MATERIALS

All materials shall be in accordance with NDOR Standard Specifications Section 1002 – Portland Cement Concrete with one modification:

Concrete shall produce a minimum 28-day compressive strength of 4,000 psi.

CONSTRUCTION REQUIREMENTS

Construction shall be in accordance with NDOR Standard Specifications Section 704 – Concrete Construction.

METHOD OF MEASUREMENT

The quantity of concrete for which payment will be made shall be computed in cubic yards from dimensions shown in the plans. No field measurement is required. Pay quantities are those shown in the plans.

BASIS OF PAYMENT

Payment will be made for Class 47B-4000 Concrete in cubic yards and shall be full payment for all labor, materials and equipment required to form, place and cure this material.

Payment deductions shall be taken when the measured 28-day compressive strength of cores or cylinders is less than the design compressive strength in accordance with NDOR Standard Specification Section 704.

Payment is full compensation for all work prescribed in this Section.

16.MICROPILES

1. DESCRIPTION OF WORK TO BE PERFORMED

1.1 Scope.

This work shall consist of constructing micropiles as shown on the Contract Drawings and Working Drawings and as specified in these Special Provisions. The contractor is responsible for furnishing all design, materials, products, accessories, tools, equipment, services, transportation, labor and supervision, and manufacturing techniques required for design, installation and testing of production and sacrificial micropiles and pile top attachments for this project. The excavation required for construction of micropiles, vertical beams, placing and compacting of backfill, and final grading around the wall and existing railroad pier foundations will be incidental to this work, no separated payment will be made.

The contractor shall select the micropile type, size, pile top attachment, installation means and methods, estimate the ground-grout bond value (based on results obtained from the Verification Load Test performed on sacrificial micropiles) and determine the required grout bond length and final micropile diameter. The micropile contractor shall design and install micropiles that will develop the load capacities indicated on the Contract Drawings. The micropile load capacities shall be verified by verification and proof load testing as required and must meet the test acceptance criteria specified herein.

The contractor shall also be responsible for containment, hauling and legal disposal of all drilling fluids and excavated materials.

1.2 Definitions.

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

Alignment Load (AL): A minimum load (maximum of 5 percent DL) applied to micropile during testing to keep the testing equipment correctly positioned.

Allowable Geotechnical Micropile Load: For Service Load Design (SLD), computed as the ultimate grout-to-ground bond strength (α bond nominal strength), divided by the geotechnical safety factor and then multiplied by the grouted bond surface area (bond length times drill hole circumference).

Ascending Stage Drilling/Grouting: The process of drilling a hole to full depth and then grouting the hole in stages from the bottom up.

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

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

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

Centralizer: A device to support and position the reinforcing steel in 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 testing of a micropile under a constant load.

Design Load (DL): The maximum unfactored load expected to be applied to the micropile during its service life.

Encapsulation: A corrugated or deformed tube protecting the reinforcing steel against corrosion.
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 and cement grout. Pile load is transferred to the surrounding ground by skin friction.

Maximum Test Load: The maximum load to which the micropile is subjected during testing.

Nominal Grout-to-Ground Bond Strength: The estimated ultimate geotechnical unit grout-toground bond strength selected for use in design.

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 allow load transfer to the ground along the micropile.

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

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

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

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

Verification Load Test: Pile load test performed in tension to verify the geotechnical design of the pile system and the construction methods proposed, prior to installation of production piles. The contractor shall provide design criteria for such piles and determine their location in the field. The contractor will design the pile and load test system.

2. SUBMITTALS

2.1 Contractor Qualifications.

At least twenty-one (21) working days prior to the start of micropile construction, the contractor shall submit a list containing at least three (3) projects completed within the last five (5) years on which the contractor has installed micropiles of similar length, load, and subsurface conditions. A brief description of each project and a reference shall be included for each project listed. As a minimum, the reference shall include an individual's name and current phone number.

