Preparing Activity: USACE Superseding
UFGS-31 62 21 (November 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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DIVISION 31 - EARTHWORK

SECTION 31 62 23

PILING: COMPOSITE, WOOD AND CAST IN-PLACE CONCRETE

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USACE / NAVFAC / AFCEC / NASA **UFGS-31 62 23 (November 2020)**

Preparing Activity: USACE **Superseding**
UFGS-31 62 21 (November 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023

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SECTION 31 62 23

PILING: COMPOSITE, WOOD AND CAST IN-PLACE CONCRETE
11/20

****

NOTE: This guide specification covers the requirements for composite, wood and cast-in-place concrete piles.

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

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

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

****

PART 1 GENERAL

1.1 DESCRIPTION

Design, furnish, install and test composite wood and cast in-place concrete piles at the locations indicated on the drawings and specified herein.[Assume test pile[s] will be directed to be placed in [a] location[s] that can be incorporated into the work.]

1.2 REFERENCES

****

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

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

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 133	(2012; R 2016) Standard Specification for Preservatives and Pressure Treatment Processes for Timber

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	(2011) Evaluation of Strength Test Results of Concrete
ACI 318	(2014; Errata 1-2 2014; Errata 3-5 2015; Errata 6 2016; Errata 7-9 2017) Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14)
ACI 318M	(2014; ERTA 2015) Building Code Requirements for Structural Concrete & Commentary

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D1.4/D1.4M	(2011) Structural Welding Code - Reinforcing Steel

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA M1	(2021) Standard for the Purchase of Treated Wood Products
AWPA M2	(2019) Standard for the Inspection of Preservative Treated Wood Products for Industrial Use

AWPA M3	(2016) Standard for the Quality Control of Preservative Treated Products for Industrial Use
AWPA M6	(2013) Brands Used on Preservative Treated Materials
AWPA T1	(2023) Use Category System: Processing and Treatment Standard
AWPA U1	(2023) Use Category System: User Specification for Treated Wood

ASTM INTERNATIONAL (ASTM)

ASTM A615/A615M	(2022) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A996/A996M	(2016) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM C31/C31M	(2022) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2021) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C172	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C1202	(2022; E 2022) Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
ASTM C1218/C1218M	(2020c) Standard Test Method for Water-Soluble Chloride in Mortar and Concrete
ASTM D25	(2012; R 2017) Standard Specification for Round Timber Piles
ASTM D1143/D1143M	(2007; R 2013) Piles Under Static Axial Compressive Load

1.3 SUBSURFACE DATA

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

1.4 BASIS OF BID

****
NOTE: Select one of the following options:
****

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

Use "Unit Price" paragraph for unit price bidding of piles. Specify unit price bid items for piles only for projects where exact quantities cannot be practically determined prior to the actual work. Lengths of piles must be determined as accurately as possible, prior to bidding, since the unit price per meter (foot) of the piles varies as the length increases or decreases.
****

1.4.1 Contractor's Geotechnical Consultant

Hire the services of an independent, Registered Professional Geotechnical Engineer, experienced in soil mechanics and Pile Dynamic Analysis, to observe test pile installation and production pile installation as specified herein. The Contractor's Geotechnical Consultant must be independent of the Contractor and must have no employee of employer relationship which could constitute a conflict of interest.

1.4.2 Contractor Experience and Qualifications

The work must be performed by a Contractor with a minimum of 5 years of experience with the installation of the required foundation system in similar soil conditions of the project site. Submit past project lists indicating experience with such foundation systems.

1.4.3 Production Pile Acceptance Criteria

Safe design capacity for piles is [_____] KN kips. Drive piles to [minimum tip elevation] [a minimum depth of [____] m feet below cut-off elevation], and to such additional depth as required to obtain a bearing capacity of not less than [_____] KN kips. The Contractor's Geotechnical Consultant will determine the terminal driving criteria based on results

of [static load test] [energy formulas.]

