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USACE / NAVFAC / AFCEC

UFGS-31 62 13.20 (November 2020)

Change 2 - 02/24

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Preparing Activity: NAVFAC

Superseding

UFGS-31 62 13.20 (August 2009)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2025

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#### SECTION 31 62 13.20

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Pile and Driving Equipment Data Form

pile driving log

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SECTION 31 62 13.20

PRECAST/PRESTRESSED CONCRETE PILES  
11/20, CHG 2: 02/24

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NOTE: This guide specification covers the requirements for precast, prestressed 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).

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

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

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NOTE: Show the following information on the drawings:

1. Locations and design loads of piles. If both tension and compression piles are contained in

design, identify by type.

2. Size, shape, and length of piles.

3. Locations, sizes, and number of prestressing steel strands. Unit stresses for prestressing strands.

4. Details of reinforcement.

5. Details of splices, if required.

6. Locations of test piles, if required.

7. Soil data, where required.

8. Identify piles as vertical or battered.

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## PART 1 GENERAL

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

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### 1.1 DESCRIPTION

Design, furnish, install and test precast prestressed 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.][ Test piles that meet performance requirements can be incorporated into the permanent work.]

### 1.2 REFERENCES

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

Use the Reference Wizard's Check Reference feature when you add a 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.

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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.

ASTM INTERNATIONAL (ASTM)

ASTM C109/C109M	(2024) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm) Cube Specimens)
ASTM C1077	(2024) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM D1143/D1143M	(2007; R 2013) Piles Under Static Axial Compressive Load
ASTM D3689/D3689M	(2007; R 2013; E 2013) Standard Test Methods for Deep Foundations Under Static Axial Tensile Load
ASTM D3966/D3966M	(2007; R 2013; E 2013) Standard Test Methods for Deep Foundations Under Lateral Load
ASTM D4945	(2017) Standard Test Method for High-Strain Dynamic Testing of Deep Foundations
ASTM E329	(2023) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

PRECAST/PRESTRESSED CONCRETE INSTITUTE (PCI)

PCI MNL-116	(2021) Manual for Quality Control for Plants and Production of Structural Precast Concrete Products, 5th Edition
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U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-220-01	(2012; with Change 2, 2024) Geotechnical Engineering
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INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2024) International Building Code
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KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4306	(2025) Pretensioned Spun High Strength Concrete Pile
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1.3 SUBSURFACE DATA

Subsurface soil data logs are provided on the project drawings.

[1.4 LUMP SUM PAYMENT

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NOTE: Use this paragraph for lump-sum contracts, consult with Contracting Officer's Technical Representative (Geotechnical Branch) on applicability of use prior to selection. This paragraph will be typically used when there are 1) relatively small quantity of piles, 2) allowable pile loading is less than 355 kN, 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.

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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.]

][1.5 UNIT PRICE

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NOTE: This paragraph is tailored for Navy.

Delete this paragraph for lump-sum contracts.

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

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. Select first bracketed text.

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For unit price bid, see SF 1442, "Solicitation, Offer and Award" and "Contract Line Item Number Schedule".  
][1.6 PAYMENT

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NOTE: This paragraph is tailored for Army.

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 (PAYMENT) 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.

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#### 1.6.1 Furnishing and Delivering Prestressed Concrete Piles

##### 1.6.1.1 Payment

Payment will be made for costs associated with furnishing and delivering the required lengths of permanent prestressed concrete 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 judgment of the Contracting Officer.

##### 1.6.1.2 Measurement

Furnishing and delivering permanent prestressed concrete piles will be measured for payment by the linear meter of piles required below the cut-off elevation as determined by the Contractor's Geotechnical Engineer, and approved by the Contracting Officer.

##### 1.6.1.3 Unit of Measure

Unit of measure: linear meter.



## 1.6.2 Driving Prestressed Concrete Piles

### 1.6.2.1 Payment

Payment will be made for costs associated with driving permanent prestressed concrete piles, which includes costs of handling, driving, and splicing of piles, 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 driving criteria.

### 1.6.2.2 Measurement

Permanent prestressed concrete piles will be measured for payment for driving on the basis of driven lengths, measured to the nearest **hundredth** of a linear **meter**, along the axis of each pile acceptably in place below the cut-off elevation shown.

### 1.6.2.3 Unit of Measure

Unit of measure: linear **meter**.

## [1.6.3 Predrilling of Prestressed Concrete Piles

### 1.6.3.1 Payment

Payment will be made for costs associated with predrilling of permanent prestressed concrete piles, which includes costs of handling, placing, and splicing of piles, cutting off piles at the cut-off elevation and removing from the work site, compiling and submitting pile driving records, grouting voids around piles, and any other items incidental to predrilling piles to the required elevation.

### 1.6.3.2 Measurement

Permanent prestressed concrete piles will be measured for payment for predrilling on the basis of the pre-drilled length, measured to the nearest tenth of a linear meter, along the axis of each pile acceptably in place below the cut-off elevation shown.

### 1.6.3.3 Unit of Measure

Unit of measure: linear **meter**.

