

1 (BSP August 6, 2012)

2 **Micropiles**

3 **General Requirements**

4 The Contractor is responsible for the design, installation and testing of micropiles  
5 and micropile top attachments for this project. The Contractor shall select the  
6 micropile type, size, micropile top attachment, installation means and methods,  
7 shall estimate the ground-to-grout bond value, and shall determine the required  
8 grout bond length and final micropile diameter. The Contractor shall design and  
9 install micropiles that will develop the load capacities specified in the Plans. The  
10 micropile load capacities shall be verified by verification and proof load testing, and  
11 shall meet the test acceptance criteria specified in this Special Provision.

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13 **Contractor's Experience Requirements And Submittal**

14 The micropile Contractor shall be experienced in the construction and load testing  
15 of micropiles and have successfully constructed at least three projects in the last  
16 five years involving construction totaling at least 50 micropiles of equal or greater  
17 capacity than required for this project. The Contractor shall submit construction  
18 details, structural details and load test results for at least three previous successful  
19 micropile load tests from different projects of similar scope to this project.

20  
21 The micropile Contractor shall design the micropile system. The micropile system  
22 shall be designed by a Professional Engineer, licensed under Title 18 RCW State  
23 of Washington, with experience in the design and construction of at least three  
24 successfully completed micropile projects over the past five years, with micropiles  
25 of equal or greater capacity than required in these plans and specifications. The on-  
26 site foremen and drill rig operators shall also have experience on at least three  
27 projects over the past five years installing micropiles of equal or greater capacity  
28 than required for this project.

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30 The Contractor shall submit a Type 2 Working Drawing consisting of the completed  
31 project reference list, including a brief project description with the owner's name  
32 and current phone numbers. This Working Drawing submittal shall also include a  
33 personnel list for the micropile system designer, supervising project Engineer, drill  
34 rig operators and on-site foremen to be assigned to the project. The personnel list  
35 shall contain a summary of each individual's experience and be complete enough  
36 for the Engineer to determine whether each individual satisfies the required  
37 qualifications.

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39 **Definitions**

40 Alignment Load (AL): A minimum initial load (5 percent FDL) applied to micropile  
41 during testing to keep the testing equipment correctly positioned.

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43 Factored Design Load (FDL): The factored design load expected to be applied to  
44 the micropile. The factored design load (FDL) is as specified in the bridge Plans.

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46 Maximum Test Load: The maximum load to which the micropile is subjected during  
47 testing. The load shall be 1.5 x FDL for verification load tests and 1.0 x FDL for  
48 proof load tests.

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50 Proof Load Test: Incremental loading of a production micropile, recording the total  
51 movement at each increment.  
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Verification Load Test. Non-production micropile load test performed to verify the design of the micropile system and the construction methods proposed, prior to installation of production micropiles.

**Micropile Design Requirements**

The micropiles shall be designed to meet the specified loading conditions, as shown in the Plans. The Contractor shall design the micropiles, and the micropile top to footing connections using the Load and Resistance Factor Design (LRFD) method.

Steel pipe used for micropile permanent casing shall incorporate an additional 1/16 inch thickness of sacrificial steel for corrosion protection. Where required as shown in the Plans, corrosion protection of the internal steel reinforcing bars, consisting of encapsulation (double corrosion protection), epoxy coating, or grout, shall be provided in accordance with Section 6-05.2 as supplemented in these Special Provisions. Where permanent casing is used for a portion of the micropile, encapsulation shall extend at least five feet into the casing.

**Micropile Design Submittals**

The Contractor shall submit Type 3E Working Drawings consisting of complete design calculations and working drawings with all details, dimensions, quantities, ground profiles, and cross-sections necessary to construct the micropile structure. The Contractor shall verify the limits of the micropile structure and ground survey data before preparing the detailed working drawings.

**Design Calculations**

Design calculations shall include the following items:

1. A written summary report which describes the overall micropile design and its compatibility with the anticipated subsurface conditions as described by the contract test hole boring logs, the Summary of Geotechnical Conditions provided in the Appendix to the Special Provisions, and the geotechnical report(s) prepared for this project.
2. Applicable code requirements and design references.
3. Micropile structure critical design cross-section(s) geometry including soil strata and piezometric levels and location, magnitude and direction of design applied loadings, including slope or external surcharge loads.
4. Design criteria including, soil shear strengths (friction angle and cohesion), unit weights, and ground-to-grout bond values and micropile drillhole diameter assumptions for each soil strata.
5. Load and resistance factors (for Load and Resistance Factor Design) used in the design of the ground-to-grout bond values, the ground-to-grout bond length, surcharges, soil/rock and material unit weights, steel, grout, and concrete materials.

