Contractor to monitor the quality of materials or processes. Process control sampling is intended to indicate the quality of materials at critical steps in production that allow intervention prior to using a material on the project.

j. "Quality Acceptance Limit" (QAL) is the limiting value of a test result that indicates acceptable material quality.

k. "Quality acceptance sampling" is sampling and testing conducted by the Contractor, or an independent testing agency, to evaluate the quality of materials used on the project. Quality acceptance sampling is conducted at regular intervals identified as "lots" to represent the

quality of that portion of the material used in the project.

l. "Required compressive strength" (f'c) is the mean compressive strength of concrete required to meet structural criteria. The required strength is the mean concrete strength for tests of properly batched concrete at the age specified herein.

m. "Supplementary cementing materials" (SCM) include coal fly ash, granulated blast-furnace slag, natural or calcined pozzolans, and ultra-fine coal ash when used in such proportions to replace the portland cement that result in considerable improvement to sustainability, durability and in some cases a reduction in initial cost.

n. "Test Section" is a slab separate from the main structure and constructed prior to main construction as an all inclusive demonstration of methods and materials. The adequacy of the Test Section must be approved by the owner's representative prior to construction of the project.

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Concrete Curing Plan

Concrete Qualification Program

Concrete Quality Control Program

Concrete Placement and Compaction

Concrete Pumping

Curing Concrete Elements

Form Removal Schedule

Laboratory Qualifications

Quality Control Personnel Qualifications

Quality Control Plan

SD-02 Shop Drawings

Formwork

Precast Elements

Reinforcing Steel

Reproductions of contract drawings are unacceptable.

Construction And Expansion Joints

SD-03 Product Data

Admixtures

Aggregates

Corrosion Inhibitors

Joint Filler

Joint Sealants

Material Safety Data Sheet

Materials for Curing Concrete

Mechanical Reinforcing Bar Connectors

Non-Shrink Grout

Preformed Joint Filler

Prestressing Steel

Reinforcing Bars

Reinforcement Supports

SD-04 Samples

Test Section

SD-05 Design Data

Concrete Mixture Requirements

Mixture Designs

SD-06 Test Reports

Aggregates

Admixtures

Cement

Concrete Mixture Proportions

Concrete Test Reports

Fresh Concrete Properties

Hardened Concrete Properties

Mechanical Reinforcing Bar Connectors

Reinforcing Bars

Supplementary Cementing Materials

Water

SD-07 Certificates

Admixtures

Cementitious Materials

Cementitious Material Mill Certificates

Field Testing Technician and Testing Agency

SD-11 Closeout Submittals

Aggregate Moisture Content

Aggregate Sampling

Concrete Test Reports

Quality Control Charts

Daily Inspection Reports

Quality Team Meetings

Sampling Logs

1.4 MODIFICATION OF REFERENCES

Accomplish work in accordance with ACI publications except as modified herein. Consider the advisory or recommended provisions to be mandatory, as though the word "shall" had been substituted for the words "should" or "could" or "may," wherever they appear.

1.5 DELIVERY, PLACING, STORAGE, AND HANDLING OF CONCRETE

Do not deliver concrete until vapor barrier, forms, reinforcement, embedded items, and chamfer strips are in place and ready for concrete placement. Store reinforcement of different sizes and shapes in separate piles or racks raised above the ground. Protect materials from contaminants such as grease, oil, and dirt. Ensure materials can be accurately identified after bundles are broken and tags removed.

1.6 CONCRETE QUALITY CONTROL

The objective of the concrete quality control program is for the Contractor to outline the procedures that will be used to construct a structure that will meet the project criteria. The Contractor shall develop and submit for review a concrete quality control program in accordance with the guidelines of ACI 121R and as specified herein. The plan shall include standard forms and checklists to be completed by Contractor's QC Manager for the concrete supplier, the reinforcing steel supplier, and installer and shall address aspects of the mix design, materials, and workmanship that may affect the ultimate performance of the structure. The plan shall also include approved laboratories. The Contractor shall provide direct oversight for the concrete qualification program inclusive of associated sampling and testing. If concrete cylinders tested during production indicate inadequate

strength, excessive chloride ion penetration, or inadequate mixing, then the owner may require the Contractor to extract concrete core samples from the hardened concrete for analysis at Contractor's expense to assure that the quality of the concrete as placed and cured will satisfy the project criteria.

Maintain a copy of ACI SP-15 and CRSI 10MSP at the project site.

1.6.1 Quality Control Plan

Submit Quality Control plan 10 working days before concrete placement for Owners review. The QC plan shall include, as a minimum, developing, submitting for review (by the Owner), and use of standard forms to:

a. Record and check off the pre-placement preparatory work. Form to be completed by Contractor's QC Manager prior to notification of the Engineer for inspection.

b. Record items that include the concrete batch tickets and a brief description of work (times, dates, equipment used, crews on site, batch, quantities, etc.) performed during the placement. These forms shall be submitted with each monthly pay request in order for a section of work to be approved for payment.

c. Record shop drawing review.

d. Check deliveries of steel reinforcement to verify conformance with shop drawings.

1.6.2 Quality Control Personnel

The contractor shall submit for approval an organizational chart defining the quality control hierarchy, the responsibilities of the various positions, including the names and qualifications of the individuals in those positions.

Submit American Concrete Institute certification for the following:

a. CQC personnel responsible for inspection of concrete operations.

b. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews.

c. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

d. Laboratory Testing Technicians: ACI Concrete Strength Testing Technician and Laboratory Testing Technician, Grade I or II.

e. Petrographer: Bachelor of Science degree in geology or petrography, trained in petrographic examination of concrete aggregate according to ASTM C294 and ASTM C295/C295M and trained in identification of the specific deleterious processes and tests identified in this specification. Resume shall detail the education, training and experience related to the project-specific test methods and deleterious materials and shall be submitted at least 20 days before petrographic and deleterious materials examination is to commence.

f. Concrete Batch Plant Operator: National Ready Mix Concrete Association

(NRMCA) Plant Manager Certification at the Plant Manager level.

1.6.2.1 Quality Manager Qualifications

The quality manager shall hold a current license as a professional engineer in the state of Texas with experience on at least five similar projects. Evidence of extraordinary proven experience may be considered by the Owner as sufficient to act as the Quality Manager.

1.6.2.2 Field Testing Technician and Testing Agency

Submit data on qualifications of proposed testing agency and technicians for review by the Owner prior to performing testing on concrete.

a. Work on concrete under this contract shall be performed by an ACI Concrete Field Testing Technician Grade 1 qualified in accordance with ACI SP-2 or equivalent. Equivalent certification programs shall include requirements for written and performance examinations as stipulated in ACI SP-2.

b. Testing agencies that perform testing services on reinforcing steel shall meet the requirements of ASTM E329.

c. Testing agencies that perform testing services on concrete materials shall meet the requirements of ASTM C1077.

1.6.3 Laboratory Qualifications for Concrete Qualification Testing

The concrete testing laboratory shall have the necessary equipment and experience to accomplish required testing. The laboratory shall meet the requirements of ASTM C1077, and be Cement and Concrete Reference Laboratory (CCRL) inspected.

1.6.4 Laboratory Accreditation

Laboratory and testing facilities shall be provided by and at the expense of the Contractor. The laboratories performing the tests shall be accredited in accordance with ASTM C1077, including ASTM C78/C78M and ASTM C1260. The accreditation shall be current and shall include the required test methods, as specified.

a. Aggregate Testing and Mix Proportioning: Aggregate testing and mixture proportioning studies shall be performed by an accredited laboratory and under the direction of a licensed/registered civil engineer in the state of Texas, who shall sign all reports and designs.

b. Acceptance Testing: Furnish all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens at the site and in the laboratory. Furnish and maintain boxes or other facilities suitable for storing and curing the specimens at the site while in the mold within the temperature range stipulated by ASTM C31/C31M.

c. Contractor Quality Control: All sampling and testing shall be performed by an approved, onsite, independent, accredited laboratory.

## 1.7 CONCRETE DURABILITY

### 1.7.1 Concrete Mixture Proportions

At least 60 days prior to concrete placement, submit concrete mixture proportions, ingredient material certificates and test data, and trial batch test data for each class of concrete proposed for use on the project. Submittal shall clearly indicate where each mixture will be used when more than one mixture design is submitted. Obtain approval from Owner prior to placement.

### 1.7.2 Concrete Design Requirements

Proportion concrete mixtures to meet the requirements listed in Table 1 in accordance with the procedures outlined in ACI 201.2R and ACI 211.1.

The mixture proportions for concrete shall be developed by the Contractor to produce the required compressive strength (f'c), drying shrinkage, durability, and constructability. The amount of cementitious material in the mixture can be minimized as long as the concrete still meets the mixture design requirements for durability and strength.

The mixture proportions and Water-Cementitious Materials Ratio for marine concrete shall be developed by the Contractor to produce the design strength (f'c) and to provide durability, workability, and mixture consistency to facilitate placement, compaction into the forms and around reinforcement without segregation or bleeding. The requirements specified in Table 1 and Table 2 below shall be incorporated in the mixture proportions.

The concrete mixture shall contain a minimum amount of Type F fly ash of 25% of cement by weight and shall not exceed 35% of cement by weight.

Slump: The concrete mixture shall be proportioned to have, at the point of deposit, a maximum slump of 4 inches as determined by ASTM C143/C143M when admixtures that affect slump are not used. Where an ASTM C494/C494M, Type F or G admixture is used, the slump after the addition of the admixture shall be no less than 6 inches nor greater than 8 inches. Slump tolerances shall comply with the requirements of ACI 117.

Table 1 - Concrete Design Requirements

| Prescriptive requirements | Minimum | Maximum |
|---|---|---|
| Concrete ASTM C157/C157M Drying Shrinkage percent, at 28 days except for high volume fly ash (HVFA) at 56 days. | -- | 0.05 percent |
| Initial acid-soluble chloride content in cast-in-place concrete per ASTM C1152/C1152M, percent/cement | -- | 0.10 |
| Initial acid-soluble chloride content in prestressed concrete determined following ASTM C1152/C1152M, percent/cement | -- | 0.08 |

| Table 2 - Concrete Quality Requirements | | | | | |
|---|---|---|---|---|---|
| Concrete Element | Maximum Aggregate Size | Design Strength PSI | Maximum Water to Cementitious Material Ratio (W/CM) | Percent Of Fly Ash By Mass Of Cementitious Material | Calcium Nitrite Corrosion Inhibitor GAL/CY |
| All Cast-In-Place and Precast Concrete | 1" | 5000 | 0.40 | 25 to 35 | 4.0 |
| Precast / Prestressed Concrete | 3/4" | As indicated on the drawings | 0.40 | 25 to 35 | 4.0 |

1.7.3 Concrete Mixture Qualifications

1.7.3.1 Previously Approved Concrete Mixtures

For identical concrete mixtures previously approved for use within the past 18 months, the previous mixture qualification submittal may be re-submitted without further trial batch testing if accompanied by:

a. A copy of the prior approvals indicating the project name, project number, and location.

b. Ingredient material test data conducted within 12 months of the submittal date.

c. Copies of the previously approved trial batch test data.

d. A log containing at least 15 sequential test results with the calculated mean and standard deviation of the production concrete for air content, and compressive strength.

If the Contractor changes material type, class, sources, or suppliers; chemical composition; and/or mix proportions, the Contractor shall provide a written opinion of the significance of the change(s). The change(s) may require additional testing at the discretion of the Owner.

1.7.3.2 New Concrete Mixtures

a. Submit complete ingredient material test data, including applicable reference specifications. Submit additional data regarding concrete aggregates if the source of aggregate changes.

b. Submit copies of test reports by independent test lab conforming to ASTM C1077 showing that the mixture has been successfully tested to produce concrete with the properties specified and that mixture will be suitable for the job conditions as described. Test reports shall be submitted along with the concrete mixture proportions. Obtain approval before concrete placement.

c. Test a minimum of one trial batch of production concrete. If batching

facilities are located such that the haul-time will exceed 30 minutes, a simulated haul time shall be included in the trial batch.

(1) Test and report fresh concrete property tests of each trial batch as follows:

(a) Slump in accordance with ASTM C143/C143M.

(b) Unit weight in accordance with ASTM C138/C138M.

(c) Temperature in accordance with ASTM C1064/C1064M.

(2) Cast specimens, test, and report hardened concrete property tests of each trial batch as follows:

(a) Compressive strength at 3, 7, 28, 56 and 90 days in accordance with ASTM C39/C39M. Use of unbonded caps in accordance with ASTM C1231/C1231M is permitted.

(b) Drying shrinkage.

(c) Initial chloride ion content.

(3) Moist cure concrete intended for cast-in-place applications in accordance with the standard moist curing conditions described in ASTM C192/C192M unless otherwise specified. Moist cure concrete intended for precast applications in the manner proposed for use on the project.

1.7.4 Concrete Qualification Program

1.7.4.1 Fresh Concrete Properties

Slump: The mixture shall be proportioned and tested for qualification.

1.7.4.2 Hardened Concrete Properties

a. Compressive Strength: The structural engineer shall specify the minimum compressive strength results at 28 days. Determine compressive strength (f'cr) for qualification of concrete mixtures and for quality acceptance testing. A compressive strength test result is defined as the mean of three properly conducted tests on 4 by 8 inch cylinders in accordance with ASTM C39/C39M. Alternatively and for concrete mixtures containing a maximum size aggregate greater than 1 inch, a strength test result shall be defined as the mean of two properly conducted 28-day tests on 6 by 12 inch cylindrical specimens in accordance with ASTM C39/C39M. In addition:

(1) Specified Compressive Strength: For structural concrete elements exposed in a marine environment, the minimum specified 28 day design strength is denoted as (f'c).

(2) Required Average Strength: The concrete shall be proportioned such that the minimum required average compressive strength (f'cr) exceeds the specified design strength (f'c) as per ACI 301.

(3) The average compressive strength may not exceed the specified strength at the same age by more than 20 percent unless approved by the Engineer of Record.

(4) Strength of any individual concrete placement shall be considered satisfactory if both the following requirements are met:

(a) The arithmetic mean of any three consecutive lot strength tests is between 1.0 and 1.2 f'c, and;

(b) No individual strength test result is less than 0.90 f'c.

(5) In the event that a placement is represented by single sampling lot, strength shall be considered satisfactory if either:

(a) The mean of the initial test is between 1.0 and 1.2 f'c, or;

(b) The mean of the initial test and retest is between 1.0 and 1.2 f'c, and neither strength test result is less than 0.90 f'c.

b. Drying Shrinkage: Determine drying shrinkage for qualification of concrete mixtures. No test results shall exceed the limits in Table 1. A drying shrinkage test result shall be the mean value from three or more individual specimens constituting a test set. If an individual specimen's measurements deviate from the mean value by more than 0.009 percent length change, the specimen's measurements shall be discarded and a new average established. Casting more than three specimens for each set is permitted. Test procedures and test specimens shall conform to the following:

Drying shrinkage specimens, typically 3 by 3 by 11.25 inch prisms for 1 inch maximum size aggregate or smaller, shall be fabricated, cured, dried, and measured at 28 days in the manner delineated in ASTM C157/C157M.

c. Acid Soluble Chloride Ion Content: Determine the chloride ion content only for qualification of concrete mixtures. Determine acid soluble chloride ion content in accordance with ASTM C1152/C1152M. The limits for allowable acid-soluble chloride ion concentrations in hardened concrete are listed in Table 1.

## 1.8 CONCRETE

### 1.8.1 Drawings

Fabrication Drawings for concrete formwork, reinforcement materials, precast elements, wall forms, and bulkhead forms must indicate concrete pressure calculations with both live and dead loads, along with material types. Provide signed, dated, and sealed design calculations for the formwork by a licensed/registered Civil or Structural Engineer in the State of Texas.

#### 1.8.1.1 Formwork

Prior to commencing work, submit drawings for approval showing details of formwork including, but not limited to: joints, supports, studding and shoring, and sequence of form and shoring removal. Reproductions of contract drawings are unacceptable.

Design, fabricate, erect, support, brace, and maintain formwork so that it is capable of supporting without failure all vertical and lateral loads that may reasonably be anticipated to be applied to the formwork.

Comply with ACI 347R. Include design calculations indicating arrangement of forms, sizes, species, and grades of supports (lumber), panels, and related components. Indicate placement schedule, construction, and location and method of forming control joints. Include locations of inserts, pipe work, conduit, sleeves, and other embedded items. Furnish drawings and descriptions of shoring and reshoring methods proposed for slabs, beams, and other horizontal concrete members.

1.8.1.2 Reinforcing Steel

Comply with ACI SP-66. Provide bending and cutting diagrams, assembly diagrams, splicing placement and laps of bars, shapes, dimensions, and details of bar reinforcing, accessories, and concrete cover. Do not scale dimensions from structural drawings to determine lengths of reinforcing bars. Only complete drawings will be accepted.

1.8.1.3 Precast Elements

Submit drawings and design calculations indicating complete information for the fabrication, handling, and erection of the precast elements. Drawings shall not be reproductions of contract drawings.

1.8.1.4 Joints

Submit a plan indicating the type and location of each construction and expansion joints. Final joint locations are subject to Owner approval.

1.8.2 Pre-Construction Submittals

1.8.2.1 Curing Concrete Elements

Submit proposed materials and methods for curing concrete elements.

1.8.2.2 Concrete Curing Plan

Submit proposed materials, methods, and duration for curing and cooling concrete elements in accordance with ACI 308.1.

Minimum wet curing duration shall be seven days.

Begin curing immediately after placement. Protect concrete from premature drying, excessively hot temperatures, and mechanical injury; and maintain minimal moisture loss at a relatively constant temperature for the period necessary for hydration of the cement and hardening of the concrete. The materials and methods of curing are subject to approval by the Owner.

1.8.2.3 Form Removal Schedule

Submit schedule for form removal indicating element and minimum length of time for form removal. Submit technical literature of forming material or liner, form release agent, form ties, and gasketing to prevent leakage at form and construction joints. Provide a full description of materials and methods to be used to patch form-tie holes.

1.8.2.4 Concrete Placement and Compaction

a. Submit technical literature for equipment and methods proposed for use in placing concrete. Include concrete pumping or conveying equipment including type, size and material for pipe, valve characteristics, and

the maximum length and height concrete will be pumped. No adjustments shall be made to the mixture design to facilitate pumping.

b. Submit technical literature for equipment and methods proposed for vibrating and compacting concrete. Submittal shall include technical literature describing the equipment including vibrator diameter, length, frequency, amplitude, centrifugal force, and manufacturer's description of the radius of influence under load. Where flat work is to be cast, provide similar information relative to the proposed compacting screed or other method to ensure dense placement.

1.8.2.5 Concrete Report

Provide a Report inclusive of materials and methods used, test results, and the field test strength (fcr) for concrete that shows compliance with the structural and durability requirements.

1.8.2.6 Preconstruction Testing of Materials

All sampling and testing shall be performed by, and at the expense of, the Contractor. Use an approved commercial laboratory or, for cementitious materials and chemical admixtures, a laboratory maintained by the manufacturer of the material. No material shall be used until notice of acceptance has been given. The Contractor will not be entitled to any additional payment or extension of time due to failure of any material to meet project requirements, or for any additional sampling or testing required. Additional tests may be performed by the Owner's testing agency at the discretion of the Owner; such testing will not relieve the Contractor of any testing responsibilities.

1.8.2.7 Material Safety Data Sheet

Submit Material Safety Data Sheets (SDS) for all materials that are regulated for hazardous health effects. Prominently post the SDS at the construction site.

1.8.2.8 Mixture Designs

Provide a detailed report of materials and methods used, test results, and the field test strength (fcr) for marine concrete required to meet structural and durability requirements.

1.8.3 Sampling

The Contractor shall be responsible for conducting concrete production process control sampling and testing in compliance with this specification.

1.8.3.1 Ingredient Material Sampling

a. Cementitious material mill certificates and test reports shall be provided for each shipment. Record the date delivered and quantity of material represented by the certificate.

b. Conduct and log aggregate moisture content at a minimum frequency of twice daily for each day's production. Use of moisture sensors in storage bins is recommended practice, but does not satisfy this requirement.

c. Aggregate sampling for gradation and dry-rodded unit weight shall be

conducted for each 100 tons delivered for use on the project, or portion thereof.

1.8.4 Reporting

1.8.4.1 Daily Inspection Reports

Contractor shall prepare daily inspection reports for all inspection activities such as base preparation, formwork preparation, reinforcement installation, concrete placement log, and temperature control activities. Submit sample forms and describe the procedure used to organize, archive, and retrieve inspection records in the Quality Program submittal.

1.8.4.2 Sampling Logs

Contractor shall maintain a concrete placement log as an electronic spreadsheet or database identifying each placement date, placement location, volume of concrete, batch ticket numbers, lot identification code, fresh concrete properties, compressive strength results, transport properties, inspection comments, and acceptance status. Contractor shall provide/transmit the concrete testing log to the Owner weekly. The Contractor shall provide copies of supporting documents for any placement requested by the Owner immediately upon request.

1.8.4.3 Quality Control Data

The Contractor shall prepare, maintain, and report separate quality control charts illustrating the slump, temperature, and compressive strength test results for each lot of each concrete mixture used on the project.

1.8.4.4 Quality Team Meetings

The contractor shall conduct regular quality control team meetings to review plans for future placements, review test results, and discuss dispensation of non-conforming materials. The quality team shall include the Contractor's quality manager, the project manager, the project superintendent, the Owner, and representatives of the testing agency and concrete producer, or approved substitutes. It is recommended that the meetings be held on a weekly or bi-weekly basis during the service life modeling submittal phases and then monthly, as the construction progresses. The transition from the weekly or bi-weekly meetings to the monthly meetings shall be with the Owner's approval.

The Contractor shall prepare quality control team meeting minutes for each meeting. The minutes shall include the date of each meeting, attendees, key discussion points, findings, recommendations, assigned tasks, assigned personnel, task completion dates, and status of each task.

1.8.4.5 Non-conforming materials

The exact location of non-conforming concrete as placed shall be identified and the Owner and Engineer of Record shall be notified immediately. There are numerous possible indicators that the as-placed concrete is non-conforming including (but not limited to) excessive compressive strength, inadequate compressive strength, excessive slump, excessive voids and honeycombing, and concrete delivery records that indicate excessive time between mixing and placement and/or excessive water was added to the mixture during delivery and placement. Any of these indicators alone are sufficient reason for the Owner to request additional sampling and testing

to quantify the concrete properties. If justified, cores may be extracted for testing, and an investigation into the cause for non-conformance shall be conducted. The investigation may include statistical analysis of the test data collected to date; appropriateness of the pre-defined QAL based on statistical analysis of production data; the impact of the non-conforming material on the structure strength and/or service life; and recommendations for concrete production process improvements, mitigation, or remediation, as appropriate.

Investigations into non-conforming materials shall be conducted at the Contractor's expense. The Contractor shall be responsible for the investigation and shall make written recommendations to adequately mitigate or remediate the non-conforming material. The Owner may accept, accept with reduced payment, require mitigation, or require removal and replacement of non-conforming material at no additional cost to the Owner.

1.8.5 Test Reports

Concrete Test Reports shall be identified by a sequential report identification code. Each report shall identify the placement date, placement location, weather, name of testing technician, time of sampling, batch ticket number, fresh concrete test results, and hardened concrete test results.

1.8.5.1 Concrete Mixture Requirements

a. Submit copies of test reports conforming to ASTM C1077 showing that the mixture has been successfully tested to produce concrete with the properties specified and that mixture will be suitable for the job conditions. Test reports shall be submitted along with the concrete mixture proportions. Obtain approval before concrete placement.

b. Fully describe the processes and methodology whereby mixture proportions were developed and tested and how proportions will be adjusted during progress of the work to achieve, as closely as possible, the designated levels of relevant properties.

1.8.5.2 Supplementary Cementing Materials

Submit test results in accordance with ASTM C618 and the physical and chemical analysis in accordance with applicable ASTM standards such as ASTM C311/C311M for fly ash. Submit test results performed within 6 months of submittal date. Update this report during construction as necessary to assure that the supplementary cementing materials used on the projects meets the ASTM criteria and the report on file is never older than 6 months.

1.8.5.3 Aggregates

Aggregate samples shall be obtained in accordance with ASTM D75/D75M and shall be representative of the materials to be used for the project. Submit test results for aggregate quality in accordance with ASTM C33/C33M, and the combined gradation curve proposed for use in the work and used in the mixture qualification, and ASTM C295/C295M for results of petrographic examination. Confirm that the potential for alkali-silica reaction are within allowable limits by conducting tests in accordance with ASTM C1260. Submit results of all tests during progress of the work in tabular and graphical form as noted above, describing the cumulative combined aggregate grading and the percent of the combined aggregate retained on each sieve. Submit test results performed within 12 months of submittal date.

1.8.5.4 Admixtures

Submit test results in accordance with ASTM C494/C494M and ASTM C1017/C1017M for concrete admixtures, ASTM C260/C260M for air-entraining admixture, and manufacturer's literature and test reports for corrosion inhibitors. Submitted data shall be based upon tests performed within 6 months of submittal. Submit certified copies of test results for the specific lots or batches to be used on the project. Test results shall be not more than 6 months old prior to use in the work. Chemical admixtures that have been in storage at the project site for longer than 6 months or that has been subjected to freezing will be retested at the expense of the Contractor.

1.8.5.5 Portland Cement

Portland cement will be accepted on the basis of manufacturer's certification of compliance, accompanied by mill test reports showing that the material in each shipment meets the requirements of the specification under which it is furnished. Mill test reports shall be no more than 1 month old, prior to use in the work. No cementitious material shall be used until notice of acceptance has been given by the Owner. Cementitious material may be subjected to check testing by the Owner from samples obtained at the mill, at transfer points, or at the project site. If tests prove that a cementitious material that has been delivered is unsatisfactory, it shall be promptly removed at Contractor's expense from the site of the work. Cementitious material that has not been used within 6 months after testing shall be retested at the Contractor's expense and shall be rejected if test results are not satisfactory. Submit test results in accordance with ASTM C150/C150M portland cement and/or ASTM C595/C595M.

1.8.5.6 Testing During Construction

During construction, the Contractor is responsible for sampling and testing aggregates, cementitious materials, and concrete as specified herein. The Owner will sample and test concrete and ingredient materials as considered appropriate. Provide facilities and labor as may be necessary for procurement of representative test samples. Testing by the Owner will in no way relieve the Contractor of the specified testing requirements.

1.8.5.7 Test Section

Horizontal Placements. No more than 90 days prior to construction, construct a Test Section 10 by 10 feet by 8 inches thick near the job site, but not as part of the structure. The Test Section shall meet all specification requirements and be acceptable to the Owner in all respects, including but not limited to delivery time, placement, consolidation, curing and surface texture. Use the Test Section to develop and demonstrate to the satisfaction of the Owner the proposed techniques of mixing, hauling, placing, consolidating, finishing, curing, initial saw cutting, start-up procedures, testing methods, plant operations, and the preparation of the construction joints. The mixing plant shall be operated and equipment calibrated prior to start of placing the Test Section. Use the same equipment, materials, and construction techniques on the Test Section as will be used in all subsequent work. Concrete production, placing, consolidating, curing, construction of joints, and all testing shall be in accordance with applicable provisions of this specification. At a minimum of three days after completion of the Test Section, extract a sufficient number of concrete cores 4 by 8 inch to conduct tests to evaluate strength, homogeneity, consolidation, and segregation. Test Results that are

unacceptable Test Section will necessitate construction of an additional Test Section at no additional cost to the Owner.

1.8.5.8 Acceptability of Work

The materials and the structure itself will be accepted on the basis of tests made by the Contractor and shall be in compliance with the criteria herein. The Owner may make check tests at its expense to validate the results of the Contractor's testing. Testing performed by the Owner will in no way relieve the Contractor from the specified testing requirements.

PART 2 PRODUCTS

2.1 CEMENTITIOUS MATERIALS

Cementitious materials shall be portland cement or cement blended with supplementary cementing materials. New submittals are required when the cementitious materials change sources or types.

The Contractor shall provide cementitious materials meeting the requirements of the applicable specification, and as modified herein. Provide mill certificates and test results conducted within six-months of the submittal date as part of the concrete mixture qualification submittal.

Provide a single manufacturer of cementitious material for each type of cement and supplementary cementing materials supplied to the project.

2.1.1 Portland Cement

Provide portland cement conforming to ASTM C150/C150M, Type II, low alkali including false set requirements with tri-calcium aluminates (C3A) content less than 10 percent and a maximum cement-alkali content of 0.80 percent Na2Oe (sodium oxide equivalent).

ASTM C150/C150M cements shall be combined with supplementary cementing materials in the concrete mixture.

2.1.2 Pozzolan

2.1.2.1 Fly Ash

Fly ash shall conform to ASTM C618, Class F, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 6 percent. Class F fly ash shall have a Calcium Oxide (CaO) content of less than 8 percent and a total equivalent alkali content less than 1.5 percent. Add with cement.

2.1.3 Supplementary Cementitious Materials (SCM) Content

The concrete mix shall always contain supplementary cementing materials whether or not the aggregates are found to be reactive in accordance with the paragraph AGGREGATES. Concrete mixtures shall be designed and proportioned to meet the requirements for strength, constructability, shrinkage, and durability.

2.2 AGGREGATES

Comply with ASTM C33/C33M Class 4S, except as modified herein.

The combined aggregates in the mixture (coarse, intermediate, and fine) shall be well graded with no more than 18 percent nor less than 8 percent of the combined aggregate retained on any individual sieve, unless satisfactory performance can be demonstrated. The No. 50 sieve may have less than 8 percent retained; sieves finer than No. 50 shall have less than 8 percent retained, and the coarsest sieve may have less than 8 percent retained. Use intermediate sizes for blending where necessary, to provide a well graded combined aggregate.

a. Provide gradation of individual and combined overall aggregate sizes using standard concrete aggregate sieves including 1-1/2 inches, one inch, 3/4 inch, 1/2 inch, 3/8 inch, No. 4, No. 8, No. 16, No. 30, No. 50, and No. 100.

b. Provide aggregates for exposed concrete from one source. Provide aggregate containing no deleterious material properties as identified by ASTM C295/C295M.

c. Where a size designation is indicated, that designation indicates the nominal maximum size of the coarse aggregate.

d. Aggregate tests shall be conducted within 6 months from the date of concrete mixture submittal.

e. Provide ASTM C1260 or ASTM C1567 test results conducted with 6 months of the submittal date showing the proposed coarse and fine aggregates are either: innocuous to alkali silica reaction; or that reactivity has been mitigated by the proposed cementitious materials as modified herein. Maximum allowable expansion is 0.08 percent at 14 days per ASTM C1260. If this is not met, then maximum allowable expansion for the proposed concrete mixture/s shall be 0.08 percent at 14 days per ASTM C1567. All aggregate sources shall be tested. Also, provide documentation that the aggregate has no history of chemical deterioration in concrete. Fine and coarse aggregates to be used in all concrete shall be evaluated and tested for alkali-aggregate reactivity. Both coarse aggregate size groups shall be tested.

2.3 WATER

Water shall comply with the requirements of ASTM C94/C94M and ASTM C1602/C1602M, except that the chloride and sulfate limits as tested in accordance with ASTM D512 and ASTM D516 shall not exceed 500 parts per million chloride ion and not more than 1000 parts per million of sulfate ion as SO4. Water shall be free from injurious amounts of oils, acids, alkalis, salts, and organic materials. Where non-potable water or water from reprocessed concrete is proposed for use in the work, submit results of tests in accordance with ASTM C1602/C1602M. Submit test results in accordance with ASTM D512 and ASTM D516.

2.4 ADMIXTURES

a. Provide certifications that chemical admixtures comply with the requirements shown in Table 3 and are compatible with each other. Use admixtures in accordance with manufacturer's recommendations, as appropriate for the climatic conditions and construction needs.

b. Do not use calcium chloride or admixtures containing chloride ion content in more than trace amounts from impurities in admixture ingredients or potable water. Provide maximum concentrations of

corrosion-inducing chemicals as shown in Table 3. For concrete that may be in contact with prestressing steel tendons, the concentration shall not exceed 60 percent of the limits given in Table 3.

| Table 3 - Limits on Corrosion-Inducing Chemicals | | |
|---|---|---|
| Chemical* | Limits, Percent** | Test Method |
| Chlorides | 0.10 | ASTM D512 |
| Fluorides | 0.10 | ASTM D1179 |
| Nitrates | 0.17 | ASTM D3867 |
| * Limits refer to water-soluble chemicals | | |
| ** Limits are expressed as a percentage of the mass of the total cementitious materials. | | |

c. The total alkali contribution of chemical admixtures shall not increase the total sodium-oxide equivalent content of the concrete mixture by more than 0.5 lb/yd3.

2.4.1 Accelerating

Comply with ASTM C494/C494M, Type C.

2.4.2 Retarding

Comply with ASTM C494/C494M, Type B, D, or G.

2.4.3 Water Reducing

Comply with ASTM C494/C494M, Type A, E, or F.

High Range Water Reducer (HRWR) shall comply with ASTM C494/C494M, Type F and ASTM C1017/C1017M.

2.4.4 Corrosion Inhibitors

Corrosion inhibitor shall be 30 percent water solution of calcium nitrite. Adjust the quantity of concrete mixing water for the mass of water in the admixture. Accelerating and set adjusted versions are acceptable, however concrete setting time and mixture workability shall be evaluated. Submit product data that shows compliance with the specified requirements.

2.5 NON-SHRINK GROUT

Comply with ASTM C1107/C1107M.

2.6 MATERIALS FOR FORMS

Provide wood, plywood, or steel. Use plywood or steel forms where a smooth form finish is required. Lumber shall be square edged or tongue-and-groove boards, free of raised grain, knotholes, or other surface defects.

Plywood: APA PS 1, B-B concrete form panels or better. Steel form surfaces

shall not contain irregularities, dents, or sags.

