

SECTION 00515 - MICROPILES

(Follow all instructions and make all edits with "Track Changes" turned on. This Section is not published in the Oregon Standard. If there are no instructions [purple text] above a subsection, paragraph, sentence, or bullet, then include it in the Project, unless the item(s) that are included in the subsection, paragraph, sentence, or bullet are not required on the Project and then they should be deleted. In general do not re-number or re-letter subsections when item(s) are deleted. Delete all purple text before preparing the final document. All other modifications to this Section will require ODOT Technical Resource and State Specifications Engineer approval.)

Section 00515 is not a Standard Specification and 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.

00515.01 Definitions:

Alignment Load (AL) - A minimum initial 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.

Casing - Steel pipe Casing, generally installed during the drilling process to stabilize the borehole when drilling through Overburden Soils. The Casing may be either temporary and withdrawn during the grouting process, or permanently left in place to provide added Micropile reinforcement.

Centralizer - A device to support and position the steel reinforcement in the center of the drillhole or Casing.

Coupler - A mechanical Coupler or other approved device that transfers load from one partial length of steel reinforcement to another.

Creep - 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 steel reinforcement against corrosion.

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

Micropile - A small-diameter, bored, cast-in-place composite pile, with the applied load 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.

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

Spacer - A device to separate individual elements of 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.

00515.02 General - Furnish Materials and provide all design, Equipment, tools, services, labor and supervision required for installing and testing Micropiles and Micropile top attachments for this Project.

Select the Micropile type, dimensions, Bond Length, pile-top attachment(s), and installation method to meet the requirements of the Specifications. Conduct verification and Proof Load Testing that demonstrates the test piles meet or exceed the specified test acceptance criteria.

(Consult with the Geotechnical Designer and modify the following section as needed to describe what subsurface information is available and how to access it. Also add descriptions of special or unusual subsurface conditions that should be noted.)

00515.03 Subsurface Investigation - The Soils and Geological Exploration Logs are available for review through the Engineer's office. The data shown for each test boring or test pit applies only to that particular boring or test pit. Subsurface conditions may vary between borings or test pits. Core samples and laboratory test results, if obtained and performed for the Project, are available for review by contacting the Engineer.

The Foundation Data shown in the Plans is a compilation of pertinent information including, but not limited to, the Soils and Geological Exploration Logs.

00515.04 Micropile Design Requirements - Design Micropiles to meet the loading conditions provided in Table 00515-1. Design Micropiles and pile top-to-footing connections using the procedures described in the most current version of the AASHTO *LRFD Bridge Design Specifications* at the time of Advertisement.

(Obtain information from designer and fill in Table 00515-1. Add rows or modify as necessary for all micropile locations included in the Project.)

TABLE 00515-1

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

* Loads are axial compression loads per Micropile unless otherwise noted.

Verification test piles may require additional structural capacity above that required for production piles. Size the structural steel and grouted sections of the Micropiles to 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.

(Use the following paragraph when moment design applies to the Project. Fill in the required nominal (ultimate) moment capacity below. 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.)

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 permanent steel casings from the designer and fill in the blank.)

Provide corrosion protection of the internal steel reinforcement according to 00515.10. Where permanent Casing is used for a portion of the Micropile, extend the double corrosion system at least 5 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 Casing used in Micropile construction.

(Use the following sentence if double-corrosion protection is required on the Project.)

Provide Double Corrosion Protection of all steel reinforcement that is not contained within permanent Casing.

00515.05 Submittals - Before beginning construction of Micropiles, submit the following to the Engineer:

(a) Qualifications - Submit contractor and personnel qualifications according to 00515.30.

