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USACE / NAVFAC / AFCEA / NASA            UFGS-31 62 16.16 (April 2006)  
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Preparing Activity: NAVFAC                Replacing without change  
                                             UFGS-02460 (February 2005)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 9 October 2006

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### SECTION TABLE OF CONTENTS

#### DIVISION 31 - EARTHWORK

#### SECTION 31 62 16.16

#### STEEL H-PILES

04/06

#### PART 1    GENERAL

- 1.1    REFERENCES
- 1.2    SUBMITTALS
- 1.3    DELIVERY, STORAGE, AND HANDLING
  - 1.3.1    Delivery and Storage
  - 1.3.2    Handling
- 1.4    BASIS FOR BIDS
- 1.5    UNIT PRICES
  - 1.5.1    Furnishing and Delivering Steel H-Piles
    - 1.5.1.1    Payment
    - 1.5.1.2    Measurement
    - 1.5.1.3    Unit of Measure
  - 1.5.2    Driving Steel H-Piles
    - 1.5.2.1    Payment
    - 1.5.2.2    Measurement
    - 1.5.2.3    Unit of Measure
  - 1.5.3    Pulled Piles
    - 1.5.3.1    Payment
    - 1.5.3.2    Measurement
    - 1.5.3.3    Unit of Measure
  - 1.5.4    Steel H-Pile Driving Tests
    - 1.5.4.1    Payment
    - 1.5.4.2    Measurement
    - 1.5.4.3    Unit of Measure
  - 1.5.5    Steel H-Piles for Load Tests
    - 1.5.5.1    Payment
    - 1.5.5.2    Measurement
    - 1.5.5.3    Unit of Measure
  - 1.5.6    Steel H-Pile Compressive Load Tests
    - 1.5.6.1    Payment
    - 1.5.6.2    Measurement
    - 1.5.6.3    Unit of Measure
  - 1.5.7    Steel H-Pile Tensile Load Tests
    - 1.5.7.1    Payment

- 1.5.7.2 Measurement
- 1.5.7.3 Unit of Measure
- 1.5.8 Steel H-Pile Lateral Load Tests
  - 1.5.8.1 Payment
  - 1.5.8.2 Measurement
  - 1.5.8.3 Unit of Measure
- 1.5.9 Pulled Load Test H-Piles
  - 1.5.9.1 Payment
  - 1.5.9.2 Measurement
  - 1.5.9.3 Unit of Measure
- 1.5.10 Steel H-Pile Points
  - 1.5.10.1 Payment
  - 1.5.10.2 Measurement
  - 1.5.10.3 Unit of Measure
- 1.5.11 Steel H-Pile Caps
  - 1.5.11.1 Payment
  - 1.5.11.2 Measurement
  - 1.5.11.3 Unit of Measure
- 1.5.12 Steel H-Pile Splices
  - 1.5.12.1 Payment
  - 1.5.12.2 Measurement
  - 1.5.12.3 Unit of Measure
- 1.5.13 Steel H-Pile Tension Anchors
  - 1.5.13.1 Payment
  - 1.5.13.2 Measurement
  - 1.5.13.3 Unit of Measure

## PART 2 PRODUCTS

- 2.1 MATERIALS
  - 2.1.1 H-Piles
  - 2.1.2 Pile Splices
  - 2.1.3 Pile Points
  - 2.1.4 Pile Caps
  - 2.1.5 Pile Tension Anchors
  - 2.1.6 FABRICATION
    - 2.1.6.1 Pile Splices
    - 2.1.6.2 [Pile Caps,] [Pile Points,] [Pile Tension Anchors]

## PART 3 EXECUTION

- 3.1 PILE DRIVING EQUIPMENT
  - 3.1.1 Pile Driving Hammers
    - 3.1.1.1 Impact Hammers
    - 3.1.1.2 Vibratory Hammers
  - 3.1.2 Pile Driving Leads
  - 3.1.3 Pile Extractors
  - 3.1.4 Jetting Equipment
- 3.2 INSTALLATION
  - 3.2.1 Lengths of Job Piles
  - 3.2.2 Pile Driving Records
  - 3.2.3 Pile Placement and Tolerances in Driving
    - 3.2.3.1 Survey Data
  - 3.2.4 Pile Penetration Criteria
  - 3.2.5 Pile Driving
    - 3.2.5.1 Splicing Piles
    - 3.2.5.2 Jetting
    - 3.2.5.3 Predrilling
    - 3.2.5.4 Heaved Piles

- 3.2.5.5 Pulled Piles
  - 3.2.5.6 Long Piles
  - 3.2.5.7 Welding
- 3.3 PILE TESTS
  - 3.3.1 Test Piles
  - 3.3.2 Pile Driving Tests
  - 3.3.3 Dynamic Testing of Piles
    - 3.3.3.1 Test Piles
    - 3.3.3.2 Job Piles
    - 3.3.3.3 Reports
  - 3.3.4 Pile Load Tests
    - 3.3.4.1 Compressive Load Test
    - 3.3.4.2 Tensile Load Test
    - 3.3.4.3 Lateral Load Test

-- End of Section Table of Contents --

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### SECTION 31 62 16.16

#### STEEL H-PILES 04/06

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

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

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

Use of electronic communication is encouraged.

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

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NOTE: The following information shall be shown on the project drawings:

1. Location, size, and cutoff elevation of project piles.
2. Location, size, cutoff elevation, and identification of test piles.
3. Subsurface soil data logs should be shown on the drawings. Other subsurface data is design information and should not be part of the contract. Data should be available for examination by the bidders at appropriate locations.

#### 4. Staging area.

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### PART 1 GENERAL

#### 1.1 REFERENCES

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

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

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

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

#### AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2006) Structural Welding Code - Steel

#### ASTM INTERNATIONAL (ASTM)

ASTM A 27/A 27M (2005) Steel Castings, Carbon, for General Application

ASTM A 36/A 36M (2005) Carbon Structural Steel

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

ASTM A 588/A 588M (2005) High-Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4 in. (100 mm) Thick

ASTM A 690/A 690M (2000a) High-Strength Low-Alloy Steel H-Piles and Sheet Piling for Use in Marine Environments

ASTM D 1143 (1981; R 1994e1) Piles Under Static Axial Compressive Load

ASTM D 3689 (1990, R 1995) Individual Piles Under Static Axial Tensile Load

ASTM D 3966

(1990; R 1995) Piles Under Lateral Loads

ASTM D 4945

(2000) High-Strain Dynamic Testing of Piles

## 1.2 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

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

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

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

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

### SD-02 Shop Drawings

[Pile splices[; G][; G, [\_\_\_\_]]]

[Submit detail drawings of pile splices prior to fabrication.]

