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USACE / NAVFAC / AFCEA UFGS-02453A (October 2001)  
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Preparing Activity: USACE (CW) Superseding  
UFGS-02453A (November 1994)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMLR dated 22 December 2004

Latest change indicated by CHG tags

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##### SECTION 02453A

#### PRESTRESSED CONCRETE PILING FOR CIVIL WORKS

10/01

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SECTION 02453A

PRESTRESSED CONCRETE PILING FOR CIVIL WORKS  
10/01

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NOTE: This guide specification covers the requirements for furnishing all plant, labor, equipment, and materials, except materials specified to be furnished by the Government, and performing all operations in connection with the manufacture, installation, and testing of prestressed concrete piles in accordance with these specifications and applicable drawings.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

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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.

ACI INTERNATIONAL (ACI)

ACI SP-66 (2004) ACI Detailing Manual

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4 (1998) Structural Welding Code -  
Reinforcing Steel

ASTM INTERNATIONAL (ASTM)

ASTM A 27/A 27M (2003) Steel Castings, Carbon, for General  
Application

ASTM A 36/A 36M (2004) Carbon Structural Steel

ASTM A 416/A 416M (2002) Steel Strand, Uncoated Seven-Wire  
for Prestressed Concrete

ASTM A 572/A 572M (2004) High-Strength Low-Alloy  
Columbium-Vanadium Structural Steel

ASTM A 615/A 615M (2004b) Deformed and Plain Billet-Steel  
Bars for Concrete Reinforcement

ASTM A 616/A 616M (1996a) Rail-Steel Deformed and Plain Bars  
for Concrete Reinforcement

ASTM A 617/A 617M (1996a) Axle-Steel Deformed and Plain Bars  
for Concrete Reinforcement

ASTM A 706/A 706M (2004b) Low-Alloy Steel Deformed and Plain  
Bars for Concrete Reinforcement

ASTM A 82 (2002) Steel Wire, Plain, for Concrete  
Reinforcement

ASTM C 150 (2004a) Portland Cement

ASTM C 260 (2001) Air-Entraining Admixtures for  
Concrete

ASTM C 33 (2003) Concrete Aggregates

ASTM C 494/C 494M (2004) Chemical Admixtures for Concrete

ASTM C 595 (2003) Blended Hydraulic Cements

ASTM C 595M (1997) Blended Hydraulic Cements (Metric)

ASTM C 618 (2003) Coal Fly Ash and Raw or Calcined  
Natural Pozzolan for Use as a Mineral  
Admixture in Concrete

ASTM C 666 (2003) Resistance of Concrete to Rapid

## Freezing and Thawing

ASTM C 88	(1999a) Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D 1143	(1981; R 1994e1) Piles Under Static Axial Compressive Load
ASTM D 3689	(1990, R 1995) Individual Piles Under Static Axial Tensile Load
ASTM D 3966	(1990; R 1995) Piles Under Lateral Loads
ASTM D 4945	(2000) High-Strain Dynamic Testing of Piles

## PRECAST/PRESTRESSED CONCRETE INSTITUTE (PCI)

PCI MNL-116	(1999) Quality Control for Plants and Production of Structural Precast Concrete Products
PCI STD-112	(1984) Standard Prestressed Concrete Piles Square, Octagonal and Cylinder

## U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
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## 1.2 UNIT PRICES

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NOTE: If Section 01270 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 01270.  
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### 1.2.1 Furnishing and Delivering Prestressed Concrete Piles

#### 1.2.1.1 Payment

Payment will be made for costs associated with furnishing and delivering the required lengths of permanent prestressed concrete piles, [including H-pile extensions,] 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.

#### 1.2.1.2 Measurement

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

#### 1.2.1.3 Unit of Measure

Unit of measure: linear meter foot.

#### 1.2.2 Driving Prestressed Concrete Piles

##### 1.2.2.1 Payment

Payment will be made for costs associated with driving permanent prestressed concrete 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.

##### 1.2.2.2 Measurement

Permanent prestressed concrete 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.

##### 1.2.2.3 Unit of Measure

Unit of measure: linear meter foot.

#### 1.2.3 Pulled Prestressed Concrete Piles

##### 1.2.3.1 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 Prestressed Concrete Piles". The cost of driving pulled and undamaged piles will be paid for at the applicable contract unit price for payment item "Driving Prestressed Concrete Piles". The cost of pulling pulled and undamaged piles will be paid for at twice the applicable contract unit price for payment item "Driving Prestressed Concrete 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 Prestressed Concrete Piles". No payment will be made for furnishing, delivering, driving, pulling, and disposing of piles, including pile points, 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 Prestressed Concrete Piles" and "Driving Prestressed Concrete Piles".

##### 1.2.3.2 Measurement

Furnishing and delivering pulled and undamaged permanent prestressed concrete piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph FURNISH AND DELIVER PRESTRESSED CONCRETE PILES. Pulling undamaged prestressed concrete piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph DRIVING PRESTRESSED CONCRETE PILES. Redriving pulled undamaged prestressed concrete piles will

be measured for payment as specified in paragraph UNIT PRICES, subparagraph DRIVING PRESTRESSED CONCRETE PILES. New piles replacing damaged piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraphs FURNISH AND DELIVER PRESTRESSED CONCRETE PILES and DRIVING PRESTRESSED CONCRETE PILES.

#### 1.2.3.3 Unit of Measure

Unit of measure: linear meter foot.

#### 1.2.4 [Prestressed Concrete Pile Driving Tests]

##### 1.2.4.1 Payment

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

##### 1.2.4.2 Measurement

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

##### 1.2.4.3 Unit of Measure

Unit of measure: each.

#### 1.2.5 [Prestressed Concrete Piles for Load Tests]

##### 1.2.5.1 Payment

Payment will be made for costs associated with furnishing, delivering, driving, pulling, and disposing of load test piles [including [pile points] [and] [splices]]; backfilling voids around piles; compiling pile driving records [; furnishing, fabricating, and mounting of strain rods and protective assembly] [; furnishing, fabricating, and mounting of inclinometer and inclinometer 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.

##### 1.2.5.2 Measurement

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

##### 1.2.5.3 Unit of Measure

Unit of measure: each.

#### 1.2.6 [Prestressed Concrete Pile Compressive Load Tests]

##### 1.2.6.1 Payment

Payment will be made for costs associated with prestressed 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.

#### 1.2.6.2 Measurement

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

#### 1.2.6.3 Unit of Measure

Unit of measure: each.

#### 1.2.7 [Prestressed Concrete Pile Tensile Load Tests]

##### 1.2.7.1 Payment

Payment will be made for costs associated with prestressed 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.

##### 1.2.7.2 Measurement

Prestressed 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.

##### 1.2.7.3 Unit of Measure

Unit of measure: each.

#### 1.2.8 [Prestressed Concrete Pile Lateral Load Tests]

##### 1.2.8.1 Payment

Payment will be made for costs associated with prestressed 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.

##### 1.2.8.2 Measurement

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

##### 1.2.8.3 Unit of Measure

Unit of measure: each.