(b) Stamped Working Drawings - Submit stamped Working Drawings according to 00150.35 that include all stamped design calculations, 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. Provide stamped Working Drawings that include, but are not limited to, the following information:

(1) Stamped Design Calculations and Documentation - Provide design calculations and documentation that includes:

- A written summary report that describes the overall Micropile design, including the type and diameter of Micropiles selected, and if applicable, a discussion of the use of any temporary Casing.
- Applicable code requirements and design references.
- Dimensions of all Micropile structural components, structural design properties, and critical design Cross Sections.
- Geotechnical design parameters and criteria, including Soil and Rock shear strengths (friction angle and cohesion), material unit weights, ground-grout bond values, and group effects if applicable.
- Factored Design Loads, including maximum verification test 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 design calculations and construction details.
- Design calculations for design of the Micropiles, including but not limited to analysis performed to determine drillhole diameters, estimated Bond Lengths, total Micropile lengths, design of corrosion protection, type and size of steel reinforcement, and if applicable, permanent Casing.
- 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 Drawing - Provide a plan view drawing that shows:

- 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 Drawing - Provide an elevation view drawing that shows:

- Micropile locations and elevations
- Micropile 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
- Corrosion protection details
- Micropile Structure connection details to Substructure footing
- Micropile Design Loads
- Summary of estimated quantities for each Substructure unit
- If applicable, location of drainage elements

(4) Steel Shop Drawings - Provide steel shop drawings for all structural steel including the details, dimensions, and schedules for all Micropile Casing and steel reinforcement, including steel reinforcement bending details and steel for Substructure and footing connection.

(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, Equipment setup, and types and accuracy of apparatus to be used for applying and measuring the test loads and pile top movements according to 00515.47. Submit Micropile Load Test Data Reports according to 00515.48.

Revise the drawings when Plan dimensions are changed due to field conditions or for other reasons. Within 30 Calendar Days after completion of the work, submit corrected stamped Working Drawings and calculations to the Engineer according to 00150.35. Provide corrected Working Drawings that represent all design changes made during the construction of the Micropile Structure.

(c) Micropile Installation Plan - At least 21 Calendar Days before beginning Micropile Work, submit a Micropile Installation Plan to the Engineer for review and approval. Provide a Micropile Installation Plan that includes, but is not limited to, the following information:

- (1)** Detailed step by step description of the proposed Micropile construction procedure, construction sequencing (including but not limited to drilling, grouting and testing procedures), anticipated ground conditions, and any special construction requirements to assure quality control. Include sufficient detail to allow the Engineer to monitor the construction and quality of the Micropiles.

(2) A list of 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 show 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 are 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.

(7) Certified mill test reports for the steel reinforcement 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, including 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 post grouting methods, if applicable.
- Estimated grout quantities.
- 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 to be displaced, if applicable.
- 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 according to 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.

The Engineer will approve or reject the Micropile Installation Plan within 21 Calendar Days after receipt of the plan. Do not begin Work until all submittals have been received, reviewed, and accepted in writing by the Engineer.

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.

Materials

00515.10 Materials - Furnish Materials meeting the following requirements:

(a) **Admixtures** - Furnish admixtures according to Section 02040. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout, if approved by the Engineer. Only add expansive admixtures to grout used for filling sealed Encapsulations and anchorage covers. Accelerators will not be permitted. Use admixtures compatible with the grout and mixed in accordance with the manufacturer's recommendations.

(b) **Cement** - Furnish Portland cement (Type I, II or III) according to Section 02010.

(c) **Grout** - Furnish neat cement or Sand/cement grout mixture with a minimum compressive strength at 28 Days as specified in the contractor's design submittal and according to 02690.30.

(d) **Water** - Use water in the grout mix according to Section 02020.

(e) **Reinforcement:**

(1) Furnish deformed bar reinforcement according to Sections 00530 and 02510, or furnish all thread, high tensile strength bars according to 02515.30. 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, furnish threading that is either continuous spiral deformed ribbing provided by the bar deformations or threading cut into the bar. If threads are cut into a reinforcing bar, furnish a bar that is one bar size number larger than the bar size designation shown, at no additional cost to the Agency.

(2) Furnish continuous thread, hollow core steel bars (hollow injection rods) according to the quality, ductility and deformation requirements of AASHTO M 31 (ASTM A615).

(3) If required, furnish mechanical splices according to 2510.20.

(f) **Permanent Casing** - Furnish permanent steel Casing with:

- A diameter and minimum wall thickness as shown on the approved Working Drawings.
- Tensile strength meeting the tensile requirements of API 5L Grade X52, API 5 CT Grade N80 or better, using the minimum yield strength in the design submittal.

