

ITEM 411

DRILLED SHAFT FOUNDATIONS

- 411.1 Description. This specification shall govern for the construction of foundations consisting of reinforced concrete shafts or columns with or without bell type concrete footings. Concrete shafts shall be placed in drilled excavations when the shafts are without bell type footings and in drilled or underreamed excavations when shafts are with bell type footings. Such foundations shall be constructed in accordance with this specification and in conformance with the details and governing dimensions shown on the plans.
- 411.2 Materials. All concrete materials shall be in accordance with the Item "Structural Concrete" and the requirements herein. Concrete shall be Class A1 or A2, but where casing is used, concrete shall be Class A1. The maximum size coarse aggregate shall be 1 1/2-inches or as specified for cased shafts. A retarder or water reducing agent will be required in all concrete when casing is used, or when shafts are placed in water. Reinforcing steel shall conform to the requirements of the Item, "Reinforcing Steel". The size and dimensions shall be as shown on the plans. Welding shall be in accordance with the Item, "Structural Welding".
- 411.3 Construction Methods
- A. Excavation. The plans indicate the expected depths and elevations where satisfactory bearing material will be encountered.
- The contractor shall perform the excavation required for the shafts and bell footings, through whatever materials encountered, to the dimensions and elevations shown on the plans or required by the site conditions. If satisfactory material is not encountered at plan elevation, the bottom of the shaft will be adjusted, or the foundation altered, as determined by the Design Engineer, to satisfactorily comply with design requirements.
- Shaft vertical plumbness alignment shall be within a tolerance of one inch per ten feet of depth. Center of shaft located under column or footing, 1 inches of horizontal plan position.
- Where caving conditions and/or excessive groundwater is encountered, no further drilling will be allowed until a construction method is employed which will prevent excessive caving.
- Do not excavate a shaft within two and half (2.5) shaft diameters (clear) of an open shaft excavation, or one in which concrete has been placed in the preceding 24 hours.
- Casing will be required when necessary to prevent caving of material or when necessary to exclude ground water. Casing shall be metal that is water tight, and of ample strength to withstand

handling stresses from the pressure of concrete, the surrounding earth and backfill materials.

When casing is required, the outside diameter of the casing shall not be less than the specified diameter of shaft.

If the elevation of the top of shaft is below ground level at the time of concrete placement, an oversize surface casing from ground elevation to a point below the top of the shaft may be required to control caving of any material into the freshly placed concrete.

When casing is used, it shall be smooth, clean and free of accumulations of hardened concrete.

Under normal operations, the removal of the casing shall not be started, until all concrete placements are completed in the shaft. When unusual conditions warrant, the casing may be pulled in partial stages. Maintain sufficient head of concrete in the casing at all times during the withdrawal, a minimum of 6-foot head of concrete shall be maintained at all times above the bottom of the casing to overcome hydrostatic pressure. Casing extraction shall be at a slow, uniform rate with the pull in line with vertical axis of the shaft.

Do not use casing other than surface casing. Do not use surface casing longer than 20 ft. without approval of Design Engineer.

Do not leave any casing in place unless authorized by design Engineer or as shown on the plan.

When the plans indicate that skin friction design has been used, any casing used will not be permitted to remain in place unless otherwise noted on the plans or permitted by written authorization of Design Engineer.

Bells shall be excavated to form a bearing area of the size and shape shown on the plans. Bell shapes varying slightly from those shown on the plans are permissible provided the bearing area equals that specified.

Bells shall be excavated by mechanical methods. Blasting shall not be permitted.

Material excavated from shafts and bells, including drilling mud shall not be used in the backfill around the completed bents or piers and shall be disposed by contractor in accordance with the plans and with federal, state and local laws. Unless otherwise shown on the plans, the slurry displacement method may also be used to construct drilled shafts.

The drilling slurry is to contain 4 to 8 percent by weight of bentonite additive. Use drilling slurry that meets the requirements mentioned hereinafter as determined by Tex-130-E.

Before Introduction into the Excavation		Sample from the Bottom of the Excavation before concreting		
Specific Gravity	% sand Content	Specific Gravity	Viscosity s/qt	% sand Content
≤1.10	≤1	≤1.15	30-50	≤4

Use Mineral slurry consisting of processed bentonite or attapulgite clays mixed with clean fresh water. Do not use PHPA (partially hydrolyzed polyacrylamide), polymeric slurry or any other fluid primarily of a polymer solution.

Use this method to support the sides of the excavation with processed mineral slurry that is then displaced by concrete to form a continuous concrete shaft.