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

For double acting hammers

R = 166.7E/(S + 2.54 P/W) (R = 2E/(S + 0.1 P/W))

For single acting hammers

R = 166.7WH/(S + 2.54 P/W) (R = 2WH/(S + 0.1 P/W))

Where:

R is the allowable static pile load in newtons pounds.
W is the weight of the striking part of the hammer in newtons pounds.
H is the effective height of fall in m feet.
E is the actual energy delivered by the hammer per blow in newton-meters foot-pounds.
S is the average net penetration in mm inches per blow for the last 5 blows after the pile has been driven to a depth where successive blows produce approximately equal net penetration (a minimum distance of 1 meter 3 feet for friction piles).
P is the weight of the pile in N (pounds). (If P is less than W, P/W must be taken as unity.)

An allowance must be made for reduced penetration caused by shock absorption of the cushion or cap blocks.

[1.4.4 Lump Sum Payment

****
NOTE: NOTE: Use this paragraph for lump-sum contracts, consult with Contracting Officer's Technical Representative (Geotechnical Branch) on applicability of use prior to selection. This paragraph will be typically used when there are 1) relatively small quantity of piles, 2) allowable pile loading is less than 355 kN 80 kips (, and 3) the subsurface conditions are well defined. Fill in Table I as required selecting columns applicable to project. Generally, pile capacity, location, and minimum tip elevation are shown on plans. Test piles and load tests are not incorporated on lump sum contracts. Delete this paragraph for unit-price contracts.
****

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

Table 1						
[Location]	Number	Size	[Capacity]	Length (Tip to Cut-Off)	[Maximum Bending Moment]	[Maximum Shear Force]

]

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

][1.4.5 Unit Price

****

NOTE: Delete this paragraph for lump-sum contracts.

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

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

****

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

****

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

****

Requirements of "FAR 52.211-18, Variation in Estimated Quantity" do not

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

][1.5 PAYMENT

****

NOTE: NOTE: Delete this paragraph for lump-sum contracts.

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

****

1.5.1 Furnishing and Delivering Piles

1.5.1.1 Payment

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

1.5.1.2 Measurement

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

1.5.1.3 Unit of Measure

Linear meter foot.

1.5.2 Driving Piles

1.5.2.1 Payment

Payment will be made for costs associated with driving permanent piles, which includes costs of handling, driving, concrete installation,[and splicing of piles,] measuring heave, redriving heaved piles, removal of [build-ups] driving heads or cutting off piles at the cut-off 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.

1.5.2.2 Measurement

Permanent piles will be measured for payment for driving on the basis of lengths including concrete section, to the nearest hundredth (tenth) of a linear meter foot, along the axis of each pile acceptably in place below the cut-off elevation shown.

1.5.2.3 Unit of Measure

Linear meter foot.

1.5.3 Pulled/Withdrawn Piles

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

1.5.3.2 Measurement

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

1.5.3.3 Unit of Measure

Linear meter foot.

[1.5.4 Pile Driving Tests

1.5.4.1 Payment

Payment will be made for costs associated with furnishing, delivering, driving, pulling, and disposing of driven test piles, concrete pile section, [including [pile driving points] [and] [splices]]; conducting pile driving tests; backfilling voids around piles; compiling pile driving test records.

1.5.4.2 Measurement

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

1.5.4.3 Unit of Measure

Each.

][1.5.5 Piles for Load Tests

1.5.5.1 Payment

Payment will be made for costs associated with furnishing, delivering, driving, pulling, and disposing of load test piles [including [pile driving 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]. No additional payment will be made for load test piles incorporated in the permanent work other than as provided.

1.5.5.2 Measurement

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

1.5.5.3 Unit of Measure

Each.

][1.5.6 Pile Static Axial Compressive Load Tests

1.5.6.1 Payment

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

1.5.6.2 Measurement

Pile static axial compressive load tests will be measured for payment on the basis of the applicable contract unit price per load test.

1.5.6.3 Unit of Measure

Each.

