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USACE / NAVFAC / AFCEC / NASA **UFGS-31 62 13.24 (November 2020)**

Change 1 - 05/22

Preparing Activity: NAVFAC **Superseding**

UFGS-31 62 13.24 (August 2011)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2022
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SECTION 31 62 13.24

CONCRETE CYLINDER PILES

11/20, CHG 1: 05/22

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SECTION 31 62 13.24

CONCRETE CYLINDER PILES
11/20, CHG 1: 05/22

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NOTE: This guide specification covers the requirements for post-tensioned, centrifugally cast cylinder piles and prestressed statically cast cylinder piles. Pile reinforcing specified in this guide specification is for steel, special reinforcement materials (i.e. composite, non-magnetic, etc.) should be added on a project by project basis.

Adhere to UFC 1-300-02 **Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.**

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR)**.**

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NOTE: To download UFGS Forms, Graphics, and Tables, go to: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables

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NOTE: The extent and location of the work to be accomplished should be indicated on the project drawings or included in the project specification.

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NOTE: The following information must be shown on the drawings:

1. Locations and design loads on piles. If both tension and compression piles are contained in design, identify by type.

2. Size, shape, and length of piles.

3. Locations, sizes, and number of longitudinal ducts for post tensioned steel. Location, sizes and number of prestressing strands. Unit stresses for post tensioned and prestressing strands or wire.

4. Details of reinforcement and tendons.

5. Details of splices, if required.

6. Locations of test piles, if required.

7. Soil data, where required.
****

PART 1 GENERAL

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NOTE: Structural engineer must confirm the structural capacity of piles and provide specific bending moments, lateral loads and other design requirements for pile design.
****

1.1 DESCRIPTION

Design, furnish, install and test concrete cylinder piles at the locations indicated on the drawings and specified herein.[Assume test pile[s] will be directed to be placed in [a] location[s] that can be incorporated into the work.][Test piles which meet performance requirements may be incorporated into permanent work.]

1.2 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically

be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
****

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 T 259	(2002; R 2017) Standard Method of Test for Resistance of Concrete to Chloride Ion Penetration

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 212.3R	(2016) Chemical Admixtures for Concrete
ACI 214R	(2011) Evaluation of Strength Test Results of Concrete
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)
ACI 318M	(2014; ERTA 2015) Building Code Requirements for Structural Concrete & Commentary
ACI SP-66	(2004) ACI Detailing Manual

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4/D1.4M	(2011) Structural Welding Code - Reinforcing Steel

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 A416/A416M	(2018) Standard Specification for Low-Relaxation, Seven-Wire for Prestressed Concrete
ASTM A572/A572M	(2021; E 2021) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

ASTM A615/A615M	(2022) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706/A706M	(2022) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A886/A886M	(2017) Standard Specification for Steel Strand, Indented, Seven-Wire Stress-Relieved for Prestressed Concrete
ASTM A996/A996M	(2016) Standard Specification for Rail-Steel and Axle-Steel Deformed 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	(2022) 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 C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C494/C494M	(2019; E 2022) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2021) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2022) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

ASTM C666/C666M	(2015) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C881/C881M	(2020a) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989/C989M	(2022) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1202	(2022; E 2022) Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
ASTM C1218/C1218M	(2020c) Standard Test Method for Water-Soluble Chloride in Mortar and Concrete
ASTM C1240	(2020) Standard Specification for Silica Fume Used in Cementitious Mixtures
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 D1143/D1143M	(2007; R 2013) Piles Under Static Axial Compressive Load
ASTM D3689	(2007; E 2013; R 2013) Standard Test Methods for Deep Foundations Under Static Axial Tensile Load
ASTM D3966/D3966M	(2007; R 2013; E 2013) Standard Test Methods for Deep Foundations Under Lateral Load
ASTM D4945	(2017) Standard Test Method for High-Strain Dynamic Testing of Deep Foundations
ASTM E329	(2021) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

POST-TENSIONING INSTITUTE (PTI)

PTI M55.1	(2019; Errata 2020) Specification for Grouting of Post-Tensioned Structures

PRECAST/PRESTRESSED CONCRETE INSTITUTE (PCI)

PCI BDM	(2011) Precast Prestressed Concrete Bridge Design Manual
PCI JR-382	(1993) PCI Journal: Recommended Practice for Design, Manufacture and Installation of Prestressed Concrete Piling
PCI MNL-116	(2021) Manual for Quality Control for Plants and Production of Structural Precast Concrete Products, 5th Edition
PCI MNL-135	(2000) Tolerance Manual for Precast and Prestressed Concrete Construction

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-220-01	(2012; with Change 1, 2021) Geotechnical Engineering

1.3 SUBSURFACE DATA

Subsurface soil data logs are[indicated][appended to the special contract requirements][provided on the project drawings].[The subsoil investigation report may be examined at [_____].]

1.4 BASIS OF BID

****

NOTE: Select one of the following options:

****

****

NOTE: Use "Lump Sum" paragraph below for lump (principal) sum bidding of piles. Use this in all projects except those where exact pile lengths cannot be practically determined prior to the actual work. Clearly show number of piles, pile capacity, pile locations, and tip and cutoff elevations on the drawings.

Use "Unit Price" paragraph for unit price bidding of piles. Specify unit price bid items for piles only for projects where exact quantities cannot be practically determined prior to the actual work. Lengths of piles must be determined as accurately as possible, prior to bidding, since the unit price per meter (foot) of the piles varies as the length increases or decreases. Refer to Standard Test Method for High-Strain Dynamic Testing of Deep Foundations (ASTM D4945).

****

1.4.1 Production Pile Acceptance Criteria

Safe design capacity for piles is [_____] KN [_____] kips. Drive piles to [minimum tip elevation] [a minimum depth of [_____] m [_____] feet below cut-off elevation], and to such additional depth as required to obtain a bearing capacity of not less than [_____] KN [_____] kips. The Contractor's Geotechnical Consultant will determine the terminal driving criteria based on results of[dynamic pile driving tests at end of drive or restrike][static load tests][wave equation analysis].

The following formulas can be used in cases where allowable pile loads are less than 355 kN 80 kips (determined using a factor of safety of 3 for individual piles and 4 for pile groups) and are presented only as a guide to aid in establishing the controlling penetration per blow, which, together with the minimum depth of penetration will serve to determine the required minimum depth of penetration of each individual pile:

$$R = \frac{2E}{S \text{ plus } 0.1} \qquad \text{For double acting hammers}$$

$$R = \frac{2WH}{S \text{ plus } 0.1} \qquad \text{For single acting hammers}$$

Where R is the approximate allowable pile load in kips; E equals the energy in foot-kips per blow based on an acceptable certified statement from the manufacturer of the hammer; W equals the weight of the hammer or ram in kips; H equals the height of fall of the hammer of ram in feet; and S equals the average inches of penetration per blow for the last three blows. An allowance will be made for reduced penetration caused by shock absorption of the cushion or cap blocks.

[1.5 LUMP SUM PAYMENT

****

NOTE: Use this paragraph for lump-sum contracts, consult with Contracting Officer's Technical Representative (Geotechnical Branch) on applicability of use prior to selection. This paragraph will be typically used when there are 1) relatively small quantity of piles, 2) allowable pile loading is less than 40 tons, and 3) the subsurface conditions are well defined. Fill in Table I as required selecting columns applicable to project. Generally, pile capacity, location, and minimum tip elevation are shown on plans. Test piles and load tests are not incorporated on lump sum contracts. Delete this paragraph for unit-price contracts.

****

Base bids upon providing the number, size, capacity, and length of piles as indicated on the [drawings.][following Table I:

Table I

[Location]	Number	Size	Capacity	Length (tip to cut-off)

]

The contract price for piling must include the cost of all necessary equipment, tools, material, labor, and supervision required to: deliver, handle, install, cut-off, dispose of any cut-offs, and meet the applicable contract requirements. The contract price also includes mobilization, pre-drilling, and redriving heaved piles. If, in redriving, it is found that any pile is not of sufficient length to provide the capacity specified, notify the Contracting Officer, who reserves the right to increase or decrease the total length of piles to be furnished and installed by changing the pile locations or elevations, requiring the installation of additional piles, or directing the omission of piles from the requirements shown and specified. Should total number of piles or number of each length vary from that specified as the basis for bidding, an adjustment in the contract price or time for completion, or both, will be made in accordance with the contract documents. Payment for piles will be based on successfully installing piles to both the minimum tip elevation and satisfying the acceptance criteria identified herein. No additional payment will be made for: damaged, rejected, or misplaced piles; withdrawn piles; any portion of a pile remaining above the cut-off elevation; backdriving; cutting off piles; splicing; build-ups; any cut-off length of piles; or other excesses beyond the assumed pile length indicated for which the Contractor is responsible.

][1.6 UNIT PRICES

****

NOTE: Delete this paragraph for lump-sum contracts.

For NAVFAC PAC projects: Where there is unit pricing for piles, use this paragraph and edit applicable attachments for inclusion in Standard Form 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items."

For NAVFAC Southeast projects, where there is a need for unit pricing of piles, include this paragraph. Refer to NAVFAC SE Instruction 00010, "Instructions for Preparing Basis of Bid Statement With Unit-Priced Items," for method of specifying unit price bid items.

****

For unit price bid, see SF 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items."

****

NOTE: For NAVFAC LANT projects, use the following paragraph for measurement and payment and subsequent sub-parts.

****

Requirements of FAR 52.211-18 Variation in Estimated Quantity do not apply to payment for piling. Each pile and test pile acceptably provided will be paid for at the bid unit price per unit length, which will include items incidental to furnishing and driving the piles including mobilization and demobilization,[jetting][predrilling][probing], redriving uplifted piles, [an additional 1.5 m 5 feet in furnished length for any test pile not driven beyond estimated pile length,] and cutting off piles at the cut-off elevation.[Include the cost for additional length for the test piles in the total unit price cost for the job.] Payment will be made for production [and test piles]at the bid unit price for the length of pile, from tip to final cut-off, actually provided, excluding buildups and splices directed by the Contracting Officer to be made. If the actual cumulative pile length driven (tip to cut-off) vary more than 25 percent from the total pile length specified as a basis for bidding, at the direction of the Contracting Officer, the unit price per unit length will be adjusted in accordance with provisions of FAR 52.236-2 Differing Site Conditions.[Payments will be made per each at the respective bid unit price for pile cut-offs, pile build-ups, pile loads tests and pile splices.][Include payments for vibration monitoring, sound monitoring, construction instrumentation and monitoring, and precondition construction surveys].

]1.7 PAYMENT

****

NOTE: This paragraph is tailored for Army. If Section 01 20 00 PRICE AND PAYMENT PROCEDURES is included in the project specifications, this paragraph title (UNIT PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs below should be inserted into Section 01 20 00 PRICE AND PAYMENT PROCEDURES.

****

1.7.1 Furnishing and Delivering Concrete Cylinder Piles

1.7.1.1 Payment

Payment will be made for costs associated with furnishing and delivering the required lengths of permanent concrete cylinder piles, which includes costs of furnishing and delivering piles to the work site. No payment will be made for the driving head or lengths of piles exceeding required lengths. No payment will be made for piles damaged during delivery, storage, or handling to the extent that they are rendered unsuitable for the work, in the opinion of the Contracting Officer.

1.7.1.2 Measurement

Furnishing and delivering permanent concrete cylinder piles will be measured for payment by the linear meter foot of piles required below the cutoff elevation as [determined by the Contracting Officer and furnished to the Contractor] [indicated].

