KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, EDITION 2015

Delete SECTION 703 and replace with the following:

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	UNITS
Drilled Shaft (*) (**)	Linear Foot
Permanent Casing (*) (Set Price)	Linear Foot
Sonic Test (Drilled Shaft) (Set Price)	Each
Core Hole (Investigative)	Linear Foot

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

703.2 MATERIALS

a. Concrete. Unless otherwise shown in the Contract Documents, provide Grade 4.0 concrete that complies with **SECTIONS 401, 402 and 1102**. Provide a mix design with a target slump of 9 inches ± 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 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 pipe that complies with **DIVISION 1900**.

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.

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 ±⅜ 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.

For drilled shafts equal to or greater than 72 inches in diameter founded in shale, or as required in the Bridge Foundation Geology Report, perform the following, prior to placement of the reinforcing cage:

- Use a full diameter flight auger or core barrel. Extensions to the auger to increase the diameter of the hole are prohibited, except when excavating a belled rock socket with an under ream attachment;
- Use a full size, clean-out bucket a minimum of 95% of the diameter of the rock socket, when needed;
- In the presence of the Engineer, sound the bottom of the finished shaft. Use a weighted tape in a 12-inch grid across the base of the shaft;
- Provide access to the entire perimeter of the shaft;
- Flocculate the finished shaft to increase the visibility in the water, prior to using the underwater video camera. Use a commercially available flocculent agent per the manufacture's recommendations.
- Prior to concrete placement, perform a video inspection to inspect the sides and base of the rock socket. Along with the Engineer, review the video to verify the socket meets the cleanliness portion of this specification, prior to concrete placement;
- Perform sonic testing for all shafts. Submit test results to the Chief Geologist for review. No work will be done above the top of drilled shaft without the approval of the Chief Geologist; and
- Any required repairs or additional testing are the Contractor's expense.

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 either pour method. Use a minimum of 1 non-corrosive circular spacer per 30 inches of circumference of the reinforcing steel cage, within 2 to 4 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.

Remove any corrosion protection coating from the sonic testing pipes by sandblasting. Sandblast the pipes to bare metal. Place the sonic testing pipes within 7 days of sandblasting.

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.

Regardless of the connection used, conduct a pressure test of each pipe upon installation in the reinforcement cage.

Test all pipes after being placed and tied in the reinforcement cage. When the drilled shaft is greater than 30 feet in length, perform a second pressure test after the reinforcement and pipes are installed in the drilled shaft but prior to placing the concrete. Pressurize the pipe to 100 psi. Seal the pipe for 3 minutes. Pressure loss can not be greater than 5% in 3 minutes.

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; or
- Down hole television camera and video recordings

Provide access to 100% of the hole from probing purposes. Probing will be done by a tape with a minimum weight of 1 pound.

Review and inspection by the Engineer prior to concrete placement does not relieve the Contractor of the responsibility for producing a defect-free shaft per specifications.

When directed by the Engineer, operate the camera and recorder such that the optimum clarity of the details can be obtained and all surface areas of the shaft, including the rock socket sides and base can be observed. Record

video and store tapes such that later review is possible. Label the recorded media, which will become the property of KDOT.

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:

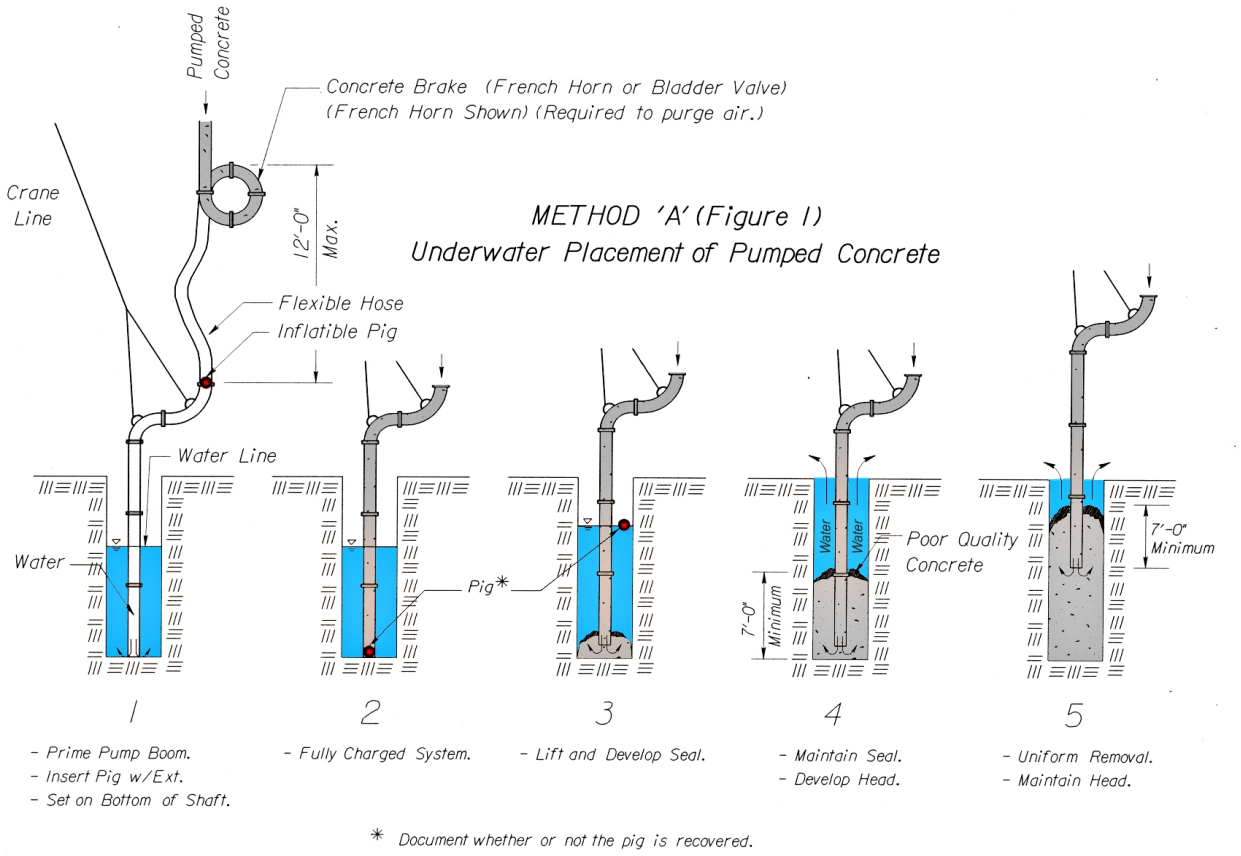
- Target slump is 9 inches ± 1 inch;
- Place concrete in the shaft with a continuous operation, without construction joints;
- Do not vibrate concrete;
- Determine the top elevation of the fresh concrete and inform the Engineer; and
- Do not use aluminum concrete pump discharge tubes or tremie tubes.

(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.

