SECTION 31 62 00

DRIVEN PILES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Pile Types

B. Determination of Length

C. Indicator Piles and Test Piles

D. Axial Compression and Tension Load Tests

E. Lateral Load Tests

F. Dynamic Pile Testing

G. Installation of Piles

1.02 MEASUREMENT AND PAYMENT

A. General: Measurement and payment for driven piles will be either by the lump-sum method or by the unit-price method as determined by the listing of the bid item for driven piles indicated in the Bid Schedule of the Bid Form.

B Lump Sum: If the Bid Schedule indicates a lump sum for driven piles, the lump-sum method of measurement and payment will be in accordance with Section 01 20 00 - Price and Payment Procedures, Article 1.03.

C. Unit Price: If the Bid Schedule indicates a unit price for driven piles, the unit-price method of measurement and payment will be as follows:

1. Measurement:

a. Furnishing of piles of designated lengths, including test piles/indicator piles, delivered to the site, will be measured for payment by the linear foot for the full length of the pile.

b. Driving of piles, including designated test piles/indicator piles, will be measured for payment as individual units (each), per each pile driven and accepted, regardless of pile length driven, tip elevation, or penetration. Driving of piles will include cutoffs. Cutoffs shall become the property of the Contractor and shall be removed from the site.

c. Load testing of test piles, axial compression and tension, lateral and dynamic tests will be measured for payment per each test performed.

d. Pile extensions will not be measured separately for payment, but will be included in the measurement of furnishing the pile. Splices will not be measured separately for payment.

e. Rejected piles will not be measured separately for payment. Extracted rejected piles shall become the property of the Contractor and shall be removed from the site.

f. Pre-drilling will not be measured separately for payment, but will be included in the measurement of driving the pile.

2. Payment: Driven piles will be paid for at the indicated Contract unit prices for the computed quantities as determined by the measurement method specified in Article 1.02.C.1.

1.03 DEFINITIONS

A. Indicator Pile: An individual pile that is tested and observed to determine its behavior during driving.

B. Test Pile: An individual pile which is tested and observed under static axial compression or tension load, under lateral load, and under dynamic load tests.

C. Reaction Pile: An individual pile that provides the reaction load required to perform the load test on a test pile. During this process the reaction pile can be subjected to either an axial compression load or an axial tension load, or lateral load.

D. Production Piles: Piles that are purchased and delivered for incorporation in the permanent structure.

1.04 REFERENCES

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

1. ASTM A36 Specification for Structural Steel

2. ASTM A252 Specification for Welded and Seamless Steel Pipe Piles

3. ASTM A444 Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process for Storm Sewer and Drainage Pipe

4. ASTM A690 Specification for High-Strength Low-Alloy Steel H-Piles and Sheet Piling for Use in Marine Environments

5. ASTM A760 Specification for Corrugated Steel, Pipe, Metallic-Coated for Sewers and Drains

6. ASTM A806 Specification for Steel Sheet, Aluminum-Zinc Alloy Coated by the Hot-Dip Process for Storm Sewer and Drainage Pipe

7. ASTM D1143 Method of Testing Piles Under Static Axial Compressive Load

8. ASTM D3689 Method of Testing Individual Piles Under Static Axial Tensile Load

9. ASTM D3966 Method of Testing Piles Under Lateral Loads

10. ASTM D4945 Method for High Strain Dynamic Testing of Piles

B. American Welding Society (AWS):

1. ANSI/AWS D1.1 Structural Welding Code - Steel

1.05 REGULATORY REQUIREMENTS

A. Comply with applicable requirements of the California Code of Regulations, Title 24, Part 2, California Building Code, Chapters 18 and 18A, "Foundations and Retaining Walls."

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00 - Submittal Procedures, and Section 01 33 23 - Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings of pile types as follows:

1. Type A: Show typical details of size, weight, splices, tip construction, and welding of splice connection.

2. Type B: Show typical details of sizes, configuration, tip construction, and welding of section connection, and class of concrete fill.

3. Types C and D: Show typical details of sizes, configurations, tip construction, and welding of section connections, and class of concrete fill.