### 1.2.9 [Pulled Load Test Prestressed Concrete Piles]

#### 1.2.9.1 Payment

Payment will be made for costs associated with load test prestressed concrete 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 "Prestressed Concrete Piles for Load Tests". The cost of pulling undamaged load test piles the second time after re-driving and testing will be paid for at twice the applicable contract unit price for payment item "Driving Prestressed Concrete Piles". The cost of re-driving pulled undamaged load test piles will be paid for at the applicable contract unit price for payment item "Driving Prestressed Concrete 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 "Prestressed Concrete Piles for Load Tests".

#### 1.2.9.2 Measurement

Pulled undamaged load test prestressed concrete piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph PRESTRESSED CONCRETE PILES FOR LOAD TESTS. Pulling undamaged load test prestressed concrete piles the second time after re-driving and testing will be measured for payment as specified in paragraph UNIT PRICES, subparagraph DRIVING PRESTRESSED CONCRETE PILES. Re-driving pulled undamaged prestressed concrete piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph DRIVING PRESTRESSED CONCRETE PILES. New load test prestressed concrete piles replacing damaged piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph PRESTRESSED CONCRETE PILES FOR LOAD TESTS.

#### 1.2.9.3 Unit of Measure

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

### 1.2.10 [Steel H-Pile Points]

#### 1.2.10.1 Payment

Payment will be made for costs associated with steel H-pile points, including furnishing, delivering, and installing.

#### 1.2.10.2 Measurement

Steel H-pile points will be measured for payment on the basis of the number of steel H-pile points required.

#### 1.2.10.3 Unit of Measure

Unit of measure: each.

### 1.2.11 [Prestressed Concrete Pile Splices]

#### 1.2.11.1 Payment

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

#### 1.2.11.2 Measurement

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

#### 1.2.11.3 Unit of Measure

Unit of measure: each.

### 1.3 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

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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 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Driving Records

Submit original pile driving records [daily] [weekly] [monthly]  
[after pile driving is completed].

Prestressed Concrete Piles[; G][; G, [\_\_\_\_]]

Submit detail drawings of piles at least 30 days prior to  
commencement of work.

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 preboring equipment at  
least 30 days prior to commencement of work.

Cutting of Piles[; G][; G, [\_\_\_\_]]

Submit the proposed method for cutting piles for desired length  
[and] [or] for removal of driving heads 30 days prior to the start  
of pile driving.

Delivery, Storage, and Handling[; G][; G, [\_\_\_\_]]

Submit delivery, storage, and handling plans for piles at least  
30 days prior to delivery of piles to the jobsite.

[Pile Load Tests[; G][; G, [\_\_\_\_]]

Submit pile load test plan at least 30 days prior to installing  
any test piles.]

Concrete Mix

Submit concrete mixture proportions prior to casting piles.

Curing of Piles[; G][; G, [\_\_\_\_]]

Submit methods and details for curing piles prior to casting  
piles.

Pile Placement and Tolerances[; G][; G, [\_\_\_\_]]

Submit pile placement plan and tolerances at least 30 days prior  
to delivery of piles to the jobsite.

[Voids[; G][; G, [\_\_\_\_]]

Submit materials and methods for forming voids.]

Driving Records Form[; G][; G, [\_\_\_\_]]

Submit the proposed form for recording pile driving records 30 days prior to commencement of work.

[Splices[; G][; G, [\_\_\_\_\_]]

Submit detail and design calculations demonstrating splice capacity at least 30 days prior to casting of piles.]

Cap Blocks[; G][; G, [\_\_\_\_\_]]

Submit the make-up of the proposed cap block, including material type, dimensions, modulus of elasticity, and coefficient of restitution. This information shall be included with the Pile Driving Equipment submittal.

#### SD-06 Test Reports

[Pile Driving Tests[; G][; G, [\_\_\_\_\_]]

Submit pile driving test data within one (1) [day] [week] after each test is completed.]

Dynamic Testing of Piles[; G][; G, [\_\_\_\_\_]]

Submit a summary report of dynamic test results for test piles within [\_\_\_\_\_] 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.]

[Pile Load Tests[; G][; G, [\_\_\_\_\_]]

Submit four copies of a pile load test report for each pile tested within one (1) [day] [week] after the load test is completed.]

#### SD-07 Certificates

Admixtures  
Aggregates  
Cement  
Pozzolan  
Prestressing Steel  
Reinforcing Steel

Submit certificates of compliance for admixtures, aggregates, cement, pozzolan, reinforcement steel, and prestressing steel prior to commencing fabrication of piles. Submit certificates for admixtures, aggregates, cement, and pozzolan along with concrete mix proportions. Submit aggregate source and gradation information for aggregates.

### 1.4 QUALIFICATIONS

The precast concrete manufacturing plant shall be certified by the Precast/Prestressed Concrete Institute (PCI), Plant Certification Program, or the manufacturer shall establish a quality control program based on PCI MNL-116 prior to the start of production.

## 1.5 DELIVERY, STORAGE, AND HANDLING

Piles shall be stored, handled, and transported in accordance with PCI MNL-116 except as follows. 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. 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 work site at no cost to the Government.

### 1.5.1 Delivery and Storage

Piles shall be held at the plant until the specified ultimate compressive strength is obtained or 14 days, whichever is greater. Storage areas for piles shall be stabilized and suitable foundations provided so differential settlement or twisting of the pile does not occur. Stacked piles shall be separated and supported by dunnage placed across the full width of each bearing point and in vertical planes between the piles. The stacks shall be limited to 1.5 m 5 feet in height unless otherwise approved. Each pile shall be stacked in a straight position and supported every 3 m 10 feet or less along its length (ends inclusive) to prevent excessive sweep in the pile.

### 1.5.2 Handling

Piles shall be lifted by means of a suitable bridle or slings attached to the pile at the [embedded or attached lifting devices] [marked pickup points]. Unless special lifting devices are attached for pickup, pickup points shall be plainly marked on all piles after removal of the forms. Alternate pickup methods or locations shall be subject to approval. Dragging of piles across the ground will not be permitted. The Contractor shall inspect each pile for sweep and structural damage such as cracking and spalling before transporting them from the storage site to the driving area. Sweep shall be checked by placing the pile on a firm level surface and rotating the pile. Sweep shall be limited to 50 mm 2 inches over the length of the pile. The Contractor shall again check the pile for excessive sweep and damage immediately prior to placement in the driving leads. Piles having excessive sweep shall be rejected.

## 1.6 [REGULATORY REQUIREMENTS]

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**NOTE: Issue (date) of regulatory requirements  
included in project specifications need not be more  
current than stated.**  
\*\*\*\*\*

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

### 1.6.1 [Concrete Aggregate Gradation]

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**NOTE: Insert applicable state highway department  
document title in which an acceptable gradation for  
the concrete aggregate is presented; i.e.,**

MISSISSIPPI STATE HIGHWAY DEPARTMENT (MS SHD)

MS SHD-01 (1990; Suppl 1991) Standard Specification  
for Road and Bridge Construction

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Gradation for concrete aggregate shall comply with:

[\_\_\_\_\_] STATE HIGHWAY DEPARTMENT [(\_\_\_\_\_)SHD]

[\_\_\_\_\_)SHD-\_\_\_\_\_] [(19\_\_\_\_)] [\_\_\_\_\_] ]

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Admixtures

Chemical admixtures shall conform to ASTM C 494/C 494M. Air-entraining admixture shall conform to ASTM C 260. Calcium chloride or admixtures containing chlorides or nitrates shall not be used.

