SECTION 31 62 16

CONCRETE-FILLED STEEL PILES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes concrete-filled steel shell piles.
B. This Section includes concrete-filled steel pipe piles.
C. Related Sections include the following:
   1. Division 1 Section "Unit Prices" for a schedule of unit prices.
   2. Division 1 Section "Construction Facilities and Temporary Controls."
   3. Division 3 Section "Cast In Place Concrete"
   4. Division 5 Section “Structural Steel”
   5. Division 9 Section "Special Coatings" for surface preparation and coatings.

1.03 UNIT PRICES

A. Basis for Bids: Base bids on number and dimensions of piles indicated from point to cutoff, plus not less than 12 inches (of overlength for cutting piles at required cutoff elevations.
B. Basis for Payment: From data obtained as a result of driving piles, calculate actual total net length of piles used. Contract price per linear foot includes labor, materials, tools, equipment, and incidentals and for performing work for furnishing, driving, cutting off and capping piles. This includes splicing and disposal of cutoffs.
   1. Measurements will be based on effective length of piles in place, with lengths measured to nearest 12 inches. Additional payment for lengths in excess of that indicated, and credit for lengths less than that indicated, will be calculated at unit prices stated in the Contract, based on net addition or deduction to total length of piling.
   2. Test piles that become part of completed foundation system will be considered as an integral part of the Work.
   3. No payment will be made for rejected piles, including piles driven out of place, defective piles, or piles damaged during handling or driving.

1.04 SUBMITTALS
A. Product Data: For each type of pile product, accessory, and paint indicated.

B. Shop Drawings: Show fabrication and installation details for piles, including splices and tip details.
   1. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
   2. Indicate locations, sizes, type, and arrangement of reinforcement.
   3. 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.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Design Mixes: For each concrete mix. Include revised mix proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
   1. Laboratory Test Reports: For evaluating concrete materials and mix design tests.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

F. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of each of the following with requirements:

G. Material Certificates: Signed by manufacturers certifying that each of the following items complies with requirements:
   1. Steel shell piles and accessories.
   2. Steel pipe piles and accessories.
   3. Concrete materials.
   4. Reinforcing materials.
   5. Admixtures.

H. Pile-Driving Equipment: 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.
   1. Include mandrel type and details.

I. Static Pile Test Reports: Submit within two days of completing test.

J. Driving Records: Submit within two days of driving.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has specialized in installing piling similar in material, design, and extent to that indicated for this Project.

B. Fabricator Qualifications: A firm experienced in producing steel pile shells similar to those indicated for this Project and with a record of successful in-service performance.
C. Survey Work: Provide pile-driving records, including surveys, layouts, and measurements, prepared by a surveyor or professional engineer who is legally qualified in jurisdiction where Project is located to perform these kinds of services.

D. Professional Engineer Qualifications: A licensed Professional Engineer who is currently registered for practice to practice in the State of New York and who is experienced in providing engineering services for piles that are similar to those indicated for this Project in material, design, and extent.

E. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.

F. Comply with requirements of the following codes & publications:

2. ACI 301, "Specifications for Structural Concrete."
3. ACI 318, "Building Code Requirements for Structural Concrete."
6. AISI's "Load and Resistance Factor Design Specification for Cold-Formed Steel Structural Members."
7. AISI's "Specification for the Design of Cold-Formed Steel Structural Members."

G. Welding Standards: Qualify welding procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

H. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Meetings."

1.06 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 pile.

PART 2 - PRODUCTS

2.01 STEEL PIPE PILES

A. Steel Pipe: ASTM A 252, Grade 2 or 3; seamless or welded. Minimum 8” diameter x 3/8” nominal wall thickness.

2.02 REINFORCING MATERIALS

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 deformed.
2.03 CONCRETE MATERIALS

A. Refer to Division 3 Sections for concrete requirements. A 28-day compressive strength (f′c) = 5000 psi, normal-weight concrete mix design is required.

2.04 PILE ACCESSORIES

A. Driving Points: Manufacturer's standard 60-degree conical driving point, with integral reinforcing ribs, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:

B. Inside Cutting Shoes: Manufacturer's standard, inside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:

C. Outside Cutting Shoes: Manufacturer's standard, outside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:

   1. Carbon-Steel Castings: ASTM A 27/A 27M, as follows:

      a. Grade 65-35 (Grade 450-240), heat treated.
      b. Grade N1.
      c. Grade 65-35 (Grade 450-240), heat treated, or Grade N1.

   2. High-Strength Steel Castings: ASTM A 148/A 148M, as follows:

      a. Grade 80-40 (Grade 550-275).
      b. Grade 90-60 (Grade 620-415).
      c. Grade 80-40 (Grade 550-275) or Grade 90-60 (Grade 620-415).

D. Splice Coupling: Manufacturer's standard splice coupling, rolled from ASTM A 36/A 36M, carbon-steel bar or cast from heat-treated carbon steel, ASTM A 27/A 27M, Grade 65-35 with interior stop and internally tapered for friction fit driving.

