

SECTION 31 63 29 - DRILLED CONCRETE PIERS AND SHAFTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Dry-installed drilled piers.
 - 2. Slurry displacement-installed drilled piers.
 - 3. Dry-installed or slurry displacement-installed drilled piers at Contractor's choice.
- B. Products installed but not furnished under this Section include the following:
 - 1. Division 05 Section "Structural Steel Framing" for furnishing anchor rods.
 - 2. Division 05 Section "Metal Fabrications" for furnishing metal embedments.
- C. Related Sections:
 - 1. Division 01 Section "Project Record Documents" for recording preexisting conditions and drilled pier progress.
 - 2. Division 01 Section "Temporary Facilities and Controls."
 - 3. Division 01 Section "Submittal Requirements".
 - 4. Division 03 Section "Cast-in-Place Concrete" for pier caps and mix designs.
- D. Project Geotechnical Documents, for reference:
 - 1. Geotechnical Engineering Report, DFW Terminal C Expansion, by ECS Southwest, LLP dated April 14th, 2022. Report Number 63: 1603-C and subsequent Addendum dated July 12, 2023.
 - 2. Geotechnical Engineering Report, DFW Terminal A Expansion, by ECS Southwest, LLP dated April 14th, 2022. Report Number 63: 1603-A and subsequent Addendums dated February 5, 2023 and July 12, 2023.

1.2 REFERENCES

- A. Definitions
 - 1. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.
 - 2. Structural Drawings: "S" series drawings of the Contract Documents.
- B. Reference Standards: Comply with requirements of the following as modified by the Contract Documents. The most recent version of the following standards and test methods may be employed as listed in the contract documents.
 - 1. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials," 2010.
 - 2. ACI 301, "Specifications for Structural Concrete," 2005.
 - 3. ACI 305.1, "Specification for Hot Weather Concreting," 2006.
 - 4. ACI 306.1, "Specification for Cold Weather Concreting", 1990.
 - 5. ACI 336.1, "Specification for the Construction of Drilled Piers," 2001.
 - 6. ACI SP-66, "ACI Detailing Manual," 2004.

7. AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," 2005, section 7.5 only.
8. AWS D1.1/D1.1M, "Structural Welding Code – Steel," 2006.
9. AWS D1.4/D1.4M, "Structural Welding Code – Reinforcing Steel," 2005.
10. CRSI MSP, "Manual of Standard Practice," 2009.
11. Standard Test Method for Low Strain Impact Integrity Testing of Deep Foundations ASTM D5882.
12. Standard Test Methods for Deep Foundations Under Lateral Load ASTM D3966
13. Standard Test Methods for Deep Foundations Under Static Axial Tensile Load ASTM D3689
14. Standard Test Methods for Deep Foundations Elements Under Static Axial Compressive Load ASTM D1143

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 1. Coordinate the Work of this Section with the Work of other Sections.
 2. Coordinate the Work of this Section with the Work of other **Design/ Construction** Packages.
- B. Pre-installation Meeting: Conduct meeting at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."
 1. Require representatives of each entity directly concerned with drilled piers to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Installer (Drilled pier subcontractor).
 - d. Manufacturer (Ready-mix concrete producer).
 - e. Owner's Testing and Inspecting Agency.
 2. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials.
 3. Review methods and procedures related to drilled piers including, but not limited to, the following:
 - a. Geotechnical report.
 - b. Existing utilities and subsurface conditions.
 - c. Coordination with temporary controls and protections.
 - d. Tolerances.
 - e. Cold- and hot-weather concreting procedures.
 - f. Forms and form removal limitations.
 - g. Temporary casing removal.
 - h. Steel reinforcement installation.
 - i. Curing procedures.
 - j. Concrete protection.
 - k. Concrete repair procedures.
 - l. Special inspection and testing and inspecting agency procedures for field quality control.

