MICROPILES
Effective: April 19, 1996
Revised: October 5, 2015

Description. This work shall consist of designing, furnishing, installing and testing the proposed micropiles according to the plans, approved shop drawings, and this Special Provision.

The Contractor shall be responsible for selecting the micropile type, installation method, bond lengths, grout pressures, and any necessary changes to the structural elements, such that the micropiles will carry both the compressive and tension design loads indicated on the plans at the maximum tolerable deflections specified. The Contractor shall demonstrate the micropile adequacy by performing pile load test(s) and micropile proof tests that satisfy the acceptance criteria of this Special Provision.

Submittals. The Contractor selected to perform this work shall satisfy the qualification requirements and shall provide shop drawings for the proposed micropile installation.

(a) Qualifications: The Contractor performing the work shall have personnel experienced in the design, construction and testing of micropiles. The Contractor shall have successfully installed a total of at least 100 micropiles on no less than five (5) different projects completed within the last five (5) years of similar project conditions and capacities to those required on this project.

The Contractor shall assign a field supervisor with experience on at least three (3) projects of similar scope to this project, completed over the past five (5) years. The on-site foreman and drill rig operator(s) must have completed three (3) projects within the last five (5) years involving micropiles of equal or greater capacity than required on this project. The Department may suspend the micropile work if the Contractor substitutes unqualified personnel and the Contractor shall be liable for additional costs resulting from the suspension.

The above experience qualifications list and personnel list shall be submitted for approval prior to or with the shop drawings submittal.

(b) Design Calculations and Shop Drawings. At least five weeks before work is to begin, the Contractor shall submit to the Engineer for review and approval, design calculations and complete shop drawings describing the micropile system, or systems, intended for use. The micropiles shall be designed and detailed to carry the tension and compression loadings indicated on the plans. The submittal shall be prepared and sealed by an Illinois Licensed Structural Engineer and include (as a minimum) the following:

(1) Design calculations including the following:

a. Geotechnical design computations that describe how the micropile bonded lengths were designed.

b. Applicable code requirements and design reference literature used in the geotechnical and structural computations.

c. Micropile design profile cross-section(s) geometry including casing plunge length(s), bonded lengths and minimum diameter, the soil/rock strata anticipated, and the piezometric levels.

d. Design criteria including soil/rock shear strengths (friction angle and cohesion), unit weights, minimum grout compressive strength, ground/grout bond values, and assumptions for each soil/rock strata.

e. Resistance factors used and the resulting factored geotechnical resistance of each portion of the micropile.

f. Structural design calculations sizing the load and proof testing frame, reaction piles and connections to both the reaction piles and micropiles. Geotechnical calculations shall be submitted to indicate that a minimum factored resistance exists for the reaction piling equal to twice the maximum test loading.

g. If proposing to modify the anchorage head assembly, connection to footing, casing, reinforcement, bearing plate or weld details shown in the plans, structural calculations supporting these changes shall also be submitted.

(2) Shop drawings including the following:

a. Plan view of the project showing:
   1. All proposed micropiles with each labeled with a unique identification number.
   2. Locations of subsurface exploration borings plotted and labeled.
   3. Proposed overall sequence of construction.
   4. Locations of micropiles to be proof tested and load tested.

b. Elevation view of project showing:
   1. The location of the existing substructures and all soil boring data plotted with all major changes in soil type or stratification identified.
   2. The proposed micropile lengths plotted at each substructure as well as the bottom of casing, top of bonded length, plunge length and minimum tip elevations indicated.
   3. All general notes for constructing the micropiles.

c. Micropile typical section showing:
   1. The proposed typical micropile configuration(s) including steel casing, reinforcement sizes, grout tubes and minimum grouted diameters (in both the cased and bonded lengths).
   2. Step by step installation procedure(s) including casing advancement, grouting elevations, re-grouting, etc.
   3. Reinforcement centralizers and spacer locations and details.

