Modifications/Changes in this update

Department of Veterans Affairs	♦	Office of Construction & Facilities Management

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DESCRIPTION OF DOCUMENT: (previous section title, number and date)
31 62 00 Driven Piles (10-06M)

CHANGES MADE:

Modifications include updating references, and the following:
Added requirement to include pile load tests
Added tolerance requirements for top of pile elevation and battered piles.
Added requirement for a pile load test work plan
Added requirement for identification for type of treatment for timber piles

SECTION 31 62 00
DRIVEN PILES

SPEC WRITER NOTE: Delete between //----// if not applicable to project. Also delete any other item or paragraph not applicable in the section and renumber the paragraphs.

PART 1 GENERAL

1.1 DESCRIPTION

This section specifies materials and installation required for the construction of impact driven foundation piles.

1.2 RELATED WORK

A. Materials testing and inspection during construction: Section 01 45 29, TESTING LABORATORY SERVICES.

B. Concrete, including materials, reinforcing steel, and mixes: Section 03 30 00, CAST-IN-PLACE CONCRETE.

C. Timber: Section 06 10 00, ROUGH CARPENTRY.

D. Steel: Section 05 12 00, STRUCTURAL STEEL FRAMING.

E. Subsurface investigation: Section 01 00 00, GENERAL REQUIREMENTS, Article, PHYSICAL DATA.

1.3 CONTRACT BASIS

A. Contract price for piles will be based upon length of piles shown and number of pile load tests indicated in the Contract Documents. Length of piles will be measured from tip to point of cutoff.

1. Adjustment of contract price shall be based upon total length of piles placed and not on length of individual piles placed. When total length of completed piles is greater or less than length shown, contract price adjustment will be made in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable.
2. No payment will be made for withdrawn, broken or rejected piles, piles out of tolerance, or for portion of pile remaining above cutoff point.
3. Contract price and time will be adjusted in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable, when artificial materials that are not shown are encountered.

1.4 TOLERANCES

Install piling with a maximum variation of 75 mm (3 inches) of center of any pile from location shown. Piles shall not be out of plumb more than 2

percent. Top of any pile at elevation of cutoff shall be within [_____] mm (inches) of the planar location indicated. // Additionally, a variation in batter, as measured on the driven pile, of not more than 6 mm per m (1/4 inch per foot) of longitudinal axis will be permitted.// Manipulation of piles to force them into position will not be permitted. Piles shall be checked for heave, and those found to have heaved shall be redriven to the required tip elevation. Piles damaged or driven outside the above tolerances shall be replaced, or additional piles driven at locations specified by the Contracting Officer at no expense to the Government.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A firm experienced in installing piles similar in material, design, and extent indicated for this Project, whose work has resulted in a history of successful in-service performance:
   1. Installer's responsibility includes providing a qualified professional engineer to prepare pile-driving records.

B. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C1077 and ASTM E329 for testing indicated, as documented according to ASTM E548 shall be engaged by the Contractor and approved by the Resident Engineer.

C. Welding Standards: Qualify welding procedures and personnel according to AWS D1.1.

D. Pre-installation Conference: Contractor shall conduct conference at Project site prior to pile installation.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent physical damage:
   1. Protect pile coatings and touch up damage to coatings before driving piles.

1.7 PROJECT CONDITIONS

A. Protect structures, underground utilities, and other construction from damage caused by pile driving.

B. Site Information: Contractor is responsible for evaluating and implementing the information provided in the geotechnical report prepared for the Project.

1.8 DESIGN MODIFICATIONS

A. Where piles are installed exceeding specified tolerances for plumb or location, the foundation design will be analyzed by the Resident Engineer

and if necessary redesigned by the Resident Engineer. The costs for analysis, redesign, and remediation shall be responsibility of Contractor.

B. Additional piles and pile cap modifications necessitated by redesign shall be furnished and installed, at no additional cost to the Government.

1.9 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Product Data: For each type of pile product, accessory, and paint indicated.

C. Shop Drawings: Show fabrication and installation details for piles, including driving points, splices, field-cut holes, and pile caps.

1. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
2. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Include design mixes, qualification data, material test reports, material certifications, pile driving equipment information.

D. Reports: Wave equation analysis report, driving of each pile, pile location plumbness, welding, and static pile test reports.

E. Hammer: Include type, make, maximum rated energy, and rated energy per blow of hammer; weight of striking part of hammer; weight of drive cap; details, type, and structural properties of hammer cushion; and details of follower and jetting equipment.

F. Certificates: Preservative treatment of timber piles. For each type of preservative-treated timber product include certification by treating plant stating type of preservative solution and pressure process used, net amount of preservative retained, and compliance with applicable standards. For waterborne-treated products include statement that moisture content of treated materials was reduced to levels indicated before shipment to Project site.

G. Warranty of chemical treatment manufacturer for each type of treatment.

H. Welding certificates.

I. Design Mixes: For each concrete mix. Include revised mix proportions when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

J. Steel Reinforcement Shop Drawings: Comply with ACI 315. Furnish shop drawings prepared by a Professional Engineer licensed in the State of the project.

K. Pile Load Testing:

1. A schedule and sequencing plan for pile testing and installation.
2. Pile Load Test Work Plan:
   a. At least two weeks before commencing pile load testing work, the Contractor shall submit a pile load test work plan describing the equipment, apparatus, procedures, and schedule for testing ACP's in accordance with ASTM D1143 // ASTM D3689 // ASTM D3966 and as specified herein, to verify the design pile capacity. The work plan shall also include the proposed instrumentation of the test pile indicating depth, location, and details of the pile.
   b. As part of the Pile Load Test Work Plan, submit shop drawings and other information describing the loading and test monitoring arrangement for pile load tests, including the following:
      1) Structural design of the test load support/reaction frame.
      2) Details of equipment and apparatus to be used for the monitoring load and pile movements.
      3) Data on testing and measuring equipment including required jack, load cell and/or gauge calibrations.
      4) Sample field data recording sheets or examples of automated data acquisition records proposed for recording load test data.

L. Record drawings at Project closeout according to Division 01 Section "Closeout Procedures."

1.10 APPLICABLE PUBLICATIONS

A. Publications listed below form a part of this specification to extent referenced. Publications are referenced in text by the basic designation only.

B. American Society for Testing and Materials (ASTM):

A27/A27M-10 ..... Standard Specification for Steel Castings, Carbon, for General Application

A36/A36M-08 ..... Standard Specification for Carbon Structural Steel

A82/A82M-07 ..... Standard Specification for Steel Wire, Plain, for Concrete Reinforcement

A148/A148M-08 ..... Standard Specification for Steel Castings, High Strength, for Structural Purposes

A252-10 ..... Standard Specification for Welded And Seamless Steel Pipe Piles

A416/A416M-10 ..... Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete

A496/A496M-07 ..... Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement

A572/A572M-07 ..... Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

A588/A588M-10 ..... Standard Specification for High-Strength Low-Alloy Structural Steel with 345 Mpa (50 ksi) Minimum Yield Point to 100 mm (4 in) Thick

A615/A615M-09b ..... Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement

A690/A690M-07 ..... Standard Specification for High-Strength Low-Alloy Nickel, Copper, Phosphorus Steel H-Piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments

A706/A706M-09b ..... Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

A767/A767M-09 ..... Standard Specification for Zinc Coated (Galvanized) Steel Bars for Concrete Reinforcement

A775/A775M-07b ..... Standard Specification for Epoxy Coated Steel Reinforcing Bars

A884/A884M-06 ..... Standard Specification for Epoxy Coated Steel Wire and Welded Wire Reinforcement

A934/A934M-07 ..... Standard Specification for Epoxy Coated Prefabricated Steel Reinforcing Bars

C33-C33M-11a ..... Standard Specification for Concrete Aggregates

C1077-11c ..... Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation

D25-99(2005) ..... Standard Specification for Round Timber Piles

D1143/D1143M-07el ..... Standard Test Methods for Deep Foundations Under Static Axial Compressive Load

D3689-07 ..... Standard Test Method for Individual Piles Under Static Axial Tensile Load