File placement[; G][; G, [\_\_\_\_]]

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

[Pile reinforcing tips or steel points]

[Pile encasements]

#### SD-03 Product Data

File driving equipment[; G][; G, [\_\_\_\_\_]]

Submit descriptions of pile driving equipment at least 30 days prior to commencement of work.

File driving records[; G][; G, [\_\_\_\_\_]]

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

Delivery, storage, and handling[; G][; G, [\_\_\_\_\_]]

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

[Pile tests[; G][; G, [\_\_\_\_\_]]]

[Submit pile load test plan at least 30 days prior to installing any test piles. Approval of the plan shall not relieve the Contractor of the responsibility for structural and operational adequacies of the testing system.]

#### SD-04 Samples

Test piles[; G][; G, [\_\_\_\_\_]]

#### SD-05 Design Data

[Wave equation analysis]

[Submit wave equation analysis.]

#### SD-06 Test Reports

[Pile driving tests[; G][; G, [\_\_\_\_\_]]]

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

[Pile driving analyzer[; G][; G, [\_\_\_\_\_]]]

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

[Pile load tests[; G][; G, [\_\_\_\_\_]]]

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

[Dynamic testing of piles]

[Submit reports of the dynamic testing of piles within one (1) [day] [week] after dynamic testing is completed.]

## SD-11 Closeout Submittals

### Pile driving records

Submit [to the Contracting Officer] complete and accurate [test and] job pile driving records as specified in paragraph entitled "Records" of this section, within [15] [\_\_\_\_\_] calendar days after completion of driving.

### 1.3 DELIVERY, STORAGE, AND HANDLING

Delivery, storage, and handling of materials shall conform to the requirements specified herein. Plans for the delivery, storage, and handling of piles shall be developed and submitted in accordance with paragraph "Submittals."

#### 1.3.1 Delivery and Storage

Piles shall be stacked during delivery and storage so that each pile is maintained in a straight position and is supported every 3 m 10 feet or less along its length (ends inclusive) to prevent exceeding the maximum camber or sweep. Piles shall not be stacked more than 1.5 m 5 feet high.

#### 1.3.2 Handling

Piles shall be lifted using a cradle or multiple points pick-up to ensure that the maximum permissible camber or sweep is not exceeded due to insufficient support, except that a one-point pick-up may be used for lifting piles that are not extremely long into the driving leads. Point pick-up devices shall be of the type that clamp to both pile flanges at each pick-up point. Holes may be burned in the flanges or webs of piles above the cutoff length for lifting piles into the leads. Piles shall not be dragged across the ground. The Contractor shall inspect piles for excessive camber and sweep and for damage before transporting them from the storage area to the driving area and immediately prior to placement in the driving leads. Camber, curvature in the pile in the direction normal to the pile flanges, shall be measured with the pile flange base laying on a flat surface and shall be the distance between the flange base at the mid-length of the pile and the flat surface. Sweep, curvature in the pile in the direction parallel to the pile flanges, shall be measured with the pile flange tips laying on a flat surface and shall be the distance between the flange tips at the mid-length of the pile and the flat surface. The maximum permissible camber [and] [or] sweep shall be 50 mm 2 inches over the length of the pile. Piles having excessive camber or sweep will be rejected.

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NOTE: For NAVFAC (Navy) projects, use and edit the appropriate following paragraph(s). Do not use for Army projects.  
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### 1.4 BASIS FOR BIDS

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NOTE: Select one of the following options:  
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NOTE: Use first option below for lump sum bidding of piles. This option should be used in all projects except those where exact pile lengths cannot be practically determined prior to the actual work. Number of piles, pile capacity, pile locations, and tip and cutoff elevations shall be clearly shown on the drawings. Use second option 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.

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[Base bids on the number, size, and length of piles from tip to cutoff as indicated. Bids shall include the retapping of piles to confirm pile capacity and/or redriving of heaved piles to the required tip elevation as directed by the Contracting Officer. The Contractor shall base bids on retapping/redriving [100] [ ] percent of the job piles. [Test piles shall be [1.5] [ ] meter [5] [ ] feet longer than bid length piles.

[Base bids on the number of load tests indicated or specified.] From the data obtained as a result of driving the test piles [and load tests] specified herein, the Government will determine and will list for the Contractor the calculated pile tip elevations, the driving resistance for piles, or both. The information will be given to the Contractor no later than 3 working days after receipt of complete test pile data. The list shall be used as the basis for ordering piles. The Contractor shall not order production piles prior to receipt of the above information from the Government.] Should the total number of piles or number of each length vary from that specified as the basis for bidding, the contract price will be adjusted in accordance with Contract Clause entitled "Changes." Adjustment in contract price will not be made for cutting off piles, for any portion of a pile remaining above the cutoff elevation, or for damaged or rejected piles.]

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NOTE: For PACNAVFACENGCOM projects: Edit applicable attachments from Document 00 41 00 for inclusion in Standard Form 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items." Select first bracketed text.

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[For unit price bid, see [SF 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items."] [Section 00 41 00, "Bid Schedules."]]

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NOTE: For LANTDIV projects, select one of the following options for basis for bids. Use first option below for lump sum bidding of piles. Use second option for unit price bidding of piles.

