

## 703 - DRILLED SHAFTS

### SECTION 703

#### DRILLED SHAFTS

##### 703.1 DESCRIPTION

Construct drilled shafts by the cased or uncased method depending upon site conditions and Contract Document requirements.

##### BID ITEMS

Drilled Shaft (\*) (\*\*)  
Permanent Casing (\*) (Set Price)  
Sonic Test (Drilled Shaft) (Set Price)  
Core Hole (Investigative)

\*Size

\*\*Cased (If Contract Documents specify the cased method.)

##### UNITS

Linear Foot  
Linear Foot  
Each  
Linear Foot

##### 703.2 MATERIALS

**a. Concrete.** Unless otherwise shown in the Contract Documents, provide Grade 4.0 concrete that complies with **SECTION 401**. Provide a mix design with a minimum field compressive strength of 3500 psi and target slump of 9 inches  $\pm$  1 inch. Do not withhold mix water at the plant and do not add water at the site.

**b. Grout/Flowable Fill.** For backfilling the cross-hole sonic testing pipes and core holes, provide non-shrink cementitious grout (mixed according to the manufacturer's directions) that complies with **DIVISION 1700**.

Provide grout or flowable fill for backfilling the void space between the temporary and permanent casing with:

- 28 day strength of 1000 psi;
- mortar sand, FA-M (**SECTION 1102**) mixed with 2 bags of Type II portland cement per cubic yard; and
- water-to-cement ratio less than 1.

**c. Granular Backfill Material.** Provide granular backfill material for backfilling the void space between the temporary and permanent casing that is fine enough to fill the entire volume. The Engineer will accept the granular material based on a visual inspection.

**d. Reinforcing Steel.** Provide steel bars for concrete reinforcement that comply with **DIVISION 1600**.

**e. Casing.** Provide casing of sufficient thickness to carry the working stresses and loads imposed on the casing during construction. At a minimum, use 14-gage corrugated metal pipe (CMP) for the permanent casing.

If required, provide a permanent casing that is less than or equal to 1 inch out-of-round. The deviation of a chord from end to end shall be a maximum of 2 inches.

The Engineer will accept the casing based on compliance with the specified requirements, and visual inspection for condition.

**f. Pipe for Sonic Testing.** Provide 2 inch diameter steel pipe that complies with ASTM A 53/A 53M, Standard Weight. Provide clean pipe (both internal and external surfaces) with watertight joints. The internal joints shall be flush. Provide screw-on watertight shoes, couplers and caps for the pipes.

Provide a Type D certification that complies with **DIVISION 2600**.

##### 703.3 CONSTRUCTION REQUIREMENTS

**a. General.** Drilled shaft lengths shown in the Contract Documents are an estimate from the top of formation elevations determined from borings. Actual formation elevations encountered at each shaft, may require the actual length of each drilled shaft be adjusted. If the Engineer changes the drilled shaft lengths, the Contractor will be advised (in writing) of the revised bottom of rock socket elevation.

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A minimum of 28 days before constructing the drilled shafts, submit an installation plan to the Engineer for review. Include the following:

- Name and experience record of the drilled shaft superintendent in charge of drilled shaft operations;
- List of proposed equipment, such as cranes, drills, augers, bailing buckets, final cleaning equipment, de-sanding equipment, slurry pumps, core-sampling equipment, tremies or concrete pumps and casing; and
- Details of concrete placement, including proposed operational procedures for tremie and pumping methods and method of achieving a sealed tremie or pump.

**b. Investigative Core Hole.** Provide NX sized (2.125 inches) core samples organized in descending elevation and stored in standard core cardboard boxes. Perform this work, from the existing ground surface elevation, 15 working days in advance of the drilled shaft construction, at locations shown in the Contract Documents or ordered by the Engineer. Extract and maintain a core of the foundation material from 4 feet above the top of the plan tip elevation to 6 feet below the plan tip elevation shown in the Contract Documents. Discard all material extracted above 4 feet above the top of the plan tip elevation. Maintain, protect and label (elevation and location) these samples for review by the KDOT. While drilling, prepare a continuous standard drilling/coring log. The logs shall remain with the sample for review. Survey the location of the core hole with the same construction tolerance as **subsection 703.3c**.

**c. Excavating the Drilled Shaft.** Prior to constructing drilled shafts, complete the excavation for the entire element.

