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USACE / NAVFAC / AFCESA / NASA **UFGS-31 62 13.24 (August 2011)**

Preparing Activity: NAVFAC **Superseding**
UFGS-31 62 13.24 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2012
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DIVISION 31 - EARTHWORK

SECTION 31 62 13.24

CONCRETE CYLINDER PILES

08/11

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SECTION 31 62 13.24

CONCRETE CYLINDER PILES
08/11

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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 items(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 GRAPHICS
Go to http://www.wbdg.org/ccb/NAVGRAPH/graphtoc.pdf**.**

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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 shall 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.

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PART 1 GENERAL

1.1 REFERENCES

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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 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.

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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 2006) Standard Method of Test for Resistance of Concrete to Chloride Ion Penetration

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	(2011) Evaluation of Strength Test Results of Concrete
ACI 318	(2011; Errata 2011) Building Code Requirements for Structural Concrete and Commentary
ACI 318M	(2011) 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 A416/A416M	(2010) Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
ASTM A496/A496M	(2007) Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM A615/A615M	(2009b) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706/A706M	(2009b) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A82/A82M	(2007) Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A886/A886M	(2010) Standard Specification for Steel Strand, Indented, Seven-Wire Stress-Relieved for Prestressed Concrete
ASTM A996/A996M	(2009b) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM C1202	(2010) Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
ASTM C1218/C1218M	(1999; R 2008) Standard Specification for Water-Soluble Chloride in Mortar and Concrete

ASTM C1240	(2011) Standard Specification for Silica Fume Used in Cementitious Mixtures
ASTM C1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C143/C143M	(2010a) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2011) Standard Specification for Portland Cement
ASTM C1567	(2011) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C172/C172M	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C31/C31M	(2010) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2011a) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2011) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C42/C42M	(2011) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C494/C494M	(2011) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2011) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2008a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C666/C666M	(2003; R 2008) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C881/C881M	(2010) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989/C989M	(2011) Standard Specification for Slag

Cement for Use in Concrete and Mortars

ASTM D1143/D1143M	(2007e1) Piles Under Static Axial Compressive Load
ASTM D3689	(2007) Standard Test Methods for Deep Foundations Under Static Axial Tensile Load
ASTM D3966	(2007) Standard Test Methods for Deep Foundations Under Lateral Load
ASTM D4945	(2008) High-Strain Dynamic Testing of Piles

POST-TENSIONING INSTITUTE (PTI)

PTI M55.1	(2003; Errata 2009) Specification for Grouting of Post-Tensioned Structures

PRECAST/PRESTRESSED CONCRETE INSTITUTE (PCI)

PCI JR-382	(1993) Recommended Practice for Design, Manufacture and Installation of Prestressed Concrete Piling
PCI MNL-116	(1999) Manual for Quality Control for Plants and Production of Structural Precast Concrete Products, 4th Edition

[1.2 LUMP SUM PAYMENT

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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 shall 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.

1.2.1 Acceptance Criteria

Safe design capacity for piles is [_____] tons. Piles shall be driven to a minimum depth of [_____] feet below cut-off elevation, and to such additional depth as required to obtain a bearing capacity of not less than [_____] tons.

The following formulas 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 shall be made for reduced penetration caused by shock absorption of the cushion or cap blocks.

]1.3 MEASUREMENT AND PAYMENT

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NOTE: For NAVFAC PAC projects: Where there is unit pricing for piles, use this paragraph and edit applicable attachments from Section 00 41 00 for inclusion in Standard Form 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items." Select first bracketed text.

The engineer of record shall work with the Government Contract Specialist to develop a basis of

bid statement with unit priced items for the project, providing base bid quantities as applicable.
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[For unit price bid, see SF 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items."] [Section 00 41 00 BID SCHEDULES.]

****
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" shall not apply to payment for piling. Each pile and test pile provided and accepted will be paid for at the bid unit price per unit length, which price shall 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 cutoff elevation. [The cost for additional length for the test piles shall be included in the total unit price cost for the job.] Payment shall be made for job [and test piles] at the bid unit price for the length of pile, from tip to final cutoff, actually provided, excluding buildups directed by the Contracting Officer to be made. Should the actual cumulative pile length driven (tip to cutoff) 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."

1.3.1 Pile Cut-off

Where the tip to cutoff length is less than that calculated from the results of test pile driving [and load testing], payment for that portion of pile not driven will be made at 75 percent of the bid unit price and no other payment will be made for making the cutoff.

1.3.2 Pile Build-ups

Payment for buildups will be made at 125 percent of the bid unit price.

1.3.3 Pulled Piles

Piles required to be pulled at no fault of the Contractor will be paid for at the bid unit price for furnishing and driving the pile in its original position plus 25 percent of the amount to cover the cost of pulling. Such pulled piles when redriven will be paid for at 25 percent of the bid unit price for the length driven.

