SECTION 00515 - MICROPILES

(Follow all instructions. If there are no instructions above a subsection, paragraph, sentence, or bullet, then include them in the project but make necessary modifications to only include project specific specifications. Delete specifications that do not apply to the project.)

Section 00515, which is not a Standard Specification, is included in this Project by Special Provision.

Description

00515.00 Scope - This work consists of designing, furnishing, constructing and testing micropiles at the locations shown and specified.

Furnish all design, materials, equipment, accessories, tools, services, transportation, labor and supervision, and manufacturing technique required for installing and testing micropiles and micropile top attachments for this project.

Select the micropile type, size, pile top attachment, installation method, ground-grout bond value and determine the required bond length and final micropile diameter to meet the requirements of the plans and these specifications. Verify the micropile factored resistances by verification and proof load that demonstrate the test piles meet or exceed the specified test acceptance criteria.

00515.02 Subsurface Investigation - The Exploration Logs for this project are available for review through the Engineer's office. The data shown for each exploratory test boring applies only to that particular boring and location. Subsurface conditions may vary between borings. Rock core samples and the results of any laboratory testing that was performed for this project are available for review by contacting the Engineer.

00515.03 Definitions

Admixture: Substance added to the grout to control bleed and/or shrinkage, improve flowability, reduce water content, or retard setting time.

Alignment Load (AL): A minimum initial load (no greater than 5 percent of the Factored Design Load) applied to the micropile during testing to keep the testing equipment correctly positioned.

Bond Length: The length of the micropile that is bonded to the ground and used to transfer the applied axial loads to the surrounding soil or rock.

Bond-breaker: A sleeve placed over the steel reinforcement to prevent load transfer.

Casing: Steel tube introduced during the drilling process in overburden soil to temporarily stabilize the drill hole. This is usually withdrawn as the micropile is grouted, although in certain types of micropiles, some casing is permanently left in place to provide added micropile reinforcement.

Centralizer: A device to support and position the reinforcing steel in the center of the drill hole and/or casing so that a minimum grout cover is provided.

Coupler: The means by which load capacity can be transmitted from one partial length of reinforcement to another.

Creep Movement: The movement that occurs during the creep test of a micropile under a constant load.

Double Corrosion Protection: A system composed of two levels of corrosion protection, usually consisting of either grout filled encapsulation or epoxy coating and grout.

Encapsulation: A corrugated or deformed tube protecting the reinforcing steel against corrosion.

Factored Design Load (FDL): The maximum load expected to be applied to the micropile during its design life.

Free (unbonded) length: The designed length of the micropile that is not bonded to the surrounding ground or grout.

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/ground bond.

Overburden: Natural or placed material that may require cased drilling methods to provide an open borehole to underlying strata.

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

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

Proof Load Test: Incremental loading of a production micropile, recording the total movement at each loading increment.

Reinforcement: The steel component of the micropile that accepts/resists applied loadings.

Sheathing: Smooth or corrugated piping or tubing that protects the reinforcing steel against corrosion.

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

Verification Load Test: Pile load test of a sacrificial micropile performed to verify the design of the micropile system and the construction methods proposed, prior to installation of production micropiles.

00515.04 Standards - The following publications form a part of this specification to the extent indicated by the references. The latest publication as of the issue date of this specification governs, unless indicated otherwise.

(a) American Society for Testing and Materials (ASTM)

American Association of State Highway and Transportation Officials (AASHTO)

ASTM	AASHTO	SPECIFICATION/TEST
A36, A572	M183, M223	Structural Steel
A82	M55	Cold-Drawn Steel Wire for Concrete Reinforcement
A252	-	Welded and Seamless Steel Pipe Piles
A615	M31	Deformed and Plain Billet Steel Bars for Concrete Reinforcement
A722	M275	Uncoated High-Strength Steel Bar for Prestressing Concrete
A775	-	Epoxy-Coated Reinforcing Steel Bars
A934	-	Epoxy-Coated Prefabricated Steel Reinforcing Bars
C 33	M80	Concrete Aggregates
C109	T106	Compressive Strength of Hydraulic Cement Mortar
C188	T133	Density of Hydraulic Cement
C 144	M45	Aggregate for Masonry Mortar
C 150	M 85	Portland Cement
C 494	M194	Chemical Admixtures for Concrete
D 1143	-	Method of Testing Piles Under Static Axial Compressive Load
D 1784		Polyvinyl Chloride (PVC) Pipe (Class 13464-B)
D 3350	M 252	Polyethylene Corrugated Tubing
D 3689	-	Method of Testing Individual Piles Under Static Axial Tensile Load
D 3966		Standard Test Method for Piles Under Lateral Load
-	T 26	Quality of Water to be Used in Concrete

(b) American Welding Society (AWS)
D1.1 Structural Welding Code-Steel
D1.4 Structural Welding Code-Reinforcing Steel

(c) American Petroleum Institute (API)
5CT (N-80) Specification for casing and tubing
RP 13B-1 Recommended Practice – Standard Procedure for Field Testing Water Based Drilling Fluids

00515.05 Micropile Design Requirements - Design micropiles to meet the loading conditions provided in Table 00515.15-1 below. Design micropiles and pile top to footing connections using the procedures described in the most current version of the *AASHTO LRFD Bridge Design Specifications*.

(Obtain information from designer and fill in Table 00515.15-1. Add rows or modify as necessary for all micropile locations included in the project.)

TABLE 00515.15-1

Location	Micropile Factored Design Load (FDL),* (kips)	
	Right Footing	Left Footing
Bridge XXX – Bent 1		
Bridge XXX – Bent 2		

* loads are axial compression loads per micropile unless otherwise noted

(Fill in the required nominal (ultimate) moment capacity. Identify the location of the nominal moment by selecting either the pile top location or the depth

below the pile top; delete the unused portion and parentheses. Obtain the moment and depth from designer. Delete the entire paragraph below if moment design does not apply to the project.)