][1.5.7 Pile Driving Shoes

1.5.7.1 Payment

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

1.5.7.2 Measurement

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

1.5.7.3 Unit of Measure

Each.

][1.5.8 Pile Splices

1.5.8.1 Payment

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

1.5.8.2 Measurement

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

1.5.8.3 Unit of Measure

Each.

][1.5.9 Vibration Monitoring

1.5.9.1 Payment

Payment will be made for costs associated with vibration monitoring.

1.5.9.2 Measurement

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

1.5.9.3 Unit of Measure

Each.

][1.5.10 Sound Monitoring

1.5.10.1 Payment

Payment will be made for costs associated with sound monitoring.

1.5.10.2 Measurement

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

1.5.10.3 Unit of Measure

Each.

][1.5.11 Preconstruction Condition Survey

1.5.11.1 Payment

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

1.5.11.2 Measurement

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

1.5.11.3 Unit of Measure

Each.

]]1.6 SUBMITTALS

****

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

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

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

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

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

SD-01 Preconstruction Submittals

Contractor Experience and Qualifications; G[, [_____]]

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

SD-02 Shop Drawings

Installation Equipment and Testing Equipment; G[, [_____]]

SD-03 Product Data

Pile Driving Equipment; G[, [_____]]

Equipment Calibration Data; G[, [_____]]

Helmet and Cushion Block; G[, [_____]]

Pile Shoes; G[, [_____]]

Calibration Report

SD-06 Test Reports

Load Test Report

Field Test and Inspection Reports

SD-07 Certificates

Timber piles; G[, [_____]]

Aggregates; G[, [_____]]

Admixtures; G[, [_____]]

Cement; G[, [_____]]

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

SD-11 Closeout Submittals

Pile records; G[, [_____]]

1.7 DELIVERY, STORAGE, AND HANDLING

Piles must be stored and handled avoiding overstress or any other condition that may cause damage to the piles. Untreated piles to be stored for an extended period of time must be inspected periodically, as well as shortly before driving, to detect damage due to fungus and insect attack. If treated piles are to be stored in a horizontal position for an extended period of time, they must be inspected periodically to ensure that the treatment does not seep to the lower half of the pile to the extent that the upper half does not contain a sufficient amount of treatment.

1.8 QUALITY CONTROL

1.8.1 Timber Piles

The producer must brand each treated pile, in accordance with AWPA M1, AWPA M2, AWPA M6, AWPA T1 and AWPA U1. Submit the inspection report of an independent inspection agency, approved by the Contracting Officer, stating that offered products comply with applicable AWPA Standards, and that the plant conforms to AWPA M3. Identify treatment on each piece by the quality mark of an agency accredited by the Board of Review of the America Lumber Standard Committee.

1.8.2 Quality Control Procedures

The Government, at its discretion, reserves the right to inspect the treating process. Notify the Contracting Officer at least 3 weeks prior to beginning the treatment, stating where preservative treatment will be done. Allow Government inspector access to all parts of the plant. Allow inspection of all facets of the treating process.

1.8.3 Installation Procedures

Submit information on the type of equipment proposed to be used, proposed methods of operation, pile driving plan including proposed sequence of driving, and details of all pile driving equipment and accessories.

1.8.4 Concrete Mix Design

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

[1.8.5 Load Test Supporting Data

Submit Jack calibration records, equipment calibration data, a testing arrangement description and diagram, and the proposed loading sequence Submit a calibration report (performed by an independent testing agency) for the drilling and load test equipment to be used. The report must include: the name, address, and phone number of testing agency; name of the project; name of the contractor; identification of the equipment; date

of calibration; and calibration data. The equipment calibration must be performed within six months from the start of the testing operation..

]1.8.6 Silica Fume Manufacturer's Representative

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

PART 2 PRODUCTS

2.1 PILES

2.1.1 Wood Sections

Pile diameters of the wooden piles must not be less than 300 mm 12 inches measured 900 mm 3 feet from the butt [note that piles 17 meters 55 feet and longer should be 330 mm at 900 mm 13 inches at 3 feet] (before forming of the tenon). Provide Douglas Fir or Southern Pine piles [clean peeled] [rough peeled] conforming to ASTM D25. Piles must [be pressure treated in accordance with AASHTO M 133, for Land and Fresh Water Piles by Pressure] [not be treated].