D3966-07 ..... Standard Test Method for Piles Under Lateral Loads

D4945-08 ..... Standard Test Method for High Strain Dynamic Testing of Piles
E94-04(2010) ..... Standard Guide for Radiographic Examination
E164-08 ..... Standard Practice for Ultrasonic Contact Examination of Weldments
E165-09 ..... Standard Test Method for Liquid Penetrant Examination
E329-11c ..... Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
E548-94e1 ..... Standard Guide for General Criteria Used for Evaluating Laboratory Competence
E709-08 ..... Standard Guide for Magnetic Particle Examination

C. American Welding Society (AWS):
D1.1/D1.1M-2010 ..... Structural Welding Code - Steel

D. Prestressed Concrete Institute (PCI):
MNL-116-99 ..... Manual for Quality Controls for Plants and Production of Structural Precast Concrete Products
MNL-120-04 ..... PCI Design Manual

E. American Wood-Preservers Association (AWPA):
M4-08 ..... Standard for the Care of Preservative Treated Wood Products
T1-11 ..... Use Category System: Processing and Treatment Standard
U1-11 ..... Use Category System: User Specification for Treated Wood
M6-96 ..... Brands Used on Forest Products

F. American Concrete Institute (ACI):
315-99 ..... Details and Detailing of Concrete Reinforcement

G. Society for Protective Coatings (SSPC):
Paint 16-82(2004) ..... Coal Tar Epoxy-Polyamide Black (or Dark Red) Paint

PART 2 - PRODUCTS

2.1 PILES

A. General: Piles shall be // friction // end-bearing // piles of ____ ton capacity. Piles shall be // timber // steel H // steel pipe // cast-in-place concrete // or // prestressed concrete // piles. Submit details of type proposed for installation, showing cross-sections, end

closures, and details of connections for approval by Resident Engineer before delivery of any material to project site.

B. Timber Piles: Timber piles shall be in one piece with an approximate uniform taper from butt to tip and shall conform to all requirements of ASTM D25. Timber piles shall be unused, clean, and peeled round timber piles treated in accordance with AWPA T1 and U1. Piles shall be fresh-headed and shaped to fit driving head. Offered products should comply with applicable AWPA Standards. Identify treatment on each piece by the quality mark of an agency accredited by the Board of Review of the America Lumber Standard Committee.
   1. Timber pile shoes shall be size and type most suitable for driving condition. Saw off tops of timber piles in a horizontal plane. Cutoffs and damaged pile surfaces shall be treated as specified in AWPA M4.
   2. Strapping: 32 mm (1.25 inch) wide, 0.78 mm (0.031 inch) thick, cold rolled, heat-treated steel; painted and waxed.
   3. Spud piles or bored holes may be used to penetrate highly resistant strata laying near surface.
   4. Contractor shall submit a signed certificate stating that preservative treatment of timber piles delivered to site complies with structural and environmental requirements. Certificate shall contain name and address of contractor, project locations, quantity of piles and date or dates of shipments, name of preservative used and retention in pounds per cubic foot of wood treated.

C. Steel H Piles:

SPEC WRITER NOTE: Adjust the steel type per the project requirements.

   1. Carbon Steel: ASTM A36/A36M. Grade _____.
   2. High-Strength, Low-Alloy, Columbium-Vanadium Steel: ASTM A572/A572M.
   3. High-Strength, Low-Alloy, H-Pile Steel: ASTM A690/A690M.
   4. High-Strength, Low-Alloy, Structural Steel: ASTM A588/A588M.
   5. Driving Points: Manufacturer’s standard one-piece driving point, fabricated from steel castings as follows to provide full bearing of web and flange of pile tip. Cast driving point with integral tapered cutting wedges and with top alignment curbs to encase web and flanges of pile:
      a. Carbon-Steel Castings: ASTM A27/A27M.
      b. High-Strength Steel Castings: ASTM A148/A148M.

