

**APPENDIX F**

**Special Provisions for Caving Shafts**

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(All New)  
(Use with the concurrence of Design and Geology)

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**DRILLED SHAFT FOUNDATIONS.**--Drilled shaft foundations having diameter(s) shall conform to the requirements for cast-in-drilled-hole piles of Section 49, "Piling," of the Standard Specifications and these special provisions.

The Contractor shall excavate the drilled shaft through all materials and conditions encountered in conformance with the dimensions shown on the plans and to the tip elevations shown on the plans or ordered by the Engineer.

When caving conditions or ground water is encountered, no further drilling shall be performed until the Contractor has received approval from the Engineer, of his written proposal for constructing the drilled shaft as shown on the plans, specified in the Standard Specifications and these special provisions. Attention is directed to Section 5-1.02, "Plans and Working Drawings" of the Standard Specifications. Construction methods shall be limited to the casing method, the water displacement method the slurry displacement method, and the concrete and drill method. The Contractor's proposed drilled shaft construction method shall include the details for drilling and stabilizing the shaft, the type and capacity of equipment, the quantity and type of construction materials, reinforcing steel fabrication and installation and concrete placement procedures. The Engineer shall be the sole judge as to the acceptability of any such proposed construction method and may disapprove any proposal which in his judgment may not produce a drilled shaft foundation in conformance with the plans and specifications.

The general methods of construction of a drilled shaft in a caving situation or when ground water is encountered are described as follows:

**CONCRETE AND DRILL METHOD.**--The concrete and drill method requires placing a low cement concrete in the caving region of the shaft. The concrete is then drilled out after it has set.

Para. 1 Fill in the diameters of the drilled holes.

**CASING METHOD.**--The casing method uses a metal liner to retain a weak, caving material and/or seal off a water bearing stratum.

**WATER DISPLACEMENT METHOD.**--The water displacement method permits the concrete to be placed under a static head of water. The use of casing may be required to prevent caving of the drilled shaft.

**SLURRY DISPLACEMENT METHOD.**--The slurry displacement method requires drilling and placing concrete through a slurry composed of water and commercial drilling mud (bentonite) in order to prevent caving of the drilled shaft.

**CONCRETE.**--Concrete placed in drilled shafts constructed by the water displacement method and the slurry displacement method shall conform to the following:

Concrete shall contain not less than 658 pounds of cement per cubic yard.

Concrete shall contain admixtures which will retard the set and enhance the flow characteristics of the mix.

Concrete shall have a nominal penetration of 3 to 4 inches.

Concrete shall be placed with a concrete pump and delivery tube system sized to maintain the minimum required concrete placement rate. The pump shall be capable of maintaining a concrete head of 15 feet at the tip of the delivery tube and the tip of the delivery tube shall be maintained at the bottom of the drilled shaft or at least 10 feet below the top surface of the concrete throughout the placement operations.

Concrete shall be placed as soon as possible after the excavation is complete and the steel reinforcing cage is placed, and within 24 hours of the completed shaft excavation. Concrete shall be placed at a minimum continuous rate of 20 linear feet of pile per hour. The concrete shall be placed simultaneously and with approximately equal discharge rates at three equally spaced locations near the perimeter of the shaft. The Contractor shall provide concrete placing equipment and schedule concrete delivery to ensure the minimum placement rate. Unless otherwise approved by the Engineer, concrete shall not be vibrated.

**REINFORCING STEEL.**--The reinforcing steel cage shall be completely fabricated prior to installation in the shaft and shall be equipped with devices to keep the cage straight, plumb and centered in the hole.

Internal bracing and centering devices shall prevent racking and distortion of the steel cage and shall maintain the straightness, plumbness and concentricity of the steel cage in the plan location. At a minimum, the reinforcing steel cage shall be supported at 2 foot spacing around the perimeter or at the quarter points, whichever yields the most support points, and at a maximum 15 feet spacing along the length. Additional supports may be required as determined by conditions in the field. The supports shall be attached in such a manner to prevent their rotation or movement out of position when the reinforcing steel cage is placed into the shaft. Internal bracing shall not occupy an area 12 inches in diameter in the center of the cage. The reinforcing steel cage shall be carefully placed within the drilled shaft in order to prevent gouging of the sides.

The reinforcing steel cage shall be secured to prevent upward or downward displacement. The maximum allowable displacement shall be 2 inches per 20 foot length of reinforcing cage or 4 inches maximum. The required splice and embedment length of the reinforcing bars shall be maintained irrespective of the reinforcing cage displacement.

- Para 9e. Delete the third sentence when the drilled shafts are less than 6 foot in diameter.
- Para 11. Delete the fifth sentence when the diameters of the drilled shafts are 6 foot or greater..

CASING.--The casing shall be steel of sufficient strength to withstand installation stresses, stresses due to lateral concrete and earth pressures and be water tight. The outside diameter of the casing shall be not less than the specified diameter of the shaft and the casing shall be smooth, clean and free from hardened concrete.