1.7.1.3 Unit of Measure

Linear meter foot.

1.7.2 Driving Concrete Cylinder Piles

1.7.2.1 Payment

Payment will be made for costs associated with driving permanent concrete cylinder piles, which includes costs of handling, driving, [and splicing of piles,][performing dynamic testing, interpreting data and submitting reports,]measuring heave, redriving heaved piles, removal of [build-ups]driving heads or cutting off piles at the cutoff elevation and removing from the work site, compiling and submitting pile driving records, backfilling voids around piles, and any other items incidental to driving piles to the required elevation.

1.7.2.2   Measurement

Permanent concrete cylinder piles will be measured for payment for driving on the basis of lengths, to the nearest hundredth of a linear meter tenth of a linear foot, along the axis of each pile acceptably in place below the cutoff elevation shown.

1.7.2.3   Unit of Measure

Linear meter foot.

1.7.3   Pulled Concrete Cylinder Piles

1.7.3.1   Payment

Payment will be made for costs associated with piles pulled at the direction of the Contracting Officer and found to be undamaged. The cost of furnishing and delivering pulled and undamaged piles will be paid for at the applicable contract unit price for payment item "Furnishing and Delivering Concrete Cylinder Piles". The cost of driving pulled and undamaged piles will be paid for at the applicable contract unit price for payment item "Driving Concrete Cylinder Piles". The cost of pulling pulled and undamaged piles will be paid for at twice the applicable contract unit price for payment item "Driving Concrete Cylinder Piles", which includes backfilling any remaining void. The cost of redriving pulled and undamaged piles will be paid for at the applicable contract unit price for payment item "Driving Concrete Cylinder Piles". No payment will be made for furnishing, delivering, driving, pulling, and disposing of piles pulled and found to be damaged and backfilling voids. New piles replacing damaged piles will be paid for at the applicable contract unit price for payment items "Furnishing and Delivering Concrete Cylinder Piles" and "Driving Concrete Cylinder Piles".

1.7.3.2   Measurement

Furnishing and delivering pulled and undamaged permanent concrete cylinder piles will be measured for payment as specified in paragraph PAYMENT, subparagraph FURNISHING AND DELIVERING CONCRETE CYLINDER PILES. Pulling undamaged concrete cylinder piles will be measured for payment as specified in paragraph PAYMENT, subparagraph DRIVING CONCRETE CYLINDER PILES. Redriving pulled undamaged concrete cylinder piles will be measured for payment as specified in paragraph PAYMENT, subparagraph DRIVING CONCRETE CYLINDER PILES. New piles replacing damaged piles will be measured for payment as specified in paragraph PAYMENT, subparagraphs FURNISHING AND DELIVERING CONCRETE CYLINDER PILES and DRIVING CONCRETE CYLINDER PILES.

1.7.3.3   Unit of Measure

Linear meter foot.

[1.7.4   Concrete Pile Driving Tests

1.7.4.1   Payment

Payment will be made for costs associated with furnishing, delivering, driving, pulling, and disposing of driven test piles, [including splices]; conducting pile driving tests; backfilling voids around piles; compiling pile driving test records[; performing dynamic testing; interpreting data;

and submitting reports].

1.7.4.2 Measurement

Concrete pile driving tests will be measured for payment on the basis of the applicable contract unit price per pile driving test.

1.7.4.3 Unit of Measure

Each.

][1.7.5 Concrete Cylinder Piles for Load Tests

1.7.5.1 Payment

Payment will be made for costs associated with furnishing, delivering, driving, pulling, and disposing of load test piles[including splices]; backfilling voids around piles; compiling pile driving records[; furnishing, fabricating, and mounting of strain rods and protective assembly][; furnishing, fabricating, and mounting of instrumentation and instrumentation protective assembly][; performing dynamic testing; interpreting data; and submitting reports]. No additional payment will be made for load test piles incorporated in the permanent work other than as provided.

1.7.5.2 Measurement

Concrete cylinder piles for load tests will be measured for payment on the basis of the applicable contract unit price per load test pile.

1.7.5.3 Unit of Measure

Each.

][1.7.6 Concrete Pile Static Axial Compressive Load Tests

1.7.6.1 Payment

Payment will be made for costs associated with concrete pile static axial compressive load tests in accordance with ASTM D1143/D1143M, including material and labor for fabricating and furnishing load frames; calibrating load cells and hydraulic jacks; furnishing specified test equipment; installing strain rods; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting pile load test reports. No payment will be made for rejected pile static axial compressive load tests.

1.7.6.2 Measurement

Concrete pile compressive load tests will be measured for payment on the basis of the applicable contract unit price per load test.

1.7.6.3 Unit of Measure

Each.

][1.7.7 Concrete Pile Static Tensile Load Tests

1.7.7.1 Payment

Payment will be made for costs associated with concrete pile static tensile load tests in accordance with ASTM D3689, including material and labor for fabricating and furnishing load frames; calibrating load cells and hydraulic jacks; furnishing specified test equipment; installing strain rods; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting pile load test reports. No payment will be made for rejected pile static tensile load tests.

1.7.7.2 Measurement

Concrete pile static tensile load tests will be measured for payment on the basis of the applicable contract unit price per number of tensile load test.

1.7.7.3 Unit of Measure

Each.

][1.7.8 Concrete Pile Lateral Load Tests

1.7.8.1 Payment

Payment will be made for costs associated with concrete pile lateral load tests in accordance with ASTM D3966/D3966M, including material and labor for fabricating and furnishing load frames; calibrating load cells and hydraulic jacks; furnishing specified test equipment; installing inclinometers; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting pile load test reports. No payment will be made for rejected pile lateral load tests.

1.7.8.2 Measurement

Concrete pile lateral load tests will be measured for payment on the basis of the applicable contract unit price per lateral load test.

1.7.8.3 Unit of Measure

Each.

][1.7.9 Pulled Load Test Concrete Cylinder Piles

1.7.9.1 Payment

Payment will be made for costs associated with load test concrete cylinder piles pulled prior to load testing at the direction of the Contracting Officer and found to be undamaged. The cost of furnishing, delivering, driving, and pulling undamaged load test piles will be paid for at the applicable contract unit price for payment item "Concrete Cylinder Piles for Load Tests". The cost of pulling undamaged load test piles the second time after redriving and testing will be paid for at twice the applicable contract unit price for payment item "Driving Concrete Cylinder Piles". The cost of redriving pulled undamaged load test piles will be paid for at the applicable contract unit price for payment item "Driving Concrete

Cylinder Piles". No payment will be made for furnishing, delivering, driving, pulling, and disposing of load test piles pulled at the direction of the Contracting Officer and found to be damaged, unless the pile was damaged due to overdriving at the request of the Engineer. New load test piles replacing damaged piles will be paid for at the applicable contract unit price for payment item "Concrete Cylinder Piles for Load Tests".

1.7.9.2 Measurement

Pulled undamaged load test concrete cylinder piles will be measured for payment as specified in paragraph PAYMENT, subparagraph CONCRETE CYLINDER PILES FOR LOAD TESTS. Pulling undamaged load test concrete cylinder piles the second time after redriving and testing will be measured for payment as specified in paragraph PAYMENT, subparagraph DRIVING CONCRETE CYLINDER PILES. Redriving pulled undamaged concrete cylinder piles will be measured for payment as specified in paragraph PAYMENT, subparagraph DRIVING CONCRETE CYLINDER PILES. New load test concrete cylinder piles replacing damaged piles will be measured for payment as specified in paragraph PAYMENT, subparagraph CONCRETE CYLINDER PILES FOR LOAD TESTS.

1.7.9.3 Unit of Measure

Unit of measure: as specified in paragraph PAYMENT, subparagraphs DRIVING CONCRETE CYLINDER PILES and CONCRETE CYLINDER PILES FOR LOAD TESTS, respectfully.

][1.7.10 Concrete Pile Splices

1.7.10.1 Payment

Payment will be made for costs associated with concrete pile splices, including all plant, labor, and material required to make the splice.

1.7.10.2 Measurement

Concrete pile splices will be measured for payment on the basis of the applicable contract unit price per pile splice.

1.7.10.3 Unit of Measure

Each.

][1.7.11 Pile Driving Shoes

1.7.11.1 Payment

Payment will be made for costs associated with pile driving shoes, including furnishing, delivering, and installing.

1.7.11.2 Measurement

Pile driving shoes will be measured for payment on the basis of the number of pile driving shoes required.

1.7.11.3 Unit of Measure

Unit of measure: each.

][1.7.12 Vibration Monitoring

1.7.12.1 Payment

Payment will be made for costs associated with vibration monitoring.

1.7.12.2 Measurement

Vibration monitoring will be measured for payment on the basis of the applicable contract unit price per vibration monitoring point.

1.7.12.3 Unit of Measure

Each.

][1.7.13 Sound Monitoring

1.7.13.1 Payment

Payment will be made for costs associated with sound monitoring.

1.7.13.2 Measurement

Sound monitoring will be measured for payment on the basis of the applicable contract unit price per sound monitoring point.

1.7.13.3 Unit of Measure

Each.

][1.7.14 Preconstruction Condition Survey

1.7.14.1 Payment

Payment will be made for costs associated with preconstruction condition surveys.

1.7.14.2 Measurement

Preconstruction condition survey will be measured for payment on the basis of the applicable contract unit price per structure to be surveyed.

1.7.14.3 Unit of Measure

Each.

][1.7.15 Construction Instrumentation and Monitoring

1.7.15.1 Payment

Payment will be made for costs associated with construction instrumentation and monitoring.

1.7.15.2 Measurement

Construction instrumentation and monitoring will be measured as a single pay item.

1.7.15.3 Unit of Measure

One.

]1.8 SUBMITTALS

****
NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.
****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Installation Procedures; G[, [_____]]

[Contractor's Geotechnical Consultant Documentation; G[, [_____]]

][Wave Equation Analysis; G[, [_____]]

] Precast Manufacturer's Quality Control Procedures; G[, [_____]]

[Instrumentation and Monitoring Program Report; G[, [_____]]

] Testing Agency Qualifications; G[, [_____]]

SD-02 Shop Drawings

****

NOTE: When the size and complexity of project warrants certification by a registered engineer, insert requirements; otherwise delete.

****

Piles; G[, [_____]]

Pile Splices; G[, [_____]]

Pile Placement; G[, [_____]]

As-Driven Survey; G[, [_____]]

Load Tests; G[, [_____]]

Pile Shoe; G[, [_____]]

SD-03 Product Data

Pile Driving Equipment; G[, [_____]]

SD-05 Design Data

Concrete Mix Design; G[, [_____]]

Grout; G[, [_____]]

Joint Sealing Material; G[, [_____]]

Prestressing Tendons; G[, [_____]]

SD-06 Test Reports

Aggregates; G[, [_____]]

[Silica Fume; G[, [_____]]

] Concrete Compressive Strength; G[, [_____]]

[Test Piles; G[, [_____]]

][Load Tests; G[, [_____]]

][Dynamic Pile Analysis; G[, [_____]]

][Destructive Pile Testing; G[, [_____]]

][Instrumentation and Monitoring Program Report; G[, [_____]]

] SD-07 Certificates

Aggregates; G[, [_____]]

Admixtures; G[, [_____]]

[Silica Fume Manufacturer's Representative; G[, [_____]]

] Prestressing Steel; G[, [_____]]

Cement; G[, [_____]]

Fly Ash and Pozzolan; G[, [_____]]

Ground Slag; G[, [_____]]

Epoxy Coating; G[, [_____]]

[Load Test Supporting Data; G[, [_____]]

] SD-11 Closeout Submittals

Pile Records; G[, [_____]]

1.9 DELIVERY, STORAGE, AND HANDLING

Store, handle, and transport piles in accordance with PCI MNL-116 except as follows. Use methods for handling and storage of piles such that the piles are not subjected to excessive bending stress, cracking, spalling, or other damage. Follow the lifting instructions of the precaster.

