Iowa Department of Transportation

SPECIAL PROVISIONS
FOR
MICROPILES

Hardin County
BRFN-065-6(42)--39-42

Effective Date
July 20, 2010

THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

090077.01 DESCRIPTION.
This work shall consist of constructing micropiles as shown on the contract plans and approved working drawings and as specified herein. The micropile specialty Contractor is responsible for furnishing of all design, materials, products, accessories, tools, equipment, services, transportation, labor, supervision, and manufacturing techniques required for design, installation, and testing of micropiles and pile top attachments for this project.

The micropile Contractor may propose an alternative micropile design that meets the requirements set forth in these specifications and plans.

The micropile Contractor shall select and provide the micropile type, size, pile top attachment, installation means and methods, verify the ground-grout bond value, the required bond length and final micropile details. The micropile Contractor shall install micropiles that will develop the load capacities indicated on the contract plans. The micropile load capacities shall be confirmed by verification and proof load testing as required and must meet the test acceptance criteria specified herein.

The Contractor shall provide the Engineer with reasonable access to all elements of the construction with stairs, ladders, man lifts or hoists. This shall include provisions for furnishing the Engineer with boat and the right to be present on any of the Contractor's floating plant or equipment.

The cost of such provisions for access shall be considered as completely covered by the contract unit prices bid for the various items of work in the contract.

A. MICROPILE CONTRACTOR'S EXPERIENCE REQUIREMENTS AND SUBMITTALS.
The micropile Contractor shall be experienced in the construction and load testing of micropiles and have at least 10 years experience and constructed at least five projects of similar size and capacity to those required in these plans and specifications.

The Contractor shall have previous micropile drilling and grouting experience in soil / rock similar to project conditions. The Contractor shall submit construction details, structural details and load test results for at least three previous successful micropile load tests from different projects of similar scope to this project.
The Contractor shall assign a supervising project engineer to supervise the work with experience on at least three projects of similar scope to this project completed over the past 5 years. The

Contractor shall not use consultants or manufacturers' representatives to satisfy the supervising engineer requirements of this section. The on-site foremen and drill rig operators shall also have experience on at least three projects over the past 5 years installing micropiles/pre-bored pile retaining wall structures.

If modifications to the micropile design are proposed, the micropiles shall be designed by a Professional Engineer licensed in the State of Iowa with experience in the design of at least three successfully completed micropile projects over the past 5 years, with micropiles of similar capacity to those required in these plans and specifications. The micropile design engineer may be either an employee of the Contractor or a separate consultant design engineer meeting the stated experience requirements.

At least 45 calendar days before the planned start of micropile construction, the Contractor shall submit 5 copies of the completed project reference list and a personnel list. The project reference list shall include a brief project description with the owner's name and current phone number and load test reports. The personnel list shall identify the micropile system design engineer (if applicable), supervising project engineer, drill rig operators, and on-site foremen to be assigned to the project. The personnel list shall contain a summary of each individual's experience and be complete enough for the Engineer to determine whether each individual satisfies the required qualifications. The Engineer will approve or reject the Contractor's qualifications within 15 calendar days after receipt of a complete submission. Additional time required due to incomplete or unacceptable submittals will not be cause for time extension or impact or delay claims. All costs associated with incomplete or unacceptable submittals shall be borne by the Contractor.

Work shall not be started, nor materials ordered, until the Engineer's written approval of the Contractor's experience qualifications is given. The Engineer may suspend the work if the Contractor uses non-approved personnel. If work is suspended, the Contractor shall be fully liable for all resulting costs and no adjustment in contract time will result from the suspension.

B. RELATED SPECIFICATIONS.

None.

C. DEFINITIONS.

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

2. **Alignment Load (AL):**
   A minimum initial load (no greater than 10% of the Design Load) applied to micropile during testing to keep the testing equipment correctly positioned.

3. **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.

4. **Bond-Breaker:**
   A sleeve placed over the steel reinforcement to prevent load transfer.

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

6. **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.

7. **Contractor:**
   The person / firm responsible for performing the micropile work.

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

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

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

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

12. **Engineer:**
    The Department or Department's authorized representative.