Design and provide a composite cross section of the micropile capable of developing a nominal moment capacity of _____ kip-ft. The location of the nominal moment is at (top of the pile)/(a depth of _____ feet below the top of the pile).

(Obtain the thickness of the sacrificial steel for steel pipe casings from the designer and fill in the blank. Delete the last sentence if permanent steel pipe casings do not apply to the project.)

Provide corrosion protection of the internal steel reinforcing bars in accordance with subsection 00515.10. Where permanent casing is used for a portion of the micropile, extend the double corrosion system at least 5.0 feet into the casing. If the micropile design relies on the casing for axial or moment capacity, incorporate an additional ____ inch thickness of sacrificial steel for corrosion protection of all permanent steel pipe casing used in micropile construction.

(Delete the following sentence if double-corrosion protection does not apply to the project.)

Provide double corrosion protection of the reinforcing bars for all reinforcing bars not contained within permanent casing.

00515.06 Micropile Working Drawings Submittals - Submit complete stamped working drawings (including micropile design calculations) and unstamped working drawings to the Engineer prior to the start of micropile construction according to 00150.35

Make revisions or corrections to the working drawing submittals as requested by the Engineer and resubmit revised drawings or submittals. Resubmit changes or deviations on the working drawings for review and approval. No adjustments or extensions in contract time or delay, or impact claims, will be allowed due to incomplete submittals.

Include all details, dimensions, quantities, ground profiles, and cross-sections necessary to construct the micropile structure. Verify the limits of the micropile structure and ground survey data before preparing the detailed working drawings.

(a) Stamped Working Drawings – Design micropiles to support the design loads provided in 00515.05 using the procedures in the most current edition of the *AASHTO LRFD Bridge Design Specifications*. Include all information required for the construction and quality control of the micropiles on the stamped working drawings. Submit the following information on stamped working drawings and documents, including, but not limited to:

(1) Design Calculations –Provide design calculations including the following:

- A written summary report which describes the overall micropile design, including the type and diameter of micropile(s) selected and (if applicable) a discussion of the use of any temporary casing,
- Applicable code requirements and design references,
- Micropile structure critical design cross-section(s) geometry including soil/rock strata and piezometric levels and location, magnitude and direction

of applied factored loadings, including slope or external surcharge loads,

- Design criteria, including soil/rock shear strengths (friction angle and cohesion), unit weights, and ground-grout bond values,
- Factored design loads and nominal and factored resistances used in the design of the ground-grout bond values, surcharges, steel, grout, and concrete materials,
- Minimum grout unconfined compressive strength at 28-days and at the time of verification and proof load testing,
- Pile to pile cap/footing connection calculations and design details,
- Design calculation sheets for both static and seismic design of the micropiles. Include analysis performed to determine drill hole diameters, estimated bond lengths, total micropile lengths and type and size of reinforcing steel. Include pile top deflection estimates and group effects (if applicable) and structural design of the micropile system (if applicable).
- Include the structure (Bridge) number, micropile structure location (Bent No. and footing), date of preparation, initials of designer and checker, and page number at the top of each page. Provide an index page with the design calculations,
- Design notes including an explanation of any symbols and computer programs used in the design.

(2) Plan View showing:

- Reference baseline and elevation datum.
- Overall plan layout of micropiles showing numbering sequence, pile diameters, position and horizontal spacing,
- Station and offset from the construction centerline or baseline to the center of all micropiles or face of micropile structure,
- Right-of-way and permanent or temporary construction easement limits, location of all known active and abandoned existing utilities, adjacent structures or other potential interferences. The centerline and dimensions of any utility, drainage structure or drainage pipe behind, passing through, or passing under the micropile structure,
- Locations of all subsurface explorations with appropriate reference base lines to fix the locations of the explorations relative to the micropile structure.

(3) Elevation View showing:

- Micropile locations and elevations, lengths, minimum hole diameters, batter and alignment, casing dimensions and lengths, reinforcement type, sizes and details, splice types and locations, centralizers and spacers, minimum grout bond zone, casing plunge lengths (if used), and corrosion protection details,
- Micropile structure connection details to substructure footing,
- Micropile Design Loads
- Summary of estimated quantities for each substructure unit,
- Location of drainage elements (if applicable),

(4) Steel Shop Drawings including:

- Shop drawings for all structural steel including the details, dimensions, and schedules for all micropile casing and reinforcing steel, including reinforcing bar bending details and steel for substructure/footing anchorage and the corrosion-protection system.

(5) Micropile Load Testing and Reporting:

- Provide detailed plans for the proposed micropile load testing method and procedures. Include all drawings, details, and structural design calculations necessary to clearly describe the proposed test method, reaction load system capacity and equipment setup, types and accuracy of apparatus to be used for applying and measuring the test loads and pile top movements in accordance with 00515.46, 00515.46(a) and 00515.46(b). Submit Micropile Load Test Data Reports in accordance with 00515.48.

Revise the drawings when plan dimensions are changed due to field conditions or for other reasons. Within 30 days after completion of the work, submit as-built drawings to the Engineer. Provide revised design calculations stamped by the approved Registered Professional Engineer for all design changes made during the construction of the micropile structure.

(b) Unstamped Working Drawings - Prior to beginning work, submit the following unstamped working drawings and documents:

(1) Detailed step-by-step description of the proposed micropile construction procedure, including construction sequencing (i.e. drilling, grouting and testing procedures) and any other special construction requirements to assure quality control. Include sufficient detail to allow the Engineer to monitor the construction and quality of the micropiles.

