Florida Department of Transportation

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JIM BOXOLD
SECRETARY

January 8, 2015

Khoa Nguyen
Director, Office of Technical Services
Federal Highway Administration
545 John Knox Road, Suite 200
Tallahassee, Florida 32303

Re: State Specifications and Estimates Office
Section **455**
Proposed Specification: **SP4551501DB Structures Foundations (Design Build).**

Dear Mr. Nguyen:

We are submitting, for your approval, two copies of the above referenced Supplemental Specification.

The changes are proposed by Juan Castellanos of the State Construction Office to clarify the language of certain drilled shaft sections.

Please review and transmit your comments, if any, within two weeks. Comments should be sent via email to SP965DS or daniel.scheer@dot.state.fl.us.

If you have any questions relating to this specification change, please call me at 414-4130.

Sincerely,

signature on file

Daniel Scheer, P.E.
State Specifications Engineer

DS/ot
Attachment
cc: Florida Transportation Builders' Assoc.
State Construction Engineer

STRUCTURES FOUNDATION (DESIGN BUILD).
(REV ~~12-2-14~~*1-8-15*)

SUBARTICLE 455-15.1.2 is deleted and the following substituted:

455-15.1.2 Drilled Shaft Installation Plan (DSIP): At the preconstruction conference or at least 15 days prior to constructing the first drilled shaft, submit a Drilled Shaft Installation Plan (DSIP) for review and acceptance by the Engineer. The DSIP will be used to govern all drilled shaft construction activities. In the event that deviations from the DSIP are observed, the Engineer may perform Independent Verification Testing/Review of the Contractor's equipment, procedures and personnel at any time during production drilled shaft construction. If, as determined by the Engineer, drilled shaft construction equipment, procedures or personnel is deemed inadequate to consistently provide drilled shafts meeting the contract requirements, the Contractor's DSIP may be withdrawn pending corrective actions. All drilled shaft construction activities shall then cease and not restart until corrective actions have been taken and the DSIP has been re-accepted.

Include in the DSIP 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 the experience requirements of 105-8.13 installing drilled shafts of the size and depth shown in the Plans 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, desanding 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 shaft excavation methods.
5. Details of slurry, including proposed methods to mix, circulate, desand, test methods, and proposed testing laboratory to document test results.
6. 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.

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-Hole 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, and procedures for visual inspection.

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. For drilled shafts for ~~miscellaneous structures~~*sign, signal, lighting and ITS structures* constructed using polymer slurry, identify the polymer slurry meeting the requirements of 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 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.

18. Methods to identify and remediate drilled shaft deficiencies.

19. Names of the CTQP qualified inspectors assigned to inspect the drilled shaft installation.

20. The name and contact information for the single representative of the Contractor, independent of field operations personnel, to resolve to the Engineer's satisfaction, conflicts in the drilled shaft installation procedures. This person shall be available within two hours notice, and shall have the authority to refer issues to higher levels (corporate, if needed).

21. A letter from the GFDEOR certifying concurrence with the DSIP.

455-15.1.2.1 Acceptance of Drilled Shaft Installation Plan. The Engineer will evaluate the drilled shaft installation plan for conformance with the Contract Documents. Within five working days, excluding weekends and Department observed holidays, after receipt of the plan, the Engineer will notify the Contractor of any comments and 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 two working days, excluding weekends and Department observed holidays, after receipt of proposed changes of their acceptance or rejection. All equipment and procedures are subject to trial and satisfactory performance in the field.

Acceptance by the Engineer does not relieve the Contractor of the responsibility to perform the work in accordance with the Contract Documents. The Engineer's acceptance is not a guarantee that the chosen methods and equipment are capable of obtaining the required results, this responsibility lies with the Contractor.

SUBARTICLE 455-15.1.3 is deleted and the following substituted:

455-15.1.3 General Methods & Equipment: Perform the excavations required for the shafts, through whatever materials encountered, to the dimensions and elevations shown in the Contract Documents, using methods and equipment suitable for the intended purpose and the materials encountered. Provide drilling tools with a diameter not smaller than the shaft diameter required in the Plans minus 1 inch. Provide equipment capable of constructing shafts supporting bridges to a depth equal to the deepest shaft shown in the Plans plus 15 foot or plus three times the shaft diameter, whichever is greater, except when the Plans require equipment capable of constructing shafts to a deeper depth. Provide equipment capable of constructing shafts supporting ~~non-bridge structures, including mast arms, signals, signs and light supports~~*sign, signal, lighting and ITS structures* to a depth equal to the deepest shaft shown in the Plans plus 5 feet.

Construct drilled shafts according to the Contract Documents using generally either the dry method, wet method, casing method, or permanent casing method as necessary to produce sound, durable concrete foundation shafts free of defects. Use the permanent casing method only when required by the Plans. When the Plans describe a particular method of construction, use this method. When the Plans do not describe a particular method, propose a method on the basis of its suitability to the site conditions and submit it for acceptance by the Engineer.

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

For drilled shafts installed to support ~~mast arms, cantilever signs, overhead truss signs, high mast light poles or other miscellaneous structures~~*sign, signal, lighting and ITS structures*, provide temporary surface casings from at least 1 foot above the ground surface to at least 5 feet below the ground surface. Do not use a temporary casing greater than the diameter of the reinforcing steel cage, plus 24 inches. Fill the oversized temporary casing with drilled shaft concrete at no additional expense to the Department. For ~~miscellaneous structure~~*sign, signal, lighting and ITS structures* foundations located within permanent sidewalks or within 5 feet of curb sections, provide temporary surface casings from no lower than the top of sidewalk to at least 5 feet below the ground surface.

For drilled shafts installed to support ~~mast arms, cantilever signs, overhead truss signs, high mast light poles or other miscellaneous~~*sign, signal, lighting and ITS* structures, fill the excavation with premixed mineral slurry meeting the requirements of 455-15.8.1 or polymer slurry meeting the requirements of 455-15.8.2 before the drill advances to the bottom of the temporary casing. Do not attempt to excavate the shaft using plain water or natural slurry. Do not attempt to excavate the shaft using dry construction method unless specifically indicated in the Plans.

SUBARTICLE 455-15.3 is deleted and the following substituted:

455-15.3 Wet Construction Method: Use the wet construction method at all sites where it is impractical to provide a dry excavation for placement of the shaft concrete.