2.6.1 Form Ties and Form-Facing Material

a. Provide a form tie system that does not leave mild steel after break-off or removal any closer than 2 inches from the exposed surface. Do not use wire alone. Form ties and accessories shall not reduce the effective cover of the reinforcement.

b. Form-facing material shall be structural plywood or other material that can absorb air and some of the high water-cementitious materials ratio surface paste that may be trapped in pockets between the form and the concrete. Maximum reuse is three times. Provide forms with a form treatment to prevent bond of the concrete to the forms. Use a controlled permeability form liner in strict accordance with the manufacturer's recommendations.

2.7 REINFORCEMENT

2.7.1 Prestressing Steel

Use seven-wire stress-relieved or low-relaxation strand conforming to ASTM A416/A416M, Grade 270. Use prestressing steel free of grease, oil, wax, paint, soil, dirt, and loose rust. Do not use prestressing strands or wire having kinks, bends, or other defects.

2.7.2 Reinforcing Bars

Comply with ACI 301 unless otherwise specified and shall meet the design yield strength and ductility requirements. Deformed reinforcing bars meeting the requirements of ASTM A615/A615M.

The reinforcing selected shall match the structural properties of the reinforcing specified.

2.7.3 Mechanical Reinforcing Bar Connectors

Comply with ACI 301. Provide 125 percent minimum yield strength of the reinforcement bar. Coat connectors in accordance with the requirements of the reinforcing bars.

2.7.4 Wire

Comply with ASTM A1064/A1064M carbon steel.

2.8 ACCESSORY MATERIALS

2.8.1 Materials for Curing Concrete

2.8.1.1 Impervious Sheeting

Comply with ASTM C171; waterproof paper, clear or white polyethylene sheeting, or polyethylene-coated burlap.

2.8.1.2 Pervious Sheeting

Comply with AASHTO M 182 or carpet covering the free surface and kept continuously wet throughout the curing period.

2.8.2 Expansion/Contraction Joint Filler / Preformed Joint Filler

Comply with ASTM D1751 or ASTM D1752, 1/2 inch thick unless otherwise indicated.

2.8.3 Joint Sealants

2.8.3.1 Horizontal Surfaces

Horizontal surfaces are defined as all surfaces with a 3 percent maximum slope. ASTM D6690 or ASTM C920, Type M, Class 25, Use T.

2.8.3.2 Vertical Surfaces

Vertical surfaces are defined as all surfaces with a slope greater than 3 percent. ASTM C920, Type M, Grade NS, Class 25, Use T. FS SS-S-200, no sag.

PART 3 EXECUTION

3.1 FORMS

a. Provide formwork with clean-out openings to permit inspection and removal of debris. Formwork shall be gasketed or otherwise rendered sufficiently tight to prevent leakage of paste or grout under heavy, high-frequency vibration. Use a release agent that does not cause surface dusting. Limit reuse of plywood to no more than three times. Reuse may be further limited by the Owner if it is found that the pores of the plywood are clogged with paste so that the wood does not absorb air and some of the high water-cementitious materials ratio paste that may be trapped in pockets between the form and the concrete.

b. Comply with ACI 301. Concrete for footings may be placed in excavations without forms upon inspection and approval by the Owner. Excavation width shall be a minimum of 4 inches greater than indicated. Set forms rigidly, mortar-tight, and true to line and grade. Chamfer above grade exposed joints, edges, and external corners of concrete 0.75 inch unless otherwise indicated. Forms submerged in water shall be watertight.

c. Patch form tie holes with a no shrink patching material in accordance with the manufacturer's recommendations and subject to approval.

d. Provide form tolerances that represent the most restrictive requirements from ACI 117. Formwork shall produce concrete surfaces that are consistent with the concrete's final use. Faces to receive fender elements shall not vary from a theoretical vertical plane by more than 1/8 inch. Surfaces to receive armor, mooring hardware, or other hardware shall be consistent with the minimum grout thickness requirements. Joint armor elements shall be cast-in-place.

3.1.1 Coating

Before concrete placement, coat the contact surfaces of forms with a no staining mineral oil, no staining form coating compound, or two coats of nitrocellulose lacquer. Do not use mineral oil on forms for surfaces to which adhesive, paint, or other finish material is to be applied.

3.1.2 Removal of Forms and Supports

After placing concrete, forms shall remain in place for the time periods specified in ACI 347R, except for concrete placed underwater, forms shall remain in place a minimum of 48 hours. Prevent concrete damage during form removal.

3.1.2.1 Special Requirements for Reduced Time Period

Forms may be removed earlier than specified if ASTM C39/C39M test results of field-cured samples from a representative portion of the structure or other approved and calibrated non-destructive testing techniques show that the concrete has reached a minimum of 100 percent of the design strength.

3.2 PLACING REINFORCEMENT AND MISCELLANEOUS MATERIALS

Comply with ACI 301. Remove rust, scale, oil, grease, clay, or foreign substances from reinforcing that would reduce the epoxy coating bond from reinforcing. Do not tack weld. Inspect and verify proper reinforcement grade, quantity, spacing, and clearance requirements prior to concrete placement.

3.2.1 Reinforcement Supports

Place reinforcement and secure with non-corrodible chairs, spacers, and hangers. Metal hangers may be used, but shall be of similar material to the reinforcing. Support reinforcement on the ground with concrete or other non-corrodible material, having a compressive strength equal to or greater than the concrete being placed and having permeability equal or less than the concrete being placed.

3.2.2 Splicing

As indicated. For splices not indicated, comply with ACI 301. Do not splice at points of maximum stress.

3.2.3 Cover

Provide concrete cover thickness as shown on the Plans. If no concrete cover is specified, provide 3" concrete cover over the steel reinforcement. Use ACI 117 to determine allowable tolerances for the placement of the steel.

3.2.4 Setting Miscellaneous Material and Prestress Anchorages

Place and secure anchors, bolts, pipe sleeves, conduits, and other such items in position before concrete placement. Plumb anchor bolts and check location and elevation. Temporarily fill voids in sleeves with readily removable material to prevent the entry of concrete. Electrically isolate exposed steel work and its anchor systems from the primary steel reinforcement with at least 2 inches of concrete. Coat exposed steel work to reduce corrosion. Take particular care to ensure against corrosion on edges and horizontal surfaces. Use epoxy coatings for protection of carbon steel plates and fittings.

3.2.5 Construction Joints

Locate joints to least impair strength. Continue reinforcement across joints unless otherwise indicated. Final joint locations are subject to

Owner approval.

## 3.3 BATCHING, MEASURING, MIXING, AND TRANSPORTING CONCRETE

Comply with ASTM C94/C94M, ACI 301, and ACI 304R, except as modified herein. Batching equipment shall be such that the concrete ingredients are consistently measured within the following tolerances: 1 percent for cement and water, 2 percent for aggregate, and 3 percent for admixtures. Furnish mandatory batch tickets imprinted with mix identification, batch size, batch design and measured weights, moisture in the aggregates, and time batched for each load of ready mix concrete. When a pozzolan is batched cumulatively with the cement, it shall be batched after the cement has entered the weight hopper.

All trucks shall arrive at the site with full water tanks and no additional water shall be added to the mix during transport from the batch plant to the job site. Mixing water shall not be added after a truck has left the plant except by authorization of the Owner.

### 3.3.1 Measuring

Make measurements at intervals as specified in paragraphs SAMPLING and TESTING.

Adjust batch proportions to replicate the mixture design using methods provided in the approved quality assurance plan. Base the adjustments on results of tests of materials at the batch plant for use in the work. Maintain a full record of adjustments and the basis for each.

### 3.3.2 Mixing

Comply with ASTM C94/C94M and ACI 301. Machine mix concrete. Begin mixing within 30 minutes after the cement has been added to the aggregates. Place concrete within 90 minutes of either addition of mixing water to cement and aggregates or addition of cement to aggregates if the air temperature is less than 85 degrees F. Reduce mixing time and place concrete within 60 minutes if the air temperature is greater than 85 degrees F except as follows: if set retarding admixture is used and slump requirements can be met, limit for placing concrete may remain at 90 minutes. Dissolve admixtures in the mixing water and mix in the drum to uniformly distribute the admixture throughout the batch.

### 3.3.3 Transporting

Comply with ACI 304R.

## 3.4 PLACING CONCRETE

Comply with ACI 304R and ACI 304.2R. Place concrete as soon as practicable after the forms and the reinforcement have been inspected and approved. Do not place concrete when weather conditions prevent proper placement and consolidation; in uncovered areas during periods of precipitation; or in standing water. Prior to placing concrete, remove dirt, construction debris, water, snow, and ice from within the forms. Deposit concrete as close as practicable to the final position in the forms. Do not exceed a free vertical drop of 3 feet from the point of discharge. Place concrete in one continuous operation from one end of the structure towards the other or lifts for vertical construction. Position grade stakes on 20 foot centers maximum for exterior slabs. No concrete shall be placed with 100 feet of

pile driving operations or earth compaction operations.

3.4.1 Vibration

Comply with the requirements of ACI 309R using vibrators with a minimum frequency of 9000 vibrations per minute (VPM). Use only high cycle or high frequency vibrators. Motor-in-head 60 cycle vibrators may not be used. For walls and deep beams, use a minimum of two vibrators with the first to melt down the mixture and the second to thoroughly consolidate the mass. Provide a spare vibrator at the casting site whenever concrete is placed. Place concrete in 18 inch maximum vertical lifts. Insert and withdraw vibrators approximately 18 inches apart. Penetrate at least 8 inches into the previously placed lift with the vibrator when more than one lift is required. Extract the vibrator using a series of up and down motions to drive the trapped air out of the concrete and from between the concrete and the forms.

For slab construction, use vibrating screeds designed to consolidate the full depth of the concrete. Hand-operated vibrators shall not be operated in the concrete at one location for more than 20 seconds. Insertion locations for hand-operated vibrators shall be between 6 to 15 inches on centers. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) shall require the immediate stopping of the operation and approved adjustment of the equipment or procedures. Vibrators shall be equipped with rubber vibrator heads.

3.4.2 Pumping

Comply with ACI 304R and ACI 304.2R. Pumping shall not result in separation or loss of materials nor cause interruptions sufficient to permit loss of plasticity between successive increments. Loss of slump in pumping equipment shall not exceed 2 inches. Do not use pipe made of aluminum or aluminum alloy. Avoid rapid changes in pipe sizes. Limit maximum size of coarse aggregate to 33 percent of the diameter of the pipe. Maximum size of well rounded aggregate shall be limited to 40 percent of the pipe diameter. Take samples for testing at both the point of delivery to the pump and at the discharge end.

3.4.3 Cold Weather

Comply with ACI 306R. Do not allow concrete temperature to decrease below 50 degrees F. Obtain approval prior to placing concrete when ambient temperature is below 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 24 hours. Placement of concrete shall be halted whenever the ambient temperature drops below 40 degrees F. When the ambient temperature is less than 50 degrees F the temperature of the concrete when placed shall be not less than 50 degrees F or more than 75 degrees F. Heating of the mixing water or aggregates may be necessary to regulate the concrete placing temperature. An accelerating admixture may be used when the ambient temperature is below 50 degrees F. Covering and other means shall be provided for maintaining the concrete at a temperature of at least 50 degrees F for not less than 7 days after placing, and at a temperature above freezing for the remainder of the curing period.

3.4.4 Hot Weather

Comply with ACI 305R. The temperature of concrete at the time of placement shall not exceed 90 degrees F. Use ice or chilled water for part of mixing

water in order to cool the concrete, proportioned such that it does not affect the water cement ratio of the design concrete mix. The concrete temperature shall be estimated in accordance with Appendix A of ACI 305R.

Aggregates shall be stored in shaded area to keep it as cool as possible. Cool water may be used to reduce the temperature of aggregates. Wetting of aggregates can cause variations in surface moisture. Moisture tests or the use of moisture probes are necessary to ensure that the correct batch adjustments are made and the water cement ratio of the concrete is maintained as specified. Do not allow the temperature of concrete to decrease below 50 degrees F. The concrete placements shall be scheduled during the coolest part of the morning or at night time. Provide additional lighting during night-time production to ensure proper inspection by Owner's inspector.

Before the start of the project, plans shall be made to minimize the exposure of the concrete to adverse conditions. Personnel in charge of concrete construction shall be aware of the damaging combinations of high air temperature, direct sunlight, drying winds, and high concrete temperature. Provide water hoses, pipes, spraying equipment, and water hauling equipment, where job site is remote to water source, to maintain a moist concrete surface throughout the curing period. Materials and means shall be on hand for erecting temporary windbreaks and shades as needed to protect against drying winds and direct sunlight. Curing materials shall be readily available at the project site to permit prompt protection of all exposed surfaces from premature drying upon completion of the placement.

Contractor shall provide and maintain a portable weather station for monitoring weather conditions before, during and after concrete placements for the slab areas like the landside platform and dock platform topping slab. The system shall be capable of measuring air temperature, wind speed and relative humidity. Measurements shall be taken 1 hour prior to concrete placement, at 15 minute intervals, and throughout the placement, and initial curing duration. Measurements shall be taken at locations as follows:

| **Measurement** | **Horizontal Location** | **Vertical Location** | **Condition** |
|---|---|---|---|
| Air Temperature | Windward edge | 4' to 6' above surface | Shaded from Sun |
| Relative Humidity | Windward edge | 4' to 6' above surface | Shaded from Sun |
| Wind Speed | Windward edge | 20 inches above surface | NA |
| Concrete Temperature | Windward edge | Concrete Surface | Shaded from Sun |

Maintain required concrete temperature using Figure 2.1.5, "Effect of Concrete Temperatures, Relative Humidity, and Wind Velocity on the Rate of Evaporation of Surface Moisture From Concrete" in ACI 305R to prevent the evaporation rate from exceeding 0.2 pound of water per square foot of exposed concrete per hour. Resulting values are only valid while bleed water is present. If bleed water is not present, then the evaporation rate has exceeded the concrete bleed rate or the concrete has reached its initial set. If the former occurs, immediate application of mitigative actions shall be implemented. Once the rate of evaporations has reached a value of 0.1 lb/ft2/hr, the contractor shall deploy and have ready means of limiting evaporation rates. If the evaporation rate is above 0.1 lb/ft2/hr

and continues to increase, evaporation limiting features shall be implemented prior to reaching 0.2 lb/ft2/hr. Concrete evaporation rates shall be controlled by one or more of the following means (listed in order of preference):

1. Cooling concrete constituents prior to and/or during mixing.
2. Fogging with fresh water after placement continuously until curing begins. Fogging is required to limit evaporation rates as described herein, however fogging must be implemented if anticipated air temperature is forecast to exceed 85 degrees Fahrenheit during the day.
3. Use of surface applied evaporation retarders.
4. Installation of wind breaks around perimeter of the area being placed. Once a wind break is erected, wind speed readings shall be taken from within the windbreak that is a distance from the windbreak of at least 3 times the windbreak height.
5. Shading placement area from direct sunlight.

When fogging, the rate of application of fog shall not cause additional water to collect on the concrete surface. Fogging shall be a high pressure air/water system that will increase the humidity level just above the concrete surface and not deposit water on the placed concrete surface. Adjust fogging pressure and/or rates to accomplish humidity increase without adding water to the surface.

If used, evaporation retarders shall be used in strict accordance with manufacturer's application instructions. Over-use of retarders can damage concrete surfaces. Apply retarder after initial screed and again after initial float. Do not disturb retarder, once applied, until secondary floating or finishing operations begin.

Curing shall begin immediately after finishing operations are complete. Completed areas shall be covering with curing materials as remaining areas area finished. Fogging shall remain in place until curing has begun.

### 3.4.5 Prevention of Plastic Shrinkage Cracking

During weather with low humidity, and particularly with high temperature and appreciable wind, develop and institute measures to prevent plastic shrinkage cracks from developing. If plastic shrinkage cracking occurs, halt further placement of concrete until protective measures are in place to prevent further cracking. Periods of high potential for plastic shrinkage cracking can be anticipated by use of Figure 2.1.5 of ACI 305R. In addition to the protective measures concrete placement shall be further protected by erecting shades and windbreaks and by applying fog sprays of water, the addition of monomolecular films, or wet covering. When such water treatment is stopped, curing procedures shall be immediately commenced. The methods and materials to remove or repair areas affected by plastic shrinkage cracks shall be suggested by the Contractor, reviewed by the Owner's Subject Matter Expert in Concrete Materials, and approved by the Owner. Cracks shall never be troweled over or filled with cement slurry.

## 3.5 SURFACE FINISHES EXCEPT FLOOR, SLAB, AND PAVEMENT

### 3.5.1 Defects

Repair formed surfaces by removing minor honeycombs, pits greater than one square inch surface area or 0.25 inch maximum depth, or otherwise defective areas. Provide edges perpendicular to the surface and patch with non-shrink grout. Patch tie holes and defects when the forms are removed. Concrete

with extensive honeycomb including exposed steel reinforcement, cold joints, entrapped debris, separated aggregate, or other defects that affect the serviceability or structural strength will be rejected, unless correction of defects is approved. Obtain approval of corrective action prior to repair. The surface of the concrete shall not vary more than the allowable tolerances of ACI 347R, unless noted otherwise or specified in this section. Exposed surfaces shall be uniform in appearance and finished to a smooth form finish unless otherwise indicated.

3.5.2 Formed Surfaces

3.5.2.1 Tolerances

Comply with ACI 117 and as indicated.

3.5.2.2 As-Cast Rough Form

Provide for surfaces not exposed to public view. Patch holes and defects and level abrupt irregularities. Remove or rub off fins and other projections exceeding 0.25 inch in height.

3.5.2.3 As-Cast Form

Provide form facing material producing a smooth, hard, uniform texture on the concrete. Arrange facing material in an orderly and symmetrical manner and keep seams to a practical minimum. Support forms as necessary to meet required tolerances. Material with raised grain, torn surfaces, worn edges, patches, dents, or other defects that will impair the texture of the concrete surface shall not be used. Patch tie holes and defects and completely remove fins.

3.6 FINISHES FOR HORIZONTAL CONCRETE SURFACES

3.6.1 Surface Finish

Provide concrete indicated with a surface finish as follows in Table 4.

**Table 4 - Surface Finishes**

| | |
|---|---|
| Dock Platform Topping Slab, Landside Platform, Bull Rail | Floated |
| Mooring Structure Cap | Medium Broom |

3.6.2 Finish

Comply with ACI 301. Place, consolidate, and immediately strike off concrete to obtain proper contour, grade, and elevation before bleedwater appears. Permit concrete to attain a set sufficient for floating and supporting the weight of the finisher and equipment. If bleedwater is present prior to floating the surface, drag excess water off or remove by absorption with porous materials. Do not use dry cement to absorb bleedwater.

3.6.2.1 Scratched

Use for surfaces intended to receive bonded applied cementitious applications. After the concrete has been placed, consolidated, struck off, and leveled, the surface shall be roughened with stiff brushes of rakes

before final set.

3.6.2.2 Floated

Exterior slabs where not otherwise specified. After the concrete has been placed, consolidated, struck off, and leveled, do not work the concrete further, until ready for floating. Whether floating with a wood, magnesium, or composite hand float, with a bladed power trowel equipped with float shoes, or with a powered disc, float shall begin when the surface has stiffened sufficiently to permit the operation.

3.6.2.3 Broomed

Perform a floated finish, then draw a broom or burlap belt across the surface to produce a coarse scored texture. Permit surface to harden sufficiently to retain the scoring or ridges. Broom transverse to traffic or at right angles to the slope of the slab.

3.6.2.4 Pavement

Screed the concrete with a template advanced with a combined longitudinal and crosswise motion. Maintain a slight surplus of concrete ahead of the template. After screeding, float the concrete longitudinally. Use a straightedge to check slope and flatness; correct and refloat as necessary. Obtain final finish by a burlap drag. Drag a strip of clean, wet burlap from 3 to 10 feet wide and 2 feet longer than the pavement width across the slab. Produce a fine, granular, sandy textured surface without disfiguring marks. Round edges and joints with an edger having a radius of 1/8 inch.

3.6.2.5 Concrete Toppings Placement

Remove dirt, laitance, and loose aggregate by means of a stiff wire broom. Keep the base wet for a period of 12 hours preceding the application of the topping. Remove excess water prior to the topping placement. Do not allow temperature differential between the completed base and the topping to exceed 10 degrees F at the time of placing. Place the topping and finish as specified for pavement.

3.7 CURING AND PROTECTION

Comply with ACI 301 and ACI 308.1 unless otherwise specified. Prevent concrete from drying by misting surface of concrete. Begin curing immediately following final set. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. Curing shall be accomplished by wet curing. Avoid damage to concrete from vibration created by pile driving, movement of equipment in the vicinity, disturbance of formwork or protruding reinforcement, by rain or running water, adverse weather conditions, and any other activity resulting in ground vibrations. Protect concrete from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks, and oil stains. Do not allow concrete to dry out from time of placement until the expiration of the specified curing period. If forms are removed prior to the expiration of the curing period, provide another curing procedure specified herein for the remaining portion of the curing period. For concrete slabs, fog spray until wet curing is started.

3.7.1 Wet Curing

Wet cure concrete using ASTM C1602/C1602M compliant or potable water for a minimum of 7 days. Pond water continuously on flat surfaces. Run misters and soaker hoses continuously to keep concrete surfaces completely saturated. Do not allow construction loads to exceed the superimposed load that the structural member, with necessary supplemental support, is capable of carrying in current condition safely and without damage.

Leaving the forms in place for seven days is a suitable alternative to wet curing.

3.7.1.1 Ponding or Immersion

Continually immerse the concrete throughout the seven-day curing period. Water shall not be 20 degrees F less than the temperature of the concrete. For temperatures between 40 and 50 degrees F, increase the curing period by 50 percent. Contractor shall ensure that the water used for ponding is well contained on the surface and is prevented from seeping into the subbase and subgrade below.

3.7.1.2 Fog Spraying or Sprinkling

Apply water uniformly and continuously throughout the curing period. For temperatures between 40 and 50 degrees F, increase the curing period by 50 percent.

3.7.1.3 Pervious Sheeting

Completely cover surface and edges of the concrete with wet cotton mats (12oz./SY). Overlap mats 12 inches over adjacent mats. Mats shall be at least as long as the width of the surface to be cured. During application, do not drag the mats over the finished concrete nor over mats already placed. Wet mats thoroughly and keep continuously wet throughout the curing period.

3.7.1.4 Impervious Sheeting

After applying wet cotton mats, cover with impervious sheeting throughout the curing period. Lay sheeting directly on the concrete surface and overlap edges 12 inches minimum. Impervious sheeting shall be a clear or opaque (10 mil minimum) polyethylene film. Provide sheeting not less than 18 inches wider than the concrete surface to be cured. Secure edges and transverse laps to form closed joints. Repair torn or damaged sheeting or provide new sheeting. Cover or wrap vertical structural elements from the top down with impervious sheeting; overlap and continuously tape sheeting joints; and introduce sufficient water to soak the entire surface prior to completely enclosing.

3.8 FIELD QUALITY CONTROL

3.8.1 Fresh Concrete Properties

For each concrete mixture, the Contractor shall take samples in accordance with ASTM C172/C172M, test and record the slump, and temperature. Adjustment of slump with chemical admixture is permitted provided the water to cementitious material ratio is not exceeded.

3.8.1.1 Slump Tests

ASTM C143/C143M. Take concrete samples during concrete placement. The maximum slump may be increased as specified with the addition of an approved high range water reducing (HRWR) admixture provided that the water-cementitious ratio is not exceeded. Perform tests at commencement of concrete placement, when test cylinders are made, and for each batch (minimum) or every 50 cubic yards (maximum) of concrete. If concrete does not pass slump test, adjust using a HRWR and test every concrete batch until two consecutive batches meet slump without adjustment.

3.8.1.2 Temperature Tests

a. Test the concrete delivered and the concrete in the forms. Perform tests in hot or cold weather conditions below 50 degrees F and above 80 degrees F for each batch (minimum) or every 50 cubic yards (maximum) of concrete, until the specified temperature is obtained, and whenever test cylinders and slump tests are made.

b. Determine temperature of each concrete sample in accordance with ASTM C1064/C1064M.

3.8.1.3 Unit Weight Test

ASTM C138/C138M. Take concrete samples during concrete placement. Perform tests at commencement of concrete placement, when test cylinders are made, and for each batch (minimum) or every 50 cubic yards(maximum) of concrete.

3.8.2 Hardened Concrete Properties

Sample and test each lot at 50 cubic yards per structure, or fraction thereof, of each design mixture of concrete placed in any one day.

Cast and cure specimens in accordance with ASTM C172/C172M, ASTM C31/C31M, and applicable requirements of ACI 305R and ACI 306R.

For each lot, record the date and time sampled, the batch ticket code, cylinder ID code the location of placement, total volume of concrete represented by the sample, and fresh concrete properties; ASTM C143/C143M for slump or ASTM C1611/C1611M for slump flow and visual stability index (VSI), ASTM C1064/C1064M for temperature, and ASTM C138/C138M unit weight.

For each lot sample, cast seven 6 by 12 inch cylinder specimens for strength. These cylinders shall be wrapped completely with slightly damped paper towels with water only. The wrapped cylinders shall be placed in either a vacuum package or double layers of sealed plastic bags. Package cylinders to prevent damage and ship to the approved testing laboratory.

In the event quality acceptance test results and retest results fail to meet the quality acceptance criteria, the entire lot shall be considered non-conforming material, refer to the paragraph REPAIR, REHABILITATION and REMOVAL.

3.8.2.1 Compressive Strength Tests

ACI 214R tests for strength - conduct strength tests of concrete during construction in accordance with the following procedures:

a. Each test shall consist of seven (7) cylinders. Test cylinders in

accordance with ASTM C39/C39M. Test one cylinder at 3 days, two cylinders at 7 days, and three cylinders at 28 days. Hold the remaining cylinder in storage. If one specimen in a test shows evidence of improper sampling, molding or testing, discard the specimen and consider the strength of the remaining cylinder to be the test result. If more than one specimen shows excess defects, the Owner may allow the entire test to be discarded. Test results shall not exceed the specified compressive strength by more than 20 percent for the age specified.

b. If the average strength test results are less than the specified strength (f'c) extract three core samples from the structure in accordance with ASTM C42/C42M, from the area that correlates to the low test results. These extracted cores shall not contain steel reinforcing. Repair core holes with non-shrink grout. Match color and finish of adjacent concrete. For concrete not meeting strength criteria, the Contractor shall prepare a remediation strategy for the review by the Owner.

c. Strength test reports shall be provided within 7 days of test completion.

3.8.2.2 Chloride Ion Concentration

Comply with Table 1. Determine water soluble chloride ion concentration. Perform test once for each mix design.

3.8.2.3 Non-Destructive Tests

Use of a rebound hammer to obtain data on the strength of the concrete surface shall be in accordance with ASTM C805/C805M. Test results from the rebound hammer and other non-destructive testing may be helpful in selecting areas to extract concrete cores for destructive testing.

3.8.3 Core Samples and Compressive Strength Testing

Obtain and test cores in accordance with ASTM C42/C42M.

If concrete in the structure is dry under service conditions, air dry cores (temperature 60 to 80 degrees F, relative humidity less than 60 percent) for 7 days before testing and test dry. Otherwise, test the cores, after moisture conditioning, in accordance with ASTM C42/C42M.

Acceptance criteria for cylinder compressive strength are provided in paragraph ACCEPTANCE OF CONCRETE STRENGTH.

Take at least three representative cores from each member or area of concrete in place that is considered potentially strength deficient. Impair the strength of the structure as little as possible. If, before testing, extracted cores show evidence of having been damaged subsequent to or during removal from the structure, take replacement cores.

Fill core holes with low slump concrete or mortar of a strength equal to or greater than the original concrete.

The Owner will evaluate and validate core tests in accordance with the specified procedures.

3.8.4 Acceptance of Concrete Strength

3.8.4.1 Standard Molded and Cured Strength Specimens

The acceptance of concrete strengths shall be based on averages of results from three consecutive compressive strength tests. When the averages of all sets of three consecutive compressive strength test results are between 1.0 and 1.2 times the field test strength (fcr), and no individual strength test falls below fcr by more than 500 psi, the strength of the concrete is satisfactory. These criteria also apply when accelerated strength testing is specified unless another basis for acceptance is specified.

3.8.4.2 Non-Destructive Tests

Non-destructive tests may be used when permitted to evaluate concrete where standard molded and cured cylinders have yielded results not meeting the criteria.

3.8.4.3 Extracted Core Tests

When the average compressive strengths of the representative cores are between 0.85 fcr and 1.2 fcr and if no single core is less than 0.75 fcr, the strength of concrete is satisfactory.

3.9 REPAIR, REHABILITATION AND REMOVAL

Before the Owner accepts the structure and final payment is made the Contractor shall inspect the structure for cracks, damage, and substandard concrete placements that may adversely affect the service life of the structure. A report documenting these defects shall be prepared that includes recommendations for repair, removal and/or remediation which, will be reviewed by the Owner's Subject Matter Expert in Concrete Materials and submitted to the Owner for approval before any corrective work is accomplished.

3.9.1 Crack Repair

Prior to final acceptance, all cracks in excess of 0.02 inches wide shall be documented and repaired. The proposed method and materials to repair the cracks shall be submitted to the Owner for approval. The proposal shall address the amount of movement expected in the crack due to temperature changes and loading.

3.9.2 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Concrete surfaces with weak surfaces less than 1/4 inch thick shall be diamond ground to remove the weak surface. Surfaces containing weak surfaces greater than 1/4 inch thick shall be removed and replaced or mitigated in a manner acceptable to the Owner.

3.9.3 Failure of Quality Assurance Test Results

Proposed mitigation efforts by the Contractor to restore the original design intent shall be reviewed by the Owner's Subject Matter Expert in Concrete Materials and approved by the Owner prior to proceeding.

-- End of Section --

SECTION 03 45 33

PRECAST STRUCTURAL CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

| | |
|---|---|
| AASHTO M 251 | (2006; R 2011) Standard Specification for Plain and Laminated Elastomeric Bridge Bearings |

AMERICAN CONCRETE INSTITUTE (ACI)

| | |
|---|---|
| ACI 318 | (2014; Errata 1-2 2014; Errata 3-5 2015; Errata 6 2016; Errata 7-9 2017) Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14) |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A27/A27M | (2020) Standard Specification for Steel Castings, Carbon, for General Application |
| ASTM A36/A36M | (2019) Standard Specification for Carbon Structural Steel |
| ASTM A47/A47M | (1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings |
| ASTM A123/A123M | (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products |
| ASTM A153/A153M | (2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware |
| ASTM A615/A615M | (2020) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement |
| ASTM A1064/A1064M | (2017) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete |
| ASTM C94/C94M | (2021a) Standard Specification for Ready-Mixed Concrete |

| | |
|---|---|
| ASTM C1107/C1107M | (2020) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink) |

PRECAST/PRESTRESSED CONCRETE INSTITUTE (PCI)

| | |
|---|---|
| PCI MNL-116 | (1999) Manual for Quality Control for Plants and Production of Structural Precast Concrete Products, 4th Edition |
| PCI MNL-120 | (2021) PCI Design Handbook - Precast and Prestressed Concrete, 8th Edition |
| PCI MNL-135 | (2000) Tolerance Manual for Precast and Prestressed Concrete Construction |

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings of Precast Members

Drawings of Precast Prestressed Concrete Members

SD-03 Product Data

Anchorage and Lifting Inserts and devices

Bearing Pads

SD-05 Design Data

Precast Prestressed Concrete Members Design Calculations

Concrete Mix Design

SD-06 Test Reports

Concrete Mix Design

Concrete and Aggregate Quality Control Testing

SD-07 Certificates

Quality Control Procedures

Construction Records

SD-11 Closeout Submittals

Concrete Batch Ticket Information

## 1.3 QUALITY ASSURANCE

### 1.3.1 Qualifications

#### 1.3.1.1 Manufacturer Qualifications

PCI MNL-116. Plants must be certified by the PCI Plant Certification Program for Categories C1 and C3 work. At the Owner's option, PCI Plant quality control program records must be available for review.

PCI MNL-116. Where panels are manufactured by specialists in plants not currently enrolled in the PCI "Quality Control Program," provide a product quality control system in accordance with PCI MNL-116 and perform concrete and aggregate quality control testing using an approved, independent commercial testing laboratory. Submit test results to the Owner.

#### 1.3.1.2 Erector Qualifications

The erector shall have prior experience of at least three years in the erection of precast structural concrete similar to the requirements of this project.

### 1.3.2 Regulatory Requirements

Provide precast non-prestressed and precast-prestressed members in conformance with ACI 318 and PCI MNL-120.

### 1.3.3 Concrete Mix Design

Thirty days minimum prior to concrete placement, submit a mix design for each strength and type of concrete. Concrete mix design and associated submittals shall be in accordance with 03 31 30 MARINE CONCRETE.

### 1.3.4 Certificates: Record Requirement

ASTM C94/C94M. Submit mandatory batch ticket information for each load of ready-mixed concrete.

## 1.4 DELIVERY, STORAGE, AND HANDLING

### 1.4.1 Transportation

#### 1.4.1.1 Transporting Members

Transport members in a manner to avoid excessive stresses that could cause cracking or other damage.

#### 1.4.1.2 Lateral Deflection or Vibration

Any noticeable indication of lateral deflection or vibration during transportation must be corrected by rigid bracing between members or by means of lateral trussing.

### 1.4.2 Storage

#### 1.4.2.1 Storage Areas

Storage areas for precast and precast-prestressed members must be stabilized, and suitable foundations must be provided, so differential

settlement or twisting of members will not occur.

1.4.2.2 Stacked Members

Stack members with adequate dunnage and bracing to control cracking, distortion, warping or other physical damage. Stack members such that lifting devices will be accessible and undamaged.

1.4.3 Handling of Members

The location of pickup points for handling of the members and details of the pickup devices must be shown in shop drawings. Members must be handled only by means of approved devices at designated locations.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The work includes the provision of precast non-prestressed concrete herein referred to as precast members and precast, prestressed concrete herein referred to as prestressed members. Precast and Prestressed members must be the product of a manufacturer specializing in the production of precast prestressed concrete members.