2.1.2 Metal Shells

Provide metal shells of steel of sufficient strength and rigidity to withstand all driving stresses, to prevent distortion caused by driving adjacent piles, to prevent collapse due to soil or hydrostatic pressure, and to maintain their shape, free from dents or deformation. Thickness of shells must be as indicated. Provide watertight shells to exclude groundwater during concrete placement. The actual or superficial perimeter of a cross section of the piles, at any point in their length, must be circular. Design the joint as specified herein, and in a manner to prevent the entrance of soil while driving, the leaking of concrete during placing, and the entrance of water at a rate that would not allow the shell to be properly dewatered before placement of concrete. The shells must be [step-tapered type with a minimum nominal diameter of [_____] mm inches at the joint between wood and shell and the diameter must increase from the joint to the cut-off elevation at a rate of not less than 10 mm per meter 1 inch per 8 feet of length] [or] [constant-section shells with a minimum nominal diameter of 300 mm12 inches].

2.1.3 Concrete

Provide materials, mixing, and placing of concrete in conformance with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide concrete with a minimum compressive strength of [_____] MPa psi at 28 days using [_____] -mm -inch maximum-size coarse aggregate. Slump must be [_____] to [_____] mm inches for manual compaction and [_____] to [_____] mm inches when concrete is mechanically vibrated.

2.1.4 Reinforcing Steel

Provide reinforcing steel of the dimensions and sizes indicated and complying with [ASTM A615/A615M, Grade [40] [60]] [ASTM A996/A996M, Grade [50] [60]].

2.2 EQUIPMENT

Submit detail drawings, to demonstrate compliance of driving equipment, including [metal shoes and] cap blocks, splicing of timber and concrete sections, and the forming, reinforcing and casting of piles. Installation equipment and testing equipment must include a list and description of equipment to be used, including manufacturer's catalog data and sufficient information to show compliance with the requirements specified.

2.2.1 Pile Hammer

Provide a hammer with a delivered energy suitable for the total weight of the pile, the character of subsurface material to be encountered, and the pile capacity to be developed without damage to the pile. The driving energy of the hammer must be not less than 20.3 kN-m 15,000 foot-pounds. Operate diesel-powered hammers at the rate recommended by the manufacturer throughout the entire driving period. Maintain sufficient pressure at the air hammer so that:

2.2.1.1 Double-Action 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.

2.2.1.2 Single-Acting Hammer

There is full upward stroke of the ram.

2.2.1.3 Differential Type Hammer

There is a slight rise of the hammer base during each upward stroke.

2.2.2 Driving Helmets or Caps

Use a driving helmet or cap, including a pile cushion, between the top of the pile and the ram to prevent impact damage to the pile. The driving helmet, or cap and pile cushion combination, must completely cover the top surface of the pile and be capable of protecting the head of the pile, minimizing energy absorption and dissipation, and transmitting hammer energy uniformly over the top of the pile.Submit helmet and cushion block information.

a. The driving helmet or cap must fit loosely around the top of the pile so that the pile is not restrained by the driving cap, if the pile tends to rotate during driving. The pile cushion may be of solid wood, of laminated construction using plywood, softwood, or hardwood boards, or of other approved cushioning material.

b. The minimum thickness of the pile cushion must be 75 mm 3 inches and the thickness must be increased so as to be suitable for the size and length of pile, character of subsurface material encountered, hammer characteristics, and required driving resistance. Use a new pile cushion at the start of driving for each pile and the pile cushion must be replaced whenever it becomes highly compressed, charred, burned, or deteriorated in any manner during driving.