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

Where drilled shafts are located in open water areas, construct the shafts by the wet method using exterior casings extending from above the water elevation into the ground to protect the shaft concrete from water action during placement and curing of the concrete. Install the exterior casing in a manner that will produce a positive seal at the bottom of the casing so that there is no intrusion or extrusion of water or other materials into or from the shaft excavation.

~~Expandable or split casings that are removable are not permitted for use below the water surface.~~

SUBARTICLE 455-15.7 is deleted and the following substituted:

455-15.7 Casings: Ensure that casings are metal, of ample strength to withstand handling and driving stresses and the pressure of concrete and of the surrounding earth materials, and that they are smooth and water tight. Ensure that the inside diameter of casing is not less than the specified size of shaft except as provided below. The Department will not allow extra compensation for concrete required to fill an oversize casing or oversize excavation.

The Engineer will allow the Contractor to supply casing with an outside diameter equal to the specified shaft diameter (O.D. casing) provided he supplies additional shaft length at the shaft tip. Determine the additional length of shaft required by the following relationship:

$$Additional\ Length = \frac{(D_1 - D_2)L}{D_2}$$

where:

D_1= casing inside diameter specified = shaft diameter specified

D_2= casing inside diameter provided ($D_2 = D_1$ minus twice the wall thickness).

L= authorized shaft length below ground for temporary casing methods or below casing for permanent casing methods.

Bear all costs relating to this additional length including but not limited to the cost of extra excavation, extra concrete, and extra reinforcing steel.

Remove all casings from shaft excavations except those used for the Permanent Casing Method. Ensure that the portion of casings installed under the Permanent Casing Method of construction below the shaft cut-off elevation remains in position as a permanent part of the drilled shaft. When casings that are to be removed become bound in the shaft excavation and cannot be practically removed, submit a proposed redesign to the Engineer for review and acceptance.

If temporary casing is advanced deeper than the minimum top of rock socket elevation shown in the Plans or actual top of rock elevation if deeper, withdraw the casing from

the rock socket and overream the shaft. If the temporary casing cannot be withdrawn from the rock socket before final cleaning, extend the length of rock socket below the authorized tip elevation one-half of the distance between the minimum top of rock socket elevation or actual elevation if deeper, and the temporary casing tip elevation.

When the shaft extends above ground or through a body of water, the Contractor may form the *exposed* portion ~~exposed above ground *and the portion above* or through a body of water,~~ with removable casing except when the Permanent Casing Method is specified. For permanent casings, remove the portion of metal casings between an elevation 2 feet below the lowest water elevation or 2 feet below ground whichever is higher and the top of shaft elevation after the concrete is cured. Dismantle casings removed to expose the concrete as required above in a manner which will not damage the drilled shaft concrete. Dismantle removable casings in accordance with the provisions of 455-17.5.

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

When conditions warrant, the Contractor may pull the casing in partial stages. Maintain a sufficient head of concrete above the bottom of the casing to overcome the hydrostatic pressure of water outside the casing. At all times maintain the elevation of the concrete in the casing high enough to displace the drilling slurry between the outside of the casing and the edge of the hole while removing the casing.

Expandable or split casings that are removable are not permitted for use below water.

SUBARTICLE 455-15.8.2 is deleted and the following substituted:

455-15.8.2 Polymer Slurry ~~For~~ *for* Shafts ~~For Miscellaneous Structures~~*for Sign, Signal, Lighting and ITS Structures*:

Materials manufactured expressly for use as polymer slurry for drilled shafts may be used as slurry for drilled shaft excavations installed to support ~~mast arms, cantilever signs, overhead truss signs, high mast light poles or other miscellaneous~~*sign, signal, lighting and ITS* structures. A representative of the manufacturer must be on-site or available for immediate contact to assist and guide the construction of the first three drilled shafts at no additional cost to the Department. This representative must also be available for on-site assistance or immediate contact if problems are encountered during the construction of the remaining drilled shafts. The Engineer will not allow polymer slurries during construction of drilled shafts for bridge foundations. Use polymer slurry only if the soils below the casing are not classified as organic, and the pH of the fluid in the hole can be maintained in accordance with the manufacturer’s published recommendations. Submit the MSDS for the product, the manufacturer’s published mixing procedures, and the manufacturer’s published range of values for pH and viscosity of the mixed slurry. Provide documentation that the polymer slurry and components meet the following requirements:

a. The polymer slurries to be used on the project and their waste products are classified as non-hazardous as defined by Resource Conservation and Recovery Act (RCRA) Subpart C rules, Table 1 of 40 CFR 261.24 Toxicity Characteristic.

b. Pull out tests demonstrate the bond between the bar reinforcement and the concrete is not materially affected by exposure to the slurry under typical construction conditions, over the typical range of slurry viscosities to be used.

c. Load tests demonstrate the bond between the concrete and the soil is not materially affected by exposure to the polymer slurry under typical construction conditions, over the typical range of polymer slurry viscosities to be used for the project versus affect of exposure to mineral slurry.

d. The method of disposal meets the approval of all federal, state and local regulatory authorities.

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

Mixed Polymer Slurry Properties		
Item to be measured	Range of Results at 68ºF	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	Range Published By The Manufacturer for Materials Excavated	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

Polymer slurry may be mixed in the cased portion of the shaft in accordance with the manufacturer's published procedures.

During construction, maintain the level of the slurry at a height sufficient to prevent caving of the hole. At any time the wet construction method of stabilizing excavations fails, in the opinion of the Engineer, to produce the desired final result, discontinue this method of construction, and propose modifications in procedure or alternate means of construction for acceptance.

SUBARTICLE 455-15.8.3 is deleted and the following substituted:

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

Take 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, using an approved 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 455-15.8.1, except as follows:

The Engineer will not require tests for pH or viscosity, nor require the fluid to meet the minimum density specified in 455-15.8.1 when slurry has not been introduced into the shaft excavation.

When using polymer slurry to support the excavation for drilled shafts installed to support ~~mast arms, cantilever signs, overhead truss signs, high mast light poles or other miscellaneous~~*sign, signal, lighting and ITS* structures, take whatever action is necessary prior to placing the concrete to bring the properties of the fluid within the ranges in 455-15.8.2.

Provide a CTQP qualified drilled shaft inspector to perform testing. The Department may also perform comparison tests. Provide equipment for such comparison tests when requested by the Engineer.