4. Type E: Show typical details of sizes, configuration, pre-stressing steel, tendon arrangement, class of concrete, lifting devices, curing methods, and pre-stressing methods. Include engineering calculations of working stresses. If splicing is required, submit details.

5. Test Piles: Show tension steel reinforcement and connections for uplift loads.

C. Pile Driving Sequential Layout:

1. Submit layout drawings showing the proposed sequence of driving the piles.

2. On the sequential layout, show each pile by identification, its driving sequence number, type, size, load bearing capacity, and pile tip elevation as planned.

3. Submit a pile numbering plan that clearly identifies and numbers each pile for reference.

D. Pile Driving Record. Maintain a pile driving record during pile driving and submit it upon completion of each day's pile driving. On the record indicate, for each pile driven, the information specified in Article 1.06.C above, and the following: type and rating of driving

equipment, overall blow count per foot and number of blows per inch penetration for the last 12 inches, and any unusual conditions encountered during driving. Also record start and end time of pile installation.

1. The Contractor shall submit a certified copy of the pile driving record to the Engineer for record purposes.

E. Equipment Review and Drawings:

1. Submit complete list of the equipment proposed for use, including a description of the characteristics of each piece of driving equipment.

   a. The Engineer will review the proposed driving equipment, accessories, and methods as a check of the adequacy of the equipment and methods for the conditions expected to be encountered.

   b. Should the equipment used by the Contractor prove to be inadequate to drive the scheduled types of piles at the locations indicated, or should the use of accessories show damage to the piles, or should it be found that the Progress Schedule cannot be maintained because of inadequate equipment or methods, the Contractor shall replace or use different types of equipment and accessories, or both, as appropriate for the conditions encountered.

2. Submit Shop Drawings of driving accessories showing compatibility with the size, configuration, handling, and driving requirements of each type of pile indicated.

3. Submit Shop Drawings showing the methods and equipment proposed for loading test piles.

1.07 QUALITY ASSURANCE

A. Pile Requirements: General and specific pile requirements shall comply with the California Building Code, Sections 1807, 1808, 1807A, and 1808A, as applicable. However, where the Contract Drawings or Specifications indicate or specify materials and construction of a better quality, higher standard, or larger size than is required by said California Building Code, the provisions of the Contract Drawings and Specifications shall take precedence over the California Building Code.

B. Installation Tolerances:

1. Deviation from plumb and angle of batter: 1/4 inch per foot of pile length, but not more than 6 inches overall.

2. Deviation from location of pile top: 6 inches.

C. Piles delivered to the site that are cracked, bowed, chipped, under size, or that break under driving stresses shall be rejected. Remove such piles from the site and replace with sound piles. Piles broken under driving stresses may be cut off and left in place if approved by the Engineer for the location.

D. Welding and welders' qualifications shall conform with the applicable requirements of Section 05 05 22 - Metal Welding.

PART 2 - PRODUCTS

2.01 PILES

A. Type A Piles: Steel H-piles conforming to ASTM A690, of size and type indicated. Steel plates and welding shall conform with applicable requirements of Section 05 12 00 - Structural Steel Framing, and Section 05 05 22 - Metal Welding.

B. Type B Piles:

1. Shell: Steel pipe conforming to ASTM A252, Grade 2, welded or seamless, of diameter and shell thickness indicated. Steel plates and welding shall conform with applicable requirements of Section 05 12 00 - Structural Steel Framing, and Section 05 05 22 - Metal Welding. For closed end pipe piles, end plates shall be structurally designed and adequately connected to the steel pipe to resist predicted driving stresses at the pile tip during installation.

2. Concrete Reinforcement: Conform with applicable requirements of Section 03 20 00 - Concrete Reinforcing, of grades and sizes indicated.

3. Concrete: Conform with applicable requirements of Section 03 30 00 - Cast-in-Place Concrete, and Section 03 05 15 - Portland Cement Concrete. Provide minimum Class 3000-1-inch concrete unless otherwise indicated.

