SECTION 31 63 33
MICROPILES

PART 1 - GENERAL

1.1 DESCRIPTION:

This specification, along with the drawings, encompasses the furnishing of all designs, materials, products, accessories, tools, equipment, services, transportation, labor and supervision, and installation techniques required for testing and installing of micropiles and pile-top attachments.

1.2 SCOPE OF WORK

The work consists of furnishing all necessary engineering and design services (if required), supervision, labor, materials, and equipment to perform all work necessary to install and test the micropiles, at project site per the specifications described herein, and as shown on the design drawings. The micropile contractor shall install a micropile system that will develop the load capacities indicated on the drawings. The micropile load capacities and measurements may be verified by testing if required and as specified herein.

1.3 RELATED WORK

A. Materials testing and inspection during construction: Section 01 45 29, TESTING LABORATORY SERVICES.
B. Concrete: Section 03 30 00, CAST-IN-PLACE CONCRETE.
C. Subsurface investigation: Section 01 00 00, GENERAL REQUIREMENTS, Article, PHYSICAL DATA.

1.4 QUALIFICATIONS OF CONTRACTOR

A. The micropile contractor shall be fully experienced in all aspects of micropile design and construction, and shall furnish all necessary plant, materials, skilled labor, and supervision to carry out the contract. The contractor will have successfully completed at least five projects in the previous five years of similar scope and size. He must also provide resumés of key personnel who will be present on site (and will be materially involved) and who will each have at least three years of relevant experience. These personnel include superintendent, driller, and project engineer/manager. Alternatively, the owner can provide a list of prequalified micropile contractors.
B. The micropile contractor shall not sublet the whole or any part of the contract without the express permission in writing of the Government.

1.5 DEFINITIONS

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

B. **Alignment Load (AL):** A nominal load applied to a micropile during testing to keep the testing equipment correctly positioned.

C. **Apparent Free Micropile Length:** The length of pile which is apparently not bonded to the surrounding ground, as calculated from the elastic load extension data during testing.

D. **Bond Breaker:** A sleeve or coating placed over the steel reinforcement to prevent load transfer.

E. **Bonded Length:** The length of the micropile that is bonded to the ground and which is conceptually used to transfer the applied axial loads to the surrounding soil or rock. Also known as the load transfer length.

F. **CASE 1 Micropile:** A pile designed to accept load (either axial or lateral)directly, and transfer it to an appropriate bearing stratum. Usually comprises significant steel reinforcement.

G. **Casing:** Steel pipe introduced during the drilling process to temporarily stabilize the drill hole. Depending on the details of the micropile construction and composition, this casing may be fully extracted during or after grouting, or may remain partially or completely in place, as part of the final pile configuration.

H. **Centralizer:** A device to centrally locate the reinforcing element(s) within the borehole.

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

J. **Core Steel:** Reinforcing bars or pipes used to strengthen or stiffen the pile, excluding any left-in drill casing.

K. **Corrosion Inhibiting Compound:** Material used to protect against corrosion (and/or lubricate the reinforcing steel inside a bond breaker).

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

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

N. **Design Load (DL):** Anticipated final maximum service load in the micropile.

O. **Duplex Drilling:** A drilling system involving the simultaneous advancement of (inner) drill rod and (outer) drill casing. Flush from the inner drill rod is permitted to exit the borehole via the annulus between rod and casing.

P. **Elastic Movement:** The recoverable movement measured during a micropile test.

Q. **Encapsulation:** A corrugated tube protecting the reinforcing steel against corrosion.

R. **Free (unbonded) length:** The designed length of the micropile that is not bonded to the surrounding ground or grout during testing.

S. **Micropile:** A small diameter, bored, cast-in-place pile, in which most of the applied load is resisted by the steel reinforcement.

T. **Overburden:** Non-lithified material, natural or placed, which normally requires cased drilling methods to provide an open borehole to underlying strata.