SUBARTICLE 455-15.11.4 is deleted and the following substituted:

455-15.11.4 Shaft Cleanliness Requirements: Adjust cleaning operations so a minimum of 50% of the bottom of each shaft will have less than 1/2 inches of sediment at the time of placement of the concrete. Ensure the maximum depth of sedimentary deposits or any other debris at any place on the bottom of the shaft excavation does not exceed 1-1/2 inches. Determine shaft cleanliness by visual inspection for dry shafts. For bridge foundations, use a shaft inspection device for wet shafts. For drilled shaft foundations for ~~miscellaneous~~ *sign, signal, lighting and ITS* structures the use of a weighted tape is permitted to verify level and clean hole bottom conditions at the time of concrete placement.

When using slurry, meet the requirements of 455-15.8 at the time of concrete placement.

455-15.11.4.1 Exceptions for Shafts for ~~Miscellaneous~~ *Sign, Signal, Lighting and ITS* Structures: Ensure the depth of sedimentary deposits or other debris does not exceed 1 inch over the bottom of the shaft when installing drilled shafts to support ~~mast arms, cantilever signs, overhead truss signs, high mast light poles or other miscellaneous~~*sign, signal, lighting and ITS* structures.

SUBARTICLE 455-16.2 is deleted and the following substituted:

455-16.2 Splicing Cage: If the bottom of the constructed shaft elevation is lower than the bottom of the shaft elevation in the Plans, extend a minimum of one half of the longitudinal bars required in the upper portion of the shaft the additional length. Continue the tie bars for the extra depth, spaced on 2 foot centers, and extend the stiffener bars to the final depth. The Contractor may lap splice these bars or use unspliced bars of the proper length. Do not weld bars to the planned reinforcing steel unless shown in the Contract Documents.

For drilled shafts supporting ~~mast arms, cantilever signs, overhead truss signs, high mast light poles or other miscellaneous structures~~*sign, signal, lighting and ITS structures*, if the shaft cleaning operations result in excavating below the required tip elevation, the reinforcing steel cage does not need to be extended. The reinforcing steel cage may be spliced to rest on the bottom of the excavation or suspended in place from the top.

SUBARTICLE 455-16.4 is deleted and the following substituted:

455-16.4 Cross-Hole Sonic Logging (CSL) Tubes: Install CSL access tubes full length in all drilled shafts from the tip of shaft to a point high enough above top of shaft to allow CSL testing, but not less than 30 inches above the top of the drilled shaft, ground surface or water surface, whichever is higher. Equally space tubes around circumference of drilled shaft. Securely tie access tubes to the inside of the reinforcing cage and align tubes to be parallel to the vertical axis of the center of the cage. Access tubes from the top of the reinforcing cage to the tip of the shaft shall be NPS 1-1/2 Schedule 40 black iron or black steel (not galvanized) pipe. Access tubes above the top of the reinforcing cage may be the same black iron or black steel pipe or Schedule 80 PVC pipe. Ensure that the CSL access tubes are free from loose rust, scale, dirt, paint, oil and other foreign material. Couple tubes as required with threaded couplers, such that inside of tube remains flush. Seal the bottom and top of the tubes with threaded caps. The tubes, joints and bottom caps shall be watertight. Seal the top of the tubes with lubricated, threaded caps sufficient to prevent the intrusion of foreign materials. Stiffen the cage sufficiently to prevent damage or misalignment of access tubes during the lifting and installation of the cage. Exercise care in removing the caps from the top of the tubes after installation so as not to apply excess torque, hammering or other stress which could break the bond between the tubes and the concrete.

Provide the following number (rounded up to the next whole number of tubes) and configuration of cross-hole sonic logging access tubes in each drilled shaft based on the diameter of the shaft.

Shaft Diameter	Number of Tubes Required	Configuration around the inside of Circular Reinforcing Cage
36 to 48 inches	4	90 degrees apart
Greater than 48 inches	1 tube per foot of Shaft Diameter	360 degrees divided by the Number of Tubes

Insert simulated or mock probes in each cross-hole-sonic access tube prior to concreting to ensure the serviceability of the tube. Fill access tubes with clean potable water and recap prior to concreting. Repair or replace any leaking, misaligned or unserviceable tubes as in a manner acceptable to the Engineer prior to concreting.

For drilled shaft foundations requiring anchor bolts, verify CSL access tubes will not interfere with anchor bolt installation before excavating the shaft. When CSL access tube locations conflict with anchor bolt locations, move the CSL access tube location plus or minus 2 inches along the inner circumference of the reinforcing cage.

For drilled shafts supporting ~~mast arms, cantilever signs, overhead truss signs, high mast light poles, or other miscellaneous~~*sign, signal, lighting and ITS* structures, if the shaft cleaning operations result in excavating below the required tip elevation, the CSL tubes do not need to be extended. I the reinforcing steel cage is suspended in place from the top rather than resting on the bottom of the excavation, clearly mark the top of shaft location on each tube.

SUBARTICLE 455-17.3 is deleted and the following substituted:

455-17.3 Forms: When the top of shaft elevation is above ground *or above water*, form the portion of the shaft above ground *and the portion of the shaft above water* with a removable form or another suitable method to the dimensions shown in the Plans~~.~~

~~When the shaft extends above the ground through a body of water, the Contractor may form the portion through the water with removable forms~~ except when the Permanent Casing Method is specified.

~~The Contractor may form the portion through the water with permanent forms, provided the forms are removed from 2 feet below the lowest water elevation to the top of shaft elevation.~~

SUBARTICLE 455-17.6.1 is deleted and the following substituted:

455-17.6.1 Cross-Hole Sonic Logging (CSL) Tests: Perform all CSL testing in accordance with ASTM D6760. Test all drilled shafts in bridge bents or piers considered nonredundant in the Plans, using CSL. For all other drilled shafts supporting bridges and ~~miscellaneous~~ *sign, signal, lighting and ITS structures*~~structures~~, perform CSL testing on any shaft suspected of containing defects. The Engineer may select shafts for CSL testing based on observations in the field or the review of the drilled shaft logs.

Engage a qualified Specialty Engineer to perform the CSL testing. The qualified CSL Specialty Engineer must have a minimum three years experience of CSL testing and have a Florida Licensed Professional Engineer supervising the collection and interpretation of data.

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, chosen randomly.

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.