1.9.1 Damaged Piles

Inspect each pile for sweep and structural damage such as cracking and spalling before transporting them to the project site and immediately prior to placement in the driving leads. Bring any unusual cracks (cracks other than crazing, surface drying, shrinkage cracks and end cracks) to the attention of the Contracting Officer. Piles which are damaged during delivery, storage, or handling to the extent they are rendered unsuitable for the work, in the opinion of the Contracting Officer, will be rejected and removed from the project site, or may be repaired, if approved, at no cost to the Government.

Any pile damaged by reason of internal defects or by improper driving must be corrected by one of the following methods approved by the Engineer for the pile in question and the Structural Engineer of Record:

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).

A pile driven below the specified butt 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.

1.9.1.1 Repairable Cracks

Piles with cracks equal to or greater than 0.15 mm 0.006 inches but less than 1.5 mm 0.06 inches must be repaired or rejected at the discretion of the Contracting Officer. As an alternate to pile rejection, the Contractor may submit a proposal to repair deficient piles. Prior to driving, piles must be restored to their required design capacity so that they can perform their intended structural function and achieve long term durability in corrosive environment.

1.9.1.2 Non-Repairable Cracks

Piles with cracks equal to or greater than 1.5 mm 0.06 inches must be rejected.

1.9.2 Pile Sweep

****
NOTE: Sweep and camber typically apply to steel piles. In special cases, this paragraph may apply to precast concrete piles.
****

Sweep must be limited to the tolerances specified in PCI MNL-116 over the length of the pile. Piles having excessive sweep must be rejected. Piles that develop non repairable cracks due to handling and installation must be rejected.

1.10 QUALITY CONTROL

1.10.1 Piles

****
NOTE: When the size and complexity of project warrants certification by a registered engineer, insert requirements; otherwise delete.
****

Prepare in accordance with ACI SP-66. Indicate placement of reinforcement including tendons. Indicate location of special embedded or attached lifting devices, employment of pick-up points, support points other than pick-up points, and any other methods of pick-up.[Provide certification by a professional engineer registered in any jurisdiction, that layout and details of reinforcement and tendons conform with that shown on the structural design drawings.]

1.10.2 Quality Control Procedures

Submit the precasting manufacturer's quality control procedures and inspection records established in accordance with PCI MNL-116.

1.10.3 Installation 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.

[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. 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) Completed Pile and Driving Equipment Data Form (which can be downloaded at: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables), 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.

][1.10.4 Contractor's Geotechnical Consultant Documentation

Hire the services of an independent, Registered Professional Geotechnical Engineer, experienced in soil mechanics and Pile Dynamic Analysis, to observe test pile installation and production 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.

Provide instructions and procedures on how the Contractor shall assist the Government in the processes of Dynamic Pile Testing and Interior Inspection of Damaged Piles.

]1.10.5 Concrete Mix Design

Submit a concrete mix design before concrete is placed, for each type of concrete used for the piles. Certify, using a Government-approved independent commercial testing laboratory, that proportioning of mix is in accordance with ACI 211.1 or ACI 318M ACI 318 for specified strength and is based on aggregate data which has been determined by laboratory tests during last twelve months. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, pozzolan, ground slag, and admixtures; and applicable reference specifications. Submit additional data regarding concrete aggregates if the source of aggregate changes. Submittal shall clearly indicate where each mix design will be used when more than one mix design is submitted.

[1.10.6 Load Test Supporting Data

Submit Jack calibration records, a testing arrangement description and diagram, and the proposed loading sequence.

]1.10.7 Silica Fume Manufacturer's Representative

Provide statement that the manufacturer's representative will be present at plant to ensure proper mix, including high range water reducer (HRWR), and batching methods.

PART 2 PRODUCTS

2.1 PILE MATERIALS

****

NOTE: Delete sentence in brackets when test piles are not required. Government requires the Contractor to employ a Geotechnical Consultant to determine the calculated tip elevation and provide oversight of piling installation and testing.

****

Provide precast concrete cylinder piles per PCI Journal Volume 38, Number 2 (PCI JR-382). Production of piles must be in accordance with PCI MNL-116.[Order test piles [3] [_____] meters [10] [_____] feet longer in length than production piles.][Drive the additional test pile length only when based upon the recommendation of the Contractor's Geotechnical Consultant and approved by the Contracting Officer.] The [Contractor's Geotechnical Consultant] [Contracting Officer] will use test pile data to determine "calculated" pile tip elevation and necessary driving resistance. This information will be given to the Contractor no later than seven days from receipt of complete test data. Use this list as the basis for ordering the piles. Do not order piles until list is provided by the [Contractor's Geotechnical Consultant] [Contracting Officer].[Provide test piles [1.5] [_____] meters [5] [_____] feet longer than the bid length.]

2.2 MATERIALS

2.2.1 Cementitious Materials

Cementitious materials must be portland cement, [blended cement]or only portland cement in combination with natural pozzolan or fly ash [or ground granulated blast furnace slag]and must conform to appropriate specifications listed below.

2.2.1.1 Cement

****

NOTE: Insert type of cement required. Generally, Types II, or I/II, is preferred. Type I, or Type III with 8 percent maximum C3A and "low alkali" may be used. Do not use Type III in conjunction with silica fume. In very special cases, Type V, "low alkali," which has limited availability, may be used.

****

****

NOTE: Cement type and quantity of cement required in mix design is dependent upon the environment, soil conditions, need for corrosion protection, and location of piling:

(a) CHLORIDE PROTECTION:

Normal Use. In fresh water or air environment, specify Type I or Type II cement. Type III may be permitted provided tricalcium aluminate (C3A) content is limited to 8 percent and it is low alkali.

Marine Use. In soil or water environments, subject to chlorides above 1,000 ppm, within about 300 m 1000 feet of the ocean or tidal water, specify Type II or Type III (with a maximum tricalcium aluminate (C3A) content of 8 percent and low alkali) cement, a minimum cementitious materials content of 335 kilograms per cubic meter 564 pounds per cubic yard and a maximum water to cementitious materials ratio of 0.40.

Seawater Exposure. In direct contact with ocean water, specify Type II or Type III (with a maximum tricalcium aluminate (C3A) content of 8 percent and low alkali) cement, a minimum cementitious materials content of 390 kilograms per cubic meter 658 pounds per cubic yard and a maximum water to cementitious materials ratio of 0.40.

(b) SULFATE RESISTANCE:

A minimum cementitious materials content of 335 kilograms per cubic meter 564 pounds per cubic yard is recommended.

Normal Use. In soils with negligible amount of sulfate, specify Type I or Type II cement. Type III cement may be permitted provided tricalcium aluminate (C3A) content is limited to 8 percent and it is low alkali.

Moderate Sulfate Exposure. In exposures with moderate sulfate content (between 0.10 and 0.20 percent in soil and less than 1500 ppm in water), specify Type II or Type III (with a maximum tricalcium aluminate (C3A) content of 8 percent and low alkali) cement and a maximum water to cementitious materials ratio of 0.40. Do not use Class C fly ash, blast furnace slag, or silica fume for cement replacement.

Severe Sulfate Exposure. In exposures with high sulfate content (exceeds 0.20 percent in soil or 1500 ppm in water), specify Type V or Type II (with a maximum tricalcium aluminate content of 5 percent)

cement, and a maximum water to cementitious materials ratio of 0.40. Do not use Class C fly ash, blast furnace slag, or silica fume for cement replacement.

****

ASTM C150/C150M, [Type I, II, or III [_____] with a maximum alkali content of 0.60 percent[; or] [ASTM C595/C595M, Type [IP(MS) or IS(MS)] [_____]] blended cement except as modified herein.] The blended cement must consist of a mixture of ASTM C150/C150M cement (with alkali content not exceeding 0.60 percent) and one of the following materials: ASTM C618 pozzolan or fly ash, or ASTM C989/C989M ground iron blast-furnace slag, or ASTM C1240 silica fume. Cement certificates must include test results in accordance with ASTM C150/C150M, including equivalent alkalies indicated in the optional chemical requirements.[Use cement with a tricalcium aluminate (C3A) content of less than [8] [5] percent.] Type III cement must not be used in conjunction with silica fume.

****

NOTE: Fly ash, pozzolan, and ground iron blast-furnace slag increase durability. They may produce uneven discoloration of the concrete during the early stages of construction, depending upon the type of curing provided. Use Fly ash/pozzolan (loss on ignition not exceeding 3 percent) for frost areas to reduce carbon interference with air entraining admixture. Straight replacement with fly ash or natural pozzolan beyond 15 percent may decrease the concrete's strength gain rate. The following options can help mitigate this slower gain rate: (1) a lower water/cement ratio may be used, (2) partial cement replacement can be completed, e. g., one sack of cement can be replaced by 1.5 sacks of fly ash, as long as the final replacement ratio meets the requirements, and (3) very fine fly ashes or pozzolans (e. g. with average particle sizes below 5 microns) can be used.

****

2.2.1.2 Fly Ash and Pozzolan

****

NOTE: Loss on ignition greater than 3 percent may result in significant variations in air content. The air entrainment admixture content may need to be varied often to maintain the same level of entrained air.

****

ASTM C618, Class N, or F except that the maximum total alkalies must be [3] [6] percent. If the aggregates are reactive the maximum calcium oxide content must be 13.0 percent. Class C must not be used.

2.2.1.3 Ground Iron Blast-Furnace Slag

ASTM C989/C989M, Grade 120.

[2.2.1.4 Silica Fume

****
NOTE: Use silica fume concrete for marine structures where low permeability and enhanced durability are necessary. The silica fume and HRWR additive should be from the same manufacturer. The Contractor and batch plant may need help from the manufacturer. Select weight percentage based on performance required. If used, a replacement of 7 percent is recommended.
****

****
NOTE: Use for high durability and low permeability. The initial cost of the concrete will increase, and supervision at the batch plant, finishing, and curing is necessary. A HRWR must be used with silica fume. The slump can be increased 50 to 125 mm 2 to 5 inches without reducing strength. Finishing may be more difficult. Proper curing is essential because there is a tendency for plastic shrinkage cracking.
****

ASTM C1240, provide silica fume that is a by-product of silicon or ferrosilicon production. Provide percent by weight of the total cementitious materials as indicated in table below.

]2.2.1.5 Supplemental Cementitious Materials (SCM) Content

The concrete mix must contain one of the four SCMs listed below, or a linear combination thereof.

SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT		
SCM	**Minimum Content**	**Maximum Content**
Class N Pozzolan or Class F Fly Ash with SiO_2 plus Al_2O_3 plus Fe_2O_3 greater than 70 percent	25 percent	35 percent
Class N Pozzolan or Class F Fly Ash with SiO_2 plus Al_2O_3 plus Fe_2O_3 greater than 80 percent	20 percent	35 percent
Class N Pozzolan or Class F Fly Ash with SiO_2 plus Al_2O_3 plus Fe_2O_3 greater than 90 percent	15 percent	35 percent
GGBF Slag	30 percent	50 percent

SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT		
SCM	**Minimum Content**	**Maximum Content**
Silica Fume	5 percent	10 percent

2.2.2 Water

Water must be fresh, clean, and potable; free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances deleterious to concrete or steel.