4. Casing splice details.

d. Anchorage head assembly details including reinforcement, casing, bearing plate, embedment/connection to footing and required weld sizes if proposing to deviate from those provided in the plans.

e. Any revisions to details shown on the plans necessary to accommodate the micropile system intended for use.

f. Micropile load and proof testing sheet showing:
   1. Load frame and anchor pile details for load tests.
   2. Load frame and reaction pile connection for proof testing production piles.
   3. Any additional reinforcement and grout strength required in the load test micropiles to permit testing to 1.5 times the design loadings.
   4. Jack, pressure gauge and load cell calibration curves.

g. The grout mix design and procedures for monitoring and recording the grout depth, volume and pressure during the grouting process.

Work shall not start on any micropile, nor shall materials be ordered, until the shop drawings and qualifications have been approved in writing by the Engineer.

Materials. The materials used for the construction of the micropiles shall satisfy the following requirements:

(a) Reinforcement Steel: Micropiles reinforcement shall consist of single or multiple elements of either 150 ksi (1034 MPa) or 75ksi (520 MPa) (f_u) high strength threadbars or deformed bars conforming to ASTM A722 or A706.

(b) Steel Couplers: Prestressing steel couplers shall be capable of developing 95 percent of the minimum specified ultimate tensile strength of the reinforcement steel.

(c) Grout: The grout shall consist of a neat cement or sand cement mixture of Type II, III or V portland cement conforming to Section 1024.01 of the Standard Specifications. The minimum compressive strength of the grout shall be as specified on the plans but not less than 4 ksi (27.6 MPa). Expansive admixtures may not be used except to seal the encapsulations and anchorage covers. Admixtures to control bleed, improve flowability, reduce water content, and retard set may be used if approved by the Engineer. Accelerators and admixtures containing chlorides are not permitted.

(d) Fine Aggregate: If sand-cement grout is used, sand shall conform to the requirements for fine aggregates according to Section 1003 of the Standard Specifications.

(e) Spacers: Spacers for separation of elements of a multi-element reinforcement shall permit the free flow of grout. They shall be fabricated from plastic, steel or material which is not detrimental to the reinforcement. Wood shall not be used. Spacers shall be placed along

the total length of the micropile so that the steel will bond to the grout. They shall be located at 10 ft (3 m) maximum centers with the upper one located a maximum of 5 ft (1.5 m) from the top of the micropile and the lower one located a maximum of 5 ft (1.5 m) from the bottom of the bonded length.

(f) Centralizers: Centralizers shall be fabricated from plastic, steel or material which is not detrimental to the reinforcing steel. Wood shall not be used. Centralizers shall be able to maintain the reinforcement position and alignment so that a minimum of 1.5 inches (38 mm) of grout cover is obtained at all locations below the cased micropile length. They shall be located at 10 ft (3 m) maximum centers with the lower one located one foot from the bottom of the bonded length.

(g) Anchorage head assembly: The materials properties, dimensions, and design details for the micropile anchorage head assembly components shall be as specified on the contact plans unless otherwise proposed by the Contractor and approved as part of the shop drawings submittal. Anchorage components may include bearing plates (ASTM A572 Grade 50), shear studs, reinforcement steel, nuts, casing and other approved components.

(h) Steel casing: Steel casing shall be flush joint API N-80 Pipe of the wall thickness and diameter shown on the plans. Any changes to this casing shall be submitted to the Department for review and approval as part of the shop drawing submittal.

Construction Requirements. The drilling method used may be rotary drilling, percussion drilling or an approved alternate. The method of installation used shall be that which prevents loss of ground around the drilled hole that may be detrimental to the structure. The drillhole shall be maintained open along its full length at the minimum drillhole diameter specified on the approved shop drawings prior to placing reinforcement and grout. Temporary casing or other approved method of micropile drillhole support shall be required in caving or unstable conditions.