1.4 SUBMITTALS, GENERAL

- A. Submittals for Work of this Section shall be prepared and submitted separately from Submittals for Work of other Sections. Submittals combining Work of this Section with that of other Sections will be returned without review.

- B. Submittals and accompanying correspondence from the Contractor shall not contain clauses defining the meaning or implication of the action taken by those reviewing the Submittal. Submittals not in compliance will be returned without review.
- C. After review of the first re-submittal, review of re-submittals is at Contractor's expense.
- D. Format:
 - 1. All Submittals, except Samples, shall be submitted in Adobe PDF format with each file being uniquely named.
 - 2. All Submittals, except Samples, will be returned in Adobe PDF format with each file being uniquely named.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include manufacturer's specifications and installation instructions.
- B. Design Mixtures: For each concrete mixture.
 - 1. See requirements of Specification section 033000. All design mixtures shall meet the requirements of ACI 318 for mixture type and strength data.
 - 2. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
 - 3. Approval of a design mixture is specific to the plant listed in the Submittal and all field test data used in preparing the design mixture shall be for concrete produced by the listed plant.
 - 4. Provide copy of approved design mixtures to Owner's Testing and Inspecting Agency prior to installing reinforcement.
- C. Shop Drawings, General
 - 1. Drawings shall be no larger than 48 inches by 36 inches (1219 mm by 914 mm).
 - 2. Reproduction of Contract Documents is unacceptable. Do not use the same sheet numbers nor section labels as used on Contract Documents. References to Contract Documents shall not be substituted for complete Shop Drawings.
 - 3. Cloud the following on each Shop Drawing. Adequacy of unclouded deviations or revisions is Contractor's responsibility regardless of Action taken on Submittal.
 - a. Questions concerning interpretation of Contract Documents.
 - b. Deviations from Contract Documents.
 - c. Revisions incorporated into re-submittals.
- D. Steel Reinforcement Shop Drawings: Drawings prepared according to ACI SP-66 that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.
 - 1. Where full length reinforcement is required, detailing shall accommodate variable length of drilled piers due to variation in elevation of suitable bearing stratum.
 - 2. Provide copy of approved Steel Reinforcement Shop Drawings to Owner's Testing and Inspecting Agency prior to installing reinforcement.
- E. Testing Procedures: The following information shall be submitted via the contractor by the deep foundation installation company and associated testing entities prior to construction:
 - 1. Written testing procedure and proposed results format for all field testing. Include recommendations for the number of piles to be tested based on the field conditions and number of piles to be installed.

2. Proposed locations for all testing. Use of any production piers for testing is subject to the satisfactory testing of those location. Otherwise, contractor shall
- F. Testing Results: The following information shall be submitted via the contractor by the deep foundation installation company and associated testing entities during construction:
1. Daily records of all observations performed in accordance with the Schedule of Special Inspections
 2. A report documenting the observations, results, and recommendations of the lateral and tension and compression tests, including all information identified in section 3.7.

1.6 INFORMATIONAL SUBMITTALS

- A. Certificates: For each type of product indicated, a Project specific statement printed on manufacturer's letterhead and signed by responsible officials of manufacturer, certifying compliance with requirements.
- B. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.
- C. Field Quality Control Submittals:
1. Minutes of pre-installation meeting.
- D. Sustainable Design Submittals:
1. Product Data for LEED Credit MR 4.1: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - a. Include statement indicating costs for each product having recycled content.
 2. Design Mixtures for LEED Credit ID 1.1: For each concrete mixture containing fly ash as a replacement for portland cement or other portland cement replacements and for equivalent concrete mixtures that do not contain portland cement replacements.
- E. Photographs or Video: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by drilled pier operations. Submit before pier installation begins.
- F. Qualification Statements: For each of the following:
1. Manufacturer.
 2. Installer.
 3. Welder.
 4. Testing agency.

1.7 CLOSEOUT SUBMITTALS

- A. Drilled pier survey – Document all final locations in project coordinates and note any deviations from the intended locations.

