

WYOMING DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION  
FOR  
MICROPILES

Project No. N103106  
Alpine Junction – Hoback Junction  
Blue Trails Slide  
Lincoln County

**REFERENCE:** The 2010 Edition of the Wyoming Department of Transportation's *Standard Specification for Road and Bridge Construction*.

**DESCRIPTION:** This special provision describes the requirements for a Micropile foundation system.

This work consists of construction of a micropile foundation to support Precast Panel (MSE) walls. Furnish all materials, products, accessories, tools, equipment, services, transportation, labor and supervision, and manufacturing techniques that are required for installation and testing of micropiles and pile top attachments for this project.

Select the installation means and methods to ensure that each micropile has an ultimate compressive axial capacity of 2.0 times the design load. Perform the work in accordance with the plans, specifications, and the shop drawings. Verify the micropile load capacities by verification and proof load testing as required, and meet the test acceptance criteria specified herein.

**DEFINITIONS:**

**Alignment load (AL):** A minimum initial load applied to micropile during testing to keep the testing equipment correctly positioned.

**Uncased (bond) length (load transfer length):** The length of the micropile that is bonded to the surrounding ground and transfers the applied axial loads to the surrounding soil mass.

**Cased length:** The designated length of pile that is not bonded to the surrounding ground.

**Maximum test load:** The maximum compressive load to which the micropile is subjected during testing: 2 x design load for verification tests and 1.67 x design load for proof load tests.

**Design Load:** The allowable load for all micropiles as specified on the plans.

Proof load test: Incremental loading of the production micropile, and recording the movement at each increment to evaluate the ability of production micropile to safely withstand in-service design loads without excessive structural movement.

Verification load test (performance test): Pile test load performed to verify the design of the micropile system and the construction methods proposed or being used.

**MATERIALS:**

Use materials for the micropile structure that are new and without defects. When directed by the Engineer, promptly remove defective materials from the site at no additional cost to the department.

Ensure admixtures for grout conform to the requirements of ASTM C 494 / AASHTO M194; admixtures are subject to the review and acceptance of the Engineer. Ensure admixtures are compatible with the grout and mixed in accordance with the manufacturer's recommendations. Expansive admixtures, accelerators, and admixtures containing chlorides are not allowed.

Use cement consisting of Portland cement conforming to ASTM C 150 / AASHTO M85, Types II, III, or V.

Ensure centralizers and spacers are fabricated from Schedule 40 PVC pipe or tube ASTM D-1785, and are securely attached to the reinforcement. Ensure centralizers and spacers are sized to position the reinforcement within ½ inch of plan location from center of pile, to allow grout tube insertion to the bottom of the drillhole, and to allow grout to flow freely up the drillhole and casing.

Ensure grout has a 3-day compressive strength of at least 2500 psi and a 28-day compressive strength of at least 4000 psi tested in accordance with ASTM C 1107. Ensure grout has a water-cement ratio of 0.40 to 0.60.

Ensure permanent steel casing/pipe has the diameter and minimum wall thickness shown on the plans. The permanent steel casing/pipe:

- (1) Must meet the tensile requirements of ASTM A252, Grade 3, except the yield strength must be 80 ksi or greater.
- (2) May be new "Structural Grade" steel pipe meeting above, but without mill certification, free from defects, and with two coupon tests per truckload delivered to the fabricator.

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

- (1) The carbon equivalency as defined in AWS D1.1, section X15.1, cannot exceed 0.45, as demonstrated by mill certifications.
- (2) the sulfur content cannot exceed 0.05 percent, as demonstrated by mill

certifications.

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

- (1) ensure the steel pipe is not joined by welded lap splicing.
- (2) ensure welded seams and splices are complete penetration welds.
- (3) partial penetration welds may be restored in accordance with AWS D1.1.
- (4) the proposed welding procedure certified by a welding specialist must be submitted for approval.

Ensure threaded casing joints develop at least the required nominal resistance used in the design of the micropile.

Ensure structural steel plates and shapes for pile top attachments conform to ASTM A 36 / AASHTO M183, or ASTM A 572 / AASHTO M223, Grade 50.