The bond zone for micropiles shall be below the following elevations:

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6. Design calculation sheets with the project number, micropile structure location, designation, date of preparation, initials of designer and checker, and page number at the top of each page. An index page shall be included with the design calculations.
7. Design notes including an explanation of any symbols and computer programs used in the design.
8. Other design calculations as required.

### **Working Drawings**

The Contractor shall submit Type 3E Working Drawings

The working drawings shall include all information required for the construction and quality control of the piling. Working drawings shall include the following items:

1. A plan view of the micropile structure identifying:
  - a. A reference baseline and elevation datum.
  - b. The offset from the construction centerline or baseline to the face of the micropile structure at all changes in horizontal alignment.
  - c. Beginning and end of micropile structure stations.
  - d. Right-of-way and permanent or temporary construction easement limits, location of all known active and abandoned existing utilities, adjacent structures or other potential interference. The centerline of any drainage structure or drainage pipe behind, passing through, or passing under the micropile structure.
  - e. Subsurface exploration locations shown on a plan view of the proposed micropile structure alignment with appropriate reference base lines to fix the locations of the explorations relative to the micropile structure.
2. An elevation view of the micropile structure(s) identifying:
  - a. Elevation view showing micropile locations and elevations; vertical and horizontal spacing; batter and alignment and the location of drainage elements (if applicable).
  - b. Existing and finish grade profiles both behind and in front of the micropile structure.
3. Design parameters and applicable codes.
4. General notes for constructing the micropile structure including the overall construction sequence, micropile installation sequence, means and methods to prevent damage to existing adjacent piles and micropiles, installation tolerances, and other special construction requirements.

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5. Start date and time schedule and micropile installation schedule providing the following:
  - Micropile number
  - Micropile Factored Design Load
  - Type and size of reinforcing steel
  - Type and size of steel casing
  - Minimum total bond length
  - Total micropile length
  - Micropile top attachment
6. Micropile structure typical sections including micropile spacing and inclination; minimum drill hole diameter; pipe casing and reinforcing bar sizes and details; splice types and locations; centralizers and spacers; grout bond zone and casing plunge lengths and corrosion protection details; and connection details to the substructure footing, anchorage, plates, etc.
7. A typical detail of verification and production proof test micropiles defining the micropile length, minimum drill hole diameter, inclination, and load test bonded and unbonded test lengths.
8. Details, dimensions, and schedules for all micropiles, casing and reinforcing steel, including reinforcing bar bending details.
9. Details and dimensions for micropile structure appurtenances such as barriers, coping, drainage gutters, fences, etc. (if applicable).
10. Details for constructing micropile structures around drainage facilities (if applicable).
11. Details for terminating micropile structures and adjacent slope construction (if applicable).

When plan dimensions are changed due to field conditions or for other reasons, the Contractor shall submit revised Type 3E Working Drawings, including supporting design calculations. Within 30 days after completion of the work, the Contractor shall submit as-built drawings to the Engineer, conforming to the requirements specified for Type 3E Working Drawings in Section 1-05.3.

#### **Construction Submittals**

The Contractor shall submit Type 2E Working Drawings consisting of the following for the micropile system or systems to be constructed:

1. Discussion of how the Contractor's construction methods accommodate and are compatible with the anticipated subsurface conditions as described in the contract test hole boring logs, the Summary of Geotechnical Conditions provided in the Appendix to the Special Provisions, and the geotechnical report(s) prepared for this project.