Locate the top of the shaft within 2 inches of the location shown in the Contract Documents. Unless otherwise shown in the Contract Documents, bore all shafts plumb to within a tolerance of 1 inch per 10 feet of length of shaft, not to exceed 6 inches over the full length of the shaft. The bottom of the shaft shall be nearly flat. The cutting edges of excavation equipment shall be normal to the vertical axis of the equipment within a tolerance of  $\pm\frac{3}{8}$  inch per foot of diameter.

Depending upon site conditions and requirements in the Contract Documents, construct the drilled shaft by either the cased or uncased method:

(1) Uncased Method. Use this method at locations anticipated to be free of caving soil or excess water inflow into the excavated shaft. Do not use the uncased method if the actual conditions show the shaft is prone to caving soil, or has water inflow that exceeds the dry pour method requirements in **subsection 703.3f**.

Excavate the shaft without the use of added water or drilling fluid. Completely excavate the shaft in a continuous operation, unless encountering rock or obstructions. Place the concrete without delay.

(2) Cased Method. Use this method at locations with caving soil or excess water inflow into the excavated shaft. Use either a permanent smooth, thick-walled casing, or a combination of a smooth, thick-walled temporary and permanent CMP casing together. All permanent casings shall be watertight.

Advancing shaft excavation by stabilizing the hole with drilling fluid is acceptable. Do not allow drilling fluid to get into the rock socket.

The concrete placement method used in a cased shaft depends on the water inflow requirements in **subsection 703.3f**.

After removal of the overburden, complete the excavation below the top of rock as an uncased core (rock socket) of the diameter shown in the Contract Documents.

Do not excavate closely spaced drilled shafts (3 drilled shaft diameters or less, center to center) until adjacent shafts are completed and cured according to the following criteria:

- Completed shafts have been allowed to set for a minimum of 24 hours after the concrete placement; and
- Developed a compressive strength of 1800 psi; or
- Without testing, the Engineer may allow excavation to proceed when the shaft has cured 72 hours after completion of the concrete placement.

If the Contract Documents specify or the Contractor elects to use permanent thick-walled casing for the closely spaced shafts, the Contractor may excavate multiple closely spaced drilled shafts. Once the concrete is placed, it must be cured according to the criteria above before excavating additional closely spaced drilled shafts.

**d. Placing Reinforcing Steel and Sonic Testing Pipes.** Tie reinforcing steel at all intersections of reinforcement, and place reinforcing steel as a unit for the full length of the shaft, prior to placing any concrete by

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either pour method. Use a minimum of 1 non-corrosive circular spacer per 30 inches of circumference of the reinforcing steel cage, within 5 to 10 feet of the bottom and top, and at intervals not to exceed 10 feet vertically. If the shaft is deepened and additional reinforcing steel cage is required, make the splice at the bottom of the steel cage.

In each shaft, place the number of testing pipes shown in the Contract Documents. All sonic testing pipes shall be the full length of the shaft from the bottom of the rock socket a minimum of 12 inches above the top of the shaft concrete. Before placement, measure and record the length of the sonic testing pipes and elevation of any pipe joints.

If multiple sections of pipe are required to reach the full length, the joints shall be watertight. The joints for all testing pipes in the shaft shall be at the same elevation. Completely seal the bottom of the pipe. After installation, fill pipes with potable water and install threaded caps. All testing pipes shall remain watertight until testing is complete.

**e. Final Inspection and Access.** At the time of placing the concrete, a minimum of 75% of the base of the shaft must have less than ½ inch of sediment. The Engineer will determine the shaft cleanliness before concrete placement by:

- Visual inspection; or
- Underwater inspection using probes.

**f. Placing Drilled Shaft Concrete.** Depending upon site conditions, place concrete by either the dry pour or wet pour method:

- Use the dry pour method if water inflow does not fill the shaft more than 4 inches in depth in a 5 minute period, and the shaft can be dewatered so a maximum of 2 inches of water is standing in the shaft when concrete placement begins.
- When the above 2 conditions can not be met, use the wet pour method.

For both the dry and wet pour methods the following common requirements for concrete placed in a cased or uncased shaft shall apply:

- Target slump is 9 inches ± 1 inch;
- Place concrete in the shaft with a continuous operation, without construction joints;
- Do not vibrate concrete;
- Determine the top elevation of the fresh concrete and inform the Engineer; and
- Do not use aluminum concrete pump discharge tubes or tremie tubes.