1.8 QUALITY ASSURANCE

A. Qualifications

1. Manufacturer: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
 - a. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
 - b. Individual with responsibility for concrete mixtures certified as an NRMCA Concrete Technologist Level 2.
2. Installer: An installer that has specialized in drilled pier work with five years' experience working in similar subsurface conditions.
3. Testing Agency: An independent agency, qualified according to ASTM C 1077 and ASTM E 329 for preconstruction testing indicated, as documented according to ASTM E 548.
 - a. Personnel performing material tests shall be minimally certified as ACI Aggregate Testing Technician – Level 1.
 - b. Personnel performing laboratory concrete tests shall be minimally certified as ACI Concrete Laboratory Testing Technician – Level 1.
 - c. Testing Agency laboratory supervisor shall be certified as ACI Concrete Laboratory Testing Technician – Level 2.
4. Land Surveyor: A land surveyor who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing layout services of the kind indicated.
5. Professional Engineer: An engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing layout services of the kind indicated.

B. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from one source, and obtain admixtures through one source from a single manufacturer.

C. Preconstruction Testing: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

D. Trial Drilled Pier: Construct trial drilled pier of diameter and depth and at location indicated or, if not indicated, of same diameter and depth as largest drilled piers, located at least three diameters clear of permanent drilled piers, to demonstrate Installer's construction methods, equipment, standards of workmanship, and tolerances.

1. Install reinforcement, fill with concrete, remove temporary casings, and terminate trial drilled pier 24 inches (600 mm) below subgrade and leave in place.
2. Install permanent casings, excavate bell, excavate rock socket, and place slurry, as required for permanent drilled piers.
3. If Architect determines that trial drilled pier does not comply with requirements, excavate for and cast another until it is accepted.

1.9 PROJECT CONDITIONS

A. Existing Utilities: Locate existing underground utilities before excavating drilled piers. If utilities are to remain in place, provide protection from damage during drilled pier operations.

1. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, adapt drilling procedure if necessary to prevent damage to utilities. Cooperate with Owner and utility companies in keeping services and facilities in operation without interruption. Repair damaged utilities to satisfaction of utility owner.

- B. Interruption of Existing Utilities: Do not interrupt any utility to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
 - 1. Notify Construction Manager and /or Owner no fewer than seven days in advance of proposed interruption of utility.
 - 2. Do not proceed with interruption of utility without Construction Manager's and/or Owner's written permission.
- C. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of Owner's geotechnical engineering consultant and represent interpretations of subsoil conditions, tests, and results of analyses conducted by Owner's geotechnical engineering consultant. Owner and Architect will not be responsible for interpretations or conclusions drawn from this data.
 - 1. The geotechnical report is included in Division 02 Section "Geotechnical Investigations."
 - 2. Make additional test borings and conduct other exploratory operations necessary for drilled piers, at no cost to Owner.
- D. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for drilled piers. Before excavating, lay out each drilled pier to lines and levels required. Record actual measurements of each drilled pier's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.
 - 1. Record and maintain information pertinent to each drilled pier and cooperate with Owner's Testing and Inspecting Agency to provide data for required reports.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Delivery and Acceptance Requirements
 - 1. Deliver materials to Project in such quantities and at such times to ensure continuity of installation.
 - 2. Do not deliver concrete until forms, reinforcement, and embedded items are in place and ready for concrete placement and all inspections have been completed.
 - 3. Field Acceptance of Concrete:
 - a. Concrete not within slump or slump flow tolerance of the approved concrete design mixture at the point of discharge shall not be used in the Work.
 - 1) Slump tolerance:
 - a) For slump 2 inches (50 mm) and less: +/- 1/2 inch (12 mm).
 - b) For slump more than 2 inches (50 mm) through 4 inches (100 mm): +/- 1 inch (25 mm).
 - c) For slump greater than 4 inches (100 mm): +/- 1.5 inches (40 mm).
 - 2) Slump flow tolerance: +/- 3 inches (75 mm).
 - b. Concrete not within +/- 1.5 percent of the air content of the approved concrete design mixture at the point of placement shall not be used in the Work.
 - c. Concrete not within temperature limits at the point of discharge shall not be used in the Work.
- B. Storage and Handling Requirements
 - 1. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Store reinforcement of different sizes and shapes in separate locations. Protect from contaminants such as grease, oil, and dirt. Ensure bar sizes can be accurately identified after bundles are broken and tags removed.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Availability: Confirm availability of all products and notify Architect of any that cannot be provided.