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

14. **Micropile:**
    A small-diameter, bored, cast-in-place composite pile in which the applied load is resisted by steel reinforcement, cement grout and frictional grout / ground bond.

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

16. **Overburden:**
    Soil material, natural or placed, that may require cased drilling methods to provide an open borehole to underlying strata.

17. **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.

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

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

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

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

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

23. Supervising Project Engineer
The Contractor's engineer, either an employee or consultant, that is assigned to supervise the design and construction of the micropiles.

24. Ultimate Grout-to-Ground Bond Values:
The estimated ultimate geotechnical unit grout-to-ground bond strength selected for use in design.

25. Verification Load Test:
Pile load test performed to verify the design of the pile system and the construction methods proposed, prior to installation of production piles.

D. REFERENCED 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.

1. American Society for Testing and Materials (ASTM) and 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
C144	M45	Aggregate for Masonry Mortar
C150	M85	Portland Cement
C494	M194	Chemical Admixtures for Concrete
D1143	-	Standard Test Method for Piles Under Static Axial Compressive Load
D1784	-	Polyvinyl Chloride (PVC) Pipe (Class 13464-B)
D3350	M252	Polyethylene Corrugated Tubing
D3689	-	Standard Test Method for Individual Piles Under Static Axial Tensile Load
D3966		Standard Test Method for Piles Under Lateral Load
-	T26	Quality of Water to be Used in Concrete

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

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

E. AVAILABLE INFORMATION.
Available information developed by the Engineer, or by Contractor includes the following geotechnical reports by Terracon:

- "Geotechnical Engineering Report for Preliminary Design of the Proposed US 65 Arch Bridge over the Iowa River, Iowa Falls, Iowa," dated April 15, 2008.
- "Review of Proposed Bond Stress for Micropile Design, US 65 Arch Bridge over Iowa River, Iowa Falls, Iowa," dated April 17, 2009.
- "Design Memorandum, US 65 Oak Street Bridge over the Iowa River, Iowa Falls, Iowa," dated July 29, revised August 3, 2009.

F. CONSTRUCTION SITE SURVEY.
Before bidding the work, the Contractor shall review the available subsurface information and visit the site to assess the site geometry, equipment access conditions, and location of existing structures and above ground facilities.

The Contractor is responsible for field locating and verifying the location of all utilities shown on the plans prior to starting the Work. Maintain uninterrupted service for those utilities designated to remain in service throughout the work. Notify the Engineer of any utility locations different from shown on the plans that may require micropile relocations or structure design modification. Subject to the Engineer's approval, additional cost to the Contractor due to micropile relocations and / or structure design modification resulting from utility locations different from shown on the plans will be paid as extra work.

Prior to start of any micropile construction activity, the Contractor and Engineer shall jointly inspect the site to observe and document the pre-construction condition of the site, existing structures and facilities.

G. MICROPILE DESIGN REQUIREMENTS.
If modifications to the micropile design are proposed, the micropiles shall be designed to meet the specified loading conditions as shown on the contract plans and approved working drawings. Design the micropiles and pile top to footing connections using the procedures contained in the FHWA "Micropile Design and Construction", Report No. FHWA NHI-05-039, dated December 2005.

The total number of micropiles, the layout (spacing and batter) of the micropiles, and the dimensions of the pile caps cannot change if a design modification is proposed.

The required geotechnical factors of safety shall be in accord with the FHWA manual, unless specified otherwise. Estimated soil/rock design shear strength parameters, unit weights, applied foundation loadings, slope and external surcharge loads, corrosion protection requirements, known utility locations, easements, right-of-ways, and other applicable design criteria will be as shown on the plans or specified herein.

Structural design of any individual micropile structure elements not covered by the FHWA manual shall be by the Load and Resistance Factor Design (LRFD) method in conformance with appropriate articles of the most current Edition of the AASHTO LRFD Bridge Design Specifications, including current interim specifications.

Where required as shown on the contract plans, corrosion protection of the internal steel reinforcing bars, consisting of epoxy coating and grout, shall be provided in accordance with Materials Section.

1. Micropile Design Submittals

At least 21 calendar days before the planned start of micropile structure construction, submit complete design calculations and working drawings to the Engineer for review and approval. Include all details, dimensions, quantities, ground profiles, and cross-sections necessary to construct the micropiles. Verify the limits of the micropile and ground survey data before preparing the detailed working drawings.