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2. If welding of casing is proposed, the Contractor shall submit the proposed welding procedure in accordance with Section 6-03.3(25).
3. Manufacturer's information, model, size, and type of equipment to be used for installing micropiles, with appropriate manufacturer's literature for review. Include detailed description of the drilling equipment and methods proposed to be used to provide drillhole support and prevent detrimental ground movements.
4. Information on headroom and space requirements for installation equipment that verify the proposed equipment can perform at the site. Plan describing how surface water, drill flush, and excess waste grout will be controlled, contained, collected, and disposed of.
5. Certified mill test reports for the reinforcing steel and certified mill test reports or independent test reports for non-mill certified steel casing used in micropile installation. The ultimate strength, yield strength, elongation, and material properties composition shall be included.
6. Grouting Plan. The plan shall include complete descriptions, details, and supporting calculations for the following:
  - a. Grout mix design and type of materials to be used in the grout including certified test data and trial batch reports.
  - b. Grouting equipment, including capacity and relation to the grouting demand and working conditions as well as provisions for back-up equipment and spare parts.
  - c. Types and sizes of grout hoses, connections, and grout delivery systems.
  - d. Methods and equipment for placing, positioning, and supporting the steel pipe casing and reinforcing bars. Centralizers and spacers shall permit the free flow of grout without misalignment of the reinforcing bar(s) and permanent casing.
  - e. Methods and equipment for accurately monitoring and recording the grout depth, grout volume and grout pressure as the grout is being placed. The Contractor shall estimate the grout take. There will be no extra payment for grout overruns.
  - f. Procedures and schedules for grout batching, mixing, and pumping including provisions for handling drilling fluid and for post grouting.
  - g. Grouting rate calculations, when requested by the Engineer. The calculations shall be based 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.

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- h. Contingency procedures for handling blockage of ducts or equipment breakdowns.
  - i. Estimated curing time for grout to achieve specified strength. During production, grout shall be tested in accordance with the **Grout Testing** subsection of this Special Provision.
  - j. Procedure and equipment for Contractor monitoring of grout quality.
7. Detailed plans for the proposed micropile load testing method. This shall include all drawings, details, and structural design calculations necessary to 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 micropile top movements in accordance with the **Micropile Load Tests** subsection of this Special Provision.
  8. Calibration reports and data for each test jack, pressure gauge and master pressure gauge and electronic load cell to be used. The calibration tests shall have been performed by an independent testing laboratory within 90 calendar days of the date submitted.
  9. Discussion of the Contractor's contingency plan if a verification load test or a proof load test fails.

**Pre-construction Meeting**

A pre-construction meeting will be scheduled by the Engineer and held prior to the start of micropile construction. The prime Contractor, micropile specialty Contractor, and excavation Contractor shall attend the meeting. The pre-construction meeting will be conducted to clarify the construction requirements for the work, to coordinate the construction schedule and activities, and to identify contractual relationships and delineation of responsibilities amongst the prime Contractor and the various Subcontractors - specifically those pertaining to excavation for micropile structures, anticipated subsurface conditions, micropile installation and testing, micropile structure survey control and site drainage control.

**Site Drainage Control**

The Contractor shall control and properly dispose of drill flush and construction related waste, including excess grout, in accordance with Section 1-07.5(3) as supplemented in these Special Provisions and all applicable local codes and regulations. The Contractor shall provide positive control and discharge of all surface water that will affect construction of the micropile installation. The Contractor shall maintain all pipes or conduits used to control surface water during construction. The Contractor shall repair damage caused by surface water in accordance with Section 1-07.13. Upon substantial completion of the work, the Contractor shall remove surface water control pipes or conduits from the site. Alternatively, with the approval of the Engineer, pipes or conduits that are left in place may be fully grouted and abandoned or left in a way that protects the structure and all adjacent facilities from migration of fines through the pipe or conduit and potential ground loss.

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### **Excavation**

The Contractor shall coordinate the work and the excavation so the micropile structures are safely constructed. The Contractor shall perform the micropile construction and related excavation in accordance with the Plans and approved submittals.

### **Micropile Allowable Construction Tolerances**

The centerline of piling shall not be more than 3 inches from indicated plan location.

The pile-hile alignment of vertical micropiles shall be plumb within 2 percent of total-length plan alignment. The pile-hole alignment of micropiles inclined up to 1:6 shall be within 4-percent of plan alignment. The pile-hole alignment of micropiles inclined greater than 1:6 shall be within 7-percent of plan alignment.

The top elevation of micropile shall be  $\pm 1$  inch maximum from vertical elevation indicated.

The centerline of reinforcing steel shall not be more than 1/2 inch from indicated location.