2.2 MANUFACTURERS

- A. In other Part 2 Articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
 - 2. Products: Subject to compliance with requirements, provide one of the products specified.
 - 3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 4. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.3 STEEL REINFORCEMENT

- A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 60 percent.
- B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
- C. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.
- D. Deformed-Steel Wire: ASTM A 496.

2.4 REINFORCEMENT ACCESSORIES

- A. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain. Cut bars true to length with ends square and free of burrs.
- B. Epoxy-Coated Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain-steel bars, ASTM A 775/A 775M epoxy coated.
- C. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating; compatible with epoxy coating on reinforcement and complying with ASTM A 775/A 775M.
- D. Zinc Repair Material: ASTM A 780, zinc-based solder, paint containing zinc dust, or sprayed zinc.
- E. Bar Centralizers: Manufactured device to assure concrete cover is achieved over reinforcement.

- F. Mechanical Bar Anchors: ASTM A 970/A 970M and obstructions or interruptions of the bar deformations, if any, shall not extend more than two bar diameters from the bearing face of the head.
- G. Mechanical Bar Splices (Type 1): System, for splicing two bars, capable of developing 125% of the bar yield strength in tension and compression.
- H. Mechanical Bar Splices (Type 2): System, for splicing two bars, capable of developing 125% of the bar yield strength in tension and compression and the specified tensile strength of the bar.

2.5 CONCRETE MATERIALS

- A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source, throughout Project:
 - 1. Portland Cement: ASTM C 150, Type as required for durability based on exposure classes according to ACI 318 (ACI 318M), gray. Supplement with the following:
 - a. Fly Ash: ASTM C 618, Class C or F
 - b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
 - c. No fly ash or ground granulated blast-furnace slag from plant co-fired with hazardous or medical waste or tire derived fuel.
 - d. Silica Fume: ASTM C 1240, amorphous silica.
 - 2. Blended Hydraulic Cement: ASTM C 595, excluding Type IS (≥ 70).
- B. Normal-Weight Aggregate: ASTM C 33, graded, 3/4-inch- (19-mm-) nominal maximum coarse-aggregate size. Provide aggregate from a single source with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.
 - 1. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- C. Water and Ice: ASTM C 1602/C 1602M.
- D. Chemical Admixtures: Provide admixtures certified by admixture manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
 - 1. Air-Entraining Admixture: ASTM C 260.
 - 2. Water Reducing, Accelerating, and/or Retarding Admixtures: ASTM C 494/C 494M.
 - 3. Plasticizing Admixtures: ASTM C 1017/C 1017M.
 - 4. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.
 - a. Available Products:
 - 1) Cortec Corporation; MCI 2000.
 - 2) Grace Construction Products, W. R. Grace & Co.; DCI-S.
 - 3) Master Builders, Inc.; Rheocrete 222+.
 - 4) Sika Corporation; FerroGard-901.
 - 5. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C 494/C 494M, Type C.
 - a. Available Products:
 - 1) Euclid Chemical Company (The); Eucon CIA.
 - 2) Grace Construction Products, W. R. Grace & Co.; DCI.
 - 3) Master Builders, BASF Construction Chemicals, LLC; Rheocrete CNI.

4) Sika Corporation; Sika CNI.

- E. Sand-Cement Grout: Portland cement, ASTM C 150, Type II; clean natural sand, ASTM C 404; and water to result in grout with a minimum 28-day compressive strength of 1000 psi (6.9 MPa), of consistency required for application.

