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USACE / NAVFAC / AFCESA **UFGS-02395 (May 2003)**

Preparing Activity: NAVFAC **Superseding UFGS-02395N (September 1999)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 22 December 2004

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PRESTRESSED CONCRETE FENDER PILING

05/03

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SECTION 02395

PRESTRESSED CONCRETE FENDER PILING
05/03

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NOTE: This guide specification covers the requirements for prestressed concrete fender piling.

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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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: Refer to NFESC TM 53-89-03, "Prestressed Concrete Fender Piling User Data Package" for details of these fender piles. The following information shall be shown on the drawings:

1. Locations and design loads of piles.

2. Size, shape, and length of piles.

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

4. Details of reinforcement and tendons.

5. Soil data, where required.

6. Embedment depth.
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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 211.1	(1991; R 2002) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 212.3R	(1991: R 1999) Chemical Admixtures for Concrete
ACI 214R	(2002) Evaluation of Strength Test Results of Concrete
ACI 318M/318RM	(2002) Metric Building Code Requirements for Structural Concrete and Commentary
ACI SP-66	(2004) ACI Detailing Manual

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(1991; R 2000) Burlap Cloth Made from Jute or Kenaf

AMERICAN WELDING SOCIETY (AWS)

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

ASTM INTERNATIONAL (ASTM)

ASTM A 153/A 153M	(2004) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 307	(2004) Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 416/A 416M	(2002) Steel Strand, Uncoated Seven-Wire

	for Prestressed Concrete
ASTM A 501	(2001) Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
ASTM A 53	(1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 563	(2004a) Carbon and Alloy Steel Nuts
ASTM A 563M	(2004) Carbon and Alloy Steel Nuts (Metric)
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 1240	(2004) Silica Fume Used in Cementitious Mixtures
ASTM C 136	(2004) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 143/C 143M	(2003) Slump of Hydraulic Cement Concrete
ASTM C 150	(2004a) Portland Cement
ASTM C 171	(2003) Sheet Materials for Curing Concrete
ASTM C 172	(2004) Sampling Freshly Mixed Concrete
ASTM C 309	(2003) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 31/C 31M	(2003a) Making and Curing Concrete Test Specimens in the Field
ASTM C 311	(2004) Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete
ASTM C 33	(2003) Concrete Aggregates
ASTM C 39	(1993a) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 494	(1992) Chemical Admixtures for Concrete
ASTM C 59/C 59M5	(2000; Rev A) Blended Hydraulic Cements

ASTM C 59/C 59M5M	(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 989	(2004) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM D 1894	(2001) Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting
ASTM D 2240	(2004) Rubber Property - Durometer Hardness
ASTM D 256	(2004) Determining the Izod Pendulum Impact Resistance of Plastics
ASTM D 4020	(2001a) Ultra-High-Molecular-Weight Polyethylene Molding and Extrusion Materials
ASTM D 570	(1998) Water Absorption of Plastics
ASTM D 638	(2003) Tensile Properties of Plastics
ASTM D 638M	(1996) Tensile Properties of Plastics (Metric)
ASTM D 792	(2000) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM F 844	(2004) Washers, Steel, Plain (Flat), Unhardened for General Use

PRECAST/PRESTRESSED CONCRETE INSTITUTE (PCI)

PCI MNL-116	(1999) Quality Control for Plants and Production of Structural Precast Concrete Products

1.2 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

Piles

Driving helmets, capblocks, and pile cushions

SD-05 Design Data

Concrete mix design

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

SD-06 Test Reports

Aggregates

Fly ash

Silica fume

Concrete

Submit concrete cylinder compressive strength test results.

SD-07 Certificates

Precasting manufacturer's quality control procedures

Suitability of pile driving equipment

[Curing of piles]

[Silica fume manufacturer's representative]

Prestressing steel

Portland cement

Concrete mix design

Reinforcing steel

[Rubbing surface]

Bolts, nuts, and washers

1.3 REQUIREMENTS

1.3.1 Piling Lengths and Quantity

Provide prestressed pretensioned concrete piles. Base bids upon the number, size, and length of piles as indicated. Adjustments in the contract price will not be made for cutting off piles or for broken, damaged, or rejected piles.