The working drawings and calculations shall be signed and sealed by the contractor's Professional Engineer or by the Consultant designer's Professional Engineer (if applicable) licensed in the State of Iowa, previously approved by the Department's Engineer. If the micropile contractor uses a consultant design engineer to prepare the design, the micropile contractor shall still have overall contract responsibility for both the design and the construction.

2. Design Calculations

If modifications to the micropile design are proposed, the design calculations shall include, but not be limited to, the following items:

- **a.** A written summary report which describes the overall micropile design.
- **b.** Applicable code requirements and design references.
- **c.** Critical design cross-section(s) geometry including soil / rock strata and piezometric levels and location, magnitude and direction of design applied loadings, including slope or external surcharge loads.
- **d.** Design criteria, including soil / rock shear strengths (friction angle and cohesion), unit weights, ground-grout bond values and micropile drill hole diameter assumptions for each soil / rock strata.
- **e.** Factors of safety and allowable stresses used in the design on the ground-grout bond values, surcharges, soil / rock and material unit weights, steel, grout, and concrete materials.
- **f.** Seismic design earthquake acceleration coefficient.
- **g.** Design calculation sheets (both static and seismic) 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. Provide an index page with the design calculations.
- **h.** Design notes, including an explanation of any symbols and computer programs used in the design.
- **i.** Pile to footing connection calculations.

3. Working Drawings.

The working drawings shall include all information required for the construction and quality control of the micropiles. Working drawings shall include, but not be limited to, the following items unless provided in the contract plans:

- **a.** A plan view of the micropile structure(s) identifying:
  - **1)** A reference baseline and elevation datum.
  - **2)** The offset from the construction centerline or baseline to the face of the micropile structure at all changes in horizontal alignment.
  - **3)** Beginning and end of micropile structure stations.

4) 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 of any drainage structure or drainage pipe behind, passing through, or passing under the micropile structure.

5) Subsurface exploration locations shown on a plan view of the proposed micropile structure alignment with appropriate reference baselines to fix the locations of the explorations relative to the micropile structure.

b. An elevation view of the micropile structure(s) identifying:

1) Elevation view showing micropile locations and elevations; vertical and horizontal spacing; batter and alignment, and the location of drainage elements (if applicable).

2) Existing and finish grade profiles both behind and in front of the micropile structure.

c. Design parameters and applicable codes.

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

e. Horizontal and vertical curve data affecting the micropile structure and micropile structure control points. Match lines or other details to relate micropile structure stationing to centerline stationing.

f. A listing of the summary of quantities on the elevation drawing of each micropile structure showing pay items and estimated quantities.

g. 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 plunge lengths (if used); corrosion protection details; and connection details to the substructure footing, anchorage, plates, etc.

h. A typical detail of verification and production proof test micropiles defining the micropile length, minimum drillhole diameter, inclination, and load test bonded and unbonded test lengths.

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

j. Details for constructing micropile structures around drainage facilities (if applicable).

Submit seven sets of the working drawings with the initial submission. Drawing sheet size shall be 11 inches by 17 inches. One set will be returned with any indicated corrections. The Engineer will approve or reject the Contractor's submittal within 15 calendar days after receipt of a complete submission. If revisions are necessary, make the necessary corrections and resubmit seven revised sets. The Contractor will not be allowed to begin micropile structure construction or incorporate materials into the work until the submittal requirements are satisfied and found acceptable to the Engineer. Changes or deviations from the approved submittals must be re-submitted for approval. No adjustments in contract time or delay or impact claims will be allowed due to incomplete submittals.

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

H. CONSTRUCTION SUBMITTALS.

The Contractor shall prepare and submit to the Engineer, for review of completeness, seven copies of the following for the micropile system or systems to be constructed:

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

2. Proposed start date and time schedule and micropile installation schedule providing the following:
- Micropile Number
- Micropile Design Load
- Type and Size of Reinforcing Steel
- Minimum Grouted Length
- Total Micropile Length
- Micropile to Precast Panel Attachment

3. Submit the proposed welding procedure, including a test weld to qualify procedure, by a qualified welding specialist.

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

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

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

7. Proposed Grouting Plan. The grouting plan shall include complete descriptions, details, and supporting calculations for the following:
- **a.** Grout mix design and type of materials to be used in the grout, including certified test data and trial batch reports.
- **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 Grout Testing section.
- **e.** Procedure and equipment for Contractor monitoring of grout quality.