2.05 PAINT

A. Paint: SSPC-Paint 16; self-priming, two-component, coal-tar epoxy polyamide.

   1. Color: Black or red.

2.06 CONCRETE MIXES

A. Refer to Division 3 Section “Cast in Place Concrete” for mix design requirements.

2.07 FABRICATION

A. Pile Lengths: Pile lengths will be verified by Architect/Engineer after submitting static pile test reports.

B. Fabricate and assemble piles in shop to greatest extent possible.
C. Fabricate full-length piles to eliminate splicing during driving.

D. Fabricate full-length piles by splicing lengths of pile together. Maintain axial alignment of pile lengths.

1. Splice Coupling: Fit splice coupling into position, and weld to adjoining steel pipe pile sections according to manufacturer's written instructions and AWS D1.1 for procedures, appearance and quality of welds, and methods used in correcting welding work.

2. Welded Splices: Accurately mill meeting ends of steel pipe piles and bevel for welding. Continuously weld pile according to AWS D1.1 for procedures, appearance and quality of welds, and methods used in correcting welding work.

3. Welded Splices: Continuously weld steel shell pile according to manufacturer's written instructions and AWS D1.1 for procedures, appearance and quality of welds, and methods used in correcting welding work.

4. Splice piles during fabrication or field installation.

E. Fit and weld driving points to tip of pile according to manufacturer's written instructions and AWS D1.1 for procedures, appearance and quality of welds, and methods used in correcting welding work.

F. Fit and weld cutting shoes to tip of pile according to manufacturer's written instructions and AWS D1.1 for procedures, appearance and quality of welds, and methods used in correcting welding work.

G. Pile-Length Markings: Mark each pile length with horizontal line at 12-inch intervals, and the distance from pile tip at 60-inch intervals.

2.08 SHOP PAINTING

A. General: Shop paint steel pile surfaces, except for surfaces to be encased in concrete, as follows:

1. Extend painting to a depth of 60 inches below finished grade to top of exposed pile.

B. remove spatter, slag, or flux deposits. Prepare surfaces according to SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."

C. Painting: Immediately after surface preparation, apply first coat of paint according to manufacturer's written instructions to provide a dry film thickness of not less than 8 mils.

1. Apply second coat to provide a dry film thickness of not less than 8 mils, resulting in a two-coat paint system thickness of not less than 16 mils.

2. Mark pile lengths after shop painting.

2.09 CONCRETE MIXING

A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94. Do not add water after mixing.

B. Refer to Division 3 Section “Cast in Place Concrete” for additional requirements.
1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from one and one-half hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of 6 to 12 inches above bottom of footing or pile cap.

3.02 DRIVING EQUIPMENT

A. Pile Hammer: Air-, steam-, or diesel-powered type capable of consistently delivering driving energy to pile within range recommended by hammer manufacturer for length and weight of pile and character of subsurface material anticipated.

B. 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.

C. 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.

D. 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 24 inches of elevation at which pile enters ground.

E. Mandrel: Expandable mandrel, capable of distributing driving energy throughout length of steel shell pile.

3.03 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 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:


C. Equip each test pile with two telltale rods, according to ASTM D 1143, 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 five blows of hammer are required to produce a total penetration of 1/4 inch or less.

1. Install reinforcement and fill pile with concrete according to requirements.
2. Before load-testing pile, allow concrete to cure a minimum of 14 days and reach its 28-day design compressive strength as established by test cylinders.

E. Provide pile reaction frame, anchor piles, equipment, and instrumentation with sufficient reaction capacity to perform tests. Notify Architect 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.
2. Number of Test Piles: Two single piles and one group of three piles.
3. Number of Test Piles: One group of test piles.

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

1. Pile Design Load: As indicated on the contract documents.

G. 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. Net settlement, after deducting rebound, of not more than 0.01 inch/ton of test load.
2. Gross settlement of not more than 1 inch, provided that load-settlement curve shows no sign of failure.

H. Driving Records: Prepare driving records for each test pile, compiled and attested to by a qualified, licensed Professional Engineer. Include same data as required for driving records of permanent piles.

I. Test piles that comply with requirements, including location tolerances, may be used on Project.

3.04 DRIVING PILES

A. General: Continuously drive piles to tip elevations or penetration resistance indicated. Establish and maintain axial alignment of leads and pile before and during driving.

B. General: Continuously drive piles to elevations or penetration resistance indicated or established by static load testing of piles. Establish and maintain axial alignment of leads and pile before and during driving.

C. Predrilling: Provide pre-excavated holes for piles driven within 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.

1. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
D. 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.

E. Pile Splices: Splice piles during installation and align pile segments concentrically.

F. Driving Tolerances: Drive piles without pile heads exceeding the following tolerances:

1. Location: 4 inches from location indicated after initial driving, and 6 inches after pile driving is completed.
2. Plumb: Maintain 1 inch in 10 feet from vertical, or a maximum of 4 inches, measured when pile is above ground in leads.
3. Batter Angle: Maximum 1 inch in 10 feet from required angle, measured when pile is above ground in leads.