1.3.2 Piles

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 of a professional engineer registered in any jurisdiction, that layout and details of reinforcement and tendons conform with that shown on the structural design drawings.]

1.3.3 Driving Helmets, Capblocks, and Pile Cushions

Show details of driving helmets, capblocks, and pile cushions. Submit 2 weeks prior to [test] pile installation.

1.4 QUALITY ASSURANCE

1.4.1 Quality Control Procedures

Submit [_____] copies of precasting manufacturer's quality control procedures established in accordance with PCI MNL-116.

[1.4.1.1 Curing of Piles

Submit proposed materials and methods.

]1.4.2 Silica Fume Manufacturer's Representative

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

1.4.3 Aggregates

Prior to pile fabrication, submit certified test reports for the following tests specified in ASTM C 33:

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

1.4.4 Fly Ash

Furnish fly ash test results performed within 6 months of submittal date. Sampling and testing shall be in accordance with ASTM C 311.

1.4.5 Silica Fume

Furnish silica fume test results performed within 6 months of submittal date. Sampling and testing shall be in accordance with ASTM C 311.

1.4.6 Portland Cement

Certification identifying cement; brand name, type, mill location, quantity to be used, size of lot represented by quality control sample, lot number, and destination of shipment.

1.4.7 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/318RM for specified strength and is based on aggregate data which has been determined by laboratory tests during last 12 months.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cement

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NOTE: Insert type of cement required. Except where moderate or high sulfate resistance is required, permit option for Type I, II, III, IP, or IS. For moderate sulfate resistance, specify Type II, III, IP(MS), or IS(MS) with a maximum tricalcium

aluminate content of 8 percent. For high sulfate resistance, specify Type III or V, with a maximum tricalcium aluminate content of 5 percent.

****

ASTM C 150, [Type I, II, or III] [_____], or ASTM C 59/C 59M5M ASTM C 59/C 59M5, Type [IP(MS) or IS(MS)] [_____] blended cement except as modified herein. The blended cement shall consist of a mixture of ASTM C 150 cement and one of the following materials: ASTM C 618 pozzolan or fly ash, or ASTM C 989 ground iron blast furnace slag. The pozzolan/fly ash content shall not exceed 25 percent by weight of the total cementitious material. The ground iron blast-furnace slag shall not exceed 50 percent by weight of total cementitious material. [Cement shall have a maximum tricalcium aluminate content of [5] [8] percent.]

2.1.2 Water

Use potable water.

2.1.3 Aggregates

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NOTE: For 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 28/c 28M9), provide valuable indicators. The mortar bar method (ASTM C 227), while more reliable, requires at least 6 months and preferably one year to yield results. In areas where reactive aggregates cannot be avoided, specify use of low alkali cement. Service records of concrete made with these materials along with tests should be used in evaluating these materials.

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NOTE: Include modification to ASTM C 33 when reactive aggregates could be encountered. More modifications may be required. Additional tests and certifications may be required in the submittal paragraphs.

****

ASTM C 33[, 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]. 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. Maximum coarse aggregate size shall be 19 mm 3/4 inch.

2.1.4 Admixtures

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

Concrete Piles."
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If required, ASTM C 494, [Type A] [Type B] and ASTM C 618, Type [N] [F] [C]. Do not use admixtures containing chlorides.

2.1.5 Mineral Admixtures

2.1.5.1 Fly Ash and Pozzolan

****
NOTE: Fly ash, pozzolan, and slag cement may produce uneven discoloration of the concrete during the early stages of construction, depending upon the type of curing provided. Fly ash or pozzolan meeting the specified test results, which are more stringent than ASTM C 618, should provide acceptable end results. Type C fly ash can be used as a replacement for up to 40 percent of the cement. Types F and C fly ash increase durability of concrete. Type F fly ash and slag are replacements for some sand and aggregates also adding to durability.
****

ASTM C 618, Type N, F, or C, except that the maximum allowable loss on ignition shall be 6 percent for Types N and F. Add with cement. Fly ash content shall not exceed 25 percent by weight of the total cementitious material.

2.1.5.2 Silica Fume

****
NOTE: Use silica fume concrete for marine structures where low permeability and enhanced durability are necessary. The silica fume and HRWR additive should be from the same manufacturer. Since this is fairly new technology, the Contractor and batch plant may need help from the manufacturer. Select weight percentage based on performance required.
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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 C 1240, provide silica fume that is a by-product of silicon or ferrosilicon production. Provide [5] [7] [10] percent by weight of the total cementitious material.

