**Drilled Shaft Inspector CBT**

**Lesson 9 – Post Installation**

Welcome to the Drilled Shaft Inspector Course. This is Lesson 9, Post Installation.

**Learning Objectives**

In this lesson, we will take a look at the following objectives:

- Identify and describe various Integrity and Load Tests
- Construction tolerances
- Describe the Drilled Shaft Pay Items
- Identify the applicable 455 specifications

**Checklist**

This slide shows a Checklist with items that need to be checked at this time.

**455-20 Construction tolerances**

Let's review the specification for construction tolerances.

Meet the following construction tolerances for drilled shafts:

(a) Ensure that the top of the drilled shaft is no more than 3 inches laterally in the X or Y coordinate from the position indicated in the plans.

(b) Ensure that the vertical alignment of the shaft excavation does not vary from the alignment shown in the plans by more than 1/4 in/ft of depth.

(c) After placing all the concrete, ensure that the top of the reinforcing steel cage is no more than 6 inches above and no more than 3 inches below plan position.

**Plan Location tolerance**

This slide illustrates the Plan location tolerance.

**Vertical Alignment tolerance**

This slide illustrates the tolerance requirements for vertical alignment. Ensure that the vertical alignment of the shaft excavation does not vary from the alignment shown in the plans by more than 1/4 in/ft. depth.

**Reinforcement Cage tolerance**

This slide illustrates the tolerance requirements for the top of the cage. After placing all the concrete, ensure that the top of the reinforcing steel cage is no more than 6 inches above and no more than 3 inches below plan position.

**455-20 Construction tolerances**

Let's keep talking about tolerances: Ensure that the reinforcing cage is concentric with the shaft within a tolerance of 1 1/2 inches. Ensure that concrete cover is a minimum of 4.5 inches unless shown otherwise in the plans. All casing diameters shown in the plans refer to I.D. (inside diameter) dimensions. However, the Contractor may use casing with an outside diameter equal to the specified shaft diameter if the extra length described in 455-15.7 is provided. In this case, ensure that the I.D. of the casing is not less than the specified shaft diameter less 1 inch.

This slide illustrates the tolerance requirements for cover and steel eccentricity.

When casing is not used, ensure that the minimum diameter of the drilled shaft is 1 inch less than the specified shaft diameter.

Ensure that the top elevation of the drilled shaft concrete has a tolerance of +1 and -3 inches from the top of shaft elevation shown in the plans.

This slide illustrates the tolerance for top of shaft elevation.

Let's read the highlighted requirement. Use excavation equipment and methods designed so that the completed shaft excavation will have a flat bottom. Ensure that the cutting edges of excavation equipment are normal to the vertical axis of the equipment within a tolerance of ±3/8 in/ft. of diameter. As you can see the contractor must construct a horizontal flat bottom.

**455-21 Constructed pit of tolerance**

What happens if an excavation is out of tolerance? The Contractor may make corrections to an unacceptable drilled shaft excavation by any combination of the following methods:

(a) Overdrilling the shaft excavation to a larger diameter to permit accurate placement of the reinforcing steel cage with the required minimum concrete cover.

(b) Increasing the number and/or size of the steel reinforcement bars.

(c) Enlargement of the bearing area of the bell excavation within tolerance allowed.

## 455-21 Constructed pit of tolerance

When the tolerances are not met, the Contractor may propose a redesign to incorporate shafts installed out of tolerance into caps or footings. Incorporate shafts installed out of tolerance at no expense to the Department. Ensure the Contractor's Engineer of Record performs any redesign and signs and seals the redesign drawings and computations. Do not begin any proposed construction until the redesign has been reviewed for acceptability and approved by the Engineer.

Backfill any out of tolerance shafts in an approved manner when directed by the Engineer until the redesign is complete and approved.

## Post-Installation Testing

After a shaft is constructed, the Engineer may require to perform some testing to verify integrity. Also some shafts may have been designated in the plans for load testing. We will now review Post-Installation testing. These may be integrity testing or load testing. The Inspector will not be performing the test, but should document which shaft, the setup in general, the time started and completed, if possible.

There are two types of post installation testing. They are Load test and Integrity Testing. Load test is where the shafts were designed to carry a specified load and "load tests" are the test flights of drilled shafts. A specific number of shafts may be designated to be load tested.

Integrity Testing is where the vast majority of drilled shafts are constructed routinely, without difficulty, and are sound structural elements. Occasionally, defects in the completed shaft can be introduced during the construction process through errors in handling of slurry, concrete, casings, cages and other factors.

Therefore, tests to evaluate the soundness or integrity of the shaft are conducted. These become even more critical when difficult drilling and installation problems were encountered. These tests may include a variety of down-hole access tube tests, including Cross-hole Sonic Logging, thermal integrity testing and the inexpensive Sonic Echo test. The goal of these integrity tests are to determine if defects, or anomalies, exist within the constructed shaft.

## Load Tests

Typically, there are three types of Load T ests conducted on drilled shafts. They are: Axial load tests, Lateral load tests, and Uplift tests. Axial load tests determine if the shaft can carry the load imposed without settling. Lateral load tests are tests that test the shafts resistance to lateral forces. Uplift tests are the opposite of axial, in that rather than push downward on the shaft, it is pulled upward to determine its resistance to being “pulled out”.

## 455-2 Static Compression Load Tests (ppt 21)

The static compression load test is covered in article 455-2 of the specifications. It is placed towards the beginning of section 455 because it applies to drilled shaft and piles.

Employ a professional testing laboratory, or Specialty Engineer with prior load test experience on at least three projects, to conduct the load test in compliance with these Specifications, to record all data, and to furnish reports of the test results to the Engineer except when the Contract Documents show that the Department will supply a Geotechnical Engineer to provide these services.

Let’s keep reviewing the static compression test specification. Do not apply test loads to piles sooner than 48 hours (or the time interval shown in the plans) after driving of the test pile or reaction piles, whichever occurs last. Allow up to four weeks after the last load test for the analysis of the load test data and to provide all the estimated production tip elevations.

Do not begin static load testing of drilled shafts until the concrete has attained a compressive strength of 3,400 psi. The Contractor may use high early strength concrete to obtain this strength at an earlier time to prevent testing delays.

Disposition of Tested Piles/Shafts: After completing testing, cut off the tested piles/shafts, which are not to be incorporated into the final structure, and any reaction piles/shafts at an elevation 24 inches below the finished ground surface. Take ownership of the cut-offs and provide areas for their disposal.

## Axial Load Tests

The most commonly used types of axial load tests are:

- Conventional Methods with a Reaction Frame and Reaction Shafts
- Osterberg Load Cell
- Statnamic Loading Device

## Conventional – Reaction Frame and Shafts

This slide shows the configuration of a conventional load test. In a conventional test, we install reaction or anchor shafts on either side of the test shaft; two or four can be used. The reaction shafts should be designed to have enough uplift capacity to serve as reaction and not fail under the maximum compression load that will be applied to the test shaft during the load test. The anchor shafts should normally be constructed first. Hydraulic jacks are placed on top of the test shaft, usually on a steel plate that is carefully leveled.

Electronic load cells are also frequently placed above or below the jacks in order to obtain an accurate measure of the load. A reaction frame spans the anchor shafts, as shown. Potential disadvantages of this method are that it is expensive compared to the other methods (perhaps twice as expensive, excluding the cost of the test shaft) and the capacity is limited because of the reaction frame. The conventional method can also be used to conduct uplift, or “pullout” test.

## Conventional – Axial

These are photos of the set-up for axial load tests on drilled shafts. On the left is a jack with a pressure gauge calibrated to load (dark gray object), an electronic load cell (silver object), and settlement gauges, in this case mechanical dial gauges. Four settlement gauges are used, one at each corner of a thick steel loading plate affixed to the head of the drilled shaft.

Reference beams that are supported on the ground at points at least 10 feet, clear, from the test and reaction shafts support the settlement gauges. These steel reference beams are shaded from the sun by means of a tarpaulin in order to minimize thermal movements in the reference beams. Two independent means, the electronic load cell and the jack pressure, read the load on the jack.

A second, independent method for reading settlement is also a good idea in case the zero is lost on the settlement gauges (very large settlements beyond the range of the settlement gauges, or blunder by field crew in hitting reference beams, etc.) This is often accomplished by making optical level readings on a scale affixed to the shaft head.

Here we see the tops of several telltales. These are unstrained rods that are anchored at various depths within the test shaft. Differences in compression between the top of the shaft and the anchor points are read by the gauges (0.0001 inch dial gauges in this photo).

These differences are converted into axial strains and then to stresses and finally to load in order to measure the distribution of load along the shaft. The keys to good telltale readings are rods that do not bind inside their sheaths and accurate estimates of concrete modulus (to convert strain to stress). These are older style tests and the more recent ones are using electronic instrumentation, rather than dials.

### Conventional – Lateral

This photo shows a lateral load test being conducted on a drilled shaft in the water. The test shaft is pushed away from the reaction shafts, not pulled toward them. The load is applied as a shear at the ground level and is measured with an electronic load cell. Both the lateral deflections at the level of the applied load and the slope of the shaft, at the head and along the shaft, are measured.

### Statnamic Load Test

An alternate way of testing drilled shafts is the Statnamic® test method. An advantage of this method, relative to the Osterberg Cell method, is that it can be used to test shafts that are not initially planned for testing. In the Osterberg Cell method the cell must be cast into the shaft at the time of construction. The principle of operation is shown here.

Heavy masses on top of the shaft are accelerated upward by a propellant. This produces a force against the masses equal to the mass of the accelerated masses times the magnitude of the acceleration and an equal and opposite force on the top of the shaft. The force is active for perhaps half a second (500 milli sec), with a rise time of 100 - 200 milli sec. This rise time is long enough to produce a stress wave in the shaft that is longer than the shaft itself (if the shaft is, say 65 ft. long or shorter), in which case the shaft can be treated for data reduction purposes as a rigid body.

On the right is a photo of a Statnamic test being performed. Gravel, contained within a steel sheath, is placed around the masses in order to cushion their impact when they fall back onto the top of the shaft. Newer support devices have recently been deployed with guides that contain the reaction masses laterally as they move upward and "catch" them as the fall back to the head of the shaft. This does away with the need for gravel and speeds up the testing process. Statnamic tests can be run to almost any magnitude of load from a few tons to 5,000 tons, by changing components in the system.

The following video shows a Statnamic test viewed from above. This one for the SR 600 over Hillsborough River project in Florida.

## Osterberg Load Cell

This slide indicates the principle of the operation of the Osterberg Cell. One 3000-ton cell is used here to test a socket in soft rock. The socket diameter is 60 inches, so the 2-inch steel plates on either side of the Osterberg Cell are 59 inches in diameter. In this case the objective of the test was to find the ultimate side shearing resistance in the soft rock. Calculations showed that if the base were used as a reaction, base failure would occur first, so a reaction socket was constructed, whose combined base and side capacity was well above the estimated capacity of the upper, or test, socket.

The Osterberg Cell rested on top of the reaction socket. In this way, 3000 tons of side shear could be put on the test socket. It would be intended that the upper (test) socket would fail before the 3000-ton limit is reached, so that the exact side shearing resistance is known. If the reaction socket is instrumented, considerable information could be gained about lower limits of side and base resistance in the reaction sockets, as well. Other configurations can be used to test end bearing only or to test both end bearing and side resistance using multiple levels of cells. If higher loads are needed, more than one cell can be placed at one level, as long as the shaft diameter can accommodate the 34-inch cell diameter.

## Integrity Tests

These are the various types of integrity testing that the Department uses in Drilled Shaft Projects.

- Cross-hole Sonic Logging (“CSL”)
- Thermal Integrity Profiling (TIP)
- Sonic Echo / Impulse-response (PIT)
- Coring & others

## Anomalies

Anomalies are defined as unusual patterns that could represent voids or soft spots in the concrete. Anomalies may be probable structural defects if they correlate to some potentially damaging occurrence during construction recorded by the Inspector.

Various post-construction structural integrity tests can give “false positives” or divergences of a sonic or ionizing radiation record from that which would be expected from a structurally perfect drilled shaft. This does not always mean that the shaft is defective. We merely use the term “anomaly” to denote any deviation from the “expected” in the integrity test record. If that deviation corresponds to a potentially damaging event during construction, then it is prudent to assume that the anomaly is a structural defect that requires further attention. Note that good inspection records are key to the interpretation of integrity tests.

### 455-17.6 – NDT of Drilled Shaft Integrity

Cross-Hole Sonic Logging (CSL) Tests: Test all drilled shafts in bridge bents or piers considered non-redundant in the plans, using CSL. For all other drilled shafts, perform CSL testing only on drilled shafts selected by the Engineer. The minimum number of shafts tested is the number of shafts indicated in the plans. The Engineer may increase the number shafts tested as deemed necessary.

Engage a qualified Specialty Engineer to perform the CSL testing.

### CSL Access Tubes

Several access tubes are placed regularly around the circumference of the cage. Our specification requires one per foot of shaft diameter. CSL Access tubes need to be cast into the concrete at the time of construction, which is the major disadvantage of tests employing access tubes. These tubes need to be straight and watertight their full length.

Remember that as the Inspector you must check to ensure the proper number of access tubes are positioned and that they are securely fastened and filled with water as specified... You must also verify that the contractor personnel checks the tubes by inserting mock probes to make sure the tubes are not obstructed and will allow the performance of the testing. Failure to do so may result in a strike on the inspector's record.

### Cross-hole Sonic Logging

This picture shows the probes used in the CSL test. The transmitter or vibration source, which is the black one, and the receiver which is the red one shown in the picture. This picture illustrates the tubes being filled with water. It is important that this is performed previous to placing concrete as we saw in the previous lesson.

The CSL tests are performed by testing one pair of tubes at a time. In one tube the vibration source or transmitter probe, is inserted and a receiver is inserted into the second tube. In the standard way of testing, the two probes will be inserted to the bottom of the tubes and will be pulled up simultaneously at the same speed while measuring data.

During the CSL measurements, the apparent signal travel time between transmitter and receiver are measured and recorded. By measuring the travel times of a pulse along a known distance, between transmitter and receiver, the velocity can be calculated as a function of distance over time. If a number of such measurements are made and compared at different points along the concrete structure, the overall integrity of the concrete can be assessed.

This slide shows a CSL test being performed. The sketch illustrates the test and the principles used by the test. Defects in the concrete will delay the arrival time at the receiver probe. The arrival time will be longer than the time in a sound concrete and the wave speed will be less.

Several variations on this method are practiced by highly skilled specialists, involving placing source and receiver at different elevations to develop a three-dimensional profile of the interior of the shaft, in a process referred to as tomography.

**455-17.6 – NDT of Drilled Shaft Integrity**

Let's continue with the CSL testing specification: When a shaft contains four tubes, test every possible tube combination.

For shafts with five or more tubes, test all pairs of adjacent tubes around the perimeter, and one half of the remaining number of tube combinations, as chosen by the Engineer. After acceptance of production shafts by the Engineer, remove all water from the access tubes or core holes and fill the tubes or core holes with a structural non-shrink grout approved by the Engineer….

Perform Cross-hole sonic logging between 72 hours and 25 calendar days of shaft concrete placement and after the concrete compressive strength exceeds 3,000 psi. Furnish information regarding the shaft, tube lengths and depths, construction dates, and other pertinent shaft installation observations and details to the Department at the time of testing.

Verify access tube lengths and their condition in the presence of the Department, at least 24 hours prior to CSL testing. If the access tubes do not provide access over the full length of the shaft, repair the existing tube or tubes or core additional hole or holes, as directed by the Engineer, at no additional cost to the Department.

Conduct offset CSL measurements between all tube pair combinations in any drilled shafts with 30% or greater in velocity reduction. Record offset measurements with source and receiver vertically offset in the tubes. When the CSL shows wave speed reductions greater than 30%, the contractor needs to provide additional field readings to perform tomography analysis.

Provide offset CSL logs and 3-D tomographic analysis of all CSL data at no additional cost to the Department in the event 30% or greater in velocity reductions are detected. These analysis will provide the location of the potential defect that can be further investigated with coring.

**Thermal Integrity Testing**

These images show the equipment used for the Thermal Integrity testing. The test is also known as the Thermal Integrity Profiling.  This is a relatively new integrity test method that takes advantage of the temperatures that are generated during cement hydration.  The internal temperature of the shaft will be a function of the amount of cementitious materials present in the shaft. In the same shaft, areas with low cement will be cooler than areas high cement.

The test can use the same access tubes used for CSL testing or can use temperature sensors attached to the reinforcement.  During the test a probe measures the internal temperature of the shaft at several points throughout the shaft.  This test has the advantage over the CSL testing in that it can give information of the integrity of the shaft outside the CSL tubes.  The disadvantage of this method is that it cannot be performed after few days because it requires the concrete to be hot.  It is typically performed between 1 and 2 days after pouring of the concrete.

This slide illustrates the performance of a thermal integrity testing.  The test is being performed at the same CSL access tubes provided in the shaft.  This test has the capability of determining accurately the shaft radius, cover, detect defects (such as zones of small cover), and small radius.  The software has the capability to determine the distortion of the cage and the three dimensional shape of the shaft.

Currently the standard specification does not require the contractor to provide CSL testing. The specs require the contractor to provide a safe and secure access to the Engineer to perform the test.  However you may see it in a special project as a requirement in which the contractor is to engage a specialty engineer to perform the test not just to provide the safe and secure access.

Let’s read the specification requirements for thermal integrity testing.  Provide safe and secure access and assistance to the Engineer, when requested, for the purpose of evaluating drilled shaft integrity via internal temperature measurements using the Thermal Integrity Test Method as described herein.

Provide access to the Engineer for testing the shafts within 4 hours of the peak temperature generation, which is expected to occur between 24 hours and 48 hours after the shaft concrete placement. Provide access to the Engineer for testing all drilled shafts in bridge bents or piers considered non-redundant in the Plans. Based on the observations during drilled shaft construction, the Engineer may test one or all drilled shafts in bridge bents or piers considered redundant in the Plans. For drilled shaft foundations supporting miscellaneous structures, only drilled shafts selected by the Engineer will be tested.

## Sonic Echo Testing (Pile Integrity Testing)

This photo shows a sonic-echo test being performed. Note that the technician has embedded a nail in the top of the shaft's concrete so as to provide a sharp sonic wave. This will help find small defects near the top of the shaft. To search for deeper defects, a larger hammer with a hard cushion might be used to produce a sonic compression wave of longer length that will propagate deeper (but with less resolution) than the sharp wave.

Advantages of the test are that it can be done on virtually any shaft without prior planning (no access tubes need be placed in the shaft) and is quick and inexpensive. Disadvantages are that it is prone to showing false positives and to missing fairly large voids or inclusions in the concrete. It is essentially 100 per cent accurate only if the void or inclusion covers about half of the cross-sectional area of the shaft and is reasonably thick (say 18 inches (0.5 m) or thicker) and the test is performed correctly.

This test is not usually effective in locating deep defects (depths greater than 60 feet (20 m) and cannot detect contact problems between the concrete and the soil or rock that is of similar strength to that of the concrete, as the signal essentially "dissipates".

False positives in this method come from changes in cross-section that are not associated with an anomaly, from changes in concrete modulus, such as at the interface between concrete placed from two different trucks, from changes in the stiffness of the soil or rock surrounding the shaft, which also dissipate sonic energy, and from testing technique errors such as setting the sensor on weak or powdery concrete.

## Coring

Coring of drilled shafts can be used as an independent integrity test method, or it can be used to attempt to confirm the presence of defects that appear as anomalies on CSL testing or pulse-echo records. Coring is not fool-proof, however, as cores can bypass serious defects. So, coring is a way of potentially confirming that the shaft is defective but not that it is not defective.

For example, a good core taken in the middle of the shaft does not necessarily mean that the shaft is good. After all, the best concrete is expected to be in the middle of the shaft where the tremie pie or pumping line was. The defects are more likely to appear towards the outside of the shaft rather than towards the inside. That is why sometimes when defects are suspected coring may be required to be performed outside the cage. Very careful coring is sometimes an effective way to investigate whether there is a soft base in the drilled shaft.

These photos show the cores from two drilled shafts. The right core shows good concrete. The left core shows contaminated and poor concrete. A disadvantage of coring is that it consumes more time and requires the core hole to be carefully filled with grout. It may also be difficult to position a coring rig atop the shaft, whereas minimal equipment is needed atop the shaft in a pulse-echo test.

As the Inspector, you might be called upon to observe the coring operation. Be a Reporter and Recorder. In this case, you would want to document the core start depth, the core run length, time, % REC, and naturally, the core barrel type and size.

### A good Shaft

This is a 70 foot long shaft constructed under mineral drilling slurry, load tested to geotechnical failure and then exhumed for observation. The shaft was almost perfectly cylindrical, and no concrete contamination could be observed.

A good shaft is more likely to occur when good construction practices, good specifications and inspection come together.

### Pay Items

We will cover in the final part of this lesson the drilled shaft pay items. Most contracts reimburse the Contractor per foot or meter of something, per each for some items and lump sum for a few things. These need to be recorded correctly. Depending upon their bid price, the difference between 30 feet or 60 feet can represent a lot of dollars. Conversely, if the pay item should be 30 feet, not 60, FDOT doesn't want to pay 60 feet.

The Contractor is entitled to be paid for what was furnished, installed and accepted. We should make a comment regarding payment for miscellaneous structures foundations. Typically for miscellaneous structures the price of the drilled shaft is included within the price of the full installed structure. Therefore, the pay items slides that we will cover will be applicable mostly for bridge foundations.

### 455-23 Method of Measurement

We will cover first the method of measurement of drilled shaft pay items. This refers to the way the quantities are determined. The first pay items we will cover is shaft excavations. There are types of shaft excavations: Unclassified and unclassified extra depth. Let's review method of measurement for unclassified shaft excavation first.

**Unclassified Shaft Excavation:** The quantity to be paid for will be the length, in feet, of unclassified shaft excavation of the diameter shown in the plans, completed and accepted, measured along the centerline of the shaft from the ground surface elevation after any required excavation per 455-1.2 to the plan bottom of shaft elevation authorized and accepted plus up to 15 feet or 3 shaft diameters, whichever is deeper, of additional excavation as authorized by the Engineer. Note how this specification is consistent with the equipment depth below ground requirements for bridges that we covered in lesson 2.

**Unclassified Extra Depth Excavation:** When excavation is required by the Engineer to extend more than 15 feet or 3 shaft diameters, whichever is deeper, below the bottom of the shaft elevation shown in the plans, the work will be considered as Unforeseeable Work. Now let's talk about test holes: The cost of all test holes will be included in the cost of Drilled Shafts.

**Measurement for payment of Cores and pilot holes:** Core: The quantity to be paid for will be the length, in feet, measured from the bottom of the shaft elevation to the bottom of the core-hole, for each authorized core drilled below the shaft excavation, completed and accepted.

When the Engineer authorizes pilot holes extending through part or all of the shaft, prior to excavation, to some depth below the shaft bottom, the quantity paid as Core (Shaft Excavation) will be the length in feet, measured from the top elevation to the bottom elevation authorized by the Engineer, completed and accepted.

Core (shaft excavation) is paid from the bottom of the shaft to the bottom of the core column. Remember that core (shaft excavation) is the core or soil boring performed at the bottom of the shaft to verify the condition of the rock or soil below the bottom of the shaft.

Pilot holes are paid from the top elevation of the pilot hole to the bottom of the pilot hole. Remember that a pilot hole in the drilled shaft specification is the soil boring with or without rock cores taken to determine the authorized tip elevations of the drilled shaft.

**Casings:** The quantity to be paid for will be the length, in feet, of each size casing as directed and authorized to be used. The length will be measured along the casing from the top of the shaft elevation or the top of casing whichever is lower to the bottom of the casing at each shaft location where casing is authorized and used, except as described below when the top of casing elevation is shown in the plans.

Casing will be paid for only when the Permanent Casing Method is specified, when the plans show a casing that becomes a permanent part of the shaft, or when the Engineer directs the Contractor to leave a casing in place which then becomes a permanent part of the shaft. No payment will be made for casings which become bound or fouled during shaft construction and cannot be practically removed. Remember that a Temporary Casing left in the hole is just that: a Temporary Casing left in hole, which the department does not pay.

When the Permanent Casing Method and the top of casing elevation are specified, the casing will be continuous from top to bottom.

When the top of the casing elevation is shown in the Contract Documents, payment will be from the elevation shown in the plans or from the actual top of casing elevation, whichever is lower, to the bottom of the casing.

**Cross-Hole Sonic Logging:** The quantity of the cross-hole sonic logging test set-ups to be paid for will be the number of drilled shafts accepted based on cross-hole sonic logging tests. This means that if a CSL testing indicates an anomaly that renders the shaft unacceptable the department does not pay for this testing.

**455-24 Basis of Payment**

Now, let's talk about the basis of payment of some shaft items. A basis of payment of a pay item is a description of what is included in the pay item. Let's see the basis of payment for Drilled Shafts.

**Drilled Shafts:** Price and payment will be full compensation for all drilled shafts, including the cost of concrete, reinforcing steel and cross-hole sonic logging tubes, including all labor, materials, equipment, and incidentals necessary to complete the drilled shaft. The cost of the reinforcing steel, including lap lengths, to accommodate shaft lengths longer than shown in the plans is included in the cost of Drilled Shafts. Costs associated with repairing defects found in the drilled shaft shall be included in the cost of the drilled shaft.

**Unclassified Shaft Excavation:** Price and payment will be full compensation for the shaft excavation (except for the additional costs included under the associated pay items for casing); removal from the site and disposal of excavated materials; restoring the site as required; cleaning and inspecting shaft excavations; using slurry as necessary; using drilling equipment; blasting procedures, special tools and special drilling equipment to excavate the shaft to the depth indicated in the plans; and furnishing all other labor, materials, and equipment necessary to complete the work in an acceptable manner.

**Test Holes:** No separate payment will be made for Test Hole. All costs of Test Holes will be included in the cost of Drilled Shafts.

**Core (Shaft Excavation):** Price and payment will be full compensation for drilling and classifying the cores/pilot hole, delivering them to the Department, furnishing drilled shaft concrete to fill the core/pilot hole, and all other expenses necessary to complete the work. When SPT tests are substituted for cores/pilot holes as provided in 455-15.6, they will be paid for at the price per foot for coring.

**Casings:** Price and payment will be full compensation for additional costs necessary for furnishing and placing the casing in the shaft excavation above the costs attributable to the work paid for under associated pay items for Unclassified Shaft Excavation.

**Protection of Existing Structures:** Price and payment will include all cost of work shown in the plans or described herein for protection of existing structures.

**Cross-Hole Sonic Logging:** Price and payment will include all costs related to the performance of the CSL testing and incidentals to the cross-hole sonic test set-up.

The drilled shaft pay items are as follows:

Item No. 455-18 Protection of Existing Structures - lump sum.

Item No. 455-88 Drilled Shaft - per foot.

Item No. 455-107 Casing - per foot.

Item No.455-111 Core (Shaft Excavation) - per foot.

Item No. 455-119 Test Loads - each.

Item No. 455-122 Unclassified Shaft Excavation - per foot.

Item No. 455-129 Instrumentation and Data Collection - lump sum.

Item No. 455-142 Cross-Hole Sonic Logging - each.

**Construction & Pay Summary**

This is the form that is completed for pay purposes. It is essentially a summary of the information the Inspector had entered on other Drilled Shaft forms during the shaft construction. The Inspector should check with the PA on projects with Miscellaneous Shafts. In many cases, they are paid for as an “ach or Lump Sum” (for example: One high mast lighting unit, all inclusive).

Though the Pay Summary may seem to not be necessary, it is nice to have the summary from a records standpoint. The form contains the following information:

1- Project information
2- Type of shaft construction
3- Construction details
4- Pay quantities
5- Adjustments

Since this form involves pay items, filling this form may or may not be your responsibility, your project administrator may decide to do it himself. It is a good practice to complete this form even for Miscellaneous Structures that are being paid as Lump Sum or Each.

## Topics covered

We have discussed the following objectives in this lesson:

- Identify and describe various Integrity and Load Tests
- Construction tolerances
- Describe the Drilled Shaft Pay Items
- Identify the applicable 455 specifications

## End of Lesson

This is the end of lesson 9. Please continue to the next lesson.