The contractor shall assign an engineer to supervise the work with at least three (3) years of experience in the design and construction of micropiles. The contractor may not use consultants or manufacturer's representatives in order to meet the requirements of this section. Drill operators and on-site supervisors shall have a minimum of two (2) years experience installing micropiles with the contractor's organization.

The engineer shall approve or reject the contractor's qualifications and staff within ten (10) working days after receipt of the submission. Work shall not be started on any micropile, nor materials ordered, until approval for the contractor's qualifications are given. The engineer may suspend the micropile work if the contractor substitutes unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, the contractor shall be fully liable for additional costs resulting from the suspension of work and no adjustment in contract time resulting from the suspension of work will be allowed.

2.2 Working Drawings and Design Calculations.

At least thirty (30) working days before the planned start of micropile construction, the contractor shall submit Working Drawings and design calculations to the engineer for review. The Working Drawings and design calculations shall be signed and sealed by a registered professional engineer licensed to practice in the State of Nebraska.

The Working Drawings shall include all information required for the design, construction and quality control of the piling. Working Drawings shall include, but not be limited to, the following items unless provided in the Contract Drawings:

1. A plan view of the micropile layout identifying:

a. A reference baseline and elevation datum.

b. The station and offset from the construction centerline to the centerline of all micropile locations.

2. An elevation view of the micropile layout identifying:

a. Elevation view showing micropile locations and elevations; vertical and horizontal spacing; batter and alignment.

b. Existing and finish grade profiles at all micropile locations.

1 Detailed step-by-step description of the proposed micropile construction procedure, including personnel, testing and equipment to assure quality control. Special attention shall be paid to the sequencing of drilling and grouting to avoid disturbing already installed micropiles. A minimum ten (10) foot lateral separation between micropiles installed within twelve (12) hours is suggested. This step-by-step procedure shall be shown on the Working Drawings in sufficient detail to allow the engineer to monitor the construction and quality of the micropiles.

4. Micropile typical sections including micropile spacing and inclination; minimum drillhole diameter; pipe casing and reinforcing bar sizes and details; splice types and locations; centralizers and spacers; grout bond zone and casing lengths;

corrosion protection details; and connection details to the substructure footing, anchorage, plates, etc.

2 If welding of casing is proposed, submit the proposed welding procedure, certified by a qualified welding specialist.

3 Plan describing how surface water, drill flush, and excess waste grout will be controlled and disposed.

4 Certified mill test reports for the reinforcing steel or coupon test results for permanent casing without mill certification. The ultimate strength, yield strength, elongation, and material properties composition shall be included. For API N-80 or P110 pipe casing, coupon test results may be submitted in lieu of mill certification.

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

a. Grout mix design and type of materials to be used in the grout including certified test data and trial batch reports.

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

c. 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 (if applicable) to be displaced.

d. Estimated curing time for grout to achieve specified strength. Previous test results for the proposed grout mix completed within one year of the start of grouting may be submitted for initial verification and acceptance and start of production work. During production, grout shall be tested in accordance with this Special Provision.

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

5 Verification and proof load testing set-up and sequence.

6 Detailed plans for the proposed micropile load testing method. This shall 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 this Special Provision. The plans shall also include a typical detail of the verification test micropiles defining the micropile length, minimum drillhole diameter, inclination, and load test bonded and unbonded test lengths.

7 Calibration reports and data for each test jack, pressure gauge and master pressure gauge and electronic load cell to be used. The calibration tests shall

have been performed by an independent testing laboratory, and tests shall have been performed within forty-five (45) calendar days of the data submitted. Testing shall not commence until the engineer has reviewed and accepted the jack, pressure gauge, master pressure gauge and electronic load cell calibration data.

The contractor shall submit five (5) sets of Working Drawings and design calculations with the initial submission. The contractor will allow the engineer 10 working days after receipt of a complete submission to review the design and Working Drawings for compliance with the project requirements outlined in the Contract Drawings and this Special Provision. If revisions are necessary, the contractor shall make the necessary corrections and resubmit five (5) revised sets. Once the submittal requirements are satisfied and found acceptable to the engineer, the contractor shall furnish five (5) sets of the final Working Drawings and

design calculations. The contractor will not be allowed to begin micropile construction or incorporate materials into the work until the submittal requirements are satisfied and found acceptable to the engineer. Changes or deviations from the final submittal must be resubmitted for review. No adjustments in contract time or delay or impact claims will be allowed due to incomplete submittals.