U. **Post Grouting:** The injection of additional grout into the load transfer length of a micropile after the Primary grout has set. Also known as regrouting or secondary grouting.

V. **Preloading:** The principle whereby load is applied to the micropile, prior to the micropile's connection to the structure, to minimize any structural movement in service.

W. **Primary Grout:** Portland cement based grout that is injected into the micropile hole prior to or after the installation of the reinforcement to provide the load transfer to the surrounding ground along the micropile and affords a degree of corrosion protection in compression.

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

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

Z. **Residual Movement:** The non-elastic (non-recoverable) movement of a micropile measured during load testing.

AA. **Safety Factor:** The ratio of the ultimate capacity to the working load used for the design of any component or interface.

AB. **Single Tube Drilling:** The advancement of a steel casing through overburden usually aided by water flushing through the casing. Also known as “external flush.” The fluid may or may not return to the

surface around the casing, depending largely on the permeability of the overburden.

AC. **Test Load (TL):** The maximum load to which the micropile is subjected during testing.

AD. **Tremie Grouting:** The placing of grout in a borehole via a grout pipe introduced to the bottom of the hole. During grouting, the exit of the pipe is kept at least 10 feet below the level of the grout in the hole.

AE. **Type A-D:** Classification of micropiles based on method and pressure of grouting (see FHWA, 1997).

AF. **Working Load:** Equivalent term for Design Load.

1.6 ALLOWABLE TOLERANCES

A. Centerline of piling shall not be more than 3 in. from indicated plan location.

B. Pile-hole alignment shall be within 2% of design alignment.

C. Top elevation of pile shall be within +1 in. to -2 in. of the design vertical elevation.

D. Centerline of core reinforcement shall not be more than ¾ in. from centerline of piling.

1.7 DESIGN CRITERIA

A. The micropiles shall be designed to meet the specified loading and movement conditions as shown on the drawings. Micropiles are to be designed assuming transfer of their load to ground is through grout-to-ground skin friction without any contribution from end bearing. The calculations and drawings required from the Contractor shall be submitted to the Government for review and acceptance in accordance to Section 3.1 “Pre-construction Submittals”.

B. The allowable working load on the pile shall not exceed the following values:

1. For compression loads:

a. $P_{allc} = (0.33 * f'_c * A_{grout} + 0.4 * fy_{casing} * A_{casing} + 0.4 * fy_{bar} * A_{bar})$

where:

P_{allc} = allowable working load (compression)

f'_c = Unconfined Compressive Strength (UCS) of grout

A_{grout} = area of grout

fy_{casing} = yield strength of casing up to 80 ksi

A_{casing} = area of steel casing (with allowance for corrosion if appropriate)

fy_{bar} = yield strength of rebar/core steel up to 80 ksi

2. For tension loads:

a. $P_{all}T = 0.6* (fy_{casing} * A_{casing}T + fy_{bar} * A_{bar})$

where:

$P_{all}T$ = allowable working load (tension)

fy_{casing} = yield strength of casing

$A_{casing}T$ = area of steel casing (at threaded joints if applicable)

fy_{bar} = yield strength of rebar/core steel

A_{bar} = area of rebar/core steel

C. The micropile top attachment shall effectively distribute the design load (DL) to the concrete footing, such that the concrete bearing stress does not exceed those in the ACI Building Code and the bending stress in the steel plates does not exceed AISC Allowable stresses for steel members.

D. The geotechnical capacity shall not be relied upon from the following stratigraphic units cohesive soil _____.
The overall length of a micropile will be selected such that the required geotechnical capacity is developed by skin friction between grout and ground over a suitable length in an appropriate stratum (sand).