2.1.2 Aggregates

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NOTE: Modify the requirements in ASTM C 33 as necessary to suit local conditions. For exposed piles in areas where reactive aggregates are found, provide for additional tests and certification to ensure that reactive aggregates will not be used. While not wholly conclusive, petrographic examination (ASTM C 295), chemical test (ASTM C 289), provide valuable indicators. The mortar bar method (ASTM C 227), while more reliable, requires at least 6 months and preferably 1 year to yield results. Consider the use of low alkali cement in combination with aggregates which deleteriously react with the alkali in cement in areas where substitution of aggregate is not feasible. Service records of concrete made with these materials along with tests should be used in evaluating these materials.

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Aggregates shall conform to ASTM C 33, Class [3S] [3M], except as specified otherwise herein. [Gradation requirements of [\_\_\_\_\_)SHD-\_\_\_\_\_] [the local state highway department requirements specified in paragraph, REGULATORY REQUIREMENTS, subparagraph CONCRETE AGGREGATE GRADATION] in lieu of those stated in ASTM C 33 will be permitted.] Fine aggregates from different sources of supply shall not be mixed or stored in the same stockpile, or used alternately in the same concrete mix or the same structure without approval. The fineness modulus of fine aggregate shall not be less than 2.40 or greater than 3.00. For piles that will be exposed to freezing and thawing, fine and coarse aggregate subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C 88 shall show a loss not greater than 10 percent. If the selected aggregates fail the soundness test, the aggregate source may be used if the concrete specimens made with the aggregates have a durability factor of not less than 80, based on 300 cycles of freezing and thawing, when tested in accordance with ASTM C 666.

### 2.1.1.3 Cement

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NOTES: Cement should be selected based on the potential for sulfate attack on the concrete. The potential is considered moderate if the pile is used in soil containing from 0.10 to 0.20 percent water soluble sulfate or used in fresh water containing sulfate from 150 to 1500 parts per million (ppm). The potential for sulfate attack is considered severe in soil or freshwater environments if the water soluble sulfate exceeds 0.20 percent or the sulfate content exceeds 1500 ppm.

Portland cement options are as follows:

Low potential - Type I, Type II, Type III, or Type V.

Moderate potential - Type I with a maximum of 10 percent tricalcium aluminate; Type II; Type III, with a maximum of 8 percent tricalcium aluminate, except the tricalcium aluminate percentage may be increased to 10 in seawater where the potential is moderate, the water-cement ratio of the concrete is below 0.45 (by weight), and the pile will be permanently submerged; or Type V.

High potential - Type V, or Type III with a maximum of 5 percent tricalcium aluminate.

Blended hydraulic cement options are as follows:

Low potential - Type IS, Type IP, Type I(PM) or Type I(SM); with or without the moderate sulfate resistance.

Moderate potential - Type IS(MS), Type IP(MS), Type I(PM) (MS), or Type I(SM) (MS).

Low alkali cement is required when aggregates from local sources may react deleteriously with the alkalis in the cement.

\*\*\*\*\*

Portland cement shall conform to ASTM C 150, Type [I, II, III, or V] [II, V, or III with a maximum of [\_\_\_\_\_] percent tricalcium aluminate, or I with a maximum of 10 percent tricalcium aluminate] [V or III with less than 5 percent tricalcium aluminate] [, low alkali]. [Blended hydraulic cement shall conform to ASTM C 595M ASTM C 595, Type [IS, IP, I(PM), or I(SM)] [IS(MS), IP(MS), I(PM) (MS), or I(SM) (MS)].]

### 2.1.1.4 Pozzolan

Pozzolan shall conform to ASTM C 618, Class C or F.

### 2.1.1.5 Prestressing Steel

\*\*\*\*\*



**NOTE: 12.70 mm (1/2-inch) diameter Grade 270, low relaxation strand is usually specified.**

The substitution of Grade 270 for Grade 250 strand will result in a slightly higher effective prestress force. The designer must analyze the pile for service loads, pickup and handling, and driving with the higher prestress force prior to permitting this option.

\*\*\*\*\*

Prestressing steel shall be seven-wire, [\_\_\_\_\_] mm inch diameter, Grade [270] [250], [low relaxation] [stress-relieved] steel strand conforming to the requirements of ASTM A 416/A 416M. [The substitution of Grade 270 stress-relieved strand for Grade 250 stress-relieved strand on a one-for-one basis will be permitted.] Steel shall be free from grease, oil, wax, paint, soil, dirt, loose rust, kinks, bends, and other defects.

#### 2.1.6 Reinforcing Steel

\*\*\*\*\*

**NOTE: ASTM A 706 should be required where welding of reinforcing steel is required or anticipated.**

\*\*\*\*\*

Non-prestressing reinforcing steel shall conform to [ASTM A 615/A 615M] [ASTM A 616/A 616M including Supplementary Requirements,] [ASTM A 617/A 617M,] [or] [ASTM A 706/A 706M,] Grade [60], deformed.

#### 2.1.7 Ties and Spirals

Steel for ties and spirals shall conform to ASTM A 82.

#### 2.1.8 Water

Water for mixing concrete shall be fresh, clean, drinkable, and free from injurious amounts of oils, acids, alkalies, salts, organic materials, or other substances that may be deleterious to concrete or steel. Undrinkable water may be used if it meets the requirements of COE CRD-C 400. Time of set for concrete made with undrinkable water may vary from one hour earlier to one and one-half hours later than a control sample made with distilled water.

#### 2.1.9 [H-Pile Extensions

H-pile extensions for composite prestressed concrete-steel piles shall be of steel conforming to the requirements of [ASTM A 36/A 36M] [ASTM A 572/A 572M].]

#### 2.1.10 [Pile Points

Pile points shall be of steel conforming to the requirements of ASTM A 27/A 27M or [ASTM A 36/A 36M] [ASTM A 572/A 572M], of the [type] [details] indicated.]

## 2.2 FABRICATION

### 2.2.1 Prestressed Concrete Piles

\*\*\*\*\*  
NOTE: Pick-up point locations should be calculated  
by the designer and shown.  
\*\*\*\*\*

Prestressed concrete piles shall be [solid] [hollow] concrete piles of the type indicated. Piles shall be cast as monolithic units of homogeneous concrete and pretensioned with prestressing steel. Manufacturing requirements for piles shall conform to PCI MNL-116 except as modified. [Voids in hollow-core piles shall be vented at the top of the pile to prevent build-up of internal pressure.] [Embedded or attached lifting devices for pick-up shall be as shown.] [Pick-up points shall be marked on the piles at the indicated location after removal of the forms.] Detail drawings of piles, showing dimensions and fabrication details including forms, reinforcement, collars, shoes, [splices,] [build-ups,] [and] [embedded or attached lifting devices,] [pick-up points,] [drain holes,] shall be submitted for approval. The Contractor shall notify the Contracting Officer one (1) week prior to the date casting of piles is to begin.