2.2.3 Aggregates

****

NOTE: For piles in areas where reactive aggregates are likely to be supplied, provide for additional tests and certification to insure that reactive aggregates will not be used. While not wholly conclusive, petrographic examination (ASTM C295/C295M, chemical test (ASTM C289), and mortar bar method (ASTM C227) are valuable indicators. While more reliable, the concrete prism test (ASTM C1293) takes 1 to 2 years to complete and is not practical. The accelerated mortar bar method (ASTM C1260) is similarly reliable and takes only 16 days to yield results. In areas where reactive aggregates can not be avoided, specify use of low alkali cement, and/or cements modified to mitigate alkali-silica reactivity. Service records of concrete made with these materials along with tests should be used in evaluating these materials.

****

****

NOTE: Include modification to ASTM C33 when reactive aggregates could be encountered. More modifications may be required. Additional tests and certifications may be required in the submittal paragraphs.

****

ASTM C33/C33M[, except as modified herein. Provide aggregate free from any substance which may be deleteriously reactive with alkalies in cement in an amount sufficient to cause excessive expansion of concrete].[Dune sand must not be used as fine aggregate.] Do not mix, store in same stockpile, or use fine aggregates from different sources of supply in same concrete mix or same structure without approval. The fineness modulus of fine aggregate must be not less than 2.40 or greater than 3.0. For piles that will be exposed to freezing and thawing, fine and coarse aggregate subjected to five cycles of the sodium sulfate soundness test must show a loss not greater than 10 percent. If the selected aggregates fail the soundness test, the Contractor may use the aggregate source, provided concrete specimens made with the aggregates to be used for the piles must have a durability factor of not less than 80 based on 300 cycles of freezing and thawing when tested in accordance with ASTM C666/C666M. Prior to pile fabrication, submit certified test reports for the following tests specified in ASTM C33/C33M[, in addition, [twice] [_____] during each shift when the concrete plant is operating, the gradation of each size of aggregate must be tested in accordance with ASTM C136/C136M]:

a. Grading

b. Amount of material finer than 75 micrometers No. 200 sieve

c. Organic impurities

d. Soundness

e. Clay lumps and friable particles

f. Coal and lignite

g. Weight of slag

h. Abrasion of coarse aggregate

i. Fineness modulus

j. Reactive aggregates

k. Freezing and thawing

2.2.3.1 Alkali-Silica Reactivity (ASR)

Fine and coarse aggregates to be used in all concrete must be evaluated and tested by the Contractor for alkali-aggregate activity.

The fine and coarse aggregates must be evaluated separately, using ASTM C1260. Test results of the individual aggregates must have a measured expansion equal to or less than 0.08 percent at 16 days after casting. Should the test data indicate an expansion of greater than 0.08 percent, the aggregates(s) must be rejected or additional testing, using ASTM C1567 must be performed as follows: utilize the Contractor's proposed low alkali portland cement [blended cement] and SCM in combination with the proposed aggregate for the test portioning. The SCM quantity must be determined that will meet all the requirements of these specifications and that will lower the ASTM C1567 expansion to equal or less than 0.08 percent at 16 days after casting.

If the above option does not lower the expansion to less than 0.08 percent at 16 days after casting, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing to the Contracting Officer for evaluation and acceptance.

2.2.4 Admixtures

****

NOTE: For guidance in use of either water-reducing admixtures, set retarding admixtures, or combination of admixtures, see ACI 543R, "Recommendations for Design, Manufacture, and Installation of Concrete Piles.

****

Chemical admixtures must conform to ASTM C494/C494M, [Type A] [Type B].

[Air-entraining admixture must conform to ASTM C260/C260M.]Do not use admixtures containing chlorides.

2.2.5   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.

2.2.6   Reinforcing Steel

****

NOTE: Minimum cover for reinforcing steel in concrete structures is dependent upon the environment, soil conditions, need for corrosion protection, and location of piling. For normal exposure minimum cover is 50 mm 2 inches. For piles exposed to marine conditions (chloride content above 1000 ppm) in or within about 300 m 1000 feet of the ocean or tidal water, use 75 mm 3 inches minimum cover, including chamfered corners. For additional detailed guidance, see following publications: ACI 543R, "Recommendations for Design, Manufacture and Installation of Concrete Piles" (ACI Manual, Part 3); State of California, Department of Public Works, Design Specifications, Volume l, Bridge Planning and Design Manual, Chapter 6. Piles to be used in a marine environment may receive a protective coating, particularly if the piles are steam cured. The protective coating should be applied to that portion of pile which remains aboveground or water line. Show areas to be protected on drawings.

****

****

NOTE: Insert grade of reinforcement. Specify ASTM A706/A706M reinforcing where welding or bending of reinforcement bars is important. In addition, ASTM A934/A934M may be specified for epoxy coating of reinforcing where extra reinforcement protection is required.

****

[ASTM A615/A615M, Grade [300 MPa] [420 MPa] [40 ksi] [60 ksi];] [ASTM A706/A706M, Grade [420 MPa] [[_____] MPa] [60 ksi] [[_____] ksi];] [ASTM A996/A996M, Grade [420 MPa] [[_____] MPa] [60 ksi] [[_____] ksi]]. Weld reinforcing steel in accordance with AWS D1.4/D1.4M.

2.2.6.1   Spirals and Ties

****

NOTE: If project has been designed for epoxy rebar, add ASTM A934/A934M, "Epoxy-Coated Prefabricated Steel Reinforcing Bars" in this paragraph and in the paragraph REFERENCES.

****

ASTM A1064/A1064M for steel spirals and ASTM A615/A615M [ASTM A706/A706M] for ties.

2.2.7   Grout

Provide cement grout for prestressed piles using materials conforming to requirements stipulated herein for concrete mixes or for post-tensioned piles, PTI M55.1. Use admixtures, if required, known to have no injurious effects on steel or concrete. Do not use admixtures containing calcium chloride. Grout must have a minimum compressive strength of 48 MPa 7,000 psi in 28 days, as determined by testing 50 mm by 50 mm by 50 mm 2 inch by 2 inch by 2 inch cubes.

2.2.8   Joint Sealing Material

The abutting joint surfaces of precast segments must be covered by a sealing material of sufficient thickness to fill all voids between the end surface, except at the core holes for the stressing strands and telltales, when brought together under compression as specified. This sealing material must attain a minimum ultimate compressive strength of 48 MPa 7,000 psi in 28 days, and must be as resistant to exposure and weathering as is the concrete.

2.2.9   Epoxy Coating

[EP-3] [_____] conforming to Section [_____], "Epoxy-Resin Systems" of [_____] DOT RBS. Coat [_____]mm [_____] feet of piles outer surface.

2.2.10   Pressure Grouting Epoxy

2.2.10.1   Crack Sealer for Pressure Grouting

ASTM C881/C881M, Type IV, Grade 1, Class B or C without filler.

2.2.10.2   Crack Surface Sealer for Pressure Grouting

ASTM C881/C881M, Type IV, Grade 3, Class B or C with mineral filler.

[2.2.11   H-Pile Extensions

Use H-pile extensions for composite prestressed concrete-steel piles of steel conforming to the requirements of [ASTM A36/A36M] [ASTM A572/A572M].

][2.2.12   Pile Driving Points

Use pile driving points of steel conforming to the requirements of ASTM A27/A27M or [ASTM A36/A36M] [ASTM A572/A572M], of the [type] [details] indicated.

]2.2.13   Prestressing/Post Tensioning Tendons

ASTM A416/A416M, Grade [1720 MPa] [1860 MPa] [250 ksi] [270 ksi], uncoated, 7 wire, low-relaxation strand or ASTM A886/A886M, Grade [1860 MPa] [[_____] MPa] [270 ksi] [[_____] ksi], indented, 7 wire, low-relaxation strand (including supplement).

2.3 CONCRETE

2.3.1 Concrete Mix Design

****

NOTE: Insert the specified compressive strength, f'c. A minimum of 48 MPa 7000 psi is normally specified. Consider reducing average overstrength factor to produce a more economical concrete mix design. ACI 318M ACI 318 may be modified for a specified compressive strength, f'c, over 35 MPa 5000 psi to permit a required average compressive strength, f'cr, of f'c plus 4.8 MPa 700 psi. Concrete may be proportioned in accordance with ACI 214R for the probability of one test in 10 falling below the specified compressive strength, f'c, if the mix design reflects actual concrete plant standard deviations and the resulting production concrete conforms to specified requirements. Do not use lightweight or fiber-reinforced concrete.

****

Concrete must have a minimum specified compressive strength, f'c, of [_____] [7000] psi at 28 days. The minimum cementitious materials content must be 354 kg per cubic meter 600 pounds per cubic yard of concrete. The design must be prepared in accordance with ACI 211.1 and ACI 318M ACI 318. The mix design must be based on current materials previously evaluated by the concrete producer whose established methods of statistical quality control is in conformance with ACI 318M ACI 318. In the absence of such data, the Contractor must sample and test the aggregates for the design of concrete. Calcium Nitrite must be added to the mix at a rate of [10 liters per cubic meter] [2.0 gallons per cubic yard].

2.3.2 Concrete Mix Design Proportioning

a. Water and cement ratio must be equal to or less than 0.40. If fly ash is used, the water and cement ratio must be calculated as the weight of water divided by the weight of cement plus 60 percent of the weight of fly ash. If silica fume is used, the water and cement ratio must be calculated as the weight of water divided by the weight of cement plus the weight of silica fume.

b. Maximum aggregate size must not exceed 19 mm 3/4 inch.

****

NOTE: Air-entrainment may be considered optional only in regions that do not experience freezing temperatures.

****

c. Air-entrainment must be 4.5 to 7.5 percent. Determine air void structure in accordance with ACI 212.3R. Spacing factor must be less than 2.5 mm 0.01 inch, the specific surface area must be greater than 0.39 square meter per 0.000016 cubic meter 600 square inches per cubic inch of air void volume, and the number of air voids per mm inch of traverse must be significantly greater than the numerical value of the percentage of air in the concrete.

2.3.3 Trial Mixtures

Trial mixtures having proportions and consistencies of the proposed mix design must be made to document the Contractor's ability to produce workable concrete which does not segregate or show excessive slump loss characteristics.

2.4 FABRICATION

Fabrication of the concrete cylinder piles, including storage and handling of materials, batching and mixing of concrete, stressing, sampling, testing and recording must follow the guidelines set forth in PCI MNL-116 "Manual for Quality Control for Plants and Production of Precast and Prestressed Products" or the QA/QC procedure established under the ISO 9002 certification program, unless otherwise noted in the specifications or approved by the Contracting Officer. Test piles must be identical to and manufactured by the same firm as the production piles.

2.4.1 Manufacturing of Piles and Pile Sections

The aggregates, cement and water must be proportioned batched by calibrated device and mixed thoroughly by suitable mixing plant to produce consistent and homogeneous concrete.

Full length, pretensioned concrete piles and post-tensioned pile sections can be manufactured by the centrifugal casting process. If this process is utilized, individual piles and pile sections must be formed and compacted by centrifugal force in a machine of suitable type so designed that the concrete molds may be revolved at speeds sufficient to ensure even distribution and dense packing of concrete without the creation of voids behind reinforcing steel.