2.1.1 Design Requirements

Design precast and prestressed members in accordance with ACI 318 and the PCI MNL-120. Precast and prestressed members shown on drawing have been designed for dead and live loads anticipated subsequent to completion of construction. Design precast and prestressed members for the handling and erection loads. Design precast and prestressed members for handling without cracking in accordance with the PCI MNL-120. Concrete toppings shall not be used in establishing the design strength of the precast and prestressed members.

2.1.1.1 Loads

Loadings must include all dead load, live load, applicable construction loads such as handling, erection loads, and other applicable loads.

2.1.1.2 Drawing and Design Calculation Information

Submit drawings and design calculations indicating complete information for the fabrication, handling, and erection of the precast and prestressed members. Include a cover page with the design calculations, signed and sealed by the registered professional engineer in the State of Texas who prepared the design. Drawings must not be reproductions of contract drawings. Design calculations, drawings of precast members, and drawings of precast prestressed concrete members must be signed and sealed by a registered professional engineer in the State of Texas experienced in the design of precast and prestressed concrete members, and submitted for approval prior to fabrication. The drawings must indicate, as a minimum, the following information:

a. Plans, elevations and other drawing views showing the following:

(1) Member piece marks locating and defining products furnished by the manufacturer.

(2) Headers for openings.

(3) Relationships to adjacent material.

(4) Joints and openings between members and between members and other construction.

(5) Location of field installed anchors.

(6) Erection sequences and handling requirements

(7) Lifting and erection inserts.

b. Elevations, sections and other details for each member showing the following:

(1) Connections between members and connections between members and other construction.

(2) Connections for work of other trades and cast-in items and their relation to other trades.

(3) Dimensioned size and shape for each member with quantities, position and other details of reinforcing steel, anchors, inserts and other embedded items.

(4) Lifting, erection and other handling devices and inserts.

(5) Surface finishes of each member.

(6) Estimated cambers.

c. Magnitude, schedule and sequence of tensioning and detensioning prestressing strands.

d. Strength properties for concrete, steel and other materials.

e. Expected camber.

f. Methods for storage and transportation.

g. All dead, live, handling, erection and other applicable loads used in the design.

h. Signature and seal of the registered design professional who prepared the design.

2.2 MATERIALS

2.2.1 Concrete

Concrete mix design for precast and prestressed concrete shall be in accordance with specification section 03 31 30 MARINE CONCRETE.

2.2.2 Grout

2.2.2.1 Nonshrink Grout

ASTM C1107/C1107M.

2.2.3 Reinforcement

2.2.3.1 Reinforcing Bars

ASTM A615/A615M, Grade 60.

2.2.3.2 Wire

ASTM A1064/A1064M.

2.2.3.3 Welded Wire Reinforcement

ASTM A1064/A1064M.

2.2.3.4 Supports for Concrete Reinforcement

Include bolsters, chairs, spacers, and other devices necessary for proper spacing, supporting, and fastening reinforcement bars and wire in place.

Ensure legs of supports in contact with formwork for sections that will be exposed to weather are hot-dip galvanized after fabrication, plastic coated, or corrosion-resistant steel bar supports.

2.2.4 Prestressing Strands

Use seven-wire stress-relieved or low-relaxation strand conforming to ASTM A416/A416M, Grade 270. Use prestressing steel free of grease, oil, wax, paint, soil, dirt, and loose rust. Do not use prestressing strands or wire having kinks, bends, or other defects.

2.2.5 Metal Accessories

Provide ASTM A123/A123M or ASTM A153/A153M galvanized.

2.2.5.1 Inserts

ASTM A47/A47M, Grade 32510, or ASTM A27/A27M Grade 60-30. Submit product data.

2.2.5.2 Structural Steel

ASTM A36/A36M.

2.2.6 Bearing Pads

Submit product data for all bearing pads being used.

2.2.6.1 Elastomeric

AASHTO M 251, for plain neoprene bearings.

2.3 PRODUCTION QUALITY CONTROL PROCEDURES

PCI MNL-116 unless specified otherwise. Submit quality control procedures established in accordance with PCI MNL-116 by the precast manufacturer.

2.3.1 Forms

Brace forms to prevent deformation. Forms must produce a smooth, dense surface. Use forms and form-facing materials that are nonreactive with concrete such as wood, metal, plastic, or other approved materials. Conform to the shapes, lines, and dimensions indicated and are within the limits of the specified fabrication tolerances. Chamfer exposed edges of columns and beams 3/4 inch, unless otherwise indicated. Provide threaded or snap-off type form ties.

2.3.2 Tolerances

Fabricate structural precast concrete members of shapes, lines and dimensions indicated, so each finished member complies with PCI MNL-135 product tolerances as well as position tolerances for cast-in items.

2.3.3 Reinforcement Placement

ACI 318 and PCI MNL-116 for placement and splicing. Place and secure steel bars, welded-wire reinforcement, and other reinforcement by means of metal bar supports and spacers. Reinforcement may be preassembled before placement in forms. Provide exposed connecting bars, or other approved connection methods, between precast prestressed and cast-in-place construction. Remove any excess mortar that adheres to the exposed connections.

2.3.4 Inserts

When the ends of the prestressed member will be exposed, recess the prestressing stands using inserts. After detensioning, remove inserts and fill the recess with nonshrink grout.

2.3.5 Lifting Devices

Provide lifting devices designed for 100-percent impact, and of materials sufficiently ductile to ensure visible deformation before fracture.

2.3.6 Identification Markings

Clearly mark each structural section in a permanent manner to indicate its location and orientation in the building and the pickup points.

Ensure each structural section has the date of casting plainly indented in the unexposed face of the concrete.

2.3.7 Concrete

2.3.7.1 Concrete Mixing

ASTM C94/C94M. Mixing operations must produce batch-to-batch uniformity of strength, consistency, and appearance.

2.3.7.2 Concrete Placing

PCI MNL-116.

2.3.7.3 Concrete Curing

PCI MNL-116.

2.3.8 Prestressing

PCI MNL-116. Do not transfer prestressing forces during detensioning until the concrete has reached a minimum compressive strength of 4,000 psi, unless a higher strength is required by the Contractor furnished design.

2.3.9 Surface Finish

Repairs located in a bearing area must be approved by the Owner prior to repairs. Defects must be repaired or rejected as specified in paragraph ACCEPTANCE/REJECTION OF DEFECTS.

2.3.9.1 Unformed Surfaces

Top surfaces of precast and prestressed deck panels shall first receive a floated finish. After application of the floated finish, the top surface shall be roughened to a full amplitude of approximately 1/4 inch.

2.3.9.2 Formed Surfaces

PCI MNL-116, Appendix C, for grades of surface finishes.

a. Unexposed Surfaces: Provide a standard grade surface finish.

b. Exposed Surfaces: Provide a standard grade surface finish.

2.3.10 Acceptance/Rejection of Defects

2.3.10.1 Minor Defects

All honeycombed areas, chipped corners, air pockets over 1/4 inch in diameter, and other minor defects involve less than 36 square inches of concrete must be repaired. Form offsets of fins over 1/8 inch must be ground smooth. All unsound concrete must be removed from defective areas prior to repairing. All surfaces permanently exposed to view must be repaired by a blend of portland cement and white cement properly proportioned so that the final color when cured will be the same as adjacent concrete. Precast and prestressed members containing hairline cracks which are visible and are less than 0.01 inches in width, may be accepted, except that cracks larger than 0.005 inches in width for surfaces exposed to the weather must be repaired.

2.3.10.2 Major Defects

Major defects are those which involve more than 36 square inches of concrete or expose stressing tendons or reinforcing steel. If one or more major defects appear in a member, it will be rejected. Cracks of a width of more than 0.01 inch will be cause for rejection of the member.

2.4 TESTS, INSPECTIONS, AND VERIFICATIONS

2.4.1 Factory Inspection

At the option of the Owner, precast and prestressed units may be inspected by the Owner prior to being transported to the job site. The Contractor must give notice 14 days prior to the time the units will be available for plant inspection. Neither the exercise nor waiver of inspection at the plant will affect the Owner's right to enforce contractual provisions after

units are transported or erected.

## PART 3 EXECUTION

### 3.1 EXAMINATION

Prior to erection, and again after installation, precast and prestressed members must be checked for damage, such as cracking, spalling, and honeycombing. As directed by the Owner, precast and prestressed members that do not meet the surface finish requirements specified in paragraph SURFACE FINISH must be repaired, or removed and replaced with new precast and prestressed members.

### 3.2 ERECTION

Precast and prestressed members must be erected after the concrete has attained the specified compressive strength, unless otherwise approved by the precast prestressing manufacturer. Erect in accordance with the approved shop drawings. PCI MNL-135 for tolerances. Provide a 1:500 tolerance, if no tolerance is specified. Brace precast and prestressed members, unless design calculations submitted with the shop drawings indicate bracing is not required. Follow the manufacturer's recommendations for maximum construction loads. Place precast and prestressed members level, plumb, square, and true within tolerances. Align member ends.

### 3.3 BEARING SURFACES

Must be flat, free of irregularities, and properly sized. Size bearing surfaces to provide for the indicated clearances between the precast and prestressed member and adjacent precast prestressed members or adjoining field placed surfaces. Correct bearing surface irregularities with nonshrink grout. Provide bearing pads where indicated or required. Place precast prestressed members at right angles to the bearing surface, unless indicated otherwise, and draw-up tight without forcing or distortion, with sides plumb.

### 3.4 GROUTING

Clean and fill indicated keyways between precast prestressed members, as indicated on the drawings.

### 3.5 PROTECTION AND CLEANING

Protect exposed-to-view surfaces against staining and other damage until completion of the work.

Upon completion of installation, swept clean and leave ready slab surfaces to receive concrete floor topping, roofing, or other covering.

### 3.6 CONCRETE TOPPING

Provide as indicated and as specified in Section 03 31 30 MARINE CONCRETE.

### 3.7 CONSTRUCTION RECORDS

Complete construction records must be kept of the manufacturing, handling, and erection of the precast-prestressed concrete members and submitted. Records must be kept for, but not limited to, the following items:

a. Specifications of material used in the manufacture of the members.

b. Time-temperature history of the concrete members from casting to the transfer of the prestress force.

c. Records of the tendon stressing operation including initial prestress force, measured elongation, how it was measured, and how the tendons were stressed and destressed.

d. Records of inspection of the members before and after the prestress force is transferred to the members.

e. Records of the inspection of the members each time they are moved.

f. Records of any defects in the member and any corrective measures taken.

-- End of Section --

SECTION 05 50 14

STRUCTURAL METAL FABRICATIONS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

| | |
|---|---|
| ANSI/ASNT CP-189 | (2020) ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel |

AMERICAN WELDING SOCIETY (AWS)

| | |
|---|---|
| AWS D1.1/D1.1M | (2020; Errata 1 2021) Structural Welding Code - Steel |
| AWS QC1 | (2016) Specification for AWS Certification of Welding Inspectors |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM E165/E165M | (2018) Standard Practice for Liquid Penetrant Examination for General Industry |
| ASTM E709 | (2021) Standard Guide for Magnetic Particle Testing |

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Materials Orders

Materials List

SD-02 Shop Drawings

Detail Drawings

Welding Procedures

Welding Repair Plan

SD-03 Product Data

Filler Metal

SD-06 Test Reports

Tests, Inspections, and Verifications

SD-07 Certificates

Welding Qualifications

Weld Inspection Log

Certified Welding Inspector

Nondestructive Testing Personnel

1.3 QUALITY ASSURANCE

1.3.1 Detail Drawings

Submit detail drawings for metalwork prior to fabrication. Include within the detail drawings catalog cuts, templates, fabrication and assembly details and type, grade and class of material as appropriate. Indicate methods of protecting the work during shipping, storage, field assembly, and installation.

1.3.2 Welding Qualifications

Prior to welding, submit certification for each welder stating the type of welding and positions qualified for, the code and procedure qualified under, date qualified, and the firm and individual certifying the qualification tests. If the qualification date of the welder or welding operator is more than 6 months old, accompany the welding operator's qualification certificate with a current certificate by the welder attesting to the fact that he has been engaged in welding since the date of certification, with no break in welding service greater than 6 months.

Conform to all requirements specified in AWS D1.1/D1.1M.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Materials Orders

Furnish copies of purchase orders, mill orders, shop orders and work orders for all materials and items used in the work. Include mill certificates and tests to show compliance with specified material properties. Include the test site address and the name of the testing agency.

2.1.2 Materials List

Furnish a list of the materials to be used in the fabrication of each item.

2.2 FABRICATION

2.2.1 Structural Fabrication

Material shall be straight before being laid off or worked. Perform straightening, if necessary, by methods that will not impair the metal. Sharp kinks or bends are cause for rejection of the material. Material with

welds will not be accepted except where welding is definitely specified, indicated or otherwise approved. Make bends using approved dies, press brakes or bending rolls. Where heating is required, take precautions to avoid overheating the metal and allow it to cool in a manner that will not impair the original properties of the metal. Proposed flame cutting of material, other than structural steel, is subject to approval by Owner and shall be indicated on detail drawings. Shearing shall be accurate and all portions of the work neatly finished. Make corners square and true unless otherwise shown. Fillet re-entrant cuts to a minimum radius of 3/4 inch unless otherwise approved. Provide finished members free of twists, bends and open joints. Tighten bolts, nuts and screws.

2.2.1.1 Dimensional Tolerances for Structural Work

Measure dimensions using an approved calibrated steel tape of approximately the same temperature as the material being measured. The overall dimensions of an assembled structural unit shall be within the tolerances indicated on the drawings or as specified in the particular section of these specifications for the item of work. Where tolerances are not specified in other sections of these specifications or shown, an allowable variation of 1/32 inch is permissible in the overall length of component members with both ends milled; component members without milled ends shall not deviate from the dimensions shown by more than 1/16 inch for members 30 feet or less in length, and by more than 1/8 inch for members over 30 feet in length.

2.2.1.2 Structural Steel Fabrication

Structural steel may be cut by mechanically guided or hand-guided torches, provided an accurate profile with a surface that is smooth and free from cracks and notches is obtained. Prepare surfaces and edges in accordance with AWS D1.1/D1.1M, Prequalification of WPSs Clause. Where structural steel is not to be welded, chipping or grinding will not be required except as necessary to remove slag and sharp edges of mechanically guided or hand-guided cuts not exposed to view. Chip, grind or machine to sound metal hand-guided cuts which are to be exposed or visible.

2.2.2 Welding

2.2.2.1 Welding of Structural Steel

2.2.2.1.1 Welding Procedures for Structural Steel

Use prequalified welding procedures for structural steel as described in AWS D1.1/D1.1M, Prequalification of WPSs Clause or qualify by tests as prescribed in AWS D1.1/D1.1M, Qualification Clause. The Contractor will be directed or authorized to make any changes in previously approved welding procedures that are deemed necessary or desirable by the Owner.

a. Submit a complete schedule of welding procedures for each steel structure to be welded prior to commencing fabrication. Provide the schedule in conformance with the requirements specified in the provisions of AWS D1.1/D1.1M

b. Provide within the schedule detailed procedure specifications and tables or diagrams showing the procedures to be used for each required joint. Include in the welding procedures filler metal, preheat, interpass temperature and stress-relief heat treatment requirements. Clearly identify each welding procedure as being prequalified or

required to be qualified by tests.

c. Show types and locations of welds designated or in the specifications to receive nondestructive testing in the welding procedures.

2.2.2.1.2 Welding Process

Perform welding of structural steel by an electric arc welding process using a method which excludes the atmosphere from the molten metal and conforms to the applicable provisions of AWS D1.1/D1.1M. Minimize residual stresses, distortion and shrinkage from welding.

2.2.2.1.3 Welding Technique

2.2.2.1.3.1 Filler Metal

Provide the electrode, electrode-flux combination and grade of filler metal conforming to the appropriate AWS specification for the base metal and welding process being used or be as shown where a specific choice of AWS specification allowables is required. Submit filler metal product data. Include the AWS designation of the electrodes to be used in the schedule of welding procedures. Use only low hydrogen electrodes for manual shielded metal-arc welding regardless of the thickness of the steel. Use a controlled temperature storage oven at the job site as prescribed by AWS D1.1/D1.1M, Fabrication Clause to maintain low moisture of low hydrogen electrodes.

2.2.2.1.3.2 Preheat and Interpass Temperature

Perform preheating as required by AWS D1.1/D1.1M, Fabrication Clause or as otherwise specified except that the temperature of the base metal must be at least 70 degrees F. Slowly and uniformly preheat the joint area by approved means to the prescribed temperature, held at that temperature until the welding is completed and then permitted to cool slowly in still air.

2.2.2.1.3.3 Stress-Relief Heat Treatment

Where stress relief heat treatment is specified or shown, perform in accordance with the requirements of AWS D1.1/D1.1M, Fabrication Clause unless otherwise authorized or directed.

2.2.2.1.4 Workmanship

Perform welding workmanship in accordance with AWS D1.1/D1.1M, Fabrication Clause and other applicable requirements of these specifications.

2.2.2.1.4.1 Preparation of Base Metal

Prior to welding inspect surfaces to be welded to ensure compliance with AWS D1.1/D1.1M, Fabrication Clause.

2.2.2.1.4.2 Temporary Welds

Make temporary welds, required for fabrication and erection, under the controlled conditions prescribed for permanent work. Make temporary welds using low-hydrogen welding electrodes and by welders qualified for permanent work as specified in these specifications. Conduct preheating for temporary welds as required by AWS D1.1/D1.1M for permanent welds except

that the minimum temperature shall be 120 degrees F in any case. In making temporary welds, do not strike arcs in other than weld locations. Remove each temporary weld and grind flush with adjacent surfaces after serving its purpose.

2.2.2.1.4.3 Tack Welds

Tack welds that are to be incorporated into the permanent work are to exhibit the same quality requirements as the permanent welds; clean and thoroughly fuse them with permanent welds. Perform preheating as specified above for temporary welds. Provide cascaded ends on multiple-pass tack welds. Remove defective tack welds before permanent welding.

2.2.3 Shop Assembly

Assemble structural unit furnished in the shop to determine the correctness of the fabrication and matching of the component parts unless otherwise specified. Do not exceed those tolerances shown. Closely check each unit assembled to ensure that all necessary clearances have been provided. Assembly in the shop shall be in the same position as final installation in the field unless otherwise specified. Immediately remedy errors or defects disclosed by the Contractor without cost to the Owner. Before disassembly for shipment match-mark each piece of a structural unit to facilitate erection in the field. Indicate the location of match-marks by circling with a ring of white paint after the shop coat of paint has been applied or as otherwise directed.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

Perform material tests and analyses certified by an approved laboratory to demonstrate that materials are in conformity with the specifications. These tests and analyses shall be performed and certified at the Contractor's expense. Perform tests, inspections, and verifications conforming to the requirements of the particular sections of these specifications for the respective items of work unless otherwise specified or authorized. Furnish specimens and samples for additional independent tests and analyses upon request by the Owner. Properly label specimens and samples and prepare for shipment. Submit certified test reports for materials with all materials delivered to the site.

2.3.1 Nondestructive Testing

When doubt exists as to the soundness of any material part, such part may be subjected to any form of nondestructive testing determined by the Owner. This may include ultrasonic, magnaflux, dye penetrant, x-ray, gamma ray or any other test that will thoroughly investigate the part in question. The cost of such investigation will be borne by the Owner if the part is found to be sound and by the Contractor if the part is found to be defective. Any defects will be cause for rejection; replace and retest rejected parts at the Contractor's expense.

2.3.2 Tests of Structural Units

The details for tests of structural units shall conform to the requirements of the particular sections of these specifications covering these items.

2.3.3 Inspection of Structural Steel Welding

Nondestructive testing of designated welds will be required. Supplemental

examination of any joint or coupon cut from any location in any joint may also be required.

2.3.3.1 Visual Examination

All visual inspection will be conducted in accordance with AWS D1.1/D1.1M, by a Certified Welding Inspector. Document this inspection in the Visual Weld Inspection Log. Submit certificates indicating that certified welding inspectors meet the requirements of AWS QC1.

2.3.3.2 Nondestructive Testing

Perform as designated or described in the sections of these specifications, the nondestructive testing of shop and field welds covering the particular items of work. Record final nondestructive testing results in the Weld Inspection Log which identifies final NDT inspection of all welds requiring inspection and submit the log.

2.3.3.2.1 Testing Agency

The nondestructive testing of welds and the evaluation of tests as to the acceptability of the welds shall be performed by a testing agency adequately equipped and competent to perform such services or by the Contractor using suitable equipment and qualified personnel. All personnel performing nondestructive testing shall be certified Level I or II in the method of NDT being utilized in accordance with ANSI/ASNT CP-189. Level I inspectors shall have direct supervision of a Level II inspector. Submit certification for nondestructive testing personnel prior to all testing. In either case, written approval of the examination procedures is required. The evaluation of tests are subject to the approval by Owner.

2.3.3.2.2 Examination Procedures

Conform to the following requirements.

2.3.3.2.2.1 Ultrasonic Testing

Examine, evaluate and report ultrasonic testing of welds in conformance to the requirements of AWS D1.1/D1.1M. Provide ultrasonic equipment capable of making a permanent record of the test indications. Make a record of each weld tested.

2.3.3.2.2.2 Magnetic Particle Inspection

Conform magnetic particle inspection of welds to the applicable provisions of ASTM E709.

2.3.3.2.2.3 Dye Penetrant Inspection

Perform dye penetrant inspection of welds conforming to the applicable provisions of ASTM E165/E165M.

2.3.3.2.3 Welds to be Subject to Nondestructive Testing

Visual examination of all welds shall be performed. Additionally, test 100% of CJP welds using ultrasonic testing. Randomly test 50% of all PJP and fillet welds or as indicated by magnetic particle or dye penetrant testing.

2.3.3.3 Test Coupons

The Owner reserves the right to require the Contractor to remove coupons from completed work when doubt as to soundness cannot be resolved by nondestructive testing. When coupons are removed from any part of a structure, repair the members cut in a neat manner with joints of the proper type to develop the full strength of the members. Peen repaired joints as approved or directed to relieve residual stress. The expense for removing and testing coupons, repairing cut members and the nondestructive testing of repairs is borne by the Owner or the Contractor in accordance with the Contract Clauses INSPECTION AND ACCEPTANCE.

2.3.3.4 Supplemental Examination

When the soundness of any weld is suspected of being deficient due to faulty welding or stresses that might occur during shipment or erection, the Owner reserves the right to perform nondestructive supplemental examinations before final acceptance. The cost of such inspection will be borne by the Owner.

2.3.4 Welding Repair Plan

Repair defective welds in accordance with AWS D1.1/D1.1M, Fabrication Clause. Remove defective weld metal to sound metal by use of air carbon-arc or oxygen gouging. Thoroughly clean surfaces before welding. Retest welds that have been repaired by the same methods used in the original inspection. Except for the repair of members cut to remove test coupons and found to have acceptable welds costs of repairs and retesting will be borne by the Contractor. Submit welding repair plans for steel, prior to making repairs.

PART 3 EXECUTION

3.1 INSTALLATION

Thoroughly clean all parts to be installed. Remove packing compounds, rust, dirt, grit and other foreign matter. Examine enclosed chambers or passages to make sure that they are free from damaging materials. Where units or items are shipped as assemblies they will be inspected prior to installation.

3.1.1 Alignment and Setting

Accurately align each structural unit by the use of steel shims or other approved methods so that no distortion of any member occurs before it is fastened in place.

3.2 TESTS

3.2.1 Workmanship

Workmanship shall be of the highest grade and in accordance with the best modern practices to conform with the specifications for the item of work being furnished.

3.2.2 Production Welding

Perform production welding conforming to the requirements of AWS D1.1/D1.1M.

-- End of Section --

SECTION 09 97 10.00 10

METALLIC COATINGS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

| | |
|---|---|
| AWS A5.01M/A5.01 | (2013) Procurement Guidelines for Consumables - Welding and Allied Processes - Flux and Gas Shielded Electrical Welding Processes |
| AWS C2.25/C2.25M | (2012; R 2018) Specification for Thermal Spray Feedstock -- Solid and Composite Wire and Rods |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM D4285 | (1983; R 2018) Indicating Oil or Water in Compressed Air |
| ASTM D4417 | (2021) Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel |
| ASTM D4541 | (2017) Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers |
| ASTM D7091 | (2021) Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nondestructive Coatings Applied to Non-Ferrous Metals |
| ASTM E337 | (2015) Measuring Humidity with a Psychrometer (The Measurement of Wet- and Dry-Bulb Temperatures) |

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

| | |
|---|---|
| SSPC AB 1 | (2015; E 2017) Mineral and Slag Abrasives |
| SSPC AB 2 | (2015; E 2016) Cleanliness of Recycled Ferrous Metallic Abrasive |
| SSPC AB 3 | (2003; E 2004) Ferrous Metallic Abrasive |
| SSPC SP 5/NACE No. 1 | (2007) White Metal Blast Cleaning |

U.S. ARMY CORPS OF ENGINEERS (USACE)

| | |
|---|---|
| EM 385-1-1 | (2014) Safety -- Safety and Health Requirements Manual |

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

| | |
|---|---|
| 29 CFR 1910 | Occupational Safety and Health Standards |
| 29 CFR 1926 | Safety and Health Regulations for Construction |

1.2 DEFINITIONS

1.2.1 Metallizing / Metallic Coating

Refers to any of several application methods for depositing sprayed-metal coatings. All metallizing shall be performed in a shop and not on the project site.

1.2.2 Wire Flame-Spray

A metallizing process in which metallic wire is melted in an oxygen and fuel gas flame and is dispersed with an airstream.

1.2.3 Arc-Spray

A metallizing process in which metallic wire is melted by an electric arc and is dispersed with an airstream.

1.3 SYSTEM DESCRIPTION

Prepare a thermal spray Job Reference Standard (JRS) prior to the onset of production work. The JRS is used at the initiation of the contract to qualify the surface preparation, thermal spray application, and sealing processes and also serves as a standard of quality in case of dispute. To prepare the JRS, solvent and abrasive blast clean a steel plate measuring 2 feet x 2 feet x 3/8 inch of the same material as the surfaces to be metallized in accordance with the requirements of the contract. Use the same abrasive blast media and equipment that will be used for the project. Mask one-fourth of the JRS plate with sheet metal and apply thermal spray coating to the unmasked portion of the plate. Apply the thermal spray coating using the same equipment, approved wire, and spray parameters to be used for the project. Operate the gun in a manner substantially the same as will be used for the project. Measure and record the approximate traverse speed and standoff distance during spraying. Once the JRS is qualified, the operating parameters must not be altered, except as necessitated by the requirements of the project. Seal two-thirds of the thermal spray coated portion of the JRS in accordance with the requirements of the contract. Apply the sealer using the same spray equipment that will be used for production. Preserve and protect the prepared JRS in such a manner that it remains dry and free of contaminants for the duration of the contract. The Coating Inspector will verify and record surface cleanliness, blast profile shape and depth, thermal spray appearance, thickness, and adhesion, and sealer thicknesses in accordance with the contract requirements.

1.3.1 General Requirements

Perform the work in accordance with the requirements of 29 CFR 1910,

29 CFR 1926, and EM 385-1-1.

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Contractor Qualifications and Experience

Delivery, Storage, And Handling Plan

Sealer

Abrasive Media

SD-04 Samples

Job Reference Standard (JRS)

SD-06 Test Reports

Applicator Qualification Test

Metallizing Wire

Arc Spray Equipment Qualification

Job Reference Standard (JRS)

Metallized Coating Inspection

Sealer System Test Reports

SD-07 Certificates

Coating Inspectors

Coating Thickness Gages

1.5 QUALITY ASSURANCE

1.5.1 Contractor Qualifications and Experience

The contractor must have a minimum of two years of documented experience in the field of thermal spray and have performed at least one similar project in the past.

1.5.2 Arc Spray Equipment Qualification

Each type and model of arc spray equipment to be used on the job must be qualified in accordance with the requirements of this subpart. Under conditions of continuous use, the equipment must be capable of keeping the actual current output, voltage, wire feed rate, atomization air pressure, and flow volume at set values and not deviate from them by more than 5 percent during a 15 minute period. The wire feed mechanism must be designed for automatic alignment. When operated continuously for 15 minutes the equipment must not sputter, pop, or stop operating. The equipment must be

capable of continuous start and stop operation for a minimum of fifteen cycles consisting of 10 seconds on and 5 seconds off, without fusing, sputtering or deposition of nodules. The applied coating must be uniform and free of blisters, cracks, loosely adherent particles, nodules, or powdery deposits. The required measurements of operating performance must be conducted and documented by the qualified Coating Inspector.

1.5.3 Metallizing Applicator Qualification

Perform the Applicator Qualification Test to qualify each worker to apply metallized coatings in accordance with the requirements of this paragraph. Use test plates to qualify applicators at the start of a job that are 12 x 12 x 0.375 inch flat steel and are of the same chemical composition as the work surfaces to be coated. The cleaning method and abrasives used to prepare the test plate are the same as that to be used on the work surfaces. Measure and record the blast profile in accordance with ASTM D4417, Method C. Apply the specified coating thickness in not less than two half lapped passes applied at right angles to each other. Test the adhesive strength in accordance with ASTM D4541 using a self-aligning Type IV adhesion tester. Measure and record the adhesion strength at five randomly selected locations. The average adhesion must not be less than 1600 psi for aluminum. Any test plate with an average adhesion value below the requirements of this paragraph or any plate with a single adhesion measurement of less than 80-percent of the specified minimum average adhesion value will be rejected. If the test fails repeat the test using a new test plate. If the test fails on the second plate the applicator will be deemed unacceptable. The specified surface profile and adhesion tests must be conducted and documented by the qualified Coating Inspector.

1.5.4 Coating Inspector Qualifications and Experience

Submit documentation of certification for all coating inspectors. The minimum certification requirement is a Certified Inspector under the National Association of Corrosion Engineers Coating Inspector Training and Certification Program. The documentation must include the NACE inspector identification numbers, date of qualification, and expiration date. In addition to certification all coating inspectors must as a minimum have performed coating inspection on at least one previous thermal spray job or have attended an SSPC tutorial on thermal spray coating application.

1.5.5 Metallized Coating Thickness Gage Qualification

Submit documentation of certification for all coating thickness gages. Use magnetic flux-type thickness gages, as described in ASTM D7091, Method B, to make all metallized coating thickness measurements. Thickness gages used on the job must be certified by the gage manufacturer as having an accuracy of 3 percent or better.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Metallizing Wire

Package, ship, and store metallizing products in accordance with fabricator's instructions. Submit delivery, storage, and handling plan that includes fabricator's instructions and Contractor's plan to execute safe delivery, storage, and handling of metallized products on project site prior to installation.

PART 2 PRODUCTS

2.1 METALLIZING WIRE

Have the wire tested by a commercial laboratory or by the manufacturer of the wire. Acceptance of metallizing wire is based on the testing requirements described in AWS A5.01M/A5.01 Schedule H (chemical analysis). The tested wire must conform to the compositional requirements specified in AWS C2.25/C2.25M for 1100 Aluminum wire. Submit a report of the test results.

2.2 SEALER

The sealer shall be Carboguard 890 by Carboline or Engineer approved equal.

2.3 ABRASIVE MEDIA

Provide angular abrasive blast media capable of producing the specified surface profile listed in paragraph Abrasive Blasting. The blast media must be steel grit, garnet, iron oxide, coal slag, silicon carbide, or aluminum oxide. New steel grit must have a Rockwell C hardness of 51 or greater and conform to the requirements of SSPC AB 3 including paragraph 4.3.3.2 Steel Grit. Steel grit hardness must be Rockwell C of 51 or greater. Recycled steel grit must conform to the requirements of SSPC AB 2 and at no time contain greater than 15 per cent round or half-round particles when viewed under a 10X microscope or magnifying glass. Garnet abrasive must conform to the requirements of SSPC AB 1, Type 1, Class A. Iron oxide abrasive must be a commercial specular hematite material. Coal slag abrasive must conform to the requirements of SSPC AB 1, Type 2, Class A. Silicon carbide and aluminum oxide abrasives must be commercially pure.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Pit, Edge, and Weld Preparation

Grind visibly rough flame-cut steel and weld metal with a disk wheel grinder or other tool to produce a smooth contour prior to abrasive blasting. Perform grinding of flame-cut edges and welds to the extent necessary to etch heat-hardened metal. Grind pits with an aspect ratio of greater than unity (as deep as they are wide) with an abrasive disk or other tool prior to blasting. Pits with sharp edges, undercut pits, and pits with an irregular horizontal or vertical orientation must also be ground smooth to the extent necessary to allow the entire surface of the pit to be blasted and coated. Grind sharp edges prior to abrasive blasting to a uniform minimum diameter of 1/8 inch.

3.1.2 Abrasive Blasting

Solvent clean and blast all ferrous surfaces to be metallized to a white metal grade in accordance with SSPC SP 5/NACE No. 1. The surface profile, as measured in accordance with subparagraph Blast Profile, must be between 2.5 and 3.5 mils. Take special care to achieve the specified blast profile on welds and flame-cut edges. In some cases, it may be necessary to either grind these surfaces with a disk wheel grinder or other tool prior to blasting or to use a harder abrasive blast media. If recycled abrasives are used, the particle size distribution of the working mix must be maintained such that a consistent blast profile is obtained. Remove weld spatter not

dislodged by blasting with impact or grinding tools and reblast the area to bring the surface to the required profile. Acceptable surfaces must be free of all visible contaminants including moisture, grease, oil, soot, and dust prior to receiving the first or any succeeding coat of metallizing.

3.1.3 Protection

Program cleaning, metallizing, and painting so that dust, dry spray, or other contaminants from the cleaning and painting operations do not contaminate surfaces ready for metallization or painting. Protect surfaces not intended to be metallized from the effects of cleaning and metallizing operations.

3.2 METALLIZING APPLICATION

Set up and operate metallizing equipment in the same manner as used to prepare the JRS. Validate equipment set up and operation using a bend test. The bend test is acceptable if the coating shows no cracks or exhibits only minor cracking with no lifting of the coating from the substrate. If the coating cracks and lifts from the substrate, the results of the bend test are unacceptable. Provide clean and dry compressed air to atomize the metallized coating.