E. Corrosion Protection:

1. Corrosion protection requirements for the various elements shall be provided meeting the requirements of Table 1 for:

a. Loading Condition: Compression and Tension.

b. Ground: Non-Aggressive

CORROSION PROTECTION

LOADING	TENSION (1)		COMPRESSION	
GROUND	AGGRESSIVE (1)	NON-AGGRESSIVE	AGGRESSIVE (1)	NON-AGGRESSIVE
CASING	a. DO NOT RELY ON CASING FOR LOAD CAPACITY	a. NONE PROVIDED TENSION LOAD ON CADING IN LESS THAN 20% OF CASING THREAD STRENGTH OR b. DO NOT RELY ON CASING FOR LOAD CAPACITY	a. MIN 01/16" CORROSION LOSS ON OUTSIDE	a. NONE
CORESTEEL	a. EPOXY COATING (2) OR b. GALVANIZATION(2) OR ENCAPSULATION IN PLASTIC SHEATH (2) AND GROUT COVER (3)	a. BARE STEEL (4) OR b. EPOXY COATING (2) OR c. GALVANIZATION (2) OR d. ENCAPSULATION IN PLASTIC SHEATH (2) AND GROUT COVER (3)	a. GROUT COVER (3) AND	a. GROUT COVER (3)

Table 1

NOTES:

1. Lettered items are options.
2. Sustained tension or temporary tension (wind, seismic, impact) on life critical structural. For temporary tension on normal structures, corrosion protection under Compression is often used.
3. Corrosion protection must extend 15 feet below corrosive material
4. Coresteel corrosion protection must extend a minimum 5 feet into casing
5. Minimum 1 inch in soil and 0.5 inch in rock. If protective coatings (epoxy, galvanization, or encapsulation) are provided

in compression, minimum cover may be 0.25 inches in soil or rock.

6. Not recommended for sustained or frequent tension loads

1.8 GROUND CONDITIONS

A. The test borings as shown on the boring location plan and logs of borings as described in the Geotechnical Report are believed to be representative of the conditions likely to be encountered on the site, and are to be used as the basis for micropile design in conjunction with the appropriate levels of engineering judgement and experience.

B. If, during installation of a pile, an obstruction is encountered that prevents the practical advancement of the hole, the hole shall be abandoned and filled with grout. A new pile shall be drilled at a location to be approved by the Government, although it must be acknowledged that in certain structures, relocation options may be severely limited, and further attempts at the original location with different methods may be required.

C. If during drilling, obstructions are encountered of a frequency, composition and location that were not portrayed, inferable, expected and/or notified at the time of preparation of the bid, the Government shall be notified immediately.

1.9 SUPPLEMENTAL SUB-SURFACE INVESTIGATION

A. Conduct supplemental sub-surface investigation for the purposes of verifying the required micropile design parameters.

B. Number of borings: a minimum of 1 per structure. For a total of two minimum.

C. Minimum depth of boring:

1. In Soil: extend below the anticipated micropile tip elevation 20 ft, or a minimum of two times the maximum pile group dimension whichever is deeper. All borings shall extend through unsuitable strata such as unconsolidated fill, peat, highly organic materials, soft fine-grained soils, and loose coarse-grained soils to reach hard dense materials.
2. In Rock:
   a. For micropiles bearing on rock, a minimum of 10 ft of rock core shall be obtained at each investigation point to verify that the boring has not terminated on a boulder.
   b. For micropiles supported on or extending into rock, a minimum of 10 ft of rock core, or a length of rock core equal to at least three times the micropile diameter for isolated micropiles or two

times the maximum micropile group dimension, whichever is greater, shall be extended below the anticipated micropile tip elevation to determine the physical characteristics of rock within the zone of foundation influence.

D. A sub-surface investigation report shall accompany the submittal drawings and calculations and shall include as a minimum:
   1. Boring logs including soil strata classifications, unit weights, moisture contents, standard penetration tests (SPT) or cone penetrometer tests (CPT) values, ground water elevations
   2. Estimation of soil shear strength parameters and determination of liquid and plastic limit for cohesive soils, and grain size distribution for granular soils.
   3. If rock is encountered, logs with rock classifications, penetration rates, degree of weathering and fracturing, recovery and RQD measurements, unconfined compressive strength, and driller's observations should be provided.
   4. Determination and discussion of the presence of hazardous, contaminated, and/or corrosive conditions if applicable. This may include resistivity, pH, and the presence of lead, sulfates, and chloride content.