The Contractor shall notify the Engineer if an obstruction is encountered. An obstruction is an unknown isolated object that causes the excavation to experience a significant decrease in the actual production rate and requires the Contractor to core, break up, push aside, or use other means to mitigate the obstruction. Subsurface conditions such as boulders, cobbles, or logs and buried infrastructure such as footings, piling, or abandoned utilities, when shown on the plans, shall not constitute an obstruction. When an obstruction is encountered, the Contractor shall notify the Engineer immediately and upon concurrence of the Engineer, the Contractor shall mitigate the obstruction with an approved method unless relocating the micropile would be less expensive.

Casing shall be installed in sections of appropriate lengths with threaded connections. The casing shall be capable of advancing the hole through the soil strata as indicated in the boring data. Welded Joints may be used if the welding detail is submitted and approved as part of the shop drawings.

The reinforcement shall be placed prior to grouting. The reinforcement shall be inserted to the desired depth without undue stress or difficulty (not driven or forced). When the reinforcement

cannot be completely inserted it shall be removed and the drill hole cleaned or re-drilled to permit insertion. The reinforcement shall be free of soil, grease, or oil that might reduce the grout to bar bond.

The micropiles shall be grouted within 24 hours after the load transfer bond length is drilled. Grout shall be free of any lumps and undispersed cement. The grout volumes and pressures shall be measured and recorded during the placement operation. The pump shall be equipped with a grout pressure gauge at the pump and a second gauge placed at the point of injection at the top of the casing to monitor grout pressures. The gauges shall be capable of measuring pressures of at least 150 psi (1.0 MPa) or twice the actual grout pressures used, whichever is greater. The grout shall be continuously agitated after mixing. All grout shall be place 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 drillhole (through grout tubes, casing, drill rods, etc.) and continued until uncontaminated grout flows from the top of the micropile. Temporary casing, if used, shall be extracted in stages ensuring that, after each length of casing is removed, the grout level is brought up to ground level before the next length is removed. The casing or grout tube shall always extend below the level of the grout in the drillhole. Upon completion of grouting, the grout tube or access valve may remain in the drill hole and anchorage head assembly provided it is filled with grout. The grout take and pressure shall be controlled to prevent any heave of the ground surface or foundations.

The Contractor shall monitor the existing foundation for movement. If movement is detected, the Contractor shall immediately stop production and notify the Engineer. Work shall not resume until the Contractor's recommendations to remedy the situation are approved by the Engineer.

The following construction tolerances shall apply to all production micropiles:

(a) The center of the micropile casing shall be within 2 in. (50 mm) of plan location in any direction at the top of the pile.

(b) The deviation of the shaft batter from that specified shall not exceed 1/8 in./ft. (10 mm/m).

(c) The top of the casing shall be within ± 2 inches (50 mm) of the plan elevation.

Micropile Load Test and Micropile Proof Test. The Contractor shall install and load test non-production micropile(s) as well as proof test selected production micropiles. The load testing shall be performed by incrementally loading the micropiles according to ASTM D 1143 for the compression loading and ASTM D 3689 for the tension loading using the Quick Load Test Method except as modified herein. Testing shall not take place until the grout has acquired the specified design strength.

The jack ram travel shall be positioned at the beginning of the test so that unloading and repositioning during the test shall not be required. When both compression and tension loading is to be performed, it shall be performed on the same micropile and the compression loading shall be conducted first. Dial gauges capable of measuring displacements to 0.001 inch (0.025 mm) shall be used to measure micropile movement of the jack from an independent reference

point. If the test setup requires reaction against the ground or a single row of reaction piles, two gauges shall be used on either side of the micropile. The reaction frame and piles shall be adequately stiff to prevent excessive deformation, misalignment or racking under peak loading. The stressing equipment shall be placed over the micropile in such a manner that the jack, load cell, and load test reaction frame are axially aligned with the anchorage head assembly reinforcement. Gauges shall have adequate travel so the total micropile movements can be measured without resetting the devices.