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 CSL test equipment as follows:

1. Include ultrasonic transmitter and receiver probes for 1.5 inch I.D. pipe which produce measurements with consistent signal strength and arrival time in uniform, good quality concrete with all tube spacings on the project.
2. Include a microprocessor based data acquisition system for display, storage, and transfer of data. Graphically display first pulse Arrival Time (FAT) during data acquisition.
3. Electronically measure and record the relative position (depth) of the probes in the tubes with each CSL signal.
4. Print the CSL logs for report presentation.
5. Provide report quality plots of CSL measurements that identify each individual test.

6. Electronically store each CSL log in digital format, with shaft identification, date, time and test details, including the transmitter and receiver gain.

455-17.6.1.2 Procedure: Perform CSL testing 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(s) or core additional hole(s), as directed by the Engineer, at no additional cost to the Department.

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 2.5 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.

Report any anomalies indicated by longer pulse arrival times and significantly lower amplitude/energy signals to the Engineer and conduct further tests as required to evaluate the extent of possible defects. 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. These measurements add four measurements per tube combination to the horizontal measurements described in this section. Offset measurements are described by the angle (in degrees) and direction the signal travels between the probes with respect to the horizontal plane: plus 45, plus 22.5 (source below receiver), and minus 45, minus 22.5 (source above receiver). Record offset measurements from the point where the higher probe is at least 5 feet below the velocity reduction to the point where the lower probe is at least 5 feet above the velocity reduction. 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.

455-17.6.1.3 Required Reports: Present the CSL testing and analysis results to the Engineer in a 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 3-D tomographic analysis using all offset data, and include color coded 3-D tomographic images in the report.

455-17.6.1.4 Evaluation of CSL Test Results: Drilled shafts with velocity reduction exceeding 30% are not acceptable without an engineering analysis.

455-17.6.1.5 Coring and/or Repair of Drilled Shafts: If a drilled shaft is unacceptable based on the CSL tests and tomographic analyses, or problems observed during drilled shaft construction, core the shaft to allow further evaluation and repair, or replace the shaft. 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 GFDEOR. The GFDEOR shall determine, with concurrence of the Engineer, the number, location, and diameter of the cores based on the results of 3-D tomographic analysis of offset and horizontal CSL data to intersect the worst anomalies found during testing. 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. Transport the cores, along with five copies of the coring log to the

Engineer. Perform strength testing by an AASHTO certified lab on portions of the cores that exhibit questionable concrete as determined by the GFDEOR. If the drilled shaft offset CSL testing, 3-D tomographic analyses 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 this Section. Engage a Specialty Engineer to perform gamma-gamma density logging to verify the integrity of the shaft outside the reinforcing cage in the same locations offset CSL data was/is required. Submit all results to the Engineer within five days of test completion for acceptance. Perform all work described in this Section at no additional cost to the Department, and with no increase in contract time.

SUBARTICLE 455-17.6.2 is deleted and the following is substituted:

455-17.6.2 Access 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. The Thermal Integrity Test Method is based on measuring the heat generation of hydrating cement. The analysis of measured temperature profiles requires knowledge of the concrete mix used and soil profile for the purposes of determining heat generation and soil insulation parameters. For typical drilled shaft concrete mixes, thermal testing should be performed between one and two days after shaft concreting.

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 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~~*sign, signal, lighting and ITS structures*, only drilled shafts selected by the Engineer will be tested.

455-17.6.2.1 Evaluation of Thermal Integrity Testing: The Engineer will evaluate the observations during drilled shaft construction and the Thermal Integrity Test results within three working days, excluding weekends and Department observed holidays, of testing the shaft. If the shaft is selected for CSL testing, the evaluation will not be given to the Contractor before all CSL testing and analysis is complete and reported to the Engineer.

455-17.6.2.2 Coring and/or Repair of Drilled Shafts: If the Engineer determines a drilled shaft is unacceptable based on the Thermal Integrity 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, retest in accordance with 455-17.6.1.5 and when requested, assist the Engineer in retesting the shaft(s) in accordance with 455-17.6.2.

SUBARTICLE 455-18 is deleted and the following is substituted:

455-18 Test Holes.

The Engineer will use the construction of test holes (method shafts) to determine if the methods and equipment used by the Contractor are sufficient to produce a shaft excavation meeting the requirements of the Contract Documents. During test hole excavations, the Engineer will evaluate the ability to control dimensions and alignment of excavations within tolerances; to seal the casing into impervious materials; to control the size of the excavation under caving conditions by the use of mineral slurry or by other means; to properly clean the completed shaft excavation; to construct excavations in open water areas; to determine the elevation of ground water; to place reinforcing steel and concrete meeting the requirements of these Specifications within the prescribed time frame; and to execute any other necessary construction operation. Revise the methods and equipment as necessary at any time during the construction of the test hole when unable to satisfactorily carry out any of the necessary operations described above or when unable to control the dimensions and alignment of the shaft excavation within tolerances.

Successfully construct test holes out of permanent position at the location shown in the Plans. Ensure the diameter and depth of the test hole or holes are the same diameter and maximum depth as the production drilled shafts. When there are shafts both on land and in water, successfully construct a test hole for each condition. When there is more than one size of drilled shaft, perform a test hole for the largest diameter for each condition. Reinforce the test hole unless otherwise directed in the Contract Documents. Conduct integrity tests on each shaft, using both cross-hole sonic logging and gamma-gamma density logging test methods. Fill the test hole with concrete in the same manner production drilled shafts will be constructed. Backfill test holes which are not filled with concrete with suitable soil in a manner satisfactory to the Engineer. Leave concreted test holes in place, except remove the top of the shaft to a depth of 2 feet below the ground line. Use the same procedure for shafts constructed in water. Restore the disturbed areas at the sites of test holes drilled out of position as nearly as practical to their original condition. When the Contractor fails to demonstrate to the Engineer the adequacy of his methods or equipment, and alterations are required, make appropriate modifications and provide additional test holes at no expense to the Department. Make no changes in methods or equipment after initial acceptance without the consent of the Engineer.

A separate test hole is not required for drilled shafts installed under ~~mast arms, cantilever signs, overhead truss signs, high mast light poles or other miscellaneous structures~~*sign, signal, lighting and ITS structures*. The first production shaft will serve as a test hole for determining acceptability of the installation method.