1.10 REFERENCED CODES AND STANDARDS

A. The following publications form a part of this specification to the extent indicated by the specific citations in other paragraphs of this Specification. In case of conflict, the particular requirements of this specification shall prevail. The latest publication as of the issue of this specification shall govern, unless indicated otherwise.

1.11 APPLICABLE PUBLICATIONS

A. Publications listed below form a part of this specification to extent referenced. Publications are referenced in text by basic designation only.

B. American Society for Testing and Materials (ASTM):

A36/A36M-08.....Standard Specification for Carbon Structural Steel

A82.....Cold-Drawn Steel Wire for Concrete Reinforcement

A252.....Welded and Seamless Steel Pipe Piles

A722/A722M-07.....Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete

A775.....Electrostatic Epoxy Coating

C33.....Concrete Aggregates

C109.....Compressive Strength of Hydraulic Cement Mortar
C188.....Density of Hydraulic Cement
D3966.....Standard Test Method for Piles Under Lateral Load
D1784.....Polyvinyl Chloride (PVC) Pipe (Class 13464-B)
C144.....Aggregates for Masonry Mortar
C150.....Portland Cement
C494.....Chemical Admixtures for Concrete
D1143.....Method of Testing Piles Under Static Axial Compressive Load
D3350.....Polyethylene Corrugated Tubing
D3689.....Method of Testing Individual Piles Under Static Axial Tensile Load

C. American Welding Society (AWS):
D1.1.....Structural Welding Code – Steel
D1.2.....Structural Welding Code – Reinforcing Steel

D. America Petroleum Institute (API):
5CT (N80).....Specification for Casing and Tubing
RP 138-1.....Recommended Practice – Standard Procedure for Field Testing Water Based Drilling Fluids

E. American Society of Civil Engineers (ASCE):
ASCE 20-96.....Standard Guidelines for the Design and Installation of Pile Foundations

F. Post Tensioning Institute (PTI):
Recommendations for Prestressed Rock and Soil Anchors

1.12 CONSTRUCTION SUBMITTALS

A. The Contractor shall prepare and submit to the GOVERNMENT, for review and approval, working drawings and relevant structural design calculations for the micropile system or systems including footing anchorage intended for use at least 21 calendar days prior to planned start of construction (but note also Paragraph 3.01 - I). All design submittals shall be sealed by a Registered Professional Engineer, currently licensed in the State of the project.

B. The Contractor shall submit a detailed description of the construction procedures proposed for use to the GOVERNMENT for review. This shall include a schedule of major equipment resources.

C. The Working Drawings shall include micropile installation details giving:
1. Micropile number, location and pattern
2. Micropile design load

3. Type and size of reinforcing steel
4. Minimum total bond length
5. Total micropile length
6. Grouting volumes and maximum pressures
7. Micropile top attachment
8. Micropile cut-off elevation

D. The Contractor shall submit shop drawings for all structural steel, including the micropile components, corrosion protection system, pile top attachment and bond length details to the GOVERNMENT for review and approval.

E. The Contractor shall submit certified mill test reports, properly marked, for the reinforcing steel, as the materials are delivered, to the GOVERNMENT for record purposes. The ultimate strength, yield strength, elongation, and material properties composition shall be included. For steel pipe used as permanent casing, or core steel, the Contractor shall submit a minimum of two representative coupon tests or mill certifications (if available) on each load delivered to the project.

F. The Contractor shall submit the grout mix designs, including details of all materials to be incorporated, and the procedure for mixing and placing the grout to the GOVERNMENT for approval. This submittal shall include certified test results verifying the acceptability of the proposed mix designs.

G. The Contractor shall submit detailed plans for the method proposed for testing the micropiles to the GOVERNMENT for review and acceptance prior to beginning load tests. This shall include all necessary drawings and details to clearly describe the test method and equipment proposed.