Ensure inner all-thread bars are deformed bars in accordance with ASTM A 722, Grade 150, epoxy coated per ASTM A 775. When a bearing plate and nut are required to be threaded onto the top end of bars for the anchorage between pile top and footing, the threading may be provided by the bar deformations or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, provide the next larger bar number designation from that shown on the plans, at no additional cost to the department. Ensure bar couplers develop the ultimate tensile strength of the bars without any evidence of failure, and ensure a maximum of two couplers are used per micropile, such that any bar portion of a coupled micropile is a 10.0 foot minimum finished length. Couplers are only allowed in the bond length. Ensure water used in the grout mix conforms to AASHTO T 26 and is potable, clean, and free from substances that may be detrimental to cement and steel.

## CONSTRUCTION:

### **Qualifications**

The work described in this Special Provision requires previous micropile drilling, grouting, and testing experience in soil/rock similar to project conditions. The work requires the Contractor to have successfully constructed at least three projects in the last five years involving construction totaling at least 100 micropiles of similar capacity to those required in this Contract. Assign an engineer to be in responsible charge of the work with experience on at least three projects of similar scope to this project, all completed over the past five years. This work requires the on-site foremen and drill rig operators to have experience on at least three projects over the past five years installing micropiles of equal or greater capacity than required by this project.

At least three calendar weeks before the planned start of micropile construction, submit five copies of the completed project reference list and a personnel list. Include with the list a brief project description with the owner's name/representative and current phone

number. Identify on the personnel list the micropile system designer, supervising engineer, drill rig operators, and on-site foremen to be assigned to the project. The personnel list must include a summary of each individual's experience and must 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 ten 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 are not paid for separately and are at no additional cost to the department.

Do not begin work or order material until the Engineer has given written approval of the Contractor's experience qualifications. The Engineer may suspend the Work if the Contractor uses non-approved personnel. If work is suspended, the Contractor is fully liable for all resulting costs, and no adjustment in contract time resulting from the suspension of work will be allowed.

#### **Submittals - Shop Drawings**

Submit shop drawings in accordance with subsection 105.2. Include the following on the shop drawings:

- (1) A plan view of the micropile structure that identifies the location of the structure within the project and drainage structures near the micropile structure.
- (2) An elevation view of the micropile structure that shows micropile locations and elevations, vertical and horizontal micropile spacing, existing grade profiles at the wall layout line, and finished top of micropiles.
- (3) General notes for constructing the micropile pile cap and micropile structure, including construction sequencing and special construction requirements.
- (4) Certificates of compliance attesting proof of compliance with specification material requirements for micropile casing, threadbar, and grout, prior to delivery of material to the project site.
- (5) Proposed grouting plan, including grout mix design (with certified test data); methods and equipment for monitoring and recording grout volume, and grout pressure (if pressure grouting is used) during grout placement; estimated curing time for grout to achieve specified strength; and procedure and equipment for monitoring of grout quality.
- (6) A thorough narrative describing the micropile installation procedures, including a description of all drilling equipment and methods; plans for control and disposal of surface water, drill flush, dust control, and excess waste grout.

- (7) A thorough narrative describing the micropile testing procedures, equipment, and setup. Include with the submittal calibration information to correlate gauge pressure to applied load for each combination of ram, jack, and gauge to be used in the Work. Clearly indicate the serial number of each component of the loading and testing assembly on the calibration graph. Also include with the submittal any micropile modifications required to ensure required structural capacity is obtained.
- (8) Certificate of calibration from an independent testing laboratory for each combination of ram, jack, and gauge to be used for loading and testing of the micropiles. Ensure the equipment has been calibrated within three months of the date of this submittal, or at the request of the Engineer. Do not begin testing until the Engineer has reviewed and accepted the calibration data.

The Engineer will review the submittal within ten days after receipt of a complete submittal. Do not begin micropile structure construction or incorporate materials into the Work until the submittal requirements are satisfied and verification test results have been reviewed and accepted by the Engineer. No adjustments in contract time or delay or impact claims will be allowed due to incomplete submittals.

#### **Preconstruction Meeting**

A preconstruction meeting will be scheduled by the Engineer and held prior to the start of micropile construction. The Engineer, the Contractor, the supervising engineer, and the micropile foremen are to attend the meeting. The preconstruction meeting will be conducted to clarify the construction requirements for the Work, to coordinate the construction schedule and activities, and to establish clearly the responsibilities amongst the parties for issues related to excavation, subsurface conditions, micropile installation and testing, micropile structure survey control, and site drainage control.

