MICROPILE FOUNDATIONS
(REV 10-20-26)

SECTION 455: Index is expanded by the following:

F. Structures Foundations - Micropiles ..... 455-51 through 455-64

SECTION 455 is expanded by the following:

455-51 Description.

Furnish and install micropiles with permanent steel casing meeting the requirements of, and in accordance with, this Specification and the Contract Documents. The work includes selecting the micropile type, installation means and methods, determining the grout-to-ground bond value, and determining the required bonded length. Furnish all labor, equipment and materials required to complete the work.

Review the available subsurface information and visit the site to assess the site geometry, equipment access conditions, and location of existing structures and above ground facilities. Assume responsibility for field locating all utilities, and any other exposed or buried obstructions within the construction area prior to starting the work.

455-52 Definitions.

The following definitions are applicable to designing and installing micropiles:

Alignment Load (AL) - An initial load (not to exceed 4 percent of Factored Design Load) applied to a micropile during testing, required to keep the testing equipment correctly positioned.

Bonded Length: The length of the micropile that is bonded to the ground and conceptually used to transfer the applied axial loads to the surrounding soil or rock. Also known as the load transfer length.

Casing - Steel tube introduced during the drilling process in overburden soil to stabilize the drill hole.

Centralizer - A device to support and position the reinforcing steel in the drill hole and casing so that the specified minimum grout cover is provided.

Coupler - The device used to transfer loads from one partial length of reinforcement to another.

Creep Movement - The movement that occurs at the top of the pile during the load test of a micropile under a constant load.

Factored Design Load (FDL): The factored load on a micropile, as shown on the Contract Documents.

Failure Load: The load where the slope of the load versus micropile head settlement curve first exceeds 0.025 inches/kip.

Micropile - A small-diameter, bored, cast-in-place composite pile, in which the applied load is resisted by steel reinforcement, cement grout and frictional grout- to-ground bond along the bonded length.

Maximum Test Load - The maximum load to which the micropile is subjected during load testing, which is the Nominal Resistance shown in the plans or 1.5 times the Factored Design Load, whichever is greater.

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Nominal Bearing Resistance - The resistance of a micropile.

Plunge length - The length of casing inserted into the bond zone to effect a transition between the upper cased portion to the lower uncased portion of the micropile.

Post-grouting - The injection of additional grout into the load transfer length of a micropile after the primary grout has set. Also known as re-grouting or secondary grouting.

Primary Grout - Portland-cement-based grout injected into the micropile hole prior to or after the installation of the reinforcement, used to transfer load to the surrounding ground along the micropile.

Production Pile - A micropile installed according to this Section, accepted in place and incorporated into the work.

Reinforcement - The steel component of the micropile that accepts and/or resists applied loadings.

Spacer - A device used to separate elements of a multiple-element reinforcement.

Unbonded Length (Free Length) - The designed length of the micropile that is not bonded by grout to the surrounding ground.

Static Load Test - Pile load test performed on a sacrificial pile to verify the adequacy of the pile design, the capacity of the pile system and the construction methods proposed, prior to installation of production piles in each representative soil condition.

Verification Load Test - Pile load test performed on production pile to verify acceptable load-displacement response at the Factored Design Load.

455-53 Personnel Qualifications.

At the preconstruction conference, or no later than 30 calendar days before any micropile related work is performed, submit a list of at least five projects, completed within the last five years, where the work included installing micropiles having a FDL not less than 80% of the largest FDL required in the Plans. For each project listed, provide a brief description of each project, the project owner's name, and the name, title and current phone number of a project owner representative.

At least 30 days prior to beginning work, submit a list identifying the Contractor's Engineer of Record, drill rig operators and on-site supervisors who will be assigned to the project. Include in the list a summary of each individual's experience.

The Contractor's Engineer of Record must have at least five years' experience in the design and construction of micropiles. including at least three successfully completed projects in the last five years with micropiles having a FDL not less than 80% of the largest FDL required in the Plans.

Drill operators and on-site supervisors must have a minimum of five years' experience in micropile construction with the Contractor's organization, including at least three projects in the last five years installing micropiles of FDL not less than 80% of the largest FDL required in the Plans.

For qualification determination purposes, on previous projects where load and resistance factor design (LRFD) method was not used, calculate the FDL as ultimate bearing capacity multiplied by 0.4, unless previous design documentation indicates otherwise.