2.3 PRODUCT QUALITY CONTROL

2.3.1 Piles

The producer must brand each treated pile, in accordance with AWPA M1, AWPA M2, AWPA M6, AWPA T1 and AWPA U1. Indicate employment of pick-up points, support points other than pick-up points, and any other methods of pick-up.

[2.3.2 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.

]2.3.3 Aggregate Tests

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

2.3.4 Slump and Strength Tests

Sample concrete in accordance with ASTM C172 at time concrete is deposited for each production line. Perform slump tests in accordance with ASTM C143/C143M. Mold cylinders in accordance with ASTM C31/C31M. Mold at least six cylinders per day or one for every [15] [45] cubic meter [20] [60] cubic yards of concrete placed, whichever is greater. Cure cylinders in same manner as piles and for accelerated curing, place at coolest point in casting bed. Perform strength tests in accordance with ASTM C39/C39M. Test two cylinders of each set at 7 days [and 14 days]. Test remaining cylinders of each set 28 days after molding.

2.3.5 Changes in Proportions

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

2.3.6 Compressive Strength Test Results

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

2.3.7 Chloride Ion Concentration

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

2.3.8 Chloride Ion Penetration

Proportion concrete to have the chloride ion penetration test in accordance with ASTM C1202 to ensure the durability of concrete in marine environment, and be below 3000 coulombs for concrete specimens tested at 56 days.

2.4 MATERIAL SUSTAINABILITY CRITERIA

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

a. Recycled content for fly ash and pozzolan

b. Recycled content for Ground Iron Blast-Furnace Slag

c. Recycled content for Silica Fume

PART 3 EXECUTION

3.1 PRELIMINARY WORK

3.1.1 Pile Length Markings

Mark each pile prior to driving with horizontal lines at 300 mm one foot intervals. Mark the interval number on pile every 1.5 m 5 feet from pile tip.

3.2 PILE DRIVING

****

NOTE: Past experience with similar structures is probably the best indicator of the need for protection. If protection is to be provided, this paragraph should be expanded to cover the type and extent of protection required. The following typical references offer detailed information on different types of pile protection:

a. Design and Construction of Ports and Marine Structures, by Alonzo DeF. Quinn, McGraw-Hill Book Company, New York, 1961.

b. Cathodic Protection, by L. M. Applegate, McGraw-Hill Book Company, New York, 1960.

c. Protection of Piling in Marine Environments, published by US Steel Corporation.

Additionally, the Construction Engineering Research Laboratory in Champaign, Illinois has done extensive research on pile protection, and may be contacted for information.

****

Submit complete and accurate pile records of each driven pile indicating the pile location (as driven), size, length, final elevations of tip and top, elevation of top of wood section, pile weight, number of splices and

locations, blows required for each m foot of penetration throughout the entire length of the pile and for the final 150 mm 6 inches of penetration, and the total driving time. The record should also include the type and size of the hammer used, the rate of operation, and the type and dimensions of the driving helmet and cushion block used. Record any unusual conditions encountered during pile installation and immediately report them to the Contracting Officer.Perform driving with fixed leads to hold the pile firmly in position, alignment, and in axial alignment with the hammer. Drive piles to or below the "calculated" tip elevation to reach a driving resistance in accordance with the schedule that the Contracting Officer will prepare from the load test results.

a. The pile hammer used for driving must be the same type, operated at the same rate and in the same manner, as that used for driving the test piles. If a pile fails to reach the "calculated" tip elevation or if a pile reaches the "calculated" tip elevation without reaching the required driving resistance, notify the Contracting Officer and perform corrective measures as instructed.

b. No piles will be driven until the excavation or fill in the area that piles are to occupy has been completed. No piles will be driven within 30.5 m100 feet of concrete less than 7 days old, unless so directed. Carefully locate piles to the lines and spacing shown and drive them to either the plumb position or the batter indicated.

c. Limit dynamic driving stresses to the crushing strength of the timber. If the pile encounters a sudden high driving resistance, cease driving and immediately notify the Contracting Officer and proceed as directed. If during driving, the pile encounters a sudden decrease in penetration resistance, investigate the cause; unless a satisfactory reason is found and the pile is undamaged, reject the pile and replace it without additional cost to the Government.

d. Take care to operate the hammer at its short stroke when the tip of the pile encounters soft material of little resistance either at the start of the driving or in passing into poor subsoil. The hammer should continue at its short stroke until sufficient resistance is built up to prevent damage due to tensile wave stresses.

