

Special Specification 4089

Augered Cast-In-Place Piles



1. DESCRIPTION

Construct augered cast-in-place piles of the size and locations shown on the plans.

An augered cast-in-place (ACIP) pile is defined as any foundation constructed by excavating soil or rock with the continuous insertion and rotation of a continuous flight auger into the ground to a specified depth, followed by pumping of fluid grout under pressure through the hollow stem of the auger to a port at the bottom of the auger, where it is injected into the excavation as the auger is withdrawn. Reinforcing steel, if specified, is inserted into the column of fluid grout following the completion of the grout placement.

2. MATERIALS

Use materials that meet the requirements of the following items.

- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"

2.1. **Grout.** Furnish Portland cement conforming to current ASTM standards, designation C150.

Furnish mineral admixtures conforming to ASTM C618, Class C or Class F. If used, mineral admixtures may consist of Fly Ash or Natural Pozzolan.

Furnish chemical admixtures conforming to ASTM C494 which may consist of, but are not limited to, water reducers or set retarders.

Furnish grout fluidifier conforming to ASTM C937.

Furnish sand, when utilized as fine aggregate, conforming to ASTM C33.

2.2. **Grout Mix Design.** Provide grout consisting of a mixture of Portland cement, fine aggregate, and water, and may also contain a mineral admixture and approved fluidifier so that the grout will exhibit the following properties:

- Maintains solids in suspension without appreciable water gain.
- Has a fluid consistency represented by an efflux time of 10 to 25 seconds per quart when tested using a flow cone with a 0.75-in.-Diameter outlet orifice in accordance with ASTM C 939, unless otherwise specified by the Engineer.
- Does not exhibit shrinkage in excess of 0.015 percent in the vertical direction, when tested in accordance with ASTM C 1090, when stored in a 100 percent humidity room at a temperature of 68 to 73 degrees F.
- Samples of the field grout mix, recovered and stored in cylinders 6 in. in diameter by 12 in. long, should exhibit a minimum compressive strength of at least 4,000 psi by 28 days after casting, or as otherwise specified by the Engineer. Alternatively, 2-in. cube samples may be recovered and tested 28 days after sampling. If cubes are used, the minimum allowable compressive strength 28 days after sampling is at least 4,400 psi.

Measure materials used to make the grout accurately by volume or weight before they are fed into the mixer, whether in the field or at the batch plant. Place the material into the mixer in the following order: (1) water, (2) admixtures, and (3) other solids in order of increasing particle size.

The admixtures may also be added at the jobsite. If that process is followed, mix the material in the following order: (1) water, (2) other solids in order of increasing particle size, and (3) admixtures (at the jobsite).

The minimum time of mixing is one minute at the jobsite. If agitated continuously, the grout may be held in the mixer or ready-mix truck for up to 2.5 hours if the air temperature is not greater than 70 degrees F or up to 2.0 hours if the air temperature is between 70 and 100 degrees F. Do not place grout if the air temperature exceeds 100 degrees F or is less than 40 degrees F.

- 2.3. **Reinforcing.** Furnish reinforcing bars, if required, conforming to ASTM A615, Gr 60.

3. EQUIPMENT

Only use pumping equipment approved by the Engineer to mix and handle the grout. Remove oil, rust inhibitors, residual drilling slurries, and other foreign materials from the mixing drums, stirring devices, pumps and lines, and other equipment in contact with grout before use.

Use a screen with a mesh with openings no larger than 0.75 in. between the mixer and the pump, or between the delivery point from a ready-mix truck and the pump, to remove large particles or cement clumps that can clog the grout injection system.

- 3.1. **Grout pump.** Provide a grout pump with positive displacement with a known volume per stroke that is capable of developing peak pressure of at least 350 psi at the pump.

Provide a grout pump equipped with, as a minimum, a calibrated pressure gauge that can accurately monitor both the peak and minimum pressures on each pump stroke. Position the pressure gauge on the immediate outlet side of the pump at ground level in such a manner that it can be easily viewed by the Engineer. The foundation contractor is to provide the Engineer with the results of a calibration performed on the pressure gauge at the beginning of the project that will demonstrate that the value indicated by the pressure gauge is within 3 percent of the actual pressure. The foundation contractor will also provide the Engineer with the volume of grout delivered by each stroke of the pump and will demonstrate to the Engineer that the actual volume of grout delivered is within 3 percent of the value provided. Recalibrate the equipment at any time, if the Engineer suspects that the grout delivery performance has changed.