(2) Manufacturer's information on the equipment to be used for installing micropiles, including the model, size and type of equipment, with appropriate manufacturer's literature for review. Provide information on the drilling methods and tools to be used and the proposed method for flushing and removal of spoils. Include information on headroom and space requirements (if appropriate) for installation equipment that verify the proposed equipment is appropriate for the site conditions and constraints,

(3) Proposed start date(s) and micropile installation schedule,

(4) Plan describing how surface water, drill flush, and excess waste grout will be contained, controlled and disposed of in accordance with all applicable permits and regulations,

(5) Details for constructing micropile structures around drainage or other facilities (if applicable),

(6) Permanent casing threading connection details. If welding of casing is proposed, submit a proposed Welding Procedure Specification (WPS) for approval. Submit qualification documents for each welder. Use welders qualified according to D1.1 for the position, process and casing diameter used on the job.

(7) Certified mill test reports for the reinforcing steel and permanent casing (if used). Check sample results for permanent casing without mill certification may be submitted in lieu of mill certification. Supply two check sample tests per truckload delivered to the fabricator, but not less than two check sample tests per project. Include the ultimate strength, yield strength, elongation, material properties and chemical composition.

(8) Grouting Plan. Include in the grouting plan complete descriptions, details, and supporting calculations for the following:

- Grout mix design and type of materials to be used in the grout including certified test data and trial batch reports. Include in the mix designs certified test results verifying that the mix designs provide the required grout strength, as specified in the submitted design calculations, for the 28-day strength and the strength required at the time of verification and proof load testing. Provide grout consistency and density requirements.
- Equipment and procedures used to mix and place the grout, including the grout pressures to be used and descriptions of any postgrouting methods (if applicable),
- Methods and equipment for accurately monitoring and recording the grout depth, grout volume and grout pressure as the grout is being placed.
- Grouting rate calculations, when requested by the Engineer. Base calculations on the initial pump pressures or static head on the grout and losses throughout the placing system, including anticipated head of drilling fluid (if applicable) to be displaced.
- 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 and acceptance and start of production work. During production, test grout in accordance with Section 00515.44(e).
- Procedure and equipment for contractor monitoring of grout quality.

(9) Calibration reports and data for each test jack, pressure gauge and master pressure gauge and load cell to be used. Provide calibration tests performed by an independent testing laboratory within 60 calendar days of the date submitted. Do not begin testing until the Engineer has reviewed and accepted the jack, pressure gauge, master pressure gauge and electronic load cell calibration data.

Do not begin work until the appropriate submittals have been received, reviewed, and accepted in writing by the Engineer. Allow 14 calendar days for review of the working drawing submittals after a complete set has been received. Additional time required due to incomplete or unacceptable submittals will be at no additional cost to the Agency

Materials

00515.10 General - Use materials meeting the following requirements:

(a) Admixtures – Furnish admixtures conforming to the requirements of AASHTO M194 (ASTM C 494). Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout, subject to the review and acceptance by the Engineer. Only add expansive admixtures to grout used for filling sealed encapsulations and anchorage covers. Accelerators are not permitted. Use admixtures compatible with the grout and mixed in accordance with the manufacturer's recommendations.

(b) Cement – Furnish Portland cement conforming to AASHTO M85 (ASTM C 150), Type I or Type II.

(c) Grout – Furnish neat cement or sand/cement mixture with a minimum 28-day compressive strength as specified in the contractor's design submittal provided in

00515.08 (a)(1) and confirmed pursuant to AASHTO T106 (ASTM C109). Confirm the minimum required compressive strength prior to verification and proof load testing, pursuant to AASHTO T106 (ASTM C109).

(d) Water – Use clean, potable water in the grout mix conforming to AASHTO T 26 and free from substances that may be injurious to cement and steel.

(e) Reinforcement:

(1) **(1)** Furnish deformed reinforcing steel bars in accordance with AASHTO M31 (ASTM A 615), Grade 60 or Grade 75 or AASHTO M275 (ASTM A 722), Grade 150. When a bearing plate and nut are required to be threaded onto the top end of reinforcing bars for the pile top to footing anchorage, provide threading that is either continuous spiral deformed ribbing provided by the bar deformations (e.g., Dywidag or Williams continuous threadbars) or threading cut into a reinforcing bar. If threads are cut into a reinforcing bar, provide the next larger bar number designation from that shown on the Plans, at no additional cost.Furnish bar tendon couplers, if required, that will develop the ultimate tensile strength of the bars without evidence of any failure.

(f) Permanent Casing Pipe: Provide permanent steel casing/pipe with the diameter and the minimum wall thickness shown on the approved Working Drawings and meeting the following requirements:

- Tensile requirements of ASTM A252, using the minimum yield strength in the design submittal,
- Minimum elongation of 15%

For permanent casing/pipe that will be welded, the following material conditions apply:

- Maximum carbon equivalency (CE) for ASTM A252 Grade 3 material as defined in AWS D1.1, Annex I, Section I 5.1, of 0.45, as demonstrated by mill certifications,
- Maximum sulfur content of 0.05%, as demonstrated by mill certifications.

For permanent casing/pipe that will be shop or field welded, weld all seams and splices using complete penetration welds.

For threaded casing joints, provide joints that develop at least the required compressive, tensile, and bending strengths used in the design of the micropile.

(g) Plates and Shapes – Furnish structural steel plates and shapes for micropile top attachments conforming to ASTM A 36 or ASTM A572 Grade 50 and as required to meet the design loads (axial and moment) in accordance with Section 00515.07 and 00515.08(a)(1).

(h) Centralizers – Fabricate centralizers from plastic, steel, or material nondetrimental to the reinforcing steel. Do not use wood centralizers.

(i) Corrosion Protection - Provide corrosion protection of the internal steel reinforcing bars as follows:

(Select one or more of the following three paragraphs as appropriate. Delete any that do not apply.)