2.1.6   Prestressing Steel

Use seven-wire stress-relieved or low-relaxation strand conforming to ASTM A 416/A 416M with a guaranteed minimum ultimate tensile strength of 1861 MPa 270 ksi. Use prestressing steel free of grease, oil, wax, paint, soil, dirt, and loose rust. Do not use prestressing strands or wire having kinks, bends, or other defects.

2.1.7   Reinforcing Steel

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NOTE: If project has been designed for epoxy rebar, add ASTM A 934/A 934M, "Epoxy-Coated Prefabricated Steel Reinforcing Bars" in this paragraph and in the paragraph entitled "References."
****

[ASTM A 615/A 615M] [ASTM A 616/A 616M] [ASTM A 617/A 617M], Grade 60 or ASTM A 706/A 706M. Weld reinforcing steel in accordance with AWS D1.4.

2.1.8   Ties and Spirals

****
NOTE: If project has been designed for epoxy rebar, add ASTM A 934/A 934M, "Epoxy-Coated Prefabricated Steel Reinforcing Bars" in this paragraph and in the paragraph entitled "References."
****

Steel, ASTM A 82 for spirals and ASTM A 615/A 615M for ties.

2.1.9   Pipe Sleeves

Use ASTM A 53, Grade B, or ASTM A 501 galvanized pipe. Sleeves shall be galvanized in accordance with ASTM A 153/A 153M with chromate wash. Do not place galvanized pipe in contact with any prestressing or reinforcing steel.

2.1.10   Bolts, Nuts, and Washers

2.1.10.1   Bolts

ASTM A 307, Grade A.

2.1.10.2   Nuts

ASTM A 563MASTM A 563, Grade A, hex style.

2.1.10.3   Washers

ASTM F 844.

2.1.11   Ultrahigh Molecular Weight Polyethylene (UHMWPE) Rubbing Surface

2.1.11.1   General

a. Materials including additives shall be traceable by original lot number.

b. Materials used shall be FDA approved or otherwise harmless to marine life.

c. Fabricated form shall be virgin resin.

2.1.11.2 Resin

a. ASTM D 4020. Virgin resin shall be homopolymer of ethylene and have an intrinsic viscosity (IV) between 22.0 and 28.0 dl/g.

b. No reprocessed resin shall be used.

c. Resin shall be oil and moisture free (0.2 percent weight maximum).

2.1.11.3 Composition and Fabricated Form

a. Resin shall comprise a minimum 95.0 percent by weight concentration in the formulation.

b. The finished form shall maintain ultraviolet stability for a minimum of 25 years and be free of saltwater or petroleum product leachable materials.

c. No unfused areas or light patches greater than 300 micrometers No. 50 sieve shall be in the final fabricated form.

d. The fabricated form shall have the following properties:

Density (ASTM D 792)	57.5-58.7 lb/cu.ft
Tensile Strength (ASTM D 638M)	
Ultimate, minimum	31.7 MPa
Ultimate Elongation, minimum	250 percent
Impact Strength (ASTM D 256)	
Test Method A, Izod	Non-break for all five determinations in sample
Hardness (ASTM D 2240), minimum	Shore D 65
Coefficient of Friction (ASTM D 1894)	
Kinetic, maximum	0.13
Static, maximum	0.20
Water Absorption (ASTM D 570)	Nil
Abrasion Index (relative to steel = 100), maximum	10

Density (ASTM D 792)	0.92-0.94 g/cc
Tensile Strength (ASTM D 638)	
Ultimate, minimum	4600 psi
Ultimate Elongation, minimum	250 percent
Impact Strength (ASTM D 256)	
Test Method A, Izod	Non-break for all five determinations in sample
Hardness (ASTM D 2240), minimum	Shore D 65
Coefficient of Friction (ASTM D 1894)	
Kinetic, maximum	0.13
Static, maximum	0.20
Water Absorption (ASTM D 570)	Nil
Abrasion Index (relative to steel = 100), maximum	10

e. Color shall be black.