- 3.2. **Auger Equipment.** Provide auger flights that are continuous from the top of the auger to the bottom tip of the cutting face of the auger, with no gaps or other breaks. The length of any auger brought to the jobsite should be such that the auger is capable of excavating a hole for the pile, and transporting grout to the bottom of the hole that is 20 percent greater than the largest depth of the pile shown on the plans. Provide auger flights that are uniform in diameter throughout the auger's length. Provide an auger with an outside diameter not be less than 3 percent smaller than the specified diameter of the pile. Only use single helix augers. The distance between flights should be approximately one-half the diameter of the auger. Maintain the hollow stem of the auger in a clean condition throughout the construction operation.

Construct the bottom of the auger flights and the attached cutting teeth so that the bottom of the excavation is flat.

In order to facilitate inspection, clearly mark the auger every 1 ft along its length so that such markers are visible to the unaided eye from the ground.

Locate the grout outlet orifice on the auger at an elevation lower than that of the cutting teeth on the bottom of the auger. Maintain the orifice closed by utilizing a plug while the auger is being advanced into the ground. Remove the plug by pressure from the orifice once grouting begins.

Guide the auger at the ground surface by a suitable guide connected to the leads of the ACIP piling rig. Place a guide approximately one-half the length of the auger above the ground surface guide, unless otherwise permitted by the Engineer. Restrain the leads that carry the rotary unit that powers the auger against rotation by an appropriate mechanism.

Establish the auger penetration rate(s) as part of the project specific test or indicator pile program as a function of stratigraphy, auger pitch, applied crowd, and applied torque.

Advance the auger into the ground at a continuous rate and at a rate of rotation that prevents excess spoil from being removed from the lateral area beyond the auger flights and transported to the ground surface. Stop the rotation of the auger when the excavation reaches plan depth.

Should refusal be encountered before plan depth is achieved, stop the rotation of the auger, and inform the Engineer. Refusal is defined as the rate of auger penetration of less than 1 foot per minute with equipment that is appropriate for the job. Proceed as directed.

4. CONSTRUCTION

4.1. **Qualification.** At least 30 days before starting the work, provide the Engineer documentation of successful installation of ACIP piles under similar subsurface and job conditions. Provide the Engineer documentation that the designated jobsite supervisor has had a minimum of 5 years of experience in the installation of ACIP piles. Alternatively, the foundation contractor may demonstrate competence to perform the work shown on the plans by installing a demonstration pile to the depth and diameter of the largest pile on the project and proving the pile's capacity by means of integrity tests or load tests, as approved by the Engineer.

4.2. **ACIP Pile Construction Plan.** Submit an ACIP pile construction plan at least 30 days before beginning construction. Begin ACIP pile construction once the construction plan submittal is accepted. Provide detailed project-specific information in the ACIP pile construction plan that includes the following:

- Project start date, an overall description, and sequence of the ACIP pile construction;
- List and sizes of proposed equipment, including cranes, augers, grout pumps, mixing equipment, and other equipment to be used in construction, including details of procedures for calibrating pressures and volumes of grout pumps.
- Mix design and description of materials for the grouts to be used on the project.
- Details of reinforcement placement, including support for reinforcing cages at the top of the pile and methods for centering the cages within the grout column.
- A pile identification plan referenced to the structural plans showing the location and a numbering system for identifying each individual pile.
- If pile load tests are specified, submit a dimensioned sketch of the loading arrangement, including sizes of primary members, data on testing and measuring equipment including required current jack, dial gauge, or load cell and monitoring instrumentation calibrations. Include load testing methods, and loading schedule and duration.
- Procedures for monitoring grout pressures while pumping and for monitoring the amount of grout placed in the excavation.
- Procedures for protecting adjacent structures, on or off the right-of-way, which may be adversely affected by foundation construction operations, if required by the Engineer.
- Other information shown on the plans or requested by the Engineer.

Demonstrate to the satisfaction of the Engineer the dependability of the equipment, techniques, and source of materials to be used on the project.