H. The Contractor shall submit to the GOVERNMENT calibration reports for each test jack, pressure gauge, and master pressure gauge to be used. The calibration tests shall have been performed by an independent testing laboratory and tests shall have been performed within one year of the date submitted. Testing shall not commence until the GOVERNMENT has approved the jack, pressure gauge and master pressure gauge calculations.

I. Work shall not begin until the appropriate submittals have been received, reviewed, and approved in writing by the GOVERNMENT. The Contractor shall allow the GOVERNMENT up to 3 weeks to review, comment upon and return the Working Drawing submittal package after a complete set has been received. Note that any 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 submittals shall be the responsibility of the Contractor (or as otherwise allocated in Table 1).

J. For welding of the high strength steel casing, submit a welding procedure, prepared by a welding specialist, for review prior to any welding.

1.13 INSTALLATION RECORDS

A. The following records will be prepared for the GOVERNMENT. The records shall be completed within 24 hours after each pile installation is completed. The records shall include the following minimum information:
   1. Pile drilling duration and observations (e.g., flush return)
   2. Information on soil and rock encountered, including description of strata, water, etc.
   3. Approximate final tip elevation
   4. Cut-off elevation
   5. Rated load capacities
   6. Description of unusual installation behavior, conditions
   7. Any deviations from the intended parameters
   8. Grout pressures attained, where applicable
   9. Grout quantities pumped
   10. Pile materials and dimensions
   11. Micropile test records, analysis, and details

B. In addition, as-built drawings showing the location of the piles, their depth and inclination, and details of their composition shall be submitted within 30 calendar days of the pile installation.

PART 2 – PRODUCTS:

2.1 WATER

A. Water for mixing grout shall be potable, clean and free from substances which may be in any way deleterious to grout or steel. If water is not potable, it shall be tested in accordance with AASHTO T26 for acceptability.

2.2 ADMIXTURES

A. Admixtures shall conform to the requirements of ASTM C494 (AASHTO M194). Admixtures which control bleed, improve flowability, reduce water content, and retard set may be used in the grout subject to the review and acceptance of the GOVERNMENT. Expansive admixtures shall only be added to the grout used for filling sealed encapsulations. Accelerators

will not be permitted. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's recommendations. Their use will only be permitted after appropriate field tests on fluid and set grout properties. Admixtures with chlorides shall not be permitted.

2.3 CEMENT

A. All cement shall be Portland cement conforming to ASTM C150 (AASHTO M85) Type I, Type II, or Type III, and shall be the product of one manufacturer. If the brand or type of cement is changed during a project, additional grout mix tests shall be conducted to ensure consistency of quality and performance in situ.

2.4 FILLERS

A. Inert fillers such as sand may be used in the grout in special situations (e.g., presence of large voids in the ground, when grout take and travel are to be limited) as approved by the GOVERNMENT.

2.5 BAR REINFORCEMENT

A. Reinforcing steel shall be deformed bars in accordance with ASTM A615 (AASHTO M31) Grade 60 or Grade 75 or ASTM A722 (AASHTO M275) Grade 150.

B. For cases of tensile loading, bar couplers, if required, shall develop the ultimate tensile stress of the bar, without any evidence of failure. For compressive loading, the coupler shall be compatible with efficient load transfer and overall reinforcement performance requirements.

2.6 PIPE/CASING

A. If the casing is to be relied upon to carry loads or reduce deflection, the permanent steel casing/pipe:

1. Shall meet the tensile requirements of ASTM A252, Grade 3, except the minimum yield strength shall be as used in the design submittal (typically 50,000 psi to 80,000 psi) and minimum elongation shall be 15%.
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.

2.7 PLATES AND SHAPES

A. Structural steel plates and shapes for pile top attachments shall conform to ASTM A36 (AASHTO M183) or ASTM A 572 Grade 50 (AASHTO M183).