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Bids shall be based on providing [ ] steel H-piles totaling [ ] linear meters] [ ] linear feet] on the assumed pile length of [ ] meters] [ ] feet} from tip to cutoff. Pile length provided over [ ] meters] [ ] feet}

for ease of installation shall be considered the responsibility of the Contractor. Provide splices [in accordance with the detail indicated] [as specified]. Piles shall be continuously driven to a minimum depth of [\_\_\_\_ meters] {\_\_\_\_ feet} below the cutoff elevation and to such additional depth as required to obtain a bearing capacity of not less than [\_\_\_\_ kilonewtons] [\_\_\_\_ tons]. The following formula shall be used as a guide in establishing the controlling penetration per blow which, together with the minimum depth of penetration ([\_\_\_\_ meters] [\_\_\_\_ feet] below cutoff elevation) will serve to determine the required depth of penetration of each individual pile:

$$R=2E/(S+0.1) \text{ for double acting hammers}$$

$$R=2WH/(S+0.1) \text{ for single acting hammers}$$

in which R is the approximate allowable pile load in pounds, E equals the energy in foot-pounds per blow based on an acceptable certified statement from the manufacturer of the hammer, W equals the weight of the hammer or ram in pounds, H equals the fall of the hammer or ram in feet, and S equals the average inches of penetration per blow for the last three blows. If after driving a pile to [\_\_\_\_ meters] [\_\_\_\_ feet] tip penetration below cutoff elevation and a bearing capacity of [\_\_\_\_ kilonewtons] [\_\_\_\_ tons] is not achieved, the Contracting Officer shall be notified. Corrective action shall be taken as directed by the Contracting Officer, such as splicing additional pile length and driving to greater depth. An adjustment to the contract cost shall be made for Contracting Officer authorized corrective action required due to inadequate bearing capacity. No reduction in price will be required for piles driven shorter than the specified tip to cutoff length when the requirements for minimum penetration and bearing capacity have been met. All costs incidental to providing steel H-piles shall be included in the lump sum contract price bid, including furnishing and driving piles, mobilization, cutting off piles at cutoff elevation, splices (except those as directed by the Contracting Officer as corrective action due to required bearing not being achieved), retapping of piles to confirm pile capacity, redriving of heaved piles to the required tip elevation, pile coatings, and providing driving records. The Contractor shall base bids on retapping/redriving [100] [\_\_\_\_] percent of the job piles.

[Payment will be at the contract unit price per unit length, including test piles, multiplied by the total length of acceptable piles actually installed. Work includes furnishing labor, materials, tools, equipment, and incidentals required for installing piles including [test piles,] [load tests,] [jetting,] [predrilling,] pile cutoff, redriving, and removal and replacement of damaged, mislocated, or otherwise rejected piles. Bids shall include the retapping of piles to confirm pile capacity and/or redriving of heaved piles to the required tip elevation as directed by the Contracting Officer. The Contractor shall base bids on retapping/redriving [100] [\_\_\_\_] percent of the job piles. Test piles shall be [1.5 m] [5 feet] [\_\_\_\_] longer than bid length piles. Base bids on the number of piles with pile length from tip to cutoff, as indicated, and on total length of piling from tip to cutoff, including test piles, as specified [in the document titled "Supplementary Instructions to Bidders."]. Include in bid a unit price per [load test[s] and] linear foot of piling based on the quantity [indicated] [stated in document titled "Supplementary Instructions to Bidders."]. From the data obtained as a result of driving the test piles [and load tests] specified herein, the Government will determine and list for the Contractor the calculated pile tip elevations, the driving resistance for piles, or both. Information will be given to the Contractor no later than 3 working days after receipt of complete test pile data. The list shall be used as the basis for ordering piles. The Contractor

shall not order job piles prior to receipt of the above information from the Government. If the Contracting Officer requires an increase or a decrease in the length of piles furnished and installed, the contract will be adjusted in accordance with "FAR 52.211-18, Variations in Estimated Quantities." [Adjustment in contract price will also be made for each increase or decrease in number of pile load tests.]]

] [1.5 UNIT PRICES

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NOTE: For USACE (Army) projects, use and edit the appropriate following paragraph(s). Do not use for Navy projects.

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NOTE: If Section 01270, "Measurement and Payment," is included in the project specifications, this paragraph title (UNIT PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs below should be inserted into Section 01270.

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1.5.1 Furnishing and Delivering Steel H-Piles

1.5.1.1 Payment

Payment will be made for costs associated with furnishing and delivering the required lengths of job piles to the work site. No payment will be made for the lengths of piles exceeding required lengths. No payment will be made for piles damaged during delivery, storage, handling, or driving to the extent that they are determined by the Contracting Officer to be unsuitable for the work.

1.5.1.2 Measurement

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

1.5.1.3 Unit of Measure

Unit of measure: linear meter foot.

1.5.2 Driving Steel H-Piles

1.5.2.1 Payment

Payment will be made for costs associated with driving job piles, which includes costs of handling [,] [and] driving, [and splicing] piles, [furnishing, installing, and operating a pile driving analyzer,] measuring pile heave, redriving heaved piles, cutting off piles at the cutoff elevation and removing cutoffs 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. No payment will be made for misplaced piles or piles exceeding the maximum limits for rotation, lateral deviation, and variation in alignment. No payment will be made for piles impaired during driving to the extent that they are

determined by the Contracting Officer to be unsuitable for the work.

#### 1.5.2.2 Measurement

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

#### 1.5.2.3 Unit of Measure

Unit of measure: linear **meter** **foot**.

### [1.5.3 Pulled Piles

#### 1.5.3.1 Payment

Payment will be made for costs associated with pulling piles, as directed, 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[s] "Furnishing and Delivering Steel H-Piles" [and "Pile Points"]. The cost of driving pulled and undamaged piles will be paid for at the applicable contract unit price for payment item[s] "Driving Steel H-Piles" [and "Pile Splices"]. The cost of pulling undamaged piles will be paid for at twice the applicable contract unit price for payment item "Driving Steel H-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 Steel H-Piles". No payment will be made for furnishing, delivering, driving, pulling, backfilling voids, and disposing of piles[, including [pile points] [and] [pile splices,]] pulled and found to be damaged. New piles replacing damaged piles will be paid for at the applicable contract unit price for payment items "Furnishing and Delivering Steel H-Piles" and "Driving Steel H-Piles".

#### 1.5.3.2 Measurement

Furnishing and delivering pulled and undamaged piles will be measured for payment as specified in paragraph "Furnishing and Delivering Steel H-Piles". Pulling undamaged piles will be measured for payment as specified in paragraph "Driving Steel H-Piles". Redriving pulled, undamaged piles will be measured for payment as specified in paragraph "Driving Steel H-Piles". New piles replacing damaged piles will be measured for payment as specified in paragraph "Furnishing and Delivering Steel H-Piles" and "Driving Steel H-Piles".