4.3. **Protection of Adjacent Structures.** The Contractor is solely responsible for evaluating the need for, design of, and monitoring of measures to prevent damage to adjacent structures, on or off the right-of-way. These measures include, but are not limited to: selection of construction methods and procedures that will prevent

caving of soils or inward movement of soils into excavations and excessive migration of grout through the ground; monitoring and controlling the vibration from construction activities, including placement of casing, sheet piling, shoring and similar ancillary features; and protecting utilities.

Monitor any structure located within 10 pile diameters clear spacing, or the planned length of the pile, whichever is greater, for vertical and horizontal movements in a manner approved by the Engineer within an accuracy of 0.01 in. Monitoring the adjacent structures will be done by an independent party approved by the Engineer and should begin before constructing piles or installing any casing, sheet piling, shoring, or similar ancillary features. In addition, document the condition of the adjacent structure, including cracks and crack widths, before and after construction of the ACIP piles. Monitor structures owned by the Texas Department of Transportation for movement, but these do not need to be monitored for condition, unless called for on the plans.

- 4.4. **Grout Testing.** Collect six 6-in. diameter by 12-in. long cylinder samples or six 2-in. cube samples for each 50 cubic yards of grout placed, but not less than six such samples per working day, nor less than six such samples for each batch of grout produced by the supplier. Take the grout samples from the ready-mix truck's chute during discharge into the grout pump hopper. Grout samples can be taken out of the auger tip after it is removed from the pile; however, care must be exercised to obtain a representative sample if taken from the top of the completed pile. Make samples more frequently if specified by the Engineer. The samples will be tested by the Texas Department of Transportation (TxDOT) at the following schedule: 2 at seven days after sampling; 2 at 28 days after sampling; and 2 will be held in reserve. Ensure samples tested at 28 days after casting exhibit a minimum compressive strength of at least 4,000 psi for cylinders and 4,400 psi for cubes.

- 4.5. **Excavation.** Perform the excavation required for the piling, through whatever materials encountered, to the size and elevations shown on the plans.

Place center of piling to be within 1 in. of the location shown on the plans. Ensure vertical piles are plumb within two percent. Install battered piles within four percent of the specified incline as determined by the angle from vertical. Any piling in violation of these tolerances will be subject to review by the Engineer.

Should muck, organics, soft clay, or other unsuitable materials be encountered within 5 ft of the ground surface, remove the material to its full depth, or to a depth of 5 ft, whichever is less, and laterally to a distance radially from the centerline of the pile not to exceed three pile diameters or half the distance to the closest adjacent pile, whichever is less. Fill the excavation with soil having a plasticity index between 7 and 20. Compact the backfill to at least 95 percent of maximum dry density as specified by Tex-114-E at moisture content within 2 percent of optimum. Complete the excavation of unsuitable material and backfilling to the Engineer's satisfaction before constructing ACIP piles. If more than 5 ft of unsuitable surface material is encountered, notify the Engineer immediately and proceed with work as directed. Should the Contractor suspect that any soils that are excavated are contaminated by hydrocarbons, refuse, or other environmentally hazardous material, notify the Engineer immediately and proceed with work as directed.

Do not install adjacent piles within six diameters, center to center, of each other until the Contractor can demonstrate that the grout in the first pile installed is fully set.

- 4.6. **Grout Placement.** Begin placing of grout within 5 minutes after the auger has achieved the planned depth. Pump the grout through the hollow stem auger into the excavation with sufficient pressure to completely fill the excavation and any soft or porous zones surrounding the excavation as the auger is withdrawn. Extract the auger at a smooth, steady rate while continuously pumping. If rotation of the auger occurs during extraction, ensure that the rotation is positive (i.e. in the same direction as during drilling). Continually maintain a head of fluid grout of at least 5 ft. above the grout orifice on the auger. Only use approved pumping equipment. Ensure the pump is a positive displacement pump capable of developing displacement pressures at the pump of not less than 350 psi. Equip the pump with a pressure gauge in clear view of the equipment operator and inspector. Calibrate the pump at the beginning of the work to determine the volume of grout pumped per stroke. Ensure the pile contractor provides a positive method of counting pump strokes. Such methods may include digital or mechanical stroke counters, or other acceptable methods.