   When driving is interrupted before final penetration is reached, do not take the record of the penetration until after at least a 300 mm 12 inches penetration has been accomplished on the resumption of driving. Minimum penetration of the tops of wood piles being used in composite piles must be 600 mm 2 feet below the low water table.

e. The length of the metal shell may vary according to requirements for proper seating of the piles, elevations of groundwater, and the required pile cut-off. Where piles longer than the specified length measured from point to cut-off elevations are required to provide specific bearing capacities, provide the longer piles by furnishing longer wood sections as directed. As an option, provide longer piles by increasing the lengths of concrete sections, but only after approval. Upon approval, where the specified bearing capacities are obtained with piles of less than the specified lengths, shorter piles may be used, but the tops of wood sections must be driven at least 600 mm 2 feet below the water table.

3.2.1 Concrete Placement

Materials, mixing, and placing of concrete must conform with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE. Use an approved method for placing concrete in the shells. Place the concrete in a continuous flow from joint to top of piles. However, no concrete will be placed in any shell until all other piles within a radius of 6 m 20 feet [or heave range] have been driven. Shells must be free of deformations and water. Place concrete by tremie and not dropped through water.

3.2.2 Splices

Unless otherwise directed, construct field splices as indicated. Splices must maintain the true alignment and position of the pile sections and develop the full strength of the pile in both bearing and bending. Proprietary prefabricated splicer sleeves may be used upon approval.

3.2.3 Tolerances in Driving

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NOTE: Foundation piles should not be more than 75 to 150 mm 3 to 6 inches from their intended plan position.

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Top of any pile at elevation of cutoff must be within [_____] mm inches of the planar location indicated. Manipulation of piles to force them into position will not be permitted. Check piles for heave and re-drive those found to have heaved to the required tip elevation. Piles damaged or driven outside the above tolerances must be replaced, or additional piles driven at locations specified by the Contracting Officer at no expense to the Government.

3.2.4 Cutting of Piles

Cut off piles at the elevations indicated by an approved method; remove surplus material from the job site.

3.2.5 Rejected Piles

Withdraw piles damaged, mislocated, or driven out of alignment beyond the maximum tolerances and replace them with new piles; or cut off and abandon them. Additional piles must be driven as directed; excess cut off from piles and unacceptable piles must be removed from the site of work. Perform all work, in connection with withdrawing and removing from the site rejected piles; without additional cost to the Government.

Any pile damaged by reason of internal defects or by improper driving must be corrected by one of the following methods approved by the Contracting Officer for the pile in question:

a. The pile is withdrawn, if practicable, and replaced by a new and, if necessary, longer pile.

b. Fill the shell with concrete, abandon the pile and install one or more replacement pile(s) adjacent to the defective pile.

A pile terminated below the specified cut-off elevation must be corrected by one of the following methods approved by the Engineer:

a. The pile is spliced (if approved).

b. A sufficient portion of the footing is extended down to properly embed the pile.

A pile driven out of its proper location or out of plumb as approved by the Engineer, must be corrected by one of the following methods approved by the engineer:

a. The pile is withdrawn, if practicable, and replaced by a new pile.

b. One or more replacement piles are driven next to the pile in question.

c. Fill the shell with concrete, abandon the pile and install one or more replacement pile(s) adjacent to the pile in question.

d. As directed by the structural engineer.

3.2.6 Predrilling

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NOTE: Predrilling is normally terminated at a depth equal to two thirds of the total length of the pile embedment.

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Predrilling will be permitted only when approved. The hole must be [_____] mm inches less in diameter than the diagonal dimension of the pile. All predrilled piles must be seated by final driving to provide the required pile capacities.