(g) Plates and Shapes - Furnish structural steel plates and shapes for Micropile top attachments meeting the requirements of ASTM A36 or ASTM A572 Grade 50 and Section 02530 and as required to meet the design loads specified in 00515.04 and 00515.05(b).

(h) Centralizers - Fabricate Centralizers from plastic, steel, or Material that is not detrimental to the steel reinforcement. Wood Centralizers are not allowed.

(i) Corrosion Protection - Provide corrosion protection of the steel bar reinforcement by using one or more of the following methods:

(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 meeting the requirements of AASHTO M 252 (ASTM D3350) or corrugated polyvinyl chloride pipe meeting the requirements of ASTM D1784 (Class 13464-B) with a minimum wall thickness of 0.03 inches. Provide an annulus opening between the reinforcing bars and the encapsulating tube of at least 0.25 inches and use a grout according to 00515.10(c).
- **Epoxy Coating:** Apply epoxy coating according to 02510.11. Bend test requirements are waived. Epoxy coating of bearing plates and nuts encased in pile concrete footings is not required. Furnish mechanical Couplers for splicing epoxy coated reinforcing bars that are either epoxy coated with the same thickness as the reinforcing bars or, for bare-steel Couplers, coated with heat-shrink wrap from section 02510.11 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 reinforcing bars, provide a minimum 3 inches of grout cover surrounding the reinforcing bar. For epoxy or galvanized reinforcing bars, provide a minimum of 2 inches of grout cover.

Labor

00515.30 Personnel Qualifications - Use personnel experienced in Micropile construction to perform the work. Relevant experience includes that with similar anticipated subsurface Materials, groundwater conditions, Micropile type, size, loads and any special construction techniques required.

Provide the following information to verify the contractor'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 size and capacity to those required in these plans and specifications. Evidence of

contractor experience in Micropile drilling and grouting in Soil or Rock Materials and conditions similar to project conditions. Provide a project reference list for each of the 5 projects that 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.

(b) Micropile On-Site Supervisor - Names and detailed experience of on-site supervisors for the Project. Provide on-site supervisors that have experience on at least 3 projects over the past 5 years installing Micropiles of similar type, size and scope to those shown in the Working Drawings and in similar geotechnical conditions to those described in the project geotechnical report for this project. List experience that includes the direct supervisory responsibility for the on-site Micropile construction operations and load testing.

(c) Micropile Drill Rig Operator - Names and detailed experience of drill operators for the Project. Provide drill rig operators that have experience on at least 3 projects over the past 5 years installing the type(s) of Micropiles required for this project and to capacities equal to, or greater than, those required in the Specifications.

(d) Micropile Registered Professional Engineer of Record - Name(s) and detailed experience of the Micropile engineer. Provide Micropile engineers that are 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, and experience designing Micropiles of similar or greater capacity to those required in the Plans and Specifications.

(e) Welder Qualifications - Submit qualification documents for each welder. Use welders qualified according to AWS D1.1 for the position, process and Casing diameter used on the Project.

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.

Submit qualifications of the contractor's Micropile engineer at least 21 Calendar Days before submittal of the stamped Working Drawings. The Engineer will approve or reject the contractor's qualifications within 7 Calendar Days after receipt of a complete submittal.

Do not begin Work or order Materials before the Engineer provides written approval of the Contractor's experience qualifications.

The Engineer may suspend the Micropile construction Work if the Contractor substitutes unapproved personnel during construction. Submit requests for substitution of field personnel to the Engineer, who will have an additional 7 Calendar Days to respond to each request.

Construction

00515.40 General - Contain and dispose of all construction related waste according to 00290.20.

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 no more than 1.0 inch above or 2.0 inches below the 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. Schedule all Micropile installations such that there is no interconnection with or damage to previously installed piles.

(a) Drilling - Provide drilling Equipment and methods suitable for drilling through the conditions to be encountered without causing damage to any overlying or adjacent Structures or services. Open the drillhole to the required nominal diameter along its full length prior to placing grout and reinforcement.