Filling the mold and spinning should be continuous and must all take place before any of the concrete in the mold has taken an initial set. Excess water forced to the center must be drained or removed prior to curing. The section must be cured in the mold until the concrete has attained the indicated strength to prevent deformation or damage during demolding.

Alternatively, concrete cylinder piles can be made by the static cast method. Extruded dry cast method must not be allowed for static cast piles.

Manufacturing by the static cast method must utilize rigid steel forms and be vibrated as necessary to ensure that the concrete is consolidated and homogeneous for the entire pile length.

Filling the mold should be continuous and must be completed for each individual pile before any of the concrete in the mold has taken an initial set. The pile must be cured in the mold until the concrete has attained the indicated strength to prevent deformation or damage during demolding. After initial set has occurred, the top form section may be removed to allow finishing of the pour stop along the exterior top face of the pile.

For both fabrication methods, the wall thickness of the pile sections must be as specified on the plans.

2.4.2 Spiral Reinforcing

****

NOTE: Minimum cover for reinforcing steel in concrete structures is dependent upon the environment, soil conditions, need for corrosion protection, and location of piling. For normal exposure minimum cover is 50 mm 2 inches. For piles exposed to marine conditions (chloride content above 1000 ppm), use 75 mm 3 inches minimum cover except at corners where 100 mm 4 inches of cover should be provided. In normal and marine conditions, 38 mm 1-1/2 inch cover may be used for post-tensioned, centrifugally cast piles using no-slump concrete, with minimum 9.15 sacks of cement per cubic meter 7 sacks cement per cubic yard. For additional detailed guidance, see following publications: ACI 543R, "Recommendations for Design, Manufacture and Installation of Concrete Piles" (ACI Manual, Part 3); State of California, Department of Public Works, Design Specifications, Volume l, Bridge Planning and Design Manual, Chapter 6. Piles to be used in a marine environment may receive a protective coating, particularly if the piles are steam cured. The protective coating should be applied to that portion of pile which remains aboveground or water line. Show areas to be protected on drawings. A marine environment is defined as in or within about 300 m 1000 feet of the ocean or tidal water.

****

Sections must have a spiral reinforcement cage, arranged and dimensioned as shown on the contract drawings. This reinforcing cage must be securely held in position during the casting or spinning of the concrete.

Center to center spacing of spiral (defined as spiral pitch) must not exceed six times the spiral wire diameter in the portion of the pile extending from the soffit of the pile cap to a location equal to the point of fixity below mudline as shown on the contract drawings.

The spiral steel reinforcing must be outside the prestress bars and must have a minimum concrete cover to the outside surface of the pile section as shown on the contract drawings.[The spiral steel reinforcing must be outside the tendon ducts and must have a minimum concrete cover of 38 mm 1-1/2 inches to the outside surface of the pile section.]

2.4.3 Arrangement of Strands

The number, size, and arrangement of the prestressing strands must be in accordance with the details shown on the contract drawings.

2.4.4 Curing of Piles

Cure piles using moist or accelerated curing. Curing of piles must be in accordance with the PCI MNL-116 except as follows.

2.4.4.1 Moist Curing

Moist cure using moist burlap coverings, plastic sheeting, or membrane curing compound until minimum strength to detension is achieved.

2.4.4.2 Accelerated Curing

After placement of concrete, moist cure for a period of 4 hours. Accelerated cure until concrete has reached specified release strength. Enclose casting bed for accelerated curing with a suitable enclosure. During application of steam or heat, increase the air temperature at a rate not to exceed 22 C degrees 40 F degrees per hour. Cure at a maximum temperature of 65 degrees C 150 degrees F until concrete has reached specified release strength. Reduce temperature at a rate not to exceed 11 C degrees 20 F degrees per hour until a temperature of 11 C degrees 20 F degrees above ambient air temperature is reached. After accelerated curing, moist cure using either water or membrane curing until a total accelerated and moist curing time of 72 hours is achieved.

2.4.5 Handling

Piles must not be demolded or lifted off from casting beds unless the designed lifting strength or minimum works cube strength of 39.3 MPa 5,700 psi (whichever is greater) has been achieved. Lifting device or crane must be such that no shock or impact is imposed on piles.

Care should be taken at all stages or transporting, lifting and handling to ensure the piles are not damaged or cracked. Piles should be stored on firm stable ground not susceptible to settlement under the weight of piles. The piles must be placed on strong supports (hard wood) which are truly level and spaced so as to avoid undue bending stress in the piles. The supports should be vertically above one another.

No pile must be driven before the 28-day strength of concrete has been achieved.

2.5 CONCRETE CYLINDER PILE POST-TENSIONED CENTRIFUGALLY CAST (ALTERNATIVE I)

2.5.1 Anchorages and End Fittings

ACI 318MACI 318, for post-tensioned assemblies.

2.5.2 Forms

Provide forms of metal, braced and stiffened against deformation, accurately constructed, watertight, and supported on unyielding casting beds. Forms must permit movement of pile without damage during release of the prestressing force. Make piles to dimensional tolerances in accordance with PCI MNL-116 and as follows:

a. Location of Reinforcing Steel

   (1) Main Reinforcement: 3 to 6 mm 1/8 to 1/4 inch from position designated on drawings.

   (2) Spacing of Spiral: Plus or minus 13 mm 1/2 inch from position designated on drawings exclusive of concrete cover requirements.

b. Location of Pipe Sleeves from True Position: Plus or minus 10 mm 3/8 inch.

2.5.3 Longitudinal Reinforcement

The number, size, and arrangement of the longitudinal post tensioned tendons must be in accordance with the details shown on the contract drawings.

The main longitude reinforcement must be fitted symmetrically, equally and continuously spread over the whole length without joint or lap. The main longitudinal post tensioned tendons should be level at the top of the pile and should fit tightly into the pile shoe and end plate.

2.5.4 Spin Casting

The spinning of the whole assembly must follow proven spinning procedure that has been used by the manufacturer in the manufacturing of similar pile sections.

2.5.5 Longitudinal Ducts (holes) for Prestressing Tendons

Details and positioning of ducts (holes) must be in accordance with PCI MNL-116, and as specified herein. Longitudinal ducts for the prestressing tendons must be formed in the walls of the pile sections during casting. The ducts must be 35 mm 1-3/8 inches (nominal diameter) and positioned so that there must be a minimum cover of 38 mm 1-1/2 inches from the edge of the ducts to the outside surface of the pile section.

2.5.6 Concrete Strength

****

NOTE: Specify "assembly strength." Assembly strength of 30 MPa 4000 psi for (Design strength) of 50 MPa 7000 psi or 0.7 of the 28-day design strength is desirable; however, some regions use 0.8 of the design strength. Check with local pile manufacturers.

****

The pile sections must not be assembled together into a pile until the compressive strength of the concrete has reached 30 MPa 4,000 psi as determined by cylinders cured in the same manner as the sections.

2.5.7 Alignment of Sections

Pile sections must be positioned in accurate alignment so that the axis of the pile does not deviate from a straight line more than 3 mm per 3 m 1/8-inch per 10 feet of length. Adjacent sections must be positioned so that the maximum deviation of the outside surface of the joint does not exceed 6 mm 1/4-inch. Where membrane curing is used, remove curing compound from abutting end-surface of sections. The abutting joining surfaces must be covered by a joint sealing material of sufficient thickness to fill voids between end surfaces, except at the core holes for the stressing. The pile section must be brought into contact and held together by a force equivalent to not less than 690 kPa 100 psi on the gross concrete area, until the sealing materials has set.

2.5.8 Post Tensioning

Tendons must be tensioned to an allowable unit stress as indicated on the plans. The specified tension must be measured by the gage pressure of the hydraulic stressing jack and verified by the elongation of the steel strand. Provide jack gage calibrated within past 6 months by a laboratory approved by the Contracting Officer. The variation in the actual elongation and the calculated elongation must not be greater than 5 percent. Tension in the tendons must be maintained by mechanical end-locks or anchors until final stress transfer. Aggregate prestress loss through transfer of stressing force from jack to temporary anchorage must not exceed an average of 10 percent in any one cable or an average of 5 percent for all cables in one pile.

2.5.9 Grouting

After tensioning all tendons, each tendon hole must be cleaned and completely filled with grout, including holes not used for tensioning. The pressure of the grout is to be slowly raised to a minimum of 690 kPa 100 psi but not over 1034 kPa 150 psi and held for at least one minute. While the grout is curing, the pile must not be moved or handled in any manner that could damage the pile.

2.5.10 Stress Transfer (Detensioning)

Transfer of the post tension force from temporary end locks to grouted tendons must not be done until the grout has reached a compressive strength of 30 MPa 4,000 psi. Prestressing tendons must be considered to be without slippage from the removal of the end locks when, upon cutting the wires between the end of the pile and the anchor with a burning torch, the wires do not part under stress with a "cup and cone" fracture, but are burned through with the torch. Piles that show evidence of prestressing cable slippage must be rejected.

2.6 CONCRETE CYLINDER PILE PRESTRESSED STATIC CAST (ALTERNATIVE II)

2.6.1 Forms

Use collapsible internal formwork to manufacture piles. Do not use a mandrel to manufacture piles. Provide forms of metal, braced and stiffened against deformation, accurately constructed, watertight, and supported on unyielding casting beds. Forms must permit movement of pile without damage during release of the prestressing force. Make piles to dimensional tolerances in accordance with PCI MNL-116, PCI MNL-135, and as follows:

a. Location of Reinforcing Steel

    (1) Main Reinforcement: 3 to 6 mm 1/8 to 1/4 inch from position designated on drawings.

    (2) Spacing of Spiral: Plus or minus 13 mm 1/2 inch from position designated on drawings exclusive of concrete cover requirements.

b. Location of Pipe Sleeves from True Position: Plus or minus 10 mm 3/8 inch.

2.6.2 Casting

2.6.2.1 Conveying

Convey concrete to formwork in accordance with PCI MNL-116, and as specified herein. Clean conveying equipment thoroughly before each run.

During placing, make any free vertical drop of the concrete less than 0.91 m 3 feet. Remove concrete which has segregated in conveying or placing.

2.6.2.2 Placing and Casting

Perform concrete casting within 3 days after pretensioning steel; however, do not deposit concrete in forms until placement of reinforcement and anchorages has been inspected and approved by pile manufacturer's quality control representative. Produce each pile of dense concrete straight with smooth surfaces with reinforcement retained in its proper position during fabrication. Use vibrator with heads smaller than the minimum distance between steel for pretensioning. Make surface of pile ends perpendicular to axis of pile. Chamfer, a minimum of [19 mm] [3/4 inch] [ends of piles].

2.6.3 Pretensioning

****

NOTE: Use minimum nominal level of prestress equal to 8.3 MPa 1200 psi in the gross pile section, resulting from the combined prestressing force in the strands after all losses.

****

Pretensioning must be performed in accordance with PCI MNL-116, and as specified herein. Measure tendon to which steel is to be pretensioned by jack pressure read on a calibrated gage and verify by elongation of steel. Use gage calibrated within last 6 months by a laboratory approved by Contracting Officer. Provide means for measuring elongation of steel to nearest 3 mm 1/8 inch. When difference between results of measurement and gage reading is more than 5 percent, determine cause of discrepancy and correct. Give tensioning steel a uniform prestress prior to being brought to design prestress. Induce same initial prestress in each unit when several units of prestressing steel in a pile are stretched simultaneously.