[1.3.4 Pile Load Test

Payment for each provided and accepted complete test loading of a single pile will be made at the contract unit price per test, which price shall include furnishing, placing, and removing testing equipment and test loads. At the direction of the Contracting Officer, load tests may be waived at a credit to the Government of the unit price bid.

]1.4 UNIT PRICES

****
NOTE: This paragraph is for Army projects. If Section 01 22 00.00 10 MEASUREMENT AND PAYMENT 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 22 00.00 10.
****

1.4.1 Furnishing and Delivering Concrete Cylinder Piles

1.4.1.1 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.

1.4.1.2 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].

1.4.1.3 Unit of Measure

Unit of measure: linear meter foot.

1.4.2 Driving Concrete Cylinder Piles

1.4.2.1 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.

1.4.2.2 Measurement

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

1.4.2.3 Unit of Measure

Unit of measure: linear meter foot.

1.4.3 Pulled Concrete Cylinder Piles

1.4.3.1 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".

1.4.3.2 Measurement

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

1.4.3.3 Unit of Measure

Unit of measure: linear meter foot.

1.4.4 [Concrete Pile Driving Tests]

1.4.4.1 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].

1.4.4.2 Measurement

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

1.4.4.3 Unit of Measure

Unit of measure: each.

1.4.5 [Concrete Cylinder Piles for Load Tests]

1.4.5.1 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.

1.4.5.2 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.

1.4.5.3 Unit of Measure

Unit of measure: each.

1.4.6 [Concrete Pile Compressive Load Tests]

1.4.6.1 Payment

Payment will be made for costs associated with concrete pile compressive load tests, 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 compressive load tests.

1.4.6.2 Measurement

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

1.4.6.3 Unit of Measure

Unit of measure: each.

1.4.7 [Concrete Pile Tensile Load Tests]

1.4.7.1 Payment

Payment will be made for costs associated with concrete pile tensile load tests, 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 tensile load tests.

1.4.7.2 Measurement

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

1.4.7.3 Unit of Measure

Unit of measure: each.

1.4.8 [Concrete Pile Lateral Load Tests]

1.4.8.1 Payment

Payment will be made for costs associated with concrete pile lateral load tests, 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.

1.4.8.2 Measurement

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

1.4.8.3 Unit of Measure

Unit of measure: each.

1.4.9 [Pulled Load Test Concrete Cylinder Piles]

1.4.9.1 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. 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".

1.4.9.2 Measurement

Pulled undamaged load test concrete cylinder piles will be measured for payment as specified in paragraph UNIT PRICES, 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 UNIT PRICES, subparagraph DRIVING CONCRETE CYLINDER PILES. Redriving pulled undamaged concrete cylinder piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph DRIVING CONCRETE CYLINDER PILES. New load test concrete cylinder piles replacing damaged piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph CONCRETE CYLINDER PILES

FOR LOAD TESTS.

1.4.9.3 Unit of Measure

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

1.4.10 [Concrete Pile Splices]

1.4.10.1 Payment

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

1.4.10.2 Measurement

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

1.4.10.3 Unit of Measure

Unit of measure: each.

1.5 PILE REQUIREMENTS

****
NOTE: Delete sentence in brackets when test piles are not required.
****

Provide cylindrical concrete piles, PCI JR-382. Production of piles shall be in accordance with PCI MNL-116. The Government will determine and list "calculated" tip elevation or driving resistance for each pile from test pile data. This information shall be given to the Contractor no later than 7 days from receipt of complete test data. [The [Contractor][Contractor's Geotechnical consultant] shall [determine "calculated" tip elevation and/or driving resistance for each pile from test pile data and] prepare a list based on information provided in the contract [and determined from the test pile data].] Use this list as the basis for ordering the piles. Do not order piles until list is submitted and approved by the Government. Test piles shall be [1.5] [_____] meter [5] [_____] feet longer than the bid length.

1.6 SUBMITTALS

****
NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated 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 submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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.

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" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Installation Procedures[; G][; G, [_____]]

[Geotechnical Consultant Documentation[; G][; G, [_____]]]

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

Order List[; G][; G, [_____]]

Precast manufacturer's quality control procedures[; G][; G, [_____]
]

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.

SD-02 Shop Drawings

Piles[; G][; G, [_____]]

Pile Load Test Arrangements[; G][; G, [_____]]

SD-03 Product Data

Pile Driving Equipment[; G][; G, [_____]]

Submit descriptions of pile driving equipment, including hammers, power packs, driving helmets, cap blocks, pile cushions, leads, extractors, jetting equipment, and predrilling equipment at least 30 days prior to commencement of work.