The Engineer will approve or reject the Contractor's qualifications and staff within five calendar days after receipt of the submission. Do not start work on any micropiles or order materials until receiving approval of the qualifications. The Engineer may suspend the micropile work if the Contractor substitutes unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, assume all

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costs resulting from the suspension of work. The Department will not allow any adjustment in Contract Time resulting from the suspension of work.

455-54 Materials.

455-54.1 General: Use only materials meeting the following requirements that are new and without defects. Assume responsibility for removing and replacing defective material placed on the project at no additional cost to the Department.

455-54.2 Reinforcing Bar Steel: Use continuous threaded steel bar reinforcement meeting the requirements of ASTM A615, Grade 75 or ASTM A722 Grade 150. Use reinforcing bar couplers capable of developing the ultimate strength of the reinforcing bar without evidence of failure.

455-54.3 Cement Grout: Use cement grout components meeting the requirements of Section 346 unless otherwise directed. Use grout for micropiles consisting of a pumpable mixture of Type I, II, III, or V portland cement meeting the requirements of ASTM C150, water, and admixtures with the minimum 28-day compressive strength shown in the Plans. Admixtures conforming to ASTM C494/AASHTO M 194, that control bleed, improve flowability, reduce water content, and retard set in the grout, are allowed when approved by the Engineer. Admixtures must be compatible with the grout and mixed in accordance with the admixture manufacturer's recommendations. Do not use accelerators or admixtures containing chlorides. The mix design must be approved by the District Materials Office.

455-54.4 Centralizers: Use centralizers fabricated from plastic or other material that is non-detrimental to the reinforcing bar steel, steel casing or grout unless otherwise indicated in the Plans. Do not use wood or aluminum. Ensure the centralizers and spacers are appropriately sized to ensure positioning the reinforcement to the center of the pile and allow a free flow of grout without misalignment of the reinforcing bars or permanent casing.

455-54.5 Permanent Steel Pipe Casing: Use permanent steel casing meeting the requirements of American Petroleum Institute (API) Specification 5CT (N-80) or API 5L X52.

Casing outside diameter must be at least the nominal diameter and wall thickness as shown in the Plans. Use flush threaded casing joints capable of developing the required nominal axial and flexural resistance used in the design of the micropiles.

455-54.6: Water: Use potable water meeting the requirements of Section 923 for mixing grout.

455-55 Micropile Design Requirements.

Design micropiles to support the design loads in accordance with the Contract Documents. Installed micropiles must have a bonded length not less than the minimum bonded length shown in the Plans. Determine lateral bracing requirements for the piles to be safely tested to the specified Maximum Test Load.

The micropile diameter must not be less than 9.5 inches and must satisfy the minimum grout cover over the steel reinforcement in SDG Table 1.4.2-1. The design diameter of the bonded zone must not exceed the outer diameter of the casing, or bit/auger, whichever is extended to the tip to construct the pile. Neglect the side friction resistance in the bond length zone within the plunge length.

The full-length center bar of all piles must:

1. Satisfy all design requirements in the contract documents, and
2. Have an ultimate tensile strength exceeding 120% of the Maximum Test Load to be used in verification pile testing.

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455-56 Installation.

455-56.1 General: Determine the drilling method, grouting procedure, grouting pressure, and the final bonded length. Estimate grout take and methods to control excess loss of grout material. Extra payment for grout overruns will not be made.

455-56.2 Drilling: Excavate as required to install the micropiles to the dimensions and elevations shown in the Plans. Use methods and equipment suitable for the intended purpose and the materials encountered, without causing damage to overlying or adjacent structures or facilities. Unless approved otherwise by the Engineer use full length casing to stabilize the hole. Provide equipment capable of constructing the micropiles to a depth equal to the deepest micropile tip elevation plus an additional 25 feet. Do not use drilling fluid containing bentonite or attapulgite clays.

Do not drill within 6 feet horizontally of any micropile with grout that has not cured for at least 12 hours.

When underpinning an existing structure:

1. Do not use vibratory hammers or impact hammers, including percussive hammers, to advance or remove casing.

2. Use full length casing to stabilize the drill hole. Do not use drilling slurry as an alternative to full-length casing.

3. Do not drill beyond the tip of temporary casing unless allowed by the Engineer when refusal drilling condition is encountered.

455-56.3 Ground Heave and Subsidence: Construct the micropiles in a manner that prevents ground heave and subsidence, including settlement of existing structures.

Monitor existing bridges and structures in accordance with 455-62. The Engineer may suspend micropile construction if ground or structure movements are detected. If the Engineer determines that the observed ground or structure movements require corrective action, take corrective actions necessary to stop the movement and remediate any resulting damage, subject to the approval of the Engineer.