### **Drilling**

The drilling equipment and methods shall be suitable for drilling through the conditions to be encountered, without causing damage to any overlying or adjacent structures or services. The drill hole shall be open along its full length to at least the design minimum drill hole diameter prior to placing grout and reinforcement. Temporary casing or other approved method of micropile drill hole support will be required in caving or unstable ground to permit the micropile shaft to be formed to the minimum design drill hole diameter. The Contractor's proposed method(s) to provide drill hole support and to prevent ground movements shall have received the approval of the Engineer. Use of drilling fluid containing bentonite is not allowed.

### **Ground Heave or Subsidence**

During construction, the Contractor shall observe the conditions in the vicinity of the micropile construction site on a daily basis for signs of ground heave or subsidence. The Contractor shall immediately notify the Engineer if signs of movements are observed. The Contractor shall 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, the Contractor shall take corrective actions necessary to stop the movement or perform repairs.

When due to the Contractor's methods or operations or failure to follow the specified/approved construction sequence, the costs of providing corrective actions will be borne by the Contractor in accordance with Section 1-07.13.

### **Pipe Casing and Reinforcing Bars Placement and Splicing**

Reinforcement may be placed either prior to grouting or placed into the grout-filled drill hole before temporary casing (if used) is withdrawn. Reinforcement surface shall be free of deleterious substances such as soil, mud, grease or oil. Micropile cages and reinforcement groups, if used, shall be sufficiently robust to withstand the installation and grouting process and the withdrawal of the drill casings without

1 damage or disturbance. Grout shall provide one inch minimum cover over bare or  
2 epoxy coated bars (1/4-inch on bar couplers) or 1/2 inch minimum cover over the  
3 encapsulation of encapsulated bars.

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5 The Contractor shall check micropile top elevations and adjust all installed  
6 micropiles to the planned elevations.

7  
8 Permanent casing, if specified, shall be installed to the minimum tip elevations  
9 shown in the Plans.

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11 Centralizers and spacers shall be provided at 10 feet centers maximum spacing.  
12 The upper and lower most centralizer shall be located a maximum of 5 feet from  
13 the top and bottom of the micropile. The central reinforcement bars with  
14 centralizers shall be lowered into the stabilized drill hole and set. The reinforcing  
15 steel shall be inserted into the drill hole to the desired depth. Bars shall not be  
16 driven or forced into the hole. The Contractor shall re-drill and reinsert reinforcing  
17 steel when necessary to facilitate insertion.

18  
19 Lengths of casing and reinforcing bars to be spliced shall be secured in proper  
20 alignment and in a manner to avoid eccentricity or angle between the axes of the  
21 two lengths to be spliced. Splices and threaded joints shall meet the requirements  
22 of Section 6-05.2 as supplemented in these Special Provisions. Threaded pipe  
23 casing joints shall be located at least two casing diameters (OD) from a splice in  
24 any reinforcing bar. When multiple bars are used, bar splices shall be staggered at  
25 least one foot.

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27 **Grouting**

28 Micropiles shall be primary grouted the same day the load transfer bond length is  
29 drilled. The Contractor shall complete the load transfer bond length drilling and  
30 primary grouting of a micropile before beginning work on another micropile in the  
31 same footing or pile cap.

32  
33 Prior to grouting, the drill hole shall be flushed with water and/or air to remove drill  
34 cuttings.

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36 The grouting equipment shall be colloidal mixers only and shall produce a grout  
37 free of lumps and undispersed cement. Contractor shall have means and methods  
38 of measuring the grout quantity and pumping pressure during the grouting  
39 operations. The grout pump shall be equipped with a pressure gauge to monitor  
40 grout pressures. A second pressure gauge shall be placed at the point of injection  
41 into the micropile top. The pressure gauges shall be capable of measuring  
42 pressures of 150 psi or twice the actual grout pressures used, whichever is greater.  
43 The grout shall be kept in agitation prior to mixing. Grout shall be placed within one  
44 hour of mixing. The grouting equipment shall be sized to enable each micropile to  
45 be grouted in one continuous operation.

