Drilled Shaft Inspector CBT

Lesson 3 – Equipment and Tools

Welcome to the Drilled Shaft Inspector Course. This is Lesson 3, Drilled Shaft Installation Process.

Learning Objectives

In this lesson we will cover the following items:

- Describe the Section 455 methods of drilled shaft installation
- Describe typical/potential construction problems associated with drilled shaft installation
- Identify & interpret the applicable 455 Specifications

One note regarding specs. Remember that our specifications uses an active language address to the contractor. When a specification says for example "provide equipment to perform something" this means the contractor is the person who must provide the equipment. If a specification says "perform excavations to a certain depth" it is the contractor who must perform the excavation.

455-15 Construction Methods and Equipment

Let's review the general requirements of our specifications for methods and equipment. Perform the excavations required for the shafts and bell footings, through whatever materials encountered, to the dimensions and elevations shown in the Contract Documents, using methods and equipment suitable for the intended purpose and the materials encountered.

Provide equipment capable of constructing shafts supporting bridges to a depth equal to the deepest shaft shown in the plans plus 15 foot or plus three times the shaft diameter, whichever is greater, except when the plans require equipment capable of constructing shafts to a deeper depth.

Provide equipment capable of constructing shafts supporting non-bridge structures, including mast arms, signals, signs and light supports to a depth equal to the deepest shaft shown in the plans plus 5 feet.

Let's continue reading the specification regarding general methods and equipment. Construct drilled shafts according to the Contract Documents using generally either the dry method, wet method, casing method, or permanent casing method as necessary to produce sound, durable concrete foundation shafts free of defects.

Use the permanent casing method only when required by the plans or authorized by the Engineer. When the plans describe a particular method of construction, use this method except when permitted otherwise by the Engineer after field trial.

When the plans do not describe a particular method, propose a method on the basis of its suitability to the site conditions and submit it for approval by the Engineer. This slide introduces the four acceptable methods in our specs to construct shafts: dry, wet, temporary casing and permanent casing method. These will be covered in detail later on.

There is the term “Engineer” used here. Engineer means the representatives of the Department in this contract that work towards the successful completion of the project and ensures the compliance of the contractor with the plans and specifications

Set a suitable temporary removable surface casing from at least 1 foot above the ground surface to at least 1-1/2 shaft diameters below the ground surface to prevent caving of the surface soils and to aid in maintaining shaft position and alignment except as noted in 455-15.8.3

For drilled shafts installed to support mast arms, cantilever signs, overheat truss signs, high mast light poles or other miscellaneous structures, provide temporary surface casting from at least 1 foot above the ground surface to at least 5 feet below the ground surface.

Do not use a temporary casing greater than the diameter or the reinforcing steel cage, plus 24 inches. Fill the oversized temporary casting with drilled shaft concrete at no additional expense to the Department. For miscellaneous structure foundations located within permanent sidewalks or within 5 feet of curb sections, provide temporary surface casings from no lower than the top of sidewalk to at least 5 feet below the ground surface.

Note the difference between the last two slides. For shafts for miscellaneous structures the minimum requirement is 5 feet below ground a one foot minimum above ground. This puts a total minimum surface casing length of 6 ft. For shafts for bridges the minimum requirement below ground is 1.5 times the diameter and 1 ft minimum above ground. In this case the minimum length of the casing is function of the diameter of the shaft.

For drilled shafts installed to support mast arms, cantilever signs, overhead truss signs, high mast light poles or other miscellaneous structures, fill the excavation with premixed mineral slurry meeting the requirements of 455-15.8.1 or polymer slurry meeting the requirements of 455-15.8.2 before the drill advances to the bottom of the temporary casing.

Do not attempt to excavate the shaft using plain water or natural slurry. Do not attempt to excavate the shaft using dry construction method unless specifically indicated in the Plans.

Notice this special requirement for shafts for miscellaneous structures. The Contractor must use a slurry, mineral or polymer. No plain water or natural slurry allowed. Also the dry method that we will be covering shortly is not allowed for miscellaneous shafts.