455-56.4 Pipe Casing: Install permanent pipe casing to the casing tip elevation shown in the Plans. Allow grout to cure in the approved production piles before cutting to pile cut off elevation.

455-56.5 Reinforcing Bars Placement and Splicing: Install full length reinforcing bars in all piles. Reinforcement surfaces must be free of deleterious substances such as soil, mud, grease or oil that might contaminate the grout or coat the reinforcement and impair bond of the reinforcement to the grout. Place reinforcement either prior to grouting or into the grout filled drill hole.

Pile reinforcement and all attachments must be capable of withstanding the installation and grouting process. Position centralizers and spacers so their center to center spacing does not exceed 10 feet. Ensure the grout cover between the reinforcement and the ground meet the requirements of SDG Table 1.4.2-1.

Locate the upper and lower centralizers a maximum of 5 feet from the top and bottom of the micropile, respectively. Lower the reinforcement bars with centralizers into the stabilized drill hole and set. Insert the reinforcing steel into the drill hole to the desired depth without resistance. Do not drive or force partially inserted reinforcing bars into the hole. If necessary, redrill and reinsert reinforcing steel to facilitate insertion. When reinforcement inserted into preplaced grout fails to reach the bottom of the drill hole, immediately remove the

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reinforcement and the grout, and clean the reinforcement. Redrill and reinsert the reinforcement as necessary to achieve conformance with the Plans.

455-56.6 Splicing: Secure casing and reinforcing bars in a manner to hold the reinforcing steel in proper alignment.

Based on the casing type, threaded casing splices must meet the requirements of API 5CT (for N-80) or API 5L (for X52) and be capable of developing the required axial and bending capacities. Reinforcing bar splices and couplers must develop 100% of the reinforcing bar ultimate strength.

455-56.7 Grouting: Provide grout mixing equipment capable of continuously agitating the grout, and that will produce a grout that is free of lumps and undispersed cement. Use a positive displacement grout pump equipped with a pressure gauge, capable of measuring pressures of at least 150 psi or twice the actual grout pressures used, whichever is greater. Size the grouting equipment to enable the grout to be pumped in one continuous operation.

Micropiles must be primary grouted before or during withdrawal of the casing from the pile tip elevation to the permanent casing tip elevation. Use a stable neat cement grout or a sand cement grout. Admixtures, if used, must be mixed in accordance with manufacturer's recommendations.

After drilling, flush hole with water or other approved fluid to remove drill cuttings and loose debris. Use a tremie or a grouting system that injects the grout from the lowest point of the drill hole. Continue injection until uncontaminated grout flows from the top of casing. Extract temporary casing in stages to ensure that after each length of casing is removed, the grout level is brought back up to the top of casing level before the next length is removed. Due to the possible porous limestone formations, the grout head may drop significantly during temporary casing extraction. Accordingly, either the tremie must be maintained at the bottom of pile or the grout continuously pressurized, until temporary casing extraction is completed.

Control the grout pressures and grout takes to prevent heave or fracturing of rock or soil formations. Upon completion of grouting, the tremie tube or tremie line may be removed or remain in the drill hole. Fill the tremie tube or tremie line with grout if left in place.

Record the following data pertaining to the grouting operation:

1. Type of mixer
2. Specific gravity
3. Types of additives (if any)
4. Grout pressure
5. Type of cement
6. Strength test samples (if any)
7. Volume of grout at each stage of grouting

Do not load micropiles until the grout has reached the specified 28-day strength. If a post-grouting system is used, submit working drawings and full details and procedures to the Engineer for review and approval.

455-56.8 Micropile Installation Records: Within 48 hours after each individual pile installation is completed, submit an installation record for that micropile. The Engineer may reject the installed micropile based on the submitted information. Required information includes, but is not limited to, the following:

1. Project Name, Project Number & Structure Number
2. Inspector name
3. Pile Number or Designation

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4. Drilling Start and End Dates
5. Drilling Start and End Time
6. Drilling equipment
7. Drill hole diameter
8. Descriptions of soil and rock indicating the depths encountered
9. Constructed bonded length
10. Casing outside diameter
11. Casing wall thickness
12. Elevation and depth of permanent casing
13. Central reinforcement size and length
14. Number of centralizers used
15. Grouting dates (primary and secondary)
16. Grouting start and end times (primary and secondary)
16. Cement type and admixtures
17. Water/cement ratio (if mixed on-site: gallons per 90 pound sack of cement)
18. Type of mixer
19. Grout density or specific gravity
20. Grout volume
21. Maximum grouting pressures (primary and secondary)
22. Elevations of strain gauges in static load test piles
23. Number of prepared grout cylinders
24. Other observations including loss of circulation, cave-in, drilling difficulties, change of drill bit etc.
25. Inspector approval section

455-57 Testing.

