

STANDARD SPECIFICATION
FOR
MICROPILE CONSTRUCTION

1. Description

- a) This work shall consist of constructing micropiles as shown on the Contract plans in accordance with these Specifications.
- b) The verification of micropile load capacities through the performance of proof load tests.
- c) The work covered by this item shall consist of furnishing of all materials, products, accessories, tools, equipment, services, transportation, labor and supervision, installation and testing of micropiles and pile top attachments.

2. Materials

- a) Admixtures for Grout: Admixtures shall conform to the requirements of ASTM C 494/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 manufacture'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 C 150/AASHTO M85, Types 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. Centralizers and spacers shall be securely attached to the reinforcement; sized to position the reinforcement within ½ inch of plan location from center of pile; sized to allow grout tremie pipe insertion to the bottom of the drillhole; and sized to allow grout to freely flow up the drillhole and casing and between adjacent reinforcing bars.
- d) Encapsulation: 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 1/32 inches. The inside annulus between the reinforcing bars and the encapsulating tube shall be a minimum of ¼ inch and be fully grouted with non-shrink grout conforming to this section.
- e) Epoxy Coating: The minimum thickness of coating applied electrostatically to the reinforcing steel shall be 0.01 inches. Epoxy coating shall be in accordance with ASTM A775 or ASTM A 934. Bend test requirements are waived. Bearing plates and nuts encased in the pile concrete footing need not be epoxy coated.

- f) Fine Aggregate: If sand – cement grout is used, sand shall conform to ASTM C 144/AASHTO M45.
- g) 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.
- h) Grout Protection: Provide a minimum 1 inch grout cover over bare or epoxy coated bars (excluding bar couplers) or minimum 1/2 inch grout cover over the encapsulation of encapsulated bars.
- i) Permanent Casing Pipe: Permanent steel casing/pipe shall have the diameter and at least minimum wall thickness shown on the Drawings. The permanent steel casing/pipe:
 - 1. shall meet the Tensile Requirements of ASTM A252, Grade 3, except the yield strength shall be a minimum of 50 ksi to 80 ksi as indicated on the drawings.
 - 2. may be new “Structural Grade” (a.k.a. “Mill Secondary”) steel pipe meeting above but without Mill Certification, free from defects (dents, cracks, tears) and with two coupon tests per truckload delivered to the fabricator.

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

- 1. the carbon equivalency (CE) as defined in AWS 1.1, Section X15.1, shall not exceed 0.45, as demonstrated by mill certifications.
- 2. 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:

- 1. the steel pipe shall not be joined by welded lap splicing.
- 2. welded seams and splices shall be complete penetration welds.
- 3. partial penetration weld may be restored in conformance with AWS D1.1.
- 4. the proposed welding procedures certified by a welding specialist shall be submitted for approval.

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

- j) Plates and Shapes: Structural steel plates and shapes for pile top attachments shall conform to ASTM A 36/AASHTO M31, Grade 420 or Grade 520 or ASTM A 722/AASHTO M275, Grade 1035. When a bearing plate and nut are required to be threaded onto the top end of reinforcing bars for the pile top to footing anchorage, the threading may be continuous spiral deformed ribbing provided by the bar deformations (e.g., Dywidag or Williams continuous threadbars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, the next larger bar number designation from that shown on the Plans shall be provided, at no additional cost.

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

3. 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 steeper than those specified herein or shown on the Plans will be made above or below the micropile structure locations without written approval of the Engineer.

c) 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 plus 1 inch or minus 2 inches maximum from vertical elevation indicated.
4. Centerline of reinforcing steel shall not be more than ½ inch from indicated location.

d) 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 determine the micropile casing size, final drillhole diameter and bond length, and central tendon 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.

e) 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 that requires remedial repair measures. Use of drilling fluid containing bentonite is not allowed.