3.2.7 Collars or Bands

Use collars or bands of an approved design where required for the protection of the top of piles against splitting, brooming, and other damage when the piles are being driven.

3.2.8 Metal Pile Shoes

Where indicated or directed, securely attach metal shoes of an approved design to the piles in a manner described in the detail drawings. Submit pile shoe material and installation details.

3.2.9 Joints

Joints between the wood and concrete sections must be as indicated in the detail drawings.

3.2.10 Welding

Conform all field welding, and preparation of materials for welding, to AWS D1.1/D1.1M or AWS D1.4/D1.4M, as appropriate, using proper materials and experienced personnel whose ability and qualifications to do acceptable work have been fully demonstrated.

3.2.11 Pile Heave

When large pile clusters or piles are driven with very close spacing, take

periodic elevations on the tops of all piles to observe and determine pile heave. Such elevations must be taken on a telltale pipe 50 mm 2 inches in diameter placed inside the pile shell and bearing on the top of the wood section. When such checking indicates that pile heave has occurred, all heaved piles must be re-driven to either the original resistance or the elevation, or both, as directed. If pile heave occurs along the shell portion of the pile, resulting in separation of the joint, the Contractor may resort to predrilling to eliminate heave or may provide a joint of sufficient tension capacity, as authorized, without additional cost to the Government.

3.2.12 Curing

[Maintain concrete in a moist condition for not less than 7 days for normal portland cement and for not less than 3 days for high-early-strength cement. For each decrease of 2 degrees 5 degrees below 20 degrees C 70 degrees F in the average curing temperature, these curing periods must be increased by 4 days for units of normal portland cement and by 2 days for units of high-early-strength cement.] [Curing must be in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.]

3.2.13 Long Piles

Piles having a slenderness ratio greater than [22] [_____] must be handled and driven with special precautions to ensure against overstress or leading from a plumb or true position. The slenderness ratio must be the pile length divided by the least radius of gyration of the pile. When a high-resistance strata lying near the surface must be penetrated, spud piles may be used only when authorized by the Contracting Officer to minimize hard driving of long piles during the early stages of driving operations.

3.2.14 Jetting of Piles

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NOTE: Jetting generally should not be permitted:

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

b. For piles subject to uplift or lateral forces.

c. For piles adjacent to existing structures.

d. For piles in closely spaced clusters unless the load capacity is confirmed by test.

****

[Jetting of piles will not be permitted] [Jetting must be discontinued at a depth approximately 1.5 m 5 feet above the "calculated" tip elevation; the remaining penetration must be achieved by driving. Before the driving of the final 1.5 m 5 feet is started, the pile must be firmly seated in place by the application of a number of reduced-energy hammer blows].

3.2.15 Survey Data

****

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

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

Add any additional requirements as necessary.
****

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

3.2.16 Protection of Existing Structures

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

3.3 FIELD TEST AND INSPECTION

Submit a complete report on the pile test, within [seven] [_____] days of completion of each pile test, including, but not limited to, a description of the pile driving equipment, driving records for both test piles and reaction piles, complete test data, analysis of test data, and recommended allowable design loads based on the pile test results. Provide final records of placement locations and depths of embedment of all piles. Prepare the report by or under the direct supervision of a registered professional engineer in the State of [_____] and experienced in pile load testing and load test analysis.

3.3.1 Test Piles

Test piles must be of the type and must be driven in the manner specified. The Contractor's Geotechnical Engineer will use test pile and load test data to determine "calculated" pile tip elevations and the necessary driving resistance. Test piles that are located within the tolerances indicated and that provide a safe design capacity as determined by the results of a satisfactory load test may be used in the finished work. Drive test piles [at the locations indicated] [in the vicinity of the soil boring test holes No. [_____]]. [Jetting will be authorized only when pile testing clearly establishes the validity of its use.] Drive test piles to the tip elevation specified or indicated. Withdraw the specified number of test piles as indicated after reaching the "calculated" tip elevation for visual inspection of the pile.