#### 1.5.3.3 Unit of Measure

Unit of measure: linear **meter** **foot**.

### ] 1.5.4 Steel H-Pile Driving Tests

#### 1.5.4.1 Payment

Payment will be made for costs associated with furnishing, delivering, driving, pulling, and disposing of driving test piles[, including [pile points] [and] [pile splices]]; conducting pile driving tests; backfilling voids around piles; compiling pile driving test records []; and furnishing, installing, and operating a pile driving analyzer and reducing its data].

#### 1.5.4.2 Measurement

Steel H-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

Unit of measure: each.

### ] [1.5.5 Steel H-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 points] [and] [pile 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][; and furnishing, installing, and operating a pile driving analyzer and reducing its data]. No additional payment will be made for load test piles incorporated in the permanent work other than as provided.

#### 1.5.5.2 Measurement

Steel H-piles for load tests will be measured for payment on the basis of the number of load test piles required.

#### 1.5.5.3 Unit of Measure

Unit of measure: each.

### ] [1.5.6 Steel H-Pile Compressive Load Tests

#### 1.5.6.1 Payment

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

#### 1.5.6.2 Measurement

Steel H-pile compressive load tests will be measured for payment on the basis of the number of compressive load tests required.

#### 1.5.6.3 Unit of Measure

Unit of measure: each.

### ] [1.5.7 Steel H-Pile Tensile Load Tests

#### 1.5.7.1 Payment

Payment will be made for costs associated with steel H-pile tensile load tests, including material and labor for fabricating and furnishing load

frames; calibrating load cells and hydraulic jacks; furnishing specified test equipment; installing strain rods; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting pile load test reports. No payment will be made for rejected pile tensile load tests.

#### 1.5.7.2 Measurement

Steel H-pile tensile load tests will be measured for payment on the basis of the number of tensile load tests required.

#### 1.5.7.3 Unit of Measure

Unit of measure: each.

### ] [1.5.8 Steel H-Pile Lateral Load Tests

#### 1.5.8.1 Payment

Payment will be made for costs associated with steel H-pile lateral load tests, including material and labor for fabricating and furnishing load frames; calibrating load cells and hydraulic jacks; furnishing specified test equipment; installing inclinometers; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting pile load test reports. No payment will be made for rejected pile lateral load tests.

#### 1.5.8.2 Measurement

Steel H-pile lateral load tests will be measured for payment on the basis of the number of lateral load tests required.

#### 1.5.8.3 Unit of Measure

Unit of measure: each.

### ] [1.5.9 Pulled Load Test H-Piles

#### 1.5.9.1 Payment

Payment will be made for costs associated with load test H-piles pulled prior to load testing as directed 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 "Steel H-Piles for Load Tests". The cost of pulling undamaged load test piles the second time after re-driving and testing will be paid for at twice the applicable contract unit price for payment item "Driving Steel H-Piles". The cost of re-driving pulled, undamaged load test piles will be paid for at the applicable contract unit price for payment item "Driving Steel H-Piles". No payment will be made for furnishing, delivering, driving, pulling, and disposing of load test piles pulled 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 "Steel H-Piles for Load Tests".

#### 1.5.9.2 Measurement

Pulled undamaged load test H-piles will be measured for payment as specified in paragraph "Steel H-Piles for Load Tests". Pulling undamaged

load test steel H-piles, the second time after redriving and testing will be measured for payment as specified in paragraph "Driving Steel H-Piles". Redriving pulled, undamaged steel H-piles will be measured for payment as specified in paragraph "Steel H-Piles for Load Tests". New load test H-piles replacing damaged piles will be measured for payment as specified in paragraph "Steel H-Piles for Load Tests".

#### 1.5.9.3 Unit of Measure

Unit of measure: as specified in paragraph "Driving Steel H-Piles" and "Steel H-Piles for Load Tests", respectfully.

### ] [1.5.10 Steel H-Pile Points

#### 1.5.10.1 Payment

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

#### 1.5.10.2 Measurement

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

#### 1.5.10.3 Unit of Measure

Unit of measure: each.

### ] [1.5.11 Steel H-Pile Caps

#### 1.5.11.1 Payment

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

#### 1.5.11.2 Measurement

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

#### 1.5.11.3 Unit of Measure

Unit of measure: each.

### ] [1.5.12 Steel H-Pile Splices

#### 1.5.12.1 Payment

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

#### 1.5.12.2 Measurement

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

#### 1.5.12.3 Unit of Measure

Unit of measure: each.

#### ] 1.5.13 Steel H-Pile Tension Anchors

##### 1.5.13.1 Payment

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

##### 1.5.13.2 Measurement

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

##### 1.5.13.3 Unit of Measure

Unit of measure: each.

#### ] ] PART 2 PRODUCTS

### 2.1 MATERIALS

#### 2.1.1 H-Piles

\*\*\*\*\*

NOTE: Selection of material should be based on a comprehensive study of strength, cost, and corrosion resistance requirements. ASTM A 36/A 36M and ASTM A 572/A 572M steels have the same corrosion resistance; ASTM A 572/A 572M can be obtained in yield strengths of 350 MPa through 448 MPa 42 ksi through 65 ksi; however, 350 MPa 50 ksi is the most available grade. ASTM A 588/A 588M has twice the atmospheric resistance of ASTM A 36/A 36M steel with 20 percent copper added.

1. Marine environment: Steel section piles exposed to seawater should be evaluated on the basis of application, location, degree of exposure, type of structure, and required service life. Where additional service life in the splash zone is required over that provided by conventional steel grades, ASTM A 690/A 690M or ASTM A 588/A 588M may be considered. ASTM A 690/A 690M steel 350 MPa 50 ksi (yield strength) has two to three times greater resistance to seawater splash zone corrosion than ordinary ASTM A 36/A 36M steel.