The casing shall be removed during concrete placement unless otherwise permitted by the Engineer. A minimum head of concrete shall be maintained above the bottom of the casing as it is removed to ensure that the concrete does not adhere to the casing, fills all voids behind the casing and displaces all drilling mud and caving foundation materials.

SLURRY.--The slurry shall be commercial quality bentonite normally used in drilling operations. The consistency of the bentonite slurry shall be such as to prevent caving of the drilled shaft during excavation, reinforcing steel installation, and concrete placement and shall conform to the following requirements:

Specific gravity	1.02 - 1.20	Mud density balance.
Funnel Viscosity	20 - 43 Sec	Marsh Funnel
Shear Strength	5.8 x 10 <sup>-4</sup> lb/in <sup>2</sup> to 20.3 x 10 <sup>-4</sup> lb/in <sup>2</sup>	Shearometer
pH	9.5 to 12	pH indicator Paper strips

Test samples shall be taken near the bottom of the shaft. Sampling and testing shall be performed by the Contractor. The results of the tests shall be made available to the Engineer, for his approval, before concrete may be placed.

The slurry shall be desanded and/ or recirculated prior to and continuously during placement of concrete. Recirculating shall remove settled sand, gravel and drill cuttings from the slurry located near the bottom of the drilled shaft and either uniformly distribute them throughout the slurry or remove them before discharging the slurry back into the shaft. Recirculating methods shall not cause the sides of the shaft to slough or cave nor cause mingling of the concrete and slurry.

The level of slurry shall be maintained in the shaft at or near ground surface during the drilling operation and the placing of the concrete.

The slurry shall become the property of the Contractor and shall be disposed of outside the highway right of way in accordance with Section 7.1.13 of the Standard Specifications.

**DRILLING.**--The vertical axis of the drilled shaft shall be not more than 1 1/2 inches in 10 feet off of plumb.

Drilling equipment shall be constructed and operated such that free passage of slurry is provided around the drilling head during its insertion and removal from the hole to the extent that scouring or caving will not occur.

Prior to the placement of the reinforcing steel cage, the Contractor shall demonstrate to the satisfaction of the Engineer that the base of the drilled shaft is free of all debris.

**INSPECTION.**--The Contractor shall furnish and install 2-inch inside diameter PVC pipes in drilled shafts excavated using the water displacement method and slurry displacement method, for the full length of drilled shafts plus 2 feet minimum clear at the pile cutoff. The pipe shall be joined with glued couplers to provide a clean, dry and unobstructed 2-inch diameter clear opening from the cutoff elevation to the shaft tip. The pipe shall be securely tied to provide an opening that will pass a 1.90 inch diameter rigid cylinder 2 foot long after the pile concrete is placed. The pipe shall be capped top and bottom. The PVC inspection pipes shall be spaced at a maximum of 2 foot 9 inches around the inside perimeter of the reinforcing steel cage or a minimum of two per shaft, whichever produces the most inspection pipes. Piles containing pipes not capable of passing the required 2 foot long cylinder shall be core drilled by the Contractor at his expense.

Determination of the structural adequacy of piles constructed using the water displacement and slurry displacement method will be made by the Engineer based upon field inspection and gamma ray inspection and/or core drilling. In the event that gamma ray scatter inspection or core drilling discloses voids or discontinuities in the quality of concrete of a pile which, in the judgment of the Engineer, indicates that the pile is not structurally adequate, the pile shall be rejected and construction of additional piles shall be suspended. Such rejection shall prevail until the Contractor, at his expense, repairs, replaces or supplements the defective pile, and the Engineer approves the remedial work. Suspension of pile construction shall remain in effect until written changes to the methods of pile construction are approved by the Engineer.

At his option, the Contractor may core drill any rejected pile to investigate the location and extent of defective work. Core drilling findings shall be available to the Engineer during analysis of the Contractor's proposed remedial work. Said core drilling shall be conducted at the Contractor's expense.

Gamma ray testing will be performed by the Engineer without cost to the Contractor. The Engineer will perform the testing within 10 working days after the completion of a drilled shaft foundation (Column or footing).

The Contractor's attention is directed to the safety criteria within the area of gamma ray testing. Unauthorized personnel will not be allowed within the area where said tests are being conducted.

All core drilled holes and PVC pipes shall be filled with grout after testing.

Full compensation for all loss or damage that the Contractor may sustain by reason of delays to his operations in connection with the pile tests and for filling core drilled holes and PVC pipe with grout shall be considered as included in the contract prices paid for drilled shaft foundations.

MEASUREMENT AND PAYMENT.--Drilled shaft foundations will be measured by the linear foot from the tip elevation shown on the plans, or the tip elevation ordered by the Engineer to the plane of shaft cut-off for the drilled shaft diameter designated in the Engineer's Estimate

The contract price paid per linear foot for drilled shaft foundations (irrespective of the method of construction) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in drilling holes, disposing of the material resulting from drilling holes, casing holes and removing water when necessary, slurry testing, furnishing and placing concrete, complete in place, as shown on the plans and as specified in these specifications and the special provisions, and as directed by the Engineer.

Bar reinforcing steel placed in the drilled shaft foundations will be measured and paid for as bar reinforcing steel (bridge).