#### **Micropile Installation**

Make every attempt to keep the holes dry. Wetting of the subsurface materials will decrease the bond strength of the materials significantly. Wet drilling methods are not acceptable.

Control and properly dispose of drill flush and construction-related waste, including excess grout, in accordance with the 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.

Control the dust during the drilling operations to limit the impacts to the environment, public traffic, and pedestrians.

Coordinate the Work and the excavation so that the micropile structures are safely constructed. Do not make excavations steeper than those specified herein or shown on the plans, above or below the micropile structure locations without prior written approval of the Engineer.

Install the micropiles within the following tolerances:

- (1) Centerline of piling cannot be more than 3 inches from indicated plan location.
- (2) Pile must be plumb within 2 percent of total length of plan alignment.
- (3) Top elevation of pile must be plus 1 inch or minus 2 inch maximum from vertical elevation shown in the plans.
- (4) Centerline of reinforcing steel must be within ½ inch from centerline of micropile.

Select the drilling method, the grouting procedure, and the grouting pressure to be used for the installation of the micropiles. Choose the method which ensures that each completed micropile has an ultimate compressive axial capacity of 2 times the design load.

Install permanent steel casing/pipe in the unbonded length prior to insertion of the reinforcing bar.

Place reinforcing prior to grouting and ensure reinforcing is free of deleterious substances that might contaminate the grout or coat the reinforcement and impair bond.

Check pile top installations and adjust all installed micropiles to the planned elevations. Prepare the interface of the top of casing and the bearing plate by sawing or other suitable means to achieve maximum contact bearing. Lack of contact bearing exceeding a gap of 1/16 inch is not allowed.

Provide centralizers and spacers (if used) at maximum 10-foot spacing. Locate the upper and lower most centralizers a maximum of 5 feet from the top and bottom of the micropile, respectively. Ensure centralizers and spacers permit the free flow of grout without misalignment of the reinforcing bars and permanent casing. Do not drive or force partially inserted reinforcing bars into the hole. Re-drill and re-insert reinforcing steel when necessary to facilitate insertion.

Provide means and methods of measuring the grout quantity and pumping pressure (if pressure grouting is used) during the grouting operations. Keep the grout mixture in agitation prior to placement, and place the grout within one hour of mixing, in one continuous operation.

The grouting of the micropile is a two-staged process to facilitate load transfer mechanisms required for the design. Grout the bond length (uncased length) of the micropile the same day the micropile is drilled. Grout the micropile to a level within 2 to 3 feet above the bottom of the cased length. Inject the grout from the lowest point of the drill hole using a grout tube. Topping off may be necessary to ensure grout level is maintained. A minimum of 8 hours later, or at the direction of the Engineer, grout the annular space inside the cased length of the micropile in a single operation, so that the top plate bears uniformly on the steel pipe and the grout. It may be necessary to inject grout through a pre-drilled hole in the top plate until clean grout exits another pre-drilled vent hole in the top plate. Pump the grout through grout tubes that will remain in the hole and be filled with grout. Use the two-stage grout process in the construction

sequence of all the micropiles, including test micropiles. Test the proof test micropiles tested in tension prior to grouting of the annular space between the bar and cased length of the micropile.

Prepare and submit to the Engineer full installation records for each micropile installed. Submit the records within one work shift after that pile installation is completed. Record the date on the micropile installation log included at the end of this specification. Complete a separate log for each micropile.

#### MICROPILE LOAD TESTS:

##### **Verification Load Testing**

Perform verification load testing of at least three (3) sacrificial test piles, at locations to be determined by the Engineer, prior to installation of any production piles. Conduct the verification tests on sacrificial micropiles that will not be incorporated into the production micropiles. The sacrificial micropiles may be located along the shoulder of the road adjacent to the wall, but the bond needs to be fully in the bedrock. Verification testing consists of a compression load test in accordance with ASTM D1143, except as modified herein, and a tension test on the same micropile after acceptance of the compression test.

Pre-production load testing will be used by the Engineer to verify the adequacy of the Contractor's drilling, installation and grouting methods, and to verify that the test pile has the planned load carrying capacity and factor of safety. Construct the sacrificial verification test piles in accordance with the contract plans and approved shop drawings. The micropile verification load test results must be reviewed and accepted by the Engineer prior to beginning installation of production micropiles. Construct a compression and tension bearing system that will not have excessive movement. Bearing systems that move excessively in either tension or compression and compromise the verification testing will not be accepted and will not be paid for.