2.8 CENTRALIZERS

A. Centralizers shall be fabricated from plastic, steel, or material that is non-detrimental to the reinforcing steel. Wood shall not be used.

2.9 CORROSION PROTECTION (SEE TABLE 1)

A. Epoxy Coating: If used, the thickness of coating applied electrostatically to the reinforcing steel shall be 7-12 mils. Epoxy coating shall be in accordance with ASTM A775/AASHTO M282 or ASTM A936. Bend test requirements shall be waived. Bearing plates and nuts encased in the pile concrete footing may not be epoxy coated (unless the footing reinforcement is epoxy coated).

B. Galvanization: If used, galvanization shall meet the requirements of ASTM A-153.

C. Encapsulation: If used, the encapsulation shall meet the requirements of PTI " Recommendations for Soil and Rock Anchors" (1996).

PART 3 - EXECUTION

3.1 INSTALLATION

A. The micropile installation technique shall be such that it is consistent with the geotechnical, logistical, environmental, and load carrying conditions of the project. The micropile contractor shall select the drilling method and the grouting procedures used for the installation of the micropiles, subject to the approval of the GOVERNMENT.

B. The drilling equipment and methods shall be suitable for drilling through the conditions to be encountered, with minimal disturbance to these conditions or any overlying or adjacent structure or service. The borehole must be open to the defined nominal diameter, full length, prior to placing grout and reinforcement.

C. Provide temporary or permanent hole support.

D. All installation techniques shall be determined and scheduled such that there will be no interconnection or damage to piles in which grout has not achieved final set.

E. Centralizers shall be provided at 10-ft center maximum spacing on central reinforcement. The uppermost centralizer shall be located a maximum of 5 ft from the top of the micropile. Centralizers shall permit the free flow of grout without misalignment of the reinforcement.

F. The central reinforcement steel with centralizers shall be lowered into the stabilized drill holes to the desired depth without difficulty. Partially inserted reinforcing bars shall not be driven or forced into the hole such that there will be no interconnection or damage to piles in which the grout has not achieved final set.

G. The grout shall be injected as per Section 5.02-B, below

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

3.2 GROUTING

A. The Contractor shall provide systems and equipment to measure the grout quality, quantity, and pumping pressure during the grouting operations. This information is to be measured and recorded by the installing contractor.

B. After drilling, the hole shall be flushed with water and/or air to remove drill cuttings and/or other loose debris. The Contractor shall provide a stable, homogenous neat cement grout or a sand cement grout with a minimum 28-day unconfined compressive strength of 4000 psi. The grout shall not contain lumps or any other evidence of poor or incomplete mixing. Admixtures, if used, shall be mixed in accordance with manufacturer’s recommendations. The pump shall be equipped with a pressure gauge to monitor grout pressures. The pressure gauge shall be capable of measuring pressures of at least 150 psi or twice the actual grout pressures used by the Contractor, whichever is greater. The grouting equipment shall be sized to enable the grout to be pumped in one continuous operation. The grout should be kept in constant agitation prior to pumping. The grout shall be injected from the lowest point of the drill hole (by tremie methods) until clean, pure grout flows from the top of the micropile. The tremie grout may be pumped through grout tubes, hollow stem augers, or drill rods. Subsequent to tremie grouting, all grouting operations associated with, for example, extraction of drill casing and pressure grouting, must ensure complete continuity of the grout column. The grout pressures and grout takes shall be controlled to prevent excessive heave in cohesive soils or fracturing of soil or rock formations. The entire pile shall be grouted to the design cut-off level. Upon completion of grouting of Type A and B piles, the grout tube may remain in the hole, but it shall be filled with grout. For Type C and D piles, grout tubes shall be installed prior to the tremie grouting.

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

D. If the Contractor uses a post-grouting system, all relevant details including grouting pressure, volume, location and mix design, shall be submitted as part of Section 3.01 "Construction Submittals".