Coordinate the rate of grout injection and rate of auger withdrawal from the grout so as to insure that the auger is continuously well submerged in the previously placed grout. Continue pumping the grout under high pressure until the cutting teeth of the auger reach the ground surface and the cutting teeth are visibly immersed in grout when they reach the ground surface. As the auger is withdrawn, the inspector will verify that a sufficient volume of grout has been placed to insure the continuity of the grout pile. Otherwise, the pile will be considered defective. In such a case, inform the Engineer immediately and proceed as directed.

Remove the excavated soil carefully from the vicinity of the completed piling to minimize grout contamination. Sieve the upper 5 ft. of the grout column to remove any soil contamination. Sieve the grout to greater depths if additional contamination is present.

- 4.7. **Surface Cleaning and Protection.** Immediately upon completion of the placement of the fluid grout, remove excess grout and spoil from the vicinity of the top of the excavation and place a suitable, temporary device within the top of the excavation and extending above the ground surface by at least 1 ft., to keep surface spoil from entering the grout column before the grout sets. Following placement of this device, remove any loose soil that has fallen into the grout column with a sieve before the grout begins its initial set. Once the grout has set, remove the temporary device without disturbing the natural soil surrounding the top of the pile.

- 4.8. **Reinforcing Steel.** Furnish the reinforcing steel and any anchor bolts or dowels shown on the plans. Provide reinforcing steel that is free of oil, soil, excessive rust, or deleterious material. Provide reinforcing steel that is free of any permanent distortion, such as bars bent by improper pickup.

Assemble the cages of reinforcing steel, consisting of the longitudinal bars and lateral reinforcement (Spiral or horizontal ties), completely and place as a unit. Where spiral reinforcement is used, tie it to the longitudinal bars at a spacing not to exceed 12 in., unless otherwise shown on the plans. Welding of the lateral reinforcement to longitudinal bars is not permitted unless otherwise shown on the plans.

Do not splice the reinforcing steel except at locations shown on the plans. If the pile is lengthened, extend the longitudinal bars and lateral reinforcement required in the upper portion of the pile to the bottom unless otherwise shown on the plans. Splices should be as close to the bottom of the pile as possible. Splicing by welding is not permitted unless shown on the plans.

Place the reinforcing steel as shown on the plans within the grout column immediately after sieving the grout and before the grout begins to take its initial set. The steel may be lowered into the grout by gravity or pushed gently to final position by the foundation contractor's personnel. Do not vibrate or drive the reinforcing steel into position without the approval of the Engineer.

Center the reinforcing steel in the excavation by means of round, plastic or concrete centralizers placed at sufficient intervals along the length of the cage and around the steel. Centralizers should be spread not greater than 20 ft. for vertical bars/cages, and 10 ft. for bars/cages installed in battered piles. Metallic spacers or spacer blocks are not permitted.

Hold the reinforcing steel in position within the grout column by appropriate supports at the ground surface until the grout reaches a minimum of 50 percent of its design strength or 3 days, whichever occurs first.

- 4.9. **Cutting Off.** Cut off the tops of piles, square with the pile axis at the elevations indicated on the plans, by cutting the hardened grout to the final cutoff point at any time after initial set has occurred.

- 4.10. **Inspection and Record.** Maintain accurate records for each pile constructed. Similar records will be maintained by the Engineer. Include the following in the records:

- Project name and number;
- Pile Contractor;
- Pile location and design pile capacity;
- Pile diameter;
- Ground surface elevation;
- Elevation of top of grout;

- Pile length;
- Pile toe (bottom) elevation;
- Auger diameter;
- Flow cone efflux time and volume of grout placed;
- Theoretical volume of excavation (where diameter = diameter of auger);
- Depth to which reinforcing steel was placed;
- Date/Time of beginning of drilling;
- Date/Time of completion of drilling;
- Date/Time grout was mixed;
- Date/Time ready-mix grout truck arrived onsite;
- Date/Time of beginning of grout pumping;
- Date/Time of completion of grout pumping;
- Date/Time of placement of reinforcing steel;
- Weather conditions, including air temperature, at time of grouting;
- Identification of grout samples taken from pile;
- Other pertinent data relative to the pile installation.

4.10.1. **Automated Monitoring.** Piles that are designated on the plans or as otherwise specified by the Engineer are to be monitored using automated equipment. For such piles, keep the following records and provide a copy to the Engineer.