2.2 CONCRETE

2.2.1 Contractor-Furnished Concrete Mix Design

****
NOTE: Insert the specified compressive strength, f'c. Consider reducing average overstrength factor to produce a more economical concrete mix design, since these piles are not critical structural elements. ACI 318M/318RM 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 [_____] psi at 28 days. The minimum cement content shall be 354 kg/cu. meter 600 pounds per cubic yard of concrete. The design shall be prepared in accordance with ACI 211.1 or ACI 318M/318RM. 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/318RM. In the absence of such data, the Contractor shall sample and test the aggregates for the design of concrete.

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.

c. Air-entrainment shall be 5 to 8 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 OF PRETENSIONED PILES

Piles shall be pretensioned concrete piles. Workmanship shall conform to standard commercial practice in prestressing plants.

2.3.1 Formwork

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. Length: 10 mm per 3 meters 3/8 inch per 10 feet.

b. Cross section: plus 13 mm to minus 6 mm plus 1/2 inch to minus 1/4 inch.

c. Deviation from straight lines: not more than 3 mm per 3 meters 1/8 inch per 10 feet of length.

d. Pile head: plus or minus 6 mm per 0.30 meter 1/4 inch per foot of head dimension from true right angle plane. Surface irregularities: plus or minus 3 mm 1/8 inch.

e. 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.

f. Location of pipe sleeves from true position: plus or minus 10 mm 3/8 inch.

2.3.2 Pretensioning

Measure tension 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.

2.3.3 Casting

2.3.3.1 Conveying

Clean conveying equipment thoroughly before each run. Convey concrete from mixer to forms as rapidly as practicable by methods which will not cause segregation or loss of ingredients. Deposit concrete as nearly as practicable to its final position. During placing, make any free vertical drop of the concrete less than one meter 3 feet. Remove concrete which has segregated in conveying or placing.

2.3.3.2 Placing and Casting

****
NOTE: Select chamfer required. Consult with local producers. Where project requires a large quantity of piling, a specific value may be specified, otherwise, use a minimum or a range of values.
****

Perform concrete casting within 3 days after pretensioning steel; however, do not deposit concrete in forms until placement of reinforcement and anchorages have 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,] [[_____] mm inch,] [between 19 and 28 mm 3/4 and 1 1/8 inch,] ends of piles and corners of square piles.

2.3.4 Curing of Piles

Cure piles using moist or accelerated curing.

2.3.4.1 Moist Curing

a. Impervious sheeting: ASTM C 171; waterproof paper, clear or white polyethylene sheeting, or polyethylene-coated burlap.

b. Pervious sheeting: AASHTO M 182.

c. Liquid membrane-forming compound: ASTM C 309, white pigmented, Type 2, Class B.

2.3.4.2 Accelerated Curing

After placement of concrete, moist cure for a period of 4 hours. Accelerate curing 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 15.6 degrees C 60 degrees F per hour. Cure at a maximum temperature of 15.6 degrees C 160 degrees F until concrete has reached specified release strength. Reduce temperature at a rate not to exceed 15.6 degrees C 60 degrees F per hour until a temperature of -7 degrees C 20 degrees F 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 Detensioning

****
NOTE: Specify "release strength." Release strength of 30 MPa 4000 psi (design strength of 35 MPa 5000 psi) or 0.8 of the 28 day design strength is desirable; however, some regions use 0.7 of the design strength (25 MPa3500 psi for design strength of 35 MPa 5000 psi). A minimum release strength of 0.6 of the design strength is required. Check with local pile manufacturers.

****

Perform releasing 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.

2.3.6 Marking

Mark pile to identify in-place impact face. Marking shall be clearly visible during driving.

2.4 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, perform product quality control procedures in accordance with PCI MNL-116. Where piling is manufactured by specialists or in plants not currently enrolled in the PCI Certification Program for Quality Control, set up a product quality control system in accordance with PCI MNL-116 and perform concrete and aggregate quality control testing using an independent commercial testing laboratory approved by the Contracting Officer in accordance with the following.

2.4.1 Aggregate Tests

Take samples of fine and coarse aggregate at the concrete batch plant and test. Perform mechanical analysis (one test for each aggregate size) in accordance with ASTM C 136 including determination of the specific gravity. Tabulate the results of the tests in accordance with ASTM C 33.