C. Types C and D Piles:

1. Shells:

a. Type C Piles: Corrugated cylindrical pipe conforming to ASTM A760, of diameter and sizes indicated.

b. Type D Piles: Tapered or step-tapered corrugated steel shell fabricated of corrugated sheet conforming to ASTM A444 or ASTM A806, or pipe sections conforming to ASTM A760 of progressively larger or smaller sizes to meet indicated requirements.

c. Shell Thicknesses: Provide thickness or gage of metal and shell reinforcement of sufficient strength and rigidity to permit installation, and to prevent distortion caused by soil pressures after removal of the mandrel.

d. Tip: ASTM A36 steel plate, of thickness as indicated, welded to shell.

2. Concrete Reinforcement: Conform with applicable requirements of Section 03 20 00 - Concrete Reinforcing, of grades and sizes indicated.

3. Concrete: Conform with applicable requirements of Section 03 30 00 - Cast-in-Place Concrete, and Section 03 05 15 - Portland Cement Concrete. Provide minimum Class 4000-1-inch concrete unless otherwise indicated.

D. Type E Piles: Pre-cast, pre-stressed concrete piles, of sizes and requirements indicated, conforming with applicable requirements of Section 03 05 18 – Pre-stressed Concrete. Provide minimum Class 6000-1-inch concrete unless otherwise indicated.

PART 3 - EXECUTION

3.01 PILE TYPES

A. Piles shall be friction piles or combined friction and end-bearing piles as indicated. Piles shall be driven to the required penetration, as indicated.

3.02 DETERMINATION OF LENGTH

A. Piles shall be of such lengths as required to develop the specified capacity, to obtain the specified penetration, and to extend into the pile cap or footing block as indicated.

B. The Contract Drawings indicate the required type of piling, the required compression and tension capacity, the minimum penetration, and the estimated pile tip elevation. Estimated tip elevations are approximate, based upon subsurface explorations, and are given only to indicate the required lengths of indicator piles and test piles.

C. Lengths of production piles will be determined by the Engineer from the data obtained from the driving of indicator piles and the load-testing of test piles.

D. The Engineer will furnish the Contractor with the production-piles' order list after completion of driving of indicator piles and load-testing of test piles.

3.03 INDICATOR PILES AND TEST PILES

A. Based upon the information indicated, the Contractor shall order and drive the indicator piles and test piles. Compression and tension capacities of the test piles shall be determined by methods hereinafter specified.

B. From the driving behavior and test pile data and the subsurface exploration data, the Engineer will determine the required length of production piles. The Engineer may also determine the required penetration based upon settlement criteria or any other factors that in the opinion of the Engineer are applicable to the work.

C. Indicator piles and test piles shall be driven at the locations indicated and to the lengths specified by the Engineer. Piles shall be driven with impact hammers unless otherwise indicated. In general, the specified length of indicator piles and test piles will be greater than the estimated length of production piles in order to provide for variation in soil conditions.

D. Driving equipment used for driving indicator and test piles shall be identical to that what the Contractor proposes to use for the driving of production piles.

E. The Contractor shall excavate the ground at each indicator and test pile to the elevation of the bottom of the pile-cap footing before the pile is driven, or the Contractor may employ "followers" to compensate for the extra depth.

F. Indicator piles and test piles shall be driven to a hammer blow count established by the Engineer at the estimated tip elevation. Test piles that do not attain the hammer blow count specified above at a depth of 1 foot above the estimated tip elevation indicated shall be allowed to "set up" for 12 to 24 hours before being re-driven. A cold hammer shall not be used for re-drive. The hammer shall be warmed up before driving begins by applying at least 20 blows to another pile.

G. If the specified hammer blow count is not attained on re-driving, the Engineer may direct the Contractor to drive a portion or all of the remaining pile length and repeat the "set up" – re-drive procedure. Piles shall be driven to the planned grade and, when not having the hammer blow count required, shall be spliced and driven until the required bearing is obtained.