## ]1.6.4 Dynamic Pile Analysis for Pre-Production Test Piles

### 1.6.4.1 Payment

Payment will be made for all costs associated with dynamic pile analysis of pre-production test piles including: compiling pile driving records; furnishing, fabricating, and mounting of strain sensors and protective assembly; furnishing, fabricating, and mounting of inclinometer and inclinometer protective assembly; performing pile dynamic testing; interpreting data; and submitting reports.

### 1.6.4.2 Measurement

Dynamic pile analysis for pre-production test piles will be measured for

payment on the basis of the applicable contract unit price per pre-production test pile. Dynamic pile analysis for pre-production test piles shall be performed in two steps as discussed in "Dynamic Pile Analysis for Pre-Production Test Piles".

#### 1.6.4.3 Unit of Measure

Unit of measure: each.

#### 1.6.5 Dynamic Pile Analysis for Production Test Piles

##### 1.6.5.1 Payment

Payment will be made for all costs associated with dynamic pile analysis of production test piles including compiling pile driving records; furnishing, fabricating, and mounting of strain sensors and protective assembly; furnishing, fabricating, and mounting of inclinometer and inclinometer protective assembly; performing dynamic testing; interpreting data; and submitting reports.

##### 1.6.5.2 Measurement

Dynamic pile analysis for production test piles will be measured for payment on the basis of the applicable contract unit price per production test pile.

##### 1.6.5.3 Unit of Measure

Unit of measure: each.

#### 1.6.6 Pulled Prestressed Concrete Piles

##### 1.6.6.1 Payment

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

##### 1.6.6.2 Measurement

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

as specified in paragraph PAYMENT, subparagraph DRIVING PRESTRESSED CONCRETE PILES. Redriving pulled undamaged prestressed concrete piles will be measured for payment as specified in paragraph PAYMENT, subparagraph DRIVING PRESTRESSED CONCRETE PILES. New piles replacing damaged piles will be measured for payment as specified in paragraph PAYMENT, subparagraphs FURNISH AND DELIVER PRESTRESSED CONCRETE PILES and DRIVING PRESTRESSED CONCRETE PILES.

#### 1.6.6.3 Unit of Measure

Unit of measure: linear meter.

### [1.6.7 Prestressed Concrete Pile Static Axial Compressive Load Tests

#### 1.6.7.1 Payment

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

#### 1.6.7.2 Measurement

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

#### 1.6.7.3 Unit of Measure

Unit of measure: each.

### ]1.6.8 Prestressed Concrete Pile Static Tensile Load Tests

#### 1.6.8.1 Payment

Payment will be made for costs associated with prestressed concrete pile static tensile load tests in accordance with ASTM D3689/D3689M, including material and labor for fabricating and furnishing load frames; calibrating load cells and hydraulic jacks; furnishing specified test equipment; installing strain rods; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting pile load test reports. No payment will be made for rejected pile static tensile load tests.

#### 1.6.8.2 Measurement

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

#### 1.6.8.3 Unit of Measure

Unit of measure: each.

]1.6.9 Prestressed Concrete Pile Lateral Load Tests

1.6.9.1 Payment

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

1.6.9.2 Measurement

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

1.6.9.3 Unit of Measure

Unit of measure: each.

]1.6.10 Pulled Load Test Prestressed Concrete Piles

1.6.10.1 Payment

Payment will be made for costs associated with load test prestressed concrete piles pulled prior to load testing at the direction of the Contracting Officer and found to be undamaged. The cost of furnishing, delivering, driving, and pulling undamaged load test piles will be paid for at the applicable contract unit price for payment item "Prestressed Concrete Piles for Load Tests". The cost of re-driving pulled undamaged load test piles will be paid for at the applicable contract unit price for payment item "Driving Prestressed Concrete Piles". No payment will be made for furnishing, delivering, driving, pulling, and disposing of load test piles pulled at the direction of the Contracting Officer and found to be damaged. New load test piles replacing damaged piles will be paid for at the applicable contract unit price for payment item "Prestressed Concrete Piles for Load Tests".

1.6.10.2 Measurement

Pulled undamaged load test prestressed concrete piles will be measured for payment as specified for "Prestressed Concrete Piles for Load Tests" (static axial, tensile, or lateral load test). Re-driving pulled undamaged prestressed concrete piles will be measured for payment as specified for "Driving Prestressed Concrete Piles". New load test prestressed concrete piles replacing damaged piles will be measured for payment as specified for "Prestressed Concrete Piles for Load Tests" (static axial, tensile, or lateral load test).

1.6.10.3 Unit of Measure

Unit of measure: as specified for "Driving Prestressed Concrete Piles" and "Prestressed Concrete Piles for Load Tests".

][1.6.11 Pile Driving Shoes

1.6.11.1 Payment

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

1.6.11.2 Measurement

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

1.6.11.3 Unit of Measure

Unit of measure: each.

][1.6.12 Prestressed Concrete Pile Splices

1.6.12.1 Payment

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

1.6.12.2 Measurement

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

1.6.12.3 Unit of Measure

Unit of measure: each.