8. 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, equipment setup, types and accuracy of apparatus to be used for applying and measuring the test loads, and pile top movements in accordance with Pile Load Tests Section.

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

10. Plan for the placement of concrete and reinforcing steel in cold weather.

Work other than test pile installation shall not begin until the construction submittals have been received, reviewed, and accepted in writing by the Engineer. Provide submittal items 1 through 10 at least 21 calendar days prior to initiating micropile construction; and item 7, as the work

progresses for each delivery and submittal. The Contractor shall allow the Engineer 7 calendar days to review the construction submittals after a complete set has been received. Additional time required due to incomplete or unacceptable submittals shall not be cause for delay or impact claims. All costs associated with incomplete or unacceptable Contractor submittals shall be the responsibility of the Contractor.

I. PRE-CONSTRUCTION MEETING.

A pre-construction meeting will be scheduled by the Engineer and held prior to the start of micropile construction. The Engineer, prime Contractor, micropile specialty Contractor, micropile design engineer, excavation Contractor and geotechnical instrumentation specialist (if applicable) shall attend the meeting. Attendance is mandatory. 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.

090076.02 MATERIALS.

Furnish materials new and without defects. Remove defective materials from the jobsite at no additional cost. Materials for micropiles shall consist of the following:

A. ADMIXTURES FOR GROUT:

Admixtures shall conform to the requirements of ASTM C494 / AASHTO M194. 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.

B. CEMENT:

All cement shall be Portland cement conforming to ASTM C150 / AASHTO M85, Types I, II, III or V.

C. 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.

D. ENCAPSULATION:

If used, encapsulation (double corrosion protection) shall be shop fabricated using high-density, corrugated polyethylene tubing conforming to the requirements of ASTM D3350 / AASHTO M252 with a nominal wall thickness of 0.003 inch. The inside annulus between the reinforcing bars and the encapsulating tube shall be a minimum of 0.2 inch and be fully grouted with non-shrink grout conforming to Materials Section.

E. EPOXY COATING:

The minimum thickness of coating applied electrostatically to the reinforcing steel shall be 0.01 inch. 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 unless the footing reinforcement is epoxy coated.

F. FINE AGGREGATE:

If sand / cement grout is used, sand shall conform to ASTM C144 / AASHTO M45.

G. GALVANIZATION:

Galvanization shall meet the requirements of ASTM A123, ASTM A153, and ASTM A385. Contractor shall notify fabricator and galvanizer of the project requirements. Galvanized pipe

piles will be exposed to plastic/wet Portland cement grout. Repair of galvanization shall be in accordance with IM 410.

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

I. 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 API N80, Grade3, or C; the yield strength shall be at least 45 ksi as used in the design submittal.

- May be new "Structural Grade" (also known as "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 for structural purposes, the following material conditions 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.

- A test weld shall be performed to qualify procedures.

Threaded casing joints shall develop at least the required compressive, tensile, and / or bending strength used in the design of the micropile.

J. PLATES AND SHAPES:
Structural steel plates and shapes for pile top attachments shall conform to ASTM A709 / AASHTO M270, Grade 50.

K. REINFORCING BARS:
If used, reinforcing steel shall be deformed bars in accordance with ASTM A615 / AASHTO M31, of appropriate Grade. 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 (for example, 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.

L. REINFORCING BAR CORROSION PROTECTION:
The corrosion protection shall be as indicated on the plans.

M. SHEATHING:
Smooth plastic sheathing, including joints, shall be watertight. Polyvinyl chloride (PVC) sheathing shall conform to ASTM D1784, Class 13464-B.

N. WATER:
Water used in the grout mix shall conform to AASHTO T26 and shall be potable, clean, and free from substances that may be injurious to cement and steel.