During and after drilling maintain a head of slurry in the shaft excavation at or near ground level or higher as necessary to counteract ground water pressure.

Just before placing reinforcing steel, use an air lift or proper size cleanout bucket to remove any material that may have fallen from the sides of excavation or accumulated on the bottom after the completion of drilling.

If the concrete placement is not started within 4 hours of completion of the shaft excavation, reprocess the hole with auger as directed (re-agitate for minimizing the mud cake built-up on the side walls), clean the bottom with an air lift or cleanout bucket, and check the slurry at bottom of the hole for compliance with slurry requirements herein and reprocess if required.

Before placing concrete, sample slurry from the bottom of the hole (shaft), and test it in accordance with Tex-130-E. Use a pump or air lift to remove slurry that does not meet the above specified requirements while adding fresh clean slurry to the top of the hole to maintain the slurry level. Continue this operation until the slurry sampled from the bottom of the holes meets the requirements.

Use a clean-out bucket or similar equipments to clean the bottom of the shaft. Drilling, de-sanding, setting reinforcing steel and concreting shall be one continuous operation.

Do not pre-drill unless it is authorized by the Design Engineer, if pre-drilling is authorized, a smaller size auger should be used for pre-drilling and the shaft shall not be drilled deeper than 20 feet above the shaft design bottom elevation. When drilling is resumed, the correct size auger should be used to ream out the pre-drilled

portion of the shaft and complete the excavation to the design elevation.

If a shaft stayed open over night, it shall be reprocessed with auger (re-agitate for minimizing the mud cake built-up on the side walls), clean the bottom with cleanout bucket, and check the slurry at bottom of the hole for compliance with slurry requirements herein and reprocess if required, then set reinforcement and concrete.

At the time concrete is placed, the excavation shall be free from accumulated seep water. All loose material shall be removed from the bottom of the excavation, prior to placing concrete.

The contractor shall provide suitable access and lighting for proper inspection of the complete excavation and to check the dimensions and alignment of shafts and underreamed excavation.

Any required lighting shall be electric. Any mechanical equipment shall be operated by air or electricity. The use of gasoline driven engines within the excavation, for pumping and drilling, will not be permitted.

When the plans require shafts in abutment bents, the embankment at the bridge ends shall be completed to grade and thoroughly compacted prior to drilling, unless otherwise permitted by the Design Engineer.

- B. Reinforcing Steel. Unless otherwise designated on the plans, all bar reinforcement shall comply with Item 440, "Reinforcing Steel". The cage of reinforcing steel, consisting of longitudinal bars and spiral reinforcement, lateral ties or horizontal bars shall be completely assembled and placed as a unit immediately prior to concrete placement.

Reinforcement shall be free of mud, oil, other surface contamination, and excessive corrosion at time of concrete placement in accordance with ACI 301. The size and configuration of vertical reinforcing and tie steel shall be as shown on the project drawings. Splice vertical reinforcing steel in accordance with plans or ACI 318 for compression or tension. Submit splice details.

If the shaft is lengthened and the plans require full depth reinforcement, a minimum of one half of the longitudinal bars required in the upper portion of the shaft shall be extended to the bottom with proper lateral reinforcement. These bars may be lap spliced, or spliced by welding by a qualified welder. Any splices required shall be in the lower portion of the shaft.

Where spiral reinforcement is used, it shall be tied to the longitudinal bars at a spacing not to exceed 12 inches. Do not weld lateral reinforcement to longitudinal bars.

The cage shall be supported and/or held down by some positive method to minimize vertical displacement during concrete placement and/or extraction of the casing. The support shall be concentric with the cage to prevent racking and distortion of the steel. An adequate number of the vertical bars shall be supported.

In uncased shafts, concrete spacer blocks, or steel chairs shall be used at sufficient intervals to insure concentric spacing for the entire length of the cage. In cased shafts, concrete spacer blocks may not be used. Metal "chair" type spacers shall be placed at sufficient intervals to insure concentric spacing inside the casing.

The elevation of the top of the steel cage shall be carefully checked before and after casing extraction. Generally, any upward or downward movement of the steel not exceeding 2 inches, per 20 feet of shaft length will be acceptable. Displacement of the steel beyond the above limits will be cause for rejection.

The minimum length of steel required for lap with column steel shall be maintained. Dowel bars may be used if the proper lap length is provided both into the shaft and into the column.

Locate and tie anchor bolts when required prior to placement of concrete. Use templates or other devices to assure accurate placement of anchor bolts.