][1.6.13 Vibration Monitoring

1.6.13.1 Payment

Payment will be made for costs associated with vibration monitoring.

1.6.13.2 Measurement

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

1.6.13.3 Unit of Measure

Unit of measure: each.

][1.6.14 Sound Monitoring

1.6.14.1 Payment

Payment will be made for costs associated with sound monitoring.

1.6.14.2 Measurement

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

1.6.14.3 Unit of Measure

Unit of measure: each.

]]1.7 SUBMITTALS

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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 and Air Force 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 and Air Force projects, or choose the second bracketed item for Army projects.

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

SD-01 Preconstruction Submittals

Installation Procedures; G

Contractor's Geotechnical Engineer Documentation; G

Wave Equation Analysis; G

[ Instrumentation and Monitoring Program Report; G

]           Testing Agency Qualifications; G

SD-02 Shop Drawings

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

      Pile Splices; G

      Pile Placement; G

      As-Driven Survey; G

      Load Tests; G

      Pile Shoe; G

SD-03 Product Data

      Pile Driving Equipment; G

SD-06 Test Reports

      Concrete Compressive Strength; G

[           Test Piles; G

][          Load Tests; G

][          Dynamic Pile Analysis; G

]           Cement Grout; G

SD-07 Certificates

      Load Test Supporting Data; G

SD-11 Closeout Submittals

      Pile Records; G

1.8 DELIVERY, STORAGE, AND HANDLING

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

1.8.1 Damaged Piles

Inspect each pile for sweep and structural damage such as cracking and spalling before transporting them to the project site and immediately prior to placement in the driving leads. Bring any cracks (cracks other

than crazing, surface drying, shrinkage cracks and end cracks) to the attention of the Contracting Officer. Piles which are damaged during delivery, storage, or handling to the extent they are rendered unsuitable for the work, in the opinion of the Contracting Officer, will be rejected and removed from the project site, or may be repaired, if approved, at no cost to the Government.

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

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

One or more replacement piles are driven adjacent to the defective pile.

A Pile Dynamic Analysis and low integrity testing must be performed by the Contractor's Geotechnical Engineer to assess the structural integrity of the driven pile(s).

A pile driven below the specified butt elevation must be corrected by one of the following methods approved by the Engineer:

The pile is spliced (if approved).

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:

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

As directed by the structural engineer.

#### 1.8.2 Non-Repairable Cracks

Piles with cracks equal to or greater than 0.15 mm will be rejected.

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NOTE: Sweep and camber typically apply to steel  
piles. In special cases, this paragraph may apply  
to precast/pre-stressed concrete piles.  
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#### [1.8.3 Pile Sweep

Limit sweep to 3 mm per 3 M over the length of the pile. Piles having excessive sweep will be rejected.

#### ]1.9 QUALITY ASSURANCE

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NOTE: The First Bracketed option is for ROKFC  
In-Kind, LPP and YRP projects and the second  
bracketed option is for other projects.  
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[The Republic of Korea (ROK) Government is the Contracting Officer and assumes quality assurance responsibilities. As such, the ROK Government is responsible for close technical oversight, review, and approval of the Contractor's pre-production and production pile installation work to include independent dynamic pile analysis on at least 10 percent of the contractor's pre-production test piles with dynamic pile analysis. The U.S. Government is charged of a construction surveillance role as a further check on the contractor's pile driving work and the quality assurance oversight being performed. The construction surveillance would include a review of the contractor's test pile driving plan, the contractor's test pile driving report, and the ROK Government test pile driving QA report, and a site visit during the initial test pile driving activities to verify that dynamic pile analysis is being conducted properly.][The Contracting Officer is responsible for close technical oversight, review, and approval of the Contractor's pre-production and production pile installation work to include independent dynamic pile analysis on at least 10 percent of the contractor's pre-production test piles with dynamic pile analysis with no fewer than one for each structure.]

#### 1.9.1 Installation Procedures

- a. Submit information on the type of equipment proposed to be used, proposed methods of operation, pile driving plan including proposed sequence of driving, and details of all pile driving equipment and accessories.
- b. Provide details of pile driving equipment and a Wave Equation Analysis of pile drivability for selection of the hammer along with a statement of driving procedures. The Wave Equation Analysis is to be completed by the Contractor's Geotechnical Engineer for each test pile location where different subsurface conditions exist and is to include the following information pertaining to the proposed pile driving equipment:
  - (1) Complete Test Pile Checklist (which is an attachment of this specification section) for each structure. Test Pile Checklist should include the maximum service load of the pile, which was determined by the structural engineer at the A-E.
  - (2) Complete Pile and Driving Equipment Data Form, (which can be downloaded at: <http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables>) for each proposed pile hammer and pile type combination.
  - (3) Copies of computer input and output sheets and graphs showing soil resistance versus blow count as well as maximum tension and compression stresses versus blow count. Analysis must be run at the estimated tip elevation as well as other required elevations to define maximum stress levels in the pile during driving.
- c. Provide detailed procedures for conducting the dynamic pile load test and equipment to be used for conducting the load test. The detailed description must explain how specific information of pile performance will be evaluated.