2.3 Mill Test Reports.

The contractor shall submit to the engineer for review and approval or rejection mill test reports for the micropile casing, prestressing steel and the bearing plate steel. The engineer may require the contractor to provide samples of any micropile material intended for use on the project.

The engineer shall approve or reject the casing, prestressing steel and bearing plate steel within five (5) working days after receipt of the test reports. The casing, prestressing steel and bearing plates shall not be incorporated in the work without the engineer's approval.

2.4 Calibration Data.

The contractor shall submit to the engineer for review and approval or rejection, calibration data for each test jack, load cell, pressure gauge, and master pressure gauge to be used. The calibration test shall have been performed by an independent testing laboratory within forty-five (45) calendar days of the date submitted. The engineer shall approve or reject the calibration data within five (5) working days after receipt of the complete data. Testing cannot commence until the engineer has approved the jack, load cell, pressure gauge, and master pressure gauge calibration.

2.5 Post-Construction.

The contractor shall submit to the engineer within thirty (30) calendar days after completion of the micropile work a report containing:

a. As-built drawings showing the location and orientation of each micropile, total micropile length, unbonded length, bond length, and tendon bond length as installed.

b. Prestressing steel manufacturer's mill test reports for the tendons incorporated in the installation.

c. Grouting records indicating the cement type, quantity injected, and the grout pressures.

d. Type of mixer used, water/cement ratio, hole diameter, hole inclination, and boring logs showing strata penetrated.

e. Verification load test and proof load test results for each micropile tested.

2.6 Existing Conditions.

The contractor is responsible for contacting a utility location service to verify the location of underground utilities before starting work.

The contractor shall survey the condition of adjoining properties and make records and photographs of any evidence of settlement or cracking of any adjacent structures.

3. CODES AND 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 shall govern, unless indicated otherwise.

3.1 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
C33	M80	Concrete Aggregates
C109	T106	Compressive Strength of Hydraulic Cement Mortar
C188	T133	Density of Hydraulic Cement
D1784		Polyvinyl Chloride (PVC) Pipe (Class 13464-B)
C144	M45	Aggregates for Masonry Mortar
C150	M85	Portland Cement
C494	M194	Chemical Admixtures for Concrete
D1143		Method of Testing Piles Under Static Axial Compressive Load
D3350	M252	Polyethylene Corrugated Tubing
D3689		Method of Testing Individual Piles Under Static Axial Tensile Load
	T26	Quality of Water to be Used in Concrete

3.2 American Welding Society (AWS).

D 1.1	Structural Welding Code - Steel
D 1.2	Structural Welding Code - Reinforcing Steel

3.3 American Petroleum Institute (API).

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

3.4 Foundations Institute Federal Highway Administration (FHWA).

No. FHWA-SA-97-070	Micropile Design and Construction Guidelines Manual

4. MATERIALS

Materials will be furnished new and without defects. Defective materials will be removed from the jobsite and replaced, at no additional cost to the owner. Materials for grouting and for micropiles shall consist of the following:

Admixtures for Grout: Admixtures shall conform to the requirements of ASTM C 494/AASHTO M 194. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout, subject to the review and acceptance of the engineer. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's recommendations. Expansive admixtures shall only be added to the grout used for filling sealed encapsulations and anchorage covers. Accelerators are not permitted. Admixtures containing chlorides are not

permitted.

Cement: All cement shall be Portland cement conforming to ASTM C 150/AASHTO M 85, Types II, III or V. If a sand-cement grout is used, Type 1PF may be used and conform to ASTM C 595.