455-57.1 General: Perform static load testing from the top of sacrificial test piles at the locations specified in the Contract Documents or as authorized by the Engineer. Install lateral bracing to static load test piles as required by design calculation prior to load tests.

The Engineer will provide written confirmation of micropile construction within five calendar days of the receipt of the static load test report. The Contractor may be allowed to continue production, at risk, prior to receipt of this written confirmation.

Perform a verification tensile or compressive load test on at least 5% of the production piles of each bent or pier (minimum 1 per bent/pier). In addition, the Engineer reserves the right to require additional verification load tests in tension (ASTM D3689) or compression (ASTM D1143) on any production pile at any time. Provide and extend the steel reinforcement in all piles as required to allow the Engineer to perform verification load test in tension at any pile.

455-57.2 Procedure for Static and Verification Load Tests: Apply an initial load not to exceed 4 percent of the Factored Design Load. Zero the pile top movement measurement (dial gauges, etc.) after the initial alignment load is applied. Follow load testing schedule in accordance with 455-57.2.1.1 for static load tests and 455-57.2.2 for verification load tests.

Maintain the applied loads using the load cell. If the applied load decreases, re-adjust the applied load. Measure pile top movement at each load increment. The load-hold period begins as soon as each test load increment is applied. Measure and record pile movement during the creep test increment and final unloading at 1, 2, 3, 4, 5, 6 and 10 minutes. If the creep rate exceeds 0.04 inch/log cycle time between 1 and 10 minutes, or the creep rate is not computed

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during the test, continue the creep test increment hold to at least 60 minutes, maintain load and record pile movement at 20, 30, 40, 50 and 60 minutes from the beginning of the creep test increment.

455-57.2.1 Static Compression Load Tests: Prior to the installation of production piles, install and test the sacrificial static load test pile(s) in accordance with ASTM D1143, at the location(s) shown in the Contract Documents or as directed by the Engineer. The Contractor may submit alternate locations to the Engineer for review and approval.

Install test piles using the same installation method and details to be used for production piles. Any changes made to static load test piles must be made to the production piles. Such changes may include, but are not limited to, the drilling and grouting method, casing length, reinforcement bar size, and reinforcement length. The depth of embedment into the bearing stratum for the production piles must not be less than for the static load test pile(s).

At the completion of static load testing, the test piles and reaction piles shall be cutoff to an elevation not less than 4 feet below grade, unless otherwise authorized by the Engineer.

455-57.2.1.1 Static Test Loading Schedule: Perform static pile load tests by incrementally loading the micropile in accordance with the following cyclic compressive loading schedule:

Table 1
Static Load Test Loading Schedule

LOAD	MINIMUM HOLD TIME
Alignment Load (0.04 FDL max)	--
0.075 FDL	4 minutes
0.150 FDL	4 minutes
0.225 FDL	4 minutes
0.300 FDL	4 minutes
0.375 FDL	4 minutes
Alignment Load	1 minute
0.150 FDL	1 minute
0.300 FDL	1 minute
0.375 FDL	1 minute
0.450 FDL	4 minutes
0.525 FDL	4 minutes
0.600 FDL	4 minutes
0.675 FDL	4 minutes
0.750 FDL	4 minutes
Alignment Load	1 minute
0.30 FDL	1 minute
0.60 FDL	1 minute
0.675 FDL	1 minute
0.750 FDL	1 minute
0.825 FDL	4 minutes
0.900 FDL	4 minutes
1.00 FDL	10 or 60 minutes (Creep Test Increment)

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Table 1 Static Load Test Loading Schedule	
LOAD	MINIMUM HOLD TIME
Alignment Load	1 minute
0.300 FDL	1 minute
0.600 FDL	1 minute
0.900 FDL	1 minute
0.975 FDL	1 minute
1.050 FDL	4 minutes
1.125 FDL	4 minutes
1.200 FDL	4 minutes
1.275 FDL	4 minutes
1.350 FDL	4 minutes
1.425 FDL	4 minutes
1.50 FDL (only if less than NBR)	4 minutes
Nominal Bearing Resistance (NBR)	10 minutes
1.20 FDL	4 minutes
0.90 FDL	4 minutes
0.60 FDL	4 minutes
0.30 FDL	4 minutes
Alignment Load	4 minutes

455-57.2.1.2 Static Load Test Acceptance Criteria: All of the following must be satisfied for the static load test pile to be considered acceptable.