3.2.1 Metallizing Application Technique

Preheat surfaces to be flame sprayed to prevent condensation of the flame on the surface to be coated. Arc spray application does not require preheating of the substrate. Surfaces to be metallized must be free of all visible contaminants including grease, oil, soot, and dust prior to receiving the first and subsequent coats of metallizing. Apply all metallizing coats in such a manner as to produce an even, continuous film of uniform thickness. Give special attention to edges, corners, crevices, seams, joints, welds, rivets, and other surface irregularities to ensure that they receive an adequate thickness of metallic coating. Operate metallizing equipment using qualified applicators in accordance with the manufacturer's recommendations. Overlap each spray pass of the sprayed metal a minimum of 40 percent on each spray pass to ensure uniform coverage. Perform manual spraying in a block pattern not exceeding 2 by 2 feet square. Build up the specified thickness of coating in multiple layers of no fewer than 2 spray coats (overlapping at right angles). Hold the application gun at such a distance from the work surface that the metal remains plastic until impact with the surface.

3.2.2 Metallizing Appearance

The thermal-sprayed coating prior to sealing must have a uniform appearance and not contain any of the following: blisters, cracks, chips or loosely adhering particles, oils or other internal contaminants, pits exposing the substrate, or nodules.

3.2.3 Metallizing Thickness

Coat surfaces with the system indicated in the metallizing schedule in accordance with the following:

3.2.3.1 System No. 8-A

Apply to a minimum average thickness of 10.0 mils and a thickness at any one spot of not less than 8.0 mils.

3.2.4 Metallizing Adhesion

The minimum average adhesion of the metallized coating is 1600 psi for aluminum. Any coating having an average adhesion value below the requirements of this paragraph or having any single adhesion measurement of less than 80-percent of the specified minimum average adhesion will be rejected.

3.2.5 Time Between Surface Preparation and Metallizing

Following surface preparation all surfaces approved for metallizing must receive the first coat of metallizing within 4 hours or prior to the appearance of flash rust, whichever is sooner.

3.2.6 Time Between Metallizing and Sealing

Within 8 hours or prior to the appearance of condensation on the receiving surfaces, whichever is sooner, seal approved sections of metallizing as metallized coatings must not be allowed to become contaminated prior to application of sealers.

3.2.7 Approved Methods of Metallizing

Metallizing methods, which employ metal wire feed stock with oxygen-fuel gas flame spray or electric-arc spray that produce coatings in conformance with requirements of this specification, are acceptable.

3.3 FIELD INSPECTION

3.3.1 Quality Control Inspection and Testing

The qualified Coating Inspector must be present during all work phases to perform and document all of the tests and inspections in paragraphs Ambient Conditions Inspection, Presurface Preparation Inspection, Surface Preparation Inspection, and metallized coating inspection.

3.3.1.1 Ambient Conditions Inspection

Ambient air and surface conditions including humidity, dew point, and surface and ambient air temperature before and during all work phases. Determine humidity in accordance with ASTM E337. Conditions specified in paragraph Environmental Requirements must be met before work is initiated.

3.3.1.2 Presurface Preparation Inspection

Identify and mark all areas requiring preparation prior to abrasive blasting as specified in paragraph Pit, Edge, and Weld Preparation as well as areas requiring solvent-type cleaning. The entire work surface does not need to be inspected at one time, but rather the Coating Inspector may choose to mark up work areas with an indelible marker as the job progresses. Measure pit depth with any suitable pit depth gage. Identify irregular shaped pits visually.

3.3.1.3 Surface Preparation Inspection

Inspect all prepared surface for compliance with the specification. Blasted surfaces must meet the requirements of SSPC SP 5/NACE No. 1. Surfaces not meeting this requirement must be reblasted and reinspected.

3.3.1.3.1 Abrasive Blast Air Cleanliness

Evaluate the compressed air cleanliness on a daily basis at the beginning of the work shift in accordance with ASTM D4285. Allow the air compressor to warm up and discharge air under normal operating conditions to allow accumulated moisture to be purged. Hold an absorbent clean white cloth in the stream of compressed air not more than 24 inch from the point of discharge for a minimum of one minute. Check the air as near as possible to the point of use and always after the position of the in-line oil and water separators. Inspect the cloth for moisture or staining. Do not use the compressed air source if there is any oil or water contamination present.

3.3.1.3.2 Recycled Blast Media Cleanliness and Shape

Evaluate the cleanliness of blast media on a daily basis at the beginning of the work shift. A clear glass container is half filled with new or recycled abrasive and distilled or deionized water is added to fill the container. The resulting slurry mixture is stirred or shaken and allowed to settle. The water is then examined for the presence of an oil sheen. If a sheen is present, the media must not be used and the source of contamination must be identified and corrected. Inspect recycled steel grit blast media at minimum once for every four hours of blasting for compliance with paragraph Abrasive Media requirements for number of round and half-round particles. Recycled steel grit working mixtures with greater than 15 percent round or half-round particles must be disposed or reconstituted by the addition of a suitable quantity of new steel grit abrasive to the working mixture. Retest the particle shape of the reconstituted steel grit prior to the commencement of blasting.

3.3.1.3.3 Blast Profile

Measure the surface profile depth in accordance with ASTM D4417, Method C. The mean value of three profile measurements taken within a 16 $in^2$ area constitutes a spot measurement. Conduct a minimum number of 3 spot measurements at random per element being matallized. The average surface profile must conform to the requirements of paragraph Abrasive Blasting. Perform spot measurements on weldments and flame-cut edges. Perform at least three spot measurements of weld and at three spot measurements of flame-cut edge. Each spot measurement on welds or flame-cut edges must conform to the requirements of paragraph Abrasive Blasting. Surfaces not meeting the profile requirement must be reblasted and reinspected.

3.3.1.3.4 Contaminants on Prepared Surface

Visually inspect abrasive blasted surfaces that have been swept, blown down, or vacuum cleaned to remove residual debris and dust for grease, oil, and dust. Use any suitable test to enhance the visual inspection for grease and oil including water break, solvent evaporation, and heat tests. Inspect for grease and oil at least once per workday or every four hours of blasting. Inspect the cleaned surfaces for residual dust using the tape test. The tape test is performed by adhering a clear piece of tape to the surface. The removed tape is inspected for adherent particles. Perform the tape test once per prepared surface of each element being metallized.

3.3.1.4 Metallized Coating Inspection

3.3.1.4.1 Equipment Setup Validation Bend Test

Record and confirm that the operating parameters are the same as were used to prepare the JRS each day or every time the thermal spray equipment is to be used. The thermal spray applicator must then apply the coating to prepared test panels and conduct the bend test. The bend test is a qualitative test used to confirm that the equipment is in proper working condition. The test consists of bending coated steel panels around a cylindrical mandrel and examining the coating for cracking. Record the results of the bend test and label and save the test panels. The test panels consist of five cold rolled steel panels measuring 2 x 6 x 0.050 inch. The panels are cleaned, blasted, and coated using the identical surface preparation procedures and spray parameters as used to prepare the working surface. The coating is applied in a cross-hatch pattern using the same number of overlapping spray passes as used to prepare the JRS. The coating thickness is measured to confirm that the coating thickness is within the specified range. Test panels are bent 180 degrees around a steel mandrel of a specified diameter. Thermal spray coating system 8-A is tested using a 0.5 inch diameter mandrel. Use a pneumatic or manual mechanical bend test apparatus to bend the test panels. Visually examine the test panels without magnification. If the bend test fails, corrective action must be taken and the bend test repeated until acceptable results are achieved. Successful completion of the bend test is required before any metallizing is applied to the working surface.

3.3.1.4.2 Atomization Air Cleanliness

Test compressed air used for atomizing metallized coatings using the method described in paragraph Abrasive Blast Air Cleanliness.

3.3.1.4.3 Metallized Coating Appearance

Visually inspect the appearance of the applied metallized coating prior to sealing for compliance with the requirements of paragraph Metallized Coating Appearance. Record areas of defective coating and mark them for repair.

3.3.1.4.4 Metallized Coating Thickness

Evaluate the thickness of the thermal spray coating for compliance with paragraph Metallizing Thickness. Make measurements using an approved and calibrated magnetic film thickness gage. Calibrate the gage on metal substantially the same in composition and surface preparation to that being coated and having a similar thickness or a minimum thickness of 1/4 inch. Use calibration thickness standards (shims) of a metallic composition and a thickness to that of the material being sprayed. Follow calibration instructions and obtain thickness standards from the manufacturer or supplier of the gage. Make thickness readings either in a straight line with individual readings taken at 1 inch intervals or spaced randomly within a 4 $in^2$ area as appropriate for the configuration of the surface being inspected. The average of five readings comprises one spot measurement. Make a minimum of 5 randomly spaced spot measurements per element being metallized. For each area evaluated the minimum average and minimum spot thickness requirements must be met. Make areas of deficient coating thickness for correction before sealing begins. Document the results of the thickness measurements.

3.3.1.4.5 Metallized Coating Adhesion

Evaluate the adhesion of the thermal spray coating for compliance with paragraph Metallizing Adhesion in accordance with ASTM D4541 using a self-aligning type IV tester described in Annex A4 of the specification. Perform a total of three randomly spaced adhesion tests for each element being metallized. Where deficiencies are noted, additional testing may be performed to help delineate the extent of area with poor adhesion. Repair areas of deficient adhesion by removing and reapplying the metallized coating. Repair areas damaged by adhesion testing by abrasive blasting and reapplication of the metallic coating. As an alternative to testing to the failure point, the tests can be interrupted when the minimum specified adhesion value is achieved. This method precludes the need to repair coatings damaged by the test. The adherent pull stubs can then be removed by heating to soften the glue or by firmly striking the side of the stub. Use a strong (minimum 3000 psi) adhesive with a rapid cure (maximum 1-hour at 70 degrees F) to adhere the pull stubs to the metallized coating. Some methyl methacrylate adhesives are known to achieve a 4000 psi bond strength in 1-hour.

3.3.2 Quality Assurance Hold Point Evaluations

The Coating Inspector must perform and document the Quality Assurance Hold Point evaluations and record the results. Work phases are delineated by the Inspection Hold Points.

3.3.2.1 Surface Preparation Quality Assurance Hold Point Evaluation

Submit to the Owner the completed documentation resulting from the inspections performed in paragraphs Ambient Conditions Inspection, Presurface Preparation Inspection, Surface Preparation Inspection, Abrasive Blast Air Cleanliness Inspection, Blast Media Cleanliness and Shape, Blast Profile, and Contaminants on Prepared Surface.

3.3.2.2 Metallized Coating Quality Assurance Hold Point Evaluation

Submit to the Owner the completed documentation resulting from the inspections performed in paragraphs Ambient Conditions Inspection, Atomization Air Cleanliness, Metallized Coating Appearance, Metallized Coating Thickness, and Metallized Coating Adhesion.

3.3.2.3 Sealed System Quality Assurance Hold Point Evaluation

Submit to the Owner the completed documentation resulting from all inspections and tests.

3.4 METALLIZING SYSTEMS TO BE APPLIED

Apply the required metallizing systems to all exposed surfaces of the fender panels.

3.5 SEALER SYSTEM INSTRUCTIONS

Perform sealing and painting in accordance with manufacturer's instructions. The clean, dry metallized surface is the receiving surface for the specified paint systems. The following methods and procedures shall be used for testing the applied sealer system:

a. For testing dry film thickness, the procedures outlined in SSPC-Paint

Application Specification No. 2 shall be followed.

b. When testing for holidays, test for holidays in the total coating system using a wet-sponge holiday detector in accordance with the manufacturer's printed instructions. Low voltage holiday detectors shall be used. Voltage settings and procedures must be in strict accordance with NACE RPO 188-88, Standard Recommended Practice for Discontinuity (Holiday) Testing of New Protective Coatings.

Sealing inspections must be conducted by an inspector certified as meeting one of the following designations: SSPC-PCI Level 2, NACE-CIP Level 2. Submit Sealer System Test Reports of to the Owner.

3.6 METALLIZING SYSTEMS AND METALLIZING SCHEDULE

| SYSTEM NO. 8-A | | | |
|---|---|---|---|
| Items or surfaces to be metallized: | | All exposed surfaces and edges of Steel Fender Panels | |
| Blast Profile (mils) | Metallizing Material | Coating Minimum (mils) | Thickness Average (mils) |
| 2.5 - 3.5 | Aluminum | 8 | 10 |

3.7 SEALER SYSTEM

Apply one (1) coat of Carboguard 890 at a dry film thickness of 4-6 mils per manufacturer's instructions.

-- End of Section --

SECTION 31 10 00

SITE CLEARING

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Clearing (Timber and Structure)

1.1.1.1 Payment

Payment will be made for costs associated with furnishing plant, labor, materials and equipments, and performing all operations necessary for clearing (timber and structures) as specified.

1.1.1.2 Unit of Measure

Unit of measure: lump sum.

1.2 DEFINITIONS

1.2.1 Brush

Brush is that growth which is less than 2 inches in diameter measured6 inches from the ground on the uphill side and is less than 6 feet in height measured from the ground on the uphill side.

1.2.2 Structures

The term "structures" includes buildings or portions thereof, walls, silos, storm or root cellars, cisterns, wells, windmills, pit silos, water towers, etc. Structures shall be removed or filled to the ground surface.

1.3 PROJECT/SITE CONDITIONS

1.3.1 Aesthetics and Pollution Control

1.3.1.1 Ground Areas

All ground areas in the zone of normal pool level fluctuations which are disturbed by clearing operations and which would become subject to erosion will be protected or restored.

1.3.1.2 Construction Roads

All construction roads proposed for use by the Contractor for removing salvaged timber or for access to the work area shall be approved, as to location and alignment, prior to construction. Where such roads are determined to be of no value to project operation or will not serve recreational access needs after project construction, the areas occupied by these roads will be restored as nearly as possible to pre-construction conditions by reasonable grading and seeding of a native cover crop along with the planting of seedling trees if in a tree cover area.

PART 2 PRODUCTS

NOT USED.

PART 3 EXECUTION

3.1 DISPOSAL OF MATERIAL

3.1.1 Burning

a. The material cleared may be burned within the contract area, and at any time within the contract period provided such burning does not interfere with inhabitants of the area by drastic changes in their accustomed environment, such as addition to air pollution or danger of fire. However, the specific time, location and manner of burning shall be subject to approval from the viewpoints of air pollution, governing fire laws and safety.

b. In the interest of conservation, as an option, make available to the general public without charge, the material scheduled for burning. No burning operations shall be conducted within 100 feet of any standing timber or flammable growth. The burning operations shall be subject to all public law governing such operations and the Contractor will be responsible for any damage to life and/or property resulting from fires that are started by its employees or as a result of its operations.

c. Furnish at the site adequate fire fighting equipment, such as back tanks, flaps, shovels, rakes, etc., to properly equip his personnel for fighting fires. Fires shall be guarded at all times and shall be under constant surveillance until they have burned out or have been extinguished.

d. Burn so thorough that the materials is reduced to ashes, except that occasional charred pieces of logs or branches not exceeding 4 inches in diameter and/or 8 feet in length will be permitted to remain. Upon approval, charred material will be buried after it is determined that it could not be disposed of by methods used in the normal burning operation. All material disposed of in such manner shall be at approved locations and shall be covered within a minimum of 18 inches of earth.

3.1.2 Burial

In certain cases, such as along drainage channels in remote areas, cleared material may be disposed of by burial in areas designated for disposal of excess excavation or spoil. When this option is used, care will be taken to insure that all such cleared material will be buried under not less than 18 inches of earth. Approval will be obtained for each area selected for debris disposal for burial prior to beginning such operations. Areas to be used for permanent roadways, levees or embankments will not be used for disposal of material from clearing operations. Areas for disposal of cleared materials by burial will not be located within 300 feet of public road crossings or of project areas to be regularly visited by the public.

-- End of Section --

SECTION 31 11 00

CLEARING AND GRUBBING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 4150.07 (2019) DOD Pest Management Program

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Herbicide Application Plan

SD-03 Product Data

Herbicides

SD-07 Certificates

Qualifications

SD-11 Closeout Submittals

Pest Management Report

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

Comply with DODI 4150.07 for requirements on Contractor's licensing, certification, and record keeping. Maintain daily records using the Pest Management Maintenance Record, DD Form 1532-1, or a computer generated equivalent. These forms may be obtained from the main web site: https://www.acq.osd.mil/eie/afpmb/docs/standardlists/dd1532-1.xlsm.

1.3.2 Qualifications

For the application of herbicides, use the services of an applicator who is commercially certified in the state where the work is to be performed as required by DODI 4150.07. Submit a copy of the pesticide applicator certificates.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site, and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

1.4.1 Storage

Storage of herbicides on the installation will not be permitted unless it is written into the contract.

1.4.2 Handling

Handle herbicides in accordance with the manufacturer's label and Safety Data Sheet (SDS), preventing contamination by dirt, water, and organic material. Protect herbicides from weather elements as recommended by the manufacturer's label and SDS. Spill kits must be maintained on herbicide control vehicles. Mixing of herbicides on the installation will not be permited unless it is written into the contract.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Herbicide

Provide herbicides currently registered by the EPA or approved for such use by the appropriate agency of the host county and approved by the Owner. Select a herbicide that is suitable for the climatic conditions at the project site. Submit manufacturer's label and SDS for herbicides proposed for use.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Herbicide Application Plan

Prior to commencing application of herbicide, submit a herbicide application plan with proposed sequence of treatment work including dates and times of application. Include the herbicide trade name, EPA registration number, chemical composition, formulation, application rate of active ingredients, method of application, area or volume treated, and amount applied. Include a copy of the pesticide applicator certificates.

3.1.2 Protection

3.1.2.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.2.2 Trees, Shrubs, and Existing Facilities

Protect trees and vegetation to be left standing from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

3.1.2.3 Utility Lines

Protect existing utility lines that are indicated to remain from damage. Notify the Owner immediately of damage to or an encounter with an unknown existing utility line. The Contractor is responsible for the repair of damage to existing utility lines that are indicated or made known to the Contractor prior to start of clearing and grubbing operations. When utility

lines which are to be removed are encountered within the area of operations, notify the Owner in ample time to minimize interruption of the service.

3.2 APPLICATION

3.2.1 Herbicide Application

Adhere to safety precautions as recommended by the manufacturer concerning handling and application of the herbicide.

3.2.1.1 Clean Up, Disposal, And Protection

Once application has been completed, proceed with clean up and protection of the site without delay. Clean the site of all material associated with the treatment measures, according to label instructions, and as indicated. Remove and dispose of excess and waste material off Owner property.

3.2.1.1.1 Disposal of Herbicide

Dispose of residual herbicides and containers off Owner property, and in accordance with the approved disposal plan, label instructions and EPA requirements.

3.3 GRUBBING

3.3.1 Grubbing

Grubbing consists of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Remove material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, to a depth of not less than 18 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Fill depressions made by grubbing with suitable material and compact to make the surface conform with the original adjacent surface of the ground.

3.4 DISPOSAL OF MATERIALS

Dispose of excess materials in accordance with the approved solid waste management permit and include those materials in the solid waste management report.

All wood or wood like materials, except for salable timber, remaining from clearing, prunning or grubbing such as limbs, tree tops, roots, stumps, logs, rotten wood, and other similiar materials shall become the property of the Contractor and disposed of as specified. All non-saleable timber and wood or wood like materials remaining from timber harvesting such as limbs, tree tops, roots, stumps, logs, rotten wood, and other similiar materials shall become the property of the Contractor and disposed as specified.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Herbicides

Upon completion of this work, submit the Pest Management Report DD Form 1532, or an equivalent computer product, to the Integrated Pest Management Coordinator. This form identifies the type of operation, brand name and

manufacturer of herbicide, formulation, concentration or rate of application used.

-- End of Section --

SECTION 31 23 00.00 20

EXCAVATION AND FILL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

| | |
|---|---|
| AWWA C600 | (2017) Installation of Ductile-Iron Mains and Their Appurtenances |

AMERICAN WELDING SOCIETY (AWS)

| | |
|---|---|
| AWS D1.1/D1.1M | (2020; Errata 1 2021) Structural Welding Code - Steel |

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

| | |
|---|---|
| AWPA C2 | (2003) Lumber, Timber, Bridge Ties and Mine Ties - Preservative Treatment by Pressure Processes |
| AWPA P5 | (2015) Standard for Waterborne Preservatives |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A139/A139M | (2016) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over) |
| ASTM A252 | (2010) Standard Specification for Welded and Seamless Steel Pipe Piles |
| ASTM C33/C33M | (2018) Standard Specification for Concrete Aggregates |
| ASTM C136/C136M | (2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates |
| ASTM D698 | (2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.)) |
| ASTM D1140 | (2017) Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing |
| ASTM D1556/D1556M | (2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place |

| | |
|---|---|
| | by Sand-Cone Method |
| ASTM D1557 | (2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3) |
| ASTM D2216 | (2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass |
| ASTM D2321 | (2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications |
| ASTM D2487 | (2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) |
| ASTM D4318 | (2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils |
| ASTM D6938 | (2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth) |

U.S. ARMY CORPS OF ENGINEERS (USACE)

| | |
|---|---|
| EM 385-1-1 | (2014) Safety -- Safety and Health Requirements Manual |

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

| | |
|---|---|
| EPA SW-846.3-3 | (1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods |

## 1.2 DEFINITIONS

### 1.2.1 Capillary Water Barrier

A layer of clean, poorly graded crushed rock, stone, or natural sand or gravel having a high porosity which is placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below a slab.

### 1.2.2 Degree of Compaction

Degree of compaction is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557, for general soil types, abbreviated as percent laboratory maximum density.

### 1.2.3 Hard Materials

Weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" but which usually

require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.4 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.5 Pile Supported Structure

As used herein, a structure where both the foundation and floor slab are pile supported.

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Shoring and Sheeting Plan

Dewatering work plan

Submit 15 days prior to starting work.

SD-06 Test Reports

Borrow Site Testing

Fill and backfill test

Select material test

Porous fill test for capillary water barrier

Density tests

Moisture Content Tests

Copies of all laboratory and field test reports within 24 hours of the completion of the test.

1.4 DELIVERY, STORAGE, AND HANDLING

Perform in a manner to prevent contamination or segregation of materials.

1.5 CRITERIA FOR BIDDING

Base bids on the following criteria:

a. Surface elevations are as indicated.

b. Pipes or other artificial obstructions, except those indicated, will not be encountered.

c. Ground water elevations indicated by the boring log were those existing at the time subsurface investigations were made and do not necessarily represent ground water elevation at the time of construction.

d. Ground water elevation is 10 feet below existing surface elevation.

e. Material character is indicated by the boring logs.

f. Hard materials will be encountered in 40 percent of the excavations at -85 feet below existing surface elevations.

g. Borrow material, suitable backfill, and bedding material in the quantities required is available at the project site.

1.6 REQUIREMENTS FOR OFF SITE SOIL

Soils brought in from off site for use as backfill shall be tested for petroleum hydrocarbons, BTEX, PCBs and HW characteristics (including toxicity, ignitability, corrosivity, and reactivity). Backfill shall not contain concentrations of these analytes above the appropriate State and/or EPA criteria, and shall pass the tests for HW characteristics. Determine petroleum hydrocarbon concentrations by using appropriate State protocols. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5035/8260B. Perform complete TCLP in accordance with EPA SW-846.3-3 Method 1311. Perform HW characteristic tests for ignitability, corrosivity, and reactivity in accordance with accepted standard methods. Perform PCB testing in accordance with accepted standard methods for sampling and analysis of bulk solid samples. Provide borrow site testing for petroleum hydrocarbons and BTEX from a grab sample of material from the area most likely to be contaminated at the borrow site (as indicated by visual or olfactory evidence), with at least one test from each borrow site. For each borrow site, provide borrow site testing for HW characteristics from a composite sample of material, collected in accordance with standard soil sampling techniques. Do not bring material onsite until tests results have been received and approved by the Owner.

1.7 QUALITY ASSURANCE

1.7.1 Shoring and Sheeting Plan

Submit drawings and calculations, certified by a registered professional engineer in the State of Texas, describing the methods for shoring and sheeting of excavations. Drawings shall include material sizes and types, arrangement of members, and the sequence and method of installation and removal. Calculations shall include data and references used.

The Contractor is required to hire a Professional Geotechnical Engineer in the state of Texas to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer shall be responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer shall update the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and shall submit an updated plan if necessary. A written report shall be submitted, at least monthly, informing the Contractor and Owner of the status of the

plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Geotechnical Engineer shall be available to meet with the Owner at any time throughout the contract duration.

1.7.2 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.7.3 Utilities

Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until backfill is completed. Report damage to utility lines or subsurface construction immediately to the Owner.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Satisfactory Materials

Any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, CL, ML, CL-ML, CH, MH free of debris, roots, wood, scrap material, vegetation, refuse, soft unsound particles, and deleterious, or objectionable materials. Unless specified otherwise, the maximum particle diameter shall be one-half the lift thickness at the intended location.

2.1.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials. Unsatisfactory materials also include man-made fills, trash, refuse, or backfills from previous construction. Unsatisfactory material also includes material classified as satisfactory which contains root and other organic matter, frozen material, and stones larger than 3 inches. The Owner shall be notified of any contaminated materials.

2.1.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM, GP-GM, GW-GM, SW-SM, SP-SM, and SM shall be identified as cohesionless only when the fines are nonplastic (plasticity index equals zero). Materials classified as GM and SM will be identified as cohesive only when the fines have a plasticity index greater than zero.

2.1.4 Common Fill

Approved, unclassified soil material with the characteristics required to compact to the soil density specified for the intended location.

2.1.5 Backfill and Fill Material

ASTM D2487, classification GW, GP, GM, GC, SW, SP, SM, SC with a maximum ASTM D4318 liquid limit of 50, maximum ASTM D4318 plasticity index of 25, and a maximum of 25 percent by weight passing ASTM D1140, No. 200 sieve.

2.1.6 Select Material

Provide materials classified as GW, GP, SW, SP, or by ASTM D2487 where indicated. The liquid limit of such material shall not exceed 50 percent when tested in accordance with ASTM D4318. The plasticity index shall not be greater than 25 percent when tested in accordance with ASTM D4318, and not more than 25 percent by weight shall be finer than No. 200 sieve when tested in accordance with ASTM D1140.

2.1.7 Topsoil

Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than one inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth. Amend topsoil pH range to obtain a pH of 5.5 to 7.

2.2 POROUS FILL FOR CAPILLARY WATER BARRIER

ASTM C33/C33M fine aggregate grading with a maximum of 3 percent by weight passing ASTM D1140, No. 200 sieve, and conforming to the general soil material requirements specified in paragraph entitled "Satisfactory Materials."

2.3 UTILITY BEDDING MATERIAL

Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Backfill to top of pipe shall be compacted to 95 percent of ASTM D698 maximum density. Plastic piping shall have bedding to spring line of pipe. Provide ASTM D2321 materials as follows:

a. Class I: Angular, 0.25 to 1.5 inches, graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

b. Class II: Coarse sands and gravels with maximum particle size of 1.5 inches, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

2.4 BORROW

Obtain borrow materials required in excess of those furnished from excavations from sources outside of Owner property.

2.5 MATERIAL FOR PIPE CASING

2.5.1 Casing Pipe

ASTM A139/A139M, Grade B, or ASTM A252, Grade 2, smooth wall pipe. Casing size shall be of the outside diameter and wall thickness as indicated. Protective coating is not required on casing pipe.

2.5.2 Wood Supports

Treated Yellow Pine or Douglas Fir, rough, structural grade. Provide wood with nonleaching water-borne pressure preservative (ACA or CCA) and treatment conforming to AWPA P5 and AWPA C2, respectively. Secure wood supports to carrier pipe with stainless steel or zinc-coated steel bands.

2.6 BURIED WARNING AND IDENTIFICATION TAPE

2.6.1 Warning Tape for Metallic Piping

Acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above. Minimum thickness of tape shall be 0.003 inch. Tape shall have a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.6.2 Detectable Warning Tape for Non-Metallic Piping

Polyethylene plastic tape conforming to the width, color, and printing requirements specified above. Minimum thickness of the tape shall be 0.004 inch. Tape shall have a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Tape shall be manufactured with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.7 DETECTION WIRE FOR NON-METALLIC PIPING

Detection wire shall be insulated single strand, solid copper with a minimum of 12 AWG.

PART 3 EXECUTION

3.1 PROTECTION

3.1.1 Shoring and Sheeting

Provide shoring bracing and sheeting where indicated. In addition to Section 25 A and B of EM 385-1-1, include provisions in the shoring and sheeting plan that will accomplish the following:

a. Prevent undermining of pavements, foundations and slabs.

b. Prevent slippage or movement in banks or slopes adjacent to the excavation.

c. Allow for the abandonment of shoring and sheeting materials in place in critical areas as the work is completed. In these areas, backfill the excavation to the elevation indicated and remove the remaining exposed portion of the shoring before completing the backfill.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

So that construction operations progress successfully, completely drain construction site during periods of construction to keep soil materials sufficiently dry. The Contractor shall establish/construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and/or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils, prevent erosion and undermining of foundations. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site, the area immediately surrounding the site, and the area affecting operations at the site shall be continually and effectively drained.

3.1.2.2 Dewatering

Groundwater flowing toward or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously, at least 3 feet below the working level.

Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly. Measure and record performance of dewatering system at same time each day by use of observation wells or piezometers installed in conjunction with the dewatering system. Relieve hydrostatic head in previous zones below subgrade elevation in layered soils to prevent uplift.

3.1.3 Machinery and Equipment

Movement of construction machinery and equipment over pipes during construction shall be at the Contractor's risk. Repair, or remove and provide new pipe for existing or newly installed pipe that has been displaced or damaged.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing

Unless indicated otherwise, remove trees, stumps, logs, shrubs, brush and vegetation and other items that would interfere with construction operations within the clearing limits. Remove stumps entirely. Grub out matted roots and roots over 2 inches in diameter to at least 18 inches below existing surface.

3.2.2 Stripping

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Material unsuitable for use as topsoil. Locate topsoil so that the material can be used readily for the finished grading. Where sufficient existing topsoil conforming to the material requirements is not available on site, provide borrow materials suitable for use as topsoil. Protect topsoil and keep in segregated piles until needed.

3.2.3 Unsuitable Material

Remove vegetation, debris, decayed vegetable matter, sod, mulch, and rubbish underneath paved areas or concrete slabs.

3.3 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Reuse excavated materials that meet the specified requirements for the material type required at the intended location. Keep excavations free from water. Excavate soil disturbed or weakened by Contractor's operations, soils softened or made unsuitable for subsequent construction due to exposure to weather. Excavations below indicated depths will not be permitted except to remove unsatisfactory material. Unsatisfactory material encountered below the grades shown shall be removed as directed. Refill with select material and compact to 95 percent of ASTM D698. Satisfactory material removed below the depths indicated shall be replaced with satisfactory materials to the indicated excavation grade; except as specified for spread footings. Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated shall be done under the direction of the Owner.

3.3.1 Pipe Trenches

Excavate to the dimension indicated. Grade bottom of trenches to provide uniform support for each section of pipe after pipe bedding placement. Tamp if necessary to provide a firm pipe bed. Recesses shall be excavated to accommodate bells and joints so that pipe will be uniformly supported for the entire length. Rock, where encountered, shall be excavated to a depth of at least 6 inches below the bottom of the pipe.

3.3.2 Hard Material Excavation

Remove hard material to elevations indicated in a manner that will leave foundation material in an unshattered and solid condition. Roughen level surfaces and cut sloped surfaces into benches for bond with concrete. Removal of hard material beyond lines and grades indicated will not be grounds for a claim for additional payment unless previously authorized by the Owner. Excavation of the material claimed as rock shall not be performed until the material has been cross sectioned by the Contractor and approved by the Owner. Common excavation shall consist of all excavation not classified as rock excavation.

3.3.3 Excavated Materials

Satisfactory excavated material required for fill or backfill shall be placed in the proper section of the permanent work required or shall be separately stockpiled if it cannot be readily placed. Satisfactory material in excess of that required for the permanent work and all unsatisfactory

material shall be disposed of as specified in Paragraph "DISPOSITION OF SURPLUS MATERIAL."

3.3.4 Final Grade of Surfaces to Support Concrete

Excavation to final grade shall not be made until just before concrete is to be placed. Approximately level surfaces shall be roughened, and sloped surfaces shall be cut as indicated into rough steps or benches to provide a satisfactory bond.

3.4 SUBGRADE PREPARATION

Unsatisfactory material in surfaces to receive fill or in excavated areas shall be removed and replaced with satisfactory materials. The surface shall be scarified to a depth of 8 inches before the fill is started. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When subgrades are less than the specified density, the ground surface shall be broken up to a minimum depth of 8 inches, pulverized, and compacted to the specified density. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 8 inches and compacted as specified for the adjacent fill. Material shall not be placed on surfaces that are muddy, frozen, or contain frost. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Material shall be moistened or aerated as necessary to plus or minus 2 percent of optimum moisture to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Minimum subgrade density shall be as specified herein.

3.4.1 Proof Rolling

Proof rolling shall be done on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade with six passes of a 15 ton, pneumatic-tired roller. Operate the roller in a systematic manner to ensure the number of passes over all areas, and at speeds between 2 1/2 to 3 1/2 miles per hour. Rutting or pumping of material shall be undercut and replaced with fill and backfill.

3.5 SUBGRADE FILTER FABRIC

Place synthetic fiber filter fabric as indicated directly on prepared subgrade free of vegetation, stumps, rocks larger than 2 inches diameter and other debris which may puncture or otherwise damage the fabric. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 3 feet overlap in all directions. Overlap fabric at joints a minimum of 3 feet. Obtain approval of filter fabric installation before placing fill or backfill. Place fill or backfill on fabric in the direction of overlaps and compact as specified herein. Follow manufacturer's recommended installation procedures.