Encapsulation: Shop fabricate the encapsulation from high-density, corrugated polyethylene tubing conforming to the requirements of AASHTO M 252 (ASTM D 3350) with a minimum wall thickness of 0.03 inches. Provide an annulus opening between the reinforcement and the encapsulating tube of at least 0.25 inches and use a grout conforming to 00515.10(c).

Epoxy Coating: Electrostatically apply an epoxy coating to the reinforcing steel between 0.007 to 0.012 inches thick. Coat with epoxy in accordance with AASHTO M284 (ASTM A775). Bend test requirements are waived. Bearing plates and nuts encased in the pile concrete footing need not be epoxy coated. Provide mechanical couplers for splicing epoxy coated rebar that are either epoxy coated with the same thickness as the rebar or, for bare-steel couplers, coated with heat-shrink wrap, selected from Section 2510.11 of the QPL. Apply heat-shrink wrap extending at least 6 inches past the ends of the couplers and 6 inches past any damaged areas.

- Grout Protection: For bare steel reinforcement provide a minimum 3 inches of grout cover surrounding the reinforcing steel. For epoxy or galvanized reinforcement provide a minimum of 2 inches of grout cover.

Labor

00515.30 Personnel Qualification Submittals - Use personnel experienced in micropile construction to perform the work. Relevant experience includes that with similar anticipated subsurface materials, groundwater conditions, micropile size, loads and special construction techniques required.

At least 14 calendar days prior to the planned start of micropile construction, provide the following information to verify the firm's experience and the qualifications of personnel scheduled to perform the micropile construction:

(a) Micropile Contractor Qualifications - Evidence of the firm's experience in the construction and load testing of micropiles and the successful construction of at least 5 projects in the last 5 years involving construction totaling at least 100 micropiles of similar capacity to those required in these plans and specifications. Evidence of contractor experience in micropile drilling and grouting in soil/rock materials similar to project conditions. Provide a project reference list for each of the 5 projects which includes:

- Brief project description with the owner's name and current phone number.
- Date of project.
- Number, size and capacity of micropiles successfully installed and tested.
- Types of soil/rock materials and groundwater conditions encountered in the project.

Micropile On-Site Supervisor and Drill Rig Operator Qualifications - Names and detailed experience of the on-site supervisors and drill operators for the Project. Employ on-site supervisors and drill rig operators with experience on at least 3 projects over the past 5 years installing micropiles of equal or greater capacity than required in these plans and specifications.

(b) Micropile Professional Engineering Designer's Qualifications - Name(s) and detailed experience of the micropile design engineer.

- Employ a Professional Engineer registered in the State of Oregon, with experience in the design of at least 3 micropile projects of similar scope to this project, successfully completed over the past 5 years
- Experience designing micropiles of similar or greater capacity to those required in these plans and specifications and,
- The micropile design engineer may be either an employee of the contractor or an independent consultant design engineer meeting the stated experience requirements.

Include in the personnel list a summary of each individual's experience with sufficient detail for the Engineer to determine whether each individual satisfies the required qualifications.

The Engineer will approve or reject the contractor's qualifications within 14 calendar days after receipt of a complete submittal. Do not begin work or order materials until the Engineer's written approval of the contractor's experience qualifications is provided. Additional time required due to incomplete or unacceptable submittals will not be cause for adjustment in contract time. Contractor is responsible for all costs associated with incomplete or unacceptable submittals.

The Engineer may suspend the Work if the contractor uses non-approved personnel. Submit requests for substitution of field personnel to the Engineer, who will have an additional 7 calendar days to respond. If work is suspended due to use of unauthorized personnel, the contractor is fully liable for all resulting costs and no adjustment in contract time will result from the suspension.

Construction

00515.40 Quality Control - Maintain and be responsible for quality control of the micropile work throughout the construction operation. The Engineer will inspect all drilling operations and verify the suitability of micropile construction procedures.

00515.41 Site Drainage - Contain and dispose of all construction related waste in accordance with the standard specifications and all applicable local codes and regulations. As part of the pollution control plan, submit the process and techniques to be used to contain, process and dispose of all discharged materials.

Contain and properly dispose of all materials displaced from the drill hole or casing such as water, cuttings and excess grout during drilling or grouting operations. Pump waste materials to a tank or basin. Do not allow remnants from the grouting process to enter adjacent water ways or other environmentally sensitive areas. Immediately cease drilling or grouting operations and notify the Engineer if such events occur.

Control and properly manage all surface water that will affect construction of the micropile installation. Maintain all pipes or conduits used to convey surface water during construction. Repair damage caused by surface water at no additional cost to the Agency.

Immediately contact the Engineer if unanticipated existing subsurface drainage structures are discovered during excavation or drilling. Suspend work in these areas until remedial measures meeting the Engineer's approval are implemented. Cost of remedial measures or repair work resulting from encountering unanticipated subsurface drainage structures, will be paid for as Extra Work according to 00196.

00515.42 Excavation - Coordinate the work and the excavation so the micropile structures are safely constructed. Perform the micropile construction and related excavation in accordance with the Plans and approved submittals. Make no excavations steeper than those specified or shown on the approved working drawing submittals above or below the micropile structure locations without written approval of the Engineer. Additional shoring considerations may need to be made pursuant to Section 00510.

00515.43 Allowable Tolerances - Install micropile to within the following tolerances.

- Centerline of piling not more than 3 inches from indicated plan location.
- Plumb within 2 percent of total-length plan alignment (vertical piles).
- Top elevation of micropile within plus 1.0 inch or minus 2.0 inches maximum from vertical plan elevation.
- Centerline of core reinforcement not more than 0.75 inches from centerline of final pile location.