1. At the end of the first load holding period at 0.750 FDL increment, the top of pile deflection shall not exceed 0.5 inch.

2. During the 1.00 FDL creep test (load-holding period), the creep rate must not exceed 0.04 inch/log cycle time between 1 and 10 minutes. When the 60-minute creep test is required, the creep rate must not exceed 0.08 inch/log cycle time between 6 and 60 minutes. Creep rate in log cycle of time must be constant or decreasing at the end of the hold period.

3. Failure does not occur.

455-57.2.1.3 Static Load Test Pile Rejection: If a static load-tested micropile fails to meet the acceptance criteria, the Contractor shall modify the design, the construction procedure, or both. These modifications may include modifying the installation methods, increasing the bonded length, changing the micropile type, increasing the micropile drill hole diameter or a combination of the above. The Contractor's Engineer of Record shall perform any re-design, and sign and seal the re-design drawings and computations.

After the design modifications, for every failed test pile, an additional static load test pile shall be installed and load tested by the Contractor to demonstrate that the micropile re-design will satisfy the acceptance criteria. This process will be repeated until the test piles satisfy the requirements of 455-57.2.1.2.

All modifications of design or construction procedures or cost of additional verification test piles and load testing shall be at the Contractor's expense.

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At the completion of static load testing, the test piles and reaction piles shall be cutoff to an elevation not less than 4 feet below grade, unless otherwise authorized by the Engineer.

455-57.2.2 Verification Load Tests: Perform verification tensile or compressive load tests on production piles selected by the Engineer in accordance with Table 2 below. Lateral bracing shall be provided as required to allow testing to the Maximum Test Load.

Table 2
Verification Load Test Loading Schedule

VERIFICATION TEST LOAD	MINIMUM HOLD TIME
Alignment Load (0.04 FDL max)	--
0.10 FDL	4 minutes
0.20 FDL	4 minutes
0.30 FDL	4 minutes
0.40 FDL	4 minutes
0.50 FDL	4 minutes
0.60 FDL	4 minutes
0.675 FDL	4 minutes
0.750 FDL	4 minutes
0.825 FDL	4 minutes
0.900 FDL	4 minutes
1.00 FDL	10 or 60 minutes (Creep Test)
0.75 FDL	4 minutes
0.50 FDL	4 minutes
0.25 FDL	4 minutes
Alignment Load (0.04 FDL max)	4 minutes

The acceptance criteria for micropile verification load tests are listed as follows. All three criteria must be satisfied for the verification test pile to be considered acceptable.

1. At the end of the load holding period at the first 0.75 FDL increment the top of pile deflection shall not exceed 0.5 inch.
2. During the 1.00 FDL creep test (load-holding period), the creep rate must not exceed 0.04 inch/log cycle time between 1 and 10 minutes, or if the 60-minute creep test is required, not exceed 0.08 inch/log cycle time between 6 and 60 minutes. Creep rate in log cycle of time shall be constant or decreasing at the end of the hold period.
3. Failure does not occur.

455-57.2.3 Testing Equipment and Data Recording: Testing equipment shall include but not limited to dial gauges, dial gauge support, calibrated jack and pressure gauge, load cell, a reaction frame, and anchor piles. A calibrated load cell is required for all load tests. The jack and pressure gauge, and the load cell shall be calibrated within 90 calendar days of the beginning of the load tests. The Contractor shall provide a description of test setup and calibration curves for the proposed jack, pressure gauge and load cell in accordance with Section 455-60. Dial gauges shall have a travel sufficient to allow the test to be completed without having to re-set the gauges. Measuring apparatus shall be according to Section 455-2.3 unless otherwise required herein. A minimum of 3 dial gauges shall be used during the static load test.

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Install vibrating wire or electrical resistance type strain gauges capable of measuring a compression load of up to the Maximum Test Load plus 20% at the locations shown in the Plans. Install heavy-duty strain gauge cables, conduits, and protective shielding to protect against construction damage. Design the instrumentation setup, including the arrangement of readout cables, to allow for adequate bonding between bar and grout at the Maximum Test Load. Provide the associated terminal boxes and readout units throughout the load test(s). When strain gauge levels are shown in the Plans, load test piles must have as a minimum one strain gauge at each level still in operation and not less than 75% of all the strain gauges in operation by the end of the test. The Engineer will reject any load test pile and corresponding load test failing to achieve the above strain gauge requirements throughout the test.