3.6 FILLING AND BACKFILLING

Fill and backfill to contours, elevations, and dimensions indicated. Compact each lift before placing overlaying lift.

3.6.1 Common Fill Placement

Provide for general site. Place in 6 inch lifts. Compact areas not accessible to rollers or compactors with mechanical hand tampers. Aerate material excessively moistened by rain to a satisfactory moisture content. Finish to a smooth surface by blading, rolling with a smooth roller, or both.

3.6.2 Backfill and Fill Material Placement

Provide for paved areas and under concrete slabs, except where select material is provided. Place in 12 inch lifts. Do not place over wet or frozen areas. Place backfill material adjacent to structures as the structural elements are completed and accepted. Backfill against concrete only when approved. Place and compact material to avoid loading upon or against the structure.

3.6.3 Select Material Placement

Provide under porous fill of structures not pile supported. Place in 6 inch lifts. Do not place over wet or frozen areas. Backfill adjacent to structures shall be placed as structural elements are completed and accepted. Backfill against concrete only when approved. Place and compact material to avoid loading upon or against structure.

3.6.4 Backfill and Fill Material Placement Over Pipes and at Walls

Backfilling shall not begin until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Backfill shall be brought to indicated finish grade. Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation 2 feet above sewer lines and 1 foot above other utility lines shall be free from stones larger than 1 inch in any dimension. Heavy equipment for spreading and compacting backfill shall not be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; the area remaining shall be compacted in layers not more than 4 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Backfill shall be placed carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Backfill shall not be placed against foundation walls prior to 7 days after completion of the walls. As far as practicable, backfill shall be brought up evenly on each side of the wall and sloped to drain away from the wall.

3.6.5 Trench Backfilling

Backfill as rapidly as construction, testing, and acceptance of work permits. Place and compact backfill under structures and paved areas in 6 inch lifts to top of trench and in 6 inch lifts to one foot over pipe outside structures and paved areas.

3.7 BORROW

Where satisfactory materials are not available in sufficient quantity from required excavations, approved borrow materials shall be obtained as specified herein.

## 3.8 BURIED WARNING AND IDENTIFICATION TAPE

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

## 3.9 BURIED DETECTION WIRE

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. The wire shall extend continuously and unbroken, from manhole to manhole. The ends of the wire shall terminate inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. The wire shall remain insulated over it's entire length. The wire shall enter manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, the wire shall terminate in the valve pit at the pump station end of the pipe.

## 3.10 COMPACTION

Determine in-place density of existing subgrade; if required density exists, no compaction of existing subgrade will be required. Density requirements specified herein are for cohesionless materials. When cohesive materials are encountered or used, density requirements may be reduced by 5 percent.

### 3.10.1 General Site

Compact fill and backfill to 95 percent of ASTM D698.

### 3.10.2 Adjacent Area

Compact areas within 5 feet of structures to 95 percent of ASTM D698.

### 3.10.3 Paved Areas

Compact top 8 inches of subgrades to 95 percent of ASTM D698. Compact fill and backfill materials to 95 percent of ASTM D698.

## 3.11 PIPELINE CASING UNDER PAVEMENT

Provide new smooth wall steel pipeline casing under new railroad and pavement in a trench by the boring and jacking method of installation. Provide each new pipeline casing, where indicated and to the lengths and dimensions shown, complete and suitable for use with the new piped utility as indicated.

### 3.11.1 Earthwork for Pipeline Casings

Provide excavation, sheet piling, shoring, dewatering, and backfilling for pipeline casings under this section.

### 3.11.2 Steel Cased Pipelines

#### 3.11.2.1 Hole for Pipeline Casing

Mechanically bore holes and case through the soil with a cutting head on a continuous auger mounted inside the casing pipe. Weld lengths of pipe together in accordance with AWS D1.1/D1.1M. Do not use water or other

fluids in connection with the boring operation.

3.11.2.2 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.11.2.3 Piped Utilities

Provide in casing using wood supports adjusted to obtained grades and elevations indicated.

3.11.2.4 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight end seals as indicated.

3.12 SPECIAL EARTHWORK REQUIREMENTS FOR SUBSURFACE DRAINS

Excavate to dimensions indicated. Provide a bedding surface of no more than one inch of Type I subdrain backfill material and place on compacted impermeable material as indicated. Backfill around and over the pipes after pipe installation has been approved. Place special granular filter material in 6 inch lifts and compact with mechanical, vibrating plate tampers or rammers until no further consolidation can be achieved. Compact backfill overlying the special granular filter material as specified for adjacent or overlying work.

3.12.1 Granular Backfill Using Filter Fabric

3.12.1.1 Perforated or Slotted Wall Pipes

Wrap one layer of filter fabric around pipe in such a manner that longitudinal overlaps are in unperforated or unslotted quadrants of the pipe. Overlap fabric a minimum of 2 inches. Secure fabric to pipe so that backfill material does not infiltrate through overlaps. Place granular material and extend it for one pipe diameter, minimum of 6 inches on each side of and 18 inches above top of pipe. Place a layer of filter fabric on top of granular filter before continuing with backfill.

3.12.1.2 Open-Joint Pipe

Wrap one layer of filter fabric around pipe joints overlapping a minimum of 2 inches in the longitudinal direction and extending at least 6 inches on both sides of the joint. Secure fabric to pipe so that backfill material does not infiltrate through overlaps. Place granular material specified and extend it for a minimum of one pipe diameter on each side of and 18 inches above top of pipe. Place a layer of filter fabric on top of granular filter before continuing with backfill.

3.12.1.3 Blind or French Drains

Install filter cloth in trenches with smoothly graded sides and bottom, free of cavities or projecting rocks. Lay the cloth flat but not stretched and secure with anchor pins. Place filter cloth so that drain water must pass through the cloth into the specified granular filter material. Overlap

ends at least of 12 inches. Place backfill on filter cloth in the direction of overlaps. Where fabric is damaged, place a new piece of filter cloth over damaged area and overlap at least of 12 inches in every direction.

## 3.13 FINISH OPERATIONS

### 3.13.1 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

### 3.13.2 Protection of Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

## 3.14 FIELD QUALITY CONTROL

### 3.14.1 Sampling

Take the number and size of samples required to perform the following tests.

### 3.14.2 Testing

Perform one of each of the following tests for each material used. Provide additional tests for each source change.

#### 3.14.2.1 Fill and Backfill Material Testing

Test fill and backfill material in accordance with ASTM C136/C136M for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D4318 for liquid limit and for plastic limit; ASTM D698 for moisture density relations, as applicable.

#### 3.14.2.2 Select Material Testing

Test select material in accordance with ASTM C136/C136M for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D698 for moisture density relations, as applicable.

#### 3.14.2.3 Porous Fill Testing

Test porous fill in accordance with ASTM C136/C136M for conformance to gradation specified in ASTM C33/C33M.

#### 3.14.2.4 Density Tests

Test density in accordance with ASTM D1556/D1556M, or ASTM D6938. When ASTM D6938 density tests are used, verify density test results by performing an ASTM D1556/D1556M density test at a location already ASTM D6938 tested as specified herein. Perform an ASTM D1556/D1556M density test at the start of the job, and for every 10 ASTM D6938 density tests thereafter. Test each lift at randomly selected locations every 2000 square feet of grade. Include density test results in daily report.

3.14.2.5 Moisture Content Tests

In the stockpile, excavation or borrow areas, a minimum of two tests per day per type of material or source of materials being placed is required during stable weather conditions. During unstable weather, tests shall be made as dictated by local conditions and approved moisture content shall be tested in accordance with ASTM D2216. Include moisture content test results in daily report.

-- End of Section --

SECTION 31 62 16.13

STEEL PIPE PILES

PART 1 GENERAL

1.1 DESCRIPTION

Install and test steel pipe piles at the locations indicated on the drawings and specified herein.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM D4945 | (2017) Standard Test Method for High-Strain Dynamic Testing of Deep Foundations |

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Wave Equation Analysis

Contractor's Geotechnical Consultant Qualifications

Installation And Testing Procedures

SD-02 Shop Drawings

Pile Placement

As-Driven Survey

SD-03 Product Data

Pile Driving Equipment

Storage and Handling

SD-06 Test Reports

Pile Performance Report

Dynamic Pile Analysis

SD-11 Closeout Submittals

Pile Records

## 1.4 STORAGE AND HANDLING

Develop and submit plans for the transportation of piles from Owner's storage area/facility to project site, temporary storage, and handling of piles prior to installation. Submit plans prior to transportation of piles to the job site.

### 1.4.1 Storage

Stack piles during storage at project site so that each pile is maintained in a straight position and is supported every 10 feet or less along its length (ends inclusive). Do not stack piles more than 5 feet high.

### 1.4.2 Handling

Lift piles to ensure that the maximum permissible curvature is not exceeded. Do not damage piles when dragging piles across the ground or barge deck.

Inspect piles for excessive curvature and for damage before transporting them from Owner's storage area/facility to the driving area and immediately prior to placement in the driving leads. Curvature in the pile must be measured with the pile laying on a flat surface and is the distance between the pile at the mid-length of the pile and the flat surface. The maximum permissible curvature is 2 inches over the length of the pile. Immediately notify owner of the piles having excessive curvature.

### 1.4.3 Damaged Piles

Inspect each pile for straightness, structural damage, and coating damage before transporting them to the project site and immediately prior to placement in the driving leads. Bring any damage to the attention of the Owner. Piles which are damaged during transportation from Owner's storage area/facility to project site, or handling to the extent they are rendered unsuitable for the work, in the opinion of the Owner, will be rejected and removed from the project site, or may be repaired, if approved, at no cost to the Owner. Contractor shall be responsible to replace the damaged pile in kind at no cost to the Owner.

Any pile damaged by reason of improper driving must be corrected by one of the following methods approved by the Engineer for the pile in question:

a. The pile is withdrawn, if practicable, and replaced by a new and, if necessary, longer pile.

b. One or more replacement piles are driven adjacent to the defective pile.

c. A Pile Dynamic Analysis and low integrity testing must be performed by the Contractor's Geotechnical Consultant to assess the structural integrity of the driven pile(s) and the soil capacity/resistance.

A pile driven below the specified cutoff elevation must be corrected by one of the following methods approved by the Engineer:

a. The pile is spliced (if approved).

b. A sufficient portion of the footing is extended down to properly embed the pile.

A pile driven out of its proper location or out of plumb as approved by the Engineer, must be corrected by one of the following methods approved by the engineer:

a. One or more replacement piles are driven next to the pile in question.

b. As directed by the structural engineer.

1.5 QUALITY CONTROL

1.5.1 Pile Placement

Prepare and submit shop drawings for pile placement.

1.5.2 Contractor's Geotechnical Consultant Qualifications

Hire the services of an independent, Registered Professional Geotechnical Engineer, experienced in dynamic pile testing and vibration monitoring to observe test pile installation as specified herein. The Contractor's Geotechnical Consultant must be independent of the Contractor and must have no employee of employer relationship, which could constitute a conflict of interest.

1.5.3 Quality Control Procedures

Submit the pile manufacturer's quality control procedures.

1.5.4 Installation And Testing Procedures

a. Submit information on the type of equipment proposed to be used, proposed methods of operation, pile driving plan including proposed sequence of driving, and details of all pile driving equipment and accessories. Submit descriptions of pile driving equipment, including hammers, power packs, driving helmets, hammer cushions, pile cushions, leads, and extractors at least 30 days prior to commencement of work.

b. Provide details of pile driving equipment and a Wave Equation Analysis of pile drivability for selection of the hammer along with a statement of driving procedures. Provide instructions and procedures on how the Contractor will perform Dynamic Pile Testing, Inspection and Monitoring of piles during installation and testing. The Wave Equation Analysis is to be completed by the Contractor's Geotechnical Consultant for each test pile location where different subsurface conditions exist and is to include the following information pertaining to the proposed pile driving equipment:

    (1) Complete Pile and Driving Equipment Data Form, for each proposed pile hammer and pile type combination.

    (2) Copies of computer input and output sheets and graphs showing soil resistance versus blow count as well as maximum tension and compression stresses versus blow count. Analysis must be run at the estimated tip elevation as well as other required elevations to define maximum stress levels in the pile during driving.

c. Provide detailed procedures for conducting the dynamic pile load test and equipment to be used for conducting the load test. The detailed description must explain how specific information of pile performance will be evaluated.

## PART 2 PRODUCTS

### 2.1 PILE REQUIREMENTS

Contractor shall install Owner-provided steel pipe piles as indicated on the drawings. All pipe piles have a minimum yield strength of 50 ksi. Contractor shall obtain a copy of the pipe pile order list, material certificates, and specifications of coating applied from the Owner prior to transportation of piles to the project site. Contractor shall verify the pile sizes and quantity, and the coated lengths per the construction drawings. Immediately notify Owner of any discrepancy or any damage to the pipe or to the coating. All piles shall be marked within top 2 feet with pile row and pile bent number (for example A-23). Contractor shall ensure the test piles are identified with additional marks: "TP B-18" for example.

### 2.2 MATERIALS

### 2.3 PILE DRIVING EQUIPMENT

Select the proposed pile driving equipment, including hammers and other required items, and submit complete descriptions of the proposed equipment in accordance with paragraph SUBMITTALS. Changes in the selected pile driving equipment will not be allowed after the equipment has been approved except as directed. No additional contract time will be allowed for Contractor proposed changes in the equipment.

#### 2.3.1 Pile Driving Hammers

Provide impact type pile driving hammers.

##### 2.3.1.1 Impact Hammers

Provide air, hydraulic or diesel-powered impact pile hammers of the single-acting, double-acting, or differential-acting type. Hammers must be capable of hard driving in excess of 20 blows per one inch. Provide boiler, compressor, or engine capacity sufficient to operate hammers continuously at the full rated speed. Hammers must have a gage to monitor hammer bounce chamber pressure for diesel hammers or pressure at the hammer for air hammers. This gage must be operational during the driving of piles and be mounted in an accessible location for monitoring by the Contractor and the Owner. Provide bounce chamber pressure gage correction tables and charts for the type and length of hose to be used with the pressure gage to the Owner. Hydraulic hammers must be equipped with a system for measurement of ram energy. The system must be in good working order and the results must be easily and immediately available to the Owner. Install an energy monitor on the hydraulic hammers and record readings every 10 inches of pile installation. Use wave equation analysis to verify that the hammer will develop stresses within acceptable limits in the piles. Position a pile cap or drive cap between the pile and hammer. Place hammer cushion or cap block between ram and the pile cap or drive cap. Hammer cushion or cap block must have consistent elastic properties, minimize energy absorption, and transmit hammer energy uniformly and consistently during the entire driving period. In accordance with paragraph SUBMITTALS, submit the following information for each impact hammer proposed:

a. Make and model.

b. Ram weight (pounds).

c. Anvil weight (pounds).

d. Rated stroke inches.

e. Rated energy range foot-pounds.

f. Rated speed (blows per minute).

g. Air pressure, hammer, and boiler and/or compressor psi.

h. Rated bounce chamber pressure curves or charts, including pressure correction chart for type and length of hose used with pounds per square inch.

i. Pile driving cap, make, and weight (pounds).

j. Cushion block dimensions and material type.

k. Power pack description.

2.3.2 Pile Driving Leads

Support and guide hammers with leads capable of driving the piles to their intended locations and within the tolerances specified. Provide two intermediate supports for the pile in the leads to reduce the unbraced length of the pile during driving and pulling.

2.3.3 Pile Extractors

Pile extractors may be vibratory or impact pile driving hammers. Impact hammers are required for pulling piles not extractable with vibratory hammers.

2.3.4 Jetting Equipment

Jetting of piles is not permitted.

PART 3 EXECUTION

3.1 PRELIMINARY WORK

3.1.1 Wave Equation Analysis (WEAP) of Pile Drivability

a. Prior to driving any pile, submit a pile Wave Equation Analysis, performed by Contractor's Geotechnical Consultant, for each size pile and distinct subsurface profile condition. These analyses must take into account the proposed hammer assembly, pile cap block and cushion characteristics, the pile properties and estimated lengths and the soil properties anticipated to be encountered throughout the installed pile length based on static capacity analysis with consideration of driving gain/loss factors. Only one specific model of pile hammer may be used for each pile type and capacity.

b. Demonstrate using the Wave Equation Analysis that the piles will not be damaged during driving, indicate that the driving stresses will be maintained within the limits below and indicate the blow count necessary to achieve the required ultimate static pile capacities.

Allowable Driving Stresses

Steel Piles

Compression - 0.9 fy
Tension - 0.9 fy

Where fy is yield strength of steel

c. All pile driving equipment provided by the Contractor will be subject to the approval of the Contractor's Geotechnical Consultant.

d. The cost of performing the Wave Equation Analyses shall be paid for by the Contractor and included in the base bid..

3.1.2 Pile Length Markings

The CONTRACTOR shall mark each pile prior to driving with horizontal lines (perpendicular to the longitudinal axis of pile) at one foot intervals, and the number of feet from pile tip at 5 foot intervals.

3.2 INSTALLATION

Inspect piles prior to installation and when in the leads immediately before driving. Handle piles so as to protect pile coatings. Repair damage or defects in pile coatings per coating manufacturer's instructions. The repairs shall be performed using the same coating as originally applied. Cut piles at cutoff grade by an approved method. Where cutoff is below existing ground or mudline elevation, complete excavation, and dewatering before driving pile to specified cutoff elevation.

3.2.1 Pile Driving Records

Keep a complete and accurate record of each pile driven. Indicate the pile location, pile identification number, deviations from pile location, cross section shape and dimensions, original length, ground elevation, tip elevation, cut-off elevations, number of blows required for each foot of penetration and number of blows for the last 6 inches penetration. Include in the record the beginning and ending times of each operation during driving of pile, type and size of hammer used, rate of operation, stroke or equivalent stroke for diesel hammer, type of driving helmet, and type and dimension of hammer cushion (capblock) and pile cushion used. Record retap data and unusual occurrences during pile driving such as redriving, heaving, weaving, splicing, obstructions, and any driving interruptions. A preprinted pile driving log for recording pile driving data and pile driving equipment is attached at the end of this section.

3.2.2 Pile Placement and Tolerances in Driving

Develop and submit a pile placement plan which shows the installation sequence and the methods proposed for controlling the location and alignment of piles. Submit pile placement plans at least 30 calendar days prior to installation of piles. Complete all foundation preparation in the area prior to the placement of piles for driving. Accurately place piles in the correct location and alignments, both laterally and longitudinally, and to the vertical lines indicated. Establish a permanent base line to provide for inspection of pile placement during pile driving operations prior to driving production piles and maintain during the installation of the production piles.

A final lateral deviation from the correct location at the cutoff elevation of not more than 3 inches will be permitted for vertical piles. Manipulation of piles will not be permitted. A variation of not more than 0.25 inch per foot of pile length from the vertical will be permitted. Redesign of pile caps or additional work required due to improper location of piles is the responsibility of the Contractor, subject to Engineer approval. A vertical deviation of not more than one inch from the correct cutoff elevations shown is permitted. Inspect piles for heave. Redrive heaved piles to the required pile driving criteria. Maintain the correct relative position of all piles by the use of templates or by other approved means. Piles damaged or not located properly or exceeding the maximum limits for lateral and vertical deviation, or variation in alignment must be pulled and new piles redriven, or provide additional piles, at a location directed at no additional cost to the Owner.

3.2.2.1 Survey Data

After the driving of each pile group is complete and before superimposed concrete is placed, provide the Owner with an as-driven survey showing actual location, top elevation, inclination and orientation of each pile. Submit the as-driven survey showing actual location and top elevation of each pile within 7 calendar days of completing the pile installation. Do not proceed with placing concrete until the Owner has reviewed the survey. Present a survey in such form that it gives deviation from plan location in two perpendicular directions and elevations of each pile to nearest half inch. Survey must be prepared and certified by a land surveyor licensed in the State of Texas.

3.2.3 Pile Penetration Criteria

The piles shall be installed to the specified tip elevation as shown on the drawings and shall meet the driving criteria established based on Dynamic Pile Analysis.

3.2.4 Pile Driving

Notify the Owner 10 days prior to driving of piles. Do not drive piles with in 100 feet of concrete less than 7 days old. Complete excavation to lines and grades shown when pile driving is completed. Drive piles to indicated tip elevation. If a pile fails to reach indicated tip elevation, notify Owner and perform corrective measures as directed. Drive production and test piles with hammers of the same model and manufacturer, same energy and efficiency, and using the same driving system. Operate hammers at all times at the speed and under the conditions recommended by the manufacturer. Where heave is anticipated, the sequence of installation must be such that pile heave is minimized by starting pile driving at the center of the group and proceeding outward. Prior to driving and with the pile head seated in the hammer, check each pile to ensure that it has been aligned correctly. Drive each pile continuously and without interruption until the required tip elevation has been attained. Deviation from this procedure will be permitted only when driving is stopped by causes that reasonably could not have been anticipated. A pile that can not be driven to the required depth because of an obstruction, as indicated by a sudden unexplained change in blow count and drifting, must be pulled and redriven or cut off and abandoned, whichever is directed by Owner. If, in driving, it is found that pile is not of sufficient length to give the capacity specified, notify the Owner, who will determine the procedure to be followed.

3.2.5 Protection of Piles

Take care to avoid damage to piles during handling, placing pile in leads, and during pile driving operations. Support piles laterally during driving, but allow rotation in leads. Maintain axial alignment of pile hammer with that of the pile.

3.2.6 Rejected Piles

Withdraw piles damaged or impaired for use during handling or driving, mislocated, or driven out of alignment beyond the maximum tolerance. Replace with new piles or cut-off and abandon damaged or impaired piles and drive new piles as directed. Remove excess cut-off from piles and unacceptable piles from the work site. Perform all work in connection with withdrawing and removing rejected piles from the site at no additional cost to the Owner.

3.2.7 Jetting of Piles

Jetting of piles is not permitted.

3.2.8 Predrilling of Piles

Predrilling of piles is not permitted.

3.2.8.1 Heaved Piles

When driving piles in clusters or under conditions of relatively close spacing, perform observations to detect heave of adjacent piles. Backdrive heaved piles to original to the required tip elevation as directed by the Contractor's Geotechnical Consultant, after reviewing the heave data, without additional cost to the Owner.

3.2.8.2 Pulled Piles

Pull and replace piles damaged or impaired for use during driving with new piles, or cut off and abandon and drive new piles as directed without additional cost to the Owner. The Owner may require that any pile be pulled for inspection. Redrive piles pulled as directed and found to be in suitable condition at another location as directed. Replace piles pulled as directed and found to be damaged with new piles at the Contractor's expense.

3.2.8.3 Long Piles

Provide pile driving rig with rigid supports so that leads remain accurately aligned. Where a high degree of accuracy is required, erect templates or guide frames at or close to the ground or water surface.

3.2.9 Protection of Existing Structures

Mitigate impact on existing facilities due to pile driving activities in accordance with the project specific document.

3.2.10 Concrete Infill

Mix and place concrete infill in accordance with Section 03 31 30 MARINE CONCRETE. Concrete shall be placed to the elevations as shown on the Drawings.

## 3.3 FIELD QUALITY CONTROL

### 3.3.1 Test Piles

Test designated production piles shown on the drawings to confirm the pile load carrying capacity (ultimate soil resistance) at the specified tip elevation. Test first four piles at the beginning of pile installation to verify the performance and efficiency of pile driving equipment chosen by contractor based on WEAP and to confirm the pile load carrying capacity. The remaining production test pile shall be tested per Contractor's schedule. The piles that do not reach the ultimate soil resistance at specified tip elevation shall be re-struck after a minimum waiting period of 14 days from the time of end of initial driving. Contractor shall account for the waiting period in the project bid and schedule. Provide and operate a pile driving analyzer as specified in paragraph DYNAMIC PILE ANALYSIS during the driving of each test pile.

#### 3.3.1.1 Dynamic Pile Analysis

Dynamic testing provides supplemental information for evaluating pile integrity, hammer and drive system performance, assess pile installation driving stresses, and pile capacities. Perform dynamic testing on piles as indicated. Provide equipment to obtain dynamic measurements, record, reduce and display its data that meet the requirements of ASTM D4945. The equipment must have been calibrated within 6 months prior to the start of the testing operations and thereafter throughout the contract duration. Employ an independent inspection firm, hereinafter referred to as the "Contractor's Geotechnical Consultant", experienced in the pile driving process, monitoring of test pile installation, and in the use of the Pile Driving Analyzer and its related equipment. Submit a performance report summarizing dynamic test results for test piles within 7 calendar days of completing field work. Perform dynamic pile analysis as follows:

#### 3.3.1.2 Pile Analyzing

10 working days prior to driving any production test pile, submit the pile and complete driving equipment data to the Owner. The Contractor's Geotechnical Consultant must use the submitted information to perform wave equation analyses and must prepare a summary report of the wave equation results. The wave equation analysis using GRLWEAP software by Pile Dynamics, Inc. or equivalent must be used to assess the ability of the proposed driving system to install the pile to the required capacity and desired penetration depth within the allowable driving stresses.

#### 3.3.1.3 Pile Drivability

Perform the initial (first 4 piles) dynamic pile analysis to check the hammer, pile and soil performance, and to determine the suitability of the proposed hammer for the size, length and type of pile being installed for the soil types encountered as the piles are driven. Pile driving criteria should be developed by the Contractor's Geotechnical Consultant based on the results of the PDA analysis and reviewed and approved by the Owner before driving the remaining piles. This initial monitoring must determine efficiency of the hammer relative to specified efficiency, effectiveness of cushion, level of compressive and tensile stress in pile and extent/location of any pile damage caused by the initial driving. With each blow of the pile, record the information listed below electronically and analyze the information using the Pile Driving Analyzer:

a. Blow number

b. Blow rate per minute and stroke.

c. Input and reflected values of force and velocity.

d. Value of upward and downward traveling force wave with time.

e. Maximum and final transferred energy to pile, hammer system efficiency.

f. Maximum compressive stress, velocity, acceleration and displacement.

g. Maximum tensile stress in pile.

h. Pile structural integrity, damage detection, extent and location.

i. Bearing capacity of pile by Case method.

If the pile, hammer and soil performance evaluation recommends changes to the hammer stroke, pile cushioning or any other aspect for the pile driving operation, incorporate these changes into production pile driving in an effort to control excessive stresses and pile damage. Replace test piles damaged or broken during installation, incorporating driving modifications as determined by the Contractor's Geotechnical Consultant and reviewed and approved by the Owner. Repeat this procedure until allowable tensile and compressive stresses are achieved in the pile and pile damage is minimized. Subject selected initial driving records to rigorous computer analysis by the Case Pile Wave Analysis Program (CAPWAP) for determination of resistance distribution, soil resistance and properties, and estimation of anticipated gain/loss factors.

3.3.1.4 CAPWAP

Signal matching analysis by CAPWAP software of the dynamic pile testing data must be performed on data obtained from the end of initial driving and the beginning of restrike of all control piles. CAPWAP analyses must be performed by an engineer who has achieved Advanced Level or better on the PDI/PDCA Dynamic Measurement and Analysis Proficiency Test for Providers of PDA Testing Services.

If the soil capacity of a test pile as determined by CAPWAP analyses is less than the required soil capacity as published on the drawings, the piles will need to be restruck to determine increase in capacity with time.

Upon completion of test pile driving, allow the piles to set-up for at least 14 days. The evaluation requires striking the set-up piles a minimum of 20-50 times, or as directed by the Contractor's Geotechnical Consultant using the same hammer which was used for the test pile driving and which will be used for production pile driving. "Warm up" the hammer and make it optimally ready prior to restriking, in order to avoid capacity losses during evaluation of restrike data. Apply maximum hammer energy during restrike in order to fully mobilize the soil resistance. However, exercise care so as to not overstress the pile. In addition to those items listed above, selected restrike driving records (as directed by the Contractor's Geotechnical Consultant are to be subjected to rigorous computer analysis by the Case Pile Wave Analysis Program (CAPWAP) for determination of resistance distribution, soil resistance and properties, and plot of applied load vs. average pile displacement based on the calculated soil properties.

3.3.1.5 Dynamic Load Test Reporting

a. Upon satisfactory completion of each dynamic load test, submit a pile performance report for the Contractor by the Contractor's Geotechnical Consultant. The submittal must be prepared and sealed by a Professional Engineer registered in the State of Texas, with a minimum of five years experience, at least two of which shall have been in data interpretation from high strain dynamic pile testing.

b. The report for the Dynamic Pile Analysis must contain the following information:

(1) Capacity of pile from Case Pile Wave Analysis Program (CAPWAP). Information resulting from analysis of a selected restrike blow.

(2) Maximum and final transferred energy, hammer system efficiency during pile installation.

(3) Maximum compressive stress, velocity, acceleration and displacement.

(4) Maximum tensile stress in pile.

(5) Pile structural integrity, damage detection, extent and location.

(6) Blows per minute and blow number.

(7) Input and reflection values of force and velocity, upward and downward traveling force wave with time.

(8) Pile skin friction and toe resistance distribution.

(9) Maximum energy transferred to pile.

c. The Contractor's Geotechnical Consultant shall establish pile driving criteria based upon the results of satisfactory pile load tests. These criteria should be used in driving the remaining piles.

If the soil resistance measured on restrike is less than the required soil capacity Resistance shown on the plans, the Engineer may direct the Contractor to drive all or a portion of the remaining test pile length and repeat the restrike testing. The Contractor will be notified by the Engineer of the necessity to perform a second restrike test within 3 days of the receipt of the test results from the initial restrike

Use either a Model 8G or PAX Pile Driving Analyzer as manufactured by Pile Dynamics, Inc., of Cleveland Ohio or approved equivalent, for dynamic testing of the pile hammer and for dynamic load testing of the test pile. All equipment necessary for the dynamic monitoring such as sensors, cables or wireless transmitters, must be furnished by the Contractor's Geotechnical Consultant. The equipment must conform to the requirements of ASTM D4945.

The Contractor's Geotechnical Consultant must be available throughout the pile driving operation to consult with the Owner when required by the Owner. The cost of changes in the Contractor's procedure, as required by evaluation of the results of the Pile Driving Analysis, will be at the Contractor's expense.

### 3.3.2 Pile Records

Keep a complete and accurate record of each pile driven. Indicate the pile location, pile identification numbers, deviations from pile location, cross section shape and dimensions, original length, ground elevation, tip elevation, cut-off elevations, number of blows required for each foot of penetration and number of blows for the last 6 inches penetration or fraction thereof. Include in the record the beginning and ending times of each operation during driving of pile, type and size of hammer used, rate of operation, stroke or equivalent stroke for diesel hammer, type of driving helmet, and type and dimension of hammer cushion (capblock) and pile cushion used. Record retap data and unusual occurrences during pile driving such as redriving, heaving, weaving, splicing, obstructions, and any driving interruptions. Submit to the Owner complete and accurate test and production pile driving records within 15 calendar days after completion of driving. Make pile driving records available to the Owner at the job site, within 24 hours after each day of pile driving. A preprinted pile driving log for recording pile driving data is attached at the end of this Specification.

### 3.3.3 Concrete Infill

Perform field quality control testing of the concrete infill in accordance with Section 03 31 30 MARINE CONCRETE.

-- End of Section --

# Pile Driving Log

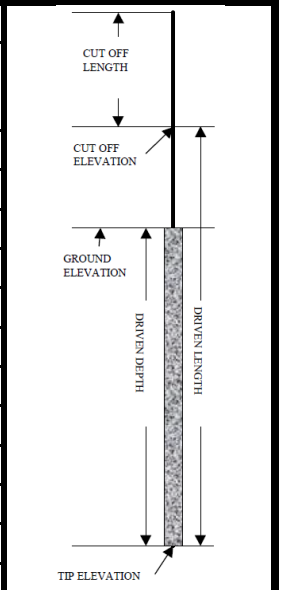
| | | | |
|---|---|---|---|
| **Project:** | | **Contractor:** | |
| **Contract No.** | | **Recording Date:** | |
| **Work Order No.** | | **Recording Scribe:** | |

| **Hammer Data** | Vibratory | Impact | Rig: |
|---|---|---|---|
| Make & Model: | | | Ram Weight: |
| Type: | | | Hammer Cushion: |

| **Pile Data** | | Cutoff Elevation: | **Time** |
|---|---|---|---|
| Structure & Pile No: | Batter: | Ground Elevation: | Finish: |
| Size, Length, & Type: | | Driven Length: | Start: |
| Station / Coordinates: | | Pile Tip Elevation: | Drive Time: |

**DRIVING RECORDS**

| Ft. | Blows | Stroke or BPM | Ft. | Blows | Stroke | Ft. | Stroke or BPM | Stroke | Ft. | Blows | Stroke or BPM | Ft. | Blows | Stroke or BPM | LAST FOOT | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | 21 | | | 41 | | | 61 | | | 81 | | | In. | Blows | Stroke |
| 2 | | | 22 | | | 42 | | | 62 | | | 82 | | | -1” | | |
| 3 | | | 23 | | | 43 | | | 63 | | | 83 | | | -2” | | |
| 4 | | | 24 | | | 44 | | | 64 | | | 84 | | | -3” | | |
| 5 | | | 25 | | | 45 | | | 65 | | | 85 | | | -4” | | |
| 6 | | | 26 | | | 46 | | | 66 | | | 86 | | | -5” | | |
| 7 | | | 27 | | | 47 | | | 67 | | | 87 | | | -6” | | |
| 8 | | | 28 | | | 48 | | | 68 | | | 88 | | | -7” | | |
| 9 | | | 29 | | | 49 | | | 69 | | | 89 | | | -8” | | |
| 10 | | | 30 | | | 50 | | | 70 | | | 90 | | | -9” | | |
| 11 | | | 31 | | | 51 | | | 71 | | | 91 | | | -10” | | |
| 12 | | | 32 | | | 52 | | | 72 | | | 92 | | | -11” | | |
| 13 | | | 33 | | | 53 | | | 73 | | | 93 | | | -12” | | |
| 14 | | | 34 | | | 54 | | | 74 | | | 94 | | | Fuel Setting | From (ft) | To (ft) |
| 15 | | | 35 | | | 55 | | | 75 | | | 95 | | | | | |
| 16 | | | 36 | | | 56 | | | 76 | | | 96 | | | | | |
| 17 | | | 37 | | | 57 | | | 77 | | | 97 | | | | | |
| 18 | | | 38 | | | 58 | | | 78 | | | 98 | | | | | |
| 19 | | | 39 | | | 59 | | | 79 | | | 99 | | | | | |
| 20 | | | 40 | | | 60 | | | 80 | | | 100 | | | | | |




**REMARKS:**

| | | |
|---|---|---|
| Driving Foreman: | Phone: | Fax: |
| Superintendent: | Phone: | Fax: |
| Project Manager: | Phone: | Fax: |

Note: When advancing pile with a vibratory hammer, enter time of day (HH:MM:SS) in “Blows” Column.