### 1.9.2 Contractor's Geotechnical Engineer Documentation

The Contractor's Geotechnical Engineer shall oversee, evaluate, analyze, and provide professional quality control during the installation and testing of pre-production test piles and production piles. Contractor's Geotechnical Engineer shall be a Licensed Professional Engineer (Civil or Geotechnical) with at least 5 years experience in the evaluation and testing of pile foundations, to include dynamic (Pile Driving Analyzer) and static load testing. A Licensed Engineer (Civil or Geotechnical) with at least 3 years of experience in dynamic and static load testing shall perform all pile foundation tests.

Provide instructions and procedures on how the Contractor will assist the Government in the processes of Dynamic Pile Testing, Inspection and Monitoring of piles during installation and testing.

### 1.9.3 Load Test Supporting Data

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

## PART 2 PRODUCTS

### 2.1 PILE REQUIREMENTS

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

Provide precast prestressed concrete piles per **KS F 4306**. Order pre-production test piles in lengths in accordance with the contract documents. The Contractor's Geotechnical Engineer shall determine required lengths and driving criteria for production piles based on results from the pre-production test pile data, subject to approval by the Contracting Officer. Production piles shall not be ordered by the Contractor until lengths and driving criteria, have been approved by the Contracting Officer. The maximum allowable pile design load will be based on the procedure recommended by Davisson (1972) for obtaining the failure load based on the load-settlement curve.

The use of local pile is permitted, subject to the approval of the contracting officer, upon the submission of acceptable test data, calculations and other information relating to the structural properties and load capacity of such elements. The allowable stresses for materials shall not in any case exceed the limitations specified in Chapter 18, **ICC IBC**.

### 2.2 PRESTRESSED CONCRETE PILES

Pretensioned spun high strength concrete piles shall be per **KS F 4306**.

### 2.3 CEMENT GROUT

Cement grout mixture proportions are the responsibility of the Contractor. The mixture proportions and the **compressive strength** test

results at 7, 14, and 28 days after curing for the Cement grout mixture should be submitted to the Contracting Officer for approval, 10 working days prior to the indicator pile driving, to verify that the grout mixture proportions selected will produce grout of the quality specified. Grout shall consist of a homogenous, pumpable, stable mixture of Portland cement and water. Final proportions of materials shall be based on results of tests made on sample mixtures of grout. The minimum compressive strength of two-inch cubes, molded, cured, and tested in accordance with **ASTM C109/C109M**, shall be **18 MPa** at 28 days. The Contractor is responsible for taking, curing, and breaking of grout test cubes for determining mix design, and all testing shall be done by an independent laboratory approved by the Contracting Officer.

## 2.4 PILE DRIVING EQUIPMENT

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

Provide Pile Driving Equipment as mentioned in this section.

### 2.4.1 Pile Hammers

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

### 2.4.2 Driving Helmets and Cushion Blocks

#### 2.4.2.1 Driving Helmets or Caps and Pile Cushions

Use a steel driving helmet or cap including a pile cushion between top of pile and driving helmet or cap to prevent impact damage to pile. Use a driving helmet or cap and pile cushion combination capable of protecting pile head, minimizing energy absorption and dissipation, and transmitting

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

#### 2.4.2.2 Hammer Cushion or Capblock

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

Use a hammer cushion or capblock between driving helmet or cap and hammer ram as recommended by the hammer manufacturer or approved equal. Replace wood capblock (hammer cushion) when it becomes highly compressed, charred or burned or becomes spongy or deteriorated in any manner. Do not replace wood capblock (hammer cushion) during final driving of any pile. Do not use small wood blocks, wood chips, rope or other materials that permit excessive loss of hammer energy.

### PART 3 EXECUTION

#### 3.1 PRELIMINARY WORK

##### [3.1.1 Wave Equation Analysis of Pile Drivability

- a. Prior to driving any pile, submit a pile Wave Equation Analysis, performed by Contractor's Geotechnical Engineer, for each size pile and distinct subsurface profile condition. These analyses must take into account the proposed hammer assembly, pile cap block and cushion characteristics, the pile properties and estimated lengths and the soil properties anticipated to be encountered throughout the installed pile length based on static capacity analysis with consideration of driving gain/loss factors. Only one specific model of pile hammer may be used for each pile type and capacity.
- b. Demonstrate using the Wave Equation Analysis that the piles will not be damaged during driving, must indicate that the driving stresses will be maintained within the limits below and indicate the blow count necessary to achieve the required ultimate static pile capacities.

#### Allowable Driving Stresses

##### Concrete

Compression -  $0.85 f'c$  minus UPL  
Tension -  $(0.25 \text{ times } (\text{the square root of } f'c)) \text{ plus}$   
UPL (Please verify unit)

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

- c. All pile driving equipment provided by the Contractor, as recommended by the Contractor's Geotechnical Engineer, shall be subject to approval by the Contracting Officer. Complete the attached pile and driving equipment data form, including hammer information, in full as part of the submittal of the results of the Wave Equation Analyses.
- d. Pay for the cost of performing the Wave Equation Analyses and include in the base bid.