SD-05 Design Data

Concrete mix design[; G][; G, [_____]]

Grout[; G][; G, [_____]]

Joint Sealing Material[; G][; G, [_____]]

Submit a concrete mix design before concrete is placed, for each type of concrete used for the piles.

SD-06 Test Reports

Aggregates[; G][; G, [_____]]

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

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

[Test piles[; G][; G, [_____]]]

[Load tests[; G][; G, [_____]]]

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

Submit concrete cylinder compressive strength test results. [Submit test pile records] [and] [load test data].[Submit a summary report of dynamic test results for test piles within [7][_____] calendar days of completing field work. [For permanent piles, submit a field summary report within one (1) day of testing. Submit a typed report summarizing the results of dynamic testing of permanent piles on a monthly basis.]]

SD-07 Certificates

Aggregates[; G][; G, [_____]]

Admixtures[; G][; G, [_____]]

Prestressing Tendons[; G][; G, [_____]]

Cement[; G][; G, [_____]]

Fly ash and pozzolan[; G][; G, [_____]]

Ground Slag[; G][; G, [_____]]

[Silica fume

] Epoxy coating[; G][; G, [_____]]

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

SD-11 Closeout Submittals

Pile records[; G][; G, [_____]]

Interior Inspection for Pile Damage[; G][; G, [_____]]

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

1.7 QUALITY ASSURANCE

1.7.1 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.]

1.7.2 Quality Control Procedures

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

1.7.2.1 Fabrication Plant Requirements

All piles shall be of new manufacture and shall be produced at a fabricating plant engaged in the manufacture of similar type units. The fabricator shall have successful experience in fabrication of precast cylinder pile units similar to units required for the Project. Fabricator must be an active member of the Precast/Prestressed Concrete Institute (PCI), and the fabricator's precast concrete manufacturing plant shall be certified by the PCI Plant Certification Program prior to the start of production. Certification shall be in the following product groups and categories: B2, B3 or B4.

Alternatively, if the proposed fabrication plant is a non-PCI certified installation, the Contractor shall demonstrate to the satisfaction of the Government, the ability to fabricate the precast units in accordance with the Project requirements. The Contractor, at his expense, shall retain the services of an independent testing or consulting firm approved by the Contracting Officer, who shall inspect the fabrication plant at least once per month during the first year of precast and concrete unit production, and issue to the Contracting Officer a report certified by a qualified Registered Professional Engineer in the state which the non-PCI certified installation is located, that all materials, methods, products and quality control meet all the requirements of the specifications, the plans and the Prestressed Concrete Institute's "Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products", PCI MNL-116. The independent testing or consulting firm shall have experience in similar types of inspections of precast operations.

If a report by the independent testing or consulting firm indicates non-conformance with the above requirements, the Contracting Officer, at the expense of the Contractor, may perform an independent inspection, and may refuse acceptance of fabricated units until the fabrication plant complies with the above requirements.

The Contractor's approved fabrication plant shall have sufficient production capacity to produce the required units without causing delay in the work. The Contracting Officer shall reserve the right to inspect the fabrication plant prior to production or at any time during production and meet with the contractor and manufacturer to discuss the facilities, materials, production methods, drawings, and production schedules.

1.7.3 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, located at the end of this section, 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 shall 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 shall explain how specific information of pile performance will be evaluated.]

[1.7.4 Geotechnical Consultant Documentation

The services of an independent, registered professional geotechnical engineer, experienced in soil mechanics and Pile Dynamic Analysis, shall be hired by the Contractor to observe test pile installation and job pile installation as specified herein. The Geotechnical Consultant shall be independent of the Contractor and shall have no employee or employer relationship which could constitute a conflict of interest.

]1.7.5 Concrete Mix Design

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.

[1.7.6 Static Load Test Supporting Data

Submit jack or load cell calibration records, a testing arrangement description and diagram, and the proposed loading sequence.

]1.8 DELIVERY, STORAGE, AND HANDLING

Piles shall be stored, handled, and transported in accordance with PCI MNL-116 except as follows. Cylinder piles shall not be transported from the casting yard until the concrete has reached the minimum required 28-day compressive strength. Methods used for handling and storage of piles shall be such that the piles are not subjected to excessive bending stress, cracking, spalling, or other damage.

1.8.1 Damaged Piles

The Contractor shall 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. Piles containing cracks other than crazing, surface drying, and shrinkage cracks shall be brought 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 shall be removed from the project site at no cost to the Government. Piles may be repaired, if approved by the Contracting Officer, at no cost to the Government.

1.8.1.1 Repairable Cracks

Piles with cracks equal to or greater than 0.15 mm 0.006 inches but less that 1.5 mm 0.06 inches shall 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 shall be restored to their required design capacity so that they can perform their intended structural function and achieve long term durability in corrosive environment.