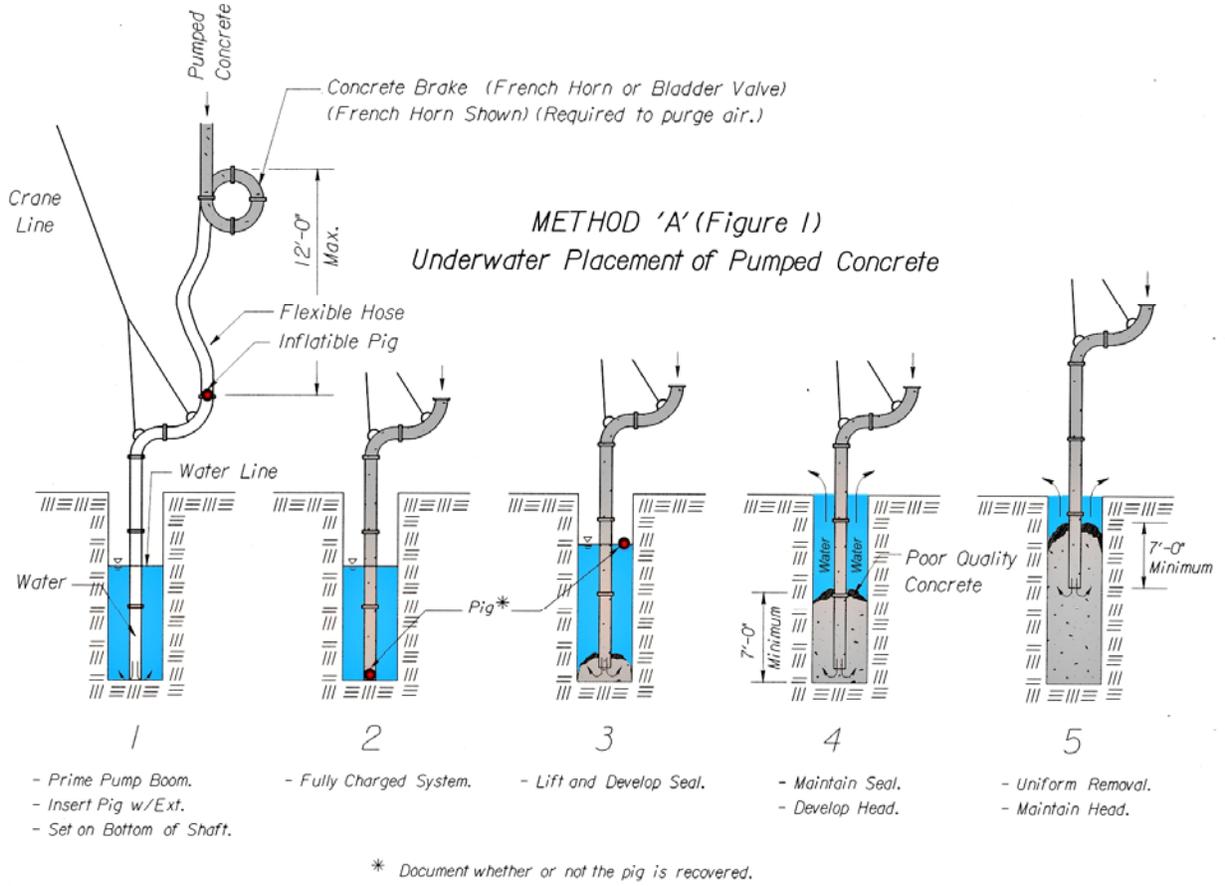
(1) Dry Pour Method. Use a centering device to deposit concrete so the falling concrete shall not come into contact with vertical and horizontal reinforcing steel and wire supports. To control the fall, extend the centering device a minimum of 8 feet into the shaft. For a cased shaft, concrete may free fall to the bottom. For an uncased shaft, the maximum fall for concrete is 5 feet.

(2) Wet Pour Method. Prior to starting concrete placement, allow the water level in the shaft to reach its static level. Place concrete with either a sealed (watertight) tremie tube or pump with a rigid and watertight extension tube. In either case, use a device (i.e. commercially available pig or flap gate) that prevents water from entering the tube while charging with concrete. The commercially available pig shall be a minimum of 110% the diameter of the tube. Clearly label the outside of the tremie and pump tubes in 12 inch increments (starting at the bottom).