00515.44 Micropile Installation - Select the drilling method, grouting procedure and grouting pressure used for the installation of the micropiles. Determine the micropile casing size, final drillhole diameter, bond length, and central reinforcement steel sizing necessary to support the specified factored loads and satisfy load testing requirements. Estimate the quantity of grout takes.

(a) Drilling - Provide drilling equipment and methods suitable for drilling through the conditions to be encountered, without causing damage to any overlying or adjacent known structures or services. The drillhole must be open along its full length to at least the design minimum drillhole diameter prior to placing grout and reinforcement.

(Select one of the two following paragraphs when micropile construction occurs near settlement-sensitive structures. Delete both paragraphs if not applicable. Consult with geotechnical designer.)

Do not use vibratory pile-driving hammers to advance micropile casings.

Provide a Vibration Monitoring Plan to the Engineer for approval if vibratory pile-driving hammers will be used to advance micropile casings. Include a preconstruction survey of affected structures and facilities. Describe methods and plans to monitor vibrations caused by pile installation and other construction activities. Demonstrate the use of equipment to detect and prevent damage to affected structures and facilities. Do not begin any construction activity until the Engineer approves this Plan.

Temporary casing or other approved method of micropile drillhole support will be required in caving or unstable ground to permit the micropile shaft to be formed to the minimum design drillhole diameter. The Engineer will review the contractor's proposed method(s) to provide drillhole support and to prevent detrimental ground movements. Detrimental ground movement is defined as movement which requires remedial repair measures. Do not use drilling fluid containing bentonite.

(b) Ground Heave or Subsidence - Observe the conditions in the vicinity of the micropile construction site on a daily basis for signs of ground heave or subsidence during construction. Immediately notify the Engineer if signs of movements are observed. Immediately suspend or modify drilling or grouting operations if ground heave or subsidence is observed, if the micropile structure is adversely affected, or if adjacent structures are damaged from the drilling or grouting. If the Engineer

determines that the movements require corrective action, take corrective actions necessary to stop the movement or perform repairs. When ground heave or subsidence occurs due to the contractor's methods or operations or failure to follow the specified or approved construction sequence, as determined by the Engineer, the contractor will bear the costs of providing corrective actions. When ground heave or subsidence occurs due to differing site conditions, as determined by the Engineer, the costs of providing corrective actions will be paid as Extra Work according to 00196.

(c) Reinforcement Placement – Place reinforcement either prior to grouting or into the grout-filled drillhole before temporary casing (if used) is withdrawn. Ensure that reinforcement surfaces are free of deleterious substances such as soil, mud, grease or oil that might contaminate the grout or coat the reinforcement and impair bond. Provide pile cages and reinforcement groups (if used) sufficiently robust to withstand the installation and grouting process and the withdrawal of the drill casings without damage or disturbance.

Provide centralizers and spacers equally spaced along the length of the micropile with a 10-foot maximum center-to-center spacing. Locate the top and bottom centralizers a maximum of 5.0 feet from the top and bottom of the micropile. Provide at least two centralizers per micropile. For micropiles less than or equal to 20 feet in length, place centralizers at the top and bottom quarter points of the micropile. Ensure that centralizers and spacers permit the free flow of grout without misalignment of the reinforcing bar(s) and permanent casing. Lower the central reinforcement bars with centralizers into the stabilized drillhole and set. Insert the reinforcing steel into the drill hole to the desired depth without difficulty. Do not force or drive partially inserted reinforcing bars into the hole. Redrill and reinsert reinforcing steel when necessary to facilitate insertion.

(d) Grouting - Measure the grout quantity and pumping pressure during the grouting operations. Provide the Engineer with records showing the quantities, test data, and grout pressures.

After drilling, flush the hole with water or air to remove drill cuttings. Use a stable neat cement grout or a sand cement grout with a minimum 28-day unconfined compressive strength as required in the contractor's submitted design, pursuant to 00515.08(a)(1). Ensure that the cement does not contain lumps or other evidence of poor mixing. Mix admixtures, if used, in accordance with manufacturer's recommendations. Use grouting equipment that produces a grout free of lumps and undispersed cement. Equip the pump with a pressure gauge to monitor grout pressures. Place a second pressure gauge at the point of injection. Ensure that the pressure gauges are capable of measuring pressures of at least 150 psi or twice the actual grout pressures used by the contractor, whichever is greater. Size the grouting equipment to enable the grout to be pumped in one continuous operation.

Inject the grout from the lowest point of the drillhole. The grout may be pumped through grout tubes, casing, hollow-stem augers, or drill rods. Control the grout pressures and grout takes to prevent excess grout take, excessive ground heave and fracturing of rock formations. Fill the entire micropile length with grout containing no voids or inclusions. Upon completion of grouting, the grout tube may remain in the hole. Fill grout tube with grout if left in place.

If a postgrouting system is to be used, submit working drawings and details to the Engineer for review in accordance with 00515.08(b).

(c) Grout Testing – Ensure that grout within the micropile verification and proof test piles attains the minimum required compressive strength as identified in the contractor's design submittal pursuant to 00515.08(a)(1) prior to load 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 pre-production verification test piles and initial production piles.

During production, test the micropile grout for compressive strength in accordance with AASHTO T106 (ASTM C109) at a frequency of no less than one set of three 2-inch grout cubes from each grout plant each day of operation or per every 10 micropiles, whichever occurs more frequently. Calculate the average of the 3 cubes tested to determine the compressive strength.

Determine grout consistency, as measured by grout density, per AASHTO T 133 (ASTM C 188) or API RP-13B-1 at a frequency of at least one test per verification or proof test micropile, conducted just prior to start of grouting. For production micropiles, perform grout density testing at a frequency at least once per each period of continuous grouting operation or once per day, whichever is more frequent. The Baroid Mud Balance used in accordance with API RP-13B-1 is an approved device for determining the grout density of neat cement grout. Ensure that the measured grout density is consistent with the contractor's approved working drawing construction submittals.