C. Pile Splices

1. Pile splices shall be constructed to develop the required design strength of the pile section.
2. Lengths of casing and reinforcing steel to be spliced shall be secured in proper alignments and in such a manner that no eccentricity between the axes of the two lengths spliced or angle between them results.

3.3 PRE-PRODUCTION PILE TESTS (REQUIRED)

A. Pile load tests shall be performed to verify the adequacy of the design of the pile system, and the proposed construction procedures prior to installation of production piles. 2 sacrificial test piles, one at each structure, with dead weight, reaction piles, or ground anchors shall be constructed immediately prior to the commencement of the installation of the production micropiles. Acceptable load and movement criteria are defined below. The Contractor shall submit for review and acceptance the proposed micropile load testing procedure. The testing program shall be provided 2 weeks prior to starting the load testing. This micropile verification load testing proposal shall be in general conformance with ASTM D-1143 +/or D-3689, and shall indicate the minimum following information:
   1. Type and accuracy of apparatus for measuring load
   2. Type and accuracy of apparatus for applying load
   3. Type and accuracy of apparatus for measuring the pile deformation
   4. Type and capacity of reaction load system, including sealed design drawings
   5. Hydraulic jack calibration report

B. These micropile load test results shall verify the suitability of the Contractor’s design and installation methods, and will be reviewed and accepted by the GOVERNMENT prior to beginning production micropiles. The tests shall be performed at a location approved by the GOVERNMENT.

C. The drilling and grouting methods, casing and other reinforcement details, and depth of embedment for the test pile shall be identical to the production piles, except where approved otherwise by the GOVERNMENT.

D. The tested micropiles shall be loaded to 200% of the compression and/or tension design load (DL) (i.e., 2.0 DL). The load tested piles must be of the same design as the production piles to ensure meaningful results. The jack shall be positioned at the beginning of the test such that the unloading and repositioning of the jack during the test will not be required. Piles shall be tested under compression loads prior to testing under tension loads. An Alignment Load (AL if required) shall be applied to the pile prior to setting the movement recording devices. This

Alignment Load shall be no more than 10% on Design Load (i.e., 0.1 DL): dial gauges shall be zeroed at the first setting of AL.

E. Axial pile load tests shall be made by loading the micropile and recording the pile head movement in the following load increments:

LOAD	HOLD TIME (MINUTES)
AL	-
0.15 DL	2.5
0.30 DL	2.5
0.45 DL	2.5
AL	1
0.15 DL	1
0.45 DL	1
.060 DL	2.5
0.75 DL	2.5
0.90 DL	2.5
1.00 DL	2.5
AL	1
0.15 DL	1
1.00 DL	1
1.15 DL	2.5
1.30 DL	10*
1.45 DL	2.5
AL	1
0.15 DL	1
1.45 DL	1
1.60 DL	1
1.75 DL	2.5
1.90 DL	2.5
2.00 DL	10
1.50 DL	5
1.00 DL	5
0.50 DL	5
AL	5

AL = Alignment Load

DL = Design Load

*Hold until meet acceptance criterion 2 below

Thereafter for special test piles not to be later used in service, further load cycles may be conducted to failure.

1. This procedure is similar to the provisions of the Quick Load Test in accordance with ASTM D-1143.

F. Measurement of pile movement shall be obtained at each increment. The load hold period shall start as soon as the test load is applied and the pile movement, with respect to a fixed reference, shall be measured and recorded at 1 minute, 2, 3, 4, and 5, and 10 minutes (load cycle maxima only).

The acceptance criteria for micropile verification load tests are:

1. The pile shall sustain the compression and tension design capacities (1.0 DL) with no more than 1/4 in. total vertical movement at the top of the pile as measured relative to the top of the pile prior to the start of testing. If an Alignment Load is used, then the allowable movement will be reduced by multiplying by a factor of (DL-AL)/DL. (This conservatively accounts for the movement in reaching AL.
2. Test piles shall have a creep rate at the end of the 130% DL increment which is not greater than 0.040 in./log cycle time from 1 to 10 minutes or 0.080 in./log cycle time from 6 to 60 minutes and has a linear or decreasing creep rate.
3. Failure does not occur at the 2.0 DL maximum compression and tension loads. Failure is defined as a slope of the load versus deflection (at end of increment) curve exceeding 0.025 inches/kip.