Centralizers and Spacers: Centralizers and spacers shall be fabricated from schedule 40 PVC pipe or tube, steel, or material non-detrimental to the reinforcing steel. Wood shall not be used. Centralizers and spacers shall be securely attached to the reinforcement; sized to position the reinforcement within 1/2 inch of plan location from center of pile; sized to allow grout tremie pipe insertion to the bottom of the drillhole; and sized to allow grout to freely flow up the drillhole and casing and between adjacent reinforcing bars.

Encapsulation: Encapsulation shall be shop fabricated using high-density, corrugated polyethylene tubing conforming to the requirements of AASHTO M 252 with a nominal wall thickness of 1/64 inch. The inside annulus between the reinforcing bars and the encapsulating tube shall be a minimum of 3/16 inch and be fully grouted with an approved non-shrink grout. This is an alternative to “epoxy coating,” below.

Epoxy Coating: The minimum thickness of coating applied electrostatically to the reinforcing steel shall be 12 mills. Epoxy coating shall be in accordance with ASTM A775 or ASTM A934. Bend test requirements are waived. Bearing plates and nuts encased in the pile concrete footing need not be epoxy coated. Epoxy coating is an alternative to “encapsulation,” above.

Fine Aggregate: If sand-cement grout is used, sand shall conform to ASTM C 144/AASHTO M45.

Micropile Grout: Neat cement or sand/cement mixture with a minimum 3-day compressive strength of 2000 psi and a minimum 28-day compressive strength of 4000 psi per AASHTO T106/ASTM C109.

Grout Protection: Provides a minimum 1 inch grout cover over epoxy coated bars (excluding bar couplers) or minimum 1/2 inch grout cover over the encapsulation of encapsulated bars.

Permanent Casing Pipe: Permanent steel casing/pipe shall have the diameter and at least minimum wall thickness shown on the approved Working Drawings. The permanent steel casing/pipe:

Shall meet the Tensile Requirements of ASTM A252, Grade 3, except the yield strength shall be a minimum of 80 ksi as used in the design submittal.

May be new "Structural Grade" (a.k.a. "Mill Secondary") steel pipe meeting above but without Mill Certification, free from defects (dents, cracks, tears) and with two coupon tests per truckload delivered to the fabricator.

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

The carbon equivalency (CE) as defined in AWS D1.1, Section X15.1, shall not exceed 0.45, as demonstrated by mill certifications.

The sulfur content shall not exceed 0.05%, as demonstrated by mill certifications.

For permanent casing/pipe that will be shop or field welded, the following fabrication or construction conditions apply:

The steel pipe shall not be joined by welded lap splicing.

Welded seams and splices shall be complete penetration welds.

Partial penetration welds may be restored in conformance with AWS D1.1.

The proposed welding procedure certified by a welding specialist shall be submitted for approval.

Threaded casing joints shall develop at least the required nominal resistance used in the design of the micropile.

Plates and Shapes: Structural steel plates and shapes for pile top attachments shall conform to ASTM A 36/AASHTO M 183, or ASTM A 572/AASHTO M 223, Grade 50.

Reinforcing Bars: Reinforcing steel shall be deformed bars in accordance with AASHTO M 31, Grade 40 or 60; or AASHTO M 275, 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, the threading may be continuous spiral deformed ribbing provided by the bar deformations (e.g., Dywidag or Williams continuous threadbars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, the next larger bar number designation from that shown on the Plans shall be provided, at no additional cost.

Bar tendon couplers, if required, shall develop the ultimate tensile strength of the bars without evidence of any failure.

Sheathing: Smooth plastic sheathing, including joints, shall be watertight. Polyvinyl chloride (PVC) sheathing shall conform to ASTM D 1784, Class 13464-B.
Water: Water for mixing grout shall be potable and conform to the requirements of Section 1005 of the Nebraska Department of Roads Standard Specification for Highway Construction.

5. DESIGN REQUIREMENTS

The micropile composition shall be designed to meet the specified loading conditions, as shown on the Contract Drawings and Working Drawings. The micropile composition and pile top to footing connections shall be designed by the contractor using the Service Load Design (SLD) procedures contained in the FHWA "Micropile Design and Construction Guidelines Manual", Report No. FHWA-SA-97-070.