### 2.2.2 Forms

Forms shall be of steel, braced and stiffened against deformation, accurately constructed, watertight, and supported on unyielding concrete casting beds. Form surfaces shall be within 6 mm 1/4 inch of a true plane in a length of 15 m 50 feet. Forms shall permit movement of the pile without damage during release of the prestressing force. Voids shall be formed.

### 2.2.3 Reinforcement and Embedments

\*\*\*\*\*  
NOTE: The minimum cover requirement should be 50 mm  
(2 inches), except in marine or other corrosive  
environments where it should be 63 mm (2-1/2 inches).  
\*\*\*\*\*

Reinforcing steel, prestressing steel, and embedded items shall be accurately positioned in the forms and secured to prevent movement during concrete placement. Steel shall have a minimum concrete cover of [\_\_\_\_\_] inches. Reinforcing steel details shall conform to ACI SP-66. Welding of reinforcing steel shall be in accordance with AWS D1.4.

### 2.2.4 Concrete Mix

\*\*\*\*\*  
NOTE: Insert the ultimate compressive strength, a  
minimum of 34.5 MPa (5000 psi), as required by the  
design. CECW-ED should be consulted prior to  
specifying strengths above 48.3 MPa (7000 psi).  
  
Insert a slump tolerance acceptable to industry in  
the vicinity of the project such as 25 to 75 mm (1  
to 3 inches).

Insert a maximum permissible water-cement ratio of 0.40 for piles exposed to seawater and 0.45 for all others.

Insert a minimum air entrainment of 4.5 percent for piles exposed to seawater and 4 percent for all others. The designer should evaluate the air entrainment requirements for strengths over 48.3 MPa (7000 psi).

Insert the nominal maximum size coarse aggregate, usually 25 mm (1 inch). The size is dependent on the amount of clear cover and spacing of strands.

\*\*\*\*\*

The concrete mix shall be selected by the Contractor to have an ultimate compressive strength of [\_\_\_\_\_] MPa psi at 28 days (90 days if fly ash is used) and a slump of [\_\_\_\_\_] to [\_\_\_\_\_] mm inches. The water-cement ratio (by weight) shall be held to the minimum consistent with workability required for placement but in no case shall it exceed [\_\_\_\_\_]. [Concrete shall be air entrained with a minimum of [\_\_\_\_\_] percent and a maximum of 6 percent air entrainment, accomplished by use of an additive at the mixer.] Nominal maximum size coarse aggregate shall be [\_\_\_\_\_] mm inch[es]. Once production begins, changes to the mix will not be permitted without written submittal and approval of the proposed changes.

#### 2.2.5 Concrete Work

Concrete shall not be deposited in the forms until the placement of the reinforcement and anchorages has been inspected and approved by the Contracting Officer. Conveying equipment shall be cleaned thoroughly before each run and the concrete conveyed from the mixer to the forms as rapidly as practicable using methods that will not cause segregation or loss of ingredients. Concrete shall be deposited as nearly as practicable in its final position in the forms. At any point in conveying, the free vertical drop of the concrete shall not exceed 900 mm 3 feet. Chuting will be permitted if the concrete is deposited into a hopper before being placed in the forms. Concrete that has segregated in conveying shall be removed. Each pile shall be produced of dense concrete with smooth surfaces. Vibrator heads shall be smaller than the minimum distance between steel pretensioning. Side forms shall not be removed until concrete has attained 24.1 MPa 3500 psi compressive strength. Dimensional tolerances shall conform to PCI MNL-116. The ends of all piles and corners of square piles shall be chamfered 19 mm 3/4 inch[or, in lieu of chamfering, may be rounded to a 25 mm 1 inch radius].

#### 2.2.6 Pretensioning

Anchorage for tensioning the prestressing steel shall be an approved type. The tension to which the steel is to be pretensioned shall be measured by the elongation of the steel and also by the jack pressure reading on a gauge or by the use of an accurately calibrated dynamometer. The gauge or dynamometer shall have been calibrated by a calibration laboratory approved by the Contracting Officer within 12 months of commencing work and every 6 months thereafter during the term of the contract. Means shall be provided for measuring the elongation of the steel to the nearest 6 mm 1/4 inch. The applied load determined from elongation measurements shall be computed using load-elongation curves for the steel used. When the difference between the results of measurement and gauge reading is more than 5

percent, the cause of the discrepancy shall be corrected. The tensioning steel shall be given a uniform prestress prior to being brought to design prestress. The same initial prestress shall be induced in each unit when several units of prestressing steel in a pile are stretched simultaneously.

#### 2.2.7 Detensioning

\*\*\*\*\*  
NOTE: Specify the release strength (0.7 times the design strength is generally acceptable in most regions of the country). Pickup and handling stresses for unusually long piles may require a higher release strength of 0.8 times the design strength.  
\*\*\*\*\*

Releasing of prestressing force in pretensioned piles shall be performed in a manner that minimizes eccentricity of prestress. Tension in the strands shall be released from the anchorage gradually. In no case shall the stress be released after casting without approval. The transfer of prestressing force shall be done when the concrete has reached a compressive strength of not less than [\_\_\_\_\_] MPa psi. The prestressing steel shall be cut or ground flush with the pile ends.

#### 2.2.8 Curing of Piles

Curing of piles shall be in accordance with the provisions contained in PCI MNL-116 except as follows. The maximum rate of heat gain shall not exceed 22 degrees C 40 degrees F per hour and the maximum concrete temperature shall not exceed 74 degrees C 165 degrees F during the curing cycle. Curing shall be continued until the concrete has attained a minimum compressive strength of 24.1 MPa 3500 psi as determined by the concrete test cylinders.

#### 2.2.9 Splices

\*\*\*\*\*  
NOTE: Splices should generally not be permitted where required lengths are available in one piece or the pile is designed for a moment connection.

Where splices are permitted, the location of the splice should be shown. Details of the splice should be shown or the Contractor should be required to submit details and calculations to demonstrate the adequacy of the splice.

\*\*\*\*\*

[Splices will not be permitted.] [Splices shall be [as indicated.] [designed by the Contractor] and 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.]

#### 2.2.10 [Build-Ups

\*\*\*\*\*  
NOTE: The use of build-ups should generally be limited to repairing the tops of seated piles

damaged during driving. Piles designed for a moment connection at the pile cap should not be repaired by a build-up. Insert the concrete strength required by design, usually a minimum of 34.5 MPa (5000 psi).

Delete this paragraph if not applicable to the project.

\*\*\*\*\*

Build-ups shall be in accordance with the procedures for build-up without driving as detailed in PCI STD-112 and shall be constructed subsequent to final seating of the pile. The joint between the pile and the build-up shall be protected by an approved mortar or epoxy. Build-ups shall be protected from standing water during the curing period. Concrete in the build-up shall have a minimum ultimate strength of [\_\_\_\_\_] MPa[psi].

## 2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

Testing during manufacture shall be performed by an approved commercial testing laboratory or by an approved laboratory maintained by the manufacturer of the material. Minimum requirements for testing during manufacture shall be as required in PCI MNL-116 except as modified.

### 2.3.1 Concrete Cylinders

A minimum of four standard 150 mm by 300 mm 6 inch by 12 inch concrete test cylinders per casting bed shall be made to indicate transfer and 28-day strengths. The test cylinders may be 100 mm by 200 mm 4-inch by 8-inch in lieu of the standard 150 mm by 300 mm 6 inch by 12 inch cylinders when the required 28-day strength of the concrete is 55.2 MPa 8000 psi or above.

### 2.3.2 Testing by Government

Facilities shall be made available to the Contracting Officer for making and testing any additional test cylinders desired.

### 2.3.3 Certificates of Compliance

The Contractor shall certify and submit Certificates of Compliance that admixtures, aggregates, cement, and pozzolan used conform with the requirements of the specifications. Manufacturer's literature indicating conformance may be submitted for admixtures.

## PART 3 EXECUTION

### 3.1 PILE DRIVING EQUIPMENT

The Contractor shall select the proposed pile driving equipment as specified and submit descriptions of the proposed equipment for approval. Equipment approval will be based on [wave equation analysis and the engineering judgment of the Contracting Officer.] [Stresses predicted by wave equation analysis shall not exceed 0.85 times the concrete compressive strength minus the effective prestress in compression and the effective prestress in tension.] [Final approval of the proposed equipment is subject to the satisfactory completion and approval of pile tests.] Changes in the selected pile driving equipment will not be allowed after the equipment has been approved by the Contracting Officer except as [specified and] directed by the Contracting Officer. No additional contract time will be allowed for Contractor proposed changes in the

equipment.

### 3.1.1.1 Pile Driving Hammers

\*\*\*\*\*

NOTE: The minimum and maximum hammer energies required may be determined from experience with similar piles in similar soil formations or by a series of wave equation analyses. The minimum energy should be 20 000 J (15,000 foot-pounds) or higher. The single acting steam-air hammer has been used quite successfully with concrete piles using various rules of thumb or empirical equations. Many Contractors prefer to use the lighter diesel hammers which utilize a longer stroke and lighter weight to deliver comparable energies of single acting steam-air hammers, and have been successful doing such.

\*\*\*\*\*

Pile driving hammers shall be of the impact type and capable of satisfying the requirement of paragraph INSTALLATION, subparagraph PENETRATION CRITERIA. Hammers shall be steam, air, [or diesel hammers] of the single acting, double-acting, or differential acting type. [The size or capacity of hammers shall be as recommended by the manufacturer for the pile type, weight, and soil formation to be penetrated.] [The rated energy of hammers shall be limited to a minimum of [\_\_\_\_\_] J foot-pounds and a maximum of [\_\_\_\_\_] J foot-pounds.] [Hammers shall be capable of [, and so demonstrated during the development of refusal criteria,] hard driving in excess of [\_\_\_\_\_] blows per 25 mm inch.] Boiler, compressor, or engine capacity shall be sufficient to operate hammers continuously at the full rated speed so that a single-acting hammer obtains a full upward stroke of the ram, a double-acting hammer operates at or near the blows per minute at which the hammer is rated, and a differential type hammer obtains a slight rise of the hammer base during each upward stroke. Single-acting hammers shall have a scale (in hundredths of a meter inches) fixed to the hammer's ram guide and a pointed indicator fixed on the ram to allow reading of the hammer's stroke. Both the scale and indicator shall be easily legible to observers on the ground. Hammers shall have a gage to monitor hammer bounce chamber pressure for diesel hammers or pressure at the hammer for air and steam hammers. This gage shall be operational during the driving of piles and shall be mounted in an accessible location for monitoring by the Contractor and the Contracting Officer. [Two spare operational bounce chamber read-out units shall be available on site.] [The Contractor shall provide bounce chamber pressure gage correction tables and charts for the type and length of hose to be used with the pressure gage to the Contracting Officer.] The following information for each hammer proposed shall be submitted:

- a. Make and model.
- b. Ram mass (kilograms) weight (pounds).
- c. Anvil mass (kilograms) weight (pounds).
- d. Mass Weight of the moving parts of the hammer.
- e. Rated stroke( mm inches).

- f. Rated energy range ( J foot-pounds).
- g. Rated speed (blows per minute).
- h. Steam or air pressure, hammer, and boiler and/or compressor (MPa psi).
- [i. Rated bounce chamber pressure curves or charts, including pressure correction chart for type and length of hose used with pressure gage ( MPa psi).]
- j. Power pack description.

### 3.1.2 Pile Driving Leads

\*\*\*\*\*  
**NOTE:** Suspended leads should not be used on jobs where accurate pile placement and alignment are required.

Sophistication of the leads called for is dependent on the complexity of the pile driving, layout of the piles, and the need for restriking. Small or simple jobs usually would not require the three-axis rotational leads. Batters should be chosen to suit the project needs.

Intermediate supports should be required when driving long piles of high-slenderness ratio. The braces serve to prevent pile overstressing and assist in maintaining the pile in a true and plumb position during driving.

\*\*\*\*\*

Leads shall align the pile and hammer concentrically, and maintain the pile in proper position and alignment throughout driving. Hammers shall be supported and guided with [suspended leads,] fixed extended leads or fixed underhung leads. [For driving battered piles, hammers shall be supported and guided with [fixed extended leads capable of achieving the batters shown on the plans] [three-axis, fixed-extended leads capable of 1H and [2-1/2V] fore and aft batter and 1H on [6V] side batter, with 30-degree rotation each side of an axis running along the center line of rotation of the crane through the center line of the leads].] The leads shall be of sufficient length to fully accommodate the combined length of the pile and hammer. [Two intermediate pile supports shall be provided in the leads to reduce the unbraced length of the pile during driving and pulling.]

### 3.1.3 Driving Helmets and Pile Cushions

\*\*\*\*\*  
**NOTE:** Selection of pile cushion is an important part of installation for prestressed concrete piles. The cushion protects the pile head from damage caused by impact and helps control tensile stresses in the concrete during driving.

\*\*\*\*\*

A driving helmet including a pile cushion shall be used between the top of the pile and the ram to prevent impact damage to the pile. The driving

helmet and pile cushion combination shall be capable of protecting the head of the pile, minimize energy absorption and dissipation, transmit hammer energy uniformly over the top of the pile and prevent excessive tensile stresses from developing in the concrete during driving. The driving helmet shall fit loosely around the top of the pile so that the pile is not restrained by the helmet if the pile tends to rotate during driving. The pile cushion may be of solid wood or of laminated construction, completely cover the top surface of the pile, and be retained by the driving helmet. Minimum thickness of the pile cushion shall be 75 mm<sup>3</sup> inches and the thickness shall be increased so as to be suitable for the size and length of pile, character of subsurface material to be encountered, hammer characteristics, and the required driving resistance. The following information for each hammer proposed shall be submitted:

- a. Pile driving helmet, make, and mass (kilograms) weight (pounds).
- b. Pile cushion material, type, proposed thickness, modulus of elasticity, and coefficient of restitution.