090076.03 CONSTRUCTION REQUIREMENTS.

A. SITE DRAINAGE CONTROL.
The Contractor shall control and properly dispose of drill flush and construction related waste, including excess grout, in accord with the standard specifications and all applicable local codes and regulations. Provide positive control and discharge of all surface water that will affect construction of the micropile installation. Maintain all pipes or conduits used to control surface water during construction. Repair damage caused by surface water at no additional cost. Upon substantial completion of the work, 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.

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

B. EXCAVATION.
Coordinate the work and the excavation so the micropile structures are safely constructed. Perform the micropile construction and related excavation in accordance with the plans and approved submittals. No excavations will be made above or below the micropile structure locations without written approval of the Engineer.

C. VIBRATION MONITORING
The Contractor shall perform vibration monitoring of the micropile construction in accordance with the "Special Provision for Vibration Monitoring".

D. COLD WEATHER CONCRETING
Contractor shall submit to the Engineer for review and approval the intended methods and schedule for the construction of the micropiles. Furthermore, if the construction of the micropiles is expected to fall between November 15 and April 1, then the submittal shall include the intended procedures and methods employed by the Contractor in order to prevent the side walls, reinforcing steel and steel casing from reaching a temperature below 40°F immediately preceding and throughout the placement of the concrete in the micropile cavity. Temperature sensors shall be installed on the casing and the reinforcing steel in a location of easy access and easy to read by the Engineer to ascertain that the rebar and the casing are of a temperature above freezing. Temperature sensors shall be installed at the cutoff elevation of the micropile and midway between the cutoff point and the highest exposed surface of the casing and the rebar. The Contractor will not be allowed to grout the void if the temperature sensors indicate that the temperature is 35°F and falling. In addition, the submittal shall include the method employed to

maintain the concrete above 40°F for the duration of the curing period as required by the specifications.

E. MICROPILE ALLOWABLE CONSTRUCTION TOLERANCES.

1. Centerline of piling shall not be more than 1 inch from indicated plan location.

2. Pile shall be installed to the inclinations shown on the plans within 1% of total-length plan alignment.

3. Top elevation of pile shall be plus 0 inch or minus 1 inch maximum from vertical elevation indicated.

4. Centerline of reinforcing steel shall not be more than 0.75 inch from indicated location.

F. MICROPILE INSTALLATION.

The micropile Contractor shall select the drilling method, the grouting procedure, and the grouting pressure used for the installation of the micropiles. The micropile Contractor shall also verify the final micropile casing size, final drillhole diameter and bond length, and central reinforcement steel sizing necessary to develop the specified load capacities and load testing requirements. The micropile Contractor is also responsible for estimating the grout take. There will be no extra payment for grout overruns.

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 drillhole must be open along its full length to at least the design minimum drillhole diameter prior to placing grout and reinforcement.

Temporary casing or other approved method of pile drillhole support will be required in caving or unstable ground to permit the pile shaft to be formed to the minimum design drillhole diameter. The Contractor's proposed method(s) to provide drillhole 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.

Costs of removal or remedial measures due to encountering unanticipated subsurface obstructions will be paid for as extra work.

2. Ground Heave, Subsidence and Grout Migration.

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, subsidence and the migration of grout into the adjacent waterway. Immediately notify the Engineer if signs of movements are observed. Contractor shall immediately suspend or modify drilling or grouting operations if ground heave, subsidence or grout migration 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. When due to differing site conditions, as determined by the Engineer, the costs of providing corrective actions will be paid as Extra Work.

3. Pipe Casing and Reinforcing Bars Placement and Splicing.

Reinforcement may be placed either prior to grouting or placed into the grout-filled drillhole before temporary casing (if used) is withdrawn. Surfaces of the reinforcement (bars and

casings) 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 (if used) shall be provided at 10 foot centers maximum spacing. The upper and lower most centralizer shall be located a maximum of 5 feet from the top and bottom of the micropile. 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 drillhole and set. The reinforcing steel shall be inserted into the drill hole to the desired depth without difficulty. Partially inserted reinforcing bars shall not be driven or forced into the hole. Contractor shall redrill and reinsert reinforcing steel when necessary to facilitate insertion.

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 Materials Section. 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, the bar splices shall be staggered at least 1 foot.