- Volume of grout placed versus depth of grout orifice for every 2-ft. increment, or less, of pile placed.
- Average maximum and minimum pump stroke pressures at ground level for every 2-ft., or less, of pile placed.
- Average maximum and minimum pump stroke pressures at auger tip for every 2-ft., or less, of pile placed, if directed by the Engineer.

4.11. **Post-Construction Testing.** Post-Installation, structural integrity tests of the piles may be specified. If so, those piles on which such tests are to be conducted and the specific test(s) to be performed will be designated on the plans. Such tests may include, but are not limited to: low-strain pulse echo, sonic logging, and Thermal Integrity Profiling. If such post-installation integrity tests are called for in the plans, the Contractor must engage an independent consultant, acceptable to the Engineer, to perform those tests and to report the results, with interpretations, to the Contractor and the Engineer. Provide access tubes, of a design acceptable to the consultant, to accommodate those tests that require access to the interior of the ACIP pile. Secure the tubes to the reinforcing steel before placing the steel in the fluid grout.

4.12. **Pile Acceptance.** The Engineer will evaluate the available field data and determine the acceptability of the completed piles. The Inspector should provide information regarding any applicable deviations in the pile installation procedures or if the materials furnished are different than those specified. The Engineer will notify the Pile Contractor if a pile is not in conformance with the specification.

4.13. **Unacceptable Piles.** Unacceptable piles are defined as piles that will not carry their intended load within allowable deflections. The following constitute construction conditions that may produce unacceptable piles:

- Piles that are out of position by more than 1 in. at the ground surface or not within the plumbness or batter limits.
- Piles in which the top of grout is more than 1 in. below or 3 in. above the elevation shown on the plans.
- Piles in which the grout volume is less than 115 percent of the theoretical volume of the excavation.
- Piles in which the grout strength is less than required.
- Piles in which the steel was not inserted as required.
- Piles that exhibit any visual evidence of grout contamination, structural damage, or inadequate consolidation (honeycombing).
- Piles that are inspected using post-construction testing methods and judged to be unacceptable by the Engineer.

Unacceptable piles will be replaced or repaired by other structural modifications no cost to the Department and as directed.

- 4.14. **Test Load.** Load test the ACIP piling, if required, in accordance with Item 405, "Foundation Load Test."

5. MEASUREMENT

ACIP piling will be measured by the foot from the top of the grout to the bottom of pile. If load tests are specified, they will be measured as a lump sum per load test.

6. PAYMENT

The work performed and materials furnished in accordance with this item and measured as provided under "Measurement" will be paid for at the unit price bid per linear foot of ACIP piling of the specified diameter, subject to the limitations for overruns authorized by the Engineer given in the Section 6.1., "Overrun."

The unit prices bid for the various classifications of ACIP piling will be full compensation for excavation; furnishing and placing grout, including additional grout required to fill an oversized excavation; furnishing and placing reinforcing steel; backfilling; disposing of cuttings; and materials, tools, equipment, labor, and incidentals. Test-loaded piling and associated anchor piling will be paid for as provided in Item 405, "Foundation Load Test." Any test load ordered by the Engineer that is not provided for in the Contract will be paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

When the bottom of the ACIP pile is placed at an elevation below plan grade, no direct payment will be made for extra reinforcement required. The extra reinforcement will be considered subsidiary to the price bid per foot of ACIP pile. No extra payment will be made for casings or formwork left in place.

If subsurface conditions dictate that any pile is to be installed to a depth less than that shown on the plans and the decrease in length is approved in writing by the Engineer, the length of pile actually constructed will be paid for at the unit price bid.

- 6.1. **Overrun.** Payment for individual completed ACIP piling lengths up to and including 5 ft. in excess of the maximum length piling will be made at the unit price bid per foot of the specified diameter.

Payment for the portion of individual completed ACIP piling length in excess of 5 ft. and up to and including 15 ft. more than the maximum length piling will be paid at a unit price equal to 115% of the unit bid price per foot of the specified diameter.

Payment for the portion of individual completed ACIP piling length in excess of 15 ft. more than the maximum length piling will be made at a unit price equal to 125% of the unit price per foot of specified diameter.