6. Splice Unit: Manufacturer's standard splice unit, fabricated from two connected steel plates, of same material as H pile, shaped and tapered to encase web and part of each flange.
7. Paint: SSPC-Paint 16; self-priming, two-component, coal-tar epoxy polyamide, // black // // red // // manufacturer's standard color //.
8. Protection: Where indicated, the steel H-piles shall be provided with //coatings// //cathodic protection// //and// //concrete encasement//.
9. Piles may be driven in single length or may be field spliced. No splices will be permitted in piles less than 7500 mm (25 feet) in length and not more than one splice will be permitted in any pile under 12 000 mm (40 feet) long. Splices shall maintain alignment and position of pile sections and develop full strength of pile in bearing and not less than 50 percent of pile in bending. Splices shall be butt-welded at flanges and web. Piles shall be driven so that the driving stress does not exceed 0.9 the minimum yield stress.

D. Steel Pipe Piles:

SPEC WRITER NOTE: Adjust the steel type and concrete strength per the project requirements.

1. Pipe Steel: ASTM A252, seamless or welded. Grade ___.
2. Piles may be installed either open-ended or with ends closed. Ends shall be closed with forged or cast steel conical point continuously welded to pipe. Minimum wall thickness of open-ended pipe shall be 6 mm (0.25 inch) for diameter less than 350 mm (14 inches) and 10 mm (0.375 inch) for diameters greater than 350 mm (14 inches). Minimum wall thickness of concrete filled pipe piles installed with closed ends shall be 2.5 mm (0.10 inch). Minimum outside diameter shall be 250 mm (10 inches) for open-ended pipe piles and 200 mm (8 inches) for pipe piles installed with closed ends.
   a. Allowable design unit stresses: 0.33 f'c average cross-sectional area of pile. For pipe sections 6 mm (0.25 inch) or more in thickness, 35 percent of minimum specified yield strength is permitted on full steel area. Minimum specified yield strength shall not be assumed greater than 250 MPa (36,000 psi) for computation purposes.
   b. Driving: Piles shall be driven to required penetration without distortion, damage or not exceeding a driving stress of 0.9 minimum specified yield strength. Tip reinforcement and steel caps shall be

provided as required. Establish and maintain axial alignment of leads and pile before and during driving.

1) Piles may be driven in single length or may be spliced with continuous butt weld. In sections below upper splice, splices shall be spaced at not less than 6000 mm (20 feet). Shell, splices and end closures shall be watertight. Driving surfaces of shell shall be square cut.

2) Do not drive pile within 3000 mm (10 feet) in granular soil and 6000 mm (20 feet) in cohesive soil of any pile in which concrete has been placed until 24 hours after concrete placement.

3. Concrete: Concrete shall be ACI 315 Type _____. The slump shall be 125 mm (5 inches) plus or minus 25 mm (1 inch). Maximum coarse aggregate size shall be 19 mm (0.75 inch), per ASTM C33.

4. Reinforcement:

SPEC WRITER NOTE: Adjust the reinforcement type per the project requirements.

a. Reinforcement Bars: ASTM A615/A615M, Grade 60; deformed.

b. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M.

c. Galvanized Reinforcing Bars: ASTM A767/A767M, Class II zinc coated, hot-dip galvanized after fabrication and bending, as follows:

1) Steel Reinforcement: ASTM A615/A615M, Grade 60.

d. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M.

e. Plain Steel Wire: ASTM A82/A82M.

f. Deformed-Steel Wire: ASTM A496/A496M.

g. Epoxy-Coated-Steel Wire: ASTM A884/A884M.

5. Filling Casings: Do not place concrete in any pile in a group until entire group is driven. Pile interior shall be cleaned and approved by Resident Engineer before placing concrete. Place concrete using funnel or hopper. Place no concrete through water, except with written approval of the Resident Engineer. Proportions of concrete so placed and method of placing shall be approved by the Resident Engineer.

6. Protection: Where indicated, the steel pipe piles shall be provided with //coatings// //cathodic protection// //and// //concrete encasement//.

E. Cast-in-Place Concrete Piles:

SPEC WRITER NOTE: Adjust the steel type and concrete strength per the project requirements.