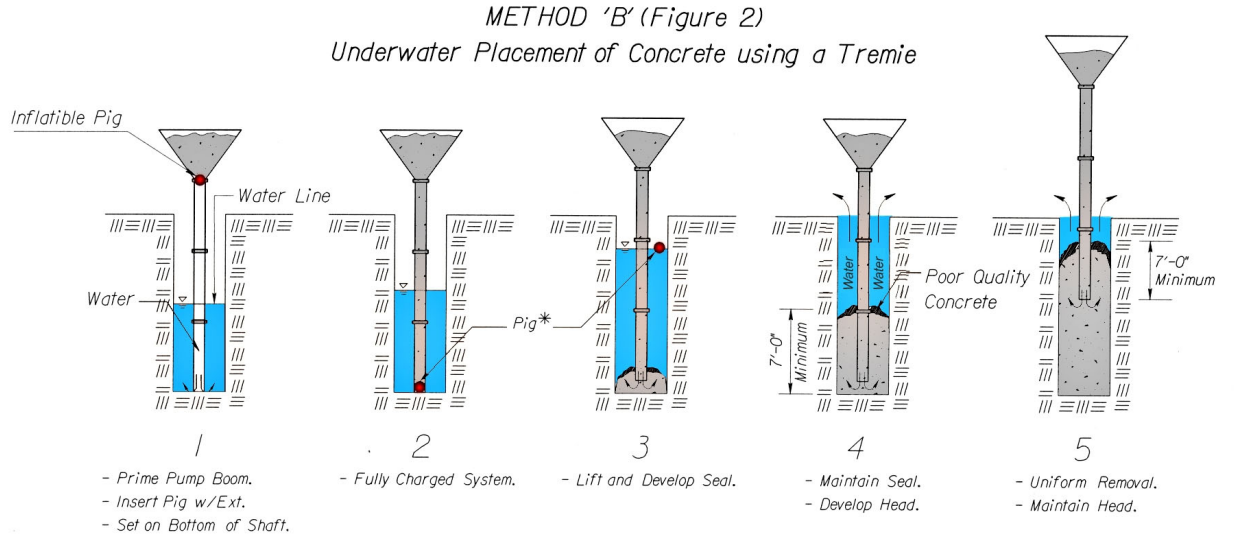
(2) Wet Pour Method. Prior to starting concrete placement, allow the water level in the shaft to reach its static level. Place concrete with either a sealed (watertight) tremie tube or pump with a rigid and watertight extension tube. In either case, use a device (i.e. commercially available pig or flap 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-foot 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:

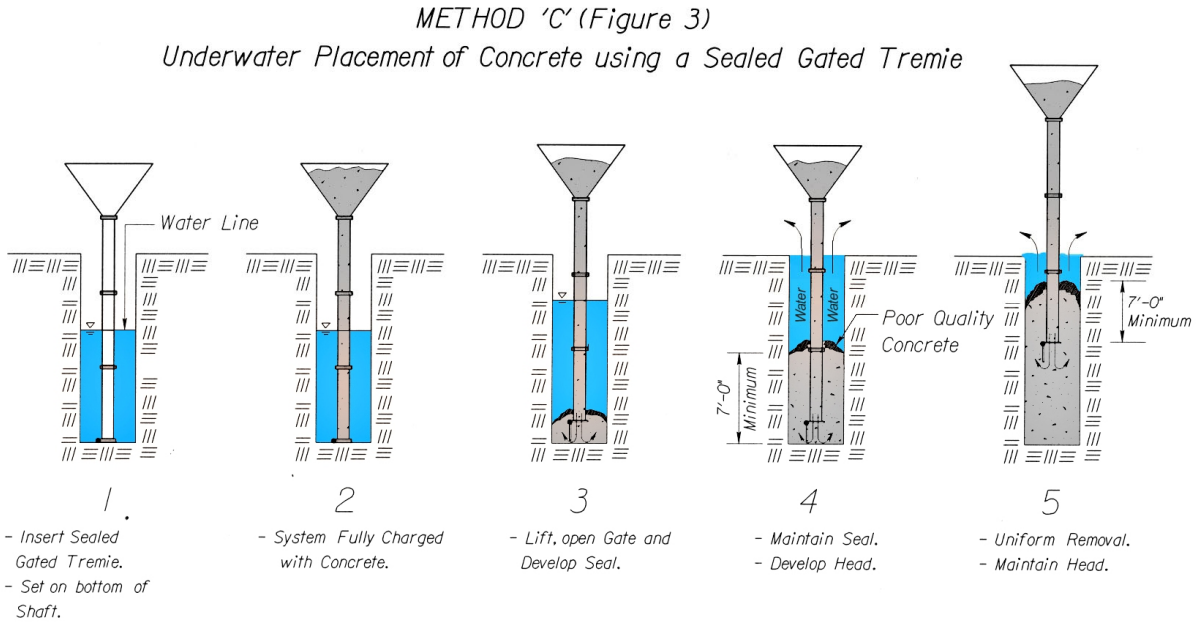


Method A (Figure 1): Use a pump and extension tube, with a pig separating the ground water and concrete, to place concrete into the shaft. Install a concrete brake (e.g. bladder valve or French horn) at the end of the pump boom to purge the air from the pump line. Fully charge the boom with concrete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



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): 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.