46  
47 The grout shall be injected from the lowest point of the drill hole and injection shall  
48 continue until uncontaminated grout flows from the top of the micropile. The grout  
49 may be pumped through grout tubes, casing, hollow-stem augers, or drill rods.  
50 Temporary casing, if used, shall be extracted in stages ensuring that after each  
51 length of casing is removed the grout level is brought back up to the ground level  
52 before the next length is removed. Additional grout shall be placed by the use of a

1 tremie pipe at all times. The tremie pipe shall always extend below the level of the  
2 existing grout in the drill hole. The grout pressures and grout takes shall be  
3 controlled to prevent excessive heave or fracturing of rock or soil formations. Upon  
4 completion of grouting, the grout tube may remain in the hole, but must be filled  
5 with grout.  
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7 If the Contractor elects to use a postgrouting system, working drawings and details  
8 shall be submitted to the Engineer for review in accordance with the **Construction**  
9 **Submittals** subsection of this Special Provision.

### 10 **Grout Testing**

11 Grout within the micropile verification and proof test micropiles shall attain the  
12 minimum specified seven day design compressive strength prior to load testing.  
13 During placement of initial verification micropiles, proof test micropiles, and  
14 production micropiles, micropile grout will be sampled and tested by the Engineer  
15 for compressive strength in accordance with WSDOT Test Method 813 and  
16 AASHTO T 106 at a frequency of no less than one set of three 2 inch grout cubes  
17 from each grout plant each day of operation or per every 10 micropiles, whichever  
18 occurs more frequently. The compressive strength will be the average of the 3  
19 cubes tested. The Contractor is responsible for sampling and testing additional  
20 grout cubes as necessary for early breaks prior to verification and proof testing.  
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22  
23 If a compressive strength test fails, the Engineer may require the Contractor to  
24 proof test some or all of the production micropiles installed since the last grout  
25 batch that met the specified compressive strength.  
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27 Grout consistency, as measured by grout density, shall be tested by the Contractor  
28 just prior to the start of micropile grouting in accordance with API RP-13B-1 at a  
29 frequency of at least one test per micropile. For the grout to be approved for use,  
30 the specific gravity reported by the test shall be between 1.8 and 1.9. The  
31 Contractor's grout consistency test equipment shall be calibrated by an  
32 independent testing laboratory. The Contractor shall not use test equipment greater  
33 than 180-calendar days past the most recent calibration date, until such equipment  
34 is recalibrated by an independent testing laboratory.  
35

### 36 **Micropile Installation Records**

37 The Contractor shall prepare and submit Type 1 Working Drawings consisting of  
38 full-length installation records for each micropile installed, including all grout  
39 volumes, pressures, and installation methods used. The records shall be submitted  
40 no later than the end of each work week and within 24 hours after all micropile  
41 installation is completed. The data shall be recorded in the micropile installation log.  
42 A separate log shall be provided for each micropile.  
43

### 44 **Micropile Load Tests**

45 The Contractor shall perform verification and proof testing of micropiles at the  
46 locations specified in this Special Provision, the Plans or as otherwise specified by  
47 the Engineer. Tests shall be performed using a tension load test in accordance with  
48 ASTM D 3689 or a compression load test in accordance with ASTM D 1143, except  
49 as modified by this Special Provision.  
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51 Completed production micropiles may be used as part of the reaction frame for  
52 proof load testing. No reaction bearing elements of the load test frame for

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verification and proof load testing of micropiles shall bear on existing structure elements.

**Verification Load Tests**

The Contractor shall perform pre-production verification micropile testing to verify the design of the micropile system and the construction methods proposed prior to installing any production micropiles. Sacrificial verification test micropiles shall be constructed in conformance with the Working Drawing submittal. Verification test micropiles shall be installed at the following locations:

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Verification load tests shall be performed to verify that the Contractor installed micropiles will meet the required compression and tension load capacities and load test acceptance criteria and to verify that the length of the micropile load transfer bond zone is adequate. The Contractor shall submit Type 2 Working Drawings consisting of the micropile verification load test results for the Engineer's acceptance prior to the installation of production micropiles.

The drilling-and-grouting method, casing length and outside diameter, reinforcing bar lengths, reinforcing bar size and strength, and depth of embedment for the verification test micropile(s) shall be identical to those specified for the production micropiles at the given locations. The verification test micropile structural steel sections shall be sized to safely resist the maximum test load.

The jack, bearing plates, and stressing anchorage shall be positioned at the beginning of the test such that unloading and repositioning during the test will not be required.