2.4.2 Strength Tests

Sample concrete in accordance with ASTM C 172 at the time the concrete is deposited for each production line. Compression tests shall conform to methods of ASTM C 39 and ASTM C 31/C 31M. Perform slump tests in accordance with ASTM C 143/C 143M. Mold at least six cylinders per day or for every 15 cubic meter 20 cubic yards of concrete placed, whichever is greater. Test two cylinders of the set at 7 days of 14 days, or at a time for establishing transfer of prestressing force (release strength) and removal of pile from forms. Perform strength tests 28 days after molding using the remaining cylinders of the set. Cure the cylinders in the same manner as the piles and place at the point where the poorest curing conditions are offered. This is the coolest point in the bed for steam curing. Cylinders to be tested at 28 days shall be moist cured.

2.4.3 Changes in Proportions

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

2.4.4 Compressive Strength Test Results

Evaluate compression test results at 28 days in accordance with ACI 214R using a coefficient of variation of 10 percent. Evaluate the strength of concrete by averaging the test results (two specimens) of each set (four specimens) of standard cylinders tested at 28 days. Not more than 10 percent of the individual specimens tested shall have an average compressive strength less than specified average compressive strength.

PART 3 EXECUTION

3.1 PILE DRIVING

3.1.1 Driving Piles

Piles shall not be driven until 100 percent of design strength has been attained and until at least 14 days after detensioning. Drive piles to the indicated tip elevation and to the minimum embedment depth shown on the drawings. Pile driving shall be conducted as one continuous operation. The pile shall be driven until the resistance criterion is met. During the initial driving and until the pile tip has penetrated beyond layers of very soft soil or below the bottom of prejetted or preformed holes, use a reduced rated driving energy of the hammer of not more than 20,235 Joules 15,000 foot-pounds per blow or as otherwise directed by the Contracting Officer, to prevent high tension-wave driving stresses which could damage the pile. Resistance criterion shall be 20 blows for 0.3 m one foot or less. The Contracting Officer may modify the criteria based upon the actual hammer being used and its rated energy and its compatibility as verified by a pile test program. If a pile fails to reach the indicated butt elevation or minimum embedment, the Contractor shall notify the Contracting Officer and perform corrective measures as directed. Provide hearing protection when noise levels exceed 140 dB.

3.1.2 Pile Driving Leads and Templates

Piles shall be driven with the hammer positioned in a fixed or swinging lead. "Free hammer" will not be permitted. Swinging lead shall be used only in conjunction with a template system to spot the piles.

3.1.3 Installation of Piles

Take care to avoid damage to piles during handling, when placing the pile in leads, and during pile-driving operations. Inspect piles when delivered, when in leads immediately before driving, and after installation. No visible cracks will be permitted. Notify the Contracting Officer of any visible cracks and perform corrective measures as directed. Laterally support piles during driving, but allow rotation in leads. Take special care to maintain the pile orientation during driving. Square the top of the pile to the longitudinal axis of the pile. Maintain axial alignment of pile hammer with that of pile.

3.1.4 Tolerances in Driving

Drive piles with a variation of not more than one percent from vertical for plumb piles. Maintain and check axial alignment of pile and leads at start of pile driving and when the pile top is approximately 1.5 m 5 feet above the indicated elevation. Make intermediate checks of pile alignment if there is evidence of pile drifting. If subsurface conditions cause pile drifting beyond the allowable axial alignment tolerance, notify the Contracting Officer and perform corrective measures as directed. Place butts within 50 mm 2 inches of the location indicated. Manipulation of pile within specified tolerances is permitted, but do not manipulate piles more than one percent of their exposed length above the mudline. Check piles for heave. Redrive, to the indicated elevation, piles found to be heaved.

3.1.5 Jetting and Predrilling Holes

If predrilled holes are used, the diameter of the hole shall not exceed the diagonal dimension of the pile and the hole shall be kept open until the pile is inserted and advanced to the bottom of the hole. Piles shall be installed in holes immediately after predrilling to minimize the potential for sloughing and collapse of the hole. Jetting of the pile to obtain penetration is permitted. Discontinue jetting or predrilled hole at a depth of 1.5 m 5 feet from the indicated tip elevation, and achieve the remaining penetration by driving. Before starting the driving of the final 1.5 m 5 feet, firmly seat the piles in place by the application of a number of reduced-energy hammer blows. The Contractor shall arrange to provide an ample supply of water at adequate pressure for effective jetting. The use and details of jetting or predrilled holes shall be approved by the Contracting Officer.