#### 13.1.2 Pile Length Markings

Mark each pile prior to driving with horizontal lines at both 30 mm and 300 mm intervals.

### 3.2 PILE DRIVING

#### 3.2.1 Driving Piles

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

Notify Contracting Officer at least 10 working days prior to driving of pre-production test piles[ and load tests]. Stop foundation excavation at 300 mm above bottom of grade beam before piles are driven. Do not drive piles within 30 meter of concrete less than 7 days old. Complete excavation to lines and grades shown when pile driving is completed. The Contractor's Geotechnical Engineer will determine the terminal driving criteria based on results of dynamic pile driving tests at the end of drive or restrrike. Drive piles to the terminal driving criteria as approved by the Contracting Officer. During initial driving and until pile tip has penetrated beyond layers of very soft soil, use a reduced driving energy of the hammer as required to prevent pile damage. If a pile fails to meet required driving criteria, notify Contracting Officer and perform corrective measures as recommended by the Contractor's Geotechnical Engineer and approved by the Contracting Officer. Provide hearing protection when noise levels exceed 70 dB. Do not handle or move piles or pile sections in any manner that would result in cracking or permanent damage to the concrete or to the grout surrounding the prestressing cables. Piles may be driven without pile guides or leads providing a hammer guide frame is used to keep the pile and hammer in

alignment.

### 3.2.2 Protection of Piles

\*\*\*\*\*  
**NOTE: Delete references to batter piles when not applicable to the project. Use more stringent criteria as necessary based on the application. Confirm with the structural engineer.**  
\*\*\*\*\*

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

### 3.2.3 [Pile Placement](#) and Tolerances in Driving

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

Submit pile placement plans at least 30 days prior to delivery of piles to the job site.

Drive piles with a variation of not more than 2 percent from vertical for plumb piles or more than 4 percent from required angle for batter piles. Maintain and check axial alignment of pile and leads at all times. If subsurface conditions cause pile drifting beyond allowable axial alignment tolerance, notify Contracting Officer and perform corrective measures as directed. Place butts within **100 mm** of location indicated. Manipulation of piles within specified tolerances will not be permitted. In addition to specified tolerances, maintain a location to provide a clear distance of at least **125 mm** from butt to edge of pile cap. If clear distance can not be maintained, then notify Contracting Officer. Check each pile for heave. Redrive heaved piles to required point elevation.

### 3.2.4 Rejected Piles

Withdraw piles damaged or impaired for use during handling or driving, mislocated, or driven out of alignment beyond the maximum tolerance. Replace with new piles or cut-off and abandon damaged or impaired piles and drive new piles as directed. Remove excess cut-off from piles and unacceptable piles from the work site. Perform all work in connection with rejected piles at no additional cost to the Government.

### 3.2.5 Predrilling of Piles

\*\*\*\*\*  
**NOTE: Predrilling should generally not be permitted**

for piles:

1. Dependent on side friction in fine-grained low permeability soils (high clay or silt content) where considerable time is required for the soil to reconsolidate around the piles.
2. Subject to uplift or lateral forces.
3. Located in cohesionless soils.
4. In closely spaced clusters unless the load capacity is confirmed by test.

\*\*\*\*\*

Predrilling to remove soil or other material representing the bulk of the volume of the pile to be driven will be permitted only when test piles clearly establish validity of its use, or as directed by the Contracting Officer. Predrilling shall be as determined by the Contractor's Geotechnical Engineer and approved by the Contracting Officer. The diameter of the predrilled hole should be greater than 50 mm larger than the pile diameter and should not be greater than 150 mm larger than the pile diameter.

Predrill only to depths required to mitigate ground vibration and/or noise or to penetrate beyond obstructions (e.g. cobbles, boulders). Where allowable limits are not otherwise stated, allowable ground vibration and noise limits shall be 25 mm per second and 70 dB, respectively, as measured at existing adjacent structures. Discontinue predrilling at least 1.5 m above the pile tip elevation and subsequently drive the pile to its final depths of penetration. Pile shall be driven a minimum 1.5 m beyond predrill depths, if the piles are not socketed into the rock.

Predrilling shall be carried out in a manner which will not impair the capacity of the piles already in place or the safety of existing adjacent structures. If the Contracting Officer determines that predrilling has disturbed the capacities of previously installed piles, those piles that have been disturbed shall be restored to conditions meeting the requirements of this specification by re-driving or by other methods acceptable to the Contracting Officer. All work in connection with restoring disturbed piles shall be done at no additional cost to the Government.

Voids around the pile shall be completely filled with cement grout. Cement grout shall be placed by tremie pipe and in one continuous operation into the annulus between the pile and the predrill wall or casing. If the predrill depth is less than 4.5 m and without fluid in the predrilled holes, the grout may be placed either by pouring or pumping. The discharge end of the tremie pipe shall be submerged at all times. Additional grout shall be added from the surface to maintain the level of the grout within 300 mm of the ground surface as grout settlement occurs. For test piles with dynamic pile analysis, voids around the pile shall be grouted after completion of dynamic testing.