2.6.4 Stress Transfer (Detensioning)

****

NOTE: Specify "release strength." Release strength of 30 MPa 4000 psi for (Design strength) of 35 MPa 5000 psi or 0.7 of the 28-day design strength is desirable; however, some regions use 0.8 of the design strength. Check with local pile manufacturers.

****

Perform release of prestressed steel in pretensioned piles in such an order that eccentricity of prestress will be minimized. Gradually release tension in strands from anchorage. Detension after approval by pile manufacturer's quality control representative. Perform transfer of prestressing force when concrete has reached a minimum compressive strength of [_____] MPa [_____] psi.

2.7 FABRICATION TOLERANCES

a. Pile ends must be plane surfaces and perpendicular to the longitudinal axis of the pile with a maximum deviation of 6 mm 1/4-inch per 12 inches at the pile head. End surfaces must also be free of spalls. Any end surface which exhibits more than ten percent of the end surface area spalled to a depth of more than 3 mm 1/8 inch will be rejected.

b. Accumulated deviation from straightness measured along two perpendicular faces of the pile, while not subjected to bending (sweep), must not exceed 3 mm per 1 m 1/8-inch per 10 feet of length.

c. Overall lengths of individual piles must be within 0.3 percent of the overall length specified.

d. The outside diameter of piles is defined as the average of two measurements taken along the axes at right angles to each other on cross section. The wall thickness is defined as the average of four measurements taken along pile axes at right angles to each other in a cross section:

Cross Sectional Dimensions	Tolerances
nominal outside diameter	minus 3 mm to plus 6 mm minus 1/8-inch to plus 1/4-inch
wall thickness of hollow section	minus 3 mm to plus 10 mm minus 1/8-inch to plus 3/8-inch

[2.8 PROTECTION FROM FREEZING

For cylinder piles exposed to freezing, provide precast drain holes through pile wall at approximate ground water elevation and fill pile with free-draining material. For piles standing in open water, place a concrete plug from lowest freeze depth to a minimum of 300 mm one foot above maximum high-water level and provide precast drain holes through pile wall just above surface of concrete plug.

]2.9 PRODUCT QUALITY CONTROL

Where piling is manufactured in a plant with an established quality control program as attested to by a current certification in the PCI "Certification Program for Quality Control" or the QA/QC procedure established under the ISO 9002 certification program, perform product quality control in accordance with PCI MNL-116 or ISO 9002, respectively. Where piling is manufactured by specialists or in plants not currently enrolled in the PCI "Certification Program for Quality Control," or the QA/QC procedure established under the ISO 9002 certification program, set-up a product quality control system in accordance with PCI MNL-116 or ISO 9002 and perform concrete and aggregate quality control testing using an independent commercial testing laboratory approved by the Contracting Officer in accordance with the following.

2.9.1 Aggregate Tests

Take samples of fine and coarse aggregate at concrete batch plant and test. Perform mechanical analysis (one test for each aggregate size) in accordance with ASTM C136/C136M. Tabulate results of tests in accordance with ASTM C33/C33M.

2.9.2 Slump and Strength Tests

Sample concrete in accordance with ASTM C172/C172M at time concrete is deposited for each production line. Perform slump tests in accordance with ASTM C143/C143M. Mold cylinders in accordance with ASTM C31/C31M. Mold at least six cylinders per day or one for every [15] [45] cubic meter

[20] [60] cubic yards of concrete placed, whichever is greater. Cure cylinders in same manner as piles and for accelerated curing, place at coolest point in casting bed. Perform strength tests in accordance with ASTM C39/C39M. Test two cylinders of each set at 7 days or 14 days, or at a time for establishing transfer of prestressing force (release strength) and removal of pile from forms. Test remaining cylinders of each set 28 days after molding.

2.9.3 Compressive Strength Test Results

Evaluate compressive strength test results at 28 days in accordance with ACI 214R using a coefficient of variation of 10 percent. Evaluate strength of concrete by averaging test results of each set of standard cylinders tested at 28 days. Not more than 10 percent of individual cylinders tested must have a compressive strength less than specified design strength.

2.9.4 Changes in Proportions

If, after evaluation of strength test results, compressive strength is less than specified compressive strength, make adjustments in proportions and water content and changes in temperature, moisture, and curing procedures as necessary to secure specified strength. Submit changes in mix design to Contracting Officer in writing.

2.9.5 Chloride Ion Concentration

Sampling and determination of water-soluble chloride ion content in accordance with ASTM C1218/C1218M. Maximum water soluble-chloride ion concentrations in hardened concrete at ages from 28 to 42 days contributed from the ingredients including water, aggregates, cementitious materials, and admixtures must not exceed 0.06 percent by weight of cement.

2.9.6 Chloride Ion Penetration

To ensure the durability of concrete in marine environment, concrete must be proportioned to have the chloride ion penetration test in accordance with ASTM C1202, and be below 3,000 coulombs for concrete specimens tested at 60 days.[Alternatively, a ponding test in accordance with AASHTO T 259 may be performed to validate chloride ion penetration in accordance with ASTM C1202.]

[2.9.7 Destructive Pile Testing

At the beginning of production, produce three additional piles with the same length as production piles which must be randomly selected by the Contracting Officer for testing by taking core samples. Take three core samples each location at 2.4m 8 feet from head and toe and at mid length of the pile or as directed by the Contracting Officer for a total of 9 core samples per pile. Visually inspect each sample for evidence of segregation and distribution of reinforcements. Test all core samples for compressive strength according to ASTM C42/C42M. The average compressive strength of any three consecutively tested samples must not be less than 85 percent of specified 28-day compressive strength of concrete. If any of the above requirements for segregation, distribution of reinforcement and strength are not met, all production piles produced until the date of testing must be subject to rejection.

In addition to the above, saw cut each pile into three equal length sections. Each section must be inspected for specified dimension, strand placement and clear cover tolerances.

]2.10   MATERIAL SUSTAINABILITY CRITERIA

For materials used, where applicable and to extent allowed by performance criteria, provide and document the following in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING:

a. Recycled content for fly ash and pozzolan

b. Recycled content for Ground Iron Blast-Furnace Slag

c. Recycled content for Silica Fume

d. Minimum [75 percent] [_____] recycled content for steel used for stressed tendon reinforcing

2.11   PILE DRIVING EQUIPMENT

Submit descriptions of pile driving equipment, including hammers, power packs, driving helmets, hammer cushions, pile cushions, leads, extractors, jetting equipment, and preboring equipment at least 30 days prior to commencement of work. Provide Pile Driving Equipment as mentioned in this section.

2.11.1   Pile Hammers

Provide a hammer capable of developing the indicated ultimate pile capacity at blow count less than 100 per 300 mm foot considering hammer impact velocity; ram weight; stiffness of hammer and pile cushions; cross section, length, and total weight of pile; and character of subsurface material to be encountered.[Use the same pile hammer, operating at the same rate and in the same manner, as that used for driving test piles.] Use wave equation analysis to verify that the hammer will develop stresses within acceptable limits in the piles. At final driving, operate pile hammer in accordance with manufacturer's recommendation. Provide the plant and equipment for air hammers that have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer. The hose connecting the compressor with the hammer must be at least the minimum size recommended by the Manufacturer. Evaluate hammer performance at the end of driving by measuring blows per minute and comparing with the manufacturer's recommendations. Measure impact velocity of open-end (single acting) diesel hammers at all times during pile driving operations with a device for this purpose. If such a device is not available, obtain the stroke by measuring the speed of operation either manually or with a device that makes the measurement automatically. Equip closed-end (double acting) diesel hammers with a bounce chamber pressure gauge in good working order, mounted near ground level so as to be easily read by the Contracting Officer. Provide a correlation chart of bounce chamber pressure and potential energy. Equip hydraulic hammers 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 Engineer.

2.11.2   Driving Helmets and Cushion Blocks

2.11.2.1   Driving Helmets or Caps and Pile Cushions

Use a steel driving helmet or cap including a pile cushion between top of pile and driving helmet or cap to prevent impact damage to pile. Use a driving helmet or cap and pile cushion combination capable of protecting pile head, minimizing energy absorption and dissipation, and transmitting hammer energy uniformly over top of pile. Provide driving helmet or cap that fits sufficiently loose around top of pile so that pile may be free to rotate without binding within driving helmet.[During test pile installation, demonstrate to satisfaction of Contracting Officer that equipment to be used on project performs specified function.] Use pile cushion of solid wood or of laminated construction using plywood, softwood or hardwood boards with grain parallel to end of pile. Select the pile cushion thickness placed on the pile head prior to driving by wave equation analysis so that the limiting driving stresses are not exceeded. Replace pile cushion at the start of driving of each pile and when it becomes highly compressed, charred or burned, or has become spongy or deteriorated in any manner. Show details of driving helmets, capblocks (hammer cushions), and pile cushions. Submit 2 weeks prior to [test] pile installation.

2.11.2.2   Hammer Cushion or Capblock

****

NOTE: Select either wood or aluminum/micarta capblock. Delete inappropriate sentences. An aluminum/micarta capblock is recommended because of its consistent elastic properties and long life. If final pile penetration resistance is based on a Wave Equation analysis, the type of capblock used should be the same as that used in the analysis.

****

Use a hammer cushion or capblock between driving helmet or cap and hammer ram consisting of[a solid hardwood block with grain parallel to the pile axis and enclosed in a close-fitting steel housing][aluminum and micarta (or equal) discs stacked alternately in a steel housing or a suitable polymer designed for this specific purpose as indicated by the hammer manufacturer]. Use steel plates at top and bottom of capblock (hammer cushion).[Replace wood capblock (hammer cushion) when it becomes highly compressed, charred or burned or becomes spongy or deteriorated in any manner].[Replace aluminum, micarta or polymer discs that have become damaged, split or deteriorated in any manner.][Do not replace wood capblock (hammer cushion) during final driving of any pile.] Do not use small wood blocks, wood chips, rope or other materials that permit excessive loss of hammer energy.

PART 3   EXECUTION

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NOTE: In some cases, cylinder piles may be advanced using using a collapsible auger inside the pile and washing the pile section down. In other cases, large diameter piles have been assembled by stacking precast rings and post tensioning them together.

****

3.1 PRELIMINARY WORK

3.1.1 Wave Equation Analysis 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	
Concrete	
Compression	0.85f'c minus UPL
Tension	(3 times (the square root of f'c)) plus UPL
f'c is compressive strength of concrete UPL = Unit Prestress after Losses (Obtain values from pile manufacturer)	

c. Perform a refined Wave Equation Analysis upon completion of the dynamic and static testing programs outlined in this specification section, taking into consideration the evaluated capacities, gain/loss factors and recommended production pile lengths.[Develop production pile driving criteria based on the results of the refined Wave Equation Evaluations.]

d. All pile driving equipment provided by the Contractor will be subject to the approval of the Contractor's Geotechnical Consultant. Complete the attached pile and driving equipment data form, including hammer information, in full as part of the submittal of the results of the Wave Equation Analyses.

e. Pay for the cost of performing the Wave Equation Analyses and include in the base bid.

3.1.2 Pile Length Markings

Mark each pile prior to driving with horizontal lines at 305 mm one foot intervals. Mark the interval number on pile every 1.52 m 5 feet from pile tip.