1. Allowable Design Stresses: 0.33 f'c on average cross-sectional area of pile. For computation purposes, assumed f'c shall not exceed 30 MPa (4000 psi). For casing thickness less than 2.5 mm (0.10 inch), no stress is permitted. For casing thickness 2.5 mm (0.10 inch) or more, less than 1.7 mm (0.067 inch) for protection, 35 percent of the minimum specified yield strength is permitted. Minimum specified yield strength shall not be assumed greater than 250 MPa (36,000 psi) for computation purposes.
2. Casings shall be uniformly tapered, step tapered, cylindrical, or a combination of these and laterally corrugated, spirally corrugated, longitudinally fluted or plain. Only one combination permitted throughout job.
   a. Uniform-Tape/r/: Minimum nominal diameter shall be 200 mm (8 inches) at tip. Diameter shall increase from tip to cut-off following standard taper.
   b. Step-Taper: Minimum nominal diameter shall be 220 mm (8 5/8 inches) at tip. Diameter shall increase, from tip to cut-off, in standard increments.
   c. Constant-Section: Minimum nominal diameter shall be 300 mm (12 inches).
   d. Casing shall be watertight. Splices shall be watertight and develop entire casing strength.
   e. Close casing tip by continuously welding tip closure.
   f. Non-watertight or damaged casings shall be replaced at no additional cost to the Government.
   g. Do not drive casing within 3000 mm (10 feet) in granular soil and 6000 mm (20 feet) in cohesive soil of any pile in which concrete has been placed, until 24 hours after concrete placement.
3. Concrete: Concrete shall be ACI 315 Type _____. The slump shall be 125 mm (5 inches) plus or minus 25 mm (1 inch). Maximum coarse aggregate size shall be 25 mm (1 inch).
4. Reinforcement:

   SPEC WRITER NOTE: Adjust the reinforcement type per the project requirements.

   a. Reinforcing bars: ASTM A615/A615M, Grade 60, deformed.
   b. Cold drawn bar for spirals, ASTM A82/A82M.
   c. Fabrication:

1) Reinforcing steel assemblies shall be detailed and fabricated in accordance with ACI 315.
2) Centralizers shall be provided at least every 9000 mm (30 feet) along the length of the reinforcement with no less than 2 centralizers per pile.

5. Filling Casings: Do not place concrete in any pile in a group until entire group is driven. Pile interior shall be cleaned and approved by Resident Engineer before placing concrete. Place concrete using funnel or hopper. Place no concrete through water, except with written approval of Resident Engineer. Proportions of concrete so placed and method of placing shall be approved by Resident Engineer.

F. Prestressed Concrete Piles:

SPEC WRITER NOTE: Adjust the size, steel type and concrete strength per the project requirements.

1. Prestressed concrete shall conform to MNL-120 and MNL-116, except as specified.
2. Prestressed concrete piles shall be 300 mm (12 inches) square and reinforced as detailed.
3. Reinforcement:

SPEC WRITER NOTE: Adjust the reinforcement type per the project requirements.

a. Reinforcing Bars: ASTM A615/A615M, Grade 60; deformed.
b. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M.
c. Galvanized Reinforcing Bars: ASTM A767/A767M, Class II zinc coated, hot-dip galvanized after fabrication and bending, as follows:
   1) Steel Reinforcement: ASTM A615/A615M, Grade 60
d. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M or ASTM A934/A934M, as follows:
   1) Steel Reinforcement: ASTM A615/A615M, Grade 60, deformed.
e. Plain Steel Wire: ASTM A82/A82M.
f. Deformed-Steel Wire: ASTM A496/A496M.
g. Epoxy-Coated-Steel Wire: ASTM A884/A884M, Class A coated.

4. Concrete for prestressed concrete piles shall develop a minimum ultimate compressive strength of 35 MPa (5,000 psi) at 28 days. Concrete mix shall contain at least 10 sacks/m^3 (7.5 sacks of cement per cubic yard) and no more than 20 L (5.0 gallons) of water per sack of cement, including surface moisture in aggregates. Maximum aggregate

size shall be 25 mm (1 inch). Slump range shall be 50 mm to 100 mm (2 to 4 inches). Concrete may be steam cured.