- C. Concrete. Concrete placement shall be performed in accordance with the provisions of the Item, "Concrete Structures", and in accordance with the requirements herein:

Concrete shall be placed as soon as possible after all excavation and de-sanding operation is complete and reinforcing steel placed, and shall be of such workability that vibrating or rodding will not be required.

Concrete placing shall be continuous for the entire length of shaft or, to the construction joint indicated on the plans.

Concrete shall be placed through a suitable tube or tremie, to prevent segregation of materials. For dry shafts of 24 in. or smaller diameter, limit free fall of concrete to 20 ft.; concrete shall not strike the reinforcing cage or sides of the holes during the placement. When free fall is used, provide a hopper with minimum 3-ft. long drop tube at the top of shaft to direct concrete vertically down the center of the shaft. Do not use shovel or other means to simply deflect the concrete discharge from the truck.

Use a suitable tube or tremie to prevent segregation of materials during the concrete placement. The minimum diameter of tremie shall be at least 8 times the largest aggregate size.

The tube or tremie may be made in sections to provide proper discharge and permit raising it as the placement progresses. A non-jointed pipe may be used if sufficient openings of the proper size are provided to allow for the flow of concrete into the shaft.

If slurry method is used for excavation, initially seal the bottom of tremie to positively separate the concrete from the slurry. The sealed tremie shall be kept on the bottom of shaft until full of concrete, then lifted slightly (no more than one foot) to force out the plug or lift off the bottom plate and permit the flow of concrete. A minimum of ten (10) feet of concrete head shall be kept above the bottom of tremie pipe during concrete placement. The displaced slurry shall be pumped to holding tanks. Do not spill onto or contaminate the site. Do not discharge slurry into or in close proximity to streams or other bodies of water. Do not excavate slurry pits. Disposal of slurry is the sole responsibility of the contractor and must be in accordance with all federal, state, city and local laws.

The elapsed time from the beginning of concrete placement in the cased portion of the shaft, until extraction of the casing is begun, shall not exceed one hour.

Placing of drilled shaft concrete under water may not be done without the permission of the Engineer. If permission is granted, the concrete shall be placed with a closed tremie or may be pumped. Provisions shall be made for a sump, or other approved method, to channel disposed water away from the shaft.

A riser block of equal diameter as the column and of a maximum height of 6 inches may be cast at the top of the completed shaft.

The top surface shall be cured and any construction joint area shall be treated as prescribed in the Item, "Concrete Structures".

No extra compensation will be allowed for the additional concrete required to fill an oversize casing or oversize excavation.

#### 411.4 Quality Assurance.

The Testing Laboratory representative will determine and report Slurry Properties as follows: % sand content in accordance with ASTM D 4380, Density in accordance with ASTM D4381. Viscosity in accordance with ASTM D6910 and Ph in accordance with ASTM D6910. The drilled shaft inspection report shall include the following: the shaft identification (location, diameter and bell size if any, length, top and bottom elevation), Date, Start/finish time of excavation, method of excavation, description of material encountered, Description and location of any obstruction or difficulties encountered during excavation and its outcome, method of cleanout of shaft bottom. Description of groundwater conditions and

the depth it was encountered. Description of casing placed (including purpose, inside diameter, thickness, length and top elevation), slurry information and depth it was introduced to the hole, start/finish time of de-sanding operation, record of reinforcing steel, method and start/finish time of concrete placement and removal of casing if any, record head of concrete above the bottom of casing before and during the withdrawal of casing, level of concrete drop off after removal of casing, volume of concrete placed versus theoretical volume of drilled shaft. The concrete delivered to site shall be sampled in accordance with ASTM C172, cylinders for strength tests shall be molded and laboratory cured in accordance with ASTM C31. Specimens shall be tested in accordance with ASTM C39; two cylinders shall be molded for 7-day test and two for 28-day test. One set of cylinders shall be molded per shaft or a pour of 50 yards per shaft. Each time a set of specimens is molded, the slump will be determined in accordance with ASTM C143 and the air content in accordance with ASTM C173 or ASTM C231.

411.5 Measurement & Payment.

- A. Drilled shafts shall be measured by the vertical foot, measured from bottom of footing or shaft to construction joint or bottom of abutment. No separate measurement will be made for the concrete, reinforcing steel or excavation. No measurement or payment will be made for casing left in place or drilling through earth above specified top of shaft elevation, or removing earth above specified top of shaft elevation for convenience of drilling.
- B. Underreamed foundations (bells) shall not be paid for directly, but shall be subsidiary to drilled shaft foundations.

There are line code(s), description(s), and unit(s) for this item.

END OF ITEM 411