2. Seawater protection: To obtain reasonably long life for a structure immersed in seawater, the steel piles shall be provided with coatings, cathodic protection, or concrete encasement. Choice of protection is ultimately based on economics; usually, more than one type of protection will be used on a structure for most economical, adequate protection. The following criteria applies:



a. The use of coating systems for protection, such as coal tar epoxy, is usually low in initial cost but may require relatively frequent maintenance; also, it is extremely difficult to renew in the tidal zone between mean tide and low tide.

b. Cathodic protection is low in initial cost and low in maintenance. It can be of value only where the piles are continually wet, as in the submerged zone.

c. Concrete encasement or metal jacketing is relatively expensive in initial cost but requires no maintenance if properly constructed. When concrete encasement is to be continuously submerged in water with low resistivity, it should (1) extend below the mudline, or (2) the steel should be coated to electrically insulate the concrete from the steel.

High-strength steel shall be used only when design analyses show that the use is the most economical solution.

ASTM A 27/A 27M cast steel is used for some commercially available pile points.

\*\*\*\*\*

[ASTM A 36/A 36M] [ASTM A 572/A 572M, Grade [\_\_\_\_]] [ASTM A 588/A 588M] [ASTM A 690/A 690M]. [Provide test piles identical to those used elsewhere in the project.] [Pile tips shall be square and blunt, as received from the mill.] [Provide pile tip reinforcements or cast [steel points](#).] [Piles shall be coated in accordance with Section 09 97 13.26, "Coating of Steel Waterfront Structures."] [Piles shall be provided with concrete [encasements](#) in accordance with Section 03 30 00.00 20, "Cast-In-Place Concrete."] H-piles shall be of the shape and sections shown. Lengths of piles shall be determined as specified in paragraph "Installation," subparagraph "Lengths of Job Piles" [and paragraph "Pile Tests," subparagraph "Test Piles"].

#### [2.1.2 Pile Splices

[ASTM A 36/A 36M] [ASTM A 572/A 572M, Grade [\_\_\_\_]] [ASTM A 588/A 588M] for splice plates.] [Materials for pile splices shall be as shown.]

#### ] [2.1.3 Pile Points

\*\*\*\*\*

NOTE: Pile points may be required when driving piles in dense sand strata, gravel strata and cobble-boulder zones, and when driving piles to refusal on a hard layer or bedrock.

\*\*\*\*\*

[ASTM A 27/A 27M for cast steel points.] [ASTM A 36/A 36M] [ASTM A 572/A 572M, Grade [\_\_\_\_]] for pile tip reinforcements.] Pile points shall [be the type] [conform to details] shown and shall be provided on all piles.]

] [2.1.4    Pile Caps

[ASTM A 36/A 36M.] [ASTM A 572/A 572M, Grade [\_\_\_\_\_] .] [ASTM A 588/A 588M.]  
Pile caps shall conform to details shown.

] [2.1.5    Pile Tension Anchors

[ASTM A 36/A 36M.] [ASTM A 572/A 572M, Grade [\_\_\_\_\_] .] [ASTM A 588/A 588M.]  
Pile tension anchors shall conform to details shown.

] [2.1.6    FABRICATION

Fabrication shall conform to the requirements shown and as specified herein  
and in Section 05 50 00, "Metal Fabrications."

] [2.1.6.1    Pile Splices

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

Pile splices shall be fabricated as shown. Detail drawings of splices  
shall be submitted in accordance with paragraph "Submittals."

] [2.1.6.2    [Pile Caps,] [Pile Points,] [Pile Tension Anchors]

[[Pile caps,] [pile points,] [and] [pile tension anchors] shall be attached  
to piles as shown.] [The top of piles shall be ground sufficiently smooth  
to provide a good welding surface for structural-shape pile caps.]

] PART 3    EXECUTION

3.1    PILE DRIVING EQUIPMENT

Select the proposed pile driving equipment, including hammers and other  
required items, and submit complete descriptions of the proposed equipment  
in accordance with paragraph "Submittals." [Final approval of the proposed  
equipment is subject to the satisfactory completion and approval of pile  
tests.] Changes in the selected pile driving equipment will not be allowed  
after the equipment has been approved except as [specified and] directed.  
No additional contract time will be allowed for Contractor proposed changes  
in the equipment.

3.1.1    Pile Driving Hammers

\*\*\*\*\*  
NOTE: When specifying the minimum driving energy,  
an allowance shall be made for reduced penetration  
caused by shock absorption of pile caps. Enter the  
appropriate minimum allowable driving energy for the  
project. Minimum allowable driving energy shall be  
not less than the following:

Design Bearing Pile	Minimum Rated Hammer
Capacity for Single	Driving Energy (Joules)

File (Metric Tons)

Up to 60	20,350
Over 60	25,750

Design Bearing Pile Capacity for Single Pile (Tons)	Minimum Rated Hammer Driving Energy (Foot-Pounds)
-----------------------------------------------------------	---------------------------------------------------------

Up to 60	15,000
Over 60	19,000

The minimum and maximum hammer energies required may be determined from experience on other jobs or by a series of wave equation analyses.

\*\*\*\*\*

Pile driving hammers shall be of the impact [or vibratory] type.

3.1.1.1 Impact Hammers

Impact hammers shall be steam, air, or diesel-powered pile hammers of the single-acting, double-acting, or differential-acting type. [The size or capacity of hammers shall be as recommended by the hammer manufacturer for the total pile mass weight and the character of the soil formation to be penetrated.] [The rated driving energy of hammers shall be limited to a minimum of [20,350] [25,750] joules [15,000] [19,000] foot-pounds.] [Hammers shall be capable of [, and so demonstrated during the development of refusal criteria,] hard driving in excess of 20 blows per 25 mm.inch.] Boiler, compressor, or engine capacity shall be sufficient to operate hammers continuously at the full rated speed. Hammers shall have a gage to monitor hammer bounce chamber pressure for diesel hammers or pressure at the hammer for air and steam hammers. This gage shall be operational during the driving of piles and shall be mounted in an accessible location for monitoring by the Contractor and the Contracting Officer. [Two spare operational bounce chamber read out units shall be available on site.] [The Contractor shall provide bounce chamber pressure gage correction tables and charts for the type and length of hose to be used with the pressure gage to the Contracting Officer.] Driving energy shall be obtained by use of a heavy ram and a short stroke with low impact velocity, rather than a light ram and a long stroke with high impact velocity. Position a pile cap or drive cap between the pile and hammer. Place hammer cushion or cap block between ram and the pile cap or drive cap. Hammer cushion or cap block shall have consistent elastic properties, shall minimize energy absorption, and shall transmit hammer energy uniformly and consistently during the entire driving period. Do not use a pile cushion block. In accordance with paragraph "Submittals," submit the following information for each impact hammer proposed:

- Make and model.
- Ram mass (kilograms). weight (pounds).
- Anvil mass (kilograms). weight (pounds).
- Rated stroke (millimeters). (inches).
- Rated energy range (joules). (foot-pounds).