SUBARTICLE 455-22.2 is deleted and the following substituted:

455-22.2 Foundation Certification Packages: Submit two copies of a certification of drilled shaft foundations to the Engineer prior to Verification Testing. Each Foundation Certification Package shall include a letter signed and sealed by the GFDEOR certifying the drilled shafts have the required axial capacity, torsional capacity, uplift capacity, overturning and lateral stability, integrity deficiencies have been corrected, and settlements will not affect the functionality of the structure. Include clearly legible copies of all shaft excavation and concreting logs, video-tapes of visual shaft bottom inspections, all CSL reports and electronic data, gamma-gamma testing reports, slurry test data, supplemental testing data, ~~and~~ analyses for the foundation

unit *and the concrete strength test results of the lots sampled*. The certification shall not be contingent on any future testing or approval by the Engineer. Submit a separate Foundation Certification Package for each foundation unit. A foundation unit is defined as all the shafts within one bent or pier for a specific bridge for each phase of construction. For ~~miscellaneous structures~~*sign, signal, lighting and ITS structures*, a foundation unit is defined as all the shafts within one intersection/interchange, for each phase of an intersection/interchange or all the shafts included in ~~a miscellaneous~~*the* structure.

STRUCTURES FOUNDATION (DESIGN BUILD).
(REV 1-8-15)

SUBARTICLE 455-15.1.2 is deleted and the following substituted:

455-15.1.2 Drilled Shaft Installation Plan (DSIP): At the preconstruction conference or at least 15 days prior to constructing the first drilled shaft, submit a Drilled Shaft Installation Plan (DSIP) for review and acceptance by the Engineer. The DSIP will be used to govern all drilled shaft construction activities. In the event that deviations from the DSIP are observed, the Engineer may perform Independent Verification Testing/Review of the Contractor's equipment, procedures and personnel at any time during production drilled shaft construction. If, as determined by the Engineer, drilled shaft construction equipment, procedures or personnel is deemed inadequate to consistently provide drilled shafts meeting the contract requirements, the Contractor's DSIP may be withdrawn pending corrective actions. All drilled shaft construction activities shall then cease and not restart until corrective actions have been taken and the DSIP has been re-accepted.

Include in the DSIP 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 the experience requirements of 105-8.13 installing drilled shafts of the size and depth shown in the Plans 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, desanding 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 shaft excavation methods.

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

6. 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.

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-Hole 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, and procedures for visual inspection.

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. For drilled shafts for sign, signal, lighting and ITS structures constructed using polymer slurry, identify the polymer slurry meeting the requirements of 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 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.

18. Methods to identify and remediate drilled shaft deficiencies.

19. Names of the CTQP qualified inspectors assigned to inspect the drilled shaft installation.

20. The name and contact information for the single representative of the Contractor, independent of field operations personnel, to resolve to the Engineer's satisfaction, conflicts in the drilled shaft installation procedures. This person shall be available within two hours notice, and shall have the authority to refer issues to higher levels (corporate, if needed).

21. A letter from the GFDEOR certifying concurrence with the DSIP.

455-15.1.2.1 Acceptance of Drilled Shaft Installation Plan. The Engineer will evaluate the drilled shaft installation plan for conformance with the Contract Documents. Within five working days, excluding weekends and Department observed holidays, after receipt of the plan, the Engineer will notify the Contractor of any comments and 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 two working days, excluding weekends and Department observed holidays, after receipt of proposed changes of their acceptance or rejection. All equipment and procedures are subject to trial and satisfactory performance in the field.

Acceptance by the Engineer does not relieve the Contractor of the responsibility to perform the work in accordance with the Contract Documents. The Engineer's acceptance is not a guarantee that the chosen methods and equipment are capable of obtaining the required results, this responsibility lies with the Contractor.

SUBARTICLE 455-15.1.3 is deleted and the following substituted:

455-15.1.3 General Methods & Equipment: Perform the excavations required for the shafts, through whatever materials encountered, to the dimensions and elevations shown in the Contract Documents, using methods and equipment suitable for the intended purpose and the materials encountered. Provide drilling tools with a diameter not smaller than the shaft diameter required in the Plans minus 1 inch. Provide equipment capable of constructing shafts supporting bridges to a depth equal to the deepest shaft shown in the Plans plus 15 foot or plus three times the shaft diameter, whichever is greater, except when the Plans require equipment capable of constructing shafts to a deeper depth. Provide equipment capable of constructing shafts supporting sign, signal, lighting and ITS structures to a depth equal to the deepest shaft shown in the Plans plus 5 feet.

Construct drilled shafts according to the Contract Documents using generally either the dry method, wet method, casing method, or permanent casing method as necessary to produce sound, durable concrete foundation shafts free of defects. Use the permanent casing method only when required by the Plans. When the Plans describe a particular method of construction, use this method. When the Plans do not describe a particular method, propose a method on the basis of its suitability to the site conditions and submit it for acceptance by the Engineer.

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

For drilled shafts installed to support sign, signal, lighting and ITS structures, provide temporary surface casings from at least 1 foot above the ground surface to at least 5 feet below the ground surface. Do not use a temporary casing greater than the diameter of the reinforcing steel cage, plus 24 inches. Fill the oversized temporary casing with drilled shaft concrete at no additional expense to the Department. For sign, signal, lighting and ITS structures foundations located within permanent sidewalks or within 5 feet of curb sections, provide temporary surface casings from no lower than the top of sidewalk to at least 5 feet below the ground surface.

For drilled shafts installed to support sign, signal, lighting and ITS structures, fill the excavation with premixed mineral slurry meeting the requirements of 455-15.8.1 or polymer slurry meeting the requirements of 455-15.8.2 before the drill advances to the bottom of the temporary casing. Do not attempt to excavate the shaft using plain water or natural slurry. Do not attempt to excavate the shaft using dry construction method unless specifically indicated in the Plans.

SUBARTICLE 455-15.3 is deleted and the following substituted:

455-15.3 Wet Construction Method: Use the wet construction method at all sites where it is impractical to provide a dry excavation for placement of the shaft concrete.

The wet construction method consists of keeping the shaft excavation filled with fluid (mineral slurry, natural slurry or water), desanding and cleaning the mineral slurry and final cleaning of the excavation by means of a bailing bucket, air lift, submersible pump or other

suitable devices and placing the shaft concrete (with a tremie or concrete pump extending to the shaft bottom) which displaces the water or slurry during concreting of the shaft excavation.