The required structural safety factors/strength factors (for SLD Design) shall be in accord with the FHWA manual, unless specified otherwise, namely:

0.40 for grout
0.25 for reinforcing bar steel
0.25 for permanent casing reinforcing
Casing tension efficiency with threaded elements = 0.70

Structural design of any individual micropile structural elements not covered in the FHWA manual shall be by the service load design method in conformance with appropriate articles of the most current Edition of the AASHTO Standard Specifications for Highway Bridges, including current interim specifications.

Steel pipe used for the micropile permanent casing shall incorporate an additional 1/16 inch thickness of sacrificial steel as corrosion protection when calculating structural dimensions.

6. CONSTRUCTION REQUIREMENTS

6.1 Equipment.

6.1.1 Drilling.

The contractor shall furnish drilling equipment suitable for the work and capable of drilling vertical or inclined holes for installation of micropiles through all subsurface materials.

Drilling means and methods shall be selected by the contractor to be consistent with the anticipated ground conditions.

6.1.2 Pumps.

The contractor shall furnish positive displacement or progressive cavity grout pumps suitable for his work.

6.1.3 Grout Hoses.

The contractor shall furnish grout hoses suitable for the contractor's work. The hoses shall be sized and rated to accommodate the contractor's pumping pressures and flows.

6.2 Micropile Allowable Construction Tolerances.

Centerline of piling shall not be more than three (3) inches from indicated plan location.

Pile shall be plumb within two (2) percent of total-length plan alignment.

Top elevation of pile shall be plus one (1) inch or minus two (2) inches maximum from vertical elevation indicated.

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

6.3 Micropile Installation.

The micropile contractor shall select the drilling method and the grouting procedure, and propose the grouting pressure used for the installation of the micropiles. The micropile contractor shall also determine the final drillhole diameter and central reinforcement steel sizing necessary to develop the specified load capacities and load testing requirements. There will be no extra payment for grout overruns due to the contractor's methods or subsurface conditions.

6.3.1 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 must 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 pile drill hole support will be required in caving or unstable ground to permit the pile 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 detrimental ground movements shall be reviewed by the engineer. Detrimental ground movement is defined as movement which requires remedial repair measures. Use of drilling fluid containing bentonite is not allowed.

6.3.2 Ground Heave or Subsidence.

During construction, the contractor shall observe the conditions vicinity of the micropile construction site on a daily basis for signs of ground heave or subsidence. Immediately notify the engineer if signs of movements are observed. 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, as determined by the engineer, the costs of providing corrective actions will be borne by the contractor.

6.3.3 Pipe Casing and Reinforcing Bars Placement and Splicing.

Reinforcing bars may be placed either prior to primary grouting or placed into the grout-filled drillhole before temporary casing is withdrawn. Reinforcement surface shall be free of deleterious substances such as soil, mud, grease or oil that might contaminate the grout or coat the reinforcement and impair bond. Pile 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 damage or disturbance.

The contractor shall check pile top elevations and adjust all installed micropiles to the planned elevations.

Centralizers and spacers shall be provided at ten (10) foot maximum spacing. The upper and lower-most centralizers shall be located a maximum of five (5) feet from the top and bottom of the reinforcement, respectively. Centralizers and spacers shall permit the free flow of grout without misalignment of the reinforcing bar(s) and permanent casing. The central reinforcement bars with centralizers shall be lowered into the stabilized drill hole and set. This reinforcing steel must be capable of insertion into the drill hole to the desired depth without difficulty. Partially inserted reinforcing bars shall not be driven or forced into the hole. The contractor shall redrill and reinsert reinforcing steel when necessary to facilitate insertion in such cases.

Lengths of casing and reinforcing bars to be spliced shall be secured in proper alignment and in a manner to avoid eccentricity or angle between the axes of the two lengths to be spliced. Splices and threaded joints shall meet the requirements of the materials section of this special provision. Threaded pipe casing joints shall be located at least two casing diameters (OD) from a splice in any

reinforcing bar. When multiple bars are used, bar splices shall be staggered at least 12 inches.