SECTION 32 12 13

BITUMINOUS TACK AND PRIME COATS

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

The bituminous material paid for will be the measured quantities of residual bituminous material used in the accepted work, provided that the measured quantities are not 10 percent over the specified quantities. Any amount of bituminous material more than 10 percent over the specified quantity will be deducted from the measured quantities. Express measured quantities in gallons at 60 degrees F. Correct volumes measured at temperatures other than 60 degrees F in accordance with ASTM D1250 using a coefficient of expansion of 0.00025 per degree F for asphalt emulsion.

1.1.2 Payment

The quantities of bituminous material, determined as specified above, will be paid for at the respective contract unit prices. Payment will constitute full compensation for all operations necessary to complete the work as specified herein.

1.1.3 Waybills and Delivery Tickets

Submit waybills and delivery tickets, during progress of the work. Before the final statement is allowed, file with the Owner certified waybills and certified delivery tickets for all bituminous materials used in the construction of the pavement covered by the contract. These submittals are required for Unit Pricing bid only. Do not remove bituminous material from storage until the initial outage and temperature measurements have been taken. The delivery or storage units will not be released until the final outage has been taken.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM D140/D140M | (2016) Standard Practice for Sampling Asphalt Materials |
| ASTM D946/D946M | (2020) Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction |
| ASTM D1250 | (2019; E 2020) Standard Guide for Use of the Joint API and ASTM Adjunct for Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils: |

| | |
|---|---|
| | API MPMS Chapter 11.1 |
| ASTM D2027/D2027M | (2019) Cutback Asphalt (Medium-Curing Type) |
| ASTM D2028/D2028M | (2015) Cutback Asphalt (Rapid-Curing Type) |
| ASTM D2995 | (1999; R 2009) Determining Application Rate of Bituminous Distributors |
| ASTM D6373 | (2016) Standard Specification for Performance Graded Asphalt Binder |

U.S. GREEN BUILDING COUNCIL (USGBC)

| | |
|---|---|
| LEED BD+C | (2009; R 2010) Leadership in Energy and Environmental Design(tm) Building Design and Construction (LEED-NC) |

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Waybills and Delivery Tickets

Local/Regional Materials

SD-06 Test Reports

Sampling and Testing

1.4 QUALITY ASSURANCE

Certificates of compliance for asphalt materials delivered will be obtained and checked to ensure that specification requirements are met. Quantities of applied material will be determined. Payment will be for amount of residual asphalt applied. Tack coat materials will not be diluted. Prime coat materials when emulsions are used can be diluted on site with potable water up to 1 part emulsion to 1 part water.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling.

1.6 EQUIPMENT, TOOLS AND MACHINES

1.6.1 General Requirements

Equipment, tools and machines used in the work are subject to approval. Maintain in a satisfactory working condition at all times. Calibrate equipment such as asphalt distributors, scales, batching equipment, spreaders and similar equipment within 12 months of their use. If the calibration expires during project, recalibrate the equipment before work can continue.

1.6.2 Bituminous Distributor

Provide a self propelled distributor with pneumatic tires of such size and number to prevent rutting, shoving or otherwise damaging the surface being sprayed. Calibrate the distributer in accordance with ASTM D2995. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled total liquid rates from 0.03 to 1.0 gallons per square yard, with a pressure range of 25 to 75 psi and with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. The distributor will be capable of circulating and agitating the bituminous material during the heating process.

1.6.3 Heating Equipment for Storage Tanks

Use steam, electric, or hot oil heaters for heating the bituminous material. Provide steam heaters consisting of steam coils and equipment for producing steam, so designed that the steam cannot come in contact with the bituminous material. Fix an armored thermometer to the tank with a temperature range from 40 to 400 degrees F so that the temperature of the bituminous material may be determined at all times.

1.6.4 Power Brooms and Power Blowers

Use power brooms and power blowers suitable for cleaning the surfaces to which the bituminous coat is to be applied.

1.7 ENVIRONMENTAL REQUIREMENTS

Apply bituminous coat only when the surface to receive the bituminous coat is dry. A limited amount of moisture (approximately 0.03 gallon/square yard) can be sprayed on the surface of unbound material when prime coat is used to improve coverage and penetration of asphalt material. Apply bituminous coat only when the atmospheric temperature in the shade is 50 degrees F or above and when the temperature has not been below 35 degrees F for the 12 hours prior to application, unless otherwise directed.

PART 2 PRODUCTS

2.1 PRIME COAT

Provide asphalt conforming to one of the following grades:

2.1.1 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2027/D2027M, Grade MC-250.

2.2 TACK COAT

2.2.1 Asphalt Cement

Provide asphalt cement conforming to ASTM D946/D946M or ASTM D6373.

2.2.2 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2028/D2028M, RC-250.

2.2.3 Local/Regional Materials

Use Local/Regional Materials or products extracted, harvested, or recovered, as well as manufactured, within a 500 mile radius from the project site, if available from a minimum of three sources. Tack and prime coat materials may be locally available. Submit documentation indicating distance between manufacturing facility and the project site. Indicate distance of raw material origin from the project site. Indicate relative dollar value of local/regional materials to total dollar value of products included in project in accordance with LEED BD+C.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Immediately before applying the bituminous coat, remove all loose material, dirt, clay, or other objectionable material from the surface to be treated by means of a power broom or blower supplemented with hand brooms. Apply treatment only when the surface is dry and clean.

3.2 APPLICATION RATE

The exact quantities within the range specified, which may be varied to suit field conditions.

3.2.1 Tack Coat

Apply bituminous material for the tack coat in quantities of not less than 0.03 gallons nor more than 0.10 gallons per square yard of residual asphalt onto the pavement surface. Do not dilute asphalt emulsion when used as a tack coat.

3.2.2 Prime Coat

Apply bituminous material for the prime coat in quantities of not less than 0.05 gallons nor more than 0.12 gallons per square yard of residual asphalt for asphalt emulsion up to a 1 to 1 dilution rate or for residual asphalt for cutback asphalt.

3.3 APPLICATION TEMPERATURE

3.3.1 Viscosity Relationship

Apply asphalt at a temperature that will provide a viscosity between 10 and 60 seconds, Saybolt Furol, or between 20 and 120 centistokes, kinematic. Furnish the temperature viscosity relation to the Owner.

3.3.2 Temperature Ranges

The viscosity requirements determine the application temperature to be used. The following is a normal range of application temperatures:

| Cutback Asphalts | |
|---|---|
| MC-30 | 85-190 degrees F |
| SC-70, MC-70, RC-70 | 120-225 degrees F |
| SC-250, MC-250, RC-250 | 165-270 degrees F |
| Asphalt Emulsion | |
| All Grades | 70-160 degrees F |
| Asphalt Cement | |
| All Grades | 275-350 degrees F |

Some of these temperatures for rapid cure cutbacks are above the flash point of the material and care should be taken in their heating.

3.4 APPLICATION

3.4.1 General

Following preparation and subsequent inspection of the surface, apply the bituminous prime or tack coat with the bituminous distributor at the specified rate with uniform distribution over the surface to be treated. Properly treat all areas and spots, not capable of being sprayed with the distributor, with the hand spray. Until the succeeding layer of pavement is placed, maintain the surface by protecting the surface against damage and by repairing deficient areas at no additional cost to the Owner. If required, spread clean dry sand to effectively blot up any excess bituminous material. No smoking, fires, or flames other than those from the heaters that are a part of the equipment are permitted within 25 feet of heating, distributing, and transferring operations of cutback materials. Prevent all traffic, except for paving equipment used in constructing the surfacing, from using the underlying material, whether primed or not, until the surfacing is completed. The bituminous coat requirements are described herein.

3.4.2 Prime Coat

Apply a prime coat at locations shown on the Drawings. The prime coat is required if it will be at least 7 days before the asphalt mixture is constructed on the underlying (base course, etc.) compacted material. The type of liquid asphalt and application rate will be as specified herein. Protect the underlying layer from any damage (water, traffic, etc.) until the surfacing is placed. If the Contractor places the surfacing within seven days, the choice of protection measures or actions to be taken is at the Contractor's option. Repair (recompact or replace) damage to the underlying material caused by lack of, or inadequate, protection by approved methods at no additional cost to the Owner. If the Contractor opts to use the prime coat, apply as soon as possible after consolidation of the underlying material. Apply the bituminous material uniformly over the surface to be treated at a pressure range of 25 to 75 psi; the rate will be as specified above in paragraph APPLICATION RATE. To obtain uniform application of the prime coat on the surface treated at the junction of previous and subsequent applications, spread building paper on the surface

for a sufficient distance back from the ends of each application to start and stop the prime coat on the paper and to ensure that all sprayers will operate at full force on the surface to be treated. Immediately after application remove and destroy the building paper.

3.4.3 Tack Coat

Apply tack coat at the locations shown on the drawings. A tack coat should be applied to every bound surface (asphalt or concrete pavement) that is being overlaid with asphalt mixture and at transverse and longitudinal joints. Apply the tack coat when the surface to be treated is clean and dry. Immediately following the preparation of the surface for treatment, apply the bituminous material by means of the bituminous distributor, within the limits of temperature specified herein and at a rate as specified above in paragraph APPLICATION RATE. Apply the bituminous material so that uniform distribution is obtained over the entire surface to be treated. Treat lightly coated areas and spots missed by the distributor by spraying with a hand wand or using other approved method. Following the application of bituminous material, allow the surface to cure without being disturbed for period of time necessary to permit setting of the tack coat. Apply the bituminous tack coat only as far in advance of the placing of the overlying layer as required for that day's operation. Maintain and protect the treated surface from damage until the succeeding course of pavement is placed.

3.5 CURING PERIOD

Following application of the bituminous material and prior to application of the succeeding layer of asphalt mixture allow the bituminous coat to cure and water or volatiles to evaporate prior to overlaying. Maintain the tacked surface in good condition until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and recoating deficient areas. Allow the prime coat to cure without being disturbed for a period of at least 48 hours or longer, as may be necessary to attain penetration into the treated course. Furnish and spread enough sand to effectively blot up excess bituminous material.

3.6 FIELD QUALITY CONTROL

Obtain certificates of compliance for all asphalt material delivered to the project. Obtain samples of the bituminous material under the supervision of the Owner. The sample may be retained and tested by the Owner at no cost to the Contractor.

3.7 SAMPLING AND TESTING

Furnish certified copies of the manufacturer's test reports indicating temperature viscosity relationship for cutback asphalt or asphalt cement, compliance with applicable specified requirements, not less than 5 days before the material is required in the work.

3.7.1 Sampling

Unless otherwise specified, sample bituminous material in accordance with ASTM D140/D140M.

3.7.2 Calibration Test

Furnish all equipment, materials, and labor necessary to calibrate the

bituminous distributor. Calibrate using the approved job material and prior to applying the bituminous coat material to the prepared surface. Calibrate the bituminous distributor in accordance with ASTM D2995.

3.7.3 Trial Applications

Before applying the spray application of tack or prime coat, apply three lengths of at least 100 feet for the full width of the distributor bar to evaluate the amount of bituminous material that can be satisfactorily applied.

3.7.3.1 Tack Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous tack coat materials in the amount of 0.05 gallons per square yard. Make other trial applications using various amounts of material as may be deemed necessary.

3.7.3.2 Prime Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous materials in the amount of 0.15 gallon per square yard. Make other trial applications using various amounts of material as may be deemed necessary.

3.7.4 Sampling and Testing During Construction

Perform quality control sampling and testing as required in paragraph FIELD QUALITY CONTROL.

3.8 TRAFFIC CONTROLS

Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

-- End of Section --

SECTION 32 17 23

PAVEMENT MARKINGS

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

1.1.1.1 Surface Preparation

The unit of measurement for surface preparation (cleaning) is the number of square feet of pavement surface prepared for marking and accepted by the Owner.

1.1.1.2 Pavement Striping and Markings

The unit of measurement for pavement markings is the number of square feet of reflective and/or nonreflective striping or markings actually completed and accepted by the Owner.

1.1.1.3 Raised Pavement Markers

The unit of measurement for raised pavement markers is the number actually placed as specified and approved by the Owner.

1.1.1.4 Removal of Pavement Markings on Roads and Automotive Parking Areas

The unit of measurement for removal of pavement markings is the number of square feet of pavement markings removed as specified and accepted by the Owner.

1.1.2 Payment

The quantities of surface preparation, pavement striping or markings, raised pavement markers, and removal of pavement markings determined as specified in paragraph Measurement, will be paid for at the contract unit price. The payment constitutes full compensation for furnishing all labor, materials, tools, equipment, appliances, and doing all work involved in preparing and marking the pavements as shown on the drawings. Remove and replace any striping or markings which required reflective media, but are placed without it, do not meet the stated minimum retro-reflective requirements, or with other defects, at no cost to the Owner. Remove and replace striping or markings which do not conform to the required physical characteristics, alignment or location required at no cost to the Owner.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 247 (2013) Standard Specification for Glass

| | |
|---|---|
| | Beads Used in Pavement Markings |
| AASHTO M 249 | (2012; R2016) Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form) |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM D471 | (2016a) Standard Test Method for Rubber Property - Effect of Liquids |
| ASTM D476 | (2015) Dry Pigmentary Titanium Dioxide Pigments |
| ASTM D522/D522M | (2017) Mandrel Bend Test of Attached Organic Coatings |
| ASTM D638 | (2014) Standard Test Method for Tensile Properties of Plastics |
| ASTM D695 | (2010) Standard Test Method for Compressive Properties of Rigid Plastics |
| ASTM D711 | (2010; R 2015) No-Pick-Up Time of Traffic Paint |
| ASTM D823 | (2018) Standard Practices for Producing Films of Uniform Thickness of Paint, Coatings, and Related Products on Test Panels |
| ASTM D1652 | (2011; E 2012) Standard Test Method for Epoxy Content of Epoxy Resins |
| ASTM D2074 | (2007; R2013) Standard Test Methods for Total, Primary, Secondary, and Tertiary Amine Values of Fatty Amines by Alternative Indicator Method |
| ASTM D2240 | (2015; E 2017) Standard Test Method for Rubber Property - Durometer Hardness |
| ASTM D2621 | (1987; R 2016) Standard Test Method for Infrared Identification of Vehicle Solids from Solvent-Reducible Paints |
| ASTM D2697 | (2003; R 2014) Volume Nonvolatile Matter in Clear or Pigmented Coatings |
| ASTM D3335 | (1985a; R 2020) Low Concentrations of Lead, Cadmium, and Cobalt in Paint by Atomic Absorption Spectroscopy |
| ASTM D3718 | (1985a; R 2015) Low Concentrations of Chromium in Paint by Atomic Absorption Spectroscopy |
| ASTM D3924 | (2016) Standard Specification for Environment for Conditioning and Testing |

| | |
|---|---|
| | Paint, Varnish, Lacquer, and Related Materials |
| ASTM D3960 | (2005; R 2013) Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings |
| ASTM D4060 | (2019) Abrasion Resistance of Organic Coatings by the Taber Abraser |
| ASTM D4061 | (2013) Standard Test Method for Retroreflectance of Horizontal Coatings |
| ASTM D4280 | (2012) Extended Life Type, Nonplowable, Raised, Retroreflective Pavement Markers |
| ASTM D4505 | (2012; R 2017) Standard Specification for Preformed Retroflective Pavement Marking Tape for Extended Service Life |
| ASTM D4541 | (2017) Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers |
| ASTM D6628 | (2003; R 2015) Standard Specification for Color of Pavement Marking Materials |
| ASTM D7234 | (2012) Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers |
| ASTM E1347 | (2006; R 2020) Standard Test Method for Color and Color Difference Measurement by Tristimulus (Filter) Colorimetry |
| ASTM E1710 | (2011) Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer |
| ASTM E2177 | (2011) Standard Test Method for Measuring the Coefficient of Retroreflected Luminance (RL) of Pavement Markings in a Standard Condition of Wetness |
| ASTM E2302 | (2003; R 2016) Standard Test Method for Measurement of the Luminance Coefficient Under Diffuse Illumination of Pavement Marking Materials Using a Portable Reflectometer |
| ASTM G154 | (2016) Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials |

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

| | |
|---|---|
| ICRI 03732 | (1997) Selecting and Specifying Concrete |

Surface Preparation for Sealers, Coatings, and Polymer Overlays

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS-STD-595A (2017) Colors used in Government Procurement

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA AC 150/5370-10 (2018; Rev H; Errata 1 2019) Standard Specifications for Construction of Airports

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD (2009; Rev 2012) Manual on Uniform Traffic Control Devices

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-B-1325 (Rev D; Notice 1; Notice 2 2017) Beads (Glass Spheres) Retro-Reflective (Metric)

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Surface Preparation Equipment List

Application Equipment List

Exterior Surface Preparation

Safety Data Sheets

Thermoplastic compound

Raised Pavement Markers Primers and Adhesives

SD-06 Test Reports

High Build Acrylic Coating (HBAC)

Thermoplastic Compound

Raised Pavement Markers Primers and Adhesives

Test Reports

SD-07 Certificates

Qualifications

Volatile Organic Compound, (VOC)

Thermoplastic Compound

SD-08 Manufacturer's Instructions

Thermoplastic Compound

1.4 QUALITY ASSURANCE

1.4.1 Regulatory Requirements

Submit certificate stating that the proposed pavement marking paint meets the Volatile Organic Compound, (VOC) regulations of the local Air Pollution Control District having jurisdiction over the geographical area in which the project is located. Submit Safety Data Sheets for each product.

1.4.2 Qualifications

Submit documentation certifying that pertinent personnel are qualified for equipment operation and handling of applicable chemicals. The documentation should include experience on five projects of similar size and scope with references for all personnel.

1.5 DELIVERY AND STORAGE

Deliver paint materials, thermoplastic compound materials, and reflective media in original sealed containers that plainly show the designated name, specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer.

Provide storage facilities at the job site for maintaining materials at temperatures recommended by the manufacturer.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Environmental Requirements

1.6.1.1 Weather Limitations for Application

Apply pavement markings to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 5 degrees F above the dew point and the air and pavement temperatures are within the limits recommended by the pavement marking manufacturer. Allow pavement surfaces to dry after water has been used for cleaning or rainfall has occurred prior to striping or marking. Test the pavement surface for moisture before beginning work each day and after cleaning. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Owner. Employ the "plastic wrap method" to test the pavement for moisture as specified in paragraph TESTING FOR MOISTURE.

1.6.1.2 Weather Limitations for Removal of Pavement Markings on Roads and Automotive Parking Areas

Pavement surface must be free of snow, ice, or slush; with a surface temperature of at least 40 degrees F and rising at the beginning of operations, except those involving shot or sand blasting or grinding. Cease operation during thunderstorms, or during rainfall, except for waterblasting and removal of previously applied chemicals. Cease waterblasting where surface water accumulation alters the effectiveness of material removal.

1.6.2 Traffic Controls

Place warning signs conforming to MUTCD near the beginning of the worksite and well ahead of the worksite for alerting approaching traffic from both directions. Place small markers along newly painted lines or freshly placed raised markers to control traffic and prevent damage to newly painted surfaces or displacement of raised pavement markers. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation.

When traffic must be rerouted or controlled to accomplish the work, provide necessary warning signs, flag persons, and related equipment for the safe passage of vehicles.

1.6.3 Lighting

When night operations are necessary, provide all necessary lighting and equipment. The Owner reserves the right to accept or reject night work on the day following night activities by the Contractor.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Surface Preparation and Paint Removal

2.1.1.1 Surface Preparation Equipment for Roads and Automotive Parking Areas

Submit a surface preparation equipment list by serial number, type, model, and manufacturer. Include descriptive data indicating area of coverage per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation. Mobile equipment must allow for removal of markings without damaging the pavement surface or joint sealant. Maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition.

2.1.1.1.1 Sandblasting Equipment

Use mobile sandblasting equipment capable of producing a pressurized stream of sand and air that effectively removes paint from the surface without filling voids with debris in asphalt or tar pavements or removing joint sealants in Portland cement concrete pavements. Include with the equipment and air compressor, hoses, and nozzles of adequate size and capacity for removing paint. Equip the compressor with traps and coalescing filters that maintain the compressed air free of oil and water.

2.1.1.1.2 Waterblasting Equipment

Use mobile waterblasting equipment capable of producing a pressurized stream of water that effectively removes paint from the pavement surface without significantly damaging the pavement. Provide equipment, tools, and machinery which are safe and in good working order at all times.

2.1.1.1.3 Shotblasting Equipment

Use mobile self propelled shotblasting equipment capable of producing an adjustable depth of paint removal and of propelling abrasive particles at high velocities on the paint for effective removal. Ensure each unit is

self cleaning and self contained. Use equipment able to confine the abrasive, any dust that is produced, and removed paint and is capable of recycling the abrasive for reuse.

2.1.1.1.4 Grinding or Scarifying Equipment

Use equipment capable of removing surface contaminates, paint build-up, or extraneous markings from the pavement surface without leaving any residue. Clean the surface by hydro blast to remove surface contaminates and ash after a weed torch is used to remove paint.

2.1.1.1.5 Chemical Removal Equipment

Use chemical equipment capable of applying and removing chemicals and paint from the pavement surface, leaving only non-toxic biodegradable residue without scarring or other damage to the pavement or joints and joint seals.

2.1.2 Application Equipment

Submit application equipment list appropriate for the material(s) to be used. Include manufacturer's descriptive data and certification for the planned use that indicates area of coverage per pass, pressure adjustment range, tank and flow capacities, and all safety precautions required for operating and maintaining the equipment. Provide and maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition, or remove them from the work site. Provide mobile and maneuverable application equipment to the extent that straight lines can be followed and normal curves can be made in a true arc.

2.1.2.1 Paint Application Equipment

2.1.2.1.1 Hand-Operated, Push-Type Machines

Provide hand-operated push-type applicator machine of a type commonly used for application of water based paint or two-component, chemically curing paint, thermoplastic, or preformed tape, to pavement surfaces for small marking projects, such as legends and cross-walks, automotive parking areas, or surface painted signs. Provide applicator machine equipped with the necessary tanks and spraying nozzles capable of applying paint uniformly at coverage specified. Hand operated spray guns may be used in areas where push-type machines cannot be used.

2.1.2.1.2 Self-Propelled or Mobile-Drawn Spraying Machines

Provide self-propelled or mobile-drawn spraying machine with suitable arrangements of atomizing nozzles and controls to obtain the specified results. Provide machine having a speed during application capable of applying the stripe widths indicated at the paint coverage rate specified herein and of even uniform thickness with clear-cut edges.

2.1.2.1.2.1 Road Marking

Provide equipment used for marking roads capable of placing the prescribed number of lines at a single pass as solid lines, intermittent lines, or a combination of solid and intermittent lines using a maximum of three different colors of paint as specified.

2.1.2.1.2.2 Hand Application

Provide spray guns for hand application of paint in areas where the mobile paint applicator cannot be used.

2.1.2.2 Thermoplastic Application Equipment

2.1.2.2.1 Thermoplastic Material

Apply thermoplastic material with equipment that is capable of providing continuous uniformity in the dimensions and reflectorization of the marking.

2.1.2.2.2 Application Equipment

a. Provide application equipment capable of continuous mixing and agitation of the material, with conveying parts which prevent accumulation and clogging between the main material reservoir and the extrusion shoe or spray gun. All parts of the equipment which come into contact with the material must be easily accessible and exposed for cleaning and maintenance. All mixing and conveying parts up to and including the extrusion shoes and spray guns must maintain the material at the required temperature with heat-transfer oil or electrical-element-controlled heat.

b. Provide application equipment constructed to ensure continuous uniformity in the dimensions of the stripe. Provide an applicator with a means for cleanly cutting off stripe ends squarely and providing a method of applying "skiplines." Provide equipment capable of applying varying widths of traffic markings.

c. Provide mobile and maneuverable application equipment allowing straight lines to be followed and normal curves to be made in a true arc. Provide equipment used for the placement of thermoplastic pavement markings of two general types: mobile applicator and portable applicator.

d. Equip the applicator with a pressurized or drop-on type bead dispenser capable of uniformly dispensing reflective glass spheres at controlled rates of flow. The bead dispenser must operate automatically to begin flow prior to the flow of binder to assure that the strip is fully reflectorized.

2.1.2.2.3 Mobile Application Equipment

Provide a truck-mounted, self-contained pavement marking machine that is capable of hot applying thermoplastic by either the extrusion or spray method.

a. Equip the unit to apply the thermoplastic marking material at temperatures according to the manufacturer's instructions, at widths varying from 3 to 12 inches, with an automatic pressurized or drop-on bead dispensing system, capable of operating continuously, and of installing a minimum of 20,000 lineal feet of longitudinal markings in an 8-hour day.

b. Equip the mobile unit with a melting kettle which holds a minimum of 6000 pounds of molten thermoplastic material; capable of heating the thermoplastic composition to temperatures as recommended by the manufacturer. Use a thermostatically controlled heat transfer liquid.

Heating of the composition by direct flame is not allowed. Oil and material temperature gauges must be visible at both ends of the kettle.

c. Equip mobile units for application of extruded markings with a minimum of two extrusion shoes; located one on each side of the truck, capable of marking simultaneous edge line and centerline stripes; each being a closed, oil-jacketed unit; holding the molten thermoplastic at a temperature as recommended by the manufacturer; and capable of extruding a line of 3 to 8 inches in width; and at a thickness of not less than 0.120 inch nor more than 0.190 inch, of generally uniform cross section.

d. Equip mobile units for application of spray markings with a spray gun system capable of marking simultaneous edgeline and centerline stripes. Surround (jacket) the spray system with heating oil to maintain the molten thermoplastic at a temperature of 375 to 425 degrees F, capable of spraying a stripe of 3 to 12 inches in width, and in thicknesses varying from 0.060 inch to 0.098 inch, of generally uniform cross section.

e. Equip the mobile unit with an electronic programmable line pattern control system, capable of applying skip or solid lines in any sequence, through any and all of the extrusion shoes, or the spray guns, and in programmable cycle lengths. In addition, equip the mobile unit with an automatic counting mechanism capable of recording the number of lineal feet of thermoplastic markings applied to the pavement surface with an accuracy of 0.5 percent.

2.1.2.2.4 Portable Application Equipment

Provide portable hand-operated equipment, specifically designed for placing special markings such as crosswalks, stop bars, legends, arrows, and short lengths of lane, edge and centerlines; and capable of applying thermoplastic pavement markings by the extrusion method. Equip the portable applicator with all the necessary components, including a materials storage reservoir, bead dispenser, extrusion shoe, and heating accessories, capable of holding the molten thermoplastic at the temperature recommended by the manufacturer, and of extruding a line of 3 to 12 inches in width, and in thickness of not less than 0.120 inch nor more than 0.190 inch and of generally uniform cross section.

2.1.2.3 Reflective Media Dispenser

Attach the dispenser for applying the reflective media to the thermoplastic dispenser and designed to operate automatically and simultaneously with the applicator through the same control mechanism. The bead applicator must be capable of adjustment and designed to provide uniform flow of reflective media over the full length and width of the stripe at the rate of coverage specified in paragraph APPLICATION.

2.1.2.4 Preformed Tape Application Equipment

Provide and use mechanical application equipment for the placement of preformed marking tape which is a mobile pavement marking machine specifically designed for use in applying pressure-sensitive pavement marking tape of varying widths. Equip the applicator with rollers, or other suitable compaction device to provide initial adhesion of the material with the pavement surface. Use additional tools and devices as needed to properly seat the applied material as recommended by the manufacturer.

## 2.2 MATERIALS

Use thermoplastic and raised pavement markers for roads. The maximum allowable VOC content of pavement markings is 150 grams per liter. Color of markings are indicated on the drawings and must conform to ASTM D6628 for roads and automotive parking areas and SAE AMS-STD-595A for airfields. Provide materials conforming to the requirements specified herein.

### 2.2.1 Methacrylate Paint

Formulate methacrylate paint to meet the requirements of FAA AC 150/5370-10, Item P-620.2, Methacrylate.

### 2.2.2 Epoxy Paint

#### 2.2.2.1 Formulation

Epoxy pavement marking material will be a two component, 100 percent solids, material formulated to provide simple volumetric mixing ratio of two volumes of component A and one volume of component B unless otherwise recommended by the manufacturer.

#### 2.2.2.2 Composition

The component A of both white and yellow must be within the following limits:

Table 1

| | White | Yellow |
|---|---|---|
| Pigments | Minimum 18 percent by weight Titanium Dioxide (ASTM D476, Type II) | 21-27 percent by weight |
| Epoxy Resin | 75-82 percent | 73-79 percent |

The epoxy resin must be free of lead, cadmium, mercury, hexavalent chromium and other toxic heavy metals as defined by the Environmental Protection Agency. Submit a manufacturer's certification of compliance with this requirement.

#### 2.2.2.3 Epoxide Value

Determine epoxide epoxy number of the epoxy resin in accordance with ASTM D1652 for white and yellow component A on pigment free basis. The epoxide number must be within plus or minus 50 of the published manufacturer's standard.

#### 2.2.2.4 Total Amine Value

Determine the amine number on the curing agent (component B) in accordance with ASTM D2074. The amine number must be within plus or minus 50 of the published manufacturer's standard.

2.2.2.5 Toxicity

Upon heating to application temperature, the material must not produce fumes which are toxic or injurious to persons or property.

2.2.2.6 Daylight Directional Reflectance

Directional reflectance of white and yellow paint (without glass beads) in accordance with ASTM E1347: White 84 percent Yellow 55 percent.

2.2.2.7 Laboratory Drying Time

The epoxy pavement marking material must have a maximum no-pick-up time of 30 minutes when tested in accordance with ASTM D711.

2.2.2.8 Curing

The epoxy material must be capable of fully curing under a constant surface temperature of 45 Degrees F or above.

2.2.2.9 Adhesion to Concrete

The catalyzed epoxy pavement marking material must have a high degree of adhesion to the specified concrete surface (100 percent concrete failure) when tested according to ASTM D7234. The concrete substrate must have a minimum compressive strength of 4,000 psi. Condition prepared specimens at a temperature of 75 plus or minus 2 Degrees F for a minimum of 24 hours and a maximum of 72 hours prior to performance of the test.

2.2.2.10 Hardness

Epoxy pavement marking materials must have a Shore D Hardness between 75 and 100 when tested in accordance with ASTM D2240. Cure the samples at 75 plus or minus 2 Degrees F for a minimum of 72 hours and a maximum of 96 hours prior to performing the tests.

2.2.2.11 Abrasion Resistance

The wear index for a catalyzed sample must not exceed 82 when tested in accordance with ASTM D4060 using a 1000 gram load, CS-17 wheels and a test duration of 1000 cycles. Run the test on cured samples of material which have been applied at a film thickness of 15 plus or minus 0.5 mils to code S-16 stainless steel plates. Cure the samples at 75 plus or minus 2 Degrees F for a minimum of 48 hours prior to performing the tests.

2.2.2.12 Tensile Strength

Epoxy pavement marking materials must have a tensile strength of at least 6,000 psi when tested in accordance with ASTM D638. Cast the Type IV specimens in a suitable mold and pull at the rate of 1/4 inch per minute using a suitable dynamic testing machine. Cure the samples at 75 plus or minus 2 Degrees F for a minimum of 12 hours and a maximum of 48 hours prior to performing the tests.

2.2.2.13 Compressive Strength

Catalyzed epoxy pavement marking materials must have a compressive strength of at least 12,000 psi when tested in accordance with ASTM D695. Condition the cast sample at 75 plus or minus 2 Degrees F for a minimum of 12 hours

and a maximum of 48 hours prior to performing the tests. The rate of compression of these samples must not exceed 1/4 inch per minute.

2.2.3 Thermoplastic Compound

2.2.3.1 Composition Requirements

Thermoplastic compound must conform to AASHTO M 249. Formulate the binder component as an alkyd resin.

2.2.3.2 Primer

a. Asphalt concrete primer: Provide thermosetting adhesive primer with a solids content of pigment reinforced synthetic rubber and synthetic plastic resin dissolved or dispersed in a volatile organic solvent for asphaltic concrete pavements. The solids content must not be less than 10 percent by weight at 70 degrees F and 60 percent relative humidity. A wet film thickness of 0.005 inch, plus or minus 0.001 inch, must dry to a tack-free condition in less than 5 minutes.

b. Portland cement concrete primer: Provide an epoxy resin primer for Portland cement concrete pavements, of the type recommended by the manufacturer of the thermoplastic composition.

2.2.4 High Build Acrylic Coating (HBAC)

Formulate High Build Acrylic Coating (HBAC) to meet the requirements of Table 2.