455-15.6 Excavations

Now let's review some basic requirements about excavations. Excavations: When pilot holes and/or load tests are performed, the Engineer will use the pilot hole and/or load test results to determine the authorized tip elevations and/or the authorized installation criteria of the drilled shafts.

Drilled shaft construction shall not begin until pilot hole and/or load test reports are approved by the Engineer. Shaft tip elevations based on pilot hole results and/or load tests may vary from the Tip Elevations presented in the plans. Extend drilled shaft excavations deeper by extra depth excavation when the Engineer determines the material encountered while drilling the shaft excavation is unsuitable and/or is not the same as anticipated in the design of the drilled shaft. In the absence of suitable strength tests or load tests to evaluate materials excavated, construct the shafts no higher than the Tip Elevations shown in the plans.

Pilot holes in our specifications are exploratory soil borings to help the Engineer confirm or modify the original shaft lengths. This information along with load tests data must be available and reviewed by the Engineer before proceeding with production shafts.

Drilled Shaft Installation Methods

The 455 Specifications set forth the four methods of drilled shaft construction. They are: Dry construction Method; Wet construction method; temporary casing method; and permanent casing method. In most cases, the Contractor is responsible for "means and methods". However, in some cases, the Plans may dictate the method to be used.

455-15.2 Dry Construction Method

A dry shaft is a shaft excavation that can be excavated to its designed depth in a relatively dry condition and where the sides and bottom of the shaft are stable and may be visually inspected by the Engineer prior to placing the concrete

Let's review the specification regarding 455-15.2 Dry Construction Method. Use the dry construction method only at sites where the ground water table and soil conditions, generally stiff to hard clays or rock above the water table, make it feasible to construct the shaft in a relatively dry excavation and where the sides and bottom of the shaft are stable and may be visually inspected by the Engineer prior to placing the concrete.

In applying the dry construction method, drill the shaft excavation, remove accumulated seepage water and loose material from the excavation and place the shaft concrete in a relatively dry excavation. Note that the requirement to use a dry excavation is not only to be in a relatively dry condition but also that the sides and bottom of the shaft are stable and also that the bottom may be visually inspected.

Use the dry construction method only when shaft excavations, as demonstrated in a test hole, have 12 inches or less of seepage water accumulated over a four hour period, the sides and bottom remain stable without detrimental caving, sloughing, or swelling for a four hour period, and the loose material and water can be satisfactorily removed prior to inspection and prior to placing concrete.

Use the wet construction method or the casing construction method for shafts that do not meet the requirements for the dry construction method. Note that is not necessary to have a 100% dry hole. 12 inches or less over a 4 hour period with stable bottom and sides, no swelling and if this water can be removed prior to concrete placement the hole can be constructed using the dry method.

Perhaps the easiest job of inspecting drilled shafts occurs when construction can be done in the dry. This does not occur very often in Florida because throughout most of the peninsula, groundwater tables are high. Therefore, bearing strata where drilled shafts are normally socketed are usually below the groundwater.

There are occasions, however, where competent soils will allow construction using dry techniques as described in Section 455-15.2. However remember that under the general requirements specifications that we covered earlier, for miscellaneous shafts the specifications states that a dry method cannot be used.

Furthermore a surface casing be used to a minimum of 5 feet below ground and a minimum of 1 feet above ground. In addition some type of mineral slurry or polymer slurry must be used. Use of Plain water is not acceptable.

This procedure consists of installing surficial casing, drilling the shaft excavation, removing the cuttings and accumulated seepage water, and placing the shaft concrete in a relatively dry excavation. Please note, however, that there are limitations on the amount of water that is allowable in the shaft over a four hour period to qualify for the dry construction techniques.

Typical problems that may occur in this method are as follows:

- Soils are unstable and the Contractor attempts to force dry shaft construction. This will result in caving problems which will lead to soil inclusions in the shaft concrete thereby affecting the shaft integrity.
- Groundwater table is too high - caving problems will lead to soil and sediment inclusions in the shaft concrete thereby affecting the shaft integrity.

Another problem comes from an excavation open too long prior to concrete placement. Soils that were originally capable of maintaining hole stability slowly lose that ability, resulting in caving which leads to soil inclusions in the shaft concrete. Soils and rock materials are subject to degradation over time. Because this time varies based upon the type of material and its physical characteristics, the longer the excavation is open, the greater the chance for problems.

Wet Shaft Method

The Wet shaft method is often called the “slurry-method”, wet shaft construction is when a slurry or water is used to keep the hole stable for the entire depth of the shaft.

Wet vs. Dry

As the word implies, inspecting something usually means seeing it. In drilled shaft construction, much of what is going on you can't see. It is below ground, and for us, almost always below water. You might say, true, but the same can be said of pile driving as well. Yes, but psychologically there is a comfort factor in the penetration resistance or counting of blows. This gives a person a "feeling" of the foundation's worth.

In drilled shaft work, there is no such thing. With large, powerful drill units, penetrating strata of differing competence can be subtle or indistinguishable. Another difference from pile driving inspection is, that as a drilled shaft inspector, you are responsible for keeping a log of the drilling, which requires classifying the materials coming out of the ground.

When you add the fact that drilling equipment, and the art of drilling itself are foreign to the novice inspector, it is easy to understand that there might be certain apprehensions about this process. These must be overcome if one is to become comfortable as a drilled shaft inspector. Most would agree that the cure for these ills, is knowledge.

Performing wet shaft construction is generally more expensive and difficult than dry shaft construction. Key elements to quality wet shaft construction are:

Experienced Contractor- It all starts here. Many General Contractors want to "do it all" and really do not have the experience, expertise or equipment to properly install wet shafts. If an inexperienced Contractor happens to get the project, you, the Inspector, are in for a real headache. In fact, the Contractor's inexperience may lead to the next two items.

Proper Maintenance of Slurry- If the slurry is not maintained properly, (i.e., density, viscosity, pH, etc.), there will be problems with either the hole caving, being unable to clean the hole properly or displace the slurry during concrete placement.

Clean Hole- A clean hole has two parts. First, the bottom of the hole must meet the cleanliness requirements. Second, the fluid in the hole must meet specification requirements prior to placing concrete. If the hole is not clean, there is little chance of having a good quality shaft in the end. Sediment, cuttings, and slurry (fluid in the hole) can prevent the concrete from being placed in the manner the designer specified.

Compatible Concrete- Concrete needs to be high slump. Just as importantly though, is that the concrete must remain workable throughout the entire time for the concrete placement. This time is represented by the “Slump Loss Test”.

This method is used:

- When a dry excavation <u>cannot</u> be maintained; and the water seepage cannot be managed.
- When the sides and bottom of the excavation are unstable; collapsing, caving, sloughing
- When loose material cannot be properly removed; sediment, cuttings, slurry, water
- In miscellaneous shafts. Remember that the dry method is not acceptable in these shafts and furthermore: no plain water or natural slurry may be used.

Unlike the dry construction method, in this situation the water table may be above the shaft tip elevation or the geology consists of unstable or “caving” soils. Think of trying to dig a hole at the beach or lake near the water’s edge. The hole stays open until you reach or get just below the water table or waterline. Then what happens? It collapses.

Well, the same goes for drilled shafts excavated below the water table or in unstable soils. During the drilling of the hole, a slurry is introduced that “stabilizes” the sides of the hole and prevents the soils from collapsing into the hole.

Upon reaching the appropriate shaft tip elevation, the hole is cleaned, fluid is checked (cleaned as needed) then the rebar cage placed. Unlike the dry shaft method, the concrete is being placed “under the water” and therefore a tremie is lowered into the hole and the concrete placed through the tremie or pump, which is carefully raised a little at a time to avoid “breaching” the concrete.

The wet method procedure consists of installing surficial casing, introducing a fluid to support the excavation, drilling the shaft excavation, cleaning the bottom of the shaft, and placing the shaft concrete with a submerged pipe or tremie from the bottom up displacing the fluid. In a relatively dry excavation.

Remember that in shafts for miscellaneous structures, in the general methods and equipment section the contractor is required to introduce slurry before the excavation reaches the bottom of the casing. In shafts for bridges the specifications does not prescribed when to add the fluid. However, a prudent contractor would add this before the water table or before the bottom of the casing is encountered.

455-15.3 Wet Construction Method

Let's review what the specs say about the wet method: Use the wet construction method at all sites where it is impractical to provide a dry excavation for placement of the shaft concrete.

The wet construction method consists of drilling the shaft excavation below the water table, keeping the shaft filled with fluid (mineral slurry, natural slurry or water), de-sanding and cleaning the mineral slurry and final cleaning of the excavation by means of a bailing bucket, air lift, submersible pump or other approved devices and placing the shaft concrete (with a tremie or concrete pump extending to the shaft bottom) which displaces the water or slurry during concreting of the shaft excavation.

Provide temporary surface casings from at least one foot above the ground surface to at least 1-1/2 shaft diameters below the ground surface to aid shaft alignment and position, to prevent sloughing of the top of the shaft, to provide for additional slurry head inside the shaft and to facilitate over-pouring of the shaft during concreting.

Where drilled shafts are located in open water areas, construct the shafts by the wet method using exterior casings extending from above the water elevation into the ground to protect the shaft concrete from water action during placement and curing of the concrete.

Install the exterior casing in a manner that will produce a positive seal at the bottom of the casing so that there is no intrusion or extrusion of water or other materials into or from the shaft excavation. Expandable or split casings that are removable are not permitted for use below the water surface.

Drilling Fluids

We will now discuss Slurry and other drilling fluids which will aid you in describing and identifying slurries. These are the types of drilling fluids used: Water, Natural, mineral slurry (Mineral slurry could bentonite or “attapulgite”), and for shafts for miscellaneous structures the specs allow the use of polymers that meet some specific requirements

Water may also be used as a drilling fluid. In some materials, plain water can maintain hole stability and permit shaft excavation and construction. It is important to note, when using water as a drilling fluid, it must be sampled, tested and meet the requirements of 455-15.8.3, Fluid in the Excavation at Time of Concrete Placement. Remember that Plain water is not permitted to be used on miscellaneous shafts.

Natural slurry is the fluid formed by the mixing of water and the naturally occurring materials (such as clays). When water is introduced into the clay-like natural deposits, a slurry is formed. Water and Natural Slurry generally do not perform well in clean, sandy soils which have little or no silt or clay fines.

It is important to note, when using natural slurry as a drilling fluid, it must be sampled, tested and meet the requirements of 455-15.8.3, Fluid in the Excavation at Time of Concrete Placement. Remember that natural slurry is not permitted to be used on miscellaneous shafts

What do we mean when we say “slurry”? “A water-based liquid consisting of minerals or man-made polymers or a combination of both, utilized to stabilize and minimize collapsing or caving of a shafts’ side walls”. This is de-sanding equipment, which is used when mineral slurries are used to clean the mineral slurry from excessive sand, allowing the contractor to recycle it.

455-15.8.1 - Slurry

Let’s review specification for slurry: When mineral slurry is used in an excavation, use only processed attapulgite or bentonite clays. Use mineral slurry having a mineral grain size such that it will remain in suspension and having sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system.

Use a percentage and specific gravity of the material to make the suspension sufficient to maintain the stability of the excavation and to allow proper placement of concrete. Ensure that the material used to make the slurry is not detrimental to concrete or surrounding ground strata.

During construction, maintain the level of the slurry at a height sufficient to prevent caving of the hole. In the event of a sudden significant loss of slurry such that the slurry level cannot practically be maintained by adding slurry to the hole, backfill the excavation and delay the construction of that foundation until an alternate construction procedure has been approved.

Thoroughly premix the mineral slurry with clean fresh water prior to introduction into the shaft excavation. Ensure that the percentage of mineral admixture used to make the suspension is such as to maintain the stability of the shaft excavation. The Engineer will require adequate water and/or slurry tanks when necessary to perform the work in accordance with these Specifications.

The Engineer will not allow excavated pits on projects requiring slurry tanks without the written permission of the Engineer. Take the steps necessary to prevent the slurry from “setting up” in the shaft, including but not limited to agitation, circulation, and/or adjusting the composition and properties of the slurry. Provide suitable offsite disposal areas and dispose of all waste slurry in a manner meeting all requirements pertaining to pollution.

455-15.8.2 – Polymer Slurry

Polymer drilling fluids are only permitted for shafts for miscellaneous structures. However they need to meet certain specific requirements as it will be shown later. In the picture note the stringy appearance of the slurry. It has a mucus-type consistency.

Polymers are permitted on Miscellaneous Structure construction.

Let’s review the specifications regarding polymer slurries. Materials manufactured expressly for use as polymer slurry for drilled shafts may be used as slurry for drilled shaft excavations up to 60 inches in diameter installed to support mast arms, cantilever signs, overhead truss signs, high mast light poles or other miscellaneous structures.

A representative of the manufacturer must be on-site or available for immediate contact to assist and guide the construction of the first three drilled shafts at no additional cost to the Department. This representative must also be available for on-site assistance or immediate contact if problems are encountered during the construction of the remaining drilled shafts as determined by the Engineer.

The Engineer will not allow polymer slurries during construction of drilled shafts for bridge foundations. Use polymer slurry only if the soils below the casing are not classified as organic, and the pH of the fluid in the hole can be maintained in accordance with the manufacturer's published recommendations.

Submit the Material Safety Data Sheets (MSDS) for the product, the manufacturer's published mixing procedures, and the manufacturer's published range of values for pH and viscosity of the mixed slurry.

The contractor must provide documentation that the polymer slurry and components meet the following requirements:

a) The polymer slurries to be used on the project and their waste products are classified as non-hazardous as defined by Resource Conservation and Recovery Act (RCRA) Subpart C rules, Table 1 of 40 CFR 261.24 Toxicity Characteristic.
b) Pull out tests demonstrate the bond between the bar reinforcement and the concrete is not materially affected by exposure to the slurry under typical construction conditions, over the typical range of slurry viscosities to be used.
c) Load tests demonstrate the bond between the concrete and the soil is not materially affected by exposure to the slurry under typical construction conditions, over the typical range of slurry viscosities to be used for the project.
d) The method of disposal meets the approval of all federal, state and local regulatory authorities

Mixing Slurry

The specifications require that the mineral slurry be premixed.

This blowup shows a mud gun, a tool typically be used to introduce slurry into a mixing container. Using a mud gun to discharge directly into the hole does not constitute premixing.

Types of Drilling Fluids

In this picture the contractor is pouring bentonite through a mud gun directly into the hole. This is not premixing and it is not in accordance with the specifications.

Mineral slurries have been used commonly in drilled shaft construction in the United States since the 1960's. Bentonite is the most commonly used, with other processed, powdered clay minerals, notably attapulgite, being used on occasion in place of bentonite, usually in saline groundwater conditions.

Clay minerals, when mixed with water in a proper manner, form suspensions of microscopic, plate-like solids within the water. This suspension, in essence, is the drilling slurry. If the fluid pressures within the slurry column in the borehole exceed the fluid groundwater pressures in a permeable formation (e.g., a sand stratum), the slurry penetrates the formation and deposits the suspended clay plates on the surface of the borehole, in effect forming a membrane, or "mudcake" that assists in keeping the borehole stable.

For mineral particles to break down into these separate plates, the mixing water must first hydrate the mineral. Not until this process is completed will mineral slurry be effective. The process requires both mixing effort (shearing) and time -- generally several hours.

One of the cardinal rules of drilling with mineral slurry is that all newly mixed slurry must be allowed to be hydrated for several hours before final mixing and introduction into a borehole. Mineral slurry should be added to the borehole only after its viscosity (resistance to flow, discussed later) stabilizes, which is an indication that the mineral has become fully hydrated.

The use of mineral Slurry provides the following:

- Maintains a Stable Borehole Prior to Concreting
- Maintains High Effective Stresses in the Soil While the Hole is Open (Retard Softening or Loosening)
- Facilitates Removal of Cuttings in “Circulation Drilling”

Slurry is employed as a construction aid in several of the general methods of drilled shaft construction (the casing methods and the wet method), and there can be no doubt that slurry plays an important role in the construction of drilled shafts. When an excavation encounters soil that may potentially cave, filling of the excavation with slurry, with the proper characteristics and at the proper time, will allow the excavation to be completed to full depth with little difficulty.

The slurry must have the proper characteristics during the drilling operations and at the time the concrete is placed. Water alone is sometimes an ideal drilling fluid and may be used successfully in areas where the formations being penetrated are permeable but, at the same time, do not slough when groundwater pressures are balanced by the drilling water and are not eroded by water (for example, cemented sand).

This slide shows a sketch of a de-sander. This device can be used to assist the Contractor in lowering the sand content of the drilling fluid. This works best with mineral slurries.

The charged slurry passes from the hopper (1) to a scalping vibrating screen (2), which removes fractions >¼ inch and from there to a storage reservoir (3). A circulating pump (4) pumps it into the cyclone (5), which separates the fines from the slurry. Fine particles are discharged via the cyclone underflow (6) and drop onto the vibrating dewatering screen (7) which separates out any fines still remaining in the slurry. The treated slurry is discharged into a holding tank (9) via the cyclone overflow (8), then to a separate outside storage tank. An automatic level control (10), operated by a float, keeps the slurry level in the storage reservoir constant during the de-sanding process. The sand is then discharged from the unit (11).

The specification imposes a maximum of 4% sand content for mineral slurries.

Managing Slurry

If the slurry is not properly managed, its ability to put materials in suspension or maintain the shaft walls is jeopardized and will lead to poor shaft quality. Here are some important points regarding slurry use:

- Proper Dosage and Solids Content are required for Proper Flowability and Cake Properties
- Thorough Mixing / Adequate Time for Hydration. All slurries hydrate in water. This means that they should be mixed in tanks and held for an appropriate time before introduction in a borehole.
- Maintenance of Head in Borehole. There should be a head of slurry above the natural water table or piezometric level to maintain a horizontal stress that helps maintain the excavation stable
- Maintenance of pH. Mixing should only be with fresh, potable water, which is buffered with a manufacturer-acceptable compound to raise its pH to a range acceptable to the manufacturer of the product before the slurry stock is added. Failure to use the proper water for hydration can cause poor performance of the slurry.

Typical Problems (ppt 48)

Typical problems on the wet method include: Inexperienced Contractor, Dirty Hole, and Improper Slurry Control. Let's take a closer look at these problems.

An inexperienced contractor could be because they:

- Don't understand the mechanics of what is happening
- Underestimate the need for slurry
- Use improper slurry for conditions
- Fail to properly use & control slurry
- Don't adequately clean the hole

A "Dirty Hole" creates the following consequences:

- Leaves cuttings and sediment which prevents good placement of concrete
- Creates voids in the shaft concrete or soft zones in the concrete.
- Impacts shaft integrity and functionality. It will reduce not only the bottom capacity but affect also the side friction.

An improper slurry control has the following consequences:

- Fails to properly suspend and facilitate the removal of sediments and cuttings
- Does not control caving
- Does not control swelling of soils
- Hinders slurry displacement during concrete placement
- Leads to a dirty hole

Other Typical problems may include:

- Formation of Bulge or Neck in the shaft - Soft ground zones that were not cased or in which the slurry was improperly maintained may end up with necks and bulges. Necks are integrity issues that render shafts unacceptable.
- Cave in of shaft walls- Improper use of casing or slurry and failure to use weighting agents in mineral slurry in running groundwater.

- Excessive mud cake buildup- Failure to agitate slurry or to place concrete in a timely manner. Excessive mud cake will reduce the side friction capacity of the drilled shaft and create integrity issues in the shaft.

Temporary casing method

Often called the “cased method”, in this method temporary casing (is used to stabilize the shaft excavation, and prevent sloughing or caving of materials, as the hole is advanced with either the Wet or Dry method of excavation. What do we mean when we say “temporary casing”? We mean casing that is to be removed and is not a separate pay item.

When do we use the temporary casing method?

- Where an open hole **cannot** be maintained
- Where soil or rock deformation will occur.
- Where constructing shafts below the groundwater table or caving overburden

This slide illustrates the temporary casing method:

- Prior to excavation, Install casing through caving soils and sealed it into a stratum of impermeable soil or rock.
- Drill the shaft excavation, advance hole to required depth.
- Clean shaft by removing the cuttings & seepage water
- Position the reinforcing cage.
- Place the concrete
- Remove the casing

455-15.4 Temporary Casing Construction Method

Let’s take a look at the specs required for the temporary casing method. Use the temporary casing method at all sites where it is inappropriate to use the dry or wet construction methods without the use of temporary casings other than surface casings. In this method, the casing is advanced prior to excavation.

When a formation is reached that is nearly impervious, seal in the nearly impervious formation. Proceed with drilling as with the wet method to the projected depth. Proceed with the placement of the concrete as with the dry method except withdraw the casing after placing the concrete. In the event seepage conditions prevent use of the dry method, complete the excavation and concrete placement using wet methods.

Here is a picture of a temporary casing being installed by a vibratory hammer and here is a picture of the casing a few minutes later.

Let's continue reading the specification: Where drilling through materials having a tendency to cave, advance the excavation by drilling in a mineral slurry. In the event that a caving layer or layers are encountered that cannot be controlled by slurry, install temporary removable casing through such caving layer or layers.

The Engineer may require over-reaming to the outside diameter of the casing. Take whatever steps are required to prevent caving during shaft excavation including installation of deeper casings. If electing to remove a casing and replace it with a longer casing through caving soils, backfill the excavation….

The Contractor may use soil previously excavated or soil from the site to backfill the excavation. The Contractor may use other approved methods which will control the size of the excavation and protect the integrity of the foundation soils to excavate through caving layers.

Before withdrawing the casing, ensure that the level of fresh concrete is at such a level that the fluid trapped behind the casing is displaced upward. As the casing is withdrawn, maintain the level of concrete within the casing so that fluid trapped behind the casing is displaced upward out of the shaft excavation without mixing with or displacing the shaft concrete.

The Contractor may use the casing method, when approved by the Engineer, to construct shafts through weak caving soils that do not contribute significant shaft shear resistance. In this case, place a temporary casing through the weak caving soils before beginning excavation.

Conduct excavation using the dry construction method where appropriate for site conditions and the wet construction method where the dry construction method is not appropriate. Withdraw the temporary casing during the concreting operations unless the Engineer approves otherwise.

Typical Problems

Typical problems with the Temporary casing method are: Casing is not “clean”: Temporary casing must be cleaned thoroughly after each use to have very low shearing resistance to the movement of fluid concrete. Casing with bonded concrete should not be allowed, because the bonded concrete will increase the shearing resistance between the casing and the column of fluid concrete placed inside the casing, and as the casing is lifted, it is possible that the column of concrete will be picked up, creating a neck or a void in the concrete. This will usually occur at the bottom of the casing and will manifest itself as a defect in the completed drilled shaft. The casing should be free of soil, lubricants and other deleterious material.

Casing is not sealed properly: It is important that the casing be sealed in the competent formation so as to prevent the slurry from flowing out of the casing or soils flowing in, producing caving in the surrounding soil. Casing is damaged: Damaged casing will produce structurally deficient sections.

Casing is not deep enough. Casing performed after predrilling: The spec requires casing installed prior to excavation. Predrilling will defeat the purpose of using casing. Significant soil caving may occur when excavation is advanced prior to set up the casing.

Permanent Casing Method

The Permanent Casing Method is also called the “cased method”, where permanent casing (casing to be left in-place and paid for) is installed prior to excavation to stabilize the shaft excavation, and the hole is advanced with either the Wet or Dry method of excavation.

What do we mean when we say “permanent casing”? It is casing that is to be left in place and is typically a separate pay item.

The permanent casing method is only used when specified in the plans. In bridge projects this will be accompanied with a corresponding pay item for the permanent casing.

This slide shows an excerpt from the Summary of Pay Items sheet indicating that 3014 LF of casing is to be furnished and installed, in other words, Permanent. Remember, temporary casings are not paid, permanent casings are.

The procedure is similar to the temporary casing installation. The main difference is that the casing will remain in the permanent casing situation. The steps will be illustrated now. First comes the installation of the casing to the required depth or elevation.

Excavate through casing to required depth or elevation. Clean hole & slurry, then place cage and the concrete.

455-15.5 Permanent Casing Method

Let's review the specification for permanent casing: Use the permanent casing method when required by the plans. In this method, place a casing to the prescribed depth before beginning excavation. If the Contractor cannot attain full penetration, the Engineer may direct the Contractor to excavate through the casing and advance the casing until reaching the desired penetration.

In some cases the Engineer may require the Contractor to over-ream the outside diameter of the casing before placing the casing. Cut the casing off at the prescribed elevation upon reaching the proper construction sequence and leave the remainder of the casing in place.

455-15.7 Casing

Now let's review some excerpts for the specifications for casings (temporary and permanent), section 455-15.7: Remove all casings from shaft excavations except those used for the Permanent Casing Method. Ensure that the portion of casings installed under the Permanent Casing Method of construction below the shaft cut-off elevation remains in position as a permanent part of the Drilled Shaft.

The Contractor may leave casings if in the opinion of the Engineer the casings will not adversely affect the shaft capacity in place. When casings that are to be removed become bound in the shaft excavation and cannot be practically removed, drill the shaft excavation deeper as directed by the Engineer to compensate for loss of capacity due to the presence of the casing.

The Department will not compensate for the casing remaining. The Department will pay for the additional length of shaft under Item No. 455-88 and the additional excavation under Item No. 455-125.

If temporary casing is advanced deeper than the Minimum Top of Rock Socket Elevation shown in the plans or actual top of rock elevation if deeper, withdraw the casing from the rock socket and over-ream the shaft. If the temporary casing cannot be withdrawn from the rock socket before final cleaning, extend the length of rock socket below the authorized tip elevation one-half of the distance between the Minimum Top of Rock Socket Elevation or actual elevation if deeper, and the temporary casing tip elevation.

When the shaft extends above ground or through a body of water, the Contractor may form the portion exposed above ground or through a body of water, with removable casing except when the Permanent Casing Method is specified (see 455-23.10). When approved, the Contractor may form drilled shafts extending through a body of water with permanent or removable casings.

However, for permanent casings, remove the portion of metal casings between an elevation 2 feet below the lowest water elevation or 2 feet below ground whichever is higher and the top of shaft elevation after the concrete is cured.

Generally when removal of the temporary casing is required, do not start the removal until completing all concrete placement in the shaft. The Engineer will permit movement of the casing by rotating, exerting downward pressure, and tapping it to facilitate extraction, or extraction with a vibratory hammer. Extract casing at a slow, uniform rate with the pull in line with the axis of the shaft. Withdraw temporary casings while the concrete remains fluid.

When conditions warrant, the Contractor may pull the casing in partial stages. Maintain a sufficient head of concrete above the bottom of the casing to overcome the hydrostatic pressure of water outside the casing. At all times maintain the elevation of the concrete in the casing high enough to displace the drilling slurry between the outside of the casing and the edge of the hole while removing the casing. The Contractor may use special casing systems in open water areas, when approved, which are designed to permit removal after the concrete has hardened. Design special casings so that no damage occurs to the drilled shaft concrete during their removal.

Topics Covered

In this lesson we have covered the following topics:

- Described the Section 455 methods of drilled shaft installation

- Describe typical/potential construction problems associated with drilled shaft installation
- Identify & interpret the applicable 455 Specifications

End of Lesson

This is the end of lesson 3. Please select the next lesson button on this page to continue to the next lesson.