Test loads shall be applied with a hydraulic jack and measured with a pressure gauge. The pressure gauge shall be graduated in 72 psi (500 kPa) increments or less. The jack and pressure gauge shall have a pressure range not exceeding twice the anticipated maximum test pressure. Monitor the creep test load hold during testing with both the pressure gauge and electronic load cell. The load cell shall be used to accurately maintain a constant load hold during the creep test load hold increment of the testing.

Micropile Load Test. The Contractor shall perform non-production micropile load test(s) to verify the design and the construction methods proposed prior to installing production micropiles. The number and general location of the load test(s) are indicated in the plans and shall be constructed and tested according to this specification and the approved shop drawings.

The micropile load test Design Load shall be taken as the maximum factored compression and tension strength group loadings indicated at any substructure covered by the load test as shown on the plans. Micropiles not founded in rock shall follow the test loading schedule shown below. Micropiles founded in rock may omit increments 1 through 12:

Load Test Schedule

Increment	Loading Applied	Increment	Loading Applied
1	Alignment Load	13	Alignment Load
2	0.25 Design Load	14	0.25 Design Load
3	0.50 Design Load	15	0.50 Design Load
4	Alignment Load	16	0.75 Design Load
5	0.25 Design Load	17	1.00 Design Load
6	0.50 Design Load	18	1.25 Design Load
7	0.75 Design Load	19	1.50 Design Load
8	Alignment Load	20	1.00 Design Load
9	0.25 Design Load	21	0.50 Design Load
10	0.50 Design Load	22	0.25 Design Load
11	0.75 Design Load	23	Alignment Load
12	1.00 Design Load		

The dial gauges shall be reset to zero after the initial Alignment Load increment is applied. The Alignment Load is defined as the minimum load necessary to maintain alignment of the stressing equipment and reaction frame. The load holding period shall start as soon as each load increment is fully applied and last for 1 minute for each increment with the exception of the 1.0 load increments which shall be held for 10 minutes. The jack shall be re-pumped as

necessary in order to maintain a constant load during this period. The micropile deflections shall be measured and recorded at the end of the load holding period. In addition, the 1.0 load hold increment shall be monitored for creep by recording the micropile movements at 1, 2, 3, 5, 6, and 10 minutes during the load hold. If the movement between the 1 and 10 minute increments exceeds 0.04 inches (1 mm), the load hold shall be extended and held for an additional 50 minutes. Movement shall be recorded at the 15, 20, 30, 40, 50 and 60 minute time increments.

A graph shall be constructed showing a plot of anchorage head assembly movement deflections versus test loading (both tension and compression) at the end of each load increment in the test schedule including the rebound measurements after unloading.

The acceptance criteria, demonstrating a successful load test, are as follows:

(a) The micropile shall carry at least 1.0 times the design compression and tension loadings with a deflection of the anchorage head assembly less than the theoretical elastic deflection from its anchorage head to the midpoint of the bonded length.

(b) The micropile shall have a creep rate not exceeding 0.08 inch (2 mm)/log cycle of time at the end of the 1.5 times the Design Load increment. The creep rate graphed on log scale shall be linear or decreasing throughout the creep load hold period.

(c) The nominal geotechnical resistance shall exceed 1.5 times the factored compression and tension design loads shown on the plans, as determined using Davisson Method as presented in AASHTO article 10.7.3.8.2.

In the event that a load tested micropile fails the acceptance criteria, the Contractor shall re-evaluate his/her design and construction procedures, making the necessary changes to install an additional non-production micropile and any additional anchor pile(s) to allow another load test. The above process shall be repeated until a successful micropile passes the load test acceptance criteria. Payment for the successful load test shall include all work associated with any failed micropile load test(s).

The Engineer will provide the Contractor with written confirmation of the micropile design and construction within 10 working days of the completion of the load test(s). This written confirmation shall confirm the adequacy of the bonded lengths and tip elevations shown on the Contractor's shop drawing or the revised values required due to any failed micropile.

Load tested micropiles and reaction piles located in non-production locations shall be cut 2 ft. (600 mm) below finished grade after completion.