4. Grouting.

Micropiles shall be primary grouted the same day the load transfer bond length is drilled. 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 and undispersed cement. 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 mixing. 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. The grout may be pumped through grout tubes, casing, hollow-stem augers, or drill rods. 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.

Grout within the micropiles shall be allowed to attain the required design strength prior to being loaded.

If the Contractor elects to use a postgrouting system, working drawings and details shall be submitted to the Engineer for review in accordance with Micropile Design Submittals Section.

5. Grout Testing.

Grout within the micropile verification and proof test piles shall attain the minimum required 3 day compressive strength of 2000 psi prior to load testing. Previous test results for the proposed grout mix completed within one year of the start of work may be submitted for initial verification of the required compressive strengths for installation of pre-production verification test piles and initial production piles. During production, micropile grout shall be tested by the Contractor for compressive strength in accordance with AASHTO T106 / ASTM C109 at a frequency of no less than one set of three 2 inch grout cubes from each grout plant each day of operation or per every 10 piles, whichever occurs more frequently. The compressive strength shall be the average of the three cubes tested.

Grout consistency, as measured by grout density, shall be determined by the Contractor per ASTM C188 / AASHTO T133 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 the grout density of neat cement grout.

The Department will take grout samples directly from the grout plant. Micropile Installation Records

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. A separate log shall be provided for each micropile.

G. PILE LOAD TESTS.

Perform verification and proof testing of piles at the locations specified herein or designated by the Engineer. Perform compression load testing in accord with ASTM D1143, tension load testing in accord with ASTM D3689, and lateral load testing in accord with ASTM D3966, except as modified herein.

1. Verification Load Tests.

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. Two sacrificial verification test piles shall be constructed in conformance with the approved working drawings. Verification test pile(s) shall be installed at the locations shown on the plans. The verification tests shall be performed on vertical test piles that are situated at or near the bottom of the excavations for the skewback footings of the bridge.

Two separate reports shall be prepared and submitted following the completion of each test. Each verification test and report shall be completed and approved before the commencement of the installation of the production micropiles at each abutment.

Verification load tests shall be performed to verify that the Contractor installed micropiles that will meet the required compression and tension load capacities and load test acceptance criteria and to verify that the length of the micropile bond zone is adequate. The micropile verification load test results must verify the Contractor's design and installation methods, and be reviewed and accepted by the Engineer prior to beginning installation of production micropiles.
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 maximum verification and proof test loads applied to the micropile shall not exceed 80% 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.

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 inch. 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 Contractor, or the Contractor's Professional Engineer shall supply the dial gages and all other testing apparatus, shall record the required load test data, and prepare the load test reports.

3. Verification Test Loading Schedule.

Test verification piles designated for compression or tension load testing to a maximum test load of 3.0 times the micropile Design Load (Service) 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:

Step	Loading	Applied Load	Hold Time (Min.)
1	Apply AL		2.5
2	Cycle 1	0.15 DL	2.5
		0.30 DL	2.5
		0.45 DL	2.5
		AL	1

Step	Loading	Applied Load	Hold Time (Min.)
3	Cycle 2	0.15 DL	1
		0.30 DL	1
		0.45 DL	2.5
		0.60 DL	2.5
		0.75 DL	2.5
		0.90 DL	2.5
		1.00 DL	2.5
		AL	1
4	Cycle 3	0.15 DL	1
		1.00 DL	1
		1.15 DL	2.5
		1.30 DL	10 to 60 minutes
		1.45 DL	2.5
		AL	1
5	Cycle 4	0.15 DL	1
		1.45 DL	1
		1.60 DL	1
		1.75 DL	2.5
		1.90 DL	2.5
		2.00 DL	5
		2.25 DL	5
		2.50DL	5
		2.75DL	5
		3.00DL	10
		2.50DL	5
		2.00DL	5
		1.50DL	5
		1.00 DL	5
		0.50 DL	5
		AL	5

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 1.30 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 (AL) shall not exceed 5% of the DL load. Dial gauges shall be reset to zero after the initial AL is applied.