f) Ground Heave or Subsidence

During construction, the Contractor shall observe the conditions vicinity of the micropile construction site on a daily basis for signs of ground heave or subsidence. Immediately notify the Engineer if signs of movements are observed. Contractor shall immediately suspend or modify drilling or grouting operations if ground heave or subsidence is observed if the micropile structure is adversely affected, or if adjacent structures are damaged from the drilling or grouting. If the Engineer determines that the movements require corrective action, the Contractor shall take corrective actions necessary to stop the movement or perform repairs. When due to the Contractor's methods or operations or failure to follow the specified/approved construction sequence, as determined by the Engineer, the costs of providing corrective actions will be done 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.

g) 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. Reinforcement surface shall be free of deleterious substances such as soil, mud, grease or oil that might contaminate the grout or coat the reinforcement and impair bond. Pile cages and reinforcement groups, if used, shall be sufficiently robust to withstand the installation and grouting process and the withdrawal of the drill casings without damage or disturbance.

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

Centralizers and spacers (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 in 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 drill hole 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 the 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, bar splices shall be staggered at least 1 foot.

h) 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.

If the Contractor elects to use a postgrouting system, Working Drawings and details shall be submitted to the Engineer for review.

i) Grout Testing

Grout within the micropile 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 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 3 cubes tested.

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

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

j) 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 included at the end of this specification. A separate log shall be provided for each micropile.

k) Pile Load Tests

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

l) Proof Load Tests

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. Proof testing shall be conducted at a frequency of 5% (1 in 20) of the subsequent production piles installed, beyond the first 20, in each abutment and pier. Location of additional proof test piles shall be as designated by the Engineer.

m) Proof Test Loading Schedule

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

	AL = Alignment Load	DL = Design Load
	LOAD	HOLD TIME
1	AL	1 minute
2	0.25 DL	1 minute
3	0.50 DL	1 minute
4	0.75 DL	1 minute
5	1.00 DL	1 minute
6	1.33 DL	10 or 60 minute Creep Test
7	1.67 DL (Maximum Test Load)	1 minute
8	AL	1 minute

Depending on performance, either a 10 minute or 60 minute creep test shall be performed at the 1.33 DL Test Load. Where the pile top movement between 1 and 10 minutes exceeds 1 mm, the Maximum Test Load shall be maintained an additional 50 minutes. Movements shall be recorded at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. The alignment load shall not exceed 5 percent of DL. Dial gauges shall be reset to zero after the initial AL is applied.

The acceptance criteria for micropile proof load tests are:

1. The pile shall sustain the compression or tension 1.0 DL test load with no more than ¼ 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 1.33 DL creep test load increment, test piles shall have a creep rate not exceeding 1 mm/log cycle time (1 to 10 minutes) or 2 mm/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 1.67 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.

n) **Proof Test Pile Rejection**

If a proof-tested micropile fails to meet the acceptance criteria, the Contractor shall immediately proof test another micropile within that footing. For failed piles and further construction of other piles, the Contractor shall modify the construction procedure or the Engineer shall modify the design 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 construction procedures, or cost of proof load testing, or replacement production micropiles, shall be paid at the Contract unit price.

4. **Method of Measurement**

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

- a) Micropiles will be measured per each, installed, and accepted.
- b) Micropile proof load testing will be measured per each.

The final pay quantities will be the design quantity increased or decreased by any changes authorized by the Engineer.

5. **Basis of Payment**

- a) The accepted quantities for the items listed below will be paid for at the Contract Unit Price and shall be full compensation for all materials, labor, equipment and incidentals to complete the work in accordance with the Plans and Specifications.
- b) The Contract Unit Price for Micropiles shall include the drilling, furnishing, and placing the reinforcing steel and casing, grouting, and pile top attachments.

- c) Payment will be made under the following bid items as set forth in the Bid Schedule:

<u>Pay Item</u>	<u>Unit</u>
Micropile	Ea.
Micropile Proof Load Test	Ea.
Micropiles Variations in Length to Top of Rock	Lin. Ft.**

**Where piles are founded in rock, micropiles will be paid on a per each basis assuming Rock at Elevation -25 feet below existing grade. Additional length or shorter length due to variations in the top of rock will be paid on an add or deduct lineal foot basis where the linear footage = Elevation - minus Elevation of As-Built Rock.