6.3.4 Grouting.

Micropiles shall be primary grouted the same day the load transfer bond length is drilled, and has been approved by the engineer. The contractor shall use a stable neat cement grout or a sand cement grout with a minimum 28-day unconfined compressive strength of 4000 psi. Admixtures, if used, shall be mixed in accordance with manufacturer's recommendations. The grouting equipment used shall produce a grout free of lumps or undispersed cement and shall be colloidally mixed. Paddle mixers shall not be used. The contractor shall have means and methods of measuring the grout quantity and pumping pressure during the grouting operations. The grout pump shall be equipped with a pressure gauge to monitor grout pressures. A second pressure gauge shall be placed at the point of injection into the pile top. The pressure gauges shall be capable of measuring pressures of at least 150 psi or twice the actual grout pressures used, whichever is greater. The grout shall be kept in agitation prior to placing. Grout shall be placed within one hour of mixing. The grouting equipment shall be sized to enable each pile to be grouted in one continuous operation. The grout shall be injected from the lowest point of the drill hole and injection shall continue until uncontaminated grout flows from the top of the pile. Temporary casing, if used, shall be extracted in stages ensuring that, after each length of casing is removed the grout level is brought back up to the ground level before the next length is removed. The tremie pipe or casing shall always extend below the level of the existing grout in the drillhole. The grout pressures and grout takes shall be controlled to prevent excessive heave or fracturing of rock or soil formations. Upon completion of grouting, the grout tube may remain in the hole, but must be filled with grout.

If the contractor elects to use a post-grouting system, Working Drawings and details shall be submitted to the engineer for review in accordance with this Special Provision.

6.3.5 Grout Testing.

If a sand-cement grout is used, the grout shall be tested according to provisions of ASTM C 1567. The mortar bars shall not exceed 0.10% expansion at 28-days. Results of the ASTM C 1567 test shall be obtained prior to the start of construction of the Verification Load Test Micropile.

Grout shall attain the minimum required 3-day compressive strength of 2000 psi prior to any load testing being conducted. 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, micropile grout shall be tested by the contractor for 28day 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 piles, whichever occurs more frequently. The compressive strength shall be the average of the 3 cubes tested.

Fluid grout density shall be determined by the contractor per ASTM C 188/AASHTO T 133 or API RP-13B-1 at a frequency of at least one test per pile, conducted just prior to start of pile grouting. The Baroid Mud Balance used in accordance with API RP-13B-1 is an approved device for determining density.

Grout samples shall be taken directly from the grout plant. Grout cube compressive strength and grout density test results shall be provided to the engineer within 24 hours of testing.

6.3.6 Micropile Installation Records.

The contractor shall prepare and submit to the engineer full-length installation records for each micropile installed. The records shall be submitted within one work shift after that pile installation is completed. The data shall be recorded on the micropile installation log form presented in FHWA-SA-97-070. A separate log shall be provided for each micropile.

7. TESTING REQUIREMENTS

Perform verification and proof testing of piles at the locations specified herein or designated by the engineer. Compression load testing shall be performed in accordance with ASTM D1143.

As a minimum, one verification load test will be required on a sacrificial micropile. The location of this test pile will be designed by the Engineer.

As a minimum, three (3) production piles will be selected by the engineer for proof testing as follows: one at Abutment No.1, one at Abutment No. 2 and one at Pier No. 1. .

7.1 Verification Load Tests.

7.1.1 General.

The contractor shall perform pre-production verification pile load testing to verify the design of the pile system and the construction methods proposed prior to installing any production piles. A minimum of one preconstruction verification pile will be installed in conformance with the approved Working Drawings. The pile shall be installed at a location within the vicinity of the wall as approved by the engineer.

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 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.

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

The upper casing can be eliminated from the verification pile at the contractor's option.

The maximum verification and proof test loads applied to the micropile shall 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. Any required increase in strength of the verification test pile elements above the strength required for the production piles shall be provided for in the contractor's bid price.