3.3.2 Load Tests

Perform load tests in accordance with ASTM D1143/D1143M[, as modified], at locations shown or directed, on test piles placed to the tip elevation indicated except as otherwise directed. Loading, testing, and recording of data must be under the direct supervision of the Contractor's Geotechnical Consultant, as well as the analysis of the load test data. The installation of piles must not proceed in a new area with substantially different subsurface conditions until a satisfactory load test has been performed in that area and the results approved. Allow a minimum of [_____] days after submission of the test pile data for approval. Unless otherwise directed, piles must not be tested sooner than [____] days after driving unless sufficient time has elapsed to allow the cast-in-place section of the pile to obtain the minimum strength of [_____] MPa psi. Test loading must conform to ASTM D1143/D1143M, cyclic loading method. Apply the load to the pile [pile group] by [hydraulic jacks acting against an anchored reaction frame] [hydraulic jacks acting against a weighted platform or box] [direct loading of a weighted platform] using a spherical bearing to transmit the load to the pile. Maintain a data plot of load versus movement during the test procedures. Determine the safe design capacity of a test pile as determined from the results of load tests according to UFC 3-220-01.Submit load test report.

3.3.3 Safe Design Capacity

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

3.3.4 Inspection

The Contracting Officer may require that certain wood sections be withdrawn for test and inspection before the shell section is added to determine the condition of the wood sections. When so required, such wood sections must be redriven only when approved. Withdrawn piles not suitable for redriving must be treated as a rejected pile as specified in paragraph PILE DRIVING. Provide a suitable light for inspecting the interiors of pile shells.

3.3.5 Pile Capacity

The capacity, as driven, of single piles not in clusters in the structure must be not less than [_____] metric tons tons. Determine the capacity by the following formula, modified according to the data obtained by the load tests.

Single-Acting Hammers
$R = 166.7WH/(S + 2.54\ P/W)$ $R = 2WH/(S + 0.1\ P/W)$

Double-Acting Hammers
$R = 166.7E/(S + 2.54\ P/W)$ $R = 2E/(S + 0.1\ P/W)$

Where:

R is the allowable static pile load in newtons pounds.
W is the weight of the striking part of the hammer in newtons pounds.
H is the effective height of fall in m feet.
E is the actual energy delivered by the hammer per blow in newton-meters foot-pounds.

S is the average net penetration in mm inches per blow for the last 5 blows after the pile has been driven to a depth where successive blows produce approximately equal net penetration (a minimum distance of 1 meter 3 feet for friction piles).
P is the weight of the pile in N pounds. (If P is less than W, P/W must be taken as unity.)

[3.4 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

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

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

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

Add any additional requirements as necessary.
****

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

][3.5 VIBRATION CONTROL

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

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

Prior to the pile driving activities, obtain baseline readings of ambient vibrations. The vibration during the pile driving activities must be limited to [a peak particle velocity of not more than 5 cm 2 inches per second.] [the limits mentioned in the [contract documents].] [Determine appropriate vibration limits as per [US Bureau of Mines] [American

Association of State Highway and Transportation Officials (AASHTO)] guidelines.]During pile driving activities, monitor the vibrations to ensure the limits are not exceeded. If the limits are exceeded, cease the pile driving activity causing the vibration until [the Vibration consultant and the Contracting Officer] are on site to observe the structures nearest to the vibration monitor which has exceeded the limits.

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

][3.6 NOISE CONTROL

****

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

****

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

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

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

][3.7 PRECONSTRUCTION CONDITION SURVEY

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

****

Perform preconstruction condition survey of [structures] [and utilities] [within 61 meters 200 feet of the pile driving activity] [specified in the plans] [decided by the Contracting Officer]. Perform outreach to the owner of the structures [28] days before performing the preconstruction

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

][3.8 CONSTRUCTION INSTRUMENTATION AND MONITORING PROGRAM

****

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

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

****

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

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

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

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

] -- End of Section --