5. Prestressing reinforcement shall be 7-wire stress relieved strands having an ultimate tensile strength of 1700 MPa (250,000 psi) and shall conform to requirements of ASTM A416/A416M. Spiral reinforcement shall be reinforcing steel, ASTM A615/A615M, or cold drawn wire, ASTM A82/A82M.
6. Pile Accessories:
   a. Pile Shoes: 25 mm (1 inch) thick, minimum, carbon-steel plate fabricated to match shape of pile tip.
   b. Pile Splices: Manufactured from carbon-steel plates or castings and capable of developing strength of continuous pile at splice location.
7. Compressive cylinder strength at transfer of prestressing force shall be at least 25 MPa (3,500 psi). Shipment from plant site, or driving will not be permitted until full compression cylinder strength is reached.
8. Initial tension in 11 mm (7/16 inch) strands, before release, shall be 84 kN (18,900 pounds) per strand. Provide lifting devices on piles at points shown.
9. The Resident Engineer reserves right to inspect, either part-time or full-time, operations at prestressing plant.
10. It shall be the contractor’s responsibility to assure that the driving stresses in the pile do not exceed 0.85 f’c-effective prestress in compression and the effective prestress in tension.

PART 3 - EXECUTION

3.1 GENERAL

A. It shall be Contractor's responsibility to furnish a specified type of pile and casing of gauges necessary to install a satisfactory pile foundation. Conversion from one type of pile to another, or from lighter to heavier casing gauges shall be at no additional cost to the Government.

B. Survey: Registered Professional Land Surveyor or Registered Civil Engineer, specified in Section 01 00 00, GENERAL REQUIREMENTS, shall establish lines and levels and stake pile locations.

1. After all piles are driven and installed, Registered Professional Land Surveyor or Registered Civil Engineer shall make field survey of completed piling work. Submit drawing to Resident Engineer showing

actual pile locations with respect to planned pile locations and indicating plumbness of piles.

C. Reports: Submit a report in quadruplicate to Resident Engineer, for each pile, detailing diameter or cross section, length, make and model of hammer, driving time, blows per minute, number of blows per 300 mm (blows per foot) in last 1500 mm (5 feet) of penetration, number of blows for each 25 mm (blows for each inch) during final 150 mm (6 inches) of penetration, and any other pertinent information.

D. Welding (Shop and Field): Qualification of welding procedures, welders, and operators shall comply with requirements of AWS D1.1. Contractor shall keep records of test results of welding procedures and submit copies of each qualified welding operator to Resident Engineer for approval before starting welding.

3.2 DRIVING EQUIPMENT

A. Pile Hammer: Air-, steam-, or diesel-powered type capable of developing ultimate pile capacity indicated considering length and weight of pile and character of subsurface material anticipated.

B. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap recommended by hammer manufacturer for type of pile.

C. Leads: Use fixed or rigid-type pile-driver leads that will hold full length of pile firmly in position and in axial alignment with hammer. Extend leads to within 600 mm (24 inches) of elevation at which pile enters ground.

SPEC WRITER NOTE: Specify load test and/or formula method to determine pile capacity as required by the Design Engineer. The Design Engineer will determine formula.

3.3 STATIC PILE TESTS

A. General: Static pile tests will be used to verify design pile lengths and to confirm design load capacity of piles.

1. Furnish test piles 1500 mm (60 inches) longer than production piles.
2. Actual length of piles will be based on results of static pile tests.

B. Pile Tests: Arrange and perform the following pile tests:

1. Axial Compressive Static Load Test: ASTM D1143.
2. Axial Tension Static Load Test: ASTM D3689.
3. Lateral Load Test: ASTM D3966.

C. Equip each test pile with two telltale rods, according to ASTM D1143, for measuring deformation during load test.

D. Drive test piles at locations indicated to a tip elevation below final cutoff elevation equal to pile length specified as basis of bid, or to refusal, whichever occurs first. Piles will be considered as driven to refusal when 5 blows of hammer are required to produce a total penetration of 6 mm (0.25 inch) or less:
   1. Allow a minimum of seven days to elapse after driving test piles before starting pile testing.