The maximum verification and proof test loads applied to the micropile must not exceed 80 percent of the structural capacity of the micropile structural elements, to include steel yield or buckling in compression, or grout crushing in compression. Position the jack at the beginning of the test such that unloading and repositioning of the jack during the test will not be required. During the testing, ensure the reaction frame is sufficiently rigid, such that excessive deformation of the testing equipment does not occur.

Test verification test piles to a maximum test load of 2.0 times the micropile design load (DL) as shown in the contract documents and approved shop drawings. The verification pile load test is done by incrementally loading and unloading the micropile in accordance with the cyclic load schedule provided below for compression loading.

Raise the load from one increment to the next immediately after recording the micropile movement. Measure and record the micropile movement to the nearest 0.001 inch with

respect to two separate independent fixed reference points at the alignment load, and at each increment of load. The test setup requires that the jacking ram and dial gauges both have enough throw for the total movement calculated. Resets due to inadequate range of the dial gauges or jacking ram are not allowed.

Monitor the load with the primary pressure gauge. Place the reference pressure gauge in series with the primary pressure gauge during each performance test. If the load determined by the reference pressure gauge and the load determined by the primary pressure gauge differ by more than ten (10) percent, the jack, primary pressure gauge, and reference pressure gauge are to be recalibrated at no additional expense to the department. Hold the load for a minimum of 2.5 minutes.

<b>Verification Test Loading Schedule</b>		
<b>Load Cycle</b>	<b>Load</b>	<b>Hold time</b>
1	0.10 DL	2.5 minute
	0.25 DL	2.5 minute
	0.50 DL	2.5 minute
	0.05 DL	2.5 minute
2	0.25 DL	2.5 minute
	0.50 DL	2.5 minute
	0.75 DL	2.5 minute
	0.05 DL	2.5 minute
3	0.25 DL	2.5 minute
	0.50 DL	2.5 minute
	0.75 DL	2.5 minute
	1.00 DL	2.5 minute
	0.05 DL	2.5 minute
4	0.25 DL	2.5 minute
	0.50 DL	2.5 minute
	0.75 DL	2.5 minute
	1.00 DL	2.5 minute
	1.33 DL	60 minutes

Verification Test Loading Schedule		
Load Cycle	Load	Hold time
		(Creep test load hold)
	1.75 DL	2.5 minute
	2.00 DL (Maximum test load)	2.5 minute
	0.05 DL	2.5 minute

Measure pile top movement at each load increment.

During the creep test, measure and record total pile movement with respect to a fixed reference point test at 1 minute, 2, 3, 4, 5, 6, 10, 20, 30, 50, and 60 minutes.

The acceptance criteria for micropile verification tests are as follows:

- (1) The pile must sustain the first compression 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 at the alignment load.
- (2) At the end of the 1.33 DL creep test load increment, the test pile must have a creep rate not exceeding 0.04 inches of movement between 1 minute and 10 minutes, or 0.08 inches of movement between 6 and 60 minutes. The creep rate must be constant or decreasing throughout the creep hold period.
- (3) Failure must not occur at the 2.0\*DL maximum test load. Failure is defined as load at which attempts to further increase the test load simply result in continued pile movement.

The Engineer will provide a written confirmation of the micropile capacity and construction within five working days of the completion of the verification load tests. This written confirmation will either confirm the capacities and bond lengths specified in the plans or reject the piles based on the verification test results.

If a verification-tested micropile fails to meet the acceptance criteria, modify the construction procedure and install an additional verification pile. Any modification of construction procedures will be at no change in the contract price unless otherwise approved by the Engineer. Submit a description of any proposed modifications to the Engineer in writing. Do not implement proposed modifications until written approval from the Engineer is received. If subsequent verification piles do not meet the acceptance criteria, continue to install verification piles as directed by the Engineer until the acceptance criteria are met. At the completion of verification testing, remove test piles down to the elevation specified by the Engineer.

Do not use verification test piles as permanent piles in the work.

**Proof Load Testing:**

Based on successful completion, review, and acceptance of the verification micropile testing, perform five (5) proof load tests in tension at locations designated by the Engineer on partially grouted production micropiles.