Where drilled shafts are located in open water areas, construct the shafts by the wet method using exterior casings extending from above the water elevation into the ground to protect the shaft concrete from water action during placement and curing of the concrete. Install the exterior casing in a manner that will produce a positive seal at the bottom of the casing so that there is no intrusion or extrusion of water or other materials into or from the shaft excavation.

SUBARTICLE 455-15.7 is deleted and the following substituted:

455-15.7 Casings: Ensure that casings are metal, of ample strength to withstand handling and driving stresses and the pressure of concrete and of the surrounding earth materials, and that they are smooth and water tight. Ensure that the inside diameter of casing is not less than the specified size of shaft except as provided below. The Department will not allow extra compensation for concrete required to fill an oversize casing or oversize excavation.

The Engineer will allow the Contractor to supply casing with an outside diameter equal to the specified shaft diameter (O.D. casing) provided he supplies additional shaft length at the shaft tip. Determine the additional length of shaft required by the following relationship:

$$Additional\ Length = \frac{(D_1 - D_2)\,L}{D_2}$$

where:

D_1= casing inside diameter specified = shaft diameter specified

D_2= casing inside diameter provided ($D_2 = D_1$ minus twice the wall thickness).

L= authorized shaft length below ground for temporary casing methods or below casing for permanent casing methods.

Bear all costs relating to this additional length including but not limited to the cost of extra excavation, extra concrete, and extra reinforcing steel.

Remove all casings from shaft excavations except those used for the Permanent Casing Method. Ensure that the portion of casings installed under the Permanent Casing Method of construction below the shaft cut-off elevation remains in position as a permanent part of the drilled shaft. When casings that are to be removed become bound in the shaft excavation and cannot be practically removed, submit a proposed redesign to the Engineer for review and acceptance.

If temporary casing is advanced deeper than the minimum top of rock socket elevation shown in the Plans or actual top of rock elevation if deeper, withdraw the casing from the rock socket and overream the shaft. If the temporary casing cannot be withdrawn from the rock socket before final cleaning, extend the length of rock socket below the authorized tip elevation one-half of the distance between the minimum top of rock socket elevation or actual elevation if deeper, and the temporary casing tip elevation.

When the shaft extends above ground or through a body of water, the Contractor may form the exposed portion with removable casing except when the Permanent Casing

Method is specified. For permanent casings, remove the portion of metal casings between an elevation 2 feet below the lowest water elevation or 2 feet below ground whichever is higher and the top of shaft elevation after the concrete is cured. Dismantle casings removed to expose the concrete as required above in a manner which will not damage the drilled shaft concrete. Dismantle removable casings in accordance with the provisions of 455-17.5.

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

When conditions warrant, the Contractor may pull the casing in partial stages. Maintain a sufficient head of concrete above the bottom of the casing to overcome the hydrostatic pressure of water outside the casing. At all times maintain the elevation of the concrete in the casing high enough to displace the drilling slurry between the outside of the casing and the edge of the hole while removing the casing.

Expandable or split casings that are removable are not permitted for use below water.

SUBARTICLE 455-15.8.2 is deleted and the following substituted:

455-15.8.2 Polymer Slurry for Shafts for Sign, Signal, Lighting and ITS Structures:

Materials manufactured expressly for use as polymer slurry for drilled shafts may be used as slurry for drilled shaft excavations installed to support sign, signal, lighting and ITS structures. A representative of the manufacturer must be on-site or available for immediate contact to assist and guide the construction of the first three drilled shafts at no additional cost to the Department. This representative must also be available for on-site assistance or immediate contact if problems are encountered during the construction of the remaining drilled shafts. The Engineer will not allow polymer slurries during construction of drilled shafts for bridge foundations. Use polymer slurry only if the soils below the casing are not classified as organic, and the pH of the fluid in the hole can be maintained in accordance with the manufacturer’s published recommendations. Submit the MSDS for the product, the manufacturer’s published mixing procedures, and the manufacturer’s published range of values for pH and viscosity of the mixed slurry. Provide documentation that the polymer slurry and components meet the following requirements:

a. The polymer slurries to be used on the project and their waste products are classified as non-hazardous as defined by Resource Conservation and Recovery Act (RCRA) Subpart C rules, Table 1 of 40 CFR 261.24 Toxicity Characteristic.

b. Pull out tests demonstrate the bond between the bar reinforcement and the concrete is not materially affected by exposure to the slurry under typical construction conditions, over the typical range of slurry viscosities to be used.

c. Load tests demonstrate the bond between the concrete and the soil is not materially affected by exposure to the polymer slurry under typical construction conditions, over the typical range of polymer slurry viscosities to be used for the project versus affect of exposure to mineral slurry.

d. The method of disposal meets the approval of all federal, state and local regulatory authorities.

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

Mixed Polymer Slurry Properties		
Item to be measured	Range of Results at 68ºF	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	Range Published By The Manufacturer for Materials Excavated	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

Polymer slurry may be mixed in the cased portion of the shaft in accordance with the manufacturer's published procedures.

During construction, maintain the level of the slurry at a height sufficient to prevent caving of the hole. At any time the wet construction method of stabilizing excavations fails, in the opinion of the Engineer, to produce the desired final result, discontinue this method of construction, and propose modifications in procedure or alternate means of construction for acceptance.

SUBARTICLE 455-15.8.3 is deleted and the following substituted:

455-15.8.3 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 apply to tests of fluid in the shaft prior to placing the concrete.

Take 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, using an approved 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 455-15.8.1, except as follows:

The Engineer will not require tests for pH or viscosity, nor require the fluid to meet the minimum density specified in 455-15.8.1 when slurry has not been introduced into the shaft excavation.

When using polymer slurry to support the excavation for drilled shafts installed to support sign, signal, lighting and ITS structures, take whatever action is necessary prior to placing the concrete to bring the properties of the fluid within the ranges in 455-15.8.2.

Provide a CTQP qualified drilled shaft inspector to perform testing. The Department may also perform comparison tests. Provide equipment for such comparison tests when requested by the Engineer.