H. A record of driving of indicator and test piles will be prepared by the Engineer that will include the number of hammer blows per foot for the entire driven length, the as-driven length of the test pile, cutoff elevation, penetration in ground, and any other pertinent information. If re-drive is necessary, the Engineer will record the number of hammer blows per inch of pile movement for the first foot of re-drive. The Contractor shall not order production piles until indicator and test pile data has been reviewed and pile order lengths are authorized by the Engineer in writing.

3.04 AXIAL COMPRESSION AND TENSION LOAD TESTS

A. Install test piles and reaction piles, of the same type and kind as permanent piles, in the locations indicated or at other locations as required by the Engineer.

1. Reinforce test and reaction piles for the full length to resist uplift loads.

2. Install test piles vertically.

B. Test piles that pass the load test in an undamaged condition may be utilized as permanent piles in the work. Reaction piles that were used to perform the pile load test may be utilized as permanent piles in the work, provided they are not damaged and that they have not moved upward more than 1/8 inch. If upward movement has occurred, piles shall be re-driven to the previous elevation.

C. Either extract damaged test piles and reaction piles and remove from the site, or cut them off 3 feet below any structure to be installed above. Holes shall be backfilled with concrete or grout.

D. Compression Load Tests: Tests shall be performed in accordance with ASTM D1143. Method of load test shall follow "Quick Load Test Method for Individual Piles" as specified in ASTM D1143, Section 5.6.

1. Commence loading of test piles not sooner than 72 hours after placement of concrete or 72 hours after installation of Type E piles. Type III cement may be used in test piles to accelerate achieving necessary minimum strengths.

2. The maximum test load shall be at least twice the design load as prescribed by the Engineer. Apply the load in increments equal to 10 percent of the maximum test load, with a constant time interval between increments of 5 minutes. Maintain the

maximum test load for not less than 15 minutes, unless the shaft has failed as determined by the Engineer.

3. Remove the test load in increments equal to 25 percent of the maximum test load, with a constant time interval between increments of 5 minutes.

4. Measure the settlement and rebound of the test pile to the nearest 0.01 inch.

E. Tension Load Tests: Tests shall be performed in accordance with ASTM D3689. Method of load test shall follow "Quick Load Test Method for Individual Piles" as specified in ASTM D3689, Section 7.7. The maximum test load shall be at least twice the design load as prescribed by the Engineer. Apply the load in increments equal to 10 percent of the maximum test load, with a constant time interval between increments of 5 minutes. Maintain the maximum test load for not less than 15 minutes, unless the pile has failed as determined by the Engineer. Remove the test load in increments equal to 25 percent of the maximum test load, with a constant time interval between increments of 5 minutes.

F. Allowable bearing capacity of the test pile shall be defined as 40 percent of the failure load. For piles 24 inches or less in diameter or width, the failure load of a pile tested under axial compressive load is that load that produces a settlement at failure of the pile head equal to:

$$S_f = S + (0.15 + 0.008D)$$

Where:

S_f = Settlement at failure in inches
D = Pile diameter or width in inches
S = Elastic deformation of total unsupported pile length in inches

G. The Engineer may require the Contractor to make additional load tests that are not indicated, in the event that the behavior of the test pile or any other pile shows any peculiarity, erratic action, or otherwise causes suspicion as to the reliability of the pile capacity.

H. Immediately following completion of load testing, submit two copies of the test report for each test pile to the Engineer for record purposes. Include in the test report the data required by ASTM D1143 and ASTM D3689, as applicable.

I. Following the completion of load tests, the Engineer will make a determination of the required penetration.

3.05 LATERAL LOAD TESTS

A. Tests shall be performed in accordance with ASTM D3966. Method of load test shall follow "Standard Loading Procedures" as specified in ASTM D3966, Section 6.1.

3.06 DYNAMIC PILE TESTING

A. Dynamic measurements shall be taken by the Contractor during the driving of test piles designated as dynamic load test piles.

B. Prior to placement in the leads, the Contractor shall make each designated concrete pile available for taking wave speed measurements and for pre-drilling the required instrument

attachment holes. Pre-driving wave speed measurements will not be required for steel piles. When wave speed measurements are made, the piling shall be in a horizontal position and not in contact with other piling.