Table 2. REQUIREMENTS FOR HIGH BUILD ACRYLIC COATINGS (HBAC)

| TEST | MINIMUM REQUIREMENT (AND MAXIMUM WHERE INDICATED) |
|---|---|
| Resin System (ASTM D2621) | Waterborne 100 percent Acrylic |
| Percent Volume Solids (ASTM D2697) | 58 percent |
| Volatile Organic Compound, max.( ASTM D3960) | 1.25 lbs/gal |
| White (SAE AMS-STD-595A) | 37925 |
| Yellow (SAE AMS-STD-595A) | 33538 |
| Shore D Hardness (ASTM D2240) | 45 |
| 1/8 inch Mandrel Bend at 5 mils Dry Film Thickness (DFT, one-week cure (ASTM D522/D522M, Method B) | No visual defects at bend (Conditions at ASTM D3924) |
| Adhesion to Concrete and Asphaltic Pavements (ASTM D4541) | 140 psi or 100 percent cohesive failure in pavement |

| Table 2. REQUIREMENTS FOR HIGH BUILD ACRYLIC COATINGS (HBAC) | |
|---|---|
| TEST | MINIMUM REQUIREMENT (AND MAXIMUM WHERE INDICATED) |
| Accelerated Weathering, Yellow, 2500 Hours UV Exposure (ASTM G154: see note 1) | Max. color loss to 33655 (SAE AMS-STD-595A) |
| Water Absorption at 168 Hours Immersion Tap Water (ASTM D471) | 9.0 percent max. weight increase (conditions at ASTM D3924) |
| Application at 65 mils Wet,One Coat, One-week Cure, (see note 2) | No visual cracking or curling (conditions at ASTM D3924) |
| No Pick-Up at 25 mils (ASTM D711) | Wet 10 minutes max. |
| Lead (ASTM D3335) | 0.06 percent max. |
| Cadmium (ASTM D3335) | 0.06 percent max. |
| Chromium (ASTM D3718) | 0.00 percent |
| Notes: | |
| (1) Properly mix and apply yellow paint at 10 mils plus or minus 2 mils DFT over a suitably sized, clean aluminum substrate (ASTM D823 ), and cure for a minimum of 48 hours: prepare four individual yellow samples. Expose three samples to continuous Ultraviolet (UV) light for 2500 hours, without cycles condensation, in accordance to ASTM G154: use UVA-340 lamps in the testing apparatus. Following exposure, compare the three exposed samples to the "one" non-exposed sample using SAE AMS-STD-595A colors 33538 and 33655 as visual references: evaluate exposed samples for degree of visual color loss. Yellow paint is rated as passing if each exposed sample appears equivalent to the non-exposed sample, and in addition, displays color loss no greater than SAE AMS-STD-595A color 33655. | |
| (2) Using double-stick, foam mounting tape (or equal) with a nominal thickness of 65 mils, apply a rectangular mold with inner dimensions of 3 in by 10 in to a clean aluminum sample approximately sized at 6 in by 12 in by 1/8 in. Do not remove the tape's plastic backing. Mix and apply excess paint into mold. Remove excess paint, by squeegee or other appropriate draw down technique, to a uniform thickness equal to the tape's height. Perform paint application and draw down within a period of no more than 60 seconds. Approximately one to two minutes following the draw down, remove tape from sample and allow coating to cure for a minimum period of one week ASTM D3924. Using a micrometer or other appropriate device, measure cured coating thickness (less sample thickness) to confirm resulting coating application was at or above 38 mils DFT. Inspect coating for visual signs of cracking and curling. Following a one week cure, the coating is rated as passing if applied greater than 38 mils DFT and visually free of both cracking and curling. | |

2.2.5 Preformed Tape

Provide adherent reflectorized strip preformed tape in accordance with

ASTM D4505 Retroreflectivity Level II, Class 1, 2 or 3, Skid Resistance Level B.

2.2.6 Raised Pavement Markers Primers and Adhesives

Use either metallic or nonmetallic markers of the button or prismatic reflector type. Provide permanent color markers as specified for pavement marking, which retain the color and brightness under the action of traffic. Provide button markers with a diameter of not less than 4 inches, spaced not more than 40 feet apart on solid longitudinal lines. Make broken centerline marker spacing in segments of 10 feet indicated with gaps of 30 feet between segments. Provide button markers with rounded surfaces presenting a smooth contour to traffic and not projecting more than 3/4 inch above level of pavement. Provide nonplowable pavement markers and adhesive epoxy conforming to ASTM D4280.

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Testing for Moisture

Test the pavement surface for moisture before beginning pavement marking after each period of rainfall, fog, high humidity, or cleaning, or when the ambient temperature has fallen below the dew point. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Owner or authorized representative.

Employ the "plastic wrap method" to test the pavement for moisture as follows: Cover the pavement with a 12 inch by 12 inch section of clear plastic wrap and seal the edges with tape. After 15 minutes, examine the plastic wrap for any visible moisture accumulation inside the plastic. Do not begin marking operations until the test can be performed with no visible moisture accumulation inside the plastic wrap. Re-test surfaces when work has been stopped due to rain.

3.1.2 Surface Preparation Demonstration

Prior to surface preparation, demonstrate the proposed procedures and equipment. Prepare areas large enough to determine cleanliness, and adhesion of remaining coating and rate of cleaning. Perform a demonstration removal of pavement marking in an area designated by the Owner. Approved demonstration area establishes the standard for the remainder of the work.

3.1.3 Test Stripe Demonstration

Prior to paint application, demonstrate test stripe application within the work area using the proposed materials and equipment. Apply separate test stripes in each of the line widths and configurations required herein using the proposed equipment. Make the test stripes long enough to determine the proper speed and operating pressures for the vehicle(s) and machinery, but not less than 50 feet long.

3.1.4 Application Rate Demonstration

During the Test Stripe Demonstration, demonstrate compliance with the application rates specified herein. Document the equipment speed and operating pressures required to meet the specified rates in each configuration of the equipment and provide a copy of the documentation to

the Owner prior to proceeding with the work.

3.1.5 Retroreflective Value Demonstration

After the test stripes have cured to a "no-track" condition, demonstrate compliance with the average retroreflective values specified herein. Take a minimum of ten readings on each test stripe with a Retroreflectometer with a direct readout in millicandelas per square meter per lux (mcd/m2/lx). Perform testing in accordance with ASTM D4061, ASTM E1710, ASTM E2177, and ASTM E2302.

3.1.6 Level of Performance Demonstration

The Owner will be present at the application demonstrations to observe the results obtained and to validate the operating parameters of the vehicle(s) and equipment. If accepted by the Owner, the test stripe is the measure of performance required for this project. Do not proceed with the work until the demonstration results are satisfactory to the Owner.

3.2 EXTERIOR SURFACE PREPARATION

Allow new pavement surfaces to cure for a period of not less than 30 days before application of marking materials. Thoroughly clean surfaces to be marked before application of the paint. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods as required.

a. For Portland Cement Concrete pavement, grinding, light shot blasting, or light scarification, to a resulting profile equal to ICRI 03732 CSP 2, CSP 3, and CSP 4, respectively, can be used in addition to water blasting on most pavements, to either remove existing coatings, or for surface preparation.

b. Do not use shot blasting on airfield pavements due to the potential of Foreign Object Damage (FOD) to aircraft. Scrub affected areas, where oil or grease is present on old pavements to be marked, with several applications of trisodium phosphate solution or other approved detergent or degreaser and rinse thoroughly after each application. After cleaning oil-soaked areas, seal with shellac or primer recommended by the manufacturer to prevent bleeding through the new paint. Do not commence painting in any area until pavement surfaces are dry and clean.

3.2.1 Early Painting of Rigid Pavements

Pretreat rigid pavements that require early painting with an aqueous solution containing 3 percent phosphoric acid and 2 percent zinc chloride. Apply the solution to the areas to be marked.

3.2.2 Early Painting of Asphalt Pavements

For asphalt pavement systems requiring painting application at less than 30 days, apply the paint and beads at half the normal application rate, followed by a second application at the normal rate after 30 days.

3.3 APPLICATION

Apply pavement markings to dry pavements only.

3.3.1 Paint

Apply paint with approved equipment at rate of coverage specified herein. Provide guidelines and templates as necessary to control paint application. Take special precautions in marking numbers, letters, and symbols. Manually paint numbers, letters, and symbols. Sharply outline all edges of markings. The maximum drying time requirements of the paint specifications will be strictly enforced, to prevent undue softening of bitumen, and pickup, displacement, or discoloration by tires of traffic. If there is a deficiency in drying of the markings, painting operations must cease until the cause of the slow drying is determined and corrected.

3.3.1.1 Waterborne Paint

3.3.1.1.1 Roads

Apply paint at a rate of 105 plus or minus 5 square feet per gallon. Apply AASHTO M 247 Type 1 beads at a rate of 7 plus or minus 0.5 pounds of glass spheres per gallon.

3.3.1.2 Solventborne Paint

Apply paint at a minimum wet film thickness of 15 mils. Apply AASHTO M 247 Type 1 beads at a minimum rate of 6 pounds of glass spheres per gallon.

3.3.1.3 Methacrylate Paint

Apply paint evenly to the pavement surface at a maximum rate of 45 square feet per gallon. Apply glass spheres conforming to FS TT-B-1325 uniformly to the wet paint on airfield pavement. Use either Type I (Gradation A), Type III, or Type IV (Gradation A or B) beads. Apply Type I (Gradation A) beads at a minimum rate of 15 pounds of glass spheres per gallon. Apply Type III beads at a minimum rate of 20 pounds of glass spheres per gallon. Apply Type IV (Gradation A or B) beads at a minimum rate of 16 pounds of glass spheres per gallon.

3.3.1.4 Epoxy Paint

Apply paint evenly to the pavement surface at a wet film thickness of 20 mils plus or minus 1 mil to cover 80 plus or minus 4 square feet per gallon. Apply glass spheres uniformly to the wet paint on road and street pavement at a rate of 7 plus or minus 0.5 pounds of glass spheres per gallon.

3.3.1.5 High Build Acrylic Coating

Apply High Build Acrylic Coating (HBAC) at a rate of 50 square feet per gallon. Apply Type IV (Gradation A) beads at a minimum rate of 16 pounds of glass spheres per gallon.

3.3.2 Thermoplastic Compound

Place thermoplastic pavement markings, free from dirt or tint, upon dry pavement. The temperature must be a minimum of 40 degrees F and rising at the time of installation. Apply all centerline, skipline, edgeline, and other longitudinal type markings with a mobile applicator. Place all special markings, crosswalks, stop bars, legends, arrows, and similar patterns with a portable applicator, using the extrusion method.

3.3.2.1 Primer

After surface preparation has been completed, prime the asphalt or concrete pavement surface with spray equipment. Allow primer materials to "set-up" prior to applying the thermoplastic composition. Allow the asphalt concrete primer to dry to a tack-free condition, usually occurring in less than 10 minutes. Allow the Portland cement concrete primer to dry in accordance with the thermoplastic manufacturer recommendations. To shorten the curing time of the epoxy resins, an infrared heating device may be used on the concrete primer. Apply asphalt concrete primer to all asphalt concrete pavements at a wet film thickness of 0.005 inch, plus or minus 0.001 inch (265 to 400 square feet per gallon). Apply Portland cement concrete primer to all concrete pavements (including concrete bridge decks) at a wet film thickness of between 0.04 to 0.05 inch 320 to 400 square feet per gallon.

After the primer has "set-up", apply the thermoplastic at temperatures no lower than 375 degrees F nor higher than 425 degrees F at the point of deposition. Apply all extruded thermoplastic markings at the specified width and at a thickness of not less than 0.125 inch nor more than 0.190 inch. Apply all sprayed thermoplastic markings at the specified width and the thickness designated in the contract plans. If the plans do not specify a thickness, apply centerline markings at a wet thickness of 0.090 inch, plus or minus 0.005 inch, and edgeline markings at a wet thickness of 0.060 inch, plus or minus 0.005 inch.

Extrude or spray thermoplastic reflectorized pavement marking compound in a molten state onto a primed pavement surface. Following a surface application of glass beads and upon cooling to normal pavement temperatures, the marking must be an adherent reflectorized strip of the specified thickness and width that is capable of resisting deformation by traffic.

3.3.2.2 Reflective Media

Immediately after installation of the thermoplastic material, mechanically apply drop-on reflective glass spheres conforming to AASHTO M 247 Type 1 at the rate of one pound per 20 square feet such that the spheres are held by and imbedded in the surface of the molten material. Accomplish drop-on application of the glass spheres to ensure even distribution at the specified rate of coverage. If there is a malfunction of either thermoplastic applicator or reflective media dispenser, discontinue operations until deficiency is corrected.

3.3.3 Raised Pavement Markers

Align prefabricated markers carefully at the spacing indicated on the drawings and permanently fix in place by means of epoxy adhesives. To ensure good bond prior to applying adhesive, thoroughly clean all areas where markers are to be set by water blasting and use of compressed air.

3.3.4 Preformed Tape

The pavement surface and ambient air temperature must be a minimum of 60 degrees F and rising. Place the preformed markings in accordance with the manufacturer's written instructions.

3.3.5 Cleanup and Waste Disposal

Keep the worksite clean and free of debris and waste from the removal and

application operations. Dispose of debris at approved sites.

## 3.4 FIELD QUALITY CONTROL

### 3.4.1 Sampling and Testing

As soon as the paint and thermoplastic materials are available for sampling, obtain by random selection from the sealed containers, four quart samples of each batch in the presence of the Owner. Two quarts will be for sampling and testing by the Contractor and two quarts will be for retention by the Owner. Accomplish adequate mixing prior to sampling to ensure a uniform, representative sample. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by number on the label. Clearly identify samples by designated name, specification number, batch number, project contract number, intended use, and quantity involved.

Test samples by an approved laboratory. If a sample fails to meet specification, replace the material in the area represented by the samples and retest the replacement material as specified above. Submit certified copies of the test reports, prior to the use of the materials at the jobsite. Include in the report of test results a listing of any specification requirements not verified by the test laboratory. At the discretion of the Owner, samples provided may be tested by the Owner for verification.

### 3.4.2 Material Inspection

Examine material at the job site to determine that it is the material referenced in the report of test results or certificate of compliance. Provide test results substantiating conformance to the specified requirements with each certificate of compliance.

### 3.4.3 Dimensional Tolerances

Apply all markings in the standard dimensions provide in the drawings. New markings may deviate a maximum of 10 percent larger than the standard dimension. The maximum deviation allowed when painting over an old marking is up to 20 percent larger than the standard dimensions.

### 3.4.4 Bond Failure Verification

Inspect newly applied markings for signs of bond failure based on visual inspection and comparison to results from Test Stripe Demonstration paragraph.

### 3.4.5 Reflective Media and Coating Application Verification

Use a wet film thickness gauge to measure the application of wet paint. Use a microscope or magnifying glass to evaluate the embedment of glass beads in the paint. Verify the glass bead embedment with approximately 50 percent of the individual bead spheres embedded and 50 percent of the individual bead spheres exposed.

### 3.4.6 Retroreflective Markings

Collect and record readings for white and yellow retroreflective markings at the rate of one reading per 1000 linear feet. The minimum acceptable average for white markings is 200 millicandelas per square meter per lux

(mcd/m2/lx) (measured with Retroreflectometer). The minimum acceptable average for yellow markings is 175 millicandelas per square meter per lux (mcd/m2/lx). Compute readings by averaging a minimum of 10 readings taken within the area at random locations. Re-mark areas not meeting the retroreflective requirements stated above.

3.4.7 Material Bond Verification and Operations Area Cleanup for Airfields

Vacuum sweep the aircraft operating area before it is opened for aircraft operations to preclude potential foreign object damaged to aircraft engines. Visually inspect the pavement markings and the material captured by the vacuum. Verify that no significant loss of reflective media has occurred to the pavement marking due to the vacuum cleaning.

-- End of Section --

SECTION 33 40 00

STORMWATER UTILITIES

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Pipe Culverts and Storm Drains

The length of pipe installed will be measured along the centerlines of the pipe from end to end of pipe without deductions for diameter of manholes. Pipe will be paid for at the contract unit price for the number of linear feet of culverts or storm drains placed in the accepted work.

1.1.2 Box Culverts

The length of box culvert installed will be measured along the centerline of the box from end to end of the box culvert. Box Culvert will be paid for at the contract unit price for the number of linear feet of box culverts placed in the accepted work.

1.1.3 Storm Drainage Structures

The quantity of manholes and inlets will be measured as the total number of manholes and inlets of the various types of construction, complete with frames and gratings or covers and, where indicated, with fixed side-rail ladders. The depth of manholes and inlets will be measured from the top of grating or cover to invert of outlet pipe.

1.1.4 Walls and Headwalls

Walls and headwalls will be measured by the number of cubic yards of reinforced concrete, plain concrete, or masonry used in the construction of the walls and headwalls. Wall and headwalls will be paid for at the contract unit price for the number of walls and headwalls constructed in the completed work.

1.1.5 Flared End Sections

Flared end sections will be measured by the unit. Flared end sections will be paid for at the contract unit price for the various sizes in the accepted work.

1.1.6 Sheeting and Bracing

Payment will be made for that sheeting and bracing ordered to be left in place, based on the number of square feet of sheeting and bracing remaining below the surface of the ground.

1.1.7 Rock Excavation

Payment will be made for the number of cubic yards of material acceptably excavated, as specified and defined as rock excavation in Section 31 23 00.00 20 EXCAVATION AND FILL, measured in the original position, and computed by allowing actual width of rock excavation with the following limitations: maximum rock excavation width, 30 inches for pipe of 12 inch

or less nominal diameter; maximum rock excavation width, 16 inches greater than outside diameter of pipe of more than 12 inch nominal diameter. Measurement will include authorized overdepth excavation. Payment will also include all necessary drilling and blasting, and all incidentals necessary for satisfactory excavation and disposal of authorized rock excavation. No separate payment will be made for backfill material required to replace rock excavation; include this cost in the unit price bid per cubic yard for rock excavation. In rock excavation for manholes and other appurtenances, 1 foot will be allowed outside the wall lines of the structures.

1.1.8 Backfill Replacing Unstable Material

Payment will be made for the number of cubic yards of select granular material required to replace unstable material for foundations under pipes or drainage structures, which will constitute full compensation for this backfill material, including removal and disposal of unstable material and all excavating, hauling, placing, compacting, and all incidentals necessary to complete the construction of the foundation satisfactorily.

1.1.9 Concrete Ditch Lining

Payment will be made for the number of linear feet of concrete ditch lining including any steel reinforcing accepted in the completed work measured along the centerline of the ditch.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

| | |
|---|---|
| AASHTO HB-17 | (2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges |
| AASHTO M 43 | (2005; R 2018) Standard Specification for Sizes of Aggregate for Road and Bridge Construction |
| AASHTO M 167M/M 167 | (2017; R 2021) Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches |
| AASHTO M 190 | (2004; R 2019) Standard Specification for Asphalt-Coated Corrugated Metal Culvert Pipe and Pipe Arches |
| AASHTO M 243 | (1996; R 2021) Standard Specification for Field-Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches |
| AASHTO M 288 | (2021) Standard Specification for Geosynthetic Specification for Highway Applications |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A48/A48M | (2003; R 2021) Standard Specification for Gray Iron Castings |
| ASTM A536 | (1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings |
| ASTM A760/A760M | (2015, R 2020) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains |
| ASTM A798/A798M | (2017) Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications |
| ASTM A807/A807M | (2019) Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications |
| ASTM A929/A929M | (2018) Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe |
| ASTM B26/B26M | (2018; E 2018) Standard Specification for Aluminum-Alloy Sand Castings |
| ASTM C12 | (2021) Standard Practice for Installing Vitrified Clay Pipe Lines |
| ASTM C32 | (2013; R 2017) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale) |
| ASTM C55 | (2017) Standard Specification for Concrete Building Brick |
| ASTM C62 | (2017) Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale) |
| ASTM C76 | (2020) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe |
| ASTM C76M | (2020) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric) |
| ASTM C139 | (2017) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes |
| ASTM C231/C231M | (2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method |
| ASTM C270 | (2019a; E 2019) Standard Specification for |

| | |
|---|---|
| | Mortar for Unit Masonry |
| ASTM C425 | (2021) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings |
| ASTM C478/C478M | (2020) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections |
| ASTM C655 | (2019a) Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe |
| ASTM C655M | (2019a) Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe (Metric) |
| ASTM C828 | (2011; R 2021) Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines |
| ASTM C923/C923M | (2020) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals |
| ASTM C1433M | (2018) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers (Metric) |
| ASTM D1751 | (2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types) |
| ASTM D1752 | (2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction |
| ASTM D2321 | (2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications |
| ASTM D2487 | (2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) |
| ASTM D3212 | (2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals |
| ASTM F1417 | (2011a; E 2020) Standard Practice for Installation Acceptance of Plastic Non-pressure Sewer Lines Using |

Low-Pressure Air

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Leakage Test

SD-07 Certificates

Hydrostatic Test on Watertight Joints

Frame and Cover or Gratings

SD-08 Manufacturer's Instructions

Placing Pipe and Box Culvert

SD-11 Closeout Submittals

Post-Installation Inspection Report

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Inspect materials delivered to site for damage and unload and store materials with minimumal handling. Do not store materials directly on the ground. Keep the inside of pipes and fittings free of dirt and debris. Before, during, and after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Owner. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe in accordance with the manufacturer's recommendations and discard if the storage period exceeds the recommended shelf life. Discard solvents in use when the recommended pot life is exceeded.

1.4.2 Handling

Handle materials in a manner that ensures delivery to the trench in sound, undamaged condition. Carry pipe to the trench.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe sizes for culverts and storm drains are indicated on the drawings.

2.1.1 Concrete Pipe

2.1.1.1 Reinforced Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C76M/ASTM C76, Class III or IV as indicated, or ASTM C655M/ASTM C655, D-Load as indicated.

2.1.2 Structural Plate, Steel Pipe, Pipe Arches and Arches

Assembled with galvanized steel nuts and bolts, from galvanized corrugated steel plates conforming to AASHTO M 167M/M 167. Provide pipe coating conforming to the requirements of AASHTO M 243.

2.2 PIPE JOINTS

Provide joints that have been tested for and meet the requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS.

2.2.1 Concrete Pipe

2.2.1.1 Rubber Gasket Joints

Provide rubber gasket joints of a design and physical requirements conforming to ASTM C443. Provide rubber gaskets that meet the oil resistant gasket requirements of ASTM C443M/ASTM C443.

2.2.1.2 Preformed Flexible Sealant Joints

Provide joints made with preformed flexible joint sealant conforming to ASTM C990.

2.3 PRECAST REINFORCED CONCRETE BOX CULVERT

Manufacture precast reinforced concrete box culverts in accordance with and conforming to ASTM C1433M/ASTM C1433.

2.4 UNDERGROUND STORMWATER RETENTION/DETENTION SYSTEM

Provide an underground stormwater retention/detention system that includes corrugated steel pipe as indicated. Provide foundation and embedment stone that is washed, crushed and angular conforming to AASHTO M 43 size 3, 357, 4, 467, 5, 56, or 57. Provide initial fill material conforming to AASHTO M 43 size 3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9 or 10. Provide geotextile conforming to AASHTO M 288.

2.5 MISCELLANEOUS MATERIALS

2.5.1 Concrete

Provide air content by volume of concrete mixture, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches. Determine air content in accordance with ASTM C231/C231M. Provide a minimum concrete covering over steel reinforcing of not less than 1 inch thick for covers and not less than 1-1/2 inches thick for walls and flooring. For concrete deposited directly against the ground, provide a covering thickness of at least 3 inches between steel and ground. Provide expansion-joint filler material conforming to ASTM D1751, or ASTM D1752, or provide be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.5.2 Mortar

Mortar is not allowed for pipe joints. Provide mortar for pipe connections to drainage structures conforming to ASTM C270, Type M, except that the

maximum placement time will be 1 hour. Provide a sufficient quantity of water in the mixture to produce a stiff workable mortar but in no case may the quantity exceed 5 gallons of water per sack of cement. Use water that is clean and free of harmful acids, alkalis, and organic impurities. Use the mortar within 30 minutes after the ingredients are mixed with water.

2.5.3 Precast Concrete Segmental Blocks

Provide precast concrete segmental block conforming to ASTM C139, not more than 8 inches thick, not less than 8 inches long, and of such shape that joints can be sealed effectively and bonded with cement mortar.

2.5.4 Brick

Provide brick conforming to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Provide mortar for jointing and plastering consisting of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. Provide joints that arecompletely filled and that are smooth and free from surplus mortar on the inside of the structure. Plaster brick structures with 1/2 inch of mortar over the entire outside surface of the walls. Lay brick in stretcher courses with a header course every sixth course for square or rectangular structures. Lay brick radially with every sixth course a stretcher course for round structures.

2.5.5 Precast Reinforced Concrete Manholes

Provide precast reinforced concrete manholes conforming to ASTM C478/C478M . Provide joints between precast concrete risers and tops that are made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph PIPE JOINTS.

2.5.6 Frame and Cover or Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load indicated on the drawings. Provide frame and cover or gratings made of cast gray iron, ASTM A48/A48M, Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26/B26M, Alloy 356.0-T6. Provide curb inlet grates conforming to the weight, shape, size, and waterway openings indicated on the plans. Stamp or cast the word "Storm Sewer" into covers so that it is plainly visible.

2.5.7 Resilient Connectors

Provide flexible, watertight connectors conforming to ASTM C923/C923M for connecting pipe to manholes and inlets.

2.5.8 Flared End Sections

2.5.8.1 Metal Flared End Sections

Provide sections of a standard design fabricated from zinc or aluminum (Type 2) coated steel sheets meeting requirements of ASTM A929/A929M.

2.5.8.2 Concrete Flared End Sections

Provide sections of a standard design fabricated with reinforced concrete.

2.5.9 Modular Trench Drains

Provide modular trench drains consisting of precast concrete sections. Provide trench with width and invert slope as indicated on the drawings. Provide trench drain sections and grates rated for DIN Class D.

2.5.9.1 Plastic Sections

Provide polyethylene, polypropylene, polyester, PVC or HDPE sections with UV inhibitors and interlocking tongue and groove joints. Provide channels with cast iron frames.

2.5.9.2 Precast Concrete Sections

Provide concrete sections made of fiber reinforced concrete or polyester polymer concrete with male/female connections between channel sections. Provide channels with or stainless steel edge rails.

2.5.9.3 Grates

Utilize galvanized steel trench grates. Attach trench grates to sections as recommended by the manufacturer.

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

2.6.1 Hydrostatic Test on Watertight Joints

Perform a hydrostatic test on the watertight joint types as proposed. This test will be conducted at the plant or by an independent laboratory. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested.

2.6.1.1 Concrete, Clay, PVC, PE, SRPE and PP Pipe

Provide joints in reinforced and nonreinforced concrete pipe meeting the performance requirements in ASTM C990M/ASTM C990 or ASTM C443M/ASTM C443. Provide joints in clay pipe meeting the test requirements in ASTM C425. Provide joints in PVC, PE, SRPE, and PP plastic pipe meeting the test requirements in ASTM D3212.

2.6.1.2 Corrugated Steel and Aluminum Pipe

Perform a hydrostatic pressure test on the proposed joining system in accordance with ASTM A760/A760M. The joining system must not leak when subjected to an internal hydrostatic pressure of 10 psi for a 10 minute period

PART 3 EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, BOX CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavate trenches, excavate for appurtenances and backfill for culverts and storm drains, in accordance with the applicable portions of Section 31 23 00.00 20 EXCAVATION AND FILL and the requirements specified below.

3.1.1 Trenching

Excavate trenches to the width indicated on the drawings or as specified herein. Trench width should permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Place sheeting and bracing, where required, within the trench width as specified, without any overexcavation.

3.1.2 Removal of Rock

Replace rock in either ledge or boulder formation with suitable materials to provide a compacted earth cushion. Provide a compacted earth cushion between unremoved rock and the pipe with a thickness of at least 8 inches or 1/2 inch for each foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Maintain the cushion under the bell as well as under the straight portion of the pipe where bell-and-spigot pipe is used. Provide a compacted earth cushion between unremoved rock and the box culvert of at least 8 inches in thickness for concrete box culverts. Excavate rock as specified and defined in Section 31 23 00.00 20 EXCAVATION AND FILL.

3.1.3 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe or box culvert is unexpectedly encountered in the bottom of a trench, remove such material to the depth required and replace with select granular material to the proper grade. Compact select granular material as specified in paragraph FINAL BACKFILL. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, perform such removal and replacement at no additional cost to the Owner.

3.2 BEDDING AND INITIAL BACKFILL

Provide a firm bedding foundation of uniform density throughout the entire length of the pipe or box culvert.

3.2.1 Concrete Pipe

Use select granular material conforming to Section 31 23 00.00 20 EXCAVATION AND FILL for haunch and bedding material. Compact haunch and outer bedding to at least 95 percent laboratory maximum density and place in layers not exceeding 6 inch loose thickness for compaction by hand-operated compactors and 200 mm 8 inches for other than hand-operated machines. Loosely place middle bedding and do not compact. After the pipe has been properly bedded, place haunch material, at a moisture content that will facilitate compaction, evenly along both sides of the pipe and thoroughly compact each layer with mechanical tampers or rammers to the springline of the pipe. Thoroughly compact the haunch material under the haunches of the pipe. For bell and spigot pipe, form a depression in bedding material for bells so entire barrel of pipe is uniformly supported. Minimize the length, depth, and width of bell depressions to that required for properly making the particular type of joint.

3.2.1.1 Trenches

After the pipe has been properly bedded and haunch material placed to the midpoint (springline) of the pipe, backfill and compact the remainder of the trench by spreading and rolling or compacting by mechanical rammers or

tampers in layers not exceeding 6 inches. Test for density as necessary to ensure conformance to the compaction requirements specified below. Leave untreated sheeting in place beneath structures or pavements.

3.2.1.2 Fill Sections

For pipe placed in fill sections, uniformly spread fill material longitudinally on both sides of the pipe in layers not exceeding 6 inches in compacted depth, and compact by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12 inches above the top of the pipe must extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet, whichever is less. After the backfill has reached at least 12 inches above the top of the pipe, place and thoroughly compact the remainder of the fill in layers not exceeding 8 inches.

3.2.2 Clay Pipe

Provide bedding for clay pipe as specified by ASTM C12.

3.2.3 Corrugated Steel and Aluminum Pipe

Provide bedding and structural backfill for corrugated steel and aluminum pipe and pipe arch in accordance with ASTM A798/A798M. It is not required to shape the bedding to the pipe geometry. However, for pipe arches, either shape the bedding to the relatively flat bottom arc or fine grade the foundation to a shallow v-shape. Structural backfill material consists of materials classified by ASTM D2487 as either GW, GM, GP-GM, GW-GM, GC, GP-GC or SW. Provide bedding for corrugated structural plate pipe meeting the requirements of ASTM A807/A807M.

3.2.4 Ductile Iron Pipe

Provide bedding for ductile iron pipe as shown on the drawings.

3.2.5 Plastic Pipe

Provide bedding for PVC, PE, SRPE and PP pipe meeting the requirements of ASTM D2321. Use Class IB or II material for PVC, PE, SRPE pipe bedding, haunching, and initial backfill. Use Class I, II, or III material for PP pipe bedding, haunching and initial backfill.

3.2.6 Precast Reinforced Box Culvert

Use granular material a minimum of 6 inches in depth for bedding precast concrete box culverts in trenches with soil foundation. Provide granular bedding in trenches with rock foundation that is 1/2 inch in depth per foot of depth of fill. The minimum depth of bedding will be 8 inch up to a maximum depth of 24 inches. Loosely place the granular bedding. Provide uniform support along the entire length of box culvert.

3.3 PLACING PIPE AND BOX CULVERT

Submit printed copies of the pipe or box culvert manufacturer's recommended pipe or box culvert installation procedures prior to installation. Thoroughly examine each section of pipe or box culvert before being laid; do not use defective or damaged pipe. Protect plastic pipe, excluding SRPE pipe, from exposure to direct sunlight prior to laying, if necessary to

maintain adequate pipe stiffness and meet installation deflection requirements. Lay pipelines to the grades and alignment indicated. Provide proper facilities for lowering sections of pipe into trenches. Place lifting lugs in vertically elongated corrugated steel or aluminum pipe in the same vertical plane as the major axis of the pipe. Do not lay pipe in water or when trench conditions or weather are unsuitable for such work. Divert drainage or dewater trenches during construction as necessary. Deflection of installed flexible pipe must not exceed the following limits:

| TYPE OF PIPE | MAXIMUM ALLOWABLE DEFLECTION (percent) |
|---|---|
| Corrugated Steel and Aluminum | 5 |
| Ductile Iron Culvert | 3 |
| Plastic (PVC, HDPE, SRPE, and pp) | 5 |

3.3.1 Concrete, Clay, PVC, Ribbed PVC, Ductile Iron Pipe

Lay pipe proceeding upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.2 Elliptical and Elliptical Reinforced Concrete Pipe

Place pipe so that the manufacturer's reference lines, designating the top of the pipe, are within 5 degrees of a vertical plane through the longitudinal axis of the pipe. Prevent damage to or misalignment of the pipe during backfilling operations.

3.3.3 PE, SRPE, and Dual Wall and Triple Wall PP Pipe

Lay on a bed shaped to line and grade and joint sections together in accordance with manufacturer's guidelines.

3.3.4 Corrugated Steel and Aluminum Pipe and Pipe Arch

Lay pipe with the separate sections joined firmly together, with the outside laps of circumferential joints pointing upstream, and with longitudinal laps on the sides. Install part paved pipe so that the centerline of bituminous pavement in the pipe, indicated by suitable markings on the top at each end of the pipe sections, coincides with the specified alignment of pipe. Provide fully paved steel pipe or pipe arch with the sheet thickness of the pipe or pipe arch painted or otherwise indicated on a label applied on the inside of the pipe or pipe arch. Coat any unprotected metal in the joints with bituminous material as specified in AASHTO M 190 or AASHTO M 243. Protect interior coating against damage from insertion or removal of struts or tie wires. Use lifting lugs to facilitate moving pipe without damage to exterior or interior coatings. Handle pipe or pipe arch and coupling bands during transportation and installation with care to preclude damage to the coating, paving or lining. Repair damaged coatings, pavings and linings in accordance with the manufacturer's recommendations prior to placing backfill. Remove and replace pipe on with coating, paving or lining that has been damaged to such an extent that satisfactory field repairs cannot be made. Accomplish vertical elongation, where indicated, in the factory. Provide suitable markings or properly placed lifting lugs to ensure placement of factory elongated pipe in a vertical plane.