(Use only one of the following two options when micropile construction occurs near settlement-sensitive Structures. Delete both options if neither is applicable. Consult with geotechnical designer.)

[Option 1 - Use the following paragraph when vibratory pile-driving hammers will NOT be allowed.]

Do not use vibratory pile-driving hammers to advance Micropile Casings.

[Option 2 - Use the following paragraph when vibratory pile-driving hammers are allowed.]

If vibratory pile-driving hammers are used to advance Micropile Casings, submit a Vibration Monitoring Plan to the Engineer for approval prior to beginning any construction activity. Allow 14 Calendar Days for plan review. Include in the Vibration Monitoring Plan a preconstruction survey of affected Structures and facilities and describe methods and plans to monitor vibrations caused by pile installation Equipment and other construction activities. Demonstrate the use of monitoring Equipment and devices to detect and prevent damage to affected Structures and facilities. Do not begin any construction activity until the Engineer approves the Vibration Monitoring Plan.

Use temporary Casing or other approved method of Micropile drillhole support, in caving or unstable ground to permit the Micropile shaft to be formed to the minimum design drillhole diameter. Do not use drilling fluid containing bentonite. Stabilize and repair detrimental ground movements caused by caving or other unstable drillhole conditions, as determined by the Engineer.

(b) Ground Heave or Settlement - Observe the conditions in the vicinity of the Micropile construction site on a daily basis for signs of ground heave, settlement or other signs of

ground displacement during construction. Immediately notify the Engineer if signs of movements are observed. Immediately suspend or modify drilling or grouting operations if ground heave or settlement 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.

(c) Reinforcement Placement - Place reinforcement according to the approved Micropile installation plan. 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 the bond. If applicable, provide pile cages and reinforcement groups with sufficient strength 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 maximum center-to-center spacing of 10 feet. 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 bars and permanent Casing. Lower the central reinforcing bars with Centralizers into the stabilized drillhole and set to the design elevation and alignment tolerances. Do not force or drive partially inserted reinforcing bars into the hole. Redrill and reinsert steel reinforcement 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 and other loose debris. 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. 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. Constantly agitate the grout prior to pumping. Place grout within one hour after mixing the grout or, if admixtures are used, within the time recommended by the manufacturer. Discard grout not placed within the allowed time limit.

Inject the grout from the lowest point of the drillhole by tremie methods until clean, pure grout flows from the top of the Micropile. 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. Subsequent to tremie grouting, ensure complete continuity of the grout column in all grouting operations. The use of compressed air to directly pressurize the fluid grout is not permissible. If required, apply Post-Grouting of Micropiles according to the approved Working Drawings and record grout pressures, quantities, mix design, and other relevant Post-Grouting

information. Upon completion of grouting, the grout tube may remain in the hole. Fill grout tube with grout if left in place.

(e) Grout Testing - Ensure that grout within the verification and proof test Micropiles attains the minimum required compressive strength, as identified in the Contractor's design submittal, 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 proof test piles.

During production, test the Micropile grout for compressive strength according to AASHTO T 106 (ASTM C109) for grout cubes or AASHTO T 22 (ASTM C39) for cylinders at a frequency of no less than three samples from each grout plant each Day of operation or three samples from each grout plant per every 10 Micropiles, whichever occurs more frequently. Calculate the average of the three samples tested to determine the compressive strength.

Determine grout consistency, as measured by grout density according to AASHTO T 121 (ASTM C138) 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 of at least once per each period of continuous grouting operation or once per Day, whichever is more frequent. Ensure that the measured grout density is consistent with the approved Micropile Installation Plan.

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 - Furnish steel rebar and permanent Casing splices that develop at least the required compressive, tensile, and bending strengths used in the design of the Micropile. Provide mechanical bar splices meeting the requirements of 00515.10(e). 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. Locate Casing joints at least two Casing outside diameters away from any bar splice, as measured along the vertical axis of the Micropile. When multiple reinforcing bars are used, stagger bar splices at least 3.0 feet.

