

# Drilled Shaft Inspector CBT

## Lesson 4 – Construction Documents

Welcome to the Drilled Shaft Inspector Course. This is Lesson 4, Construction Documents.

### Learning Objectives

In this lesson we will cover the following items:

- Locate Plan Sheet Details Related to Drilled Shafts
- Calculate REC % and RQD
- Identify key elements of the Drilled Shaft Installation Plan
- Identify & interpret applicable 455 Specifications

### Project Document Governing Order

The Coordination of Contract Documents is set forth in section 5-2 of the Standard Specifications for Road and Bridge Construction. The Governing order of documents with their description are:

**Special Provisions** – Specific clauses adding to or revising the Standard Specification, setting forth conditions varying from or additional to the Standard Specifications, for a specific project.

**Technical Special Provisions** – Specifications prepared, signed and sealed by an Engineer registered in the State of Florida other than the State Specifications Engineer, or his designee, which are made part of the Contract as an attachment to the Specifications Package.

**Plans** – The approved plans, including reproductions thereof, showing the location, character, dimensions and details of the work to be done.

**Technical Special Provisions** – Specifications prepared, signed and sealed by an Engineer registered in the State of Florida other than the State Specifications Engineer, or his designee, which are made part of the Contract as an attachment to the Specifications Package.

**Design Standards** – Are FDOT standard design sheets for common items and are typically included in Plan sets. An example of this type of sheet is the “Notes and Details for Square Pre-stressed Concrete Piles”, Index No. 20600.

**Developmental Standards** – A specification developed around a new process, procedure, or material and designated as a developmental specification.

**Supplemental Specifications** – Approved additions and revisions to the Standard Specifications.

**Standard Specifications** – The directions, provisions and requirements contained herein, together with all stipulations contained in the plans or in the contract documents, setting out or relating to the method and manner of performing the work, or to the quantities and qualities of materials and labor to be furnished under the contract.

## **Definition of an Engineer**

You will find the word “Engineer” many times throughout the Department specifications and plans. Here is how the specifications define the term Engineer: The Engineer is the Director, Office of Construction, acting directly or through his duly designated representatives.

This means that any FDOT employee working in the project and consultant working for the Department and authorized to represent the Department in a project is part of the “Engineer” term.

## **Plans & Specification Checklist**

A Plans and Documents Checklist is useful for ensuring to remember to check all of the documents.

## **Inspector References**

As a Drilled Shaft Inspector you can perform your duties only if you know and understand the construction of drilled shafts as well as the project to be constructed. That is, you must know what the design intent was, how the Contractor proposes to construct the shafts, and the specifications which are your tools to assure that the drilled shafts are properly constructed.

Here is a list of the documents that you should have available prior to start working as an inspector in a particular project.

- Approved Drilled Shaft Installation Plan
- Complete set of Project Plans with Pay Items
- Minutes of Previous Meetings
- Special Provisions
- Technical Special provisions for project
- Standard Specifications

- Supplemental Specifications
- Design Standards
- Project Geotechnical Report

Several of the pertinent items that a drilled shaft Inspector needs are standard specifications and documents applicable to drilled shafts on all Department of Transportation projects. Other items are project specific items such as plans, special provisions, shop drawings, and contractor submittals.

## **Important Plans and Drawings**

Here is a brief list of some plans and drawings that you should be familiar with.

- Key Sheet
- Summary of Pay Items
- Plan and profile
- Special Provisions
- Structural Plans:
  - General Notes
  - Report of Core Borings
  - Foundation Layout Plans
  - Bridge Hydraulic Sheet
  - Drilled Shaft Details
  - Bent/Pier Plans
- Design: Some drilled shafts details are indicated in the Design Standards. For example there are Design Standards that indicate drilled shaft dimensions and reinforcement details for two types of miscellaneous structures: Design Standard 17743 for mast arms and Design Standard 17502 for high mast light poles.

## **Plans Review**

Next, we are going to review samples of typical plans that you may encounter on drilled shaft construction. The first plan we are going to talk about is the Key sheet. It is the first sheet of the plan set. The Key sheet includes the financial project number, the county and the project name.

## **Plan Set – Sheet 1 (key Sheet)**

It will also include the governing specifications, design standards. It is important to know what specifications are being followed in the contract. As inspector you will need to be familiar with the specifications package that is part of the contract documents of the particular project you're working on.

It will also include a record of the revisions that have been made to plans.

## **Plan Set – Sheet 2 (Summary of Pay items)**

Now let's look at the Summary of Pay Items sheet: This sheet indicates the pay items for the project. We will take a look at the drilled shaft related items:

We can see some typical items for drilled shafts such as drilled shaft for 36" and 60" diameter, casing 60" diameter, excavation unclassified, cross sonic logging. Later on this course we will discuss in detail what these items cover.

Notice that there is a quantity for casing 60" diameter here. This is because in this project the plans were requiring permanent casing on the 60" drilled shafts. Only permanent casings required in the plans get paid. Temporary casing will not get paid. So if the contractor decides that he needs to use casing to support temporary the excavation for the 36" casing he could do it but he will not get paid separately for this casing.

## **Plan Set – Sheet 3 (Plan 7 Elevation)**

Plan and Elevation sheet. This plan shows the plan and elevation of the structure with the location of the proposed piers or bents.

This is the enlarged area that shows the plan location. Note in this particular case the location of the bascule piers only. There will be typically more than one page to show all the structure and to show all the bents and piers included in the structure.

## **Plan Set – Sheet 4 (Report of Core Borings)**

Report of Core Borings. This is the drawing where the soil borings are represented. This plan will typically consist of more than one sheet depending on the number of borings taken during the design phase. Let's explore some areas of this drawing.

Here is the typical soil legend that you will find in this type of drawing.

Let's look at the notes section of this plan. This notes section explains other symbols that may be used in this plan and special information that may be relevant to the drilled shaft construction. For example, the contractor is advised that artesian water was observed or expected at certain elevation and how high the water reached.

WOH: means weight of hammer in the Standard Penetration Test. This is means a very loose or a very soft material or maybe even a void was encountered. We will cover later on what is a Standard Penetration test, or SPT. 50=2": This means that during the SPT test the hammer reached 50 blows and only advanced 2 ". This in the industry of soil boring is considered refusal. In general, every time an SPT sampler requires 50 blows or more and advancing less than 6" is considered refusal.

Note also the symbols for casing used. This refers to the casing used during the execution of the soil boring. If the soil testing firm needed to use casing during the soil borings, this will typically indicate the presence of permeable soils and formations. Water and drilling fluids are required to maintain the cooling of the drilling tools. If these get lost through the soil or rock formations the drilling will need to use casing to hold the drilling fluid or water.

Now let's take a look at the table for relative density and consistency of soils. This table is used as a guide to have an idea of the relative density of the soils encountered, for granular soils such as sand and gravel. For cohesive soils such as clay and silt, this table can be used to have an idea of the soil consistency.

Now let's take a look at the soil boring column. The numbers at the left of the soil column indicate the results of the Standard Penetration Test, SPT in blows per foot. We will discuss this test later. Notice the Loss of Circulation at right hand side of your boring at around Elevation -60. Also note this boring also warns about artesian water.

The information contained in the blocks at the left hand correspond to rock core test results. Notice how this information is on the rock layers, limestone. You would not have rock core information on soil. Information such as recovery, RQD as well as split tensile and unconfined compression test results is also included in these blocks. We will cover later what RQD and recovery is.

## **Plan Set – Sheet 5 (Foundation Layout)**

Now, let's look at the Foundation layout Plan. This may be actually a group of several drawings depending on the complexity of the structure. The foundation layout include details on the location of the individual shafts. Soil boring locations may also be shown in this plan. There may be also be notes related to drilled shaft construction and an explanatory legend.

Here is a look at the legend. It may contain existing foundation symbols, proposed drilled shaft symbols, boring locations etc.

Here are a view of the type of notes that this plan may contain.

Here is a detail of one end bent on this plan. In this plan the new drilled shaft foundation and the existing pile foundation are indicated.

This is a continuation of the Foundation layout plans.

Here we see a detail of the bascule pier in plan view.

Let's continue with the foundation layout drawings. We will explore some notes and the drilled shaft data table to learn some important concepts and points you should be aware.

## **Plan Set – Sheet 7 (Foundation Layout)**

The notes have additional criteria and instructions to install the shafts. You may see less notes in your projects than this drawing, because designers have been directed to reduce the amount of notes and instead use modified special provisions to address particular situations. That is why it is very important for you to have knowledge of the particular specifications of the project, not just a copy of the standard specifications.

In bridge projects the geotechnical engineer will produce a drilled shaft length letter detailing the required production tip elevations which are based on load tests and soil borings called pilot holes. These production tip elevations may be different from whatever elevations were anticipated and presented in the plans. If there are no load testing nor any pilot holes or any other field testing to verify these tip elevations, the tip elevations indicated in the plans will be the ones to construct the shafts to.

Note 6 mentions the rock socket. Rock socket is the portion of the shaft that will be in contact with rock. The drilled shaft length letter may contain a revision of the required rock socket lengths. If there are no field testing at all, the rock sockets indicated in the plans will be the ones that must be met. Note 7 indicates what type of material should be considered good enough to be considered part of the rock socket.

Drilled shafts must meet both: the required tip elevations (indicated in the plans or revised by the drilled shaft length letter) and the rock socket lengths (indicated in the plans or revised by the drilled shaft length letter). There may be a note, like note 8 specifying the test hole, which is the methods shaft that contractors are required to perform to prove their Installation methods.

Pilot holes are soil borings to be performed by the contractor prior to beginning of production lengths. This constitutes additional information that the geotechnical engineer will use to verify or adjust the production shaft lengths and rock socket lengths. Pilot holes may be SPT soil borings with SPT testing and soil sampling, rock coring or a combination of both.

Let's also take a look at another note regarding artesian water.

This note warns the contractor about the presence of artesian water. In many parts of Florida special hydrogeological conditions in which the groundwater has an unusual pressure, higher than the location of the top of the aquifer strata and even higher than the ground surface elevation, may be present. This condition is known as artesian water condition. Presence of water surcharge areas, sinkholes, connected voids and cavities in the limestone formations favor the presence of artesian water.

Let's explore the Drilled Shaft Data Table that it is part of the foundation layout drawings.

There are two parts in the drilled shaft data table. The Design Criteria and the Installation Criteria.

In the Design Criteria section the plan designer has included the data required to design the shafts such as the scour elevation, down drag, the phi factor and the factored design load. These values are used by the Geotech Engineer to produce the Drilled Shaft length letter. It may be used by the Contractor's specialty engineers when they propose a design change or Cost Saving Initiative change.

The installation criteria section includes the lengths, sizes and elevations that the shafts must meet. Based on the load test, pilot holes and any other field testing the geotechnical engineer will verify and adjust if required the tip elevation and the minimum rock socket elevation. Note: the geotechnical engineer will not be able to raise the shafts above the minimum tip elevation indicated in the table.

## **Scour**

Scour is soil erosion produced by running water. This slide illustrates the different types of scour that may occur. The designers of the foundation must account for this scour. You will notice that the depths of the foundations will always be several feet below the estimated scour elevation.

Here is a picture illustrating scour. This bridge was founded on short timber piles. A 50-year storm caused scour around the pier to about half the length of the piles. The remaining pile embedment was inadequate to resist the applied structure and water forces. The downstream piles plunged and the pier rotated, broke the upstream piles and fell into the scour hole.

Here is another picture illustrating scour. This abutment was affected by scour forces that eroded the end fill to a point where the footing was undermined.

This photo shows that even abutments that are protected by riprap can be subjected to scour forces.

### **Plan Set – Sheet 8 (Hydraulic Sheet)**

This is the Bridge Hydraulic Recommendations sheet. In this page information such as water elevations and scour elevations are indicated.

Here is a detail of the Bridge Hydraulic Sheet that shows the long term scour elevation, the 100 year scour elevation and the 500 year scour elevation. In addition other information such as water elevations are present in this drawing.

Here is the Drilled Shaft Details sheet. This sheet shows details on size, length of the shaft, including reinforcement details.

### **Plan Set – Sheet 9 (Drilled Shaft Details)**

Here you see dimensions, lengths and elevations of the shaft and reinforcement.

CSL Tubes may not be shown on plans since they are required by specs.

Here is a drilled shaft cross section that shows the distribution of longitudinal reinforcement and the dimensions of the transversal reinforcement.

### **Plan Set – Sheet 10 (Bent/Pier Plan)**

Here is the Bent/Pier plan drawing. You will find this type of plan to include the details of the end bents and interior bents or piers. This is a detail drawing of the end bent.

On newer plan sets, the top of the shaft elevation or cutoff elevation is shown in the Drilled Shaft Data Table.

### **Rock Socket**

This slide illustrates what is rock socket in drilled shafts. This is a requirement indicated in the Drilled Shaft Data Table, or could be also indicated in a Letter issued by the Geotechnical Engineer.



Rock socket is defined as the portion of the shaft in contact with rock material. It is a main part of the Geotechnical Engineer design of the shaft penetration. Some designers only count in the rock socket length to determine the capacity of the drilled shaft. It is very important to meet this requirement.

Even though typically once you find rock, it will be continuous from that point down, in Florida this is not necessarily true. There may be areas in which sand layers are within rock layers.

Remember that Drilled shafts must meet both: the required tip elevations (indicated in the plans or revised by the drilled shaft length letter) and the rock socket lengths (indicated in the plans or revised by the drilled shaft length letter)

### **455-15.6.1 – Pilot Hole**

We already explained what a pilot hole is when we talked about drilled shaft construction in FDOT. Let's read now what the specifications indicate about pilot holes.

When pilot holes are shown in the plans core a pilot hole, prior to shaft excavation, in accordance with ASTM D 2113 Standard Practice for Diamond Core Drilling for Site Excavation and the Department's Soils & Foundations Handbook using a double or triple wall core barrel through part or all of the shaft, to a depth of 3 times the diameter of the drilled shaft below the tip elevation shown in the plans, as directed by the Engineer. The Engineer may require the Contractor to cut any core to a total depth below the bottom of the drilled shaft excavation of up to 5 times the diameter of the drilled shaft.

### **CPAM 10.5.5**

Drilled Shafts are not part of Construction Quality Control CQC and therefore the responsibility for maintaining logs of the Pilot Hole, Core and Shaft are the responsibility of the Department and CEI personnel working for the Department.

### **455-15.6.2 – Cores**

The Department may require the Contractor to take rock cores at the bottom of the shaft. Let's read what the specifications direct the contractor to do regarding cores.

Cores: Take cores when shown in the plans or directed by the Engineer to determine the character of the material directly below the shaft excavation. Provide equipment to retrieve the core from a depth of 5 times the diameter of the drilled shaft below the

bottom of the drilled shaft excavation in accordance with ASTM D 2113 Standard Practice for Diamond Core Drilling for Site Excavation. Cut the cores with an approved core barrel to a minimum depth of 3 times the diameter of the drilled shaft below the bottom of the drilled shaft excavation after completing the shaft excavation, as directed by the Engineer.

The Engineer may require the Contractor to cut any core to a total depth below the bottom of the drilled shaft excavation of up to 5 times the diameter of the drilled shaft. For cores or pilot holes, use only a double or triple wall core barrel designed: (a) To cut a core sample from 4 to 6 inches in diameter, at least 5 feet in length, and, (b) So that the sample of material cored can be removed from the shaft excavation and the core barrel in an undisturbed state.

Note that the Department specifications require the rock cores be 4" to 6" in diameter and smaller cores are not permitted. Additionally, single-tube core barrels are not permitted.

The Engineer will inspect the cores and determine the depth of required excavation. When considered necessary by the Engineer, take additional cores. Place the core samples in suitable containers, identified by shaft location, elevation from and to, and job number, and deliver to the Department within 48 hours after cutting.

When called for in the plans, substitute Standard Penetration Tests (SPT) for coring. In such cases, supply these tests at no additional cost per foot to the Department above that bid for core (shaft excavation). In some case the plans may call to perform SPT testing in lieu of rock cores, particularly in areas where it is expected that not good recoveries may be achieved from the coring process. We will explain later what SPT tests are.

Provide areas for the disposal of unsuitable materials and excess materials as defined in 120-5 that are removed from shaft excavations, and dispose of them in a manner meeting all requirements pertaining to pollution.

### **Standard Penetration Test Borings**

The Standard Penetration Test (SPT) is performed during the advancement of a soil boring to obtain an approximate measure of the dynamic soil resistance, as well as a disturbed drive sample (split-barrel type).

The SPT is conducted at the bottom of a borehole. At regular depth intervals, the drilling process is interrupted to perform the SPT. The SPT involves the driving of a hollow, thick-walled tube into the ground and measuring the number of blows to advance the split-barrel sampler a vertical distance of 1 foot.

A drop weight system is used for the pounding where a 140-lb hammer repeatedly falls from 30 inches to achieve three successive increments of 6 inches each. The first increment is recorded as a “seating”, while the number of blows to advance the second and third increments are summed to give the N-value (“blow count”) or SPT-resistance (reported in blows per foot).

If the sampler cannot be driven 18 inches, the number of blows per each 6 inch increment and per each partial increment is recorded on the boring log together with the penetration, reported to the nearest inch. For partial increments, the depth of penetration is recorded in addition to the number of blows. Occasionally, a longer split-spoon is used and a fourth 6 inch increment is driven. This is to merely obtain additional soil sample and is not considered in the “N” value.

After the sampler has been removed from the borehole and detached from the drill rods, the sampling spoon can be disassembled and the soil in the sampling spoon can be examined. If there is soil within the sampler, the soil boring inspector will record the length of the sample recovered or the percent recovery, describe the soil and record the SPT results.

Then the inspector will note the location of each stratum with respect to the bottom of the sampler barrel. The inspector will then place a representative portion of each stratum into a waterproof container (jar) and properly label, store and transport the samples to the laboratory facility. In the report of core borings, the N values will be presented at the left side of each boring.

## **Rock Cores**

Now let’s talk about rock cores for soil exploration. Core drilling is used to obtain intact samples of rock for testing purposes and for assessing rock quality and structure. Rock coring may be required during the execution of pilot holes, prior to construct production drilled shafts or after the excavation of the shaft to verify the conditions of the rock underneath the shaft bottom.

The rock coring is performed usually in segments, called runs that are typically 5 ft. in length. Even though for soil exploration purposes smaller sizes are typically used, in our specifications we require core diameters of 4 to 6”.

## **Conventional Rock Coring (ppt 70)**

Coring is performed with the use of core barrels. This slide presents a diagram that illustrates the rock core operation for a double core barrel. Remember that only double or triple barrels are acceptable in our specifications.

Core drilling requires special equipment and procedures. The diamond core bit and double-tube core barrel are basic equipment. The assembly consists of an outer rotating tube or barrel attached to a core barrel head at the top end and the diamond drilling bit at the bottom. An inner tube and core lifter receive and hold the sample stationary within the rotating assembly during drilling. Drilling fluid within double- and triple-tube core barrels is circulated between the inner and outer tubes, providing the core sample protection from the fluid's circulation and erosion of soft or weathered rock.

The optimum rotation speed of drilling varies with the type of bit used, the diameter of the core barrel, and the kind of material to be cored. Excessive rotation speed will result in chattering and rapid wear of the bit and the core will break. Low speed results in less wear and tear on the bit and better cores but lower rates of progress. In medium to hard rock, typically the rotational speed used is 300 to 1,500 RPM for diamond bits and 100 to 500 RPM for metal carbide bits.

The advance rate of the coring bit depends on the material's firmness, the downward pressure applied on the bit, and the rotation speed. The driller must carefully adjust the pressure. Too much pressure causes the bit to plug and to shear the core from its base. Bit pressure is controlled by a hydraulic or screw feed on the drilling machine.

### **Core Barrels**

Here is a picture of a double tube core barrel. Core barrels may be single-tube, double-tube, or triple-tube. Single barrels are not acceptable in our specifications. The standard is a double-tube core barrel, which offers better recovery by isolating the rock core from the drilling fluid stream and consists of an inner and outer core barrel.

However, in some materials, especially expansive types, the split- liner may come apart due to material expansion, which can provide for difficulty in removing the liner and core. In these types of materials, a solid liner or a triple-barrel core barrel may be used.

In some regions only triple-tube core barrels are used in rock coring. In a multi-tube system, the inner tube may be longitudinally split to allow observation and removal of the core with reduced disturbance.

## **Rock Coring Video**

This video illustrates rock coring.

This picture illustrates the common barrel components. Double tube Core barrel. Diamond bit w/ carbide reaming shell. Inner barrel shoe assembly.

## **Core Drilling Observations**

It is important to record the coring activity including information concerning fluids, pressure & rates, and procedural items.

## **Fluids**

Estimate and note the amount of water return relative to the amount being injected through the drill rods and its color. Careful observation of drill water return changes can indicate potential intervals where solution features, cavities or very porous materials are encountered. Changes in the color of the return water can indicate stratigraphic changes and degrees of weathering such as clay-filled joints and cavity fillings.

## **Pressure & Rates**

If available, hydraulic pressure being exerted by the drill should be recorded on each run as well as the fluid water pressure. While the drill is turning, the inspector should correlate drilling depths to drilling action (e.g., smooth or rough), increases and decreases applied by the drill operator to the feed control valve, and the rate of penetration.

Rod drop depths, which indicate open zones, should be recorded. Changes in drilling rates can be related to changes in composition and/or rock structure and, in areas of poor core recovery, may provide the only indication of the subsurface conditions. The drilling rate should be monitored and recorded on the boring log in the units of minutes per foot.

Field Logs should at least include the following:

- Size and type of core bit and barrel used; bit changes;
- Size, type, and depth of casing; casing shoe and/or casing bit used; problems or observations made during placement of the casing; change in depth of casing setting during drilling;

- Core run data such as Depth, length, and time for each run; length/depth of pull (the actual interval of core recovered in the core run); amount of core actually recovered; amount of core loss or gain; and amount of core left in the hole. There are two important measures that the inspector needs to make on the core runs: Recovery and Rock Quality Designation which we will cover later.

## **Drilled Shaft Rock Core Log**

This is the Department's Drilled Shaft Rock Core Log form that may be used for recording rock core data. The next slide will show you the lower part of the form.

This is the lower part of the Drilled Shaft Rock Core Log form, that may be used for recording rock core data.

## **Pilot Hole Log**

This is the Department's Pilot Hole Log, used to record core runs and SPT sampling when pilot holes are performed.

## **Core Handling & Preservation**

Rock cores must be handled properly to avoid damage and mislabeling. It is important that as little disturbance as possible be made to the core upon removal from the core barrel.

It is preferred that the core be extruded from the core barrel with the barrel in a close to a horizontal position onto a tray (PVC cut in half for transfer to core box) or into the core box. This will induce the least amount of disturbance.

Cores allowed to fall onto the ground can produce several problems, such as:

- it may have induced breaks (called mechanical)
- the orientation is messed up
- is not in proper order or conditions

Ensure the top and bottom of the core is identified. Note – when placing in core box, the top of the core is to the left and the bottom of the run is to the right.

## **Recovered Rock Cores**

Here is a photograph a box containing two core runs. Each compartment of the box is 5 feet long. The core should be properly placed and labeled. We will now cover what recovery and RQD are.

## **Recovery %**

The core recovery is the length of rock core recovered from a core run, and the Percent Recovery (REC) or recovery ratio is the ratio of the length of core recovered to the total length of the core drilled on a given run, expressed as either a fraction or a percentage. Core length should be measured along the core centerline.

When the recovery is less than the length of the core run, the non-recovered section should be assumed to be at the end of the run unless there is reason to suspect otherwise (e.g., weathered zone, drop of rods, plugging during drilling, loss of fluid, and rolled or recut pieces of core). Non-recovery should be marked as NCR (no core recovery) on the boring log, and entries should not be made for bedding, fracturing, or weathering in that interval.

The recovery tell us how continuous the rock is independent of how fractured or jointed the rock is. Loss of recovery from 100% may mean the presence of voids or non-rock materials, since soils cannot be recovered by the coring procedure. But also in our rock low recoveries may be due to improper means and methods to core. Also in some cases the rock itself may be difficult to core due to presence of voids, shells and fossils.

Let's use this slide to illustrate the recovery calculation. In this example we have recovered 39 inches out of the 5.0 feet run cored.

Please calculate the percentage of recovery: Core lengths, the run, are typically measured in feet. Recovery is often measured in inches, as that is the most common type of measuring tape on the job site. Remember to convert both length and recovery to the same units, either feet or inches. Let's work in feet. Therefore convert first the recovery in inches to feet and then divide by the 5 feet length of the core run.

Dividing by 1; 39 inches is equal to 3.25 feet. Divide that by 5 feet and multiply by 100 gives us the recovery in percentage. Can Recovery be greater than 100%? No.

## **Rock Quality Designation (RQD)**

The Rock Quality Designation (RQD) is a modified core recovery percentage in which the lengths of all pieces of sound core over 100 mm (4 in) long are summed and divided by the length of the core run. The RQD is an index of rock quality. It provides an idea of how fractured, sheared, and jointed the rock is.

Here is a chart that classifies rock based on the RQD values. After you have finished viewing this chart, select the next button or press shift+n on your keyboard.

## **Measuring of Core Pieces**

The same piece of core could be measured three ways: along the centerline, from tip to tip, or along the fully circular barrel section. The recommended procedure is to measure the core length along the centerline. The centerline measurement is preferred because: (1) it results in a standardized RQD not dependent on the core diameter, and (2) it avoids unduly penalizing of the rock quality for cases where the fractures parallel the borehole and are cut by a second set.

## **Rock Quality Designation (RQD)**

Given the information provided determine the RQD. Remember to use the same units for the length of the core and for the length of the pieces recovered. In this, let's work in inches now. A 5 feet run is 60". For RQD purposes only include the pieces longer than 4". Please compute the RQD.

The summation of the pieces longer than 4" is 36". We then divide 36 by 60 times 100 and obtained 60% as RQD. Can RQD be greater than Recovery? No. Can RQD be greater than 100? No.

## **Material Identification**

We will now cover some basic concepts regarding Soil and Rock Identification. Drilled Shaft Inspectors should be able to identify and describe properly the materials coming out of the hole. If you have problems identifying materials or don't have experience identifying and describing soils, please ask your supervisor to help you in getting some training in soil and rock description. A local District Materials office may be a good place to get assistance if help is needed.

The Inspector needs to record the materials coming out of the hole and determine if the materials observed are as expected from review of the Boring data.

If the Boring data (Report of Core Borings, Pilot Holes, etc.) shows rock at 50 feet, the designer relied on that information in their design. If the material at 50 feet is sand, the Engineer needs to be informed and the length of the shaft may vary accordingly.

We will show a short video illustrating drilled shaft auger drilling and dumping material. You will also note an inspector in the background taping the hole.

This picture illustrates how rock in their natural state may look very differently when coming out of the hole on the drilling tool.



The foundation engineer is concerned with the construction of some type of engineering structure on or in the earth. For engineering purposes, we shall consider the earth to be made up of rock and soil.

Soil, is considered unconsolidated, and will be defined as naturally occurring mineral particles that are readily separated into relatively small pieces, and in which the mass may contain air, water, or organic materials (derived from decay of vegetation). The mineral particles of the soil mass are formed from decomposition of the rock by weathering and chemical processes.

Rock, is considered consolidated, and is that naturally occurring material composed of mineral particles so firmly bonded together that significant effort is required to separate the particles.

### **Soil Type**

Soils are defined by their principal size components. Gravel and sand are coarse-grained components that can be distinguished by eye. Silt and clay are fine-grained components, too fine to distinguish individual grains. Therefore, they are identified by their physical behavior. Organic soils have an organic component plus sand, silt or clay. Most soils with organics are soft and not satisfactory for providing support.

### **Rock**

Rock is classified with respect to its geological origin, and in Florida, the rock is classified as Sedimentary.

The rock type most encountered in our drilled shaft projects will be limestone, though some sandstones are possible. These type of rocks belong to the sedimentary rocks group. Sedimentary rocks are formed by the cementation of sedimented soils or precipitated materials. Limestone for example is mostly formed by precipitation of calcite, aragonite and typically includes accumulation of shells, corals and fossilized organisms.

Our limestone is frequently vuggy and very porous. Parts of the state are known for their sinkhole activity. Even where sinkhole activity is relatively unlikely, the limestone can still be very porous. The relative hardness of the limestone varies widely and can occur over short distances.

## Field Identification of Materials

This slide shows the Field Identification of Materials document. To review this document, select the resources button at the bottom of this page.

## Drilled Shaft Installation Plan

The Drilled Shaft Installation Plan is a shop drawing describing in detail the Contractor's tools and methods of constructing the drilled shafts. Section 455-15-1.2, Drilled Shaft Installation Plan describes the minimum requirements of the Drilled Shaft Installation Plan. The intent behind having the Contractor submit this item is to cause him to put thought and planning into the project.

Normally, contractors want to take a "wait and see" attitude. For most Contractors, that is the extent of their pre-job planning; desiring to rely on flexibility to adjust once on site and the job begins to develop. There are so many unknowns when dealing with subsurface conditions, that the Contractor could benefit himself to pay closer attention to details regarding methods of installation and equipment ahead of time, thereby minimizing some of the unknown factors. A smooth and successful start will usually be carried all the way through the job.

As a Drilled Shaft Inspector you must receive a copy of the Contractor's approved Drilled Shaft Installation Plan. You should be familiar with the installation plan well in advance of the start of shaft construction.

This slide shows of the drilled Shaft Installation plan submittal and review process. After reviewing the slide, select the continue button or press shift+n on your keyboard.

### 455-15.1.2 - Drilled Shaft Installation Plan

Let's review the specification on Drilled Shaft Installation Plan. At the preconstruction conference submit a drilled shaft installation plan for review by the Engineer. Final approval will be subject to satisfactory performance. Include in this plan the following details

1. Name and experience record of drilled shaft superintendent or foreman in responsible charge of drilled shaft operations.

Ensure the drilled shaft superintendent or foreman in responsible charge of the drilled shaft operations has a minimum of one year of experience of installing drilled shafts of the size and depth shown in the plans and a minimum of three years experience in the construction of drilled shafts using the following methods:

- a. Mineral slurry,
- b. Casings up to the length shown in the plans,
- c. Shaft drilling operations on water under conditions as shown in the plans.

2. List and size of proposed equipment, including cranes, drills, augers, bailing buckets, final cleaning equipment, de-sanding equipment, slurry pumps, core sampling equipment, tremies or concrete pumps, casings, etc.

3. Details of sequence of construction operations and sequence of shaft construction in bents or shaft groups. 4. Details of the shaft excavation.

This slide shows a sample of the list of equipment proposed in a Drilled Shaft Installation Plan. After reviewing the slide, select the continue button or press shift+n on your keyboard.

5. Details of slurry, including proposed methods to mix, circulate, desand, test methods, and proposed testing laboratory to document test results.

6. The sixth item that must be included in the Drilled Shaft Installation Plan is: Details of proposed methods to clean shaft after initial excavation.

7. Details of shaft reinforcement, including methods to ensure centering/required cover, cage integrity during placement, placement procedures, cage support, and tie downs.

8. Details of concrete placement, including elapsed concrete placement times and proposed operational procedures for concrete tremie or pump, including initial placement, raising during placement, and overfilling of the shaft concrete. Provide provisions to ensure proper final shaft cutoff elevation.

9. Details of casing removal when removal is required, including minimum concrete head in casing during removal.

This slide shows a sample of the concrete placement information submitted by the Contractor. After reviewing the slide, select the continue button or press shift+n on your keyboard.

10. Required submittals, including shop drawing and concrete design mixes.
11. Details of any required load tests, including equipment and procedures, and recent calibrations for any jacks or load cells.
12. Proposed cross sonic logging CSL Specialty Engineer to perform, log analyze, and report the test results.
13. Methods and equipment proposed to prevent displacement of casing and/or shafts during placement and compaction of fill.
14. Provide the make and model of the shaft inspection device, if applicable.
15. Details of environmental control procedures used to prevent loss of slurry or concrete into waterways or other protected areas.
16. Proposed schedule for test shaft installation, load tests and production shaft installation.
17. Other information shown in the plans or requested by the Engineer.
18. For drilled shafts for miscellaneous structures constructed using polymer slurry, identify the polymer slurry meeting the requirements of Section 455-15.8.2, the pH and viscosity ranges recommended by the manufacturer for the materials to be excavated and a description of the mixing method to be used.

Submit the Material Safety Data Sheets (MSDS) for the product, and certifications that the polymer slurry and components meet the requirements of Section 455-15.8.2. Submit the contact information for the manufacturer's representative available for immediate contact during shaft construction and the representative's schedule of availability.

The Engineer will evaluate the drilled shaft installation plan for conformance with the Contract Documents. Within 20 days after receipt of the plan, the Engineer will notify

the Contractor of any additional information required and/or changes that may be necessary in the opinion of the Engineer to satisfy the Contract Documents.

The Engineer will reject any part of the plan that is unacceptable. Submit changes agreed upon for reevaluation. The Engineer will notify the Contractor within seven days after receipt of proposed changes of their acceptance or rejection. All equipment and procedures are subject to trial and satisfactory performance in the field.

### **End of Lesson**

This is the end of lesson 4. Please continue to the next lesson.