Take grout samples directly from the grout plant. Provide grout cube compressive strength and grout density test results to the Engineer within 24 hours of testing.

00515.45 Micropile Splices - Secure lengths of casing and reinforcing bars to be spliced in proper alignment and in a manner to avoid eccentricity or angle between the axes of the two lengths to be spliced. Ensure that splices and threaded joints meet the requirements of Section 00515.10(e) and (f). Locate threaded pipe casing joints at least two casing diameters (OD) from a splice in any reinforcing bar. When multiple bars are used, stagger bar splices at least 1.0 foot.

Construct micropile casing and reinforcing bar splices so as to develop the required nominal design strength of the micropile section.

00515.46 Pile Load Tests - Perform verification and proof testing of piles at the locations specified herein or designated by the Engineer.

(Select the pile load test method(s) to be used from the three options listed below. Delete the ones that do not apply.)

- Perform compression load testing in accordance with ASTM D1143 except as modified herein.
- Perform tension load testing in accordance with ASTM D3689 except as modified herein.
- Perform lateral load testing in accordance with ASTM D3966, except as modified herein.

When both compression and tension load testing is to be performed on the same pile, test the pile under compression loads prior to testing under tension loads.

Ensure that the maximum verification and proof test loads applied to the micropile do not exceed 80 percent of the structural capacity of the micropile structural elements, to include steel yield in tension, steel yield or buckling in compression, or grout crushing in compression. Verification test piles may require additional structural capacity to meet this Provide any increase in the structural capacity of verification test piles, above that required for production piles, necessary to meet these project requirements.

(Fill in the blank in the following paragraph and provide the location of all Verification Test Piles. Obtain information from the designer.)

(a) Verification Load Tests - Perform pre-production verification pile load testing on sacrificial micropiles to verify the design of the pile system and the construction methods proposed prior to beginning work on any aspect of production piles. Construct _____ sacrificial verification test piles in conformance with the approved Working Drawings. Install verification test pile(s) at the following locations:

Verification Test Pile	Station	Offset
VT – 1	_____	_____

The Engineer may adjust these locations depending on actual site conditions and other factors. The Engineer will determine the location of additional verification test piles, if needed.

Perform verification load tests to verify that the contractor-installed micropiles will meet the loading requirements in compression and tension, the load test acceptance criteria and to verify that the length of the micropile bond zone is adequate. The micropile verification load test results must verify the contractor's design and installation methods, and be reviewed and accepted by the Engineer prior to beginning installation of production micropiles. Report the verification load test data to the Engineer within 3 days of completing the testing.

Use the drilling-and-grouting method, casing length and outside diameter(s), reinforcing bar lengths, depth of embedment (bond zone) and all other installation materials and methods used for the verification test pile(s) identical to those specified for the production piles at the given locations. Size the verification test micropile structural steel sections to safely resist the maximum test load.

(1) Testing Equipment and Data Recording – Provide dial gauges, dial gauge support, jack and pressure gauges, load cells and a reaction frame for use in testing the micropiles. The load cell is required only for the creep test portion of the verification test.

Provide a description of test setup and jack, pressure gauge and load cell calibration curves in accordance with the Section 00515.08. Design the testing reaction frame to be sufficiently rigid and of adequate dimensions such that excessive deformation of the testing equipment does not occur. Align the jack, bearing plates, and stressing anchorage such that unloading and repositioning of the equipment will not be required during the test.

Apply and measure the test load with a hydraulic jack and pressure gauge. Provide a pressure gauge graduated in 100 psi increments or less. Provide a jack and pressure gauge with a pressure range not exceeding twice the anticipated maximum test pressure. Provide a jack ram travel sufficient to allow the test to be done without resetting the equipment. Position the jack at the

beginning of the test such that unloading and repositioning during the test will not be required. Monitor the creep test load hold during verification tests with both the pressure gauge and the load cell. Use the load cell to accurately maintain a constant load hold during the creep test load hold increment of the verification test.

Measure the pile top movement with a dial gauge capable of measuring to 0.001 inch. Provide a dial gauge having a sufficient travel to allow the test to be done without having to reset the gauge. Visually align the gauge to be parallel with the axis of the micropile and support the gauge independently from the jack, pile or reaction frame. Use a minimum of two dial gauges when the test setup requires reaction against the ground or single reaction piles on each side of the test pile. Record the required load test data and supply the results to the Engineer.

(2) Verification Test Loading Schedule - Test verification piles designated for compression or tension load testing to a maximum test load of 1.5 times the micropile Factored Design Loads provided in 00515.07 or as shown on the Plans.

(Obtain information from designer and fill in the table below).

Incrementally load the micropile in accordance with the following cyclic load schedule for both compression and tension loading:

AL = Alignment Load (≤ 0.04FDL)
FDL = Factored Design Load

Loading Cycle	Increment	Load	Hold Time (min.)
AL	1	AL	2.5
Cycle 1	2	0.075 FDL	4
	3	0.15 FDL	4
	4	0.225 FDL	4
	5	0.30 FDL	4
	6	0.375 FDL	4
Cycle 2	7	AL	1
	8	0.15 FDL	1
	9	0.30 FDL	1
	10	0.375 FDL	1
	11	0.45 FDL	4
	12	0.525 FDL	4
	13	0.60 FDL	4
	14	0.675 FDL	4
	15	0.75 FDL	4
Cycle 3	16	AL	1
	17	0.30 FDL	1
	18	0.60 FDL	1
	19	0.675 FDL	1
	20	0.75 FDL	1
	21	0.825 FDL	4
	22	0.90 FDL	4
	23	0.975 FDL	60* (Creep Test)

Cycle 4	24	AL	1
	25	0.30 FDL	1
	26	0.60 FDL	1
	27	0.90 FDL	1
	28	0.975 FDL	1
	29	1.05 FDL	4
	30	1.125 FDL	4
	31	1.20 FDL	4
	32	1.275 FDL	4
	33	1.35 FDL	4
	34	1.425 FDL	4
	35	1.50 FDL	4
	36	1.20 FDL	4
	37	0.90 FDL	4
	38	0.60 FDL	4
	39	0.30 FDL	4
	40	AL	15

*Measure and record pile movement during the creep test at intervals of 1, 2, 3, 4, 5, 6, 10, 20, 30, 50, and 60 minutes as soon as the test load is applied.

