

construction within each substructure bent or footing group. The submittal shall address the Contractor's proposed time delay and/or the minimum concrete strength necessary before initiating a shaft excavation adjacent to a recently installed drilled shaft.

- (3) Shaft Excavation. A site specific step by step description of how the Contractor anticipates the shaft excavation to be advanced based on their evaluation of the subsurface data and conditions expected to be encountered. This sequence shall note the method of casing advancement, anticipated casing lengths, tip elevations and diameters, the excavation tools used and drilled diameters created. The Contractor shall indicate whether wet or dry drilling conditions are expected or if the water table will be sealed from the excavation.
- (4) Slurry Quality Control. When the use of slurry is proposed, details covering the measurement and control of the hardness of the mixing water, agitation, circulation, de-sanding, sampling, testing, and chemical properties of the slurry shall be submitted.
- (5) Shaft Cleaning and Inspection. Method(s) and sequence proposed for the shaft cleaning operation as well as recommendations on how the shaft excavation will be inspected under the installation conditions anticipated.
- (6) Reinforcement Placement. Details of reinforcement placement including cage centralization devices to be used and method to maintain proper elevation and plan location of cage within the shaft excavation during concrete placement. The method(s) of adjusting the cage length if rock is encountered at an elevation other than as shown on the plans.
- (7) Concrete Placement. Details of concrete placement including proposed operational procedures for free fall, tremie or pumping methods. The sequence and method of casing removal shall also be stated along with the top of pour elevation, and method of forming through water above streambed.
- (8) Mix Design. The proposed concrete mix design(s).

The Engineer will evaluate the drilled shaft installation procedure and notify the Contractor of acceptance, need for additional information, or concerns with the installation's effect on the existing or proposed structure(s).

### CONSTRUCTION REQUIREMENTS

**516.05 General.** Excavation for drilled shaft(s) shall not proceed until written authorization is received from the Engineer. The Contractor shall furnish an installation log for each shaft installed. The Contractor shall be responsible for verification of the dimensions and alignment of each shaft excavation as directed by the Engineer.

Unless otherwise approved in the Contractor's installation procedure, no shaft excavation shall be made within four shaft diameters center to center of a shaft with concrete that has a compressive strength less than 1500 psi (10,300 kPa). The site-specific soil strengths and installation methods selected will determine the actual required minimum spacing, if any, to address vibration and blow out concerns.

**516.06 Construction Methods.** The construction of drilled shafts may involve the use of one or more of the following methods to support the excavation during the various phases of shaft drilling, cleaning, and concrete placement dependent on the site conditions encountered. Surface water shall not be permitted to enter the hole.

The following are general descriptions indicating the conditions when these methods may be used.

- (a) **Dry Method.** The dry method consists of drilling the shaft excavation, removing accumulated water and loose material from the excavation, and placing the reinforcing cage and concrete in a predominately dry excavation. This method shall be used only at sites where the groundwater and soil conditions are suitable to permit the drilling and dewatering of the excavation without causing excessive water infiltration, boiling, squeezing, or caving of the shaft side walls. This method allows the concrete placement by tremie or concrete pumps, or if the excavation can be dewatered, the concrete can be placed by free fall within the limits specified for concrete placement according to Article 516.12.
- (b) **Wet Method.** The wet construction method may be used at sites where dewatering the excavation would cause collapse of the shaft sidewalls or when the volume and head of water flowing into the shaft is likely to contaminate the concrete during placement resulting in a shaft defect. This method uses water or slurry to maintain stability of the shaft perimeter while advancing the excavation. After the excavation is completed, the water level in the shaft is allowed to seek equilibrium, the base is cleaned, the reinforcing cage is set, and the concrete is discharged at the base using a tremie pipe or concrete pump, displacing the drilling fluid upwards.
- (c) **Temporary Casing Method.** Temporary casing shall be used when either the wet or dry methods provide inadequate support to prevent sidewall caving or ensure excessive deformation of the hole. Temporary casing may also be used to reduce the flow of water into the excavation to allow dewatering, adequate cleaning, and inspection, or to insure proper concrete placement. Temporary casing left in place may constitute a shaft defect; no temporary casing will be allowed to remain permanently in place without the specific approval of the Engineer.

Before the temporary casing is broken loose, the level of concrete in the casing shall be a minimum of 5 ft (1.5 m) above the bottom of the casing. The casing shall not be broken loose by any method which may cause separation of the concrete. After being broken loose and as the casing is withdrawn, additional concrete shall be added to maintain sufficient head so that water and soil trapped behind the casing can be displaced upward and discharged at the ground surface without contaminating the concrete in the shaft or at the finished construction joint.

- (d) **Permanent Casing Method.** When called for on the plans or proposed as part of the Contractor's accepted installation procedure, the Contractor shall install a permanent casing of the diameter, length, thickness, and strength specified. When permanent casings are used, the lateral loading design requires intimate contact between the casing and the surrounding soils. If the installation procedure used to set the permanent casing results in annular voids between the permanent casing and the drilled excavation, the voids shall be filled with a sand-cement grout to maintain the lateral load capacity of the surrounding soil, as assumed in the design. No permanent casing will be allowed to remain in place beyond the limits shown on the plans without the specific approval of the Engineer. A sand-cement grout mix shall be used to fill any visible gaps, which may exist between the permanent casing and either the drilled excavation or temporary casing.
- (e) **Removable Forms.** When the shaft extends above the streambed through a body of water and permanent casing is not shown, the portion above the streambed shall be formed with removable casings, column forms, or other forming systems as approved by the Engineer. The forming system shall not scar or spall the finished concrete or leave in place any forms or casing within the removable form limits as shown on the plans unless approved as part of the installation procedure. The forming system shall not be removed until the concrete has attained a minimum compressive strength of 2500 psi (17,200 kPa) and cured for a minimum of 72 hours. For shafts extending through water, the concrete shall be protected from water action after placement for a minimum of seven days.

**516.07 Slurry.** If the Contractor proposes to use a method of slurry construction, it shall be submitted with the installation plan. Measures for preventing anomalies from sand fallout shall be included in the plan. During construction, the level of the slurry shall be maintained at a height sufficient to prevent caving of the hole. In the event of a sudden or significant loss of slurry to the hole, the construction of that foundation shall be stopped and the shaft excavation backfilled or supported by temporary casing, until a method to stop slurry loss, or an alternate construction procedure has been approved by the Engineer.

**516.08 Excavation Cleaning and Inspection.** Materials removed or generated from the shaft excavations shall be disposed of according to Article 202.03.

After excavation, each shaft shall be cleaned. The cleaning operation shall result in at least of 50 percent of the base of each shaft having less than 1/2 in. (13 mm) of sediment or debris at the time of concrete placement. The depth of sediment or debris at any place on the base of the shaft shall be a maximum of 1 1/2 in. (38 mm).

Shaft cleanliness shall be determined using the methods as submitted/accepted in the installation procedure.

A shaft excavation shall be overreamed when, in the opinion of the Engineer, the sidewall has softened, swelled, or has a buildup of slurry cake. Overreaming may also be required to correct a shaft excavation which has been drilled out of tolerance. Overreaming may be accomplished with a grooving tool, overreaming bucket, or