**Testing Equipment and Data Recording**

Testing equipment shall include dial gauges, dial gauge support, jack and pressure gauge, electronic load cell, and a reaction frame. The load cell is required only for the creep test portion of the verification test. The Contractor shall provide a description of test setup and jack, pressure gauge and load cell calibration curves in accordance with the **Working Drawings** subsection of this Special Provision. Additionally, the Contractor shall not use test jacks, pressure gauges and master pressure gauges, and electronic load cells greater than 90 calendar days past their most recent calibration date, until such items are recalibrated by an independent testing laboratory.

The Contractor shall design the testing reaction frame to be sufficiently rigid and of adequate dimensions such that excessive deformation of the testing equipment does not occur.

The Contractor shall apply and measure the test load with a hydraulic jack and pressure gauge. The pressure gauge shall be graduated in 75 psi increments or less. The jack and pressure gauge shall have a pressure range of no more than twice the anticipated maximum test pressure. Jack ram travel shall be sufficient to allow the test to be done without resetting the equipment. The Contractor shall monitor the creep test load hold during verification tests with both the pressure gauge and the electronic load cell. The Contractor shall use the load cell to

1 accurately maintain a constant load hold during the creep test load hold increment  
2 of the verification test.

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4 The Contractor shall measure the micropile top movement with a dial gauge  
5 capable of measuring to 1 mil (0.001 inch). The dial gauge shall have a travel  
6 sufficient to allow the test to be done without having to reset the gauge. The  
7 Contractor shall visually align the gauge to be parallel with the axis of the micropile  
8 and support the gauge independently from the jack, micropile or reaction frame.  
9 The Contractor shall use two dial gauges when the test setup requires reaction  
10 against the ground or single reaction micropiles on each side of the test micropile.

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12 The required load test data shall be recorded by the Contractor.

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14 **Verification Test Loading Schedule**

15 The Contractor shall test the verification micropiles to a maximum test load of 1.5  
16 times the micropile Factored Design Load shown in the Plans. The verification  
17 micropile load tests shall be made by incrementally loading the micropile in  
18 accordance with the following cyclic load schedule:

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20 AL = Alignment Load FDL = Factored Design Load

21	LOAD	HOLD TIME
22	AL	1 minute
23	0.075 FDL	4 minutes
24	0.150 FDL	4 minutes
25	0.225 FDL	4 minutes
26	0.300 FDL	4 minutes
27	0.375 DL	4 minutes
28	AL	1 minute
29	0.150 FDL	1 minute
30	0.300 FDL	1 minute
31	0.375 FDL	1 minute
32	0.450 FDL	4 minutes
33	0.525 FDL	4 minutes
34	0.600 FDL	4 minutes
35	0.675 FDL	4 minutes
36	0.750 FDL	4 minutes
37	AL	1 minute
38	0.300 FDL	1 minute
39	0.600 FDL	1 minute
40	0.675 FDL	1 minute
41	0.750 FDL	1 minute
42	0.825 FDL	4 minutes
43	0.900 FDL	4 minutes
44	1.00 FDL	60 minutes
45		(Creep Test Load Hold)
46	AL	1 minute
47	0.300 FDL	1 minute
48	0.600 FDL	1 minute
49	0.900 FDL	1 minute
50	0.975 FDL	4 minutes
51	1.050 FDL	4 minutes
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1	1.125 FDL	4 minutes
2	1.200 FDL	4 minutes
3	1.275 FDL	4 minutes
4	1.350 FDL	4 minutes
5	1.425 FDL	4 minutes
6	1.500 FDL	4 minutes
7		(Maximum Test Load)
8	1.200 FDL	4 minutes
9	0.900 FDL	4 minutes
10	0.600 FDL	4 minutes
11	0.300 FDL	4 minutes
12	AL	15 minutes

14 After the hold time at each load, Micropile top movement shall be measured and  
15 recorded. The verification test micropile shall be monitored for creep at the 1.000  
16 Factored Design Load (FDL). Micropile movement during the creep test shall be  
17 measured and recorded at 1, 2, 3, 4, 5, 6, 10, 20, 30, 50, and 60 minutes. The  
18 alignment load shall not exceed 5 percent of the FDL load. Dial gauges shall be  
19 reset to zero after the initial AL is applied.