E. Provide pile reaction frame, anchor piles, equipment, and instrumentation with sufficient reaction capacity to perform tests. Notify Resident Engineer at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation:
   1. Number of Test Piles: Two single piles, or as directed by Resident Engineer.

F. Driving Test Piles: Use test piles identical to those required for the Project and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.

G. Test Pile Driving Records: Prepare driving records for each test pile, compiled and attested to by a qualified professional engineer. Include same data as required for driving records of permanent piles.

H. Test piles that comply with requirements, including location tolerances, may // may not// be used at production pile locations.

3.4 ALLOWABLE LOAD ON PILES

A. Maximum axial capacity of vertical pile shall be allowable axial load applied concentrically in direction of its axis. Structural strength of piles shall be limited by allowable unit stresses specified.

B. Maximum allowable capacity of piles shall be established by driving control test piles in locations shown and conducting load tests.
   1. No foundation piles shall be driven until test reports of test piles, as required by ASTM D1143 // ASTM D3689 // ASTM D3966 are received and written approval is given by Resident Engineer.
   2. Load tests shall be conducted as specified in ASTM D1143 // ASTM D3689 // ASTM D3966, standard loading procedure. The load test of a single pile shall be to twice the design load.

C. Approval Criteria: Allowable design capacity of test piles shall be one-half of the load that results in the lesser of the following two values:
   1. Gross settlement of not more than 25 mm (1 inch), provided that load-settlement curve shows no sign of failure.

2. Settlement not less than the value of ‘s’, where

metric	in-lb
s = (4 + 8d)/1000 +Δ (meters)	s = 0.15+ d/10 +Δ (feet)
where d = diameter of piles (meters)	where d = diameter of piles (feet)
Δ = elastic deformation of the pile (meters) as determined by test pile for that area of foundation, when driven, using equivalent make and model of pile hammer and same operation of hammer, with regard to speed, height or fall, stroke, and pressure.	Δ = elastic deformation of the pile (feet) as determined by test pile for that area of foundation, when driven, using equivalent make and model of pile hammer and same operation of hammer, with regard to speed, height or fall, stroke, and pressure.

D. Additional load tests an increase in production pile length or number, and/or modifications to the pile cap may be required if the test pile fails the load test.

E. Additional costs of load test to evaluate installation discrepancies is the responsibility of the Contractor.

F. Resident Engineer may require group load tests up to 150 percent of maximum allowable capacity of any pile group.If tests disclose that bearing capacity of group is lower than required, retesting shall be at the expense of the Owner. Retesting performed to evaluate installation discrepancies is the responsibility of the Contractor.

SPEC WRITER NOTE: Substitute formulas as appropriate for the project.

G. Pile Capacity During Driving: Capacity of single piles not in clusters shall be not less than _____ metric tons (_____ tons). The pile capacity during installation shall be determined by the following formulas, modified according to the data obtained by the load test:
For piles with capacities of 36 metric tons (40 tons) or less.

	metric	in-lb
For Single-Acting Hammers:	$R = \frac{166.7\ WH}{S + 2.5\ P/W}$	$R = \frac{2WH}{S + 0.1\ P/W}$
For Double-Acting Hammers:	$R = \frac{166.7\ E}{S + 2.5\ P/W}$	$R = \frac{2E}{S + 0.1\ P/W}$

Where: R is the allowable static pile load in Newtons (pounds).

W is the weight of the striking part of the hammer in Newtons (pounds).

H is the effective height of fall in meters (feet).

E is the actual energy delivered by the hammer per blow in Newton meters (foot pounds).

S is the average net penetration in mm (inches) per blow for last five blows after the pile has been driven to a depth where successive blows have produced approximately equal net penetration for a minimum distance of last 75 mm (3 feet).

P is the weight of the pile in pounds. If P is less than W, P/W shall be taken as unity.

Dynamic pile stresses should not exceed stresses mentioned above.

SPEC WRITER NOTE: Use 9491 Newton meters (7000 foot pounds) for timber piles only.

For piles that have a design capacity greater than 36 metric tons (40 tons), the use of a wave equation analysis shall be used to determine the driving criteria. The wave equation analysis shall include the final set criteria and driving stresses in the pile during installation. The contractor shall submit the results of the wave equation analysis prior to the start of the test program.