1.8.1.2 Non-Repairable Cracks

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

1.8.2 Pile Sweep

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

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 CEMENTITIOUS MATERIALS

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

2.1.1.1 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 shall 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 shall 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 shall 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., 1 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.

****

2.1.1.2 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 shall be 3

[6] percent. If the aggregates are reactive the maximum calcium oxide content shall be 13.0 percent. Class C shall not be used.

2.1.1.3 Ground Iron Blast-Furnace Slag

ASTM C989/C989M, Grade 120.

[2.1.1.4 Silica Fume

****
NOTE: Use silica fume concrete for marine structures where low permiability 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.

]

2.1.1.5 Supplemental Cementitious Materials (SCM) Content

The concrete mix shall 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

SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT		
SCM	**Minimum Content**	**Maximum Content**
Class N Pozzolan or Class F Fly Ash with SiO2 plus Al2O3 plus Fe2O3 greater than 90 percent	15 percent	35 percent
GGBF Slag	30 percent	50 percent
Silica Fume	5 percent	10 percent

2.1.2 Water

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

2.1.3 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 shall 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 shall 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 shall 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 shall 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 shall be tested in accordance with ASTM C136]:

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

2.1.3.1 Alkali-Silica Reactivity (ASR)

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

The fine and coarse aggregates shall be evaluated separately, using ASTM C1260. Test results of the individual aggregates shall 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) shall be rejected or additional testing, using ASTM C1567 shall 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 shall 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.

2.1.4 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 shall conform to ASTM C494/C494M, [Type A] [Type B]. [Air-entraining admixture shall conform to ASTM C260/C260M.] Do not use admixtures containing chlorides.

2.1.5 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 1, 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][420] ([40][60]);] [ASTM A706/A706M , Grade [420] ([60]);][ASTM A996/A996M , Grade [420] ([60]]). Weld reinforcing steel in accordance with AWS D1.4/D1.4M.

2.1.5.1 Spirals

****

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 entitled "References."

****

[ASTM A82/A82M] [ASTM A496/A496M]

2.1.6 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 shall 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.

2.1.7 Joint Sealing Material

The abutting joint surfaces of precast segments shall 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 shall be as resistant to exposure and weathering as is the concrete.

2.1.8 Epoxy Coating

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

2.1.9 Pressure Grouting Epoxy

2.1.9.1 Crack Sealer for Pressure Grouting

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

2.1.9.2 Crack Surface Sealer for Pressure Grouting

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

2.1.10 Prestressing/Post Tensioning Tendons

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

2.2 CONCRETE

2.2.1 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 1 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 shall have a minimum specified compressive strength, f'c, of [_____][7000] psi at 28 days. The minimum cementitious materials content shall be 354 kg per cubic meter 600 pounds per cubic yard of concrete. The design shall be prepared in accordance with ACI 211.1 and ACI 318M ACI 318. The mix design shall 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 shall sample and test the aggregates for the design of concrete. Calcium Nitrite shall be added to the mix at a rate of [10 liters per cubic meter] [2.0 gallons per cubic yard].

2.2.2 Concrete Mix Design Proportioning

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

b. Maximum aggregate size shall 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 shall be 4.5 to 7.5 percent. Determine air void structure in accordance with ACI 212.3R. Spacing factor shall be less than 2.5 mm 0.01 inch, the specific surface area shall 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 shall be significantly greater than the numerical value of the percentage of air in the concrete.

2.2.3 Trial Mixtures

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

2.3 FABRICATION

Fabrication of the concrete cylinder piles, including storage and handling of materials, batching and mixing of concrete, stressing, sampling, testing and recording shall 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 shall be identical to, and manufactured by the same firm as the production piles.

2.3.1 Manufacturing of Piles and Pile Sections

The aggregates, cement and water shall 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 shall 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 shall 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 shall be cured in the mold until the concrete has attained the indicated strength to prevent deformation or damage during demolding.

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

Manufacturing by the static cast method shall 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 shall be completed for each individual pile before any of the concrete in the mold has taken an initial set. The pile shall 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 shall be as specified on the plans.

2.3.2 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 1, 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 shall have a spiral reinforcement cage, arranged and dimensioned as shown on the contract drawings. This reinforcing cage shall be securely held in position during the casting or spinning of the concrete.

Center to center spacing of spiral (defined as spiral pitch) shall not exceed 6 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.

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

2.3.3 Arrangement of Strands

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

2.3.4 Curing of Piles

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

2.3.4.1 Moist Curing

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

2.3.4.2 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.

2.3.5 Handling

Piles shall 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 shall 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 shall 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 shall be driven before the 28-day strength of concrete has been achieved.

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

2.4.1 Anchorages and End Fittings

ACI 318M ACI 318, for post-tensioned assemblies.