2.6 STEEL CASINGS

- A. Steel Pipe Casings: ASTM A 283/A 283M, Grade C, or ASTM A 36/A 36M, carbon-steel plate, with joints full-penetration welded according to AWS D1.1/D1.1M.
- B. Corrugated-Steel Pipe Casings: ASTM A 929/A 929M, steel sheet, zinc coated.
- C. Liners: Comply with ACI 336.1.

2.7 SLURRY

- A. Slurry: Pulverized bentonite, pulverized attapulgite, or polymers mixed with water to form stable colloidal suspension; complying with ACI 336.1 for density, viscosity, sand content, and pH.

2.8 CONCRETE MIXTURES

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data according to ACI 301, to meet requirements herein and to meet durability requirements based on exposure classes according to ACI 318 (ACI 318M).
1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.
 2. Each combination of material proposed for use shall have separate backup documentation, except accelerating admixture or retarding admixture use can be provided without separate backup documentation.
 3. Slump, air content, and maximum allowable chloride-ion content limits of ACI 301 do not apply.
- B. Contractor, Installer, and Manufacturer shall coordinate to provide concrete mixtures that meet the minimum requirements indicated in this Article in hardened concrete at completion of Project.
- C. Contractor, Installer, and Manufacturer shall coordinate to establish properties of fresh concrete to facilitate placement and finishing with minimal segregation and bleeding. Factors shall include, but are not limited to, slump or slump flow, set time, method of placement, rate of placement, hot and cold weather placement, curing, and concrete temperature.
- D. Cementitious Materials: Use fly ash, pozzolan, and ground granulated blast-furnace slag as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 50 percent.
1. Minimum cementitious materials content requirements for floors from ACI 301 do not apply.
 2. Limit percentage, by weight, of cementitious materials other than portland cement in concrete subject to exposure class F3 according to ACI 318 (ACI 318M).
- E. Admixtures: Use admixtures according to manufacturer's written instructions and the following.

1. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 2. Use corrosion-inhibiting admixture in concrete designated as exposure class C2.
- F. The minimum compressive strength at the age indicated shall be the higher of:
1. The value for structural design loads indicated.
 2. The value required for durability based on exposure classes according to ACI 318 (ACI 318M).
- G. Proportion normal-weight concrete mixture as follows:
1. Minimum Compressive Strength for Loads: 4000 psi (27.6 MPa) at 28 days.
 2. Exposure Classifications: See General Notes.

2.9 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI MSP

2.10 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and furnish batch ticket information.
1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 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

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by drilled pier operations.

3.2 EXCAVATION

- A. Unclassified Excavation: Excavate to bearing elevations regardless of character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.
1. Obstructions: Unclassified excavation may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. No changes in the Contract Sum or the Contract Time will be authorized for removal of obstructions.
 2. Obstructions: Unclassified excavated materials may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. Payment for removing obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work will be according to Contract provisions for changes in the Work.
- B. Classified Excavation: Excavation is classified as standard excavation, special excavation, and obstruction removal and includes excavation to bearing elevations as follows:

1. Standard excavation includes excavation accomplished with conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work.
 2. Special excavation includes excavation that requires special equipment or procedures above or below indicated depth of drilled piers where drilled pier excavation equipment used in standard excavation, operating at maximum power, torque, and downthrust, cannot advance the shaft.
 - a. Special excavation requires use of special rock augers, core barrels, air tools, blasting, or other methods of hand excavation.
 - b. Earth seams, rock fragments, and voids included in rock excavation area will be considered rock for full volume of shaft from initial contact with rock.
 3. Obstructions: Payment for removing unanticipated boulders, concrete, masonry, or other subsurface obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work will be according to Contract provisions for changes in the Work.
- C. Prevent surface water from entering excavated shafts. Conduct water to site drainage facilities.
- D. Excavate shafts for drilled piers to indicated elevations. Remove loose material from bottom of excavation.
1. Excavate bottom of drilled piers to level plane within 1:12 tolerance.
 2. Remove water from excavated shafts before concreting.
 3. Excavate rock sockets of dimensions indicated.
 4. Cut series of grooves about perimeter of shaft to height from bottom of shaft, vertical spacing, and dimensions indicated.
- E. Do not allow an excavated shaft to remain open for more than 12 hours or overnight without placing concrete in the shaft.
- F. Notify and allow Owner's Testing and Inspecting Agency to test and inspect bottom of excavation. If unsuitable bearing stratum is encountered, make adjustments to drilled piers as determined by Owner's Testing and Inspecting Agency.
1. Do not excavate shafts deeper than elevations indicated unless approved by Architect.
 2. Payment for additional authorized excavation will be according to Contract provisions for changes in the Work.
- G. End-Bearing Drilled Piers: Probe with auger to a depth below bearing elevation, equal to two times the diameter of the bearing area of drilled pier. Determine whether voids, clay seams, or solution channels exist.
1. Test first three drilled piers and one of every six drilled piers thereafter.
 2. Fill auger-probe holes with grout.
- H. End-Bearing Drilled Piers: Probe with auger to a depth of two times the diameter below bottom elevation of shaft, and visually inspect and classify soil. Verify continuity and thickness of stratum.
1. Test first three drilled piers and one of every six drilled piers thereafter.
- I. Excavate shafts for drilled piers spaced closer than 10 feet (3 m) and for drilled piers occurring in fragile or sand strata only after adjacent drilled piers are filled with concrete and allowed to set.
- J. Slurry Displacement Method: Stabilize excavation with slurry maintained a minimum of 60 inches (1500 mm) above ground-water level and above unstable soil strata to prevent caving or sloughing of shaft. Maintain slurry properties before concreting.

1. Excavate and complete concreting of drilled pier on same day if possible, or redrill, clean, and test slurry in excavation before concreting.
 2. Clean bottom of each shaft before concreting.
- K. Temporary Casings: Install watertight steel casings of sufficient length and thickness to prevent water seepage into shaft; to withstand compressive, displacement, and withdrawal stresses; and to maintain stability of shaft walls.
1. Remove temporary casings, maintained in plumb position, during concrete placement and before initial set of concrete.
- L. Bells: Excavate bells for drilled piers to shape, base thickness, and slope angle indicated. Excavate bottom of bells to level plane and remove loose material before placing concrete.
1. Shore bells in unstable soil conditions to prevent cave-in during excavation, inspection, and concreting.

3.3 PERMANENT STEEL CASINGS

- A. Install steel casings where indicated of minimum wall thickness indicated and of diameter not less than diameter of drilled pier.
1. Install casings as excavation proceeds, to maintain sidewall stability.
 2. Fabricate bottom edge of lowest casing section with cutting shoe capable of penetrating rock and achieving water seal.
 3. Connect casing sections by continuous penetration welds to form watertight, continuous casing.
 4. Remove and replace or repair casings that have been damaged during installation and that could impair strength or efficiency of drilled pier.
 5. Fill annular void between casing and shaft wall with grout.
- B. Corrugated-Steel Casings: Provide corrugated-steel casings formed from zinc-coated steel sheet.
1. Corrugated casings may be delivered in sections or panels of convenient length and field connected according to manufacturer's written instructions.

3.4 STEEL REINFORCEMENT

- A. Comply with recommendations in CRSI MSP for placing and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
- C. Fabricate and install reinforcing cages symmetrically about axis of shafts in a single unit.
- D. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover over reinforcement using centralizers. Do not tack weld crossing reinforcing bars.
1. Weld reinforcing bars according to AWS D1.4/D1.4M, where indicated.
- E. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
1. Install anchor rods, accurately located, to elevations required, and complying with tolerances in Section 7.5 of AISC 303.