#### 3.1.4 Cap Blocks

The cap block (hammer cushion) used between the driving cap and the hammer ram may be of solid hardwood block with grain parallel to the pile axis and enclosed in a close-fitting steel housing or may consist of aluminum and approved industrial type plastic laminate disks stacked alternately in a steel housing. Steel plates shall be used at the top and the bottom of the cap block. The cap block shall be replaced if it has been damaged, highly compressed, charred, or burned or has become spongy or deteriorated in any manner. If a wood cap block is used, it shall not be replaced during the final driving of any pile. Under no circumstances will the use of small wood blocks, wood chips, rope, or other material permitting excessive loss of hammer energy be permitted.

#### 3.1.5 Pile Extractors

Impact hammers are required for pulling piles.

#### 3.1.6 [Jetting Equipment

Jetting equipment shall have not less than two removable or fixed jets of the water or combination air-water type. Water jets shall be designed so that the discharge volume and pressure are sufficient to freely erode the material immediately under and adjacent to piles without resulting in pile drift. Jetting equipment including plant description, volume of water and pressure, and size and length of hoses and pipes shall be submitted for approval.]

#### 3.1.7 [Preboring Equipment

The auger of the preboring equipment shall be sufficiently rigid to drill the pilot hole within the tolerances for pile driving specified in paragraph INSTALLATION, subparagraph PILE PLACEMENT AND TOLERANCES. Auger diameter shall not exceed two-thirds the [diameter] [width] of the pile.]

### 3.2 INSTALLATION

#### 3.2.1 Lengths of Permanent Piles

[The lengths of piles required are indicated on the drawings.] [The



estimated quantities of piles listed in the unit price schedule are given for bidding purposes only. The Contracting Officer will determine the actual lengths of piles required to be driven below cutoff elevation for the various locations in the work and will furnish the Contractor a quantities list indicating lengths and locations of all piles to be placed.

Pile length determination will be made from the results of the pile tests specified in paragraph PILE TESTS.] [The Contracting Officer will determine the number of overlenth piles required, if any, to provide for variations in subsurface conditions.]

### 3.2.2 Pile Placement and Tolerances

[Foundation preparation (removal of unsuitable material and densification of foundation fill) shall be completed in an area prior to driving permanent piles within that area.] A pile placement plan and tolerances shall be developed to show the installation sequence and the methods proposed for controlling the location and alignment of piles and submitted for approval. Piles shall be placed accurately in the correct location and alignments, both laterally and longitudinally, and to the vertical or batter lines indicated. The Contractor shall establish a permanent baseline during pile driving operations to provide for inspection of pile placement by the Contracting Officer. The baseline shall be established prior to driving permanent piles and shall be maintained during the installation of the permanent piles. Prior to driving and with the pile head seated in the hammer, the Contractor shall check each pile for correct alignment. The alignment of battered piles shall be checked and monitored during driving with an accurate batter board level [and surveying instrument]. A final lateral deviation from the correct location at the cutoff elevation of not more than [75] [150] mm [3] [6] inches will be permitted. A vertical deviation from the correct cutoff elevations shown on the drawing of not more than [25] [50] mm [1] [2] inch[es] will be permitted. A final variation in alignment of not more than 20 mm per meter 1/4 inch per foot of longitudinal axis will be permitted. [A final variation in rotation of the pile about its center line of not more than 7.5 degrees will be permitted.] The correct relative position of all piles shall be maintained by the use of templates or by other approved means. Piles not located properly or exceeding the maximum limits for rotation, lateral deviation, and/or variation in alignment shall be pulled and redriven at a directed location.

### 3.2.3 Pile Driving

Piles shall not be driven within 30 m 100 feet of concrete less than 7 days old unless otherwise authorized. Driving shall not result in cracking, crushing, or spalling of concrete. [The sequence of installation shall be such that pile heave is minimized.] [Where heave is anticipated, pile driving shall start at the center of the group and proceed outward [and vertical piles shall be driven prior to those battered where practicable].]

The Contracting Officer shall be notified 30 days prior to the date driving is to begin.

#### 3.2.3.1 Driving Records

\*\*\*\*\*  
NOTE: The Specifier should attach a sample form  
pile driving record to the end of this specification.  
\*\*\*\*\*

The Contractor shall develop a driving records form for recording the pile

driving operations, obtain approval of this form, and compile complete records of the operations. Pile driving records shall include pile dimensions and location, pile identification number, casting date, date driven, original pile length, cutoff and tip elevations, [batter alignment,] description of hammer used, rated hammer energy, observed stroke and rate of hammer operation (blows per minute), [air or steam pressure at the hammer or bounce chamber pressure,] length of pressure hose, penetration under the combined weight of the pile and hammer, number of blows required for each meter foot of penetration throughout the entire length of each pile and for each 25 mm inch of penetration in the last 300 mm foot of penetration, time for start and finish of driving, total driving time in minutes and seconds for each pile, cushion information including changes during driving, and any other information as required or requested. Record shall also include information such as unusual driving conditions, interruptions or delays during driving, observed pile damage, heave detected in adjacent piles, records of restriking, depth and description of voids formed adjacent to the pile, and any other pertinent information.

### 3.2.3.2 Penetration Criteria

\*\*\*\*\*

**NOTE: Penetration criteria must be given to provide guidance for determining relative pile capacity attained during driving and also to prevent structural damage to the pile. Friction piles are generally driven to a predetermined tip. End bearing piles are generally driven to a specified blow count to verify capacity and to prevent overdriving. The length or penetration rate should be determined from pile tests when performed. Prestressed concrete piles can generally sustain 8 to 10 blows per 25 mm for the last 300 mm (8 to 10 blows per inch for the last foot) of driving.**

**Criteria for stress limitations during driving are provided in EM 1110-2-2902, Design of Pile Foundations.**

\*\*\*\*\*

Piles shall be driven to the required [depth of penetration] [refusal blow count] as [shown] [determined by the Contracting Officer] or until the maximum permissible blow count is exceeded. [The required [depth of penetration] [refusal blow count] will be established subsequent to the analysis of pile tests as specified in paragraph PILE TESTS.] The maximum permissible blow count shall be [limited to [ ] blows per 25 mm inch, for the last [ ] mm inches of penetration] [or] [established from wave equation analyses so that stresses in the pile are limited to 0 MPa psi in tension and 0.85 times the compressive strength in compression].

### 3.2.3.3 Driving

Permanent [and test] piles shall be driven with hammers of the same model and manufacturer, same energy and efficiency, and using the same driving system. The hammer shall be operated at all times at the speed and under the conditions recommended by the manufacturer subject to the approval. Once pile driving has begun, conditions such as alignment and batter shall be kept constant. Each pile shall be driven continuously and without interruption until the required [depth of penetration] [refusal blow count] [penetration criteria] has been attained. Deviation from this procedure

will be permitted only for necessary changes to the pile cushion or whenever driving is stopped by causes that reasonably could not have been anticipated. Pile cushion changes will be considered necessary whenever the cushion has become highly compressed, charred, burned, or deteriorated.

Changes to the cushion will not be allowed near the end of driving. A pile that cannot be driven to the required depth because of an obstruction, as indicated by a sudden unexplained change in blow count and drifting, shall be pulled and redriven or shall be cut off and abandoned, whichever is directed.

