455 STRUCTURES FOUNDATIONS
(REV 12-9-21) (FA 12-14-21) (7-22)

SUBARTICLE 455-5.11.2 is deleted and the following substituted:

455-5.11.2 Bearing Criteria: For foundations requiring 100% dynamic testing, the Engineer will determine the bearing of all piles using the data received from dynamic load testing equipment utilizing internally or externally mounted sensors according to the methods described in 455-5.12.1.

For foundations not requiring 100% dynamic testing, the Engineer will determine the number of blows required to provide the required bearing according to the methods described herein. Determine the pile bearing by computing the penetration per blow with less than 1/4 inches rebound averaged through 12 inches of penetration. When it is considered necessary by the Engineer, determine the average penetration per blow by averaging the penetration per blow through the last 10 to 20 blows of the hammer.

The Engineer will accept piles within two Working Days after the final drive is performed, including any instrumented restrikes performed to ensure bearing has been met and that any potential relaxation will not reduce the required capacity to less than the required nominal bearing resistance (NBR).

SUBARTICLE 455-10.1 is deleted and the following substituted:

455-10.1 General: Submit the completed Pile Driving Installation Plan Form (Form No. 700-020-01) with the following information at the preconstruction conference or no later than 30 days before driving the first pile.

1. List and size of proposed equipment including cranes, barges, driving equipment, jetting equipment, compressors, and preformed pile hole equipment. Include manufacturer’s data sheets on hammers.

2. Methods to determine hammer energy in the field for determination of pile capacity. Include in the submittal necessary charts and recent calibrations for any pressure measuring equipment.

3. Detailed drawings of any proposed followers.

4. Detailed drawings of templates.

5. Details of proposed load test equipment and procedures, including recent calibrations of jacks and required load cells.

6. Sequence of driving of piles for each different configuration of pile layout.

7. Details of proposed features and procedures for protection of existing structures.

8. Proposed plan for monitoring settlements and vibrations of adjacent structures, identifying the proposed equipment, the structures and the specific points that will be monitored.

9. Required shop drawings for piles, cofferdams, etc.

10. Methods and equipment proposed to prevent displacement of piles during placement and compaction of fill within 15 feet of the piles.

11. Methods to prevent deflection of battered piles due to their own weight and to maintain their as-driven position until casting of the pile cap is complete.

12. Proposed pile splice locations and details of any proprietary splices anticipated to be used.

13. Methods and equipment proposed to prevent damage to voided or cylinder piles due to interior water pressure.

Notify the Engineer of any test pile driving and production pile driving at least one week prior to beginning the installation operations of any pile.

ARTICLE 455-14 is expanded by the following:

455-14 Materials.

455-14.1 Concrete: Use concrete meeting the requirements of Section 346, unless otherwise shown in the Plans.

455-14.2 Reinforcing Steel: Meet the reinforcing steel requirements of Section 415.

455-14.3 Polymer Slurry: Use a product listed on the Department's Approved Product List (APL) meeting the requirements of 932-5.

SUBARTICLE 455-15.1.2 is deleted and the following substituted:

455-15.1.2 Drilled Shaft Installation Plan (DSIP): At the preconstruction conference submit a DSIP for review by the Engineer. Final approval will be subject to satisfactory performance. Include in this plan the following details:

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

a. Wet Method (mineral and polymer 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, and equipment to install and remove casing.

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

4. Details of shaft excavation methods, including casing installation procedures.

5. Details of slurry, including proposed methods to mix, circulate, desand, test methods, and proposed CTQP certified technician that will perform and document the fluid tests.

6. Details of proposed methods to clean the shaft 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. Include 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) and Thermal Integrity Testing for Drilled (TITDS) Specialty Engineer to supervise field testing and report the test results.

13. Methods and equipment proposed to prevent displacement of casing and/or shafts during placement and compaction of fill.

14. Provide the make and model of the shaft inspection device, if applicable.

15. Details of environmental control procedures used to prevent loss of slurry or concrete into waterways or other protected areas.

16. Proposed schedule for test shaft installation, load tests and production shaft installation.

17. For drilled shafts constructed using polymer slurry, identify the polymer slurry, the pH and proposed viscosity ranges and a description of the mixing method to be used. Submit the contact information for the manufacturer’s representative available for immediate contact during shaft construction and the representative’s schedule of availability.