- F. Protect exposed ends of extended reinforcement, dowels, or anchor rods from mechanical damage and exposure to weather.
- G. Field bending of reinforcement is not permitted except where specifically indicated.
- H. Epoxy-Coated Reinforcement: Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M. Use epoxy-coated steel wire ties to fasten epoxy-coated steel reinforcement.
- I. Zinc-Coated Reinforcement: Repair cut and damaged zinc coatings with zinc repair material according to ASTM A 780. Use galvanized steel wire ties to fasten zinc-coated steel reinforcement.

3.5 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.
- B. Do not add water to concrete during delivery, at Project site, or during placement.
 - 1. Do not place concrete in the rain.
- C. Concrete slurry mix used to prime or clean concrete pump shall not be placed into the Work unless slurry design mixture has been submitted and approved.
- D. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by Owner's Independent Testing and Inspecting Agency.
 - 1. Construct a construction joint if concrete placement is delayed more than one hour. Level top surface of concrete and insert joint dowel bars. Before placing remainder of concrete, clean surface laitance, roughen, and slush concrete with commercial bonding agent or with sand-cement grout mixed at ratio of 1:1.
- E. Dry Method: Place concrete to fall vertically down the center of drilled pier without striking sides of shaft or steel reinforcement.
 - 1. Where concrete cannot be directed down shaft without striking reinforcement, place concrete with chutes, tremies, or pumps.
 - 2. Vibrate top 60 inches (1500 mm) of concrete.
- F. Slurry Displacement Method: Place concrete in slurry-filled shafts by tremie methods or pumping. Control placement operations to ensure that tremie or pump pipe is embedded no fewer than 60 inches (1500 mm) into concrete and that flow of concrete is continuous from bottom to top of drilled pier.
- G. Coordinate withdrawal of temporary casings with concrete placement to maintain at least a 60-inch (1500-mm) head of concrete above bottom of casing.
 - 1. Vibrate top 60 inches (1500 mm) of concrete after withdrawal of temporary casing.
- H. Screed concrete at cutoff elevation level and apply scoured, rough finish. Where cutoff elevation is above the ground elevation, form top section above grade and extend shaft to required elevation.
- I. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When average high and low temperature is expected to fall below 40 deg F (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
 2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
- J. Hot-Weather Placement: Comply with ACI 305.1 and as follows:
1. Maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Place concrete immediately on delivery. Keep exposed concrete surfaces and formed shaft extensions moist by fog sprays, wet burlap, or other effective means for a minimum of seven days.

3.6 TOLERANCES

- A. Construct drilled piers to remain within ACI 336.1 tolerances.
1. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit design and construction proposals to Architect for approval before proceeding.

3.7 FIELD QUALITY CONTROL

- A. Testing and Inspecting: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Special Inspections:
1. Observe drilling operations and maintain complete and accurate records for each pier: Continuous.
 2. Verify placement locations and plumbness, confirm pier diameters, bell diameters if applicable, lengths, embedment into bedrock if applicable, and adequate end bearing strata capacity: Continuous.
 3. Formwork for shape, location, and dimensions: Periodic.
 4. Steel reinforcement grade, size, number, length, lap length, lap location, bend location, cover, and support: Periodic.
 5. Steel reinforcement welding: Periodic.
 6. Verification of use of required design mixture: Periodic.
 7. Concrete placement, including conveying and depositing: Continuous.
 8. Inspection results shall be reported in Adobe PDF format, with each file being uniquely named, to authorities having jurisdiction, Architect, Contractor, and Installer within 48 hours of inspection. Specifically indicate items that are in non-compliance with the requirements of the Contract Documents.
- C. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
1. Testing Frequency: Obtain one composite sample for each drilled pier but not more than one sample for each truck load.
 - a. When frequency of testing will provide fewer than five strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143/C 143M; one test at point of discharge for each compressive-strength test but no fewer than one test for each concrete load. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method, for normal-weight concrete; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and 80 deg F (27 deg C) and above, and one at test at point of discharge for each set of compressive-strength specimens.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure three 6 by 12-inch cylinder specimens or five 4 by 8-inch cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one laboratory-cured 6 by 12-inch specimen or two laboratory-cured 4 by 8-inch specimens at 7 days and one set of two 6 by 12-inch specimens or one set of three 4 by 8-inch specimens at age required for concrete class.
7. Acceptance of Concrete Strength:
 - a. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa) where the specified minimum compressive strength is 5000 psi (34.5 MPa) or less, or by more than 10 percent of the specified minimum compressive strength when the specified minimum compressive strength is more than 5000 psi (34.5 MPa).
 - b. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
8. Test results shall be reported in Adobe PDF format, with each file being uniquely named, to Architect, Contractor, Installer, and Manufacturer within 48 hours of testing. Reports shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design requirements, concrete mixture proportions and materials, field test results, and compressive breaking strength and type of break for both 7-day tests and tests at age required for concrete class. Specifically indicate items that are in non-compliance with the requirements of the Contract Documents.