Apply and measure the test load with a load cell or hydraulic jack with a pressure gauge. The pressure gauge shall be graduated in 50 psi increments or less. The jack and pressure gauge shall have a pressure range not exceeding twice the anticipated maximum test pressure. Jack ram travel shall be sufficient to allow the test to be performed without re-setting the equipment. Monitor the creep test holding loads during verification tests with both the pressure gauge and the electronic load cell. Use the load cell to accurately maintain a constant load during the creep test load-holding periods in the verification tests.

455-57.2.4 Grout Testing: Previous test results for the proposed grout mix completed within one year of the start of work may be submitted for initial verification of the required compressive strengths for installation of static load test piles. Additionally, the design grout density and tolerance shall be submitted to the Engineer for review.

Cast a set of minimum six (6) 4" x 8" grout cylinders in accordance with ASTM C31, except pour grout in a single lift into cylinder molds without rodding, from each grout plant each day of operation, or per every 10 piles, whichever occurs more frequently. Compressive strength tests shall be performed in accordance with ASTM C39. From each grout cylinder set, two (2) cylinders shall be tested at 3 days and 7 days, with the remaining two cylinders to be tested at the 28-day interval. The compressive strengths shall be the average of the 2 cylinders tested. The results of all compression tests shall be recorded and provided to the Engineer.

Grout consistency as measured by grout density shall be determined by the Contractor in accordance with ASTM C188/AASHTO T 133 or API RP-138-1 at a frequency of at least one test per batch conducted just prior to start of pile grouting. A mud balance meeting the requirements of API RP-138-1 is acceptable for determining the grout specific gravity (or density) of neat cement grout. Do not use grout with specific gravity (or density) outside of the acceptable range.

Grout samples shall be taken from the grout point of placement. Provide grout compressive strength and grout density test results to the Engineer within 24 hours after testing is completed on a sample or set of samples.

455-58 Submittals.

455-58.1 General: Prepare shop drawings and design calculations describing the micropile system or systems intended for use. Submit the shop drawings, working drawings and design calculations during the preconstruction meeting or at least 30 calendar days prior to the commencement of micropile field work.

Include in the working drawings and shop drawings all details, dimensions, quantities, ground profiles, and cross-sections necessary to construct and test the production and verification micropiles.

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455-58.2 Design Calculations: Design calculations for portions of the micropile design not fully detailed in the Plans shall include, but not be limited to, the following items:

1. Design parameters, assumptions, and applicable codes and Specifications.

2. A written summary report which describes the overall micropile design, including the factored design load and the estimated pile top movement at the service limit state and the maximum test load.

3. Applicable code requirements and design references.

4. Micropile structure critical design cross-section geometry including soil/rock strata and piezometric levels and location, magnitude and direction of design and applied maximum test loadings.

5. Design criteria including, soil/rock shear strengths (friction angle and cohesion), unit weights, and ground-grout bond values and micropile drill hole diameter assumptions for each soil/rock strata.

6. Load and resistance factors used in the design on the ground-to-grout bond values, soil/rock and material unit weights, steel, grout, and concrete materials.

7. Design calculation sheets with the project number, micropile location, designation, date of preparation, first initial and last name of designer and checker, and page number at the top of each page. Provide a cover page and an index page with the design calculations.

8. Design notes including an explanation of any symbols, acronyms and computer programs used in the design.

455-58.3 Shop Drawings: The shop drawings shall include all information required for the construction and quality control of the micropile construction. Shop drawings shall include, but not be limited to, the following items unless provided in the Contract Plans:

1. Design parameters, applicable codes and specifications;

2. General notes for constructing the micropile structure including construction sequencing or other special construction requirements;

3. Micropile typical sections including micropile spacing and inclination;

4. Minimum drill hole diameter;

5. Permanent steel casing pipe diameter, wall thickness, material type and material grade;

6. Reinforcing bar sizes, material grade and details;

7. Reinforcing bar splice types and locations (if any);

8. Minimum grout cover;

9. Spacers, centralizers and their locations;

10. Grout bonded length;

11. A typical detail of verification and production micropiles defining the micropile length, minimum drill hole diameter, inclination, and load test bonded and unbonded test lengths;

12. Details, dimensions, and schedules for all micropiles, casing and reinforcing steel, including any reinforcing bar bending details.