- f. Rated speed (blows per minute).
- g. Steam or air pressure, hammer, and boiler [and] [or] compressor (MPa). (psi).
- [h. Rated bounce chamber pressure curves or charts, including pressure correction chart for type and length of hose used with pressure gage (bar). (pounds per square inch).]
- i. Pile driving cap, make, and mass (kilograms). weight (pounds).
- j. Cushion block dimensions and material type.
- k. Power pack description.

#### [3.1.1.2 Vibratory Hammers

[The use of vibratory hammers is dependent upon satisfactory driving and load testing of piles.] [Final approval of the proposed hammer and other driving equipment is subject to the satisfactory completion and approval of the pile tests.] [The size or capacity of hammers shall be as recommended by the hammer manufacturer for the total pile mass weight and the character of the soil formation to be penetrated.] The hammer shall provide for maintaining a rigid connection between the hammer and the pile. In accordance with paragraph "Submittals," submit the following information for each vibratory hammer proposed:

- a. Make and model.
- b. Eccentric moment (newton-meters). (inch-pounds).
- c. Dynamic force (kilonewtons). (tons).
- d. Steady state frequency or frequency range (cycles per minute).
- e. Vibrating mass (kilonewtons). weight (pounds).
- f. Amplitude (millimeters). (inches).
- g. Maximum pull capacity (metric tons). (tons).
- h. Nonvibrating mass (kilonewtons). weight (pounds).
- i. Power pack description.

#### ]3.1.2 Pile Driving Leads

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

Vibratory hammers are typically operated free hanging without leads unless accurate placement and alignment of the piles are required.

\*\*\*\*\*

Hammers shall be supported and guided with [suspended leads,] fixed extended leads or fixed underhung leads. [Vibratory hammers shall be

operated free hanging without leads.] [For driving battered piles, impact hammers shall be supported and guided with three-axis, fixed-extended leads capable of 1 H and 2-1/2 V fore and aft batter and 1 H on 6 V side batter, with 30 degree rotation each side of an axis running along the center line of rotation of the crane through the center line of the leads]. [For driving battered piles, vibratory hammers shall be supported and guided with fixed extended leads or templates.] [Two intermediate supports for the pile in the leads shall be provided to reduce the unbraced length of the pile during driving and pulling.]

### 3.1.3 Pile Extractors

Pile extractors may be vibratory [and] [or] impact pile driving hammers. Impact hammers are required for pulling piles not extractable with vibratory hammers.

### [3.1.4 Jetting Equipment

\*\*\*\*\*  
**NOTE: Jetting should not be used on piles carrying significant tension loads, lateral loads, or compression loads developed predominantly from skin friction.**  
\*\*\*\*\*

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

## ] 3.2 INSTALLATION

Inspect piles when delivered and when in the leads immediately before driving. [Piles shall be handled so as to protect pile coatings. Repair damage or defects in pile coatings as specified.] Cut piles at cutoff grade by an approved method. Where cutoff is below existing ground or mudline elevation, complete excavation, sheeting, and dewatering before driving pile to cutoff elevation.

### 3.2.1 Lengths of Job Piles

The estimated quantities of piles are given for bidding purposes only. The Contracting Officer will determine the actual lengths of piles required to be driven below cutoff elevation for the various locations in the work and will furnish the Contractor a quantities list indicating lengths and locations of all piles to be installed. [These actual lengths will be determined from the results of the pile tests specified in paragraph "Pile Tests."] [The Contracting Officer will determine the number of overlength piles required to provide for variations in subsurface conditions.] Where required bearing capacities are attainable with piles of lesser length than those specified, shorter piles may be used subject to prior written approval.

### 3.2.2 [Pile Driving Records](#)

Develop a form for compiling pile driving records which must be approved,

or use the preprinted forms attached at the end of this section for recording pile driving data. Complete and accurate records of the pile driving operations shall be compiled on the approved form and submitted in accordance with paragraph "Submittals." Driving records for each pile shall include date driven, pile identification number, cross section shape and pile dimensions, location, deviations from design location, original length, ground elevation, top elevation, tip elevation, [batter alignment,] description of hammer used, number of blows required for each 300 mm foot of penetration throughout the entire length of the pile and for each 25 mm inch of penetration in the last 300 mm foot of penetration, total driving time in minutes and seconds, and any other pertinent information as required or requested such as unusual driving conditions, interruptions or delays during driving, damage to pile resulting from driving, heave in adjacent piles, redriving, weaving, obstructions, jetting, predrilling, and depth and description of voids formed adjacent to the pile. Additional data required to be recorded for impact hammers include the rate of hammer operation, make, size, and the length of the bounce hose. Additional data required to be recorded for vibratory hammers include hammer power pack description, make, size, wattage horsepower applied to pile, and hammer operating frequency.