### 3.2.6 [Pile Splices](#)

\*\*\*\*\*

**NOTE: Splicing of piles normally should not be permitted except where extremely long or heavy piles**

are required. If splices are permitted, drawings should indicate splice details. (See PCI standard drawings for typical splice details).

\*\*\*\*\*

Make splices as indicated. Splices must be capable of developing the full strength of the member in compression, tension, shear, and bending. Submit detail drawings of splices and design calculations demonstrating the strength of the splice for approval. Submit information for shop and field pile splices prior to fabrication.

### 3.2.7 Build-Ups

\*\*\*\*\*

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

\*\*\*\*\*

Where required, build-up shall be proposed by the Contractor and approved by the Contracting officer with concurrence from the Structural Engineer of Record.

### 3.2.8 Pile Cut-Off

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

### 3.2.9 Patching

Provide a 25 mm minimum conical depression around embedded lifting loops. Where indicated or directed, cut off lifting loops at bottom of depression and patch depression with epoxy mortar.

### 3.2.10 As-Driven Survey

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

### 3.2.11 Protection of Existing Structures

\*\*\*\*\*

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



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

Add any additional requirements as necessary.

\*\*\*\*\*

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

### 3.2.12 Pile Shoe

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

## 3.3 FIELD QUALITY CONTROL

### 3.3.1 Test Piles

\*\*\*\*\*

NOTE: Select the second bracketed option when soil conditions dictate the use of a test pile longer than production piles. The ordered pile length for test piles should be 2.0 m longer than ordered length for production piles to allow additional penetration if driving conditions dictate. Indicate location and number (if required) of test piles on plans, or list appropriate soil boring test hole numbers.

\*\*\*\*\*

Test piles include pre-production test piles with and without dynamic pile analysis, [pre-production test piles with static load test,] [pre-production test piles with tensile load test,] [pre-production test piles with lateral load test,] and production test piles with dynamic pile analysis. Total number of pre-production test piles shall be a minimum of 10 percent of total number piles for a structure with no fewer than 2 for each structure. Total number of pre-production test piles with dynamic pile analysis shall be a minimum of 40 percent of total number of pre-production test piles with no fewer than 2 for each structure or as determined by the contracting officer. Pre-production test piles without dynamic pile analysis shall be driven to the driving criteria approved by the Contracting Officer. Pre-production test piles without dynamic pile analysis will aid in establishing the pile order list. Total number of production test piles with dynamic pile testing shall be a minimum of 1 percent of total number of piles for a structure with no fewer than 2 for each structure. Production test pile with dynamic pile analysis will be used to verify the driving criteria approved by the Contracting Officer. Individual production test pile with dynamic pile analysis shall be driven on different dates, with dates equally spaced and spanning the entire production pile phase of the project, or as otherwise directed by the Contracting Officer.

Use test piles of type, and drive as specified for piling elsewhere in this section. Order pre-production test piles in length indicated in the contract documents. The [Contractor's Geotechnical Engineer][Contracting Officer] will use test pile data to determine production pile lengths and pile driving criteria, subject to review and approval by the Contracting Officer. Drive test piles at the locations indicated, or as otherwise directed by the Contracting Officer. Use test piles in the finished work if located properly and offering adequate capacity. Pre-drilling or jetting is permitted only when test piles clearly establish validity of its use, or as directed by the Contracting Officer. Provide and operate a Pile Driving Analyzer as specified in paragraph DYNAMIC PILE ANALYSIS during the driving of test piles. Modify driving as required based upon recommendation of Contractor's Geotechnical Engineer and approval of the Contracting Officer.

### [3.3.2 Dynamic Pile Analysis for Pre-Production Test Piles

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

Dynamic testing provides supplemental information for evaluating pile integrity, hammer and drive system performance, assess pile installation driving stresses, and pile capacities. Use test piles of type as specified elsewhere in this section. Provide equipment to obtain dynamic measurements, record, reduce and display its data that meet the requirement of ASTM D4945. The equipment must have been calibrated within 24 months prior to the start of the testing operations and thereafter throughout the contract duration. Drive[ test] piles at the locations indicated or at the locations selected by the Contracting Officer. Employ an independent inspection firm, hereinafter referred to as the "Contractor's Geotechnical Engineer", experienced in the pile driving process[, monitoring of test pile installation,] and in the use of the Pile Driving Analyzer and its related equipment. Perform dynamic pile analysis as follows:

#### 3.3.2.1 Pile Analysis

10 working days prior to driving the test piles, submit the pile and complete driving equipment data to the Contracting Officer. The Contractor's Geotechnical Engineer must use the submitted information to perform wave equation analyses and must prepare a summary report of the wave equation results. The wave equation analysis using GRLWEAP software by Pile Dynamics, Inc. or equivalent must be used to assess the ability of the proposed driving system to install the pile to the required capacity and desired penetration depth within the allowable driving stresses. Approval of the proposed driving system by the Contracting Officer must be based upon the wave equation analyses indicating that the proposed driving system can develop a pile capacity of [\_\_\_\_\_] kN at a driving resistance not greater than 15 mm/blow within allowable driving stress limits. The hammer must also be sized or adjustable such that the penetration per blow at the required ultimate capacity does not exceed 15 mm.

