

**STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION**

**SPECIAL PROVISION
FOR
MICROPILE INSTALLATION AND TESTING**

**PROJECT IM 0901(148), PCN 01KK
MEADE COUNTY**

MARCH 18, 2014

I. DESCRIPTION

This work shall consist of furnishing all labor, equipment, materials, and qualified personnel necessary to construct and test micropiles in accordance with this special provision at locations designated in the plans or as directed by the Engineer. The micropile load capacities shall be verified by verification and proof load testing as required and must meet the test acceptance criteria specified herein.

II. MATERIALS

A. Admixtures for Grout: Admixtures shall conform to the requirements of AASHTO M194/ASTM C494. 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 not be used. Accelerators are not permitted.

B. Cement: All cement shall be Portland cement conforming to Section 750, Types I, II, III or V.

C. Fine Aggregate: If sand/cement grout is used, the fine aggregate shall conform to Section 800.

D. Water: Water used in the grout mix shall conform to Section 790.

E. Grout: Grout shall be neat cement or sand/cement mixture with a minimum 28-day compressive strength of 5,000 psi per AASHTO T106/ASTM C109.

F. Permanent Casing/Pipe: Permanent steel casing/pipe shall have the diameter, minimum wall thickness, and the minimum yield strength as shown

in the structure plans. The permanent steel casing/pipe shall conform to API N80 with inspection, testing, and dimensions in accordance with API 5CT.

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 XI5.1, 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 compressive, tensile, and bending strength used in the design of the micropile.

G. Reinforcing Bars: Reinforcing steel shall be #18 fully threaded bars meeting the chemical and physical requirements of ASTM A615, Grade 75.

H. Centralizers: Centralizers shall be fabricated from schedule 40 PVC pipe or tube, steel, or material non-detrimental to the reinforcing steel.

III. CONSTRUCTION REQUIREMENTS

A. Micropile Contractor's Experience Requirements and Submittal

The micropile Contractor shall be experienced in the construction and load testing of micropiles and have successfully constructed at least 5 projects in the last 5 years involving construction totaling at least 100 micropiles of similar capacity to those required in these plans and specifications.

The micropile 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 with the installation plan noted in the Construction Submittals.

The micropile Contractor shall assign an Engineer to supervise the work with experience on at least 3 projects of similar scope to this project completed

over the past 5 years. The on-site foreman and drill rig operators shall also have experience on at least 3 projects over the past 5 years installing micropiles of equal or greater capacity than required in these plans and specifications.

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 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 until the Engineer's written approval of the Contractor's experience qualification 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. 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 locations of existing structures and above ground facilities.

C. Construction Submittals

The Contractor shall prepare and submit to the Engineer, for review of completeness, 5 copies of their micropile installation plan including:

1. Detailed step-by-step description of the proposed micropile construction procedure, including personnel, testing, and equipment to assure quality control.
2. Proposed start date and micropile installation schedule.
3. If welding of casing is proposed, submit the proposed welding procedure, certified by a qualified welding specialist.

4. Plan describing how surface water, drill flush, and excess waste grout will be controlled and disposed.
5. Certified mill test reports for the reinforcing steel and permanent casing. The ultimate strength, yield strength, elongation, and material composition shall be included.
6. 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. The allowable production tolerance from the mix design targets.
 - c. The method that will be used to test the grout for consistency or density.
 - d. Identification of the 3rd party testing firm who will be performing the grout compressive testing.
 - e. Methods and equipment for accurately monitoring and recording the grout depth, grout volume and grout pressure as the grout is being placed.
 - f. 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.
 - g. 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 Section III. M of this special provision.
7. 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 Section III, Construction Requirements, Pile Load Tests.
8. Calibration reports and data for each test jack, pressure gauge and master pressure gauge and electronic load cell to be used. The calibration tests shall have been performed by an independent testing laboratory, 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

Work shall not begin until the construction submittals have been received, reviewed, and accepted in writing by the Engineer. The Contractor shall provide required submittals 21 calendar days prior to initiating micropile construction. The Contractor shall allow 14 calendar days for review of 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.