21 The acceptance criteria for micropile verification load tests are:

- 23 1. The micropile shall sustain the first 1.000 FDL test load with no more than  
24 the following total vertical movement at the top of the micropile, relative to  
25 the position of the top of the micropile prior to testing.

27 \*\*\* \$\$\$ \$\$ \*\*\*

- 29 2. At the end of the 1.000 FDL creep test load increment, test micropiles  
30 shall have a creep rate not exceeding 0.040 inch/log cycle time (1 to 10  
31 minutes) or 0.080 inch/log cycle time (6 to 60 minutes). The creep rate  
32 shall be linear or decreasing throughout the creep load hold period.
- 34 3. Failure does not occur at the maximum test load of 1.005 FDL. Failure is  
35 defined as a slope of the load versus deflection curve (at end of  
36 increment) exceeding 0.025 inches/kips or at which attempts to further  
37 increase the test load simply result in continued micropile movement.

39 The Engineer will provide the Contractor written acceptance or rejection of the  
40 verification load tests within five working days.

42 **Verification Test Micropile Rejection**

43 If a verification tested micropile fails to meet the acceptance criteria, the Contractor  
44 shall modify the design, the construction procedure, or both, and shall perform  
45 another verification test incorporating the revisions. These modifications may  
46 include modifying the installation methods, increasing the bond length, or changing  
47 the micropile type. Any modification that necessitates changes to the structure will  
48 require the Engineer's review and acceptance. Any modifications of design or  
49 construction procedures or cost of additional verification test micropiles and load  
50 testing shall be at no additional expense to the Contracting Agency. At the  
51 completion of verification testing, test micropiles shall be removed down to an

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elevation two feet below finished ground line, except as otherwise specified in the Plans or by the Engineer.

**Proof Load Tests**

The Contractor shall proof load test the specified number of production micropiles at locations specified by the Engineer. Additional proof tests will be required if modifications are made in the micropile installation methods subsequent to the first production micropile, or if any of the proof tests fail.

**Proof Test Loading Schedule**

Proof tests shall be conducted by incrementally loading the micropile in accordance with the following schedule:

AL = Alignment Load	FDL = Factored Design Load
LOAD	HOLD TIME
AL	1 minute
0.10 FDL	4 minutes
0.20 FDL	4 minutes
0.30 FDL	4 minutes
0.40 FDL	4 minutes
0.50 FDL	4 minutes
0.60 FDL	4 minutes
0.70 FDL	4 minutes
0.80 FDL	4 minutes
0.90 FDL	4 minutes
1.00 FDL	10 or 60 minutes (Creep Test)
0.75 FDL	4 minutes
0.50 FDL	4 minutes
0.25 FDL	4 minutes
AL	4 minutes

Depending on performance, either a 10 minute or 60 minute creep test shall be performed at the maximum test load of 1.0067 FDL. Where the micropile top movement between 1 and 10 minutes exceeds 0.040 inch, the maximum test load shall be maintained an additional 50 minutes. Movements shall be recorded at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. The alignment load shall not exceed 5 percent of FDL. Dial gauges shall be reset to zero after the initial AL is applied.

The acceptance criteria for micropile proof load tests are:

1. The micropile shall sustain the maximum test load of 1.00 FDL with no more than the following total vertical movement at the top of the micropile, relative to the position of the top of the micropile prior to testing.

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2. At the end of the 1.00 FDL creep test load increment, test micropiles shall have a creep rate not exceeding 0.040 inch/log cycle time (1 to 10 minutes) or 0.080 inch/log cycle time (6 to 60 minutes). The creep rate shall be linear or decreasing throughout the creep load hold period.

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**Proof Test Micropile Rejection**

If a proof-tested micropile fails to meet the acceptance criteria, the Contractor shall proof test another micropile as selected by the Engineer. For failed micropiles the Contractor shall submit a Type 2 Working Drawing consisting of a repair procedure. For further construction of subsequent micropiles, the Contractor shall modify the design, the construction procedure, or both. These modifications may include installing replacement micropiles, incorporating failed micropiles at not more than 50 percent of the maximum load attained, post grouting, modifying installation methods, increasing the bond length, or changing the micropile type. Any modification that necessitates changes to the structure design will require the Engineer's review and acceptance.