2.4.2 Forms

Provide forms of metal, braced and stiffened against deformation, accurately constructed, watertight, and supported on unyielding casting beds. Forms shall 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.

2.4.3 Longitudinal Reinforcement

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

The main longitude reinforcement shall 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.

2.4.4 Spin Casting

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

2.4.5 Longitudinal Ducts (holes) for Prestressing Tendons

Details and positioning of ducts (holes) shall be in accordance with PCI MNL-116, and as specified herein. Longitudinal ducts for the prestressing tendons shall be formed in the walls of the pile sections during casting. The ducts shall be 35 mm 1-3/8 inches (nominal diameter) and positioned so that there shall 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.

2.4.6 Concrete Strength

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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 shall 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.

2.4.7 Alignment of Sections

Pile sections shall 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 shall 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 shall 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 shall 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.

2.4.8 Post Tensioning

Tendons shall be tensioned to an allowable unit stress as indicated on the plans. The specified tension shall 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 shall not be greater than 5 percent. Tension in the tendons shall 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 shall not exceed an average of 10 percent in any one cable or an average of 5 percent for all cables in one pile.

2.4.9 Grouting

After tensioning all tendons, each tendon hole shall 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 shall not be moved or handled in any manner that could damage the pile.

2.4.10   Stress Transfer (Detensioning)

Transfer of the post tension force from temporary end locks to grouted tendons shall not be done until the grout has reached a compressive strength of 30 MPa 4,000 psi. Prestressing tendons shall 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 shall be rejected.

2.5   CONCRETE CYLINDER PILE PRESTRESSED STATIC CAST (ALTERNATIVE II)

2.5.1   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 shall 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.

2.5.2   Casting

2.5.2.1   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.

2.5.2.2   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].

2.5.3   Pretensioning

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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 shall 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.

2.5.4 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.

2.6 FABRICATION TOLERANCES

a. Pile ends shall 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 shall 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 0.118 inch will be rejected.

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

c. Overall lengths of individual piles shall 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
wall thickness of hollow section	minus 3 mm to plus 10 mm minus 1/8-inch to plus 3/8-inch

[2.7 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.

]2.8 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.

2.8.1 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. Tabulate results of tests in accordance with ASTM C33/C33M.

2.8.2 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.

2.8.3 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 shall have a compressive strength less than specified design strength.

2.8.4 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.

2.8.5 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 shall not exceed 0.06 percent by weight of cement.

2.8.6 Chloride Ion Penetration

To ensure the durability of concrete in marine environment, concrete shall 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.]

2.8.7 [Destructive Pile Testing]

At the beginning of production, produce three additional piles with the same length as production piles which shall 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 shall 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 shall be subject to rejection.

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

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.

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3.1 PILE DRIVING EQUIPMENT

3.1.1 Pile Hammers

Furnish a hammer capable of developing the indicated ultimate pile capacity 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.] Obtain required driving energy of hammer, except for diesel hammers, by use of a heavy ram and a short stroke with low impact velocity. At final driving, operate pile hammer in accordance with manufacturer's recommendation for driving either end bearing piles or friction piles. At final driving, operate diesel powered hammers at rate recommended by manufacturer for hard driving. Maintain pressure at steam or air hammer so that: (1) for double-acting hammer, the number of blows per minute during and at completion of driving of a pile is equal approximately to that at which hammer is rated; (2) for single-acting hammer, there is a full upward stroke of the ram; and (3) for differential type hammer, there is a slight rise of hammer base during each upward stroke.

3.1.2 Driving Helmets and Cushion Blocks

3.1.2.1 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 laminated, ring-shaped construction using 25 mm 1 inch hardwood boards or 19 mm 3/4 inch plywood. Provide pile cushion with thickness of [_____] [152] mm [6] inches minimum, cut to fit the head of the pile. Thickness shall be increased so as to be suitable for the size and length of pile, character of the sub-surface material to be encountered, hammer characteristics, and the required driving resistance. 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, and pile cushions. Submit 2 weeks prior to [test] pile installation.

3.1.2.2 Hammer Cushion or Capblock

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NOTE: Select aluminum/micarta/polymer 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 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 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. [Replace aluminum, micarta or polymer discs that have become damaged, split or deteriorated in any manner]. [Do not replace capblock 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.