Micropile Proof Test: The Contractor shall install a set of micropiles at each substructure unit designated to have micropiles for the purpose of conducting a proof test on a production micropile. A set of micropiles is defined as the minimum number of micropiles (production or sacrificial) required to proof test a production micropile and provide the proof test load frame reaction capacity. If the contactor chooses to install additional production micropiles prior to

proof testing, re-grouting or additional micropiles may be required at the contractor expense should the proof test not pass the acceptance criteria.

The proof test Design Load shall be taken as the maximum factored compression and maximum tension strength group loadings indicated at each substructure, shown on the plans. The loadings shall be incrementally applied according to the schedule shown below:

Proof Test Schedule

Increment	Loading Applied	Increment	Loading Applied
1	Alignment Load	7	0.90 Design Load
2	0.15 Design Load	8	1.00 Design Load
3	0.30 Design Load	9	0.75Design Load
4	0.45 Design Load	10	0.50 Design Load
5	0.60 Design Load	11	0.25 Design Load
6	0.75 Design Load	12	Alignment Load

The dial gauges shall be reset to zero after the initial Alignment Load increment is applied. The Alignment Load is defined as the minimum load necessary to maintain alignment of the stressing equipment and reaction frame. The load holding period shall start as soon as each load increment is fully applied and last for 1 minute for each increment with the exception of the 1.00 load increment which shall have a 10 minute load hold. If the top of the micropile movement between the 1 minute and 10 minute time intervals exceeds 0.04 inches (1 mm), the 1.00 load hold shall be maintained for an additional 50 minutes. The jack shall be re-pumped as necessary in order to maintain a constant load during this period. The micropile deflections shall be measured and recorded at the end of the load holding period. The 1.00 load hold increment shall be monitored by recording the micropile movements at 1, 2, 3, 5, 6, and 10 minutes and if extended shall be recorded at the 20, 30, 50, and 60 minutes during the load hold.

A graph shall be constructed showing a plot of anchorage head assembly movement deflections versus test loading (both tension and compression) at the end of each load increment in the test schedule including the rebound measurements after unloading.

The acceptance criteria, demonstrating a successful load test, are as follows:

(a) The micropile shall carry at least 1.0 times the design compression and tension loadings with a deflection of the anchorage head assembly less than the theoretical elastic deflection from its anchorage head to the midpoint of the bonded length.

(b) The micropile shall have a creep rate not exceeding 0.08 inch (2 mm)/log cycle of time at the end of the 1.0 times the Design Load increment. The creep rate graphed on log scale shall be linear or decreasing throughout the creep load hold period.

In the event that a production micropile fails the proof test acceptance criteria, the Contractor shall re-evaluate his/her design and construction procedures, make the necessary changes and install an additional non-production micropile and additional anchor pile(s), outside the proposed

footing and proof test the revised micropile. The above process shall be repeated until a micropile passes the acceptance criteria. The set of production micropiles installed as part of the failed proof test shall be cut flush with the bottom of the footing and supplemented by micropiles installed using improved design and installation methods adjacent to the failed micropiles. The failed load test(s), any supplemental or additional anchor piles, or micropiles cut flush with the bottom of the footing shall be included with the successful micropile proof test loading.

Basis of Payment. This work will be paid for at the contract unit price each for MICROPILES, and shall be compensation in full for designing, furnishing and installing the production micropiles incorporated in the final structure, according to the contract plans, approved shop drawings, and the Special Provisions. Pile load testing of non-production micropiles passing the acceptance criteria will be paid for at the contract unit price each for MICROPILE LOAD TEST and shall be compensation in full for designing, furnishing and installing the load tested micropile(s), anchor piles, reaction frame, and applying the test loads. Micropile proof testing of selected production micropiles will be paid for at the contract unit price each for MICROPILE PROOF TEST and shall be compensation in full for installing the anchor piles, reaction frame, and applying the test loads.

Obstruction mitigation will be paid for according to Article 109.04 of the Standard Specifications.