All modifications to the production micropile design to ensure the required structural capacity is obtained for the load tests are the Contractor's responsibility. For proof testing, do not grout the annular space between the bar and cased (unbonded) length until acceptance of the test results by the Engineer. Only grout the bond length for the testing purposes. Monitor movement of the bar and the top of the micropile separately. Measure and record the ground anchor movement at each load in the same manner as for verification tests. Diligently pursue installation and testing of subsequent proof tests at the required frequency. Test proof test piles within 48 hours of the time that the grout in that pile reaches the specified three-day strength.

Test piles for proof load testing to a maximum of 1.67 times the micropile design load (DL) as shown on the working drawings. Record the micropile movements to the nearest 0.001 inch at each load increment. Proof tests are done by incrementally loading the micropile in accordance with the following schedule:

	<b>Load</b>	<b>Hold time</b>
1	0.10 DL	2.5 minute
2	0.25 DL	2.5 minute
3	0.50 DL	2.5 minute
4	0.75 DL	2.5 minute
5	1.00 DL	2.5 minute
6	1.33 DL	10 or 60 minute creep test
7	1.67 DL	2.5 minute
8	0.05 DL	2.5 minute

Depending on performance, either a 10 minute or 60 minute creep test must be performed at the 1.33 DL test load. Measure and record total pile movement with respect to a fixed reference point during the creep test at 1 minute, 2, 3, 4, 5, 6, and 10 minutes. If the total movement between 1 and 10 minutes exceeds 0.04 inches, maintain the 1.33DL load for an additional 50 minutes. Then record total movements at

15, 20, 25, 30, 45 and 60 minutes. Start the Load Hold time when the pump begins to load the anchor from the 1.00DL load to the creep test load.

The acceptance criteria for micropile proof test loads are as follows:

- (1) The pile must sustain the design load with no more than 0.5-inch total movement at the top of the pile, relative to the position of the top of the pile at the alignment load.
- (2) At the end of the 1.33 DL creep test load increment, test piles must have a creep rate not exceeding 0.04 inches of movement between 1 minute and 10 minutes, or 0.08 inches of movement between 6 and 60 minutes. The creep rate must be constant or decreasing throughout the creep load hold period.
- (3) Failure must 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.

If a proof-tested micropile fails to meet the acceptance criteria, immediately proof test two of the production micropiles installed after the last proof test micropile which met the acceptance criteria. If 100 percent of these micropiles meet the acceptance criteria, replace the failed micropile. If less than 100 percent of these piles meet the acceptance criteria, proof test the remaining production micropiles installed after the last proof test micropile which met the acceptance criteria, and replace any micropile which fails to meet the acceptance criteria.

If the Contractor chooses to modify the construction procedure, install and test an additional verification test pile using the modified construction procedure. Any modification that requires changes to the structure design requires the Engineer's prior review and acceptance. Any modifications of the construction procedures, or cost of additional verification test piles, verification and/or proof load testing, or replacement production micropiles, are at no additional cost to the department.

#### MEASUREMENT AND PAYMENT:

The Engineer will measure:

1. Micropiles by the linear foot, from the elevation shown on the plans to the bottom of the hole as drilled
2. Verification Test Pile for micropiles by the actual number of test piles installed at the direction of the Engineer

The department will pay as follows:

The accepted quantities will be paid for at the contract unit price per unit of measurement for each of the pay items listed below.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>	<b>Measure to the Nearest</b>	<b>Pay to the Nearest</b>
Special Item FT-A (5.5 Inch Micropiles)	FT	0.1 FT	FT
Special Item EA-A (Micropile Verification Test)	EA	EA	EA

Payment for micropiles will be full compensation for all drilling, hauling and disposal of drill cuttings, performing all necessary pumping; grout and grout overruns, reinforcement including couplers and bearing plate steel; all backfilling; removal of casings; any casings left in place; and for furnishing all tools, labor, equipment, and incidentals necessary to complete the work. Grout will not be paid for separately but will be included in the work. Proof Testing will not be paid for separately but will be included in the work. Verification testing will be paid separately.

Payment for Verification Test Micropiles includes all micropile materials, tools, labor, equipment, bearing structures, and incidentals necessary to complete the test, including multiple reaction piles.

03-17-11