G. The Contractor will provide the GOVERNMENT a written report confirming micropile geometry and construction details within 7 working days after the completion of the pre-production tests. This written confirmation will either confirm the bond lengths as shown in the drawings for micropiles or propose modifications based upon the results of the verification tests.

H. When a micropile fails to meet the acceptance criteria, modifications shall be made to the design, the construction procedures, or both. These modifications include, but are not limited to, installing replacement micropiles, modifying the installation methods, increasing the bond length, regrouting via pre-placed re-grout tubes, or changing the micropile type. Any modification which requires changes to the structure shall have prior review and acceptance of the GOVERNMENT.

I. The contractor guarantees that should the test pile fail to give acceptable results, the design will be modified and a new test pile installed and tested at the contractors expense. Contractor also

guarantees that all structural damage caused by inability of his piles to support the working loads satisfactorily for a period of two years will be repaired or replaced at contractors own expense.

5.02 PRODUCTION PILE TESTING

A. The Contractor shall proof test at least a further 2 production micropiles, one at each structure. The piles to be tested will be approved by the Government. At the Contractor's suggestion, but with the Owner's concurrence, tension tests may be performed based to maximum DL in compression or tension for friction piles with sufficient structural tension capacity.

The test sequence shall be as follows:

LOAD	HOLD TIME (MINUTES)
AL	-
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*
1.00 DL	4
0.75 DL	4
0.50 DL	4
0.25 DL	4
AL	4

AL = ALIGNMENT LOAD

DL = DESIGN LOAD

*Hold until meet acceptance criterion 2 of next paragraph

The acceptance criteria for micropile proof load tests are:

1. The pile shall sustain the compression and tension design capacities (1.0 DL) with no more than 1/4 in. total vertical movement at the top of the pile as measured relative to the pile prior to the start of testing. If an Alignment Load is used, then the allowable movement

will be reduced by multiplying by a factor of (DL-AL)/DL. (This conservatively accounts for the movement in reaching AL.)

2. Test piles shall have a creep rate at the end of the 130% DL increment which is not greater than 0.040 in./log cycle time from 1 to 10 minutes or 0.080 in./log cycle time from 6 to 60 minutes and has a linear or decreasing creep rate.
3. failure does not occur at the maximum compression and tension load increment. Failure is defined as a slope of the load verses deflection (at end of increment) curve exceeding 0.025 inches/kip.

B. If a micropile that is proof tested fails to meet the acceptance criteria, the contractor shall be directed to proof test another micropile in the vicinity. For failed piles and further construction of other piles, the Contractor shall modify the design, the construction procedure, or both. These modifications include, but are not limited to, installing replacement micropiles, incorporating piles of reduced load capacities, modifying the installation methods, increasing the bond length, or changing the micropile type and engineering and construction of additions to pile caps at no additional cost to the Government. Any modification which requires changes to the structure shall have prior review and acceptance of the Government. Any modifications of design or construction procedures shall be at the Contractor’s expense.

C. Contractor also guarantees that all structural damage caused by inability of his piles to support the working loads satisfactorily for a period of two years will be repaired or replaced at contractors own expense.

3.4 LATERAL TESTING

A. If required, lateral loading testing shall be conducted, prior to axial testing, in accordance with ASTM 3966. During both pre-production verification and proof test phases, care must be exercised to not cause permanent structural damage to the pile which will subsequently reduce the axial capacity. Therefore, the acceptance criterion, typically expressed as a maximum total movement at a certain load, must be carefully selected by the Government, as being realistic and not potentially damaging to the structure.

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