455-58.4 Micropile Installation Pile (MIP) Submittal: Prepare and submit an MIP to the Engineer, for review and approval. Provide the following information in the MIP:

1. Detailed systematic description of the proposed micropile construction procedure, including personnel, testing, and equipment to assure quality control. This systematic

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procedure shall be shown on the working drawings in sufficient detail to allow the Engineer to monitor the construction and quality of the micropiles.

2. Proposed start date and time schedule and micropile installation schedule providing the following:

a. Micropile number
b. Micropile design load
c. Type, grade and size of reinforcing steel
d. Depth of permanent casing
e. Minimum bonded length
f. Total micropile length

3. If welding of casing is proposed, submit the proposed welding procedure.

4. Information on headroom and space requirements for installation equipment that verifies the proposed equipment can perform at the site.

5. A plan describing how surface water, drill flush, and excess waste grout will be controlled and disposed.

6. Certified mill test reports for the reinforcing steel or coupon test results for permanent casing without mill certification. The certified mill test reports must include the ultimate strength, yield strength, elongation, and material properties composition. For API N-80 pipe casing, coupon test results may be submitted in lieu of mill certification.

7. Proposed grouting plan. The grouting plan shall include complete descriptions, details, and supporting calculations for the following:

a. Grout mix design and type of materials to be used in the grout including certified test data and trial batch reports. Include the required water cement ratio and specific gravity (or density) acceptable ranges.

b. Methods and equipment for accurately monitoring and recording the grout depth, grout volume and grout pressure as the grout is being placed.

c. If post-grouting technique is used, provide details regarding the post-grouting operation, including details of post-grouting tubes, sequencing of grouting along the bonded length, and maximum grouting pressure, etc.

d. Estimated curing time for grout to achieve specified strength. Previous test results for the proposed grout mix completed within one year of the start of grouting may be submitted for initial verification test pile installation. During verification test pile and production pile installation, grout shall be tested in accordance with 455-57.2.4.

e. Procedure and equipment for the monitoring of grout quality.

8. Detailed plans for the proposed micropile load testing method including all drawings, details, and structural design calculations necessary to clearly describe the proposed test method, reaction load system capacity and equipment setup, details for laterally bracing the unsupported length of the test piles, types and accuracy of apparatus to be used for applying and measuring the test loads and pile top movements as required herein.

9. Calibration reports and data for each test jack, pressure gauge and master pressure gauge and electronic load cell to be used. The calibration tests shall have been performed by an independent testing laboratory, and tests shall have been performed within 90 calendar days of the date submitted. Testing shall not commence until the Engineer has reviewed and approved the jack, pressure gauge, master pressure gauge and electronic load cell calibration data.

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455-58.5 Certificates of Compliance: Submit a certificate of compliance for the portland cement and reinforcing steel bars verifying that the material or assemblies comply with the requirements of the Contract and Specifications.

The shop drawings and design calculations for portions of the micropile design not fully detailed in the Plans must be signed and sealed by the Contractor's Engineer of Record. The Certificates of Compliance must be signed by an officer or director of the Contractor with the authority to bind the Contractor.

The Engineer will approve or reject the shop drawings, Work plan submittal and design calculation submittals within five calendar days after receipt of the submission. If the submittal is rejected, make all necessary corrections and resubmit for review and approval. Subsequent changes to or deviations from the approved submittals must be submitted for approval. No adjustments in Contract Time or delay or impact claims will be allowed due to incomplete submittals.

Do not begin work until the construction submittals have been accepted in writing by the Engineer. Processing of shop drawings and Work Plan Submittal shall be in accordance with Section 5-1.4 of the FDOT Specifications. Additional time required due to incomplete or unacceptable submittals shall not be cause for delay or impact claims. All costs associated with incomplete or unacceptable submittals shall be the responsibility of the Contractor.

Provide revised drawings and design calculations signed and sealed by the Contractor's Engineer of Record for all design changes made during the construction of the micropiles.

Submit to the Engineer, within 10 calendar days after completion of a micropile static load test, an installation report documenting the following:

1. Reinforcing steel manufacturer's mill test reports for the reinforcing steel bars incorporated in the installation.
2. Micropile inspection record of the test pile.
3. Grouting records indicating the cement type, quantity injected, the grout pressures, the grout density and tolerances, and the grout compressive strength.
4. A signed and sealed static load test report that includes all the information and documentation required in 455-2.8. This report shall include all collected data, graphs necessary to establish acceptability of the piles in accordance with 455-57.2.1. In addition, the report shall include a signed & sealed letter to the Department confirming whether the design assumptions were met by the static load tests before proceeding with production foundation construction.