The acceptance criteria for micropile verification load tests are:

a. The pile shall sustain the first compression or tension 1.0 DL test load with no more than 0.5 inch total vertical movement at the top of the pile, relative to the position of the top of the pile prior to testing.

b. At the end of the 1.30 DL creep test load increment, test piles shall have a creep rate not exceeding 0.04 inch/log cycle time (1 to 10 minutes) or 0.08 inch/log cycle time (6 to 60 minutes or the last log cycle if held longer). The creep rate shall be linear or decreasing throughout the creep load hold period.

c. Failure does not occur at the 2.0 DL maximum test load. Failure is defined as load where the slope of the load versus head settlement curve first exceeds 0.000025 inch/pound.

The Contractor's Professional Engineer will provide the Department the results of the micropile verification tests and report, and written confirmation of the micropile design and construction within 7 working days of the completion of the verification load tests. This

written confirmation will either confirm the capacities and bond lengths specified in the working drawings for micropiles or reject the piles based upon the verification test results.

4. Verification Test Pile Rejection.

If a verification-tested micropile fails to meet the acceptance criteria, 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.

5. Proof Load Tests.

If required, perform proof load tests on the first set of production piles installed at each designated substructure unit prior to the installation of the remaining production piles in that unit. The first set of production piles is the number required to provide the required reaction capacity for the proof tested pile. The initial proof test piles shall be installed at the locations shown on the plans or working drawings. Location of additional proof test piles shall be as designated by the Engineer.

6. Proof Test Loading Schedule.

Test piles designated for compression or tension proof load testing to a maximum test load of 1.60 times the micropile Design Load (DL) 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:

Step	Loading	Applied Load	Hold Time (Min.)
1	Apply AL		2.5
2	Load Cycle	0.15 DL	2.5
		0.30 DL	2.5
		0.45 DL	2.5
		0.60 DL	2.5
		0.75 DL	2.5
		0.90 DL	2.5
		1.00 DL	2.5
		1.15 DL	2.5
		1.30 DL	10 to 60 minutes
		1.45 DL	2.5
		1.60 DL	2.5
3	Unload Cycle	1.30 DL	4
		1.00 DL	4
		0.75 DL	4
		0.50 DL	4
		0.25 DL	4
		AL	4

Depending on performance, either a 10 minute or 60 minute creep test shall be performed at the 1.30 DL Test Load. Where the pile top movement between 1 and 10 minutes exceeds 0.04 inch, the Maximum Test Load shall be maintained and 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% of DL. Dial gauges shall be reset to zero after the initial AL is applied. The acceptance criteria for micropile proof load tests are:

a. The pile shall sustain the compression or tension 1.0 DL test load with no more than 0.5 inch total vertical movement at the top of the pile, relative to the position of the top of the pile prior to testing.

b. At the end of the 1.30 DL creep test load increment, test piles shall 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). The creep rate shall be linear or decreasing throughout the creep load hold period.

c. Failure does not occur at the 1.60 DL maximum test load. Failure is defined as load where the slope of the load versus head settlement curve first exceeds 0.000025 inch/pound.

7. Proof Test Pile Rejection.

If a proof-tested micropile fails to meet the acceptance criteria, the Contractor shall immediately proof test another micropile within the footing. 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, postgrouting, 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.

090077.04 METHOD OF MEASUREMENT

Measurement will be made as follows for the quantity, as specified or directed by the Engineer:

- Micropiles will be measured in lineal feet, installed, and accepted, the length of the micropiles.
- Micropile Verification Load Test will be measured per each.

090077.05 BASIS OF PAYMENT

The quantities accepted for payment will be paid for at the contract unit prices for the following items:

Pay Item	Unit
Micropile Verification Load Test for Bridge	Each
Micropiles for Bridge	Lineal Feet

The contract unit prices for the above items will be full and complete payment for providing all design, materials, labor, equipment, and incidentals to complete the work. Where verification test piles are designated as sacrificial, the micropile verification load test bid item shall include the cost of the sacrificial micropile, including furnishing the test instrumentation, recording the test data and preparing the test reports for each of the verification tests.

The Unit contract amount for "Micropiles for Bridge" shall include the drilling, furnishing, and placing the reinforcing steel and casing, grouting, and pile top attachments. The micropile Contractor is also responsible for estimating the grout take and for the disposal of cuttings and water. There will be no extra payment for grout overruns.