### 3.2.3 Pile Placement and Tolerances in Driving

A pile placement plan which shows the installation sequence and the methods proposed for controlling the location and alignment of piles shall be developed and submitted in accordance with paragraph "Submittals." [Foundation preparation [removal of unsuitable material and densification of foundation fill] shall be completed in the area prior to the placement of piles for driving.] Piles shall be placed accurately in the correct location and alignments, both laterally and longitudinally, and to the vertical [or batter] lines indicated. The Contractor shall establish a permanent base line to provide for inspection of pile placement by the Contracting Officer during pile driving operations. The base line shall be established prior to driving job piles and shall be maintained during the installation of the job piles. A final lateral deviation from the correct location at the cutoff elevation of not more than [75] [100] mm [3] [4] inches will be permitted for vertical [and battered] piles. [Manipulation of piles will not be permitted.] [Manipulation to move piles into position will be permitted only within the aforementioned tolerance to return the pile to the design location[, however, piles shall not be manipulated more than 1.5 percent of the exposed length above the [ground] [mudline] surface].] A variation of not more than 21 mm per meter 0.25 inch per foot of pile length from the vertical for vertical piles nor more than 42 mm per meter 0.50 inch per foot of pile length from the required angle for batter piles will be permitted. [In addition to complying with the tolerances stated herein, the clear distance between the heads of piles and the edges of caps shall be not less than 150 mm 6 inches. With prior approval of the Contracting Officer, the Contractor may provide additional concrete and reinforcement to maintain the required minimum clear distance. Redesign of pile caps or additional work required due to improper location of piles will be the responsibility of the Contractor.] [A final variation in rotation of the pile about the center line of the web of not more than 7.5 degrees will be permitted.] [A vertical deviation of not more than [25] [50] mm [1] [2] inch from the correct cutoff elevations shown will be permitted.] Inspect piles for heave. Redrive heaved piles to the required tip elevation. The correct relative position of all piles shall be maintained by the use of templates or by other approved means. Piles damaged or not located properly or exceeding the maximum limits for rotation, lateral and vertical deviation, [and] [or] variation in alignment

shall be pulled and new piles redriven, or provide additional piles, at a location directed at no additional cost to the Government.

#### 3.2.3.1 Survey Data

After the driving of each pile group is complete and before superimposed concrete is placed, provide the Contracting Officer with an as-driven survey showing actual location and top elevation of each pile. The Contractor shall not proceed with placing concrete until the Contracting Officer has reviewed the survey and verified the safe load for the pile group driven. A survey shall be presented 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 shall be prepared and certified by a licensed land surveyor.

#### 3.2.4 Pile Penetration Criteria

The controlling [tip elevation] [depth of penetration] [driving resistance] [refusal blow count (number of blows required to attain the final 25 mm inch of penetration)] for job piles will be determined by the Contracting Officer. [The required [tip elevation] [depth of penetration] [driving resistance] [refusal blow count] will be established subsequent to the analysis of pile tests as specified in paragraph "Pile Tests."] [Driving with a vibratory hammer shall be terminated when the rate of penetration is less than [\_\_\_\_\_] mm inch per minute.]

#### 3.2.5 Pile Driving

The Contracting Officer shall be notified 30 days prior to the date pile driving is to begin. Piles shall not be driven within 30 m 100 feet of concrete less than 7 days old. Job [and test] piles shall be driven with hammers of the same model and manufacturer, same energy and efficiency, and using the same driving system. Hammers shall be operated at all times at the speed and under the conditions recommended by the manufacturer. [Where heave is anticipated, the sequence of installation shall be such that pile heave is minimized by starting pile driving at the center of the group and proceeding outward [and by driving vertical piles prior to driving battered piles where practicable.]] Prior to driving and with the pile head seated in the hammer, each pile shall be checked to ensure that it has been aligned correctly and that the orientation of the web about the centerline is as shown. Once pile driving has begun, conditions such as alignment [and batter] shall be kept constant. [The alignment of battered piles shall be checked and monitored during driving with an accurate batter board level [and surveying instrument]]. Each pile shall be driven continuously and without interruption until the required [tip elevation] [depth of penetration] [driving resistance] [refusal blow count] has been attained. Deviation from this procedure will be permitted only when driving is stopped by causes that reasonably could not have been anticipated. A pile that can not be driven to the required depth because of an obstruction, as indicated by a sudden unexplained change in blow count and drifting, shall be pulled and redriven or shall be cut off and abandoned, whichever is directed. After piles are driven, they shall be cutoff square as required at the indicated cutoff elevation. [Cutoff piles shall be capped as shown.] Any voids around piles or abandoned holes for pulled piles shall be backfilled with sand and compacted to the same density as the surrounding soil. If, in driving, it is found that pile is not of sufficient length to give the capacity specified, notify the Contracting Officer, who will determine the procedure to be followed.

#### [3.2.5.1 Splicing Piles

[Splicing of piles will not be permitted.] [A pile that has not reached the required refusal blow count when the top has been driven to the cutoff elevation shall be spliced as shown and driven to a sufficient depth to develop the required refusal blow count.] [When approved, provide splices of the full penetration butt weld type [or proprietary prefabricated splicer sleeves.] Use only one splice per length of pile. Avoid field splices for lengths under 24 m 80 feet. Construct splices to maintain the true alignment and position of the pile sections. Splices shall develop the full strength of the pile in both bearing and bending.]

#### 3.2.5.2 Jetting

\*\*\*\*\*

NOTE: Jetting shall not generally be permitted when:

1. Piles are 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. Piles are subject to significant uplift.
3. Piles are adjacent to existing structures.
4. Piles are in closely spaced clusters, unless the load capacity is confirmed by test and unless jetting and spudding is completed before final driving of any pile in the cluster.

\*\*\*\*\*

[Jetting of piles will not be permitted.] [Jetting shall be used to assist driving piles through strata that can not be penetrated practicably by use of the hammer alone when authorized by the Contracting Officer. After the penetration of the strata requiring jetting has been accomplished, jetting shall be discontinued and the driving shall be resumed with the hammer alone. Jetted piles shall be seated by driving not less than 300 mm 1 foot after jetting has been stopped.] [Jetting of piles may be used in driving only when specifically authorized by the Contracting Officer]. [Discontinue jetting when the pile tip is approximately 1.5 m 5 feet above the required pile tip elevation. Drive pile the final 1.5 m 5 feet of penetration. Jetting method and equipment shall be approved by the Contracting Officer prior to commencing jetting operation.]

#### ]3.2.5.3 Predrilling

\*\*\*\*\*

NOTE: Predrilling shall not generally be permitted when:

1. Piles are 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. Piles are subject to significant uplift.
3. Piles are adjacent to existing structures.



4. Piles are in closely spaced clusters, unless the load capacity is confirmed by test and unless predrilling is completed before final driving of any pile in the cluster.