Furnish threaded Casing joints that develop at least the required compressive, tensile, and bending strength used in the design of the Micropile. If welding of permanent high strength steel Casing is required, submit a Welding Procedure Specification (WPS) meeting the requirements of AWS D1.1 for review and written approval by the Engineer, prior to any welding operation. Weld all permanent Casing seams and splices using complete penetration welds.

00515.46 Pile Cap Connection - Furnish and install all Materials required to connect Micropiles to pile caps in accordance with the accepted stamped Working Drawings.

00515.47 Pile Load Tests - Perform verification and proof testing of piles at the locations shown, specified, or as directed. Confirm the grout has achieved the minimum required grout compressive strength prior to verification and Proof Load Testing.

(Use the following paragraph when compression load testing is required.)

Perform compression load testing meeting the requirements of ASTM D1143, except as modified by this subsection.

(Use the following paragraph when tension load testing is required.)

Perform tension load testing meeting the requirements of ASTM D3689, except as modified by this subsection.

(Use the following paragraph when lateral load testing is required.)

Perform lateral load testing meeting the requirements of ASTM D3966, except as modified by this subsection.

(Use the following paragraph when compression and tension load testing is required.)

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.

(Fill in the blank in the following paragraph with the number of required sacrificial 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 according to the approved Working Drawings. Install verification test pile(s) at the following locations:

(Provide the location(s) of verification test piles in by filling in the blank. Copy and paste the location line to as required to list all of the locations. Renumber "VT - 1" as necessary. Obtain information from the designer.)

Verification Test Pile	Station	Offset
VT - 1	_____	_____

Verification test pile locations may be adjusted by the Engineer depending on actual site conditions and other factors. If additional verification test piles are needed, the location will be determined by the Engineer.

Perform Verification Load Tests to verify that the Contractor-installed Micropiles will meet the loading requirements in compression and tension and the load test acceptance criteria, and to verify that the length of the Micropile bond zone is adequate. Demonstrate to the Engineer that the Micropile Verification Load Test results verify the Contractor's design and installation methods. The Engineer reviews and accepts the Contractor's design and installation methods prior to beginning production installation. For each verification test provide the Micropile Load Test Data Report to the Engineer within 5 Calendar Days of completing the testing.

For verification test piles, use the drilling and grouting methods, Casing and reinforcement details, depth of embedment (bond zone), and all other installation Materials and methods specified for the production piles, unless otherwise approved by the Engineer. At the completion of verification testing, remove test piles down to 2 feet below Roadway Subgrade or as directed.

(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 according to 00515.05. Design the testing reaction frame to be sufficiently rigid and of adequate dimensions to prevent excessive deformation of the testing Equipment. 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 completed 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 completed 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 Factored Design Loads provided in 00515.04 or as shown. 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.

(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 as indicated in Table 00515-2:

AL = Alignment Load ($\leq 0.04\text{FDL}$)
FDL = Factored Design Load

TABLE 00515-2

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.

(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 have 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 pile Creep rate does not exceed 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.

Submit a Micropile Load Test Data Report, according to 00515.48. The Engineer will respond within 5 Calendar Days after receipt of the report with either acceptance or rejection of the tested Micropile.

(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. Submit to the Engineer any modifications that necessitate changes to the Structure. Do not proceed with further Micropile testing or construction without approval from 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 the pile 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

Proof Load Test locations may be adjusted by the Engineer. 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. For each proof test, provide the Micropile Load Test Data Report to the Engineer within 5 Calendar Days of completing the testing.

(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 00515.04 or as shown. Provide testing Equipment and data recording devices in accordance with 00515.47(a)(1). Incrementally load the proof test

Micropiles according to Table 00515-3, to be used for both compression and tension loading:

AL = Alignment Load ($\leq 0.04\text{FDL}$)

FDL = Factored Design Load

TABLE 00515-3

Loading 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.

Submit a Micropile Load Test Data Report, according to 00515.48. The Engineer will respond within 5 Calendar Days after receipt of the report with either acceptance or rejection of the tested Micropile.