3.2 PILE DRIVING

3.2.1 Driving Piles

****
NOTE: Delete bracketed option for foundation

excavation when not required. Delete items in brackets dealing with tip elevation and driving resistance when test piles or load tests are not used. Delete item in brackets regarding predrilling or jetting when procedure is not used. If needed, insert maximum hammer energy for no tip resistance. This can be determined by comparing tensile stresses in pile resulting from a Wave Equation Analysis with effective prestress in pile.
****

Notify Contracting Officer 10 days prior to driving of [test]piles[and load test].[Stop foundation excavation at 300 mm one foot above foundation grade before piles are driven. Do not drive piles within 30 meter 100 feet of concrete less than 7 days old. Complete excavation to lines and grades shown when pile driving is completed.] Piles may be driven when the specified 28-day concrete strength has been achieved but not less than 7 days after casting.[The Contractor's Geotechnical Consultant will determine the terminal driving criteria based on results of [dynamic pile driving tests at the end of drive or restrike] [static load tests] [wave equation analysis].] Drive piles to [the terminal driving criteria] [or below "calculated"] [indicated tip elevation] [to reach a driving resistance established by the [dynamic pile driving tests at the end of drive or restrike] [static load tests] [wave equation analyses (WEAP)] in accordance with the schedule which the [Contractor's Geotechnical Consultant] [Contracting Officer] will prepare from the test-pile driving data]. During initial driving and until pile tip has penetrated beyond layers of very soft soil [or below bottom of predrilled or prejetted holes], use a reduced driving energy of the hammer as required to prevent pile damage. Refusal criteria will be established by the Contracting Officer. If a pile fails to reach ["calculated"] [indicated] tip elevation, [or if a pile reaches ["calculated"] tip elevation without reaching required driving resistance,] notify Contracting Officer and perform corrective measures as directed. Provide hearing protection when noise levels exceed 140 dB. Do not handle or move piles or pile sections in any manner that would result in cracking or permanent damage to the concrete or to the grout surrounding the prestressing cables. Piles may be driven without pile guides or leads providing a hammer guide frame is used to keep the pile and hammer in alignment.

3.2.2 Protection of Piles

****
NOTE: Delete references to batter piles when not applicable to the project.
****

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.[Where pile or projecting reinforcement orientation is essential, take precautionary measures to maintain the orientation during driving.][Take special care in supporting battered piles to prevent excessive bending stresses in pile.] Square top of pile to longitudinal axis of pile. Maintain axial alignment of pile hammer with that of the pile. If the Contractor elects to use a pile head with projecting strands or mild steel reinforcement, prevent direct impact forces from being transmitted through the reinforcement, by using a special driving head.

3.2.3 Pile Placement and Tolerances in Driving

****
NOTE: Omit references to batter piles when not applicable to the project. Select appropriate tolerances for type of pile. Use more stringent criteria as necessary based on the application. Confirm with the structural engineer.
****

Submit pile placement plans at least 30 days prior to delivery of piles to the job site. Drive piles with a variation of not more than 2 percent from vertical for plumb piles or more than 4 percent from required angle for batter piles. Maintain and check axial alignment of pile and leads at all times. If subsurface conditions cause pile drifting beyond allowable axial alignment tolerance, notify Contracting Officer and perform corrective measures as directed. Place butts within 100 mm 4 inches of location indicated.[Manipulation of piles within specified tolerances[will not be permitted.][will be permitted, to a maximum of 1-1/2-percent of their exposed length above ground surface or mudline.]] In addition to specified tolerances, maintain a location to provide a clear distance of at least 125 mm 5 inches from butt to edge of pile cap. If clear distance can not be maintained, then notify Contracting Officer. Check each pile for heave. Redrive heaved piles to required point elevation.

3.2.4 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 Government.

3.2.5 Jetting of Piles

****
NOTE: Jetting should generally not be permitted for piles:

1. Dependent on side friction in fine-grained low permeability soils (high clay or silt content) where considerable time is required for the soil to reconsolidate around the piles.

2. Subject to uplift or lateral forces.

3. Adjacent to existing structures.

4. In closely spaced clusters unless the load capacity is confirmed by test.
****

Water jets will[not] be permitted.[Use jetting to assist driving piles through strata that cannot be penetrated practicably by use of the hammer alone.[Restrict driving to a static weight while water is being injected to prevent inducing tensile stresses in the piles which damage the concrete.] Discontinue jetting and resume hammer driving after the penetration of the strata requiring jetting has been accomplished.][Discontinue jetting when the pile tip is approximately 1.5 m 5 feet above the [calculated][indicated]pile tip elevation. Drive pile the final 1.5 m 5 feet of penetration or more to meet the required driving criteria.][Take adequate measures for collecting and disposing of runoff water.][Jetting method and equipment must be approved by the Contracting Officer prior to commencing jetting operation.] Before starting final driving, firmly seat piles in place by application of a number of reduced energy hammer blows.[Employ measures, including use of a silt curtain, to contain turbid water created by jetting piles.]

3.2.6   Predrilling of Piles

Predrilling to remove soil or other material representing the bulk of the volume of the pile to be driven[will [not] be permitted][will be provided].[The diameter of the hole must not exceed two-thirds the width of the pile.][Predrill only to a depth of [_____] meters feet below cut-off elevation prior to setting piles.][Discontinue drilling when the pile tip is approximately 1.5 m 5 feet above the [calculated] [indicated] pile tip elevation. Drive pile the final 1.5 m 5 feet of penetration or more to meet the required driving criteria.]

3.2.7   Pile Splices

****

NOTE: Splicing of piles normally should not be permitted except where extremely long or heavy piles are required. If splices are permitted, drawings should indicate splice details. (See PCI standard drawings for typical splice details).

****

[Splicing of piles is not permitted.] [Make splices as indicated. Splices must be capable of developing the full strength of the member in compression, tension, shear, and bending. Submit detail drawings of splices and design calculations demonstrating the strength of the splice for approval Submit information for shop and field pile splices prior to fabrication.]

3.2.8   Build-Ups

****

NOTE: Insert compressive strength required by design, usually a minimum of 35 MPa 5,000 psi. Insert maximum percent of build-ups permitted for project. The percent will depend on criticality of pile failure at build-up; whether the top of the pile is designed as a moment connection; exposure of piles to external physical or corrosive damage. Normally, for piles supporting piers exposed to seawater, limit percentage of build-ups to 10 percent.

****

Where required, pile section may be extended to cut-off elevation by means of a cast-in-place reinforced concrete build-up. Make build-up in accordance with PCI BDM. Construct build-ups made after completion of driving in accordance with detail, "Build-Up Without Driving." Make build-ups to be driven in accordance with detail "Build-Up With Driving." Have details of means for protecting joints by a suitable mortar or epoxy approved by Contracting Officer. Where build-ups are exposed to water, protect cast-in-place section from water during curing period. Concrete in build-up must have a minimum compressive strength of [_____] MPa psi. Build-ups will not be permitted on more than [_____] percent of total number of piles. If this percent figure is exceeded, or if in the judgment of the Contracting Officer, the clustered location of build-ups is undesirable, withdraw piles of insufficient length and replace with longer piles. Payment for such withdrawal and replacement will be made as an adjustment to the contract price.

3.2.9 Pile Cut-Off

Cut-off piles with a smooth level cut using pneumatic tools, sawing, or other suitable methods approved by Contracting Officer. Use of explosives for cutting is not permitted. Remove cut-off sections of piles from the site and off government property upon completion of the work.

3.2.10 As-Driven Survey

After the driving of each pile group is complete and before concrete is placed, provide the Contracting Officer with an as-driven survey showing actual location and top elevation of each pile. Do not proceed with placing concrete until the Contracting Officer has reviewed the survey and verified the safe load for the pile group driven. Present a survey in such form that it gives deviation from plan location in two perpendicular directions and elevations of each pile to nearest 13 mm half inch. Survey must be prepared and certified by a licensed land surveyor.

3.2.11 Protection of Existing Structures

****

NOTE: Include this paragraph only when protection of existing structures from pile driving activities is required.

The designer must indicate on the drawings all structures and facilities for which protection is required. The designer must also provide a project specific document that details design criteria, requirements for preconstruction condition surveys, post construction condition surveys, geotechnical instrumentation to measure ground movements and any other requirements.

Add any additional requirements as necessary.

****

Mitigate impact on existing facilities due to pile driving activities in accordance with the [project specific document] [_____].

3.2.12 Pile Shoe

Submit details about pile shoe used,if any. Where indicated or directed, securely attach pile shoes of an approved design to the piles in a manner described in the detail drawings.

3.3 FIELD QUALITY CONTROL

3.3.1 Test Piles

****
NOTE: Select the second bracketed option when soil conditions dictate the use of a test pile longer than production piles. The ordered pile length for test piles should be 1.5 m 5 feet longer than ordered length for production piles to allow additional penetration if driving conditions dictate. Indicate location and number (if required) of test piles on plans, or list appropriate soil boring test hole numbers.
****

[Use test piles of type, and drive as specified for piling elsewhere in this section.][Order test piles [_____] meters feet longer in length than production piles. Drive the additional test pile length only at the direction of the Contracting Officer.] The [Contractor's Geotechnical Consultant] [Contracting Officer] will use test pile data to determine "calculated" pile tip elevation or necessary driving criteria. Drive test piles [at the locations indicated] [in vicinity of soil boring test holes Nos. [_____], [_____], and [_____]]. Drive test piles to [indicated tip elevation] [indicated bidding lengths] [required driving criteria]. Use test piles, if located properly and offering adequate driving resistance in finished work.[Pre-drilling or jetting is permitted only when test piles clearly establish validity of its use, or as directed by the Contracting Officer.][Provide and operate a pile driving analyzer as specified in paragraph DYNAMIC PILE ANALYSIS during the driving of each test pile. Modify driving as required based upon recommendation of [Contracting Officer] [Contractor's Geotechnical Consultant and approval of the Contracting Officer].]

3.3.1.1 Dynamic Pile Analysis

Submit a performance report summarizing dynamic test results for [test] piles within [7] [_____] calendar days of completing field work.[For production piles, submit a performance report within one day of testing. Submit a typed report summarizing the results of dynamic testing of production piles on a monthly basis.]

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 [_____] percent of the [test] piles during the full length of the pile driving and during restrike a minimum of [_____] days after initial driving. Dynamic pile testing must also be performed on [_____] production piles as chosen by the Contracting Officer. Use [test] piles of type as specified elsewhere in this section. 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. Drive [test] piles at the locations indicated or at the locations selected by the Contracting Officer. 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. Perform dynamic pile analysis as follows:

3.3.1.2 Pile Analyzing

[_____] working days prior to driving the [test] piles, submit the pile and complete driving equipment data to the Contracting Officer. 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. Approval of the proposed driving system by the Contracting Officer must be based upon the wave equation analyses indicating that the proposed driving system can develop a pile capacity of [_____] kN kips at a driving resistance not greater than [_____] blows per mm blows per inch within allowable driving stress limits. The hammer must also be sized or adjustable such that the penetration per blow at the required ultimate capacity does not exceed 12 mm 0.5 inches.

3.3.1.3 Pile Drivability

Perform each dynamic pile analysis in two steps. The first step is 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. This initial monitoring must determine whether pre-augering or jetting is appropriate, 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, augering 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 Contracting Officer. 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.

Upon completion of [test] pile driving, allow the piles to set-up for at least [72 hours] [_____ days]. After evaluation of pile, hammer and soil performance by the Contractor's Geotechnical Consultant, the second step of the dynamic pile analysis may proceed. This portion of 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 minimum of three copies of] 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 [_____].

