open water, extend casings from above the water elevation into the ground to protect the shaft concrete from the water during concrete placement and curing.

4) *Double Casing Method*

Use the double casing construction method if the Contract requires or, as an alternative for the temporary casing method, in the presence of severe groundwater or unstable soil conditions. Make the temporary exterior casing larger than the Contract required shaft diameter and set a permanent interior casing into the top of the founding stratum after excavation completion.

Supply the interior casing with a permanent inner diameter equal to the shaft diameter shown on the Plans. Use a temporary exterior casing with an inner diameter at least 6 in [150 mm] larger than the interior casing. After placing the exterior casing, complete the excavation as shown on the Plans. Set the interior casing into the top of the founding stratum and brace it at the top. Remove the temporary casing after filling interior casing with concrete. Add concrete to maintain top of shaft elevation during removal. After the concrete initially sets, do not adjust the interior casing position.

(d)*Obstructions*

The Department defines an obstruction as unexpected manmade materials through which excavation cannot advance. The Department does not consider removal of tools, lost in the excavation, obstructions. Removal of naturally-occurring material, regardless of difficult or removal method, is not considered an obstruction.

Remove obstructions encountered during excavation. Notify the Engineer, in advance, of the proposed obstruction removal method. Include a cost estimate for excess costs in accordance with Subsection 104.03, "Differing Site Conditions," for obstruction removal compensation. Use blasting methods if approved by the Engineer.

(2)Slurry

Before introducing it into the shaft, hydrate the slurry by premixing the material with fresh water in accordance with the slurry manufacturer's instructions. Provide slurry tanks with the capacity for slurry circulation, storage, and treatment. The Department will not allow the use of excavated slurry pits. Use either mineral (bentonite or attapulgite) or polymer slurry.

Provide de-sanding equipment to limit slurry sand content at any point in the bore hole. Ensure slurry sand content is less than 4 percent by volume for mineral slurry, and less than 1 percent for polymer slurry. The Engineer does not require de-sanding to set temporary casings.

During drilling, maintain a slurry surface in the shaft at least 4 ft [1.2 m] above the highest expected water table elevation and at a level that prevents the hole from caving.

When there is a sudden loss of slurry from the hole, stop drilling and take corrective action to prevent slurry loss. Prevent the slurry from "setting up" in the shaft. If the slurry construction method fails to produce the Contract required results, stop and use an alternative method approved by the Engineer.

When the excavation reaches the elevation shown on the Plans and clean, allow at least 30 min for polymer slurry to stand undisturbed. Clean the excavation base with a submersible pump or air lift.

Maintain the density, viscosity, and pH of the slurry during shaft excavation in accordance with Table 516:1 for mineral slurry and Table 516:2 for polymer slurry.

Table 516:1
Acceptable Range of Mineral Slurry

Property, Method	At the Time of Slurry Introduction	In Hole at Time of Concreting
Density, [a] Density Balance (lb/ft³ [kg/m³])	64.3 – 69.1 [1,030 – 1,107]	64.3 – 75.0 [1,030 – 1,200]
Viscosity, Marsh Cone (s/qt [s/L])	28 – 45 [30 – 48]	28 – 45 [30 – 48]
pH, pH paper or meter	8 – 11	8 – 11

Note: Perform tests when slurry temperature are above 40 °F [4 °C].
[a] Density values are for fresh water. Increase density values 2.0 lb/ft³ [32 kg/m³] for salt water.

Table 516:2
Acceptable Range of Polymer Slurry

Property, Method	At the Time of Slurry Introduction	In Hole at Time of Concreting
Density, [a] Density Balance (lb/ft³ [kg/m³])	62.4 – 63.0 [1,000 – 1,010]	62.4 – 63.5 [1,000 – 1,017]
Viscosity, Marsh Cone (s/qt [s/L])	30 – 40 [32 – 42]	30 – 40 [32 – 42]
pH, pH paper or meter	9 – 11	9 – 11

Note: Perform tests when slurry temperature are above 40 °F [4 °C].
[a] Density values are for fresh water. Increase density values 2.0 lb/ft³ [32 kg/m³] for salt water

Take slurry samples using an Engineer approved sampling tool. Extract slurry samples from the base of the shaft and from 10 ft [3 m] above the shaft base. Perform four sets of tests during the first 8 hr of slurry use. When the results are acceptable and consistent, perform one test set for every 4 hr of slurry use.

Make corrections if the test results indicate unacceptable slurry samples. Place concrete when the resampling and retesting indicate acceptable values.

Provide reports of tests, signed by an authorized representative, after completion of each drilled shaft.

Dispose of slurry at approved locations.

(3)Exterior Casings

Ensure casings produce a positive seal that prevents water or other material from piping into or out of the hole. If substituting a casing with a longer or larger diameter casing through caving soils, stabilize the excavation with slurry or backfill before installing the new casing.

Consider subsurface exterior casings as temporary unless designated in the Contract as permanent casing. Remove temporary casing before completing placement of concrete in cased drilled shaft. While removing casing from the hole, maintain at least 5 ft [1.5 m] of fresh concrete in the casing above the surrounding