C. The Contractor shall furnish the equipment, materials, and labor necessary for drilling holes in the piles for mounting the instruments. Instruments will be attached near the head of the pile with expansion-type bolts for concrete piles or through drilled holes on steel piles.

D. The Contractor shall provide access to the pile for attaching instruments after the pile is placed in the leads. A platform with minimum size of 4 by 4 feet (16 square feet) designed to be raised to the top of the pile while the pile is located in the leads shall be provided by the Contractor.

E. The Contractor shall furnish electric power for the dynamic test equipment. The power supply at the outlet shall be 10 amp, 115 volt, 55-60 cycle, A.C. only. Field generators used as the power source shall be equipped with meters for monitoring voltage and frequency levels.

F. The Contractor shall drive the pile to the design tip elevation or other depth specified by the Engineer. The stresses in the piles will be monitored during driving with the dynamic test equipment to ensure that the values determined do not exceed the allowable values. If necessary, the Contractor shall reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer in order to maintain stresses below the allowable values. If non-axial driving is indicated by the dynamic test equipment measurements, the Contractor shall immediately realign the driving system.

G. The Contractor shall wait up to 24 hours and, after the instruments are re-attached, re-tap the dynamic load test pile. A cold hammer shall not be used for the re-drive. The hammer shall be warmed up before re-drive begins by applying at least 20 blows to another pile. The maximum amount of penetration required during re-drive shall be 6 inches, or the maximum total number of hammer blows required will be 50, whichever occurs first. After re-tapping, the Engineer will either provide the cut-off elevation or specify additional pile penetration and testing for that dynamic load test pile. CAPWAP analyses of dynamic pile testing data shall be performed on data obtained for the beginning of re-drive of the driven piles.

3.07 INSTALLATION OF PILES

A. Pile Types: Provide piles of the type indicated and of the length and configuration necessary to perform the following:

1. Achieve the required penetration as determined by the Engineer;

2. Extend into the pile cap or structure footing to the location indicated; and

3. Attain indicated capacity.

B. Penetration and Bearing: Install piles to the required penetration, or to the required bearing, as determined by the various load tests performed for the purpose. Jetting will not be permitted unless specifically approved in writing by the Engineer for the location.

C. Predrilled Holes:

1. Where piles are to be driven through new embankment and the depth of the embankment is greater than 5 feet at the pile location, drive the pile in a hole, drilled through the embankment, of diameter not less than the greatest cross-section dimension of the pile. After driving the pile, fill any annular space around the pile with dry sand or pea gravel.

2. When necessary to achieve the required penetration, drill holes of diameter not greater than 90 percent of the least cross-sectional dimension of the pile at the depth being drilled, and drive the pile therein to the required penetration. Locations and types of pre-drilling shall be approved by the Engineer in writing.

3. When, in the Contractor's opinion, a larger hole is needed to prevent damage to piles, submit substantiating data and obtain the Engineer's written approval before drilling holes of larger cross-section. Holes greater than 100 percent of the cross-sectional dimension of the pile will not be permitted.

D. Pile Driving:

1. Complete embankment construction, filling, and backfilling to the required elevations before starting of pile-driving operations. Unless otherwise specified, an embankment settlement period of at least six months will be required before installation of piles.

2. Do not drive piles within 20 feet of concrete less than seven days old.

3. Drive interior footing piles before driving perimeter piles.

4. If necessary, provide adequate lateral support for installed individual piles to prevent excessive temporary flexural stresses or movement of the pile top out of tolerance.

5. Maintain the hammer coaxial with the pile during the driving operation by using a combination of driving cap and leads.

6. Investigate any sudden decrease in driving resistance for possible breakage of the pile. If a sudden decrease in driving resistance cannot be correlated to boring data or some incident in the driving, and if the pile cannot be inspected, such decrease in driving resistance will be cause for rejection of the pile.

7. Re-drive any pile that is raised during driving of adjacent piles, to the original tip elevation.

8. Splice piles only by methods and at places approved by the Engineer in writing.

9. Cut off piles at top elevation indicated. Repair piles that are damaged when cut off requires written approval of the Engineer.