SUBARTICLE 455-15.11.4 is deleted and the following substituted:

455-15.11.4 Shaft Cleanliness Requirements: Adjust cleaning operations so a minimum of 50% of the bottom of each shaft will have less than 1/2 inches of sediment at the time of placement of the concrete. Ensure the maximum depth of sedimentary deposits or any other debris at any place on the bottom of the shaft excavation does not exceed 1-1/2 inches. Determine shaft cleanliness by visual inspection for dry shafts. For bridge foundations, use a shaft inspection device for wet shafts. For drilled shaft foundations for sign, signal, lighting and ITS structures the use of a weighted tape is permitted to verify level and clean hole bottom conditions at the time of concrete placement.

When using slurry, meet the requirements of 455-15.8 at the time of concrete placement.

455-15.11.4.1 Exceptions for Shafts for Sign, Signal, Lighting and ITS Structures: Ensure the depth of sedimentary deposits or other debris does not exceed 1 inch over the bottom of the shaft when installing drilled shafts to support sign, signal, lighting and ITS structures.

SUBARTICLE 455-16.2 is deleted and the following substituted:

455-16.2 Splicing Cage: If the bottom of the constructed shaft elevation is lower than the bottom of the shaft elevation in the Plans, extend a minimum of one half of the longitudinal bars required in the upper portion of the shaft the additional length. Continue the tie bars for the extra depth, spaced on 2 foot centers, and extend the stiffener bars to the final depth. The Contractor may lap splice these bars or use unspliced bars of the proper length. Do not weld bars to the planned reinforcing steel unless shown in the Contract Documents.

For drilled shafts supporting sign, signal, lighting and ITS structures, if the shaft cleaning operations result in excavating below the required tip elevation, the reinforcing steel cage does not need to be extended. The reinforcing steel cage may be spliced to rest on the bottom of the excavation or suspended in place from the top.

SUBARTICLE 455-16.4 is deleted and the following substituted:

455-16.4 Cross-Hole Sonic Logging (CSL) Tubes: Install CSL access tubes full length in all drilled shafts from the tip of shaft to a point high enough above top of shaft to allow CSL testing, but not less than 30 inches above the top of the drilled shaft, ground surface or water surface, whichever is higher. Equally space tubes around circumference of drilled shaft. Securely tie access tubes to the inside of the reinforcing cage and align tubes to be parallel to the vertical axis of the center of the cage. Access tubes from the top of the reinforcing cage to the tip of the shaft shall be NPS 1-1/2 Schedule 40 black iron or black steel (not galvanized) pipe. Access tubes above the top of the reinforcing cage may be the same black iron or black steel pipe or

Schedule 80 PVC pipe. Ensure that the CSL access tubes are free from loose rust, scale, dirt, paint, oil and other foreign material. Couple tubes as required with threaded couplers, such that inside of tube remains flush. Seal the bottom and top of the tubes with threaded caps. The tubes, joints and bottom caps shall be watertight. Seal the top of the tubes with lubricated, threaded caps sufficient to prevent the intrusion of foreign materials. Stiffen the cage sufficiently to prevent damage or misalignment of access tubes during the lifting and installation of the cage. Exercise care in removing the caps from the top of the tubes after installation so as not to apply excess torque, hammering or other stress which could break the bond between the tubes and the concrete.

Provide the following number (rounded up to the next whole number of tubes) and configuration of cross-hole sonic logging access tubes in each drilled shaft based on the diameter of the shaft.

Shaft Diameter	Number of Tubes Required	Configuration around the inside of Circular Reinforcing Cage
36 to 48 inches	4	90 degrees apart
Greater than 48 inches	1 tube per foot of Shaft Diameter	360 degrees divided by the Number of Tubes

Insert simulated or mock probes in each cross-hole-sonic access tube prior to concreting to ensure the serviceability of the tube. Fill access tubes with clean potable water and recap prior to concreting. Repair or replace any leaking, misaligned or unserviceable tubes as in a manner acceptable to the Engineer prior to concreting.

For drilled shaft foundations requiring anchor bolts, verify CSL access tubes will not interfere with anchor bolt installation before excavating the shaft. When CSL access tube locations conflict with anchor bolt locations, move the CSL access tube location plus or minus 2 inches along the inner circumference of the reinforcing cage.

For drilled shafts supporting sign, signal, lighting and ITS structures, if the shaft cleaning operations result in excavating below the required tip elevation, the CSL tubes do not need to be extended. I the reinforcing steel cage is suspended in place from the top rather than resting on the bottom of the excavation, clearly mark the top of shaft location on each tube.

SUBARTICLE 455-17.3 is deleted and the following substituted:

455-17.3 Forms: When the top of shaft elevation is above ground or above water, form the portion of the shaft above ground and the portion of the shaft above water with a removable form or another suitable method to the dimensions shown in the Plans except when the Permanent Casing Method is specified.

SUBARTICLE 455-17.6.1 is deleted and the following substituted:

455-17.6.1 Cross-Hole Sonic Logging (CSL) Tests: Perform all CSL testing in accordance with ASTM D6760. Test all drilled shafts in bridge bents or piers considered nonredundant in the Plans, using CSL. For all other drilled shafts supporting bridges and sign, signal, lighting and ITS structures, perform CSL testing on any shaft suspected of containing

defects. The Engineer may select shafts for CSL testing based on observations in the field or the review of the drilled shaft logs.

Engage a qualified Specialty Engineer to perform the CSL testing. The qualified CSL Specialty Engineer must have a minimum three years experience of CSL testing and have a Florida Licensed Professional Engineer supervising the collection and interpretation of data.

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, chosen randomly.

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.

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 CSL test equipment as follows:

1. Include ultrasonic transmitter and receiver probes for 1.5 inch I.D. pipe which produce measurements with consistent signal strength and arrival time in uniform, good quality concrete with all tube spacings on the project.
2. Include a microprocessor based data acquisition system for display, storage, and transfer of data. Graphically display first pulse Arrival Time (FAT) during data acquisition.
3. Electronically measure and record the relative position (depth) of the probes in the tubes with each CSL signal.
4. Print the CSL logs for report presentation.
5. Provide report quality plots of CSL measurements that identify each individual test.
6. Electronically store each CSL log in digital format, with shaft identification, date, time and test details, including the transmitter and receiver gain.

455-17.6.1.2 Procedure: Perform CSL testing 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(s) or core additional hole(s), as directed by the Engineer, at no additional cost to the Department.

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 2.5 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.