[A pile that has not reached the required [refusal blow count] [penetration criteria] when the top has been driven to the cutoff elevation shall be reported to the Contracting Officer. The Contracting Officer will direct the Contractor to drive a replacement pile at an adjacent location or pull the pile and drive a longer pile in its place.] A pile which cannot be driven to the required tip elevation because the maximum permissible [blow count] [driving stress] is exceeded shall be reported to the Contracting Officer. The Contracting Officer will direct the Contractor to cut off the pile, pull and redrive the pile, or perform other corrective measures. Corrective measures may consist of [adding a pile at an adjacent location] [or] [requiring the Contractor to utilize jetting or preboring when redriving the pile].

[Jetting] [or] [preboring] to assist pile driving is specified in paragraph(s) [JETTING] [and] [PREBORING]. [Soil and water rising inside the pile more than 3 m 10 feet above the original ground or water level or to within 1.5 m 5 feet of the pile top shall be removed from inside hollow concrete piles before driving is continued unless approved methods are used to prevent pile damage. Vent holes to release internal pressure shall be provided as required when driving cylinder piles.] Observations shall be made to detect heave in accordance with paragraph HEAVED PILES. After piles are driven, the driving head or any excess pile above the cutoff elevation shall be removed in accordance with paragraph CUTTING OF PILES. Voids occurring around piles as a result of pile driving shall be backfilled [using a thick tremie-placed slurry consisting of [\_\_\_\_\_] parts sand, [\_\_\_\_\_] parts bentonite, and [\_\_\_\_\_] parts portland cement, except the upper 900 mm 3 feet of the void shall be earth filled and densified to the same density as the surrounding soil].

#### 3.2.3.4 Heaved Piles

When driving piles in clusters or under conditions of relatively close spacing, observations shall be made to detect heave of adjacent piles. Heaved piles shall be [restruck sufficiently to relieve soil setup and] driven to the original penetration criteria.

#### 3.2.3.5 Pulled Piles

Piles damaged or impaired for use during driving shall be pulled and replaced with new piles, or shall be cut off and abandoned and new piles driven as directed. The Contracting Officer may require that any pile be pulled for inspection. Piles pulled at the direction of the Contracting Officer and found to be in suitable condition shall be redriven at a directed location. [The abandoned hole for any pile that is pulled and moved to an adjacent location shall be filled with an approved thick tremie-placed slurry consisting of [\_\_\_\_\_] parts sand, [\_\_\_\_\_] parts Bentonite, and [\_\_\_\_\_] parts Portland cement.]

### 3.2.3.6 Jetting

\*\*\*\*\*

NOTE: Jetting should generally not be allowed on piles carrying significant tension loads, lateral loads, or compression loads developed predominantly from skin friction; on piles adjacent to existing structures; or on piles in closely spaced clusters unless the load capacity is confirmed by test.

Jetting is normally not performed in cohesive soils.

A pile that is jetted during driving is not likely to have the same capacity as one that is not. Therefore, if jetting is proposed, it must be incorporated into the pile test program.

\*\*\*\*\*

[Jetting of piles will not be permitted.] [Jetting may be used to assist driving only when specifically authorized.] [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.] [Jetted piles shall be driven not less than [300 mm 1 foot] [1.5 m 5 feet] after jetting has been stopped unless otherwise authorized. Adequate measures shall be taken for collecting and disposing of runoff water.]

### 3.2.3.7 Preboring

\*\*\*\*\*

NOTE: Preboring should not be allowed on piles carrying significant tension loads, lateral loads, or compression loads developed predominantly from skin friction.

Preboring is normally not performed in cohesionless soils.

A pile that is prebored is not likely to have the same capacity as one that is not. Therefore, if preboring is proposed, it must be incorporated into the pile test program.

\*\*\*\*\*

[Preboring will not be allowed.] [Preboring to remove soil will be permitted. The diameter of the hole should not exceed two-thirds the width of the pile. Prebored piles shall be driven not less than [\_\_\_\_\_] mmfeet below the bottom of the prebored hole, unless otherwise authorized, and shall be firmly seated by the application of a number of reduced energy hammer blows.]

### 3.2.4 Cutting of Piles

The proposed method for cutting of piles for removal of driving heads must be approved and shall not damage the pile concrete or reinforcement steel left in place. The use of explosives will not be permitted. Driving heads

shall not be removed until heaved piles are redriven to the original penetration criteria. Cut off sections of piles shall be removed from the site upon completion of the work.

#### 3.2.5 Splicing

[Splicing of driven piles will not be permitted.] [Splicing of piles shall be as indicated.] [Splicing of driven piles will not be permitted unless directed by the Contracting Officer. For a driven pile that has not attained sufficient resistance when the pile head is at the established cut-off elevation, the Contracting Officer may direct the Contractor to continue driving until such resistance is attained and extend the seated pile up to the specified cut-off elevation by splicing. Splicing of driven piles shall conform to the requirements of paragraph FABRICATION, subparagraph SPLICES.]

#### 3.2.6 [Build-Ups

The Contracting Officer may direct the Contractor to repair pile tops damaged during driving by removing the damaged portion and adding a reinforced concrete build-up. Build-ups shall be constructed subsequent to final seating of piles. Build-ups shall conform to the requirements of paragraph FABRICATION, subparagraph BUILD-UPS.]

#### 3.2.7 [Piles Exposed to Freezing

[Hollow piles exposed to freezing shall be provided with drain holes through the pile at the ground water elevation and shall be filled with free-draining material.] [Hollow piles standing in open water and exposed to freezing shall be plugged with concrete from the lowest freeze depth to a minimum of 300 mm 1 foot above the maximum high water level and shall be provided with drain holes through the pile wall just above the surface of the concrete plug.]]

### 3.3 PILE TESTS

\*\*\*\*\*

NOTE: This specification allows for two types of pile tests: pile driving tests and pile load tests.

Pile driving tests are used to determine the blow count required to drive a pile to a given penetration or to refusal on a hard layer. Pile driving tests may be performed with a pile driving analyzer attached to piles to record the information listed in paragraph PILE DRIVING ANALYZER. Pile load tests are used to determine pile capacity. The combination of pile driving tests and pile load tests gives information on pile capacity versus refusal blow count. Pile driving analyzer data may be used in some instances in place of pile load tests to reduce the number of load tests required for a project.

Delete this paragraph when not applicable to the project.

\*\*\*\*\*

[Pile driving tests] [and] [pile load tests] shall be performed as [specified and shown] [or] [directed]. The Contracting Officer will

develop the correlation between [pile driving resistance] [pile length] and pile capacity during the [pile driving tests] [and] [pile load tests] for the selected pile driving system. Based on the correlations developed, the Contracting Officer will determine the [refusal blow count] [pile length] for the permanent piles. Changes in the approved pile driving system during or after completion of tests will not be allowed unless additional tests are performed as directed to establish the correlation between [driving resistance] [length] and pile capacity for the proposed changed system. For changes in the approved pile driving system proposed by the Contractor, required additional [pile driving tests] [and] [pile load tests] shall be performed at Contractor's expense and no additional contract time will be allowed.