3.1.6 Splices

Splicing of piles is not permitted.

3.1.7 Buildup

Buildups are not permitted.

3.1.8 Pile Cutoffs

Cut off piles with a smooth level cut using pneumatic tools, sawing, or other suitable methods approved by the Contracting Officer. The use of explosives for cutting is not permitted.

3.1.9 Patching

a. Embedded Lifting Loops. Provide a 25 mm one inch minimum conical depression around embedded lifting loops. Cut off lifting loops at bottom of depression and patch depression with epoxy mortar.

b. Pile Butt. Apply 25 mm one inch thick layer of epoxy mortar cover over exposed prestressing strand on pile butt after driving.

3.2 EQUIPMENT

3.2.1 Pile Hammers

Furnish a hammer having a capacity at least equal to the hammer manufacturer's recommendation for the total weight of pile and character of subsurface material to be encountered. Obtain the required driving energy of the hammer, except for diesel hammers, by use of a heavy ram and a short stroke with low-impact velocity. The pile hammer shall be capable of operating at a reduced energy level (1/2 to 2/3 of rated energy level) during seating of the piles in preformed holes and when driving through soft or loose materials. The driving energy of the hammer, at final driving, shall be not less than 40.650 Joules 30,000 foot-pounds. At final driving, operate the pile hammer in accordance with the manufacturer's recommendation. At final driving, operate diesel-powered hammers at the rate recommended by the manufacturer for hard driving.

Maintain sufficient pressure at the steam hammer so that (1) for double-acting hammer, the number of blows per minute during and at the completion of driving of a pile is equal approximately to that at which the 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 the hammer base during each downward stroke.

3.2.2 Driving Helmets, Capblocks, and Pile Cushions

3.2.2.1 Driving Helmets or Caps and Pile Cushions

****

NOTE: Insert minimum and maximum thicknesses for pile cushion. An absolute minimum would be 75 mm 3 inches and the actual required thickness would depend upon pile length, hammer energy, design load, required final penetration resistance, and character of subsurface material to be encountered. Generally thicker blocks are required for longer piles, larger hammers, and harder driving. A wave equation analysis is useful in determining required thicknesses for pile cushion. Minimum thickness is to protect head of pile. Pile cushion should also have a maximum thickness to ensure effective driving. Select when pile cushion is to be replaced. It is generally recommended that a new pile cushion be used at the start of driving of each pile.

****

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. The driving helmet or cap-and-pile cushion combination shall be capable of protecting the head of the pile, minimize energy absorption and dissipation, and transmit hammer energy uniformly over the top of the pile. The driving helmet or cap shall fit sufficiently loose around the top of the pile so that the pile may be free to rotate without binding within the driving helmet. The Contractor shall demonstrate to the satisfaction of the Contracting Officer that the equipment to be used on the project performs the above function. The pile cushion shall be of laminated construction using softwood boards with the grain parallel to the end of the pile. The thickness of the pile cushion shall be 300 mm 12 inches minimum. The cushion shall not be changed near the end of driving. Replace the pile cushion when it has become compressed beyond two-thirds of its original thickness, charred, or burned, or has become spongy or deteriorated in any manner. Use new cushions for initial driving of each pile. During redriving or restriking of piles, a used cushion assembly shall be used. The Contractor shall submit to the Contracting Officer at least 2 weeks before the start of pile driving operations detailed drawings of the driving helmet and pile cushion to be used.

3.2.2.2 Hammer Cushion or Capblock

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NOTE: Select either wood or aluminum/micarta capblock. Delete inappropriate sentences. An aluminum/micarta capblock is recommended because of its consistent elastic properties and long life. If final pile penetration resistance is based on a

wave equation analysis, the type capblock used should be the same as that used in the analysis.
****

Use a hammer cushion or capblock between driving helmet or cap and hammer ram consisting of [a solid hardwood block with grain parallel to the pile axis and enclosed in a close-fitting steel housing] [aluminum and micarta (or equal) discs stacked alternately in a steel housing]. Use steel plates at top and bottom of capblock. [Replace wood capblock when it becomes highly compressed, charred or burned, or becomes spongy or deteriorated in any manner.] [Replace aluminum or micarta discs that have become damaged, split, or deteriorated in any manner.] [Do not replace wood 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.