(3) Proof Test Pile Rejection - If a proof-tested Micropile fails to meet the acceptance criteria, proof test additional Micropiles within that footing or Substructure unit as directed by the Engineer. For failed piles and construction of replacement piles, modify the design, the construction procedure, or both. Modifications may include installing replacement Micropiles, incorporating remaining untested piles at reduced load capacities, post grouting, modifying installation methods, increasing the Bond Length, or changing the Micropile type. Submit to the Engineer any modifications that necessitate changes to the Structure design. Do not proceed with further Micropile testing or construction without the Engineer's approval.

00515.48 Micropile Load Test Data Reports - Report the Micropile verification and Proof Load Test data to the Engineer in the form of a summary report that includes, at a minimum, the following information:

- 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 engineer.
- Results of the load test, including completed testing field data records for load increments and time periods in 00515.47(a)(2) and 00515.47(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 according to 00515.47(a)(3), 00515.47(a)(4), 00515.47(b)(2), and 00515.47(b)(3).
- Comparison of load testing results and acceptance criteria.
- Summary statement of load test results, including whether the load test met or failed to meet the criteria.
- Hydraulic jack pressure gauge and load cell calibration report.
- Material certifications or check sample results 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 00515.05(b)(5).

00515.49 Micropile Installation Log - Prepare and submit a Micropile Installation Log to the Engineer for each Micropile installed, within 24 hours of Micropile installation. A copy of the Micropile Installation Log is available from the ODOT Construction Forms website at:

<https://www.oregon.gov/ODOT/Construction/Pages/Forms.aspx>

At a minimum, include the following information:

- Micropile drilling duration
- Description of Soil and Rock encountered
- Final tip elevation
- Cutoff elevations for the top and bottom of the Casing
- Nominal Resistance
- Description of unusual installation behavior or conditions
- Grout pressures attained during grouting
- Grout quantities pumped into Micropiles
- Micropile Materials and dimensions

Measurement

(Use subsections (a) through (d) as instructed. Re-alphabetize subsections to be sequential, beginning with (a).)

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

(Use the following subsection (a) when Pay Item (a) is included in the Pay Item list below.)

(a) Provide Micropile Equipment - No measurement of quantities will be made for providing Micropile Equipment.

(Use the following subsection (b) when Pay Item (b) is included in the Pay Item list below.)

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

(Use the following subsection (c) when Pay Item (c) is included in the Pay Item list below.)

(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. Micropile Verification Load Tests performed at the option of the Contractor will not be measured.

(Use the following subsection (d) when Pay Item (d) is included in the Pay Item list below.)

(d) Micropile Proof Load Test - Micropile Proof Load Tests will be measured on the unit basis for each Proof Load Test completed, reported, and accepted. Micropile Proof Load Tests performed at the option of the Contractor will not be measured.

Payment

(Delete the "(s)" or parentheses from the word "item(s)" as appropriate.)

00515.90 Payment - The accepted quantities of Work performed under this Section will be paid for at the Contract unit price, per unit of measurement, for the following item(s):

(Delete Pay Item(s) from the list that are not included in the Schedule of Items, but do not change the alpha characters next to the Pay Items.)

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

(Use the following paragraph and bullets when item (a) is included in the Pay Item list above.)

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%

(Use the following paragraph when item (b) is included in the Pay Item list above.)

Item (b) includes designing, drilling, furnishing, and placing all steel reinforcement and Casing, grouting, and all Micropile top attachments. No payment will be made for Micropiles that fail Micropile Proof Load Tests.

(Use the following paragraph when item (c) is included in the Pay Item list above.)

Item (c) includes payment for furnishing all Materials, providing all Equipment, and labor required to construct sacrificial Verification Load Test piles, conduct the load test, and report the results as specified. No payment will be made for failed Micropile Verification Load Tests.

(Use the following paragraph when item (d) is included in the Pay Item list above.)

Item (d) includes payment for furnishing all Materials, providing all Equipment, and labor required to conduct Proof Load Tests, and report the results as specified. No payment will be made for failed Micropile Proof Load Tests.

Payment will be payment in full for furnishing and placing all Materials, providing, erecting, maintaining, and replacing all Equipment, and for all labor and Incidentals necessary to complete the Work as specified.