E. Type A Piles:

1. Design the driving cap with grooves in the base to conform loosely to the "H" configuration of the pile. The bearing surface of the grooves shall be true, without roughness. The driving cap shall extend down the side of the pile at least four inches and shall be loosely attached to the hammer so that it will at all times rest squarely over the entire surface of the pile.

2. Make splices as indicated by electric-arc field welding in accordance with AWS D1.1 Cut-off damaged portion of pile top before splicing. Take care to align the sections connected so that the axis of the pile will be straight. Refer to Section 05 05 22 - Metal Welding, for welding requirements.

F. Type B Piles:

1. Protect the heads of piles from direct impact of the hammer by using an approved head block or shoe.

2. Make splices as indicated by electric-arc field welding in accordance with AWS D1.1 Cut-off damaged portion of pile top before splicing. Take care to align the sections connected so that the axis of the pile will be straight. Refer to Section 05 05 22 - Metal Welding, for welding requirements.

3. Remove rejected pipe pile and replace with new pipe. When rejected pipe pile cannot be removed, furnish and install replacements. Cut off abandoned pipe 3 feet below the structure, and fill the abandoned pipe with Class 3000 concrete. Backfill and compact holes.

4. Concrete to be placed using tremie pipe that can extend to the bottom of the pipe. Concrete will not be allowed to free fall during placement. Vibration of the concrete will not be required except in the top 15 feet of the pipe. Discharge concrete into the hopper at a continuous and rapid rate. Any break in the placement of the concrete shall be the basis for rejection of the pile. The Contractor shall verify the integrity of the pile.

5. Pipe piles may be driven with open ends, and the soil, rock or deleterious material adequately removed with auger or by other approved method to width and depth indicated to allow concrete to bond to the inside of the pipe. Inspect driven pipe shell for internal damage and misalignment and for the presence of water, and correct damaged or defective conditions before placement of concrete. Piles partially filled with water shall be dewatered or concrete-filled using the tremie method.

G. Types C and D Piles:

1. Shells will be inspected for collapse, tears, splits, or reduced diameter throughout their length after shells have been driven and before reinforcing steel and concrete are placed therein.

2. Provide adequate inspection equipment, such as lights and CCTV/video tape equipment as required.

3. For acceptance, the pile shell shall be:

   a. Free of collapsed sections and tears;

   b. Free of water, except that a minor amount of water may be permitted if it can be absorbed by placing a suitable amount of dry sand-cement mixture in the tip of the pile, if this condition cannot be corrected in this manner then use method specified in Article 3.07 F.5. herein; and

c. Visible to the bottom of the casing.

4. Remove rejected pile shells and replace with new shells. When rejected shells cannot be removed, furnish and install replacements. Cut off abandoned shells three feet below the structure and fill the abandoned shells with Class 4000 concrete. Backfill and compact holes.

5. Immediately prior to installing the reinforcing steel assembly, place a 1:2 sand-cement grout in bottom of pile shell to a minimum depth of 12 inches.

6. Assemble reinforcing steel as a complete unit and install in pile before starting to place concrete.

7. Concrete to be placed using tremie pipe that can extend to the bottom of the pipe. Concrete will not be allowed to free-fall during placement. Vibration of the concrete will not be required except in the top 15 feet of the shell. Discharge concrete into the hopper at a continuous and rapid rate. Any break in the placement of the concrete shall be the basis for rejection of the pile. The Contractor shall verify the integrity of the pile.

H. Type E Piles:

1. Protect the heads of piles from direct impact of the hammer by acceptable cushion head block, so that no cracking, spalling, or chipping occurs.

2. If piles have extended reinforcing steel and protective concrete for driving, remove such protective concrete to expose the reinforcing steel upon completion of driving.

3. When piles are driven or cut off below the elevation of the bottom of the cap, extend the pile to the elevation of the bottom of the cap by means of a reinforced concrete extension. Submit details for approval prior to fabrication.

END OF SECTION 31 62 00