Report any anomalies indicated by longer pulse arrival times and significantly lower amplitude/energy signals to the Engineer and conduct further tests as required to evaluate the extent of possible defects. 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. These measurements add four measurements per tube combination to the horizontal measurements described in this section. Offset measurements are described by the angle (in degrees) and direction the signal travels between the probes with respect to the horizontal plane: plus 45, plus 22.5 (source below receiver), and minus 45, minus 22.5 (source above receiver). Record offset measurements from the point where the higher probe is at least 5 feet below the velocity reduction to the point where the lower probe is at least 5 feet above the velocity reduction. 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.

455-17.6.1.3 Required Reports: Present the CSL testing and analysis results to the Engineer in a 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 3-D tomographic analysis using all offset data, and include color coded 3-D tomographic images in the report.

455-17.6.1.4 Evaluation of CSL Test Results: Drilled shafts with velocity reduction exceeding 30% are not acceptable without an engineering analysis.

455-17.6.1.5 Coring and/or Repair of Drilled Shafts: If a drilled shaft is unacceptable based on the CSL tests and tomographic analyses, or problems observed during drilled shaft construction, core the shaft to allow further evaluation and repair, or replace the shaft. 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 GFDEOR. The GFDEOR shall determine, with concurrence of the Engineer, the number, location, and diameter of the cores based on the results of 3-D tomographic analysis of offset and horizontal CSL data to intersect the worst anomalies found during testing. 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. Transport the cores, along with five copies of the coring log to the Engineer. Perform strength testing by an AASHTO certified lab on portions of the cores that exhibit questionable concrete as determined by the GFDEOR. If the drilled shaft offset CSL testing, 3-D tomographic analyses 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 this Section. Engage a Specialty Engineer to perform gamma-gamma density logging to verify the integrity of the shaft outside the reinforcing cage in the same locations offset CSL data was/is required. Submit all results to the Engineer within five days of test completion for acceptance. Perform all work described in this Section at no additional cost to the Department, and with no increase in contract time.

SUBARTICLE 455-17.6.2 is deleted and the following is substituted:

455-17.6.2 Access 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. The Thermal Integrity Test Method is based on measuring the heat generation of hydrating cement. The analysis of measured temperature profiles requires knowledge of the concrete mix used and soil profile for the purposes of determining heat generation and soil insulation parameters. For typical drilled shaft concrete mixes, thermal testing should be performed between one and two days after shaft concreting.

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 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 sign, signal, lighting and ITS structures, only drilled shafts selected by the Engineer will be tested.

455-17.6.2.1 Evaluation of Thermal Integrity Testing: The Engineer will evaluate the observations during drilled shaft construction and the Thermal Integrity Test results within three working days, excluding weekends and Department observed holidays, of testing the shaft. If the shaft is selected for CSL testing, the evaluation will not be given to the Contractor before all CSL testing and analysis is complete and reported to the Engineer.

455-17.6.2.2 Coring and/or Repair of Drilled Shafts: If the Engineer determines a drilled shaft is unacceptable based on the Thermal Integrity 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, retest in accordance with 455-17.6.1.5 and when requested, assist the Engineer in retesting the shaft(s) in accordance with 455-17.6.2.

SUBARTICLE 455-18 is deleted and the following is substituted:

455-18 Test Holes.

The Engineer will use the construction of test holes (method shafts) to determine if the methods and equipment used by the Contractor are sufficient to produce a shaft excavation meeting the requirements of the Contract Documents. During test hole excavations, the Engineer will evaluate the ability to control dimensions and alignment of excavations within tolerances; to seal the casing into impervious materials; to control the size of the excavation under caving conditions by the use of mineral slurry or by other means; to properly clean the completed shaft excavation; to construct excavations in open water areas; to determine the elevation of ground water; to place reinforcing steel and concrete meeting the requirements of these Specifications within the prescribed time frame; and to execute any other necessary construction operation. Revise the methods and equipment as necessary at any time during the construction of the test hole when unable to satisfactorily carry out any of the necessary operations described above or when unable to control the dimensions and alignment of the shaft excavation within tolerances.

Successfully construct test holes out of permanent position at the location shown in the Plans. Ensure the diameter and depth of the test hole or holes are the same diameter and maximum depth as the production drilled shafts. When there are shafts both on land and in water, successfully construct a test hole for each condition. When there is more than one size of drilled shaft, perform a test hole for the largest diameter for each condition. Reinforce the test hole unless otherwise directed in the Contract Documents. Conduct integrity tests on each shaft, using both cross-hole sonic logging and gamma-gamma density logging test methods. Fill the test hole with concrete in the same manner production drilled shafts will be constructed. Backfill test

holes which are not filled with concrete with suitable soil in a manner satisfactory to the Engineer. Leave concreted test holes in place, except remove the top of the shaft to a depth of 2 feet below the ground line. Use the same procedure for shafts constructed in water. Restore the disturbed areas at the sites of test holes drilled out of position as nearly as practical to their original condition. When the Contractor fails to demonstrate to the Engineer the adequacy of his methods or equipment, and alterations are required, make appropriate modifications and provide additional test holes at no expense to the Department. Make no changes in methods or equipment after initial acceptance without the consent of the Engineer.

A separate test hole is not required for drilled shafts installed under sign, signal, lighting and ITS structures. The first production shaft will serve as a test hole for determining acceptability of the installation method.

SUBARTICLE 455-22.2 is deleted and the following substituted:

455-22.2 Foundation Certification Packages: Submit two copies of a certification of drilled shaft foundations to the Engineer prior to Verification Testing. Each Foundation Certification Package shall include a letter signed and sealed by the GFDEOR certifying the drilled shafts have the required axial capacity, torsional capacity, uplift capacity, overturning and lateral stability, integrity deficiencies have been corrected, and settlements will not affect the functionality of the structure. Include clearly legible copies of all shaft excavation and concreting logs, video-tapes of visual shaft bottom inspections, all CSL reports and electronic data, gamma-gamma testing reports, slurry test data, supplemental testing data, analyses for the foundation unit and the concrete strength test results of the lots sampled. The certification shall not be contingent on any future testing or approval by the Engineer. Submit a separate Foundation Certification Package for each foundation unit. A foundation unit is defined as all the shafts within one bent or pier for a specific bridge for each phase of construction. For sign, signal, lighting and ITS structures, a foundation unit is defined as all the shafts within one intersection/interchange, for each phase of an intersection/interchange or all the shafts included in the structure.