- D. Micropile Preconstruction Meeting:** A micropile preconstruction meeting will be scheduled by the Engineer and held prior to the start of micropile construction. The Engineer, prime Contractor, micropile specialty Contractor, micropile load testing specialist, and representatives from SDDOT's Geotechnical Engineering Activity shall attend the meeting. Attendance is mandatory. The micropile preconstruction meeting will be conducted to clarify the construction requirements for the work, to coordinate delineation of responsibilities amongst the prime Contractor and micropile specialty Contractor, anticipated subsurface conditions, and micropile installation and testing.
- E. Site Drainage Control:** The Contractor shall control and properly dispose of drill flush and construction related waste, including excess grout, in accordance with the standard specifications and all applicable local codes and regulations. Contain and properly dispose of all materials displaced from the drill hole or casing such as water, cuttings, and excess grout during drilling or grouting operations.
- F. Excavation:** Perform the micropile construction and related excavation in accordance with the Plans and approved submittals.
- G. Micropile Allowable Construction Tolerances:**
1. Centerline of piling shall not be more than 3 inches from indicated plan location.
 2. Pile shall be plumb within 2 percent of total-length plan alignment.
 3. Top elevation of pile shall be within plus 1 inch or minus 2 inches maximum from vertical elevation indicated.
 4. Centerline of reinforcing steel shall not be more than 0.75 inches from indicated location.

H. Micropile Installation: The micropile Contractor shall select the drilling method, the grouting procedure, and the grouting pressure used for the installation of the micropiles. For informational purposes only, the estimated quantity of grout take is listed in the plans. There will be no extra payment for grout overrun.

I. 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. After drilling, flush the hole with water and/or air to remove drill cuttings. The drillhole must be open along its full length to at least the design minimum drillhole diameter prior to placing grout and reinforcement. Use of drilling fluid containing bentonite is not allowed.

It is the micropile specialty contractor's responsibility to select the proper drilling equipment and methods for the site conditions. Refer to the project plans for site specific subsurface conditions.

J. Ground Heave or Subsidence: During construction, the Contractor shall observe the conditions in the vicinity of the micropile construction site for signs of ground heave or subsidence. Notify the Engineer immediately if signs of movements are observed. Immediately suspend or modify drilling or grouting operations if ground heave or subsidence is observed, if the micropile structure is adversely affected, or if adjacent structures are damaged from the drilling or grouting. If the Engineer determines that the movements require corrective action, 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.

K. Reinforcement Placement: The central reinforcement bar shall be placed prior to grouting of drill hole. Reinforcement 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.

Provide centralizers and spacers equally spaced along the length of the micropile with a 10-foot maximum center-to-center spacing. Locate the upper and lower most centralizers a maximum of 5 feet from the top and bottom of the micropile respectively. Centralizers and spacers shall permit the free flow of grout without misalignment of the reinforcing bar and permanent casing. Lower the central reinforcement bar with centralizers into the stabilized drillhole and set. Insert the reinforcing steel into the drillhole to the desired depth without difficulty. Do not force or drive partially inserted reinforcing bars

into the hole. Redrill and reinsert reinforcing steel when necessary to facilitate insertion.

Splices and threaded joints shall meet the requirements of Section II, Materials. Threaded pipe casing joints shall be located at least two casing diameters from a splice in any reinforcing bar.

- L. Grouting:** Micropiles shall be grouted the same day the load transfer bond length is drilled. The grouting equipment used shall produce a grout free of lumps and undispersed cement. The grouting equipment shall be sized to enable each pile to be grouted in one continuous operation. 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 pumping. Grout shall be placed while in the pumpable range. Under no circumstances shall water or admixtures be added to the grout following the initial batching.

The grout shall be injected from the lowest point of the drillhole and injection shall continue until uncontaminated grout flows from the top of the pile. The grout may be pumped through grout tubes, casing, or drill rods which must be kept extended below the level of the existing grout in the drill hole. The grout pressures and grout take shall be controlled to prevent excessive heave or fracturing of the Spearfish Formation.

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

- M. Grout Testing:** Grout within the micropile verification and proof test piles shall attain the minimum required compressive strength of 5,000 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 3rd party tester for 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 3 cubes tested.

Grout consistency or grout density shall be determined by the Contractor. The frequency of testing shall be at least one test per pile, conducted just prior to start of pile grouting.

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

N. Pile Load Tests: Perform verification and proof testing of micropiles at the locations specified herein or designated by the Engineer. Perform tension load testing in accordance with ASTM D3689.

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.

O. Micropile Design Loads: Design loads for the micropile are:

<u>Str. No.</u>	<u>Unfactored Design Load (kips)</u>	
	<u>Abut.</u>	<u>Pier</u>
47-078-533	129	156
47-084-546	75	103

P. Micropile Verification Load Tests: Perform pre-production verification pile load testing on sacrificial micropiles to verify the design of the pile system and the construction methods proposed prior to installing any production piles. Sacrificial verification test piles shall be constructed at the following locations:

<u>Str. No.</u>	<u>Verification Test Pile</u>	<u>Vicinity</u>
47-078-533	VTP-1	Abut. No. 6
47-084-546	VTP-2	Abut. No. 1

These locations may be adjusted by the Engineer depending on actual site conditions. The location of additional verification test piles, if needed, shall be determined by the Engineer.