Measure the pile top movement at each load increment. Start the load-hold period as soon as each test load increment is applied. Reset dial gauges to zero after the initial AL is applied.

(3) Verification Test Pile Acceptance Criteria - The acceptance criteria for micropile verification load tests are:

(Obtain information from designer and fill in the blanks. Delete the first bullet if the structural components of the verification test pile haves to be increased to accommodate the maximum required verification test load.)

Delete the first bullet if the structural components of the verification test pile has to be increased to accommodate the maximum required verification test load.)

- The pile sustains the first compression or tension ____ FDL test load with no more than _____inch total vertical movement at the top of the pile, relative to the top of the pile prior to the start of testing.
- At the end of the ____ FDL creep test load increment, test piles have a creep rate not exceeding 0.04 inch/log cycle time (1 to 10 minutes) or 0.08 inch/log cycle time (6 to 60 minutes or the last log cycle if held longer) and the creep rate is linear or decreasing throughout the creep load hold period.
- Failure does not occur at the ____ FDL maximum test load. Failure is defined as the load where the slope of the load versus head deflection curve (at the end of increment) first exceeds 0.025 inch/kip.

The Engineer will provide the contractor written confirmation of the micropile design and construction within 3 working days of the receipt of the contractor's complete Micropile Load Test Data report. This written confirmation will either confirm the capacities evaluated relative to the acceptance criteria and the bond lengths specified in the micropile Working Drawings or reject the piles based upon the verification test results.

(4) Verification Test Pile Rejection - If a verification-tested micropile fails to meet the acceptance criteria, modify the design, the construction procedure, or both. These modifications may include modifying the installation methods, increasing the bond length, or changing the micropile type. The Engineer will review any modification that necessitates changes to the structure. Do not proceed with further micropile testing or construction without the Engineer's approval. Contractor is responsible for costs associated with any modifications of design or construction procedures or cost of additional verification test piles and load testing. At the completion of verification testing, remove test piles down to 2 feet below roadway subgrade or to the elevation specified by the Engineer.

(b) Proof Load Tests - Perform proof load tests on one production pile at each designated substructure unit (footing) unless otherwise directed. The Engineer will determine piles to be tested in each substructure unit. Proof test micropiles are required at the following substructure unit locations:

(Identify the micropile locations selected for testing below. Add rows for each micropile location to be proof tested. Obtain information from the designer.)

Proof Test Pile	**Location**	**Footing**
Bridge No. ___,	Bent __	Right, Center or Left

These locations may be adjusted by the Engineer depending on actual site conditions and other factors. The Engineer will designate the location of additional proof test piles.

Perform proof load tests to verify the production micropiles will meet the loading requirements in compression and tension and the load test acceptance criteria. Report the proof load test data to the Engineer within 1 day of completing the testing on each micropile proof load tested.

(1) Proof Test Loading Schedule - Test piles designated for compression or tension proof load testing to a maximum test load of 1.0 times the micropile Factored Design Load(s) provided in 00515.07 or as shown on the Plans. Provide testing equipment and data recording devices in accordance with 00515.46(a)(1). Incrementally load the proof test micropiles in accordance with the following schedule, to be used for both compression and tension loading:

AL = Alignment Load (≤ 0.04FDL)
FDL = Factored Design Load

Cycle	Increment	Applied Load	Hold Time (min.)
Apply AL	1	AL	2.5
Load Cycle	2	0.10 FDL	4
	3	0.20 FDL	4
	4	0.30 FDL	4
	5	0.40 FDL	4
	6	0.50 FDL	4
	7	0.60 FDL	4
	8	0.70 FDL	4
	9	0.80 FDL	4
	10	0.90 FDL	4
	11	1.00 FDL	10 or 60 minutes*

Unload Cycle	12	0.90 FDL	4
	13	0.75 FDL	4
	14	0.60 FDL	4
	15	0.45 FDL	4

* Where the pile top movement between 1 and 10 minutes exceeds 0.04 inch, maintain the 1.0 FDL increment an additional 50 minutes and measure and record pile movements at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. Reset dial gauges to zero after the initial AL is applied.

(2) Proof Test Pile Acceptance Criteria - The acceptance criteria for micropile proof load tests are:

(Obtain information from the designer and fill in the blanks.)

- The pile sustains the compression or tension ____ FDL with no more than _____ inch total vertical movement at the top of the pile, relative to the top of the pile prior to the start of testing.
- At the end of the ____ FDL creep test load increment, test piles have a creep rate not exceeding 0.04 inch/log cycle time (1 to 10 minutes) or 0.08 inch/log cycle time (6 to 60 minutes) and the creep rate is linear or decreasing throughout the creep load hold period.
- Failure does not occur at the ____ FDL maximum test load. Failure is defined as the load where the slope of the load versus head deflection curve first exceeds 0.025 inch/kip.