3.2 PRELIMINARY WORK

3.2.1 Wave Equation Analysis of Pile Drivability

a. Prior to driving any pile, the Contractor shall submit a pile Wave Equation Analysis, performed by his Geotechnical Consultant, for each size pile, pile hammer and distinct subsurface profile condition. These analyses shall 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. The Wave Equation Analysis shall demonstrate that the piles will not be damaged during driving, shall 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	
Concrete	0.85f'c - UPL
Tension	(3 times (the square root of f'c)) plus UPL

where:

f'c is compressive strength of concrete
UPL = Unit Prestress after Losses
(Obtain values from pile manufacturer)

c. Upon completion of the dynamic and static testing programs outlined in this specification section, a refined Wave Equation Analysis shall be performed taking into consideration the evaluated capacities, gain/loss factors and recommended production pile lengths. Production pile driving criteria shall be developed based on the results of the refined Wave Equation Evaluations.

d. All pile driving equipment furnished by the Contractor shall be subject to the approval of the [Contractor's Geotechnical Consultant] [Contracting Officer]. Complete the attached pile and driving equipment data form, including hammer information, as part of the submittal of the results of the Wave Equation Analyses.

e. The cost of performing the Wave Equation Analyses shall be paid for by the Contractor and included in the base bid.

3.2.2 Order List

The Contractor shall submit to the Contracting Officer for approval an itemized list for piles prior to placing the order with the supplier. The list shall indicate the pile lengths required at each location as shown on the plans and the corresponding ordered length of each pile. The ordered length of each pile may, at the option of the Contractor, vary from the pile length as shown to the plans at each location by plus 1219 mm plus 4 feet. The Contractor shall review the order list periodically during the driving of production piles, and adjust it as necessary to reduce the number of cut-offs, and the amount of build-ups, subject to the approval, and/or upon the direction of the Contracting Officer. Load testing and refined wave equation analysis shall be completed prior to submission of an order list.

3.2.3 Pile Length Markings

The Contractor shall mark each pile prior to driving with horizontal lines at 305 mm one foot intervals, and the number of feet from pile tip at 1.52 m 5 foot intervals.

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 job piles. The ordered pile length for test piles should be 1.5 m 5 feet longer than ordered length for job 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 and drive test piles of type as specified for piling elsewhere in this section.][Order test piles [_____] meters feet longer in length than production piles. The additional test pile length shall be driven only at the direction of the Contracting Officer.]The Contractor's geotechnical consultant shall use Contractor test pile data to determine the "calculated" pile tip elevation or necessary driving resistance. 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]. Use test piles, if located properly and offering adequate driving resistance in finished work. [Pre-drilling or jetting is permitted only when approved by the Contracting Officer.][A pile dynamic analyzer shall be provided and operated as specified in paragraph DYNAMIC PILE ANALYSIS during the driving of each test pile. Modify driving as required based upon recommendation of Contractor's Geotechnical Consultant and approval of the Contracting Officer.]

[3.3.2 Dynamic Pile Analysis

The purpose of dynamic testing is to provide supplemental information for evaluating pile hammer performance, driving stresses, and bearing capacities. Dynamic testing shall be conducted during the entire time piles are initially driven or redriven and during pile restrike testing. Use test piles of type(s) as specified for use in this contract. Equipment to obtain dynamic measurements, record, reduce and display its data shall be furnished and meet the requirement of ASTM D4945. The equipment shall have been calibrated within 12 months of the date of use throughout the contract duration. Drive test piles at the locations indicated. The contractor shall employ a licensed geotechnical engineer, 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. Dynamic pile analysis shall be performed as follows:

a. Each dynamic pile analysis shall be performed 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 driven for the soil types encountered as the piles are driven. This initial monitoring shall 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 every fifth blow of the pile the information listed below shall be electronically recorded and analyzed by the Pile Driving Analyzer.

(1) Blow number

(2) Blow rate per minute and/or stroke.

(3) Input and reflected values of force and velocity.

(4) Value of upward and downward traveling force wave with time.

(5) Maximum and final transferred energy to pile, hammer system efficiency.

(6) Maximum compressive stress, velocity, acceleration and displacement.

(7) Maximum tensile stress in pile.

(8) Pile structural integrity, damage detection, extent and location.

(9) 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 these changes shall be incorporated into production pile driving in an effort to control excessive stresses and pile damage. Test piles damaged or broken during installation shall be replaced, incorporating driving modifications as determined by the Contractor's Geotechnical Consultant and reviewed and approved by the Contracting Officer. This procedure shall be repeated until allowable tensile and compressive stresses are achieved in the pile and/or pile damage is minimized. [Selected initial driving records shall be subjected 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.]

b. Upon completion of test pile driving the piles shall be allowed to set-up for at least 72 hours. 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 restriking the test 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 shall be used for production pile driving. The Contractor shall warm the hammer prior to restriking the test piles by striking the ground or other object a minimum of 30 blows. 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. At a minimum, the test pile indicated with the least resistance shall be subjected to CAPWAP analysis.

c. Performance Report:

(1) Upon satisfactory completion of each dynamic load test a minimum of three copies of a Pile Performance Report shall be submitted for the Contractor by the Contractor's Geotechnical Consultant. The submittal shall be prepared within three working days of the completion of the dynamic load test and sealed by a Professional Engineer registered in the State of [_____] experienced in the project region.