Verification load tests shall be performed to verify that the installed micropiles will meet the required 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 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 size (length, diameter, and wall thickness), reinforcing bar size and lengths, and depth of embedment (bond zone) for the verification test piles shall be identical to those specified for the production piles at the given locations.

Q. 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 Construction 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 100 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 required load test data shall be recorded by the contractor and verified by the Engineer.

R. Verification Test Loading Schedule: The verification pile load tests shall be made by incrementally loading the micropile in accordance with the following cyclic load schedule for 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	1.0
3	Cycle 2	0.15 DL	1.0
		0.45 DL	1.0
		0.60 DL	2.5
		0.75 DL	2.5
		0.90 DL	2.5
		1.00 DL	2.5
		AL	1.0
4	Cycle 3	0.15 DL	1.0
		1.00 DL	1.0
		1.15 DL	2.5
		1.30 DL	10 to 60 minutes
		1.45 DL	2.5
		AL	1.0
5	Cycle 4	0.15 DL	1.0
		1.45 DL	1.0
		1.60 DL	1.0
		1.75 DL	2.5
		1.90 DL	2.5
		2.00 DL	10.0
		1.50 DL	5.0
		1.00 DL	5.0
		0.50 DL	5.0
AL	5.0		

AL = Alignment Load

DL = Unfactored Design Load

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 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.

S. Verification Load Test Acceptance Criteria: The acceptance criteria for micropile verification load tests are:

1. The pile shall sustain the first tension 1.0 DL test load with no more than 0.50 inch total vertical movement at the top of the pile, relative to the position of the top of the pile prior to testing.

2. 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.
3. Failure does not occur at the 2.00 DL maximum test load. Failure is defined as the load where the slope of the load versus head settlement curve first exceeds 0.025 inch/kip.

At the completion of verification testing, test piles shall be removed to 1' below finished ground or as specified by the Engineer.

- T. Proof Load Tests:** Perform proof load tests on the first set of production piles installed at each 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 location of proof test piles shall be as determined by the Engineer.

Proof load tests shall be performed to verify that the contractor-installed production micropiles will meet the loading requirements and load test acceptance criteria. The contractor shall report the proof load test data to the Engineer within 1 day of completing the testing on each micropile proof load tested.

- U. Proof Test Loading Schedule:** Test piles designated for tension proof load testing to a maximum test load of 1.60 times the micropile Design Load. Proof tests shall be made by incrementally loading the micropile in accordance with the following schedule for 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	4.0
		1.00 DL	4.0
		0.75 DL	4.0
		0.50 DL	4.0
		0.25 DL	4.0
		AL	4.0

Depending on performance, either a 10 minute or 60 minute creep test shall be performed at the 1.30 DL load increment. Where the pile top movement between 1 and 10 minutes exceeds 0.04 inch, the Maximum Test Load shall be maintained an additional 50 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.

V. Proof Load Test Acceptance Criteria: The acceptance criteria for micropile proof load tests are:

1. The pile shall sustain the tension 1.0 DL test load with no more than 0.50 inch total vertical movement at the top of the pile, relative to the position of the top of the pile prior to testing.
2. 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.
3. Failure does not occur at the 1.60 DL maximum test load. Failure is defined as the load where the slope of the load versus head settlement curve first exceeds 0.025 inch/kip.

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

IV. METHOD OF MEASUREMENT

- A. **Micropile Verification Load Test:** Micropile verification load tests will be measured on a per each basis for the number of specified verification load test piles successfully constructed, tested, and accepted.
- B. **Micropile Proof Load Test:** Micropile proof load tests will be measured on a per each basis for the number of specified load tests successfully completed and accepted.
- C. **Micropile:** Micropile will be measured on a per each basis for the number of specified production micropiles successfully installed and accepted.

V. BASIS OF PAYMENT

- A. **Micropile Verification Load Test:** Micropile verification load test will be paid for at the contract unit price per each. Payment will be full compensation for furnishing all materials, equipment, and labor required to conduct and report the load test results as specified.
- B. **Micropile Proof Load Test:** Micropile proof load test will be paid for at the contract unit price per each. Payment will be full compensation for furnishing all materials, equipment, and labor required to conduct and report the load test results as specified.
- C. **Micropile:** Micropile will be paid for at the contract unit price per each. Payment will be full compensation for drilling, furnishing, placing casing, reinforcing steel, splices, centralizers, and grouting of the micropile.

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