D. Pile Tests:

1. Perform low strain impact integrity testing on all drilled piers in accordance with ASTM D 5882.
2. Perform Tension, Compression, and Lateral testing in accordance with ASTM D3689, D1143, and D3966 on a minimum of 1 of each pier type indicated to be installed by the contract documents.
3. Testing shall not be performed until the concrete has cured for a minimum of 7 days.
4. Test results shall be reported in Adobe PDF format, with each file being uniquely named, to Architect, Contractor, and Installer within 48 hours of testing. Specifically indicate items that are in non-compliance with the requirements of the Contract Documents.

E. A report for each drilled pier will be prepared by Owner's Testing and Inspecting Agency as follows:

1. Actual top and bottom elevations.
2. Actual drilled pier diameter at top, bottom, and bell.
3. Top of rock elevation.
4. Description of soil materials.
5. Description, location, and dimensions of obstructions.
6. Final top centerline location and deviations from requirements.

7. Variation of shaft from plumb.
 8. Shaft excavating method.
 9. Dates, locations and results of all load and integrity testing.
 10. Design and tested bearing capacity of bottom.
 11. Depth of rock socket.
 12. Levelness of bottom and adequacy of cleanout.
 13. Properties of slurry and slurry test results at time of slurry placement and at time of concrete placement.
 14. Ground-water conditions and water-infiltration rate, depth, and pumping.
 15. Description, purpose, length, wall thickness, diameter, tip, and top and bottom elevations of temporary or permanent casings. Include anchorage and sealing methods used and condition and weather tightness of splices if any.
 16. Description of soil or water movement, sidewall stability, loss of ground, and means of control.
 17. Bell dimensions and variations from original design.
 18. Date and time of starting and completing excavation.
 19. Inspection report.
 20. Condition of reinforcing steel and splices.
 21. Position of reinforcing steel.
 22. Concrete placing method, including elevation of consolidation and delays.
 23. Elevation of concrete during removal of casings.
 24. Locations of construction joints.
 25. Concrete volume.
 26. Concrete testing results.
 27. Remarks, unusual conditions encountered, and deviations from requirements.
- F. Prepare drilled pier survey indicating as-built location of pier centerlines and elevation of top of drilled pier.
- G. Non-Conforming Work
1. An excavation, concrete, or a drilled pier will be considered defective if it does not pass tests and inspections.
 2. Additional Tests: Testing and inspecting agency will make additional tests of concrete if test results indicate that slump, compressive strengths, or other requirements have not been met, as directed by Architect.
 - a. Continuous coring of drilled piers may be required, at Contractor's expense, if temporary casings have not been withdrawn within specified time limits or if observations of placement operations indicate deficient concrete quality, presence of voids, segregation, or other possible defects.
 3. Correct deficiencies in the Work, at Contractor's expense, that test reports and inspections indicate does not comply with the Contract Documents. Re-inspection and re-testing shall be at Contractor's expense.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION