4551508 STRUCTURES FOUNDATIONS.
COMMENTS FROM INTERNAL/INDUSTRY REVIEW

Anonymous

Comments: (6-23-23 Industry)
Currently proposed: 1. The shaft location is not within a distance equal to the shaft depth, or five shaft diameters, whichever is greater, from an edge of adjacent lane, utility structure, or any structure. Consider clarification of "utility structure". Does this only cover utlitiy poles? Does it include buried conduit? Does it include buried irrigation lines? Storm drain pipe?
Response: Yes to all the questions.
Action(s):No change needed.

****

Larry Jones
Work Phone:
E-Mail: Larry.Jones@dot.state.fl.us

Comments: (7-7-23 Industry)
Table 455-4 should mirror the same "in freshwater/saltwater environment" language as Tables 455-2 & 455-2.
Response: Yes. Thank you.
Action(s): Change made.

****

Tancredo Marte
Work Phone: 386-943-5419
E-Mail: Tancredo.Marte@dot.state.fl.us

Comments: (7-7-23 Industry)
: In reference to "The shaft location is not within a distance equal to the shaft depth, or five shaft diameters, whichever is greater, from an edge of an adjacent lane, utility structure, or any structure", often times mast arm drilled shaft are installed in tight ROW, area with lots of existing utilities, existing structures, and intersection geometry constraints, leaving no options but install a mast arm drilled installed a few feet from existing utilities and existing structures. Making a requirement that drilled shaft should be clear from existing utilities and existing structures up to the depth of the drilled shaft or 5 times the shaft diameter will create lots of problems on where to install mast arm drilled shafts or even possible, especially in area with lots of utilities and existing structures. I think there should be an exemption to the location of where to install drilled shafts, such as tight ROW, alots of existing utilities, and existing structures. As long as the drilled shaft can be installed safely away from existing utilities and/or existing structure given the constraints of the location.
Response: What you suggest is similar to the current language. However, in our meetings with the LESS committee, they requested a specific distance criterion to be defined and that is what we did. The distance criterion proposed here is consistent with section 108-2. Shafts not meeting this requirement would not qualify for waving the continuous fluid testing. Alternatively, the contractor will have to adjust his methods and operations to have a continuous drilled shaft operation and/or avoid leaving unprotected excavations for some times. The proposed changes were reviewed by the industry during the internal review process and no objections came to this proposed language.
Action(s): No changes.

****

Dongming White
Work Phone: 305-470-5486
E-Mail: dongming.white@dot.state.fl.us

Comments: (7-19-23 Industry) Please see comments in the following.

Responses: In the attachment Jc to DW pdf document. Comments are mostly from old language that was not change.
Action(s): Editorial changes made.

(Specifications Office 7-31-23): Comments and Responses are in the following pages due to the manner/length they were submitted.

****

ORIGINATION FORM

Proposed Revisions to the Specifications

(Please provide all information - incomplete forms will be returned)

Date: 3/7/23

Originator: Juan Castellanos

Telephone: 9546777032

email: juan.castellanos@dot.state.fl.us

Office: Construction

Specification Section: SS 455

Article/Subarticle: 455-15.8, 455-17.6, 455-20

Associated Section(s) Revisions:

Will the proposed revision require changes to the following Publications:

Publication	Yes	No	Office Staff Contacted	Date
Standard Plans Index			Rick Jenkins/Joshua Turley	2/6/23
Traffic Engineering Manual			Dana Knox	2/6/23
FDOT Design Manual			Gevin McDaniel	2/6/23
Construction Project Administration Manual			Rick Jenkins/Joshua Turley	2/6/23
Basis of Estimate/Pay Items			Ryan Gray	2/6/23
Structures Design Guidelines			Ben Goldsberry	2/6/23
Approved Product List			Karen Byram	2/6/23
Materials Manual			Susan Musselman	2/21/23
Maintenance Specs			Deanna Hutchison	2/6/23

Will this revision necessitate any of the following:

Design Bulletin ☐ **Construction (DCE Memo)** ☐ **Estimates Bulletin** ☐ **Materials Bulletin** ☐

Have all references to internal and external publications in this Section been verified for accuracy? YES

Synopsis: Summarize the changes:

455-15.8: Expands to 6 ft diameter shafts the exemption to have continuous testing for certain miscellaneous shafts. Defines the safe distance within which the exemption is not permitted. 455-15.8.3. Allows the use of sodium bicarbonate up to 5 lb/5000 galls to facilitate the use of polymer slurries. 455-17.6 Expand the ASTM standard number for thermal testing to ASTM7949-14 to include the year. Requires CSL testing to be performed within 25 days.

Justification: Why does the existing language need to be changed?

Change to 455-20 is required to avoid a conflict with Standard Index 649-031. Change to ASTM 7949-14 is required to make sure a valid reference is used for the thermal testing. The other changes were requested by the LESS comittee to expedite construction of shafts for miscellaneous structures.

Do the changes affect either of the following types of specifications (Hover over type to go to site.):

Special Provisions ☐ **Developmental Specifications** ☐

List Specifications Affected: (ex. SP3270301, Dev330TL, Dev334TL etc.)

Contact the State Specifications Office for assistance completing this form.

Daniel Strickland 850-414-4130 Daniel.Strickland@dot.state.fl.us or Darla Hunsicker 850-414-4114 Darla.Hunsicker@dot.state.fl.us

1. Are changes in line with promoting and making meaningful progress on improving safety, enhancing mobility, inspiring innovation, and fostering talent; explain how?

No

2. What financial impact does the change have; project costs, pay item structure, or consultant fees?

None

3. What impacts does the change have on production or construction schedules?

No impacts. These chages were requested by the LESS committee.

4. How does this change improve efficiency or quality?

It reduces some requirements for LESS contractors.

5. Which FDOT offices does the change impact?

Construction.

6. What is the impact to districts with this change?

None.

7. Does the change shift risk and to who?

No.

8. Provide summary and resolution of any outstanding comments from the districts or industry.

No comments received yet. These changes were required by the LESS industry.

9. What is the communication plan?

Through industry review, and normal specifications review process.

10. What is the schedule for implementation?

July 2024.

STRUCTURES FOUNDATIONS.
(REV 3-7-23)

SUBARTICLE 455-15.8 is deleted and the following substituted:

455-15.8 Slurry and Fluid in Excavation:

455-15.8.1 General: Thoroughly premix the slurry in a mixing tank with clean fresh water prior to introduction into the shaft excavation. Introduce slurry before the excavation advances below the bottom of the casing. Ensure that the percentage of polymer or mineral admixture used to make the suspension is such as to maintain the stability of the shaft excavation. Provide adequate water and/or slurry tanks to perform the work in accordance with this Section. 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 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.

For shafts to support sign, signal, lighting, and ITS structures, polymer slurry may be mixed in the casing portion, in accordance with the APL approved instructions if the following conditions are met:

1. Contractor tests and verifies the polymer slurry meets the property requirements of 455-15.8.3, before continuing the excavation below the casing.

2. Polymer mix continues to be added as required below the bottom of the casing, to maintain the slurry properties during the excavation within compliance of 455-15.8.3.

3. Slurry sampling and testing is performed at intervals not exceeding one hour, in the middle of the excavation depth at the time of testing to verify the properties are maintained within compliance throughout the excavation.

4. If failing to demonstrate the properties are maintained within compliance of 455-15.8.3, discontinue this mixing method and use a slurry pre-mixed in a tank.

Provide a CTQP qualified drilled shaft inspector to perform control tests using suitable apparatus on the slurry mixture to determine the slurry and fluid properties as specified in 455-15.8.2 to 455-15.8.4.

Measure the viscosity of the freshly mixed slurry regularly as a check on the quality of the slurry being formed using an approved measuring device.

Perform tests from the fluid in the excavation to determine density, viscosity, and pH value to establish a consistent working pattern, taking into account the mixing process and blending of freshly mixed slurry and previously used slurry. Repeat tests to determine density, viscosity, and pH value at intervals not exceeding 2 hours during the first 8 hours slurry is in use and every 4 hours thereafter, including overnight, until concrete placement. Perform density, viscosity, and pH tests again when the excavation reaches the midpoint. When the contractor operations require the shaft excavation to be interrupted and performed in multiple shifts, the continuous testing may be waived if the excavation at the time of suspension of the operations is not deeper than the bottom of the casing provided.

For shafts to support sign, signal, lighting, and ITS structures up to ~~5~~ 6 feet in diameter and up to 40 feet in depth, when the contractor operations require the shaft to be constructed in multiple shifts, the continuous testing may be waived if the excavation at the time of operations suspension is not deeper than the bottom of the casing provided, or if all the conditions below are met:

1. The shaft location does not pose a safety risk to the public, adjacent lane, utility pole, or any structure, if the excavation failsis not within a distance equal to the shaft depth, or five shaft diameters, whichever is greater, from an edge of an adjacent lane, utility structure, or any structure.

2. Slurry testing is performed at the time of suspending operations and at a time not exceeding 12 hours after that or at the time the operations resume whichever comes first. Testing shall be performed at intervals not exceeding 2 hours for the first 8 hours after resuming operations and every 4 hours thereafter.

3. Slurry testing shall be performed on at least two samples each time, one sample approximately three feet from the bottom and one sample from the middle of the excavation depth at the time the operations were suspended. The results must indicate the polymer slurry meets the viscosity requirements of 455-15.8.3. If this requirement is not met, do not continue without testing for more than 4 hours including the time periods between shifts.

4. The contractor performs soundings of the fluid level, at intervals of 15 minutes or longer, that demonstrate the fluid level is stable over two consecutive soundings.

5. If when resuming operations, slurry does not meet density, pH, or both, adjust the slurry to meet all property requirements of 455-15.8.3. Re-test slurry to verify properties meet the requirements, before resuming operations. Continue testing the slurry every 4 hours after resuming operations until completion of the excavation.

The Department may perform comparison tests as determined necessary during the mineral and polymer slurry operations.

If, at any time in the opinion of the Engineer, the wet construction method fails to stabilize the excavation, discontinue this method of construction, backfill the excavation and submit modifications in procedure or alternate means of construction for approval.

455-15.8.2 Mineral Slurry: When mineral slurry is used in an excavation, use only processed attapulgite or bentonite clays with up to 2% (by dry weight) of added polymer. Use mineral slurry having a mineral grain size such that it will remain in suspension and having viscosity and gel characteristics to transport excavated material to a screening system. Use a percentage and specific gravity of the material to make a suspension able 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 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.

Perform the following tests on the mineral slurry supplied to and in the shaft excavation and ensure that the results are within the ranges stated in the table below:

Table 455-2		
Item to be measured	Range of Results at 68ºF fluid temperature	Test Method
Density	64 to 73 lb/ft^3 (in fresh-water environment) 66 to 75 lb/ft^3 (in salt-water environment)	Mud density balance: FM 8-RP13B-1
Viscosity	30 to 40 seconds	Marsh Cone Method: FM 8-RP13B-2
pH	8 to 11	Electric pH meter or pH indicator paper strips: FM 8-RP13B-4
Sand Content	4% or less	FM 8-RP13B-3

The Contractor may adjust the limits in the above table when field conditions warrant as successfully demonstrated in a test hole or with other methods approved by the Engineer. The Engineer must approve all changes in writing before the Contractor can continue to use them.

During construction, maintain the level of mineral slurry in the shaft excavation within the excavation and at a level not less than 4 feet above the highest expected piezometric water elevation along the depth of a shaft.

455-15.8.3 Polymer Slurry: 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. 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 recommendations.

Perform the following tests on the polymer slurry supplied to and in the shaft excavation and ensure that the results are maintained within the ranges stated in the table below:

Table 455-3 Mixed Polymer Slurry Properties		
Item to be measured	Range of Results at 68ºF fluid temperature	Test Method
Density	62 to 65 lb/ft^3 (in fresh-water environment) 64 to 67 lb/ft^3 (in salt-water environment)	Mud density balance: FM 8-RP13B-1
Viscosity for bridges and main structure foundations	50 seconds to upper limit defined by the APL	Marsh Cone Method: FM 8-RP13B-2
Viscosity for miscellaneous structure foundations	50 seconds to upper limit recommended by the manufacturer based on soil type	Marsh Cone Method: FM 8-RP13B-2

Table 455-3 Mixed Polymer Slurry Properties		
Item to be measured	Range of Results at 68ºF fluid temperature	Test Method
pH	Range published by the manufacturer for materials excavated	Electric pH meter or pH indicator paper strips: FM 8-RP13B-4
Sand Content	0.5% or less	FM 8-RP13B-3

If desired, sodium bicarbonate or soda ash may be added to the fluid in the shaft to raise the pH. Premix polymer slurry in accordance with the manufacturer's published procedures. Do not mix the slurry in the excavation as a means to prepare slurry. When approved by the Engineer, adjustments to slurry properties can be made in the excavation.

During construction, maintain the level of the slurry at a height sufficient to prevent caving of the hole and which should not be lower than 4 feet above the highest expected piezometric water elevation along the depth of the shaft.

Ensure the method of disposal meets the requirements of local authorities.

455-15.8.4 Fluid in Excavation at Time of Concrete Placement: When any fluid is present in any drilled shaft excavation, including shafts to support sign, signal, lighting and ITS structures, the applicable test methods and reporting requirements described in 455-15.8.1, 455-15.8.2 and 455-15.8.3 apply to tests of fluid in the shaft prior to placing the concrete.

When mineral slurries are used, ensure the properties at the time of concrete placement are within the acceptable ranges indicated in 455-15.8.2. When polymer slurries are used ensure the properties of the polymer slurry are within the following acceptable ranges at the time of concrete placement:

Table 455-4 Polymer Slurry Properties at Time of Concrete Placement		
Item to be measured	Range of Results at 68ºF fluid temperature	Test Method
Density	62 to 65 lb/ft^3 (fresh water) 64 to 67 lb/ft^3 (salt water)	Mud density balance: FM 8-RP13B-1
Viscosity	50 seconds to upper limit defined by the APL	Marsh Cone Method: FM 8-RP13B-2
pH	Range published by the manufacturer for materials excavated	Electric pH meter or pH indicator paper strips: FM 8-RP13B-4
Sand Content	0.5% or less	FM 8-RP13B-3

Test samples of the fluid in the shaft from within 1 inch of the base of the shaft and from the middle of the shaft height for shafts up to 60 feet in depth. Test samples of the fluid in the shaft from within 1 inch of the base of the shaft and at intervals not exceeding 30 feet up the shaft for shafts deeper than 60 feet. Use a sampling tool designed to sample over a depth range of 12 inches or less. Take whatever action is necessary prior to placing the concrete to bring the fluid within the specification and reporting requirements, outlined in the tables in 455-15.8.2 and 455-15.8.3, except as follows:

The Engineer will not require tests for pH or viscosity, nor require the fluid to meet the minimum density specified in 455-15.8.2 and 455-15.8.3 when neither polymer nor mineral slurry has been introduced into the shaft excavation.

SUBARTICLE 455-17.6 is deleted and the following substituted:

455-17.6 Non-Destructive Testing of Drilled Shaft Integrity:

455-17.6.1 Thermal Integrity Testing for Drilled Shafts (TITDS): Perform all TITDS in accordance with ASTM D7949-14, which details two alternative procedures:

Method A: uses a thermal probe lowered into access ducts installed in the deep foundation element during construction.

Method B: uses multiple embedded thermal sensors attached to the reinforcing cage installed in the deep foundation element during construction.

. Test method shafts, load test shafts, and all drilled shafts in bridge bents or piers considered nonredundant in the Plans, using TITDS. For all other drilled shafts, perform TITDS 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 of shafts tested as deemed necessary.

Engage a qualified Specialty Engineer to supervise the TITDS. The qualified TITDS Specialty Engineer must have a minimum of six months experience of TITDS, have a Florida Licensed Professional Engineer and supervise the collection and interpretation of data. The individual performing the TITDS in the field must work for the Specialty Engineer firm and have a minimum of six months' experience of TITDS. The Contractor shall provide all necessary assistance to the TITDS Specialty Engineer to satisfactorily perform the testing.

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 meeting the requirements of Section 934 from the bottom via tremie tube. Place the grout utilizing enough pressure to fill the tubes or core holes completely.

If the Contractor determines at any time during the non-destructive testing and evaluation of the drilled shaft that the drilled shaft should be replaced, no further testing or evaluation of that shaft is required.

455-17.6.1.1 Equipment: Furnish TITDS test equipment in accordance with ASTM D7949-14 as follows:

1. Provide thermal probes with four orthogonally oriented infrared sensors able to be used in 1-1/2 inch I.D. pipes.

2. Provide a computer based TITDS data acquisition system for display of signals during data acquisition.

3. Provide a depth encoder sensor to determine probe depths.

4. Provide an air compressor and power supply with sufficient pressure to air lift the water from the access tubes.

455-17.6.1.2 Procedure: For non-bridge structures, perform TITDS testing between the minimum and maximum times shown below after the batching time of the first truck load placed in the drilled shaft, unless otherwise directed by the Engineer.

Table 455-6		
Shaft Diameter (inches)	Minimum time (hours)	Maximum time (hours)
36 - 48	24	54
49 - 60	24	72
61 - 72	24	72
73 - 84	24	90
85 - 120	24	108

The Contractor may propose modifications in the above table for site specific and special concrete mix conditions, as demonstrated from lab and field testing and instrumentation. The Engineer must approve all changes to the testing times prior to the Contractor using them.

For bridges, prior to production drilled shaft and load test drilled shaft installation, perform TITDS in accordance with ASTM D7949-14 Method B to determine the temperature variability and time to peak temperature for each project specific concrete mix. Obtain temperature measurements at least every 15 minutes during curing on the method shafts pi[illegible] Submit the TITDS results within three working days of performing the tests, in accordance with 455-17, including the proposed temperature peak time established from the TITDS. The Engineer will review the results of the test and concur with the proposed peak time or revise it. After the peak time is established for each mix, perform TITDS in accordance with ASTM D7949-14 Method A on production drilled shafts and load test shafts, within the following times after batching the first truck:

$$\text{Minimum time (hours)} = \text{Peak time (hours)} - 8$$

$$\text{Maximum time (hours)} = \text{Peak time (hours)} + 4D$$

Where:

D = Drilled shaft diameter in feet.

Peak time: Time after batching the first truck load that was placed in the drilled shaft, at which the maximum temperature is observed.

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 the end of concrete placement. If the access tubes do not provide access over the full length of the shaft, repair the existing tube(s) or core additional hole(s), as directed by the Engineer, at no additional cost to the Department.

Just prior to inserting the thermal probe, remove water from the access tubes. Store the removed water in an insulated container for later replacement. Allow the thermal probe to acclimate in accordance with the equipment manufacturer recommendations. Continuously record temperatures at depth intervals of 3.0 inches or less from the top to the bottom of each access tube. Repeat the test at each access tube until two sets of data from the same access tube provide similar results. Return the warm water to the access tubes immediately after the testing has been completed.

Immediately report any potential defects indicated by low temperature anomalies to the Engineer.

455-17.6.1.3 Required TITDS Reports: Submit the TITDS data and analysis results to the Engineer in a signed and sealed report, together with all electronic data, within ~~48 hours~~three working days of testing. The report shall include as minimum the following items:

1. Graphs displaying all temperature measurements and average temperature versus depth.
2. Indication of unusual temperatures, including cooler local deviations from the average at any depth from the overall average over the entire length.
3. A graph displaying the average temperature and theoretical temperature versus depth.
4. Variations in temperature between access tubes which may indicate variations in cage alignment.
5. When ASTM D7949-14 method B is used, include a chart indicating the variability of temperature vs. time, for all wires and the average. Submit the peak time in hours for the average temperature of the wires.
6. The calculated radius of the shaft throughout the entire depth.
7. Calculated concrete cover throughout the entire depth.
8. Shaft Details, Probe Details, Environmental Details, Tube Run Selection and Shaft Adjustment Data that show the measurements, inputs, and adjustments to the data. Screen captures of these pages from the TIP Reporter software will be acceptable.
9. A conclusion stating whether the tested shaft is free from integrity defects, meets the minimum concrete cover and diameter requirements by the specifications and the cage is properly aligned. When anomalies are detected, include in the report a three-dimensional rendering of the shape of the shaft.

455-17.6.1.4 Evaluation of TITDS Test Results: The Engineer will evaluate the observations during drilled shaft construction and TITDS results to determine whether or not the drilled shaft construction is acceptable. Drilled shafts not meeting the minimum cover and diameter requirements, or having integrity defects, are not acceptable without an engineering analysis.

455-17.6.1.5 Coring and/or Repair of Drilled Shafts: If the Engineer determines a drilled shaft is unacceptable based on the TITDS tests and other testing, or observes problems during drilled shaft construction, core the shaft to allow further evaluation and repair, or replace the shaft as directed by the Engineer. If coring to allow further evaluation of the shaft and repair is chosen, one or more core samples shall be taken from each unacceptable shaft for full depth of the shaft or to the depth directed by the Engineer. The Engineer will determine the number, location, and diameter of the cores based on the results of the TITDS. Keep an accurate log of cores. Properly mark and place the cores in a crate showing the shaft depth at each interval of core recovery. Submit the coring log and transport the cores to the location designated by the Engineer. Perform strength testing by an AASHTO certified lab on portions of the cores as required by the Engineer. If the TITDS and coring indicate the shaft is defective, propose remedial measures for approval by the Engineer. Such improvement may consist of~~,~~ but is not limited to correcting defective portions of the shaft, providing straddle shafts to compensate for capacity loss, or providing a replacement shaft. Repair all detected defects and conduct post repair integrity testing using horizontal and offset CSL testing and 3-D tomographic imaging as described in 455-17.6.2. Engage a Specialty Engineer to perform gamma-gamma density logging calibrated to 1-1/2 inch black iron access tubes, prior to and after the repair is performed, to verify the integrity of the shaft outside the reinforcing cage in the same locations where the repair was required. When straddle shafts or replacement shafts are used to correct a deficient foundation, perform TITDS in accordance with 455-17.6.1 through 455-17.6.3 to verify integrity of these shafts. Submit all results to the Engineer within five days of test completion for approval. Perform all work described in this subarticle at no additional cost to the Department, and with no increase in Contract Time.

455-17.6.2 Cross Sonic Logging (CSL) and Tomography: When required by the Engineer, perform CSL testing in accordance with ASTM D6760 within 25 days of completion of the shaft. Perform the test within 25 days of completion of the shaft. Engage a qualified Specialty Engineer to perform the CSL testing. The qualified CSL Specialty Engineer must be a Professional Engineer in the State of Florida and have a minimum of six months' experience of CSL testing, supervising the collection of CSL data and interpretation of CSL results. The individual performing the CLS testing in the field must work for the Specialty Engineer firm and have a minimum of six months' experience of CSL testing. The Contractor shall provide all necessary access and assistance to the CSL Specialty Engineer to satisfactorily perform the testing.

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. Pull the probes simultaneously, starting from the bottoms of the tubes, over an electronic depth measuring device. Perform the CSL tests with the source and receiver probes in the same horizontal plane. Continuously record CSL signals at depth intervals of 2-1/2 inches or less from the bottom of the tubes to the top of each shaft. Remove all slack from the cables prior to pulling to provide accurate depth measurements in the CSL records. When the measurements indicate a 30% or greater reduction in velocity between one or more pairs, take one or two concrete cores to allow further evaluation and repair, or replace the shaft as directed by the Engineer. Determine the location of the concrete cores by performing 3D tomographic analysis using the CSL measurements. The core depths shall be at least 5 feet deeper than the bottom of the anomaly determined by the 3D tomography analysis or full depth if the anomaly is within 5 feet of the bottom of the shaft. The Engineer may accept a drilled shaft without ~~rock~~ concrete cores if an EFR demonstrates that the anomaly does not affect the structural and the geotechnical axial capacity, the structural and geotechnical lateral stability, the settlement behavior of the shaft, and that the anomaly will not impact the durability of the foundation.

When repairs are done, perform CSL measurements in all tube pair combinations with the source and receiver running at the same horizonal plane and at the vertical offsets of 45 degrees above and below. Perform all measurements including the offset measurements from the point where the higher probe is at least 5 feet below the lower limit of the repaired zone to the point where the lower probe is at least 5 feet above the upper limit of the repaired zone. Offset measurements must be as follows: plus 45 degrees (source below receiver) and minus 45 degrees (source above receiver). Use the measurements of these two offsets in combination with the horizontal measurements to perform the 3D tomography. Provide the CSL measurements, CSL logs and 3D tomographic analysis at no additional cost to the Department.

After acceptance of production shafts by the Engineer, fill the tubes or core holes with a structural non-shrink grout in accordance with 455-17.6.1.

If the Contractor determines at any time during the non-destructive testing and evaluation of the drilled shaft that the drilled shaft should be replaced, no further testing or evaluation of that shaft is required.

455-17.6.2.1 Required CSL Reports: Present the CSL data and analysis results to the Engineer in a signed and sealed report. Include CSL logs with analyses of first pulse arrival time (FAT) versus depth and pulse energy/amplitude versus depth. Present a CSL log for each tube pair tested with any defect zones identified on the logs and discussed in the test report as appropriate. When offset measurements are required, perform 3D tomographic analysis using all offset data, and include color coded 3D tomographic images in the report.

455-17.6.2.2 Evaluation of Cross Hole Sonic logging Testing: The Engineer will evaluate the observations during drilled shaft construction and the CSL test results to determine whether or not the drilled shaft construction is acceptable. Drilled shafts with velocity reduction exceeding 30% are not acceptable without an engineering analysis.

455-17.6.2.3 Coring and/or Repair of Drilled Shafts: If the Engineer determines a drilled shaft is unacceptable based on the CSL test and other testing, core the shaft to allow further evaluation and repair, or replace the shaft in accordance with 455-17.6.1.5.

If repairs are performed or additional shafts installed to correct a deficient foundation, conduct integrity testing and submit the results to the Engineer in accordance with 455-17.6.1.5.

ARTICLE 455-20 is deleted and the following substituted:

455-20 Construction Tolerances.

Meet the following construction tolerances for drilled shafts:

1. 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.

2. Ensure that the vertical alignment of the shaft excavation does not vary from the alignment shown in the Plans by more than 1/4 inches per foot of depth.

3. 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.

4. Ensure that the reinforcing cage is concentric with the shaft within a tolerance of 1-1/2 inches. Ensure that the horizontal concrete cover is a minimum of 4-1/2 inches unless shown otherwise in the Plans.

5. Ensure that the minimum diameter of the drilled shaft is not smaller than the specified shaft diameter minus 1 inch. 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 smaller than the specified shaft diameter minus 1 inch. When approved, the Contractor may elect to provide a casing larger in diameter than shown in the Plans to facilitate meeting this requirement. When conditions are such that a series of telescoping casings are used, provide the casing sized to maintain the minimum shaft diameters listed above.

6. Except when abutting or encroaching within a sidewalk, ensure that the top elevation of the drilled shaft concrete has a tolerance of plus 1 inch and minus 3 inches from the top of shaft elevation shown in the Plans.

7. When abutting or encroaching within a sidewalk, ensure that the top elevation of the drilled shaft is flush with the sidewalk surface.

8. The dimensions of casings are subject to American Petroleum Institute tolerances applicable to regular steel pipe.

9. 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 plus or minus 3/8 inches per foot of diameter.

ARTICLE 455-44 is deleted and the following substituted:

455-44 Pile Installation.

Meet the following requirements:

1. Locate the piles as shown on the drawings.

2. Should soft, compressible muck, organics, clay or other unsuitable materials (non A-1, A-3, A-2-4 or limestone materials) be encountered, remove the unsuitable material to a maximum depth of 5 feet and a radial distance around the pile centerline of two pile diameters, unless otherwise indicated in the Plans. Backfill with clean granular backfill materials (A-1, A-3, A-2-4), placed and compacted in maximum 12 inch lifts to at least 95% of maximum dry density as determined by FM 1-T180. Complete this work to the Engineer's satisfaction prior to ACP construction. Should more than 5 feet depth or excessive quantities of unsuitable material be encountered, immediately advise the Engineer and proceed with the work as directed by the Engineer.

3. Provide continuous auger flighting from the bottom of the pile to the top of ground at the time of drilling with no gaps or other breaks, except for connections. Ensure the auger flights are uniform in diameter throughout its length, and of the diameter specified for the piles less a maximum of 3%. Provide augers with a distance between flights of approximately half the diameter of the auger.

4. Use augers with the grout injection hole located at the bottom of the auger head below the bar containing the cutting teeth, and with pile auger leads containing a bottom guide.

5. Construct piles of the length and diameter shown on the Plans.

6. Clearly mark the auger leads to facilitate monitoring of the incremental drilling and grout placement. Provide individual foot marks with 5 foot increments highlighted and clearly visible. Provide a clear reference mark on the moving auger assembly to facilitate accurately monitoring the vertical movement of the auger.

7. Place piles by rotating a continuous flight hollow shaft auger into the ground at a continuous rate that prevents removal of excess soil. Stop advancement after reaching the predetermined depth.

8. Should auger penetration to the required depth prove difficult due to hard materials/refusal, the pile location may be predrilled, upon approval of the Engineer, through the obstruction using appropriate drilling equipment, to a diameter no larger than one-half the prescribed finish diameter of the ACP. Commence grouting immediately upon reaching the required tip elevation to minimize ground loss and soil relaxation. Should non-drillable material be encountered preventing placement to the depth required, immediately advise the Engineer and proceed with the work as directed by the Engineer. Refusal is defined as the depth where the penetration of the standard auger equipment is less than 12 inches per minute.

9. Plug the hole in the bottom of the auger prior to advancing into the ground.

10. Pump the grout with sufficient pressure as the auger is withdrawn to completely fill the auger hole, preventing hole collapse and to cause the lateral penetration of the grout into soft or porous zones of the surrounding soil or rock. Prior to commencing withdrawal of the auger, establish a head of at least 5 feet of grout by pumping a volume of grout equivalent to 5 feet of pile volume. Do not include the volume or strokes required to prime the grout pumping system in the volume required to build this initial head. Maintain this head of at least 5 feet of grout above the injection point around the perimeter of the auger to displace and remove any loose material from the hole. Maintain positive rotation of the auger at least until placement of the grout.

11. Once the grout head has been established, greatly reduce the speed of rotation of the auger and commence extraction at a rate consistent with the pump discharge. Maintain extraction at a steady rate to prevent a locked-in auger, necking of the pile, or a substantially reduced pile section. Ensure grout starts flowing out from the hole when the cutting head is at least 5 feet below the ground surface. Place a minimum volume of grout in the hole of at least 115% of the column of the auger hole from a depth of 5 feet to the tip. Place a minimum volume of grout in the hole of at least 100% of the column of the auger hole from the ground surface to a depth of 5 feet. Do not include any grout needed to create surplus grout head in the volume of grout placed into the hole. If the grout does not flow out from the hole when the cutting head is at least 5 feet below the ground surface, redrill the pile under the direction of the Engineer. If grouting is interrupted for any reason, reinsert the auger by drilling at least 5 feet below the tip of the auger when the interruption occurred, and then regrout.

Use this method of placement at all times. Do not depend on the stability of the hole without the earth filled auger.

12. Assume responsibility for the grout volume placed. If less than 115% of the theoretical volume of grout is placed in any 5 foot increment (100% in the top 5 foot increment), reinstall the pile by advancing the auger 10 feet or to the bottom of the pile if that is less, followed by controlled removal and grout injection.

13. Furnish and install the reinforcing steel and anchoring bolts as shown in the Contract Documents. For ACP for miscellaneous structures and low clearance post options for noise walls, use wheels or other approved noncorrosive spacing devices within 3 feet of the bottom, within 3 feet of the top, and intervals not exceeding 10 feet along the pile to ensure concentric spacing for the entire length of the cage. Do not use block or wire type spacers. Use a minimum of one spacer per 30 inches of circumference or perimeter of cage with a minimum of three at each level. For noise wall ACP in which the full reinforcement is attached to the post, spacing devices within 3 feet of the top of the pile are not required.

14. Use reinforcement that is without kinks or nonspecified bends, free of mud, oil or other coatings that could adversely affect the bond. Make splices in reinforcement as shown on the Contract Documents, unless otherwise approved by the Engineer. Place the required steel reinforcement while the grout is still fluid, and immediately after finishing grouting and clearing it from any contaminating material. Install the steel cage into the grout by its own weight or manually. Do not use a mechanical equipment or tool to impact the steel cage or to force it into the grout. If the steel cage cannot be placed completely following this procedure, redrill and regrout the pile.

15. Leave any temporary supports of/for items placed into a grouted pile (reinforcement template, anchor bolt template, precast column supports, etc.) in place for a

minimum of 12 hours after completion of the pile. Do not place wall panels or other loads, before piles are accepted and the grout has set a minimum of seven days or reached the 28 day strength.