\*\*\*\*\*

Predrilling [shall be permitted] [shall not be permitted] [shall be provided]. [Discontinue predrilling when the pile tip is approximately 1.5 m 5 feet above the required pile tip elevation. Drive pile the final 1.5 m 5 feet of penetration. Predrilling equipment and method shall be approved by the Contracting Officer prior to commencing predrilling operation.]

#### 3.2.5.4 Heaved Piles

When driving piles in clusters or under conditions of relatively close spacing, observations shall be made to detect heave of adjacent piles. Heaved piles shall be backdriven to original [depth of penetration] [tip elevation] [refusal blow count] without additional cost to the Government.

#### 3.2.5.5 Pulled Piles

Piles damaged or impaired for use during driving shall be pulled and replaced with new piles, or shall be cut off and abandoned and new piles driven as directed without additional cost to the Government. The Contracting Officer may require that any pile be pulled for inspection. Piles pulled as directed and found to be in suitable condition shall be redriven at another location as directed. Piles pulled as directed and found to be damaged shall be replaced by new piles at the Contractor's expense.

#### 3.2.5.6 Long Piles

Handle and drive piles of a high slenderness ratio carefully to prevent overstress. Provide pile driving rig with rigid supports so that leads remain accurately aligned. Where a high degree of accuracy is required, erect templates or guide frames at or close to the ground or water surface.

#### 3.2.5.7 Welding

AWS D1.1/D1.1M.

### [3.3 PILE TESTS

\*\*\*\*\*

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

\*\*\*\*\*

Pile Tests - [Pile driving tests] [and] [pile load tests] shall be performed as [specified and as shown] [or] [as directed]. The Contracting Officer will develop the correlation between [pile driving resistance] [pile length] and pile capacity during the [pile driving tests] [and] [pile load tests] for the selected pile driving system. Based on the correlations developed, the Contracting Officer will determine the [refusal blow count] [pile length] for the job piles. Changes in the approved pile driving system during or after completion of tests will not be allowed unless additional tests are performed as directed to establish the correlation between [driving resistance] [length] and pile capacity for the proposed changed system. For changes in the approved pile driving system proposed by the Contractor, required additional [pile driving tests] [and] [pile load tests] shall be performed at the Contractor's expense and no additional contract time will be allowed. [In accordance with paragraph "Submittals," develop and submit a detailed pile load test plan which shall include drawings as appropriate and contain the following information:

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

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

#### ] [3.3.1 Test Piles

\*\*\*\*\*

NOTE: Insert the number of test piles required. The number of test piles is normally between 5 and 10 percent of the total number of piles required, dependent upon the magnitude of the project. Test piles are furnished 1.5 m 5 feet longer than job piles to allow additional penetration if driving conditions dictate. Delete this paragraph if test piles are not required.

\*\*\*\*\*

Provide [\_\_\_\_\_] test piles of the same size and type as specified for job piles. [Furnish test piles [1.5] [\_\_\_\_\_] meter [5] [\_\_\_\_\_] feet longer than length specified for job piles and drive the additional depth, if

directed.] Test piles [shall be of the indicated lengths and ] shall be placed at the [indicated] [or] [directed] locations. Test piles shall be driven with the same equipment specified in paragraph "Pile Driving Equipment" and in the same manner specified in paragraph "Pile Driving" for job piles. The driving record data shall be recorded for each test pile driven as specified in paragraph "Pile Driving Records." [A [pile driving analyzer](#) shall be provided and operated as specified by the manufacturer during the driving of each test pile.] If approved after test completion, include properly located test piles in the finished work. [Withdraw [\_\_\_\_\_] test piles after reaching the specified tip elevation to provide for visual inspection of the pile.]

#### ] 3.3.2 [Pile Driving Tests](#)

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

#### ] 3.3.3 [Dynamic Testing of Piles](#)

\*\*\*\*\*

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

\*\*\*\*\*

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

##### 3.3.3.1 Test Piles

\*\*\*\*\*

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

\*\*\*\*\*

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

#### [3.3.3.2 Job Piles

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

#### ]3.3.3.3 Reports

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

#### [3.3.4 Pile Load Tests

\*\*\*\*\*  
NOTE: Each ASTM pile load test specification listed offers a number of options as to how the test is performed. Specify the required load testing option and any modifications to include other desired requirements.

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

1. One-half the test load which causes a

settlement/movement of 0.25 mm per 907 kg 0.01 inch  
per ton of test load.

2. One-half the test load that causes a gross  
settlement/movement of 25 mm one inch provided the  
load-settlement curve shows no sign of failure.

\*\*\*\*\*

Perform load tests at locations shown, or as directed. Provide testing and measuring equipment, perform loading, and provide observation facilities for personnel to inspect, record, and analyze settlement/movement and deflection of piles under test loads. Do not mobilize load test equipment until directed by the Contracting Officer. Pile load tests shall be performed under the supervision of a registered professional engineer provided by the Contractor and experienced in conducting pile load tests. Loading frames and equipment for pile load tests shall be ready to be placed in operation as soon as a load test pile has been driven. The loading equipment shall be of sufficient capacity to apply the maximum load specified in a safe manner. Loading of each test pile shall be started when directed. The Contractor shall be responsible for the application of loads. The magnitude of applied loads shall be accurately determined and controlled using a calibrated load cell and readout device. The design working load, as confirmed by the results of load tests, will be determined by the Contracting Officer. Load test piles indicated or directed to be driven in permanent locations may be incorporated into the work if, after satisfactory completion of load test, they are approved for inclusion in the work. Any pile load test not accomplished in accordance with this specification will be rejected. A new pile load test shall be conducted for each rejected pile load test. The Contractor shall compile a report for each pile load test which shall include, as a minimum, all applicable information required by the specified test.

] [3.3.4.1 Compressive Load Test

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

] [3.3.4.2 Tensile Load Test

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

] [3.3.4.3 Lateral Load Test

Perform [\_\_\_\_\_] pile lateral load tests in accordance with ASTM D 3966 [, as modified]. Lateral load tests shall consist of jacking two piles apart with a hydraulic jack, with one pile serving as the reaction pile for the other. A lateral load of [\_\_\_\_\_] kN tons shall be applied to each pair of lateral load test piles. Required movement readings shall be made and recorded for each pile.

] -- End of Section --