Lower the rigid tube into the shaft with the bottom of the tube resting on the bottom of the rock socket, and fully charge the system (tube and hopper or pumping system) with concrete. Once the system is fully charged, raise the tube off the bottom of the rock socket by 1 tube diameter, and allow the concrete to seal the discharge end of the tube. Maintain the tube at this elevation until a minimum of 7 feet head of concrete is developed. Maintain a minimum 7 foot head of concrete during the concrete placement. Prior to raising the tube, determine the top elevation of the fresh concrete and inform the Engineer.

For wet pours, follow the steps listed in the previous paragraph, regardless of the Method (A, B or C) used to place concrete in the shaft:

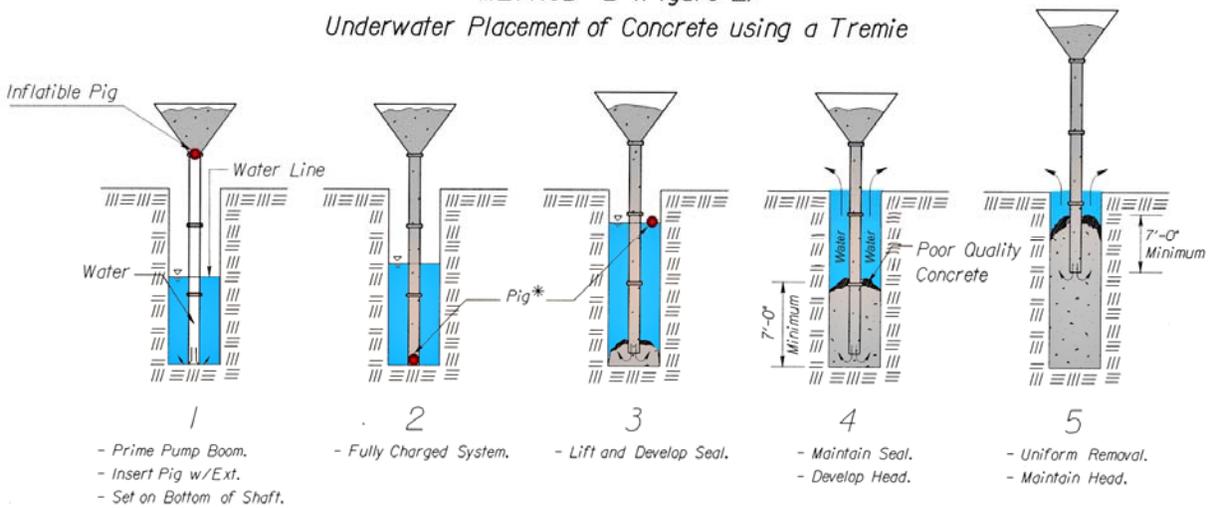
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**Method A (Figure 1):** Use a pump and extension tube, with a pig separating the ground water and concrete, to place concrete into the shaft. Install a concrete brake (e.g. bladder valve or French horn) at the end of the pump boom to purge the air from the pump line. Fully charge the boom with concrete (no air gaps) then install the pig in the top of the extension tube.

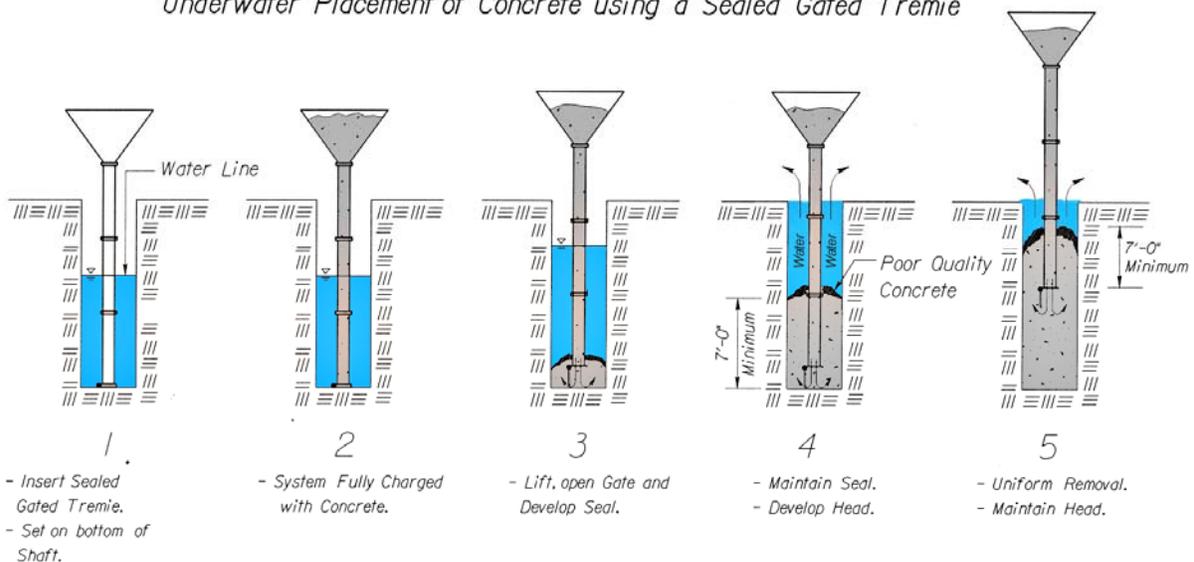
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METHOD 'B' (Figure 2)  
Underwater Placement of Concrete using a Tremie