3.3.5 Structural-Plate Steel

Install structural plate in accordance with ASTM A807/A807M. Assemble structural plate in accordance with instructions furnished by the manufacturer. Instructions must show the position of each plate and the order of assembly. Tighten bolts progressively and uniformly, starting at one end of the structure after all plates are in place. Repeat the operation to ensure that all bolts are tightened to meet the torque requirements of 200 foot-pounds plus or minus 50 foot-pounds. Check power wrenches used by the use of hand torque wrenches or long-handled socket or structural wrenches for amount of torque produced. Check and adjust power wrenches frequently as needed, according to type or condition, to ensure proper adjustment to supply the required torque.

3.3.6 Structural-Plate Aluminum

Assemble structural plate in accordance with instructions furnished by the manufacturer. Instructions must show the position of each plate and the order of assembly. Tighten bolts progressively and uniformly, starting at one end of the structure after all plates are in place. Repeat the operation to ensure that all bolts are torqued to a minimum of 100 foot-pounds on aluminum alloy bolts and a minimum of 150 foot-pounds on galvanized steel bolts. Check power wrenches used by the use of hand torque wrenches or long-handled socket or structural wrenches for the amount of torque produced. Check and adjust power wrenches as frequently as needed, according to type or condition, to ensure that they are in proper adjustment to supply the required torque.

3.3.7 Multiple Culverts

Where multiple lines of pipe are installed, adjacent sides of pipe must be at least half the nominal pipe diameter or 3 feet apart, whichever is less.

3.3.8 Precast Reinforced Concrete Box Culvert

Proceed upgrade with laying of sections and point tongue ends of tongue-and-groove box culvert section in the direction of flow.

3.4 JOINTING

3.4.1 Concrete and Clay Pipe

3.4.1.1 Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe and Box Culverts

Follow the recommendation of the particular manufacturer in regard to sealing compound special installation requirements. When lubricants, primers, or adhesives are used, only apply on surfaces that are dry and clean. Affix sealing compounds to the pipe or box culvert not more than 3 hours prior to installation of the pipe or box culvert. Protect sealing compounds from the sun, blowing dust, and other deleterious agents at all times. Inspect sealing compounds before installation of the pipe or box culvert, and remove and replace any loose or improperly affixed sealing compound. Align the pipe or box culvert with the previously installed pipe or box culvert, and pull the joint together.

3.4.1.2 Flexible Watertight Joints

Use lubricants, cements, adhesives, and other special installation requirements for gaskets and jointing materials as recommended by the manufacturer. When lubricants, cements, or adhesives are used, only apply on surfaces that are clean and dry. Affix gaskets and jointing materials to the pipe not more than 24 hours prior to the installation of the pipe, and protect from the sun, blowing dust, and other deleterious agents at all times. Inspect gaskets and jointing materials before installing the pipe; remove and replace any loose or improperly affixed gaskets and jointing materials. Align the pipe with the previously installed pipe, and push the joint home. If the gasket becomes visibly dislocated when joining sections of pipe, remove the pipe and remake the joint.

3.4.2 Corrugated Steel and Aluminum Pipe

3.4.2.1 Field Joints

Provide transverse field joints designed so that the successive connection of pipe sections will form a continuous line free of appreciable irregularities in the flow line. Provide joints meeting the general performance requirements described in ASTM A798/A798M. Suitable transverse field joints which satisfy the requirements for one or more of the joint performance categories can be obtained with the following types of connecting bands furnished with suitable band-end fastening devices: corrugated bands, bands with projections, flat bands, and bands of special design that engage factory reformed ends of corrugated pipe. Keep the space between the pipe and connecting bands free from dirt and grit so that corrugations fit snugly. While being tightened, tap the connecting band with a soft-head mallet of wood, rubber or plastic, to take up slack and ensure a tight joint. Fill the annular space between abutting sections of part paved, and fully paved pipe and pipe arch, in sizes 30 inches or larger, with a bituminous material after jointing. Provide field joints for each type of corrugated metal pipe that maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installations. Provide bands of the type, size, and sheet thickness indicated. Provide angles or lugs and bolts of the size indicated. Provide bands and angles or lugs and bolts as specified in the applicable standards or specifications for the pipe.

3.4.2.2 Flexible Watertight, Gasketed Joints

Use lubricants or cements and other special installation requirements as recommended by the gasket manufacturer. Where sleeve type gaskets are used, place the gasket over one end of a section of pipe for half the width of the gasket. Then double over the other half over the end of the same pipe. When the adjoining section of pipe is in place, roll the doubled-over half of the gasket over the adjoining section. Correct any unevenness in overlap so that the gasket covers the end of pipe sections equally. Center connecting bands over adjoining sections of pipe, and place rods or bolts in position and tighten nuts. Band Tightening: Tighten the band evenly, keep even tension on the rods or bolts, and the gasket; properly seat the gasket in the corrugations. Keep watertight joints uncovered for a period of time designated by the Owner. Before covering joints, measure the tightness of the nuts with a torque wrench. If the nut has tended to loosen its grip on the bolts or rods, retighten the nut with a torque wrench and keep uncovered until a tight, permanent joint is assured.

## 3.5 DRAINAGE STRUCTURES

### 3.5.1 Manholes and Inlets

Construct manholes of precast reinforced concrete. Construct inlets of precast or cast in place reinforced concrete. Provide manholes and inlets complete with frames and covers or gratings; and with fixed galvanized steel ladders as indicated. The wall along the line where steel ladders are installed must be vertical for its entire length. Adequately anchor ladders to the wall by means of steel inserts spaced not more than 6 feet vertically, and install to provide at least 6 inches of space between the wall and the rungs. Make pipe connections to concrete manholes and inlets with flexible, watertight connectors.

## 3.6 UNDERGROUND STORMWATER RETENTION/DETENTION SYSTEM

Install pipe and collection chambers as recommended by the manufacturer. Place foundation and embedment stone as recommended by the manufacturer of the pipe. Begin compaction of initial fill after 12 inches of material have been placed over the pipe. Compact initial fill in 6 inch thick layers to 90 percent maximum density. Use roller with a gross vehicle weight not exceeding 12,000 lbs and a dynamic force not exceeding 20,000 lbs.

## 3.7 FINAL BACKFILL

Backfill trenches with satisfactory material deposited in layers of a maximum of 8 inches loose thickness and compacted to 90 percent of maximum density for cohesive soils and 95 percent of maximum density for cohesionless soils in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL. Testing is the responsibility of the Contractor and will be performed at no additional cost to the Owner. Unless otherwise specified, determine field in-place density of final backfill at a frequency of one test per 50 linear feet, or fraction thereof, of each lift of backfill. Submit test results in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL. Do not displace or damage pipe or box when compacting final backfill by rolling or operating heavy equipment parallel with the pipe or box. Movement of construction machinery over a culvert or storm drain at any stage of construction will be at the Contractor's risk. Repair or replace any damaged pipe. Protect concrete pipes with a minimum of 3 feet of cover prior to permitting heavy construction equipment to pass over them during construction. Provide the minimum cover for construction loads over corrugated steel pipes as specified in Section 26, Division II of AASHTO HB-17. Provide minimum cover for construction loads over plastic pipes as specified in ASTM D2321.

## 3.8 FIELD QUALITY CONTROL

### 3.8.1 Tests

Testing is the responsibility of the Contractor. Perform all testing and retesting at no additional cost to the Owner.

#### 3.8.1.1 Leakage Test

Test pipe lines for leakage prior to completing backfill by performing either an exfiltration test, low pressure air pipeline test or by individual pipe joint testing. Submit leakage test results to the Owner.

3.8.1.1.1 Exfiltration Test

Prior to exfiltration tests, backfill the trench up to at least the lower half of the pipe. If required, place sufficient additional backfill to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. When the water table is 2 feet or more above the top of the pipe at the upper end of the pipeline section to be tested, measure infiltration using a suitable weir or other device acceptable to the Owner. Perform exfiltration test by filling the line to be tested with water so that a head of at least 2 feet is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. Allow the filled line to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, reestablish the head. Measure the amount of water required to maintain this water level during a 2-hour test period. Leakage as measured by the exfiltration test must not exceed 0.2 gallons per inch in diameter per 100 feet of pipeline per hour. Correct visible leaks encountered regardless of leakage test results.

3.8.1.1.2 Low Pressure Air Pipeline Tests

Perform low pressure air testing for vitrified clay pipes in accordance with ASTM C828. Perform low pressure air testing for plastic pipe in accordance with ASTM F1417. Perform low pressure air testing procedures for other pipe materials using the pressures and testing times prescribed in ASTM C828, after consultation with the pipe manufacturer.

3.8.1.1.3 Individual Pipe Joint Testing

Testing of individual joints for leakage by low pressure air or water must conform to ASTM C1103M/ASTM C1103.

3.8.1.2 Deflection Testing

Conduct deflection test no sooner than 30 days after completion of final backfill and compaction testing. Clean or flush all lines prior to testing. Perform a deflection test on entire length of installed flexible pipeline upon completion of work adjacent to and over the pipeline, including backfilling, placement of fill, grading, paving, placement of concrete, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads must not exceed the limits in paragraph PLACING PIPE AND BOX CULVERT above as percent of the average inside diameter of pipe. Use a mandrel to determine if allowable deflection has been exceeded.

3.8.1.2.1 Laser Profiler

Inspect pipe interior with laser profiling equipment. For initial post installation inspections for pipe diameters larger than 48 inches, perform a visual inspection of the pipe interior.

3.8.1.2.2 Mandrel

Pass the mandrel through each run of pipe by pulling it by hand. If deflection readings in excess of the allowable deflection of average inside diameter of pipe are obtained, stop and begin test from the opposite direction. The mandrel must meet the pipe manufacturer's recommendations and the following requirements. Provide a mandrel that is rigid, nonadjustable, has a minimum of 9 fins, pulling rings at each end, and is engraved with the nominal pipe size and mandrel outside diameter. The mandrel must be 5 percent less that the ceritified-actual pipe diameter for

plastic pipe, 5 percent less than the certified-actual pipe diameter for corrugated steel and aluminum, 3 percent less than the certified-actual pipe diameter for ductile iron culvert pipe. The Owner will verify the outside diameter (OD) of the Contractor provided mandrell through the use of Contractor provided proving rings.

3.8.1.3 Tracer Wire Continuity

Test tracer wire for continuity after initial and final backfilling of pipes. Verify that tracer wire is locatable with electronic utility location equipement. Repair breaks or separations and re-test for continuity.

3.8.2 Inspection

3.8.2.1 Post-Installation Inspection

Perform a CCTV inspection and video recording of pipes with diameters 48 inches or less. Visually inspect pipes with diameters larger than 48 inches. Inspect each segment of pipe for alignment, settlement, joint separations, soil migration through the joint, cracks, buckling, bulging and deflection. An engineer must evaluate all defects to determine if any remediation or repair is required.

3.8.2.1.1 Concrete Pipe

An engineer must evaluate all pipes with cracks with a width greater than 0.25 mm 0.01 inches, but less than 0.10 inches to determine if any remediation or repair is required.

3.8.2.1.2 Flexible Pipe

Check each flexible pipe (PE, PVC, PP, corrugated steel and aluminum) for rips, tears, joint separations, soil migration throught the joint, cracks, localized buckling, bulges, settlement and alignment.

3.8.2.1.3 Post-Installation Inspection Report

The deflection results and final post installation inspection report must include: a copy of all video taken, pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line, deflection and deformation of flexible pipe, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).

3.8.3 Repair of Defects

3.8.3.1 Leakage Test

When leakage exceeds the maximum amount specified, correct source of excess leakage by replacing damaged pipe and gaskets and retest.

3.8.3.2 Deflection Testing

When deflection readings are in excess of the allowable deflection of average inside diamater of pipe are obtained, remove pipe which has excessive deflection and replace with new pipe. Retest 30 days after completing backfill, leakage testing and compaction testing.

3.8.3.3 Inspection

Replace pipe or repair defects indicated in the Post-Installation Inspection Report.

3.8.3.3.1 Concrete Pipe

Replace pipes having cracks with a width greater than 0.1 inches.

3.8.3.3.2 Flexible Pipe

Replace pipes having cracks or splits.

3.9 PROTECTION

Protect storm drainage piping and adjacent areas from superimposed and external loads during construction.

3.10 WARRANTY PERIOD

Pipe segments found to have defects during the warranty period must be replaced with new pipe and retested.

-- End of Section --

SECTION 35 59 13.16

MOLDED MARINE FENDERS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

| | |
|---|---|
| AISC 360 | (2016) Specification for Structural Steel Buildings |

AMERICAN WELDING SOCIETY (AWS)

| | |
|---|---|
| AWS D1.1/D1.1M | (2020; Errata 1 2021) Structural Welding Code - Steel |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A36/A36M | (2019) Standard Specification for Carbon Structural Steel |
| ASTM A123/A123M | (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products |
| ASTM A153/A153M | (2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware |
| ASTM A479/A479M | (2021) Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels |
| ASTM A572/A572M | (2018) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel |
| ASTM D256 | (2010; R 2018) Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics |
| ASTM D297 | (2015; R 2019) Rubber Products - Chemical Analysis |
| ASTM D395 | (2016; E 2017) Standard Test Methods for Rubber Property - Compression Set |
| ASTM D412 | (2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension |
| ASTM D429 | (2014) Rubber Property-Adhesion to Rigid |

| | |
|---|---|
| | Substrates |
| ASTM D430 | (2006; R 2012) Standard Test Methods for Rubber Deterioration - Dynamic Fatigue |
| ASTM D471 | (2016a) Standard Test Method for Rubber Property - Effect of Liquids |
| ASTM D624 | (2000; R 2020) Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers |
| ASTM D4020 | (2011) Ultra-High-Molecular-Weight Polyethylene Molding and Extrusion Materials |
| ASTM D6370 | (1999; R 2019) Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA) |
| ASTM D1149 | (2007; R 2012) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber |
| ASTM D1894 | (2014) Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting |
| ASTM D2240 | (2015; E 2017) Standard Test Method for Rubber Property - Durometer Hardness |
| ASTM D4020 | (2011) Ultra-High-Molecular-Weight Polyethylene Molding and Extrusion Materials |
| ASTM F593 | (2017) Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs |
| ASTM F594 | (2009; R 2020) Standard Specification for Stainless Steel Nuts |
| ASTM F844 | (2019) Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use |
| ASTM F2192 | (2005; R 2022) Standard Test Method for Determining and Reporting the Berthing Energy and Reaction of Marine Feeders |

BRITISH STANDARDS INSTITUTE (BSI)

| | |
|---|---|
| BSI 903-A9 | (2020) Physical Testing of Rubber – Determination of Abrasion Resistance International Organization for Standardization |

INTERNATIONAL NAVIGATION ASSOCIATION (PIANC)

| | |
|---|---|
| PIANC 2002 | (2002) Guidelines for the Design of Fender |

Systems: 2002

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

| | |
|---|---|
| ISO 17025 | (1999) General Requirements For The Competence Of Testing And Calibration Laboratories |
| ISO 2781 | (2018) Rubber, Vulcanized or Thermoplastic - Determination of Density |
| ISO 9000 | (2015) Quality Management Systems – Fundamentals and Vocabulary |
| ISO 9001 | (2015) Quality Management Systems-Requirements |

U.S. DEPARTMENT OF DEFENSE (DOD)

| | |
|---|---|
| MIL-PRF-907 | (2020; Rev H) Antiseize Thread Compound, High Temperature |

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

| | |
|---|---|
| FS RR-C-271 | (Rev G) Chains and Attachments, Carbon And Alloy Steel |

## 1.2 SYSTEM DESCRIPTION

### 1.2.1 Molded Fenders

Molded fenders are elements manufactured by the molded process. They typically have embedded metal plates cast into the molds. The fender elements are typically used as fenders for medium to large, flat sided vessels. The elements can be used as stand-alone fenders, combined with multiple fenders and a face panel, and energy absorbing elements at the wale. They include the shear fenders which absorb energy by deflecting parallel to the attachment plane. Examples of molded fender shapes are 'Leg Type', 'Arch Type', 'Cell Type', and 'Cone Type'.

## 1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Quality Control Personnel/Organization Qualifications

SD-02 Shop Drawings

Fender System(s)

Fender Hardware

Panels

SD-03 Product Data

Facing

Molded Fender

Restraint Chains

Stainless Steel Hardware

SD-05 Design Data

Design Calculations

Energy-Deflection Curve

Load-Deflection Curve

Rubber Fenders

SD-06 Test Reports

Factory Performance Testing

Fender Chemical Properties

Fender Physical Properties

Independent Performance Verification Testing

SD-07 Certificates

Fender Warranty

Stainless Steel Hardware Certificates

SD-08 Manufacturer's Instructions

Installation Instructions

SD-10 Operation and Maintenance Data

Fender Manual

## 1.4 DELIVERY, HANDLING AND STORAGE

Fenders must be undamaged when delivered. Handle and store fenders so as to prevent damage, such as bending or abrading end fittings, cutting of rubber, or damage to coating of hardware. Protect fenders from exposure to damaging liquids, oils, greases and extended exposure to sunlight.

### 1.4.1 Rejection

Fenders that are delivered to the site in a damaged condition or that are not in conformance with this specification are subject to rejection. Replace any rejected materials with suitable materials, at no additional cost to the Owner.

### 1.4.2 Fender Marking

Unless unsuitable for specified fender or otherwise specified, identify all

fenders in readable characters at least 1 in high, either directly or on corrosion- and sunlight resistant permanently attached tags. The markings must include the following:

a. Full or abbreviated manufacturer name,

b. Fender size model or part number designation,

c. Fender serial number,

d. Rated performance (energy and reaction), and

e. Other information as the purchase specification or contract requires.

1.4.3 Fender Instructions and Manual

Provide installation instructions and a fender manual describing maintenance requirements for each fender type. Include performance and testing literature. Include all hardware details, dimension and material characteristics.

1.4.4 Handling Material

Store, handle and place coated, galvanized, or metallized (protection) material in a manner that will minimize damage to the protection and will not reduce its effective protective value. Handle all work in accordance with manufacturer's instructions and recommendations. Repair damaged surfaces as directed and per the Manufacturer's recommendations. Wide fabric slings used for lifting, and strips, slings, blocks, skids, cradles, and other supports must provide ample bearing areas. In transporting, fasten and protect materials in a manner that will prevent movement and preclude chafing and rubbing, and when unloading, do not dump or drop. Place material in position carefully on suitably prepared beds and with a minimum of handling.

1.5 QUALITY CONTROL AND ASSURANCE

1.5.1 Molded Fenders

Fender elements must be manufactured of rubber, homogeneous and free from any defects, impurities, pores or cracks. Where internal plates are used, the rubber must be bonded to integral steel mounting plates. The plates must be fully encased in rubber to a minimum thickness of 1/16 inch.

1.5.2 Elastomer Skin

The elastomer skin of the fender must be free from cracks, burrs, warpage, checks, chipped or blistered surfaces, and must have a smooth surface.

1.5.3 Steel Fabrication

The steel used in fabrication must be free from kinks, sharp bends, and other conditions which would be detrimental to the finished product. Manufacturing processes must not reduce the strength of the steel to a value less than intended by the design. Manufacturing processes must be done neatly and accurately. Make bends by controlled means to insure uniformity of size and shape.

1.5.4 Welding

AWS D1.1/D1.1M. Provide sufficient size and shape welds to develop the full strength of the parts connected by the welds. Welds must transmit stress without permanent deformation or failure when the parts connected by the weld are subjected to proof and service loadings.

1.6 QUALITY CONTROL PERSONNEL/ORGANIZATION QUALIFICATIONS

1.6.1 Fender Supplier

The Fender Supplier shall be an organization regularly engaged in the manufacture and production of rubber marine fender systems (inclusive of panels and chain restraint system) similar in material, design, and extent to that indicated and with a minimum 10-year proven track record in supplying fenders of a similar type and size as those proposed for this project. The supplier must have produced at least 500 fender units, of the type specified. The Fender Supplier shall apply a system of Quality Management which conforms to ISO 9000 and ISO 9001 or a recognized equivalent. This system must be certified by an acknowledged and accredited organization, and proof of adherence to this system must be submitted.

1.6.2 Fender Engineer

The fender supplier shall engage the services of a Professional Engineer licensed in Texas to design the fender panel and chain restraint system. The Professional Engineer shall have at least 5 years of demonstrated experience in fender panel design in similar applications.

1.6.3 Independent Testing Laboratory

The Independent Testing Laboratory must be regularly engaged in the performance testing of rubber marine fenders with a minimum 3-year track record of testing fenders of a similar type and size as those used for this project. The laboratory must be capable of testing each fender in strict compliance with the specified testing protocols. The Independent Testing Laboratory shall be certified by ISO 17025 or a recognized equivalent.

1.7 DESIGN CALCULATIONS

Design calculations, signed and sealed by a Professional Engineer licensed in Texas, demonstrating that the fender system (including fender, panel, chains, and chain anchorage system) meets the performance objectives. Include factored reaction forces and geometry for all concrete anchorages.

1.8 SHOP DRAWINGS

Submit shop drawings and specifications for the complete fender system(s), inclusive of anchorage hardware, signed and sealed by a Professional Engineer licensed in Texas. Include details of internal stiffener components, details for connection of facing to panel. Also include all support chains and the connecting element details for each location to the panel and to the supporting structure. All materials used for complete fabrication of the panel and fender restraint system shall be clearly identified.

1.9 FENDER WARRANTY

The fender supplier shall warranty the fender assemblies for a period not less than 12 months from the realized date of Substantial Completion for the dock, as approved by the Owner. The warranty shall be issued directly to the Owner and shall not be limited in dollar value.

PART 2 PRODUCTS

2.1 MOLDED FENDERS

2.1.1 Configuration

Provide dimensions, material specifications, and method of manufacture for each type of fender.

2.1.1.1 Molded Fender

Fenders shall be of the manufacturer, model and rubber grade as shown on the drawings, or an equivalent approved by the Engineer. Fenders must be molded and continuous in the length indicated. Molded sections must not be mechanically bonded. The fenders must be black in color. Each fender must be molded of rubber, homogeneous and free from any defects, impurities, pores or cracks, and bonded to integral, steel mounting plates. The mounting plates must be fully encased in rubber with a minimum thickness of 1/16 inch. The fender and hardware must be designed for and be factory tested to the loads specified. Fender anchor bolts and method of anchorage must be of the size and spacing dimensions required by the manufacturer's design and testing; however, the size and spacing of anchor bolts indicated must be construed to be the minimum required, unless exceeded by the requirements of the fender manufacturer's design.

Unless otherwise approved by the Owner, fender chemical composition shall be compliant with the following table:

**Table 1: Fender Chemical Properties**

| Property | Test Standard | Requirements |
|---|---|---|
| Density | ISO 2781 | Max 1.20 g/cc |
| Polymer (rubber) | ASTM D6370 | Min 45% |
| Carbon Black | ASTM D6370 | Min 20% |
| Ash Content | ASTM D297 | Max 5% |
| Rubber Filler Ratio | -- | >1.2 |

Unless otherwise approved by the Owner, fender physical properties of the rubber material shall be compliant with the following table:

**Table 2: Fender Physical Properties**

| Property | Test Standard | Condition | Requirements |
|---|---|---|---|
| Tensile Strength | ASTM D412 Die C | Original | Greater Than or Equal To 16.0 MPa |
| | | Aged 96 hours at 70 degrees C | Greater Than or Equal To 12.8 MPa |
| Elongation at Break | ASTM D412 Die C | Original | Greater Than or Equal To 350% |
| | | Aged 96 hours at 70 degrees C | Greater Than or Equal To 280% |
| Hardness | ASTM D2240 | Original | Less Than or Equal To 78 degrees Shore A |
| | | Aged 96 hours at 70 degrees C | Less Than or Equal To Original + 6 to 8 degrees Shore A |
| Compression Set | ASTM D395 Method B | 22 hours at 70 degrees C | Less Than or Equal To 30% |
| Tear Resistance | ASTM D624 Die B | Original | Greater Than or Equal To 70kN/m |
| Ozone Resistance | ASTM D1149 | 50 pphm at 20% strain, 40 degrees C, 100 hours | No cracks |
| Seawater Resistance | ASTM D471 | 28 days at 95 degrees C | Hardness: Less Than or Equal To + or - 10 degrees Shore A Volume: +10/-5% |
| Abrasion Resistance | BSI 903-A9 Method B | 1,000 or 3,000 revolutions | 0.5cc per 1,000 revolutions |
| Bond Strength | ASTM D429 (Rubber to Steel) | Rubber to steel | Greater Than or Equal To 7N/mm |
| Dynamic Fatigue | ASTM D430 Method B | 15,000 cycles | Less Than or Equal To 10 pinpricks <0.5mm long (Grade 0 or Grade 1) |

2.1.2 Performance Requirements

Submit rated performance data (RPD) and published performance curves per ASTM F2192 or PIANC 2002 WG 33 for the rubber fenders.

2.1.2.1 Ship Fenders

Each of the rubber fenders for ship berthing as identified on the drawings shall have the following performance characteristics:

Minimum Energy: 733 ft-kips or 994 kN.m, at 6 degree Berthing Angle (includes ten percent manufacturing tolerance).

Maximum Reaction: 361 kips or 1,606 kN (includes ten percent manufacturing tolerance).

2.1.2.2 Barge Fenders

Each of the rubber fenders for barge berthing as identified on the drawings shall have the following performance characteristics:

Minimum Energy: 298 ft-kips or 404 kN.m, at 6 degree Berthing Angle (includes ten percent manufacturing tolerance).

Maximum Reaction: 181 kips or 804 kN (includes ten percent manufacturing tolerance).

2.1.3 Source Quality Control

2.1.3.1 Factory Performance Testing

All molded fenders shall be factory tested by the manufacturer in accordance with PIANC 2002 WG 33, Appendix A. Fenders shall be pre-loaded (compressed in their normal loaded configuration) to the rated deflection of the fender a minimum of three full cycles of fully compressing and releasing the rubber element(s). The fourth cycle of the break-in loadings shall be used to represent the performance of the individual fender elements, and it must show that actual energy absorption and reaction forces comply with the performance criteria presented above.

Load-deflection curves for the fourth cycle shall be recorded for each fender, with serial number clearly delineated on the record, and submitted to the Owner for review and approval prior to shipment. The load-deflection curve must then be integrated to generate an Energy-Deflection Curve for the fender. Include both the curves in the test results to be submitted.

All fenders that fail to meet the performance required by the specification will be rejected. Maintain an inspection and record system to verify that all materials, workmanship and completed work conform to the specified requirements. Sample specimens for testing and inspection of the materials, dimensions, and performance. The specimens to be used for the material tests shall be taken directly from the product or from the rubber prepared in the same lot, under the same conditions and in the same vulcanization process as the products to be furnished. Furnish test results from samples to the Owner, if requested.

2.1.3.2 Independent Performance Verification Testing

The Contractor shall engage the services of an approved Independent Testing Laboratory to perform verification testing of fender performance.

Performance verification tests shall be conducted on randomly selected two ship fenders and two barge fenders performed by an independent third party testing facility with experience testing rubber marine fenders. The fenders

will be selected by the Engineer prior to shipment from the manufacturer's factory. Fender selection will be from a list of serial numbers and corresponding factory test results submitted by the Contractor.

The Contractor will deliver the fenders to the Independent Test Facility and then to the Project site. The cost of these tests, including transportation, shall be paid by the Contractor.

The fenders shall be tested in accordance with PIANC 2002 WG 33, Appendix A. If any of the tested fenders fail to meet the performance required by this section, then additional two ship fenders and two barge fenders, randomly selected by the Engineer shall be tested at the Contractor's expense. If any of the additional fenders fail to meet the performance requirement, all of the remaining fenders shall be tested at the Contractor's expense. All fenders that fail to meet the performance required by the specification will be rejected and replaced by new fenders. All new fenders shall be tested in accordance with PIANC WG33, Appendix A.

2.1.4 Fender Hardware

Submit manufacturer's product data for all fender hardware, including chain anchorage brackets, bolts, anchor bolts, inserts, nuts, washers, chains, turnbuckles, dimensions, material specifications, working loads and ultimate loads, as applicable. For anchor bolts and inserts, include methods and materials for installation.

2.1.4.1 Stainless Steel Hardware

Submit stainless steel hardware certificates of compliance certifying that materials meet the requirements specified herein.

2.1.4.1.1 Plates and Angles

ASTM A479/A479M, Type 316L stainless steel for plates, angles, and miscellaneous hardware required to attach the fenders to the structure.

2.1.4.1.2 Bolts, Nuts, and Washers

ASTM F593 or ASTM F594, Group 2 (316 alloy) stainless steel for nuts and bolts. ASTM F844 for washers, except fabricate washers of 316 alloy stainless steel.

2.1.4.1.3 Antiseize Compound

MIL-PRF-907.

2.1.4.2 Restraint Chains and Shackles

Chains and shackles must meet the requirements of FS RR-C-271. Design loads to size the chains shall be determined by multiplying the calculated chain load by a factor of safety of 3.0 minimum to 3.5 maximum. As a minimum, the chains shall be 1.25" in size with minimum breaking load = 120 kips. Pad-eyes for mounting chains to fender panels and the dock surface shall be designed with a factor of safety of 2.0 applied to the calculated chain load; designed in accordance with AISC 360.

The chain restraint system, including anchor pad eyes for attaching the proposed chains to mounting surface, are to be designed and supplied by the Fender Supplier. Chain assemblies shall be provided for following

conditions:

a) To prevent the fender assembly from sagging or drooping under its own weight.

b) To resist vertical forces caused by the ship hull to fender panel friction based on maximum fender reaction.

c) To resist lateral forces caused by the ship hull to fender panel friction based on maximum fender reaction.

d) To resist tensile loads cause by top, bottom, or corner impact on the fender panel and prevent its transfer to the rubber fender.

e) To resist loads from mooring hardware fitted to the fender panel, as shown and specified on the contract drawings.

As a minimum, the chain system and its anchorage shall be designed for:

a) Horizontal line contact applied at any elevation over the flat height of the panel.

b) Vertical line contact applied along the side edge of fender panel. The system for barge fenders shall be designed for low corner impact with vertical line contact length of 4 ft.

c) Loads from mooring hardware fitted to the fender panels, as defined on contract drawings.

2.1.4.2.1 Tensioning Devices

All chains shall be furnished with shackles and a tensioning device. The tensioning device length shall not comprise more than 1/3 of the total chain assembly length.

2.1.4.2.2 Chain Anchorage

Chain anchorage brackets shall be stainless steel, in accordance with part 2.1.4.1.1. The chain anchorage brackets shall be designed for 1.5 times minimum proof load of chain. All anchor bolt embeds shall be designed to resist 125% of ultimate bolt strength.

2.1.4.2.3 Chain Component Selection

All chain components, including shackles and tensioners hardware, shall be hot dipped galvanized in accordance with ASTM A123/A123M and ASTM A153/A153M, as applicable.

2.1.5 Panels

Panel design must be of closed box construction for optimum strength and corrosion resistance. Material thickness must be 3/8 inch (10 mm)minimum when one side is exposed and 1/2 inch (12 mm) minimum when both sides are exposed. Panel length and width shall be as indicated on the Contract Drawings. Vertical and top edges of all panels shall be chamfered as shown on the Contract Drawings. Perform pressure testing to ensure an air and water tight. Submit shop drawings indicating the dimensions of the panels.

The steel used in fabrication shall conform to ASTM A36/A36M or

ASTM A572/A572M Grade 50, unless otherwise approved by the Engineer. It shall be free from kinks, sharp bends, and other conditions which would bedetrimental to the finished product.

Manufacturing processes shall not reduce the strength of the steel to a value less than intended by the design. Manufacturing processes shall be done neatly and accurately.

Make bends by controlled means to provide uniformity of size and shape. Fender panels, stool plates and brackets shall be designed for all simultaneous loads applied to them by a vessel and by the rubber fender unit that are generated by the rated performance of the fender supplied, with consideration of appropriate manufacturer's tolerances.

Fender panels shall be designed to limit hull pressure to 4,000 psf. As a minimum, the fender panel shall be designed for:

a) Horizontal line contact applied at any elevation over the flat height of the panel

b) Vertical line contact applied along the side edge of fender panel. The system for barge fenders shall be designed for low corner impact with vertical line contact length of 4 ft.

Fender panels shall be metallized in accordance with 09 97 10.00 10 METALLIC COATINGS.

2.1.5.1 Facing

a. Facing tiles on the panels shall be UHMW PE (ultra high molecular weight polyethylene) conforming to ASTM D4020 and black in color. Facing tiles shall be ultraviolet stabilized with minimum 2.5% carbon black. Facing shall provide a 0.20 maximum coefficient of friction per ASTM D1894.

b. Facing tiles shall be drilled and counterbored for the studs or mounting bolts. The counterbored hole shall leave a minimum of 1 inch of material between the panel and washer.

c. Provide a minimum wear surface thickness of ¾ inches. The wear surface is defined as the distance between the face pad beyond the projection of the fixing bolt or stud.

d. All exposed edges of the facing tiles shall include 1 inch, 45-degree chamfers.

e. All bolts used to fasten the facing to the panel shall be AISI Type 316 Stainless Steel and a minimum of 5/8" in diameter. All bolt head shall be recessed into facing so that bolts do not protrude beyond facing.

f. The UHMW PE shall exhibit no failure when tested per ASTM D256, Method B.

g. Facing connections shall be configured to account for thermal properties of polyethylene.

PART 3 FENDER SYSTEM INSTALLATION

Install the fenders in the position and at the spacing indicated on the drawings, and in accordance with the fender supplier's instructions. Fender

system shall be plumb, level and aligned to within 1 inch of the dimensions, elevation and location indicated. Fender anchor bolts shall be cast-in-place. Contractor shall utilize a template to ensure the required bolt pattern. Templates must ensure that anchors are installed in direct contact or at least 1 inch clear of concrete reinforcement. Tighten the bolts per the manufacturer's requirements. Coat threads of bolts with antiseize compound prior to applying washers and nuts. Recoat bolt thread projection beyond nut after tightening.

-- End of Section --