The jack shall be positioned at the beginning of the test such that unloading and repositioning during the test will not be required. When both compression and tension load testing is to be performed on the same pile, the pile shall be tested under compression loads prior to testing under

tension loads

7.1.2 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 Submittals Section.

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. The pressure gauge shall be graduated in 50 psi increments or less. The jack and pressure gauge shall have a pressure range not exceeding twice the anticipated maximum test pressure. Jack ram travel shall be sufficient to allow the test to be done without resetting the equipment. Monitor the creep test load hold during verification tests with both the pressure gauge and the electronic 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 inches. The dial gauge shall have a travel sufficient 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.

The required load test data shall be recorded by the engineer.

7.1.3 Verification Test Loading Schedule.

Test verification piles designated for compression or tension load testing to a maximum test load of 2.5 times the micropile Design Load shown on the Plans or Working Drawings. The verification pile load tests shall be made by incrementally loading the micropile in accordance with the following cyclic load schedule for both compression and tension loading:

LOAD STEP	HOLD TIME
AL (0.05 DL)	1 minute
0.25 DL	1 minute
0.50 DL	1 minute
AL	1 minute
0.25 DL	1 minute
0.50 DL	1 minute
0.75 DL	1 minute
AL	1 minute
0.25 DL	1 minute

LOAD STEP	HOLD TIME
0.50 DL	1 minute
0.75 DL	1 minute
1.00 DL	1 minute
AL	1 minute
0.25 DL	1 minute
0.50 DL	1 minute
0.75 DL	1 minute
1.00 DL	1 minute
1.33 DL	**60 minutes (Creep Test Load Hold)**
1.75 DL	1 minute
2.00 DL	1 minute
2.25 DL	1 minute
2.50 DL (Maximum Test Load)	10 minutes
AL	1 minute

AL = Alignment Load
DL = Design Load

The test load shall be applied in increments of 25 percent of the DL load. Each load increment shall be held for a minimum of 1 minute. Pile top movement shall be measured at each load increment. The load-hold period shall start as soon as each test load increment is applied. The verification test pile shall be monitored for creep at the 1.33 Design Load (DL). Pile movement during the creep test shall be measured and recorded at 1, 2, 3, 4, 5, 6, 10, 20, 30, 50, and 60 minutes. The alignment load shall not exceed 5 percent of the DL. Dial gauges shall be reset to zero after the initial AL is applied.

The acceptance criteria for micropile verification load tests are:

1 At the end of the 1.33 DL creep test load increment, test piles shall have a creep rate not exceeding 0.04 inches/log cycle time (1 to 10 minutes) or 0.08 inches/log cycle time (6 to 60 minutes or the last log cycle if held longer). The creep rate shall be linear or decreasing throughout the creep load hold period.
2 Failure does not occur at the 2.5 DL maximum test load. Failure is defined as the load at which attempts to further increase the test load simply result in continued pile movement.

The contractor shall provide the engineer a written report of the test within 3 working days of the completion of each verification load test. This written confirmation will either confirm the capacities and bond lengths specified in the Working Drawings for production micropiles, or cause modifications to be made. The engineer will review the report and respond within 3 days of receiving each complete report. Should the engineer observe that any Verification Test pile has been

installed, and/or tested in a manner which has adversely affected the quality and/or relevance of the test data, then the contractor shall repeat the Verification Test pile in question, at no additional expense to the Owner. Should the engineer judge that further Verification Tests are warranted, to provide additional data to validate design assumptions, such test piles will be installed and tested at the contractor's unit rate for the first Verification Test Pile.

7.1.4 Verification Test Pile Rejection

If a verification tested micropile fails to meet the acceptance criteria, the contractor shall modify the design, the construction procedure, or both. These modifications may include modifying the installation methods, increasing the bond length, or changing the micropile type. Any modification that necessitates changes to the structure shall require the engineer's prior review and acceptance. Any modifications of design or construction procedures or cost of additional verification test piles and load testing shall be at the contractor's expense. At the completion of verification testing, test piles shall be removed down to the elevation specified by the engineer.