**Method B (Figure 2):** Use a tremie tube, with a pig separating the ground water and concrete, to place concrete into the shaft. Once the tremie tube is resting on the bottom of the shaft, install the pig just below the hopper in the top of the tremie tube. Fully charge the tremie tube and hopper (forcing the pig to the bottom of the tremie tube), then raise the tremie tube by 1 tremie diameter and seal the discharge end of the tremie tube with the fresh concrete.

METHOD 'C' (Figure 3)  
Underwater Placement of Concrete using a Sealed Gated Tremie



**Method C (Figure 3):** Use a tremie tube, with a sealed gate separating ground water and concrete, to place concrete in the shaft. Fully charge the tremie tube and hopper, then raise the tremie tube by 1 tremie diameter and seal the discharge end of the tremie tube with the fresh concrete.

When the concrete reaches the top of the shaft, continue placing concrete (over-pump) to expel any excess water, debris or unsound concrete. On all wet pours, regardless of the method used, the Engineer will make a set of

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cylinders (in addition to normal concrete cylinder sampling requirements) from the top of the shaft after completing over-pumping. This set of cylinders will be used to verify a compressive strength of 1800 psi before proceeding with subsequent substructure (i.e. columns, abutments, etc.) construction.

Prior to constructing the portion of the substructure that attaches to the drilled shaft, thoroughly clean the top of the drilled shaft to facilitate the bond at the cold joint.

**g. Raising Temporary Casing.** Do not remove the temporary casing until the concrete in the shaft has met the following conditions:

- Completed shafts have been allowed to set for a minimum of 24 hours after the concrete placement; and
- Developed a compressive strength of 1800 psi; or
- Without testing, the Engineer may allow excavation to proceed when the shaft has cured 72 hours after completion of the concrete placement.

However, immediately after completing concrete placement in the permanent casing, it is acceptable to raise and hold the temporary casing at the embedment depth plus 6 inches.

Before completely raising the temporary casing, backfill the space between the 2 casings according to **subsection 703.3j**.

**h. Curing.** Cure the exposed surfaces of the shafts with wet burlap a minimum of 2 days. Do not use liquid membrane curing.

Cure all cylinders in the field, alongside and under the same conditions as the concrete they represent.

**i. Sonic Testing.**

(1) General. Perform sonic testing on all drilled shafts constructed by the wet pour method. Perform sonic testing on any dry pour method as directed by the Engineer. Conduct the sonic testing between 2 and 21 days after the drilled shaft is completed. The Engineer has the option to require additional testing.

Secure the services of an independent, experienced testing organization to take the cross-hole sonic logging measurements. Submit to the Engineer, the testing organization's record of experience, a written description of the testing procedures, operation manuals for the testing equipment, and samples of previous test results indicating both sound and defective concrete.

(2) Sonic Logging Equipment. Provide sonic logging equipment capable of identifying any faults, honeycombing or poor concrete at KDOT specified operating settings:

- A time base that shall provide the "zero signal" and "first arrival" are 2 to 3 divisions apart on the horizontal axis;
- Select an amplitude signal that fills  $\frac{2}{3}$  to  $\frac{3}{4}$  of the screen vertically; and
- Set the gain on 2.0.

Provide test results on thermal or graphical printouts with the vertical scale representing the vertical position along shaft, and the horizontal scale representing the propagation time.

(3) Sonic Logging Test Procedure. Immediately prior to testing, verify the pipes are free from blockages and filled with water. Determine the elevation of the top of the drilled shaft and the top of each pipe. Measure each pipe to determine the depth, and provide the information to the Engineer.