Submit to the Engineer, within 10 calendar days after completion of a micropile verification load test, an installation report documenting the following:

1. Reinforcing steel manufacturer's mill test reports for the reinforcing steel bars incorporated in the installation.
2. Micropile inspection record of the verified pile.
3. Grouting records indicating the cement type, quantity injected, the grout pressures, the grout density and tolerances, and the grout compressive strength.
4. A signed and sealed verification load test report shall include all collected data, graphs necessary to establish acceptability of the verified piles in accordance with 455-57.2.2. In addition, the report shall include a signed & sealed letter to the Department confirming whether the verified pile is acceptable.

455-59 Protection of Material.

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Store steel reinforcement and casing above the surface of the ground, upon platforms, skids, or other supports, and protect it as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placing steel reinforcement and casing in the work, ensure that the steel reinforcement and casing are free from loose rust, scale, dirt, paint, oil, and other foreign material.

Store bagged cement material, stacked on pallets, in a weathertight, properly ventilated structure, and protect from moisture.

455-60 Construction Tolerances.

Meet the following construction tolerances for micropiles:

1. If the position tolerance is not shown in the Plans, ensure that the top of the micropile is no more than, the diameter of the top of the pile divided by 6 laterally from the position indicated in the Plans. Contact the Engineer immediately if actual field condition requires a change in the design micropile location.

2. Ensure that the axial alignment of the micropile does not deviate more than 1/4 inch per foot from the vertical or batter line indicated in the Plans.

3. If the elevation tolerance is not shown in the Plans, ensure that the final elevation of the micropile head is no more than 1 inch above, or 2 inches below the elevation shown in the Plans.

4. Ensure the reinforcing steel is concentric with the micropile within a tolerance of 1/2 inch.

455-61 Unacceptable Micropiles.

Unacceptable micropiles are micropiles that fail for any reason, including, but not limited to, the following:

1. Micropiles not meeting the required penetration, minimum tip elevations or the required bonded lengths;

2. Micropiles where the tolerances of 455-60 are not met.

3. Micropiles with integrity deficiencies and contaminated grout.

4. Micropiles where the grout strength is less than the minimum strength required in the Plans;

5. Micropiles where the reinforcement did not reach the bottom of the hole;

6. Micropiles subjected to verification load test that do not meet the acceptance criteria.

When a pile is unacceptable, the Contractor may propose a foundation redesign to add piles into pile caps or footings at no expense to the Department. The Contractor's Engineer of Record must perform any redesign, and sign and seal the redesign drawings and calculations. Do not begin any proposed construction until the redesign has been reviewed and accepted by the Engineer.

455-62 Protection of Existing Structures.

Protect existing structures and bridge piers from settlement and vibration in accordance with Section 108. Inspect and document the condition of the following existing structures, and survey and monitor for settlement the following existing structures:

1. as shown in the Plans.

2. within a distance of one-half of the micropile depth, measured from the center the micropile.

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3. within a distance of two times the depth of the excavation for the pile cap.

Set up monitoring points approved by the Engineer on the existing piers adjacent to the micropile work and perform settlement monitoring at these locations using conventional surveying method at least three times on every work shift.

455-63 Method of Measurement.

The quantity to be paid for will be the length, in feet, of micropiles authorized by the Engineer, completed, and accepted.

455-64 Basis of Payment.

Price and payment will be full compensation for all micropiles, including the cost of grout, reinforcing steel, casing, and including all labor, materials, equipment, and incidentals necessary to complete the micropiles, performance of the static load tests, verification load tests, design, recording, load test data collection and professional services to prepare the static load test and verification load test reports.

No separate payment will be made for the verification load tests performed within by the Contractor to meet the minimum quantity requirements specified in 455-57.1. Any verification load test that does not meet the acceptance criteria defined in 455-57.2.2 will not count towards the minimum quantity requirement.

Each additional Verification load test requested by the Engineer in excess of the quantities specified in 455-57.1, will be paid separately as 10 feet of micropile for a tension test or 25 feet of micropile for a compression test specifically required by the Engineer, if it meets the acceptance criteria defined in 455-57.2.2. No payment will be made for a verification load test that does not meet the acceptance criteria.

Payment will be made under:

Item No. 455-39- Micropiles, Furnish and Install - per foot.

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