7.2 Proof Load Tests.

7.2.1 General.

The locations of proof test piles shall be as designated by the engineer based on construction records and sequence of micropile installation.

7.2.2 Proof Test Loading Schedule.

Test piles designated for compression or tension proof load testing to a maximum test load of 1.67 times the micropile Design Load shown on the Plans or Working Drawings. Proof tests shall be made by incrementally loading the micropile in accordance with the following schedule, to be used for both compression and tension loading:

LOAD STEP	HOLD TIME
AL	1 minute
0.25 DL	1 minute
0.50 DL	1 minute
0.75 DL	1 minute
1.00 DL	1 minute
1.33 DL	10 or 60 minute (Creep Test)
1.67 DL (Maximum Test Load)	1 minute

AL	1 minute

AL = Alignment Load
DL = Design Load

Depending on performance, either a 10 minute or 60 minute creep test shall be performed at the 1.33 DL Test Load. Where the pile top movement between 1 and 10 minutes exceeds 0.04 inches, 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 DL. Dial gauges shall be reset to zero after the initial AL is applied.

The acceptance criteria for micropile proof load tests are:

1. Failure does not occur at the 1.67 DL maximum test load. Failure is defined as the load at which attempts to further increase the test load simply result in continued pile movement.

2. At the end of the 1.33 DL creep test load increment, test piles shall have a creep rate not exceeding 0.04 inches/log cycle time (1 to 10 minutes) or 0.08 inches/log cycle time (6 to 60 minutes). The creep rate shall be linear or decreasing throughout the creep load hold period.

The contractor shall record all proof test records and submit each test result to the engineer within one working day of testing.

7.2.3 Proof Test Pile Rejection.

If a proof-tested micropile fails to meet the acceptance criteria, the contractor shall immediately proof test another micropile. For failed piles and further construction of other piles, the contractor shall modify the design, the construction procedure, or both. These modifications may include installing replacement micropiles, incorporating piles at not more than 50% 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 shall require the engineer's prior review and acceptance. Any modifications of design or construction procedures, or cost of additional verification test piles and verification and/or proof load testing, or replacement production micropiles, shall be at the contractor's expense

8. METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Micropile. Measurement will be made for the quantity of micropiles installed in accordance with these special provisions, as specified or directed by the Engineer, on a lineal foot basis. Measurement will be made from the plan tip elevation to the top of the cased length as shown in the contract drawings.

The final pay quantities will be the design quantity increased or decreased by any changes authorized by the Engineer. Payment for this item may be overrun or underrun at the direction of the engineer without adjustment in the contract unit price.

All costs associated with and incidental to constructing the micropile, including all excavation required for construction of micropiles, drilling, furnishing, and placing the reinforcing steel and casing, grouting, and pile top attachment shall be included in the contract unit price for the following:

Micropile, Lineal Feet

Micropile Verification Load Test. All costs associated with and incidental to properly performing the micropile verification load test, including design, drilling, furnishing and installing the sacrificial load test micropile, reaction frame (and micropiles if needed), load test equipment, performing and reporting the load test results, as accepted and approved by the engineer, shall be included in the contract unit price for the following:

Micropile Verification Load Test, EACH

Payment for this item will be measured per each.

Micropile Proof Load Test. All costs associated with and incidental to properly and successfully performing the micropile proof load test on a production micropile as selected by the engineer, including reaction frame (and micropiles if needed), load test equipment, performing and reporting the load test results, except for the production micropile, as accepted and approved by the engineer, shall be included in the contract unit price for the following:

Micropile Proof Load Test, EACH

Payment for this item will be measured per each.

17.GIRDER RELOCATION

DESCRIPTION OF WORK TO BE PERFORMED

The existing exterior steel box girders shall be removed and reinstalled as the exterior girders (Girders A & E) in the widened bridge structure. The existing girders are continuous and approximately 178 ft in length with fully welded splices.

Newly fabricated steel box girders shall be installed in the positions formerly occupied by the relocated girders described above (Girders B & D).