G. Excavation: Clean out pile by removing soil and debris from inside pile.

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 Architect.

1. Rejected piles may be abandoned and cut off as directed by Architect.
2. Leave rejected piles in place and install new piles in locations as directed by Architect.
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 48 inches.

I. Cutting off: Cut off tops of driven piles square with pile axis and at elevations indicated.

J. Driving Record: Maintain accurate driving records for each pile. Include the following data:

K. Driving Record: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer. Include the following data:

1. Project name and number.
2. Name of Contractor.
3. Type of pile and date of casting.
4. Pile location in pile group and designation of pile group.
5. Sequence of driving in pile group.
6. Pile dimensions.
7. Ground elevation.
8. Elevation of tip after driving.
9. Final tip and cutoff elevations of pile after driving pile group.
10. Records of redriving.
11. Elevation of splices.
12. Type, make, model, and rated energy of hammer.
13. Weight and stroke of hammer.
14. Type of pile-driving cap used.
15. Cushion material and thickness.
17. Pile-driving start and finish time; and total driving time.
18. Time, pile-tip elevation, and reason for interruptions.
19. Record of number of blows for each 12 inches of penetration, and number of blows per 1 inch for the last 6 inches of driving.
20. Pile deviations from location and plumb.
21. Record preboring, jetting, or special procedures used.
22. Record of unusual occurrences during pile driving.

3.05 CONCRETE PLACEMENT

A. Do not place concrete until other piles within a radius of 20 feet have been driven and approved.
B. Inspection: Before placing concrete, allow testing and inspecting agency to visually inspect that each pile is clean, watertight, plumb, and free of distortion or other defects.
C. Place concrete in a continuous operation and without segregation immediately after cleaning out pile.
D. Place concrete by means of bottom discharge bucket, flexible drop chute, elephant-trunk hopper, or tremie or pump concrete into place.
E. Place concrete in a dry pile, unless placement underwater is approved by Architect/Engineer.
   1. Place concrete underwater by tremie method or pumping. Control placement operations to ensure tremie is embedded no less than 60 inches into concrete, and flow of tremied concrete is continuous from bottom to top of pile.
   2. Other methods of depositing concrete may be used, if approved by Architect.
F. Reinforcement: Comply with recommendations of CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
   1. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover to reinforcement.
   2. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.
G. Consolidate final 10 feet of concrete during placement to ensure concrete is thoroughly worked around reinforcement and into corners.
H. Screed concrete at cutoff elevation level and apply a scoured, rough finish.

3.06 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing agency to perform field quality-control testing in accordance with the contract documents and Section 1704.9 of the 2008 New York City Building Code.
B. High-Strain Dynamic Monitoring: High-strain dynamic monitoring will be performed and reported according to ASTM D 4945 during initial driving and during restriking on the following number of piles:
1. Number of Test Piles: 12 single piles.
2. Number of Test Piles: 15 percent of piles.

C. Low-Strain Integrity Measurement: Low-strain integrity measurements will be performed and reported for each pile.

D. Weld Testing: In addition to visual inspection, welds will be inspected and tested according to AWS D1.1 and the inspection procedures listed below, at testing agency's option. Correct deficiencies in and retest welds to determine compliance with requirements.

1. Liquid Penetrant Inspection: ASTM E 165.
2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
3. Radiographic Inspection: ASTM E 94 and ASTM E 142; minimum quality level "2-2T."

E. Concrete: Sampling and testing of concrete for quality control will include the following:

1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
   a. Slump: ASTM C 143; one test at point of placement for each compressive-strength test, but no less than one test for each concrete load.
   b. Air Content: ASTM C 231, pressure method; one test for each compressive-strength test.
   c. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each set of compressive-strength test.
   d. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test, unless otherwise directed. Mold and store cylinders for laboratory-cured test specimens, unless field-cured test specimens are required.
   e. Compressive-Strength Tests: ASTM C 39; one set for each truck load. One specimen will be tested at seven days, two specimens will be tested at 28 days, and one specimen will be retained in reserve for later testing if required.

2. When frequency of testing will provide fewer than five strength tests for a given class of concrete, testing will be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

3. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing in-place concrete.

4. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test result falls below specified compressive strength by more than 500 psi (3.45 MPa).

5. Test results will be reported in writing to Architect/Engineer, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive-strength tests will contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, concrete type and class, pile locations of concrete batch, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both seven- and 28-day tests.
6. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as sole basis for acceptance or rejection.

7. Additional Tests: Testing and inspecting agency will make additional tests of concrete when test results indicate concrete strengths or other requirements have not been met.

3.07 TOUCHUP PAINTING

A. Clean field welds, splices, and abraded painted areas and field-apply paint according to SSPC-PA 1. Use same paint and apply same number of coats as specified for shop painting.

1. Apply touchup paint before driving piles to surfaces that will be immersed or inaccessible after driving.

3.08 DISPOSAL

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

END OF SECTION 31 62 16