(3) For both Dry and Wet Pours. When the concrete reaches the top of the shaft, continue placing concrete (over-pump) to expel any excess water, debris or unsound concrete. If the casing extends above the planned shaft elevation the excess material must be expelled by providing an outlet in the casing above the planned elevation of the shaft. Do not bail the excess material out of the shaft.

On all wet pours, regardless of the method used, the Engineer will make a set of 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. If a minimum compressive strength of 1800 psi has not been reached by the seventh day, then chip away the weak concrete until the Engineer agrees that you have reached sound concrete.

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
- If compressive strength does not meet 1800 psi, the Engineer may allow the Contractor to proceed when the shaft has cured 5 days 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 raising the temporary casing completely, backfill the space between the 2 casings according to **subsection 703.3j**.

h. Curing. Prior to erecting forms and reinforcing steel for the columns, cure the exposed surfaces of the shafts with wet burlap a minimum of 2 days. If supplemental cementitious materials are used between October 1 thru April 30, then cure a minimum of 5 days. Do not use liquid membrane curing.

Cure cylinders used to facilitate construction in the field, alongside and under the same conditions as the concrete they represent. The 28-day cylinders will be cured per KT-22.

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 and issue reports. 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; and
- Select a gain to produce an amplitude signal that fills ⅔ to ¾ of the screen along the vertical access of the waveform plot for portions of the shaft that correspond to good quality concrete;

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.

The testing organization shall make suggestions for changes in the Crosshole Sonic Logging (CSL) testing procedure based on known shaft construction issues or survey access issues. Such changes could include, but would not be limited to changing the frequency of data collection along the length of the shaft or offsetting the transducers from the horizontal plane. Any such suggested changes in CSL data collection procedures must be approved in advance by the Engineer.

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. Plumb each pipe to determine the depth, and provide the information to the Engineer.

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 Chief Geologist the report of the CSL test results stamped by a licensed Professional Engineer that includes data plots (recorded on thermal or graphical printouts) with the profiles referenced to the top of the shaft or top of the pipe elevation. A copy of the report shall be sent by the testing organization to the Contractor. No work shall be done above the top of the drilled shaft without approval from the Chief Geologist. 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. Provide the report of CSL results, stamped by a licensed Professional Engineer, within 1 week of conducting the sonic test. The CSL practitioner does not have the information available to make recommendations for shaft acceptance or correction as part of the normal course of testing a shaft.

(5) Coring. If the sonic logging inspection indicates an anomaly for any zone of the shaft represented by loss of signal, a reduction in apparent sonic velocity greater than 15%, or where the velocity is equal to or less than 15% and as directed by the Chief Geologist, or where a survey was not complete due to problems associated with access tubes, drill cores (NX size, 2.125 inches or larger) at locations and depths approved by the Engineer. Drill cores NX size (2.125 inches, or larger), however if the location of the anomaly prevents an NX size core, with the approval of the

Engineer, drill a smaller size (minimum A size, 1.25 inch) core. Mark the beginning and end of each core and record the total length of the core and the total length recovered, core recover must be greater than 95%. 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

a. Drilled Shafts. 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%.

b. Permanent Casing. 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.

c. Sonic Test (Drilled Shaft) (Set Price).

- For the initial sonic test on each shaft, the Engineer will measure for payment, each sonic test, per shaft (i.e. sonic logging between all possible combinations of pipes represents a single sonic test).
- When the sonic testing indicates defective concrete in the drilled shaft, the Engineer requests cores from the shaft, and the cores reveal unsound concrete, the Engineer will not measure for payment the cores for that shaft. The Engineer will not measure for payment additional sonic tests/cores required to validate repairs to the shaft.
- When the sonic testing indicates defective concrete in the drilled shaft, and the Engineer requests cores from the shaft, and the cores reveal sound concrete, the Engineer will pay for the cores as Extra Work according to **SECTION 104**.

d. Core Hole (Investigative). When shown in the Contract Documents, 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.

e. Payment. 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 **SECTION 104**.

10-12-2020 GSBS (RH)
Jan-2021 Letting