#### 3.3.2.2 Pile Drivability

Perform each dynamic pile analysis in two steps. The first step is to

check the hammer, pile and soil performance, and to determine the suitability of the proposed hammer for the size, length and type of pile being installed for the soil types encountered as the piles are driven. This initial monitoring must determine whether predrilling is appropriate, efficiency of the hammer relative to specified efficiency, effectiveness of cushion, level of compressive and tensile stress in pile and extent/location of any pile damage caused by the initial driving. With each blow of the pile, record the information listed below electronically and analyze the information using the Pile Driving Analyzer:

- (1) Blow number.
- (2) Blow rate per minute and stroke.
- (3) Input and reflected values of force and velocity.
- (4) Value of upward and downward traveling force wave with time.
- (5) Maximum and final transferred energy to pile, hammer system efficiency.
- (6) Maximum compressive stress, velocity, acceleration and displacement.
- (7) Maximum tensile stress in pile.
- (8) Pile structural integrity, damage detection, extent and location.
- (9) Bearing capacity of pile by Case method.

If the pile, hammer and soil performance evaluation recommends changes to the hammer stroke, pile cushioning, augering or any other aspect for the pile driving operation, incorporate these changes into production pile driving in an effort to control excessive stresses and pile damage. Replace test piles damaged or broken during installation incorporating driving modifications as determined by the Contractor's Geotechnical Engineer and reviewed and approved by the Contracting Officer. Repeat this procedure until allowable tensile and compressive stresses are achieved in the pile and/or pile damage is minimized. Subject selected initial driving records to rigorous computer analysis by the Case Pile Wave Analysis Program (CAPWAP) for determination of resistance distribution, soil resistance and properties, and estimation of anticipated gain/loss factors.

### 3.3.2.3 CAPWAP

Signal matching analysis by CAPWAP® software of the dynamic pile testing data must be performed on data obtained from the end of initial driving and the beginning of restrike of all control piles. CAPWAP analyses must be performed by an engineer who has achieved Advanced Level or better on the PDI / PDCA Dynamic Measurement and Analysis Proficiency Test for Providers of PDA Testing Services.

After evaluation of pile, hammer and soil performance by the Contractor's Geotechnical Engineer, the second step of the dynamic pile analysis may proceed. This portion of the evaluation requires striking the set-up piles a minimum of 20-50 times, or as directed by the Contractor's Geotechnical Engineer using the same hammer which was used for the[ test] pile driving and which will be used for production pile driving. "Warm

up" the hammer and make it optimally ready prior to restriking, in order to avoid capacity losses during evaluation of restrike data. Apply maximum hammer energy during restrike in order to fully mobilize the soil resistance. However, exercise care so as to not overstress the pile. In addition to those items listed above, selected restrike driving records (as directed by the Contractor's Geotechnical Engineer are to be subjected to rigorous computer analysis by the Case Pile Wave Analysis Program (CAPWAP) for determination of resistance distribution, soil resistance and properties, and plot of applied load vs. average pile displacement based on the calculated soil properties.

#### 3.3.2.4 Dynamic Load Test Reporting

Upon satisfactory completion of all pre-production load testing, Contractor shall submit the Performance Report with the production pile order list for Contracting Officer review and approval.

The report for the Dynamic Pile Analysis must contain the following information:

- a. Capacity of pile from Case Pile Wave Analysis Program (CAPWAP). Information resulting from analysis of a selected restrike blow.
- b. Maximum transferred energy, hammer system efficiency during pile installation.
- c. Maximum compressive stress, velocity, and displacement.
- d. Maximum tensile stress in pile.
- e. Pile structural integrity, damage detection, extent and location.
- f. Blows per minute and blow number.
- g. Input and reflection values of force and velocity, upward and downward traveling force wave with time.
- h. Pile skin friction and toe resistance distribution.
- i. Final embedded pile lengths after dynamic loading test.

The maximum allowable pile design load must be proposed by the Contractor's Geotechnical Engineer based upon the results of a satisfactory pile load test conducted on a pile driven as specified herein and must include the effects of load transfer to the soil above the foundation stratum. The maximum allowable pile design load will be based on the procedure recommended by Davisson (1972) for obtaining the failure load based on the load-settlement curve.

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

The Contractor's Geotechnical Engineer must be available throughout the pile driving operation to consult with the Contracting Officer when required by the Contracting Officer. The cost of changes in the Contractor's procedure, as required by evaluation of the results of the Pile Driving Analysis, will be at the Contractor's expense.

### ]3.3.3 Static Load Tests

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

Submit test set-up and procedures.