(2) The report for the Dynamic Pile Analysis shall contain the following information:

(a) Bearing capacity of pile from Case Pile Wave Analysis Program (CAPWAP). Information resulting from analysis of a selected restrike blow.

(b) Maximum and final transferred energy, hammer system efficiency during pile installation.

(c) Maximum compressive stress, velocity, acceleration and displacement.

(d) Maximum tensile stress in pile.

(e) Pile structural integrity, damage detection, extent and location.

(f) Blows per minute and blow number.

(g) Input and reflection values of force and velocity, upward and downward traveling force wave with time.

(h) Pile skin friction and toe resistance distribution.

(i) Maximum energy transferred to pile.

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

d. The equipment to be used for dynamic testing of the pile hammer and soil performance and for dynamic load testing of the test pile shall be either a model GCPC or a PAK Pile Driving Analyzer as manufactured by Pile Dynamics, Inc., of Cleveland Ohio or approved equivalent.

e. All services of the Contractor's Geotechnical Consultant shall be paid for by the Contractor. The Contractor's Geotechnical Consultant shall 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, shall be at the Contractor's expense.

]3.3.3 Static Load Tests

****
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, permit anchor piles only if approved by the Contracting Officer's Technical Representative (Geotechnical Branch). Insert figure (tons) corresponding to 200 percent of the design load. Select appropriate acceptance criteria. The offset method (first option) is usually recommended.
****

Perform compressive static load tests on [_____] test piles in accordance with ASTM D1143/D1143M [Procedure A (Quick Load Test)] [Procedure B (Maintained Test)] [and] [Procedure C (Loading in Excess of Maintained Test)] [as modified herein]. Allow a minimum of 72 hours following final test pile driving for pile set-up prior to load testing. [Do not use anchor piles.] Increase load in increments until rapid progressive settlement takes place or until application of total compressive load of [_____]metric tons(tons) 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. Loading, testing, and recording and analysis of data must be under the direct supervision of a Registered Professional Engineer, registered in the state of project location, and provided and paid for by the Contractor.

3.3.3.1 Safe Design Capacity

The safe design capacity of a test pile as determined from the results of load tests shall be the lesser of the two values computed according to the following:

a. One-half of that load which causes a net settlement after rebound of not more than 0.28 mm per metric ton 0.01 inch per ton of total test load.

b. One-half of the load that causes a gross settlement of not more than 25 mm 1 inch, provided the load settlement curve shows no sign of failure.

[3.3.4 Tensile Load Test

Perform tensile load tests on [_____] test piles in accordance with ASTM D3689, as modified [and] in paragraph STATIC LOAD TESTS. A tensile load of [_____]kN(tons) shall be applied to each tensile load test pile. In performing the tension load test, the ultimate load to be applied shall be one and one-half times the safe tension capacity, and the Standard Loading Procedure shall be employed.

][3.3.5 Lateral Load Test

Perform lateral load tests on [_____] piles in accordance with ASTM D3966, as modified [and] in paragraph STATIC LOAD TESTS. Lateral load tests shall consist of jacking two piles apart with a hydraulic jack, with one pile serving as the reaction pile for the other. A lateral load of [_____] kN tons shall be applied to each pair of lateral load test piles. Required movement readings shall be made and recorded for each pile.

]3.3.6 Pile Records

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NOTE: Omit reference to load test when not required in project. Omit reference to test piles and "calculated tip elevation" when test piles are not driven. Where special or unusual soil conditions are expected, consultation with the Contracting Officer's technical representative (Geotechnical Branch) regarding special engineering supervision of driving, testing, recording and analysis of data for project may be useful.
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NOTE: The Specifier shall attach the specifications pile driving log graphic (for all pile driving projects) and the pile driving equipment data form (for projects using PDA) to the end of this specification section.
****

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, obstructions, [jetting,] and any driving interruptions. A preprinted pile driving log for recording pile driving data[and pile driving equipment data form] is included at the end of this section.

3.4 PILE DRIVING

3.4.1 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]. The Contractor's geotechnical consultant shall be present during[[the first 2 days][_____]] pile driving operations. [Foundation excavation shall be stopped at 300 mm 1 foot above foundation grade before piles are driven. When pile driving is completed, excavation shall be completed to lines and grade shown.] Piles may be driven when the specified 28-day concrete strength has been achieved but not less than 7 days after casting. Drive piles to [or below the "calculated"] [indicated] [minimum] tip elevation[to reach] [until reaching] a driving resistance established by the wave equation analyses (WEAP) in accordance with the schedule which the Contractor's geotechnical consultant shall 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 shall be approved 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. Piles or pile sections shall not be handled or moved 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.

3.4.2 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.