The Engineer will provide the contractor written confirmation of the micropile design and construction within 1 working day of the receipt of the contractor's complete Micropile Load Test Data report. This written confirmation will either confirm the capacities evaluated relative to the acceptance criteria or reject the piles based upon the proof test results.

(3) Proof Test Pile Rejection - If a proof-tested micropile fails to meet the acceptance criteria, immediately proof test another micropile within that footing or substructure unit as directed by the Engineer. For failed piles and further construction of other piles, modify the design, the construction procedure, or both. These modifications may include installing replacement micropiles, incorporating remaining untested piles at reduced load capacities (not more than 50% of the maximum load attained), postgrouting, modifying installation methods, increasing the bond length, or changing the micropile type. The Engineer will review any modification that necessitates changes to the structure design. Do not proceed with further micropile testing or construction without the Engineer's approval..

Contractor is responsible for all costs associated with any modifications of design or construction procedures, additional verification test piles and verification or proof load testing, or replacement production micropiles. No extension of contract time will be granted as a result of failed verification or proof load tests.

00515.47 Installation Records - Prepare and submit to the Engineer full-length Micropile Installation Logs for each micropile installed within 24 hours of micropile installation. A copy of the Micropile Installation Log is attached at the end of this section. Include the following information as a minimum:

- Micropile drilling duration
- Final tip elevation
- Cutoff elevations for the top and bottom of the casing
- Rated load capacities
- Description of unusual installation behavior or conditions
- Grout pressures attained during grouting
- Grout quantities pumped into micropiles
- Micropile material and dimensional properties

00515.48 Micropile Load Test Data Reports - Report the micropile load test data to the Engineer in the form of a summary report which includes, at a minimum, all of the following items:

- Project description.
- Description of site and subsurface conditions including information on the subsurface conditions encountered at the load test location.
- A listing of key personnel involved with the testing and production of the micropile including the grout plant operator, drill rig operator, on-site supervisor and micropile design engineer.
- Micropile Installation Log pursuant to Section 00515.47.
- Results of the load test, including completed testing field data records for load increments and time periods stipulated in Sections 00515.46(a)(2) and 00515.46(b)(1) and appropriate presentation figures, charts and graphs. Record the required load test data and submit to the Engineer for verification.
- Statement of load testing requirements and acceptance criteria pursuant to Sections 00515.46(a)(3) and (a)(4) and 00515.46(b)(2) and (b)(3).
- Comparison of load testing results and acceptance criteria.
- Summary statement of load test results, including whether the load test met the criteria or failed to meet it.
- Hydraulic jack pressure gauge and load cell calibration report.
- Material certifications for permanent casing (if used), reinforcement and grout compressive strength testing.

Submit the Micropile Load Test Data Report as a Stamped Working Drawing according to Section 00515.06(a). Time frames for submitting and the review of these reports are addressed in Sections 00515.46(a), 00515.46(a)(3), 00515.46(b) and 00515.46(b)(2).

Measurement

00515.80 Measurement – The quantities of work performed under this Section will be measured according to the following:

(a) Furnish Micropile Equipment – No measurement of quantities will be made for furnishing micropile equipment

(b) Micropiles – Micropiles will be measured on the unit basis for each production micropile installed and accepted.

(c) Micropile Verification Load test – Micropile verification load tests will be measured on the unit basis for each for verification load test pile constructed, tested and accepted.

(d) Micropile Proof Load Test - Micropile proof load testing will be measured on

the unit basis for each proof load test completed, reported and accepted.

Payment

00515.90 Payment – The accepted quantities of work performed will be paid for at the Contract unit price, per unit of measurement for the following items:

Pay Item	Unit of Measurement
(a) Furnish Micropile Equipment	Lump Sum
(b) Micropiles	Each
(c) Micropile Verification Load Test	Each
(d) Micropile Proof Load Test	Each

Partial payments for Item (a) will be made as follows:

- When drilling equipment is on the job, assembled and verification load test drilling is underway…… 75%

- When the installation of the micropiles is complete, accepted and the drilling equipment has been removed from the site ……..……. 25%

Item (b) includes drilling, furnishing and placing all reinforcing steel and casing, grouting, and all micropile top attachments.,.

Item (c) includes payment for furnishing all materials, equipment and labor required to construct verification load test piles, conduct the load test and report the results as specified. .

Item (d) includes payment for furnishing all materials, equipment and labor required to conduct the proof load test and report the results as specified. .

Payment will be payment in full for furnishing and placing all materials, furnishing, erecting, maintaining, and replacing all equipment, and for all labor and incidentals necessary to complete the work as specified.
No separate or additional payment will be made for:

- Excess grout takes
- Verification or Proof test micropiles that failed acceptance criteria

MICROPILE INSTALLATION LOG

Project: **Contract No.**

Bridge No. _____ Bent No./Footing: _____

Pile Designation: _____ Installation Date: _____

Drill Operator: _____ Inspector: _____

Drilling Rig/Drill Method: _____

Grout Plant/Operator: _____

	Date	Time	Casing Dia./Wall Thickness	
Start of Drilling :			Pile Inclination	
End of Drilling :			Reinforcement Size/Length	
Start of Grouting :			Cement Type	
End of Grouting :			Admixtures	
Pile Completion :			w/c ratio	

Installation Quantities

Upper Cased Length		feet	Tremie Grout Quantity		bags
Cased & Bond Length (Plunge)		feet	Pressure Grout Quantity		bags
Bond Length below Casing		feet	Post Grout Quantity (if used)		bags
Total Pile Length		feet	Total Grout Quantity		bags

Comments - Drilling

Depth from BOF (ft.)	Soil/Rock Description	Flush Description	Comments

Comments - Pile Grouting

Depth from BOF (ft.)	Pressure Range Max/Ave (psi)	Comments

BOF = Bottom of Footing, Elevation: _____ ft.