[The Contractor shall develop and submit for approval a detailed pile test plan which shall include drawings as appropriate and contain the following information:

- a. Method of reacting static test loads.
- b. Method of supporting reference beams.
- c. Method of attaching and supporting dial gages for measuring pile movements.
- d. Method of applying static test load to piles.
- e. Method of setup of secondary measurement system (surveyor's level, laser beam, etc.).
- f. Details of strain rod fabrication and installation.
- g. Details of loading frame and reaction systems design, including design computations and fabrication details.
- h. Calibration curves for the load cell and readout device.
- [i. Details of inclinometer installation.]

Approval of the plan shall not relieve the Contractor of the responsibility for structural and operational adequacies of the testing system.]

### 3.3.1 [Test Piles

Test piles shall be of the indicated lengths and shall be placed at the [indicated] [or] [directed] locations. Test piles shall be driven with the same equipment specified in paragraph PILE DRIVING EQUIPMENT and in the same manner specified in paragraph DRIVING for permanent piles. The driving record data shall be recorded for each test pile driven. [A pile driving analyzer shall be provided and operated as specified in paragraph PILE DRIVING ANALYZER during the driving of each test pile.]]

### 3.3.2 [Pile Driving Tests

[\_\_\_\_] pile driving tests shall be performed. The Contracting Officer will be present during each pile driving test. Pile driving tests shall be carried to completion without interruption. Any pile driving test not accomplished in accordance with this specification shall be redone at no additional cost to the Government. Each driving test pile shall be pulled within one (1) [day] [week] after the completion of that pile driving test,

damages documented, and stored at construction site. Pulled test piles shall be removed from the site when directed.]

### 3.3.3 Dynamic Testing of Piles

\*\*\*\*\*  
NOTE: Dynamic testing should be specified during initial driving if its purpose is to monitor drive system performance and driving stresses. If the purpose is to evaluate pile capacity, specify restriking of piles and dynamic testing during restrike. Restriking is best performed on test piles. Restrike driving may significantly affect the Contractor's installation sequence; therefore, identify the locations and piles to be restruck whenever possible.  
\*\*\*\*\*

The Contractor shall provide [employ a specialty engineering firm to] perform dynamic testing on test piles [and permanent piles] to determine velocity of stress wave propagation, acceleration, monitor hammer and drive system performance, assess pile installation stresses and integrity [, and to evaluate pile capacity]. Personnel experienced in performing wave equation analysis, dynamic testing, and interpretation of results shall be furnished to install and operate the testing equipment, and to furnished to install and operate the testing equipment, and to interpret its results. Equipment to obtain dynamic measurements, record, reduce and display its data shall be furnished and meet the requirement of ASTM D 4945. The equipment shall have been calibrated within 12 months thereafter throughout the contract duration. All power requirements for operating the equipment shall be supplied by the Contractor. Prior to commencing pile driving, a wave equation analysis shall be performed and the results submitted.

#### 3.3.3.1 Test Piles

\*\*\*\*\*  
NOTE: Delete the first bracket insert if testing is to be performed on all test piles.  
\*\*\*\*\*

Dynamic testing shall be performed on [\_\_\_\_\_] test piles as indicated. Testing shall be performed during the full length of pile driving. Piles which are statically load tested shall be restruck within 48 hours after completion of static load test to correlate static and dynamic test results. [Piles installed as part of pile driving test shall be restruck after a minimum waiting period of [\_\_\_\_\_] days.] The hammer shall be warmed up prior to restriking. Restriking shall consist of restriking the pile for 50 blows or until the pile penetrates an additional 75 mm 3 inches, whichever occurs first. In the event the pile movement is less than 6 mm 1/4 inch during restrike, the restrike may be terminated after 20 blows.

#### 3.3.3.2 [Permanent Piles

Dynamic pile testing shall be performed on [\_\_\_\_\_] permanent piles during the full length of initial driving [and during restrike driving]. Tested piles shall be as [indicated] [selected by the Contracting Officer over the duration of installation]. The Contracting Officer will direct testing of additional piles if the hammer or driving system is modified or replaced.]

### 3.3.3.3 Reports

A summary report of dynamic test results for test piles shall be prepared and submitted in accordance with paragraph SUBMITTALS. The report shall discuss pile capacity obtained from dynamic testing as it compares to static test results computed by the Government, and also include velocity of stress wave propagation, acceleration, evaluation of hammer and driving system performance, driving stress levels, and pile integrity. [A CAPWAPC, or similar, analysis of the dynamic test data shall be performed on data obtained from the end of initial driving and the beginning of restrrike for [\_\_\_\_\_] test piles as directed. The analysis shall be used to predict pile capacity, establish resistance distribution, and predict quake and damping factors.] Refined wave equation analyses incorporating the results of dynamic testing and analysis shall be included. [For permanent piles, a field summary report shall be prepared and submitted in accordance with paragraph SUBMITTALS. The field summary report shall minimally contain energy transferred to the pile, calculated driving stresses, pile integrity and estimated pile capacity at the time of testing.] The report for the test piles [and the monthly report for permanent piles] shall include the pile driving record as an attachment and also address the items listed in paragraph "7.1.5 Dynamic Testing" of ASTM D 4945.

### 3.3.4 [Pile Load Tests

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**NOTE: Each ASTM pile load test specification listed herein offers a number of options as to how the test is performed. Specify the load testing options desired and any other special requirements should be specified. See EM 1110-2-2906 for additional information.**  
\*\*\*\*\*

Pile load tests shall be performed under the supervision of a registered professional engineer provided by the Contractor and experienced in conducting pile load tests. Loading frames and equipment for pile load tests shall be ready to be placed in operation as soon as a load test pile has been driven. The loading equipment shall be of sufficient capacity to apply the maximum load specified in paragraph(s) [COMPRESSIVE LOAD TEST], [TENSILE LOAD TEST], [and] [LATERAL LOAD TEST] in a safe manner. Loading of each test pile shall be started when directed by the Contracting Officer. The Contractor shall be responsible for the application of loads. The magnitude of applied loads shall be accurately determined and controlled using a calibrated load cell and readout device. The design working load, as confirmed by the results of load tests, will be determined by the Contracting Officer. Load test piles indicated or directed to be driven in permanent locations may be incorporated into the work if, after satisfactory completion of load test, they are approved for inclusion in the work. Any pile load test not accomplished in accordance with this specification will be rejected. A new pile load test shall be conducted for each rejected pile load test. The Contractor shall compile a report for each pile tested which shall include, as a minimum, all applicable information required by the specified test.]

#### 3.3.4.1 [Compressive Load Test

[\_\_\_\_\_] pile compressive load tests shall be performed in accordance with ASTM D 1143, as modified [and] in paragraph PILE LOAD TESTS. A compressive load of [\_\_\_\_\_] kN tons shall be applied to each compressive load test pile.]



#### 3.3.4.2 [Tensile Load Test

[\_\_\_\_\_] pile tensile load tests shall be performed in accordance with ASTM D 3689, as modified [and] in paragraph PILE LOAD TESTS. A tensile load of [\_\_\_\_\_] kN tons shall be applied to each tensile load test pile.]

#### 3.3.4.3 [Lateral Load Test

[\_\_\_\_\_] pile lateral load tests shall be performed in accordance with ASTM D 3966, as modified [and] in paragraph PILE 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.]

-- End of Section --