Perform compressive load tests on [\_\_\_\_\_] test piles in accordance with **ASTM D1143/D1143M** Procedure [A: Quick Test] as modified herein..[ Allow a minimum of [72 hours][\_\_\_\_\_]days] following final test pile driving for pile set-up prior to load testing.][ Do not use anchor piles.] Provide apparatus for applying vertical loads as required by method, using load from weighted box or platform [or reaction frame attached to sufficient uplift piles to safely take required load] applied to pile by hydraulic jack. Increase load in increments until rapid progressive settlement takes place or until application of total compressive load of [\_\_\_\_\_] **kN** for compressive load tests . Consider load test satisfactory when [after one hour at full test load gross settlement of pile butt is not greater than gross elastic pile compression plus **4 mm** plus one percent of pile tip diameter ,] [slope of gross load-settlement curve under full test load does not exceed **1.5 mm per metric ton**,] [net settlement after removal of test load does not exceed **19 mm**]. Perform load tests at locations[ as proposed by the Contractor's Geotechnical Engineer and] as directed by the Contracting Officer. Additional load tests, at Government expense, may be required by the Contracting Officer. Perform the loading, testing, and recording and analysis under the direct supervision of a Registered Professional Engineer, registered in the state of project location, and provided and paid for by the Contractor.[ Submit test pile records][ and ][load test data] within 7 calendar days of test completion.

#### [3.3.3.1 Safe Design Capacity

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

#### ]3.3.4 Tensile Load Test

Perform tensile load tests on [\_\_\_\_\_] test piles in accordance with **ASTM D3689/D3689M**. Apply a tensile load of [\_\_\_\_\_] **kN** to each tensile load test pile. In performing the tension load test, apply the ultimate load equal to two times the maximum service load, and employ the Standard Loading Procedure.

Perform load tests at locations[ as proposed by the Contractor's Geotechnical Engineer and] as directed by the Contracting Officer. Additional load tests, at Government expense, may be required by the Contracting Officer. Perform the loading, testing, and recording and analysis under the direct supervision of a Registered Professional Engineer, registered in the state of project location, and provided and

paid for by the Contractor.

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

#### ][3.3.5 Lateral Load Test

Perform lateral load tests on [\_\_\_\_\_] piles in accordance with **ASTM D3966/D3966M**. Lateral load tests must consist of jacking two piles apart with a hydraulic jack, with one pile serving as the reaction pile for the other. Apply a lateral load of [\_\_\_\_\_] **kN** to the lateral load test piles. Sufficient number of reaction piles shall be installed and used for lateral load tests in accordance with the contracting officer's directions. Record required movement readings for each pile.

Perform load tests at locations as proposed by the Contractor's Geotechnical Engineer and as directed by the Contracting Officer. Additional load tests, at Government expense, may be required by the Contracting Officer. Perform the loading, testing, and recording and analysis under the direct supervision of a Registered Professional Engineer, registered in the state of project location, and provided and paid for by the Contractor.

#### ]3.3.6 **Pile Records**

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

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

Keep a complete and accurate record of each pile driven. Indicate the pile location, deviations from pile location, cross section shape and dimensions, original length, ground elevation, tip elevation, cut-off elevations, batter alignment, number of blows required for each **300 mm** of penetration and number of blows for the last **100 mm** penetration or fraction thereof as required for the driving criteria. Include in the record the beginning and ending times of each operation during driving of

pile, type and size of hammer used, rate of operation, stroke or equivalent stroke for diesel hammer, type of driving helmet, and type and dimension of hammer cushion (capblock) and pile cushion used. Record retap data and unusual occurrences during pile driving such as re-driving, heaving, weaving, splicing, obstructions, and any driving interruptions. [Install an energy monitor on the hammers and record readings every 250 mm of pile installation.] A preprinted pile driving log for recording pile driving data and pile driving equipment data form, which can be downloaded at:

<http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables>.

### [3.3.7 Testing Agency Qualifications

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

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

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

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

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

Add any additional requirements as necessary.

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

### ] [3.5 VIBRATION CONTROL

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

\*\*\*\*\*

Perform vibration monitoring at the locations decided by the Contractor during the pile driving operations. Perform vibration monitoring [using] [seismographs] [and geophones] within a distance of 25 meters 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 5 years of experience in vibration monitoring. A minimum of 14 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 2.5 cm per second.. 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 decided by the Contractor during the pile driving operations. Perform noise monitoring using noise meters. 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 5 years of experience in noise monitoring. A minimum of 14 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 contract documents. 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 CONSTRUCTION INSTRUMENTATION AND MONITORING PROGRAM

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**NOTE: Include this section if instrumentation is to be installed due to concerns about vibration, settlement, lateral movement, etc. during pile driving activities. Instrumentation should be specified and included in the specification. This section can be deleted if there are no instrumentation requirements.**  
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**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 [Instrumentation and Monitoring Program Report](#) detailing the proposed program of instrumentation and monitoring, establishing threshold values of monitored parameters, and describing the response plans that will be implemented when threshold parameters are exceeded. The report must include details about instrumentation consultant's experience, appropriate types, quantities, locations and monitoring frequencies of the instruments.

Upon acceptance of the instrumentation and monitoring program, provide, install and monitor the instrumentation and interpret the data. Submit instrumentation data reports not less than every 7 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.

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ATTACHMENTS:

Test Pile Checklist

Pile and Driving Equipment Data Form

Pile Driving Log

-- End of Section --