3.5 INSTALLATION

A. Order of Driving: Install piles in such an order and with sufficient spacing to insure against distortion or injury to piles already in place.

1. Hammer capacity shall be not less than // 9491 // 20338 // Newton meters (// 7000 // 15000 // foot pounds) energy per blow.
2. Before starting to drive piles, hammer data, including cap-block arrangement, weight and length of stroke of striking parts of hammer, number of operating blows per minute, piston area, and effective piston

pressure to be maintained shall be submitted to Resident Engineer for approval.

3. Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of 150 to 300 mm (6 to 12 inches) above bottom of footing or pile cap.
4. Provide a proper anvil and cushion to prevent pile butt damage.
5. Cap or cushion block shall consist of one solid block of hardwood of proper shape and dimensions to fit hammer. Grain of the block shall be parallel to the axis of pile. If laminated materials are used, strength of such materials shall be equal to or greater than hardwood. Continuous or frequent introduction of materials to cushion the hammer blows will not be permitted.
6. Do not use wood chips, small blocks, shavings, or similar materials to cushion hammer blow.
7. No piles shall be driven through overburden without prior approval of Resident Engineer.
8. Drilling, spudding, or jetting may be used only when approved by Resident Engineer and shall be performed at no additional cost to the Government. Methods employed shall be subject to Resident Engineer's approval. Final 1500 mm (5 feet) of pile penetration shall be obtained with hammer alone.
9. Predrilling: Provide pre-excavated holes for piles driven within 4500 mm (15 feet) of existing structures or underground utilities, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
   a. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
10. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.

B. Using data obtained from control test piles, drive foundation piles to bearing stratum and driving resistance established by test piles. If allowable capacity is not obtained in bearing stratum, drive piles deeper until required driving resistance is obtained. Penetration of all piles in a group should not vary more than 3000 mm (10 feet) unless approved by Resident Engineer.

C. Make no penetration measurements for purpose of determining resistance to driving when pile heads are damaged to extent that may effect measured

penetration nor immediately after a fresh cushion block has been inserted under striking part of hammer. Make measurements with minimum interruption of driving.

D. If, during driving of any pile, previously driven piles show signs of heaving, redrive disturbed piles to their original driving resistance, at no additional cost to the Government.

E. Remove soil that heaves during or after driving to maintain grades. Do not place concrete in empty casing until all driving and redriving has been completed within radius in which driving of adjacent pile casings may result in heaving.

F. Clean out steel pipe pile by removing soil and debris from inside pile before placing steel reinforcement.

G. Where the protective shell of treated wood is impaired at a point which after installation will be not less than 3 m (10 feet) below the ground, make repairs in accordance with AWPA M4 unless the pile is damaged to such extent that it is rejected.

H. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances. Fill holes left by withdrawn piles as directed by Resident Engineer.

1. Rejected piles may be abandoned and cut off as directed by Resident Engineer.
2. Leave rejected piles in place and install new piles in locations as directed by Resident Engineer.
3. Fill holes left by withdrawn piles that will not be filled by new piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding 1800 mm (72 inches).

I. Cut off tops of piles by an approved method square with pile axis and at required elevations.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Contractor will engage a qualified independent testing agency, approved by the Resident Engineer, to perform field quality-control testing.

B. High-strain dynamic monitoring shall be performed and reported according to ASTM D4945 during initial driving and during restriking on 12 percent // 15 percent // of single piles.

C. Low-strain integrity measurement shall be performed and reported for each pile.

D. Weld Testing: In addition to visual inspection, welds shall be tested and inspected according to AWS D1.1 and the inspection procedures listed below, at testing agency's option. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

1. Liquid Penetrant Inspection: ASTM E165.
2. Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
3. Radiographic Inspection: ASTM E94, minimum quality level "2-2T."
4. Ultrasonic Inspection: ASTM E164.

3.7 DISPOSAL

Remove withdrawn piles and cutoff sections of piles from site and legally dispose of them off Owner’s property.

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