18. When settlement and vibration monitoring of adjacent structures are required as per 108-2, submit a proposed monitoring plan identifying the proposed equipment, the structures and the specific points that will be monitored.

19. Procedure for grouting non-destructive testing access tubes.

20. Other information shown in the Plans or requested by the Engineer.

EXPECTED IMPLEMENTATION JULY 2022

DRAFT

The Engineer will evaluate the DSIP for conformance with the Contract Documents. Within 20 days after receipt of the plan, the Engineer will notify the Contractor of any additional information required and/or changes that may be necessary to meet the above requirements and satisfy the Contract Documents. The Engineer will reject any part of the plan that does not meet specifications, plans or has the potential to affect the integrity of adjacent structures or negatively affect the environmental conditions. Submit changes agreed upon for reevaluation. The Engineer will notify the Contractor within seven days after receipt of proposed changes of their acceptance or rejection. All equipment and procedures are subject to trial and satisfactory performance in the field.

Acceptance by the Engineer does not relieve the Contractor of the responsibility to perform the work in accordance with the Contract Documents. The installation plan is for the Contractor to explain the approach to the work and allow the Engineer an opportunity to comment on the equipment and procedures chosen before field operations begin. The Engineers 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 455-15.8 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 ft diameter and up to 40 ft 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 fails.

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 (fresh water) 64 to 67 lb/ft^3 (salt water)	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
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

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 455-16.3 is deleted and the following substituted:

455-16.3 Support, Alignment, and Tolerance: Tie and support the reinforcing steel in the shaft so that the reinforcing steel will remain within allowable tolerances as specified in 455-20 and Section 415.

Ensure concentric spacing for the entire length of the cage. As a minimum, use centering devices consisting of wheels or other approved noncorrosive spacing devices within 3 feet of the bottom, within 6 feet of the top, and intervals not exceeding 10 feet along the cage length. Do not use block or wire type spacers. Ensure no permanent metallic elements will be within the concrete cover space. Use a minimum of one spacer per 30 inches of circumference of cage with a minimum of four at each level. Provide spacers at the bottom of the drilled shaft reinforcing cage as required to maintain the proper position of the cage.

For shafts to support sign, signal, lighting and ITS structures, when a casing with an inside diameter (I.D.) larger than the required shaft diameter is used, provide, within the portion of the oversized casing, centering devices specially dimensioned or other means to ensure the shaft, the cage and the upright are concentric.

Provide spacers within 3 feet of the bottom and at intervals not exceeding 10 feet along the reinforcement, with a minimum of two levels of spacers below the bottom of the casing.

Check the elevation of the top of the steel cage before and after placing the concrete. If the cage is not within the specified tolerances, correct, and submit a revised DSIP to the Engineer for approval. Do not construct additional shafts until receiving approval from the Engineer.

ARTICLE 455-47 is deleted and the following substituted:

455-47 Auger Cast Pile Installation Plan (ACPIP).

At the preconstruction conference, but no later than 30 days before ACP construction begins, submit an ACPIP for approval by the Engineer. Provide the following detailed information on the plan:

1. Name and experience record of ACP superintendent or foreman in responsible charge of ACP operations. Place a person in responsible charge of day to day ACP operations who possesses satisfactory prior experience constructing auger cast piles similar to those described in the Contract Documents. The Engineer will give final approval subject to satisfactory performance in the field.
2. List and size of the proposed equipment, including cranes, augers, concrete pumps, mixing equipment etc.
3. Details of grout mixing procedures and proposed pump calibration procedures.
4. Details of pile installation methods.
5. Details of reinforcement placement and method of centering in pile, including details of all temporary supports for reinforcement, anchor bolts, precast columns, etc.
6. Details of how and by whom the grout volumes will be determined, monitored and documented.
7. Required submittals, including shop drawings and cement grout design mixes.
8. Proposed plan for monitoring settlements of adjacent structures, identifying the proposed equipment, the structures and the specific points that will be monitored.
9. Other information shown in the Plans or requested by the Engineer.