3.4.3 Bail Out of Pile Interior

During initial pile placement/setting or driving, soil or water may rise inside the pile to levels above the original mudline/water elevation potentially resulting in high internal pressures building up inside the pile. Consequently, the Contractor shall make observations after pile setting and during pile driving to determine if soil or water is rising within the pile. The Contractor shall bail out soil and/or water to the original elevation(s) or lower as necessary to relieve resultant internal pressures upon approval or direction of the Contracting Officer. Piles damaged by such pressures, as a result of the Contractor's failure to adequately monitor and remove soil or water rise, shall be replaced by the Contractor at no additional cost to the Government.[Vent holes to release internal pressure shall be provided as required when driving cylinder piles.]

3.4.4 Interior Inspection for Pile Damage

For all test piles and production piles, when pile damage due to high internal pressures is suspected, when directed by the Contracting Officer, the Contractor shall bail out soil and water from inside the pile to the original mudline or lower, but not closer than 4.6 m 15 feet from the pile tip, as directed by the Contracting Officer, and inspect the inside of the pile for damage. The Contractor shall provide all required equipment to allow the Contracting Officer to assist in the inspection including: lights, boatswain's chair, lift, oxygen, etc. The Contractor is hereby reminded that he must comply with all applicable OSHA, Federal, and local safety and environmental requirements while performing this work.

During the inspection, all cracking shall be noted as to length, width and depth, and recorded. If any of the crack criteria are not met, the Contractor must modify his approach and continue the process until an accepted driving procedure and equipment are established.

3.4.5 Tolerances in Driving

****

NOTE: Omit references to batter piles when not applicable to the project. Select appropriate tolerances for type of pile.

****

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.

3.4.6 Rejected Piles

Piles damaged or impaired for use during handling or driving, mislocated, or driven out of alignment beyond the maximum tolerance shall be withdrawn and replaced by new piles or shall be cut off and abandoned and new piles driven as directed. Excess cut off from piles and unacceptable piles shall be removed from the work site. All work in connection with withdrawing and removing rejected piles from the site shall be done at no additional cost to the Government.

3.4.7 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.[Jetting [may] [shall] be used to assist driving piles through strata that cannot be penetrated practicably by use of the hammer alone. [Driving shall be restricted to a static weight while water is being injected to prevent inducing tensile stresses in the piles which damage the concrete.] After the penetration of the strata requiring jetting has been accomplished, jetting shall be discontinued and hammer driving shall be resumed.][Care should be exercised during jetting so that excessive internal hydrostatic pressure, which may damage the pile, does not build up anywhere within the pile. Internal jetting will not be permitted without prior written approval of the Contracting Officer. Discontinue jetting when the pile tip is approximately 2.1 m 7 feet above the [calculated] [indicated] pile tip elevation. Drive pile the final 2.1 m 7 feet of penetration.][Adequate measures shall be taken for collecting and disposing of runoff water.][Jetting method and equipment shall 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.[Measures, including use of a silt curtain, shall be employed to contain turbid water created by jetting piles.]

3.4.8 Predrilling of Piles

****

NOTE: Predrilling 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. Located in cohesionless soils.

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

****

Predrilling to remove soil or other material representing the bulk of the volume of the pile to be driven[will[not] be permitted] [shall be provided]. [The diameter of the hole should 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.]

3.4.9 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 shall be capable of developing the full strength of the member in compression, tension, shear, and bending. Detail drawings of splices and design calculations demonstrating the strength of the splice shall be submitted for approval.]

3.4.10 Build-Ups

3.4.10.1 Pretensioned Piles

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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. Construct buildups in accordance with the design drawings. 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 shall have a minimum compressive strength of [_____] MPa psi. Build-ups will not be permitted on more than [_____][10] 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.

3.4.10.2 Post-Tensioned Piles

Build-up piles to specified cut-off elevation by a cast-in-place extension of the pile, by a pile section, or by use of an acceptable length of pile cut-off. Make splice between pile and build-up by a poured plug of reinforced concrete extending a minimum of one outside-pile-diameter into the pile and an equal length into build-up where possible. Splice plug may be an extension of pile-to-cap connecting plug. If pile tops are damaged during driving, remove damaged portion and build-up pile as necessary.

3.4.11 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. Cut off sections of piles shall be removed from the site upon completion of the work.

[3.5 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

****

Note: Include this paragraph only when special testing and inspection of seismic-resisting systems is required by ASCE7-05 Appendix 11A Quality Assurance Provisions.

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 ASCE7-05 Appendix 11A Quality Assurance Provisions. This includes indicating the locations of all structural components and connections requiring inspection.

****

Special inspections and testing for seismic-resisting systems and components shall be done in accordance with Section 01 45 35 SPECIAL INSPECTION FOR SEISMIC-RESISTING SYSTEMS.]

-- End of Section --