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 maximum allowable pile design load must be proposed by the Contractor's Geotechnical Consultant based upon the results of a satisfactory pile load test conducted on a pile driven as specified herein and must include the effects of load transfer to the soil above the foundation stratum.

Use either a model 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.

Pay for all services of the Contractor's Geotechnical Consultant. The Contractor's Geotechnical Consultant must be available throughout the pile driving operation to consult with the Contracting Officer when required by the Contracting Officer. 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 Load Tests

3.3.2.1 Static Load Tests

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NOTE: If pile load tests are required and approved by the Contracting Officer, specify number and location of piles. Select method of load test. In ASTM D1143/D1143M, permit anchor piles only if approved by the Contracting Officer's Technical Representative (Geotechnical Branch). Insert figure kips kN corresponding to 200 percent of the design load. Select appropriate acceptance criteria. The offset method (first option) is usually recommended.

****

Submit test set-up and procedures. Perform compressive load tests on [_____] test piles in accordance with ASTM D1143/D1143M (standard loading procedure) as modified herein.[Allow a minimum of [72 hours] [_____ days] following final test pile driving for pile set-up prior to load testing.][Do not use anchor piles.] Provide apparatus for applying vertical loads as required by method, using load from weighted box or platform[or reaction frame attached to sufficient uplift piles to safely take required load] applied to pile by hydraulic jack. Increase load in increments until rapid progressive settlement takes place or until application of total compressive load of [_____] KN kips for compressive load tests. Consider load test satisfactory when[after one hour at full test load gross settlement of pile butt is not greater than gross elastic pile compression plus 4 mm 0.15 inch plus one percent of pile tip diameter or width in [_____] mm inches,][slope of gross load-settlement curve under full test load does not exceed 1.5 mm per metric ton 0.05 inches per ton,][net settlement after removal of test load does not exceed 19 mm 3/4 inch.] Perform load tests at locations[as proposed by the Contractor's Geotechnical Consultant and] as directed by the Contracting Officer. Additional load tests, at Government expense, may be required by the Contracting Officer. Perform the loading, testing, and recording and analysis under the direct supervision of a Registered Professional Engineer, registered in the state of project location, and provided and paid for by the Contractor.[Submit test pile records][and][load test data] within seven calendar days of conducting the test.

[3.3.2.1.1 Safe Design Capacity

Determine the safe design capacity of a test pile as determined from the results of load tests according to UFC 3-220-01.

]3.3.2.2 Tensile Load Tests

Perform tensile load tests on [_____] test piles in accordance with ASTM D3689, as modified[and]in paragraph LOAD TESTS. Apply a tensile load of [_____] kN kips to each tensile load test pile. In performing the tension load test, apply the ultimate load equal to one and one-half times the safe tension capacity, and employ the Standard Loading Procedure.

Perform dynamic measurements on [_____] piles designated as dynamic test piles in accordance with ASTM D4945 during driving. During easy driving, ensure that damaging tension stresses do not develop in the pile. Signal matching must be performed by the Contractor's Geotechnical Consultant on representative data collected at the end of the initial driving and at the beginning of all restrike events. Additional signal matching analysis must be performed as determined by the Engineer.

3.3.2.3 Lateral Load Tests

Perform lateral load tests on [_____] piles in accordance with ASTM D3966/D3966M, as modified[and]in paragraph LOAD TESTS. Lateral load tests must consist of jacking two piles apart with a hydraulic jack, with one pile serving as the reaction pile for the other. Apply a lateral load of [_____] kN kips to each pair of lateral load test piles. Record required movement readings for each pile.

3.3.3 Pile Records

Submit pile[and test pile] records.[Submit load test data and results.]

Keep a complete and accurate record of each pile driven. Indicate the pile location, deviations from pile location, cross section shape and dimensions, original length, ground elevation, tip elevation, cut-off elevations, [batter alignment,]number of blows required for each 300 mm foot of penetration and number of blows for the last 150 mm 6 inches penetration or fraction thereof [as required]for the "calculated" [driving resistance]. 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, [jetting,]and any driving interruptions.[Install an energy monitor on the hammers and record readings every 300 mm 12 inches of pile installation.] A preprinted pile driving log for recording pile driving data[and pile driving equipment data form], which can be downloaded at: https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables

[3.3.4 Testing Agency Qualifications

Engage an independent testing agency qualified according to ASTM C1077 and ASTM E329 for testing indicated. Submit testing agency qualifications to the Contracting Officer for approval.

][3.4 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

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NOTE: Include this paragraph only when special inspection and testing for seismic-resisting systems is required by the International Building Code (IBC).

This paragraph will be applicable to both new buildings designed and to existing building seismic rehabilitation designs done according to UFC 1-200-01, "General Building Requirements" and UFC 3-310-04, "Seismic Design for Buildings".

The designer must indicate on the drawings all locations and all features for which special inspection and testing is required in accordance with Chapter 17 of the IBC. This includes indicating the locations of all structural components and connections requiring inspection.

Add any additional requirements as necessary.

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Perform special inspections and testing for seismic-resisting systems and components in accordance with Section 01 45 35 SPECIAL INSPECTIONS.

][3.5 VIBRATION CONTROL

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NOTE: Include this paragraph when vibration monitoring is required. Add any additional criteria or requirements as necessary to the particular project.

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Perform vibration monitoring at the locations [shown in the plan] [decided by the Contracting Officer] during the pile driving operations. Perform vibration monitoring [using] [seismographs][and geophones] within a distance of [61] [_____] meters [200] [_____] feet from the pile driving activity.[Engage the services of a qualified, independent vibration consultant, acceptable to the Government, to conduct the vibration monitoring. The vibration consultant must have minimum of [five] [_____] years of experience in vibration monitoring. A minimum of [28] [_____] days before the installation of vibration monitors, submit to the Government the name of the vibration consultant and a list of at least [three] [_____] previously completed projects of similar scope and purpose.]

Prior to the pile driving activities, obtain baseline readings of ambient vibrations. The vibration during the pile driving activities must be limited to [a peak particle velocity of not more than [5] [_____] cm [2.0] [_____] inches per second] [the limits mentioned in the [contract documents]].[Determine appropriate vibration limits as per [US Bureau of Mines] [American Association of State Highway and Transportation Officials (AASHTO)] guidelines.] During pile driving activities, monitor the vibrations to ensure the limits are not exceeded. If the limits are exceeded, cease the pile driving activity causing the vibration until [the Vibration consultant and the Contracting Officer] [_____] are on site to observe the structures nearest to the vibration monitor which has exceeded the limits.

The Contractor must be responsible for all damages resulting from the pile driving operations and must take whatever measures necessary to maintain peak particle velocity within the specified limit. After completion of the project, remove the vibration monitors off the site and off Government property and restore the monitoring locations back to their original condition.

][3.6 NOISE CONTROL

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NOTE: Include this paragraph when noise monitoring is required. Add any additional criteria, references or requirements as necessary to the particular project.

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Perform noise monitoring at the locations [shown in the plan] [decided by the Contracting Officer] [at noise sensitive public areas] during the pile driving operations.[Perform noise monitoring using [noise meters][, and] [_____]].[Engage the services of a qualified, independent noise consultant, acceptable to the Government, to conduct the noise monitoring. The noise consultant must have minimum of [five] [_____] years of experience in noise monitoring. A minimum of [28] [_____] days before the installation of noise monitors, submit to the Government the name of the noise consultant and a list of at least [three] [_____] previously completed projects of similar scope and purpose.]

Prior to the pile driving activities, obtain baseline readings of ambient noise levels.[The noise limits are mentioned in the [plan] [contract documents].][Determine appropriate noise limits as per [local agency] [Occupation Safety and Health Administration] guidelines.] During pile driving activities, monitor the noise to ensure the limits are not exceeded. If the limits are exceeded, cease the pile driving activity and install noise mitigation measures.

The Contractor must be responsible for all damages resulting from the pile driving operations and must take whatever measures necessary to maintain noise within the specified limit. After completion of the project, remove the noise monitors off the site and off Government property and restore the monitoring locations back to their original condition.

][3.7 PRECONSTRUCTION CONDITION SURVEY

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NOTE: Add any additional criteria, references or requirements as necessary to the particular project.

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Perform preconstruction condition survey of [structures][and utilities] [within [61] [_____] meters [200] [_____] feet of the pile driving activity] [specified in the plans] [decided by the Contracting Officer]. Perform outreach to the owner of the structures [28] [_____] days before performing the preconstruction condition survey. The Contractor must obtain written permission from the owner of the structure prior to accessing the structure. The preconstruction condition survey must include video and photographic documentation of the exterior and interior of above ground structures and of the interior of underground structures. Video documentation must be in high definition, and show existing conditions and highlight, where possible, existing cracks, deteriorated concrete, exposed and corroded reinforcement, cracked or broken brick or mortar, and other signs of distress. For utilities, perform the survey when the greatest extent of the interior is exposed. Provide supplementary artificial lighting as needed. The video must include annotation with location and structure nomenclature which describes any areas of distress over the video and time code superimposed on the video. Photographs must be accompanied by sketches or descriptions that indicate the location and direction of each photograph. For each structure surveyed, provide a Pre-Construction Condition Survey Report following completion of the survey. The report must contain all documentation associated with the survey including DVD copies. In the report, include notes, sketches, photographs, and videos. Provide general information, such as location details and structure type, as well as particular information on materials, condition, existing damage, aperture and persistence of cracks, and disrepair observed during visual survey. Provide a graphical depiction of locations of damage or other features of concern. Submit the Preconstruction Condition Survey Reports no later than [28] [_____] days before the commencement of pile driving activity. Accept responsibility for damages to existing adjacent or adjoining structures created by pile driving work, and repair any damages to these structures without cost to the Government.

][3.8 CONSTRUCTION INSTRUMENTATION AND MONITORING PROGRAM

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NOTE: Include this section if instrumentation is to be installed due to concerns about vibration, settlement, lateral movement, etc. during pile driving activities. Instrumentation should be specified and included in the specification. This section can be deleted if there are no instrumentation requirements.

Add any additional criteria or requirements as necessary for the particular project.

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Prepare a geotechnical instrumentation program to monitor settlement[and lateral movement] of temporary and permanent structures, utilities, [embankments] [and excavations] during pile driving. The design and distribution of instrumentation must demonstrate an understanding of the need, purpose and application of each proposed type.[Perform noise and vibration monitoring in accordance with NOISE CONTROL and VIBRATION CONTROL sections.]

Monitoring must extend before, during and for a period after completion of construction activities related to pile driving when long-term performance issues are a concern. The monitoring plan must be designed to protect adjacent structures and utilities against damage due to the pile driving activities. Establish limiting values of vertical [and horizontal] movement [and angular distortion] [and vibration] for each structure and utility within the zone of influence, subject to review by the Government.

Prepare an Instrumentation and Monitoring Program Report detailing the proposed program of instrumentation and monitoring, establishing threshold values of monitored parameters, and describing the response plans that will be implemented when threshold parameters are exceeded. The report must include details about instrumentation consultant's experience, appropriate types, quantities, locations and monitoring frequencies of the instruments.

Upon acceptance of the instrumentation and monitoring program, provide, install and monitor the instrumentation and interpret the data. Submit instrumentation data reports not less than every [_____] days after the monitoring program has begun. Take corrective actions, as necessary, based on the field instrumentation data and as defined in the instrumentation and monitoring program.

] -- End of Section --