3.3 FIELD QUALITY CONTROL

3.3.1 Pile Records

For each pile, keep a record of the number of blows required for each 0.30 m foot of penetration and the number of blows for the last 150 mm 6 inch penetration or fraction thereof. Include in the record the beginning and ending times of each operation during driving of pile, type and size of the hammer used, rate of operation, stroke or equivalent stroke for diesel hammer, type of driving helmet, and type and dimension of the hammer cushion (capblock) and pile cushion used. Record re-tap data and any unusual occurrence during driving of the pile. Include in the record performance characteristics of jet pump, unassisted penetration of pile, jet-assisted penetration of pile, and tip elevation before driving and at end of driving. Notify Contracting Officer 10 days prior to driving of piles. Submit complete and accurate records of installed piles to Contracting Officer within 15 calendar days after completion of the pile driving. Make pile-driving records available to the Contracting Officer at the job site within 24 hours of each day's pile driving. A preprinted form for recording pile driving data is included at the end of this section.

PILE DRIVING LOG

CONTRACT NO.____________________________ CONTRACT NAME__________________________
CONTRACTOR__________________________________ TYPE OF PILE________________________
PILE LOCATION_______________ PILE SIZE: BUTT/TIP: _________ LENGTH__________
GROUND ELEVATION_____________________________ CUT OFF ELEVATION______________
PILE TIP ELEVATION____________________ VERTICAL (_____) BATTER 1 ON (_____)
SPLICES ELEVATION_______________________ COMPANY______________________________

HAMMER: MAKE & MODEL____________________ WT. RAM__________________________
STROKE__________________________ RAM RATED ENERGY____________________________
DESCRIPTION & DIMENSIONS OF DRIVING CAP_______________________________________
CUSHION MATERIALS & THICKNESS____

INSPECTOR____

"DEPTH" COLUMN OF PILE DRIVING RECORD REFERENCED TO:
________________________ CUT-OFF ELEVATION
________________________ FINISH FLOOR ELEVATION

TIME: START DRIVING________ FINISH DRIVING_________ DRIVING TIME__________
INTERRUPTIONS (TIME, TIP ELEV. & REASON)______________________________________
JET PRESSURE & ELEVATIONS____

____

DRIVING RESISTANCE

DEPTH M	NO. OF BLOWS	DEPTH M	NO. OF BLOWS	DEPTH M	NO. OF BLOWS
0	______	5.4	______	10.8	______
0.3	______	5.7	______	11.1	______
0.6	______	6.0	______	11.4	______
0.9	______	6.3	______	11.7	______
1.2	______	6.6	______	12.0	______
1.5	______	6.9	______	12.3	______
1.8	______	7.2	______	12.6	______
2.1	______	7.5	______	12.9	______
2.4	______	7.8	______	13.2	______
2.7	______	8.1	______	13.5	______
3.0	______	8.4	______	13.8	______
3.3	______	8.7	______	14.1	______
3.6	______	9.0	______	14.4	______
3.9	______	9.3	______	14.7	______
4.2	______	9.6	______	15.0	______
4.5	______	9.9	______	15.3	______
4.8	______	10.2	______	15.6	______
5.1	______	10.5	______	15.9	______

SHEET 1 OF 2

PILE DRIVING LOG

16.2	______	23.1	______	29.7	______
16.5	______	23.4	______	30.0	______
16.8	______	23.7	______	30.3	______
17.1	______	24.0	______	30.6	______
17.4	______	24.3	______	30.9	______
17.7	______	24.6	______	31.2	______
18.0	______	24.9	______	31.5	______
18.3	______	25.2	______	31.8	______
18.6	______	25.5	______	32.1	______
18.9	______	25.8	______	32.4	______
19.2	______	26.1	______	32.7	______
19.5	______	26.4	______	33.0	______
19.8	______	26.7	______	33.3	______
20.1	______	27.0	______	33.6	______
20.4	______	27.3	______	33.9	______
20.7	______	27.6	______	34.2	______
21.0	______	27.9	______	34.5	______
21.3	______	28.2	______	34.8	______
21.6	______	28.5	______	35.1	______
21.9	______	28.8	______	35.4	______
22.2	______	29.1	______	35.7	______
22.5	______	29.4	______	36.0	______
22.8	______				