Conduct the sonic logging test procedure between all possible combinations of pipes (i.e. 4 pipes have 6 different combinations, 5 pipes have 10 different combinations, 6 pipes have 15 different combinations, 7 pipes have 21 different combinations, 8 pipes have 28 different combinations, etc.). If the sonic testing detects faults, the Engineer may require retesting with the probes in the same or different horizontal plane.

Configure sonic logging to settings in **subsection 703.3i.(2)**.

Use a winch to simultaneously raise the probes from the bottom of the pipes at a maximum rate of 12 inches per second. Take all slack out of the cables before switching on the analyzer.

(4) Record of Testing. After completing sonic testing, provide the Engineer the test results (recorded on thermal or graphical printouts) with the profiles referenced to the top of the pipe elevation. Inform the Engineer on site of any faults, honeycombing or poor concrete detected by a fainting of the signals and a sudden lengthening of the propagation time. Diagram (horizontal and vertical cross-sections) any defects found within the shaft to identify the location, width and thickness of the defect. Within 5 business days of conducting the sonic test, provide the

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Engineer a report (sealed by a licensed Professional Engineer) of the results and recommendations for acceptance or correction of each drilled shaft.

(5) Coring. If the sonic logging inspection indicates defective concrete, drill cores (NX size, 2.125 inches or larger) at locations directed by the Engineer. Mark the beginning and end of each core and record the total length of the core and the total length recovered. Provide the Engineer the recorded information and the core samples labeled with their location and relative elevation. If the concrete is defective, submit a written proposal to repair the drilled shaft. The proposal must be approved by the Engineer before repairs commence.

(6) Filling Core Holes. Fill core holes by pressure grouting with non-shrink grout described in **subsection 703.2b**. Use a pipe extending to the bottom of the hole to fill it from the bottom to the top.

(7) Filling Pipes. After completing sonic testing and final acceptance of the drilled shaft is made, fill the sonic testing pipes with the specified non-shrink grout. If the Contractor can expel enough water from sonic testing pipes leaving 2 feet or less of standing water in the sonic testing pipe, grout may free fall to the bottom of the pipe. If more than 2 feet of water remains in the bottom of the sonic testing pipe, prevent the grout from free falling through the water using a tremie tube extending to the bottom of the sonic testing pipe.

**j. Backfill.** When a temporary casing and a permanent casing are used, backfill the space (between casings) with the material specified in the Contract Documents:

- Granular material fine enough to fill the entire volume; or
- Grout or flowable fill described in **subsection 703.2b**.
  - If the space contains water, use a pump with an extension pipe or tremie (extending to the bottom of the space) to fill the space.
  - If the space is dry, the grout/flowable fill may free fall to the bottom of the shaft.
  - Fill the space with grout/flowable fill to the top of the casing, then, completely remove the temporary casing.

When the Contract Documents do not specify a material for backfill, use the granular material before extracting the temporary casing. After extracting the temporary casing, fill the rest of the space with granular material.

### 703.4 MEASUREMENT AND PAYMENT

The Engineer will measure drilled shafts by the linear foot measured from the bottom of the rock socket to the top of the completed drilled shaft. The Engineer will not consider a request for additional compensation, unless the overall length of a drilled shaft changes by more than 20%.

The Engineer will measure the accepted permanent casing by the linear foot, if a permanent casing is required, but not specified in the Contract Documents. The Engineer will not measure the permanent casing if:

- Contract Documents require Drilled Shafts (Cased).
- Contractor uses the casing for their convenience.
- Casing is a temporary casing.

The Engineer will measure each sonic test, at locations designated in the Contract Documents and added locations, per shaft (i.e. sonic logging between all possible combinations of pipes represents a single sonic test). If the sonic testing indicates defective concrete in the drilled shaft, the Engineer will measure the first sonic test for payment, and the Contractor is responsible for subsequent sonic testing of that shaft.

The Engineer will measure the investigative core hole by the linear foot, from the existing ground surface to 6 feet below the drilled shaft tip elevation.

Payment for "Drilled Shaft" and "Core Hole (Investigative)" at the contract unit prices, and "Permanent Casing" and "Sonic Test" at the contract set unit prices is full compensation for the specified work.

If the Engineer lengthens the drilled shaft during construction, the Engineer will measure and pay for additional reinforcing steel as Extra Work according to **subsection 104.6**. If the sonic testing indicates defective concrete in the shaft, and the Engineer requests cores from the shaft, the Engineer will not measure the cores for payment if the cores reveal defective concrete. If the cores reveal sound concrete, the Engineer will pay for the cores as Extra Work according to **subsection 104.6**.