Driving resistance in blows per 25 mm for last 0.30 m of penetration:

DEPTH________ DEPTH________

25mm___ 50mm___100mm___125mm___150mm___175mm___200mm___225mm___ 250mm___

275mm___300mm___

ELEV.________ ELEV.________

REMARKS____

____

CUT OFF ELEVATION: FROM DRAWING ________________

TIP ELEVATION = GROUND ELEVATION - DRIVEN DEPTH = ________________

DRIVEN LENGTH = CUT OFF ELEVATION - TIP ELEVATION = ________________

CUT OFF LENGTH = PILE LENGTH - DRIVEN LENGTH = ________________

SHEET 2 OF 2

PILE DRIVING LOG

CONTRACT NO.____________________________ CONTRACT NAME__________________________
CONTRACTOR__________________________________ TYPE OF PILE________________________
PILE LOCATION______________ PILE SIZE: BUTT/TIP: _________ LENGTH___________
GROUND ELEVATION_____________________________ CUT OFF ELEVATION______________
PILE TIP ELEVATION____________________ VERTICAL (_____) BATTER 1 ON (_____)
SPLICES ELEVATION_______________________ COMPANY____________________________

HAMMER: MAKE & MODEL___________________ WT. RAM_________________________
STROKE_________________________ RAM RATED ENERGY____________________________
DESCRIPTION & DIMENSIONS OF DRIVING CAP___________________________________
CUSHION MATERIALS & THICKNESS____

INSPECTOR____

"DEPTH" COLUMN OF PILE DRIVING RECORD REFERENCED TO:
________________________ CUT-OFF ELEVATION
________________________ FINISH FLOOR ELEVATION

TIME: START DRIVING________ FINISH DRIVING_________ DRIVING TIME___________
INTERRUPTIONS (TIME, TIP ELEV. & REASON)___________________________________
JET PRESSURE & ELEVATIONS____

____

DRIVING RESISTANCE

DEPTH FT.	NO. OF BLOWS	DEPTH FT.	NO. OF BLOWS	DEPTH FT.	NO. OF BLOWS
0	______	18	______	36	______
1	______	19	______	37	______
2	______	20	______	38	______
3	______	21	______	39	______
4	______	22	______	40	______
5	______	23	______	41	______
6	______	24	______	42	______
7	______	25	______	43	______
8	______	26	______	44	______
9	______	27	______	45	______
10	______	28	______	46	______
11	______	29	______	47	______
12	______	30	______	48	______
13	______	31	______	49	______
14	______	32	______	50	______
15	______	33	______	51	______
16	______	34	______	52	______
17	______	35	______	53	______

SHEET 1 OF 2

PILE DRIVING LOG

54	______	77	______	99	______
55	______	78	______	100	______
56	______	79	______	101	______
57	______	80	______	102	______
58	______	81	______	103	______
59	______	82	______	104	______
60	______	83	______	105	______
61	______	84	______	106	______
62	______	85	______	107	______
63	______	86	______	108	______
64	______	87	______	109	______
65	______	88	______	110	______
66	______	89	______	111	______
67	______	90	______	112	______
68	______	91	______	113	______
69	______	92	______	114	______
70	______	93	______	115	______
71	______	94	______	116	______
72	______	95	______	117	______
73	______	96	______	118	______
74	______	97	______	119	______
75	______	98	______	120	______
76	______				

DRIVING RESISTANCE IN BLOWS PER INCH FOR LAST FOOT OF PENETRATION:

DEPTH_________ DEPTH_________

1"___2"___3"___4"___5"___6"___7"___8"___9"___10"___11"___12"___

ELEV.________ ELEV._________

REMARKS____

CUT OFF ELEVATION: FROM DRAWING ________________

TIP ELEVATION = GROUND ELEVATION - DRIVEN DEPTH = ________________

DRIVEN LENGTH = CUT OFF ELEVATION - TIP ELEVATION = ________________

CUT OFF LENGTH = PILE LENGTH - DRIVEN LENGTH = ________________

SHEET 2 OF 2

-- End of Section --