

**SECTION 31 63 36**  
**GROUTED MICROPILES**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

This work shall consist of micropiles; designed, furnished, installed and tested in accordance with these specifications and as shown on the contract drawings.

**1.2 DEFINITIONS**

Satisfactory Bearing Material: Rock is assumed to occur at bottom of micropile elevations shown.

**1.3 REFERENCED DOCUMENTS**

See the geotechnical investigation report (included as an Appendix to these specifications) prepared by Professional Service Industries (PSI), dated July 2, 2015 for borings, information on rock quality and other recommendations.

**1.4 RELATED WORK**

- A. Materials testing and inspection during construction: Section 01 45 29, TESTING LABORATORY SERVICES.
- B. Safety requirements and blasting operations: Section 01 00 00, GENERAL REQUIREMENTS, Article, ACCIDENT PREVENTION.
- C. Subsurface Investigation: Section 01 00 00, GENERAL REQUIREMENTS, Article, PHYSICAL DATA
- D. Earth excavation: Section 31 20 00, EARTH MOVING.
- E. Concrete, including materials and mixes: Section 03 30 53, (SHORT-FORM) CAST-IN-PLACE CONCRETE.

**1.5 CONTRACT BASIS**

- A. For bidding purposes all piles shall be assumed to be 60 feet long with the following breakdown of material excavation.
  - 1. Soil/Weathered Rock Excavation: 40 feet
  - 2. Rock Excavation: 20 feet
- B. Contract price for micropiles will be based upon total length for each type of micropile shown and number of micropile load tests indicated in the Contract Documents. Length of micropiles will be measured from bottom of the rock socket to top of steel plate of the micropile. The diameter of the micropile is defined as the minimum diameter of the shaft.
  - 1. Adjustment of contract price shall be based upon total length of each type of micropile placed and not on the length of individual micropiles. When the total length of each type of completed micropile is greater or less than the length shown due to unsuitable

soils or design modifications by the Contracting Officer Representative (COR), contract price adjustment will be made in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable.

2. Contract price and time will be adjusted in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable, when artificial materials that are not shown are encountered.

#### **1.6 CLASSIFICATION OF EXCAVATION**

##### **A. Soil/Weathered Rock Excavation:**

Soil or weathered rock that can be reasonably excavated with the rock auger, i.e. rock auger advancement greater than 150 mm (6 inches) per 15 minutes (see rock auger refusal, 1.5.C-2, below)

##### **B. Sloping Weathered Rock Excavation:**

Excavation of soil/weathered rock that can typically be excavated with the rock auger, except when the steeply sloping orientation of the stratum causes the rock auger to run askew.

##### **C. Rock Excavation:**

1. Excavation of material that meets the rock auger refusal criteria and requires the rock core barrel or other hard rock excavation techniques for removal.
2. Rock auger refusal is defined as a penetration rate of less than 150 mm (6 inches) in 15 minutes, while operating a micropile drilling rig, rated with a torque capacity of at least 110 kN-meters (1,000,000 inch-pounds), applying a continuous down pressure of at least 220 kN (50,000 pounds), equipped with a rock auger that contains conical carbide-tipped ("Kennemetal") teeth.

##### **D. Nominal Soil or Weathered Rock Seams:**

Nominal soil or weathered rock seams below rock auger refusal will be excavated and considered as rock for rock excavation quantities. A nominal soil or weathered rock seam is one which is less than 600 mm (2 feet) thick. Where soil or weathered rock seams or voids of 600 mm (2 feet) or greater are excavated within a mixed rock/soil or rock/weathered rock profile, excavation is classified as soil/weathered rock excavation until rock auger refusal is again established.

#### **1.7 MEASUREMENT AND PAYMENT FOR ROCK EXCAVATION**

- A. Measurement: Excavation type in units of length shall be considered to change at the upper contact with a different excavation type as defined by section 1.5.
- B. Payment: Contract unit rates per length of each type of micropile shall be provided for each excavation condition type noted above in Section 1.5. Contract price and time will be adjusted for overruns or underruns in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable.
- C. Payment for Differing Site Conditions: No payment will be made for any rock excavation beyond micropile limits unless additional excavation is directed by the COR. When rock excavation, as classified, is encountered, contract price and time will be adjusted in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable.

#### **1.8 TOLERANCES**

Install micropiles with not more than the lesser of 1/24th of micropile shaft diameter or 75 mm (3 inches) from design center location. Micropiles shall not be out of plumb more than 1 percent of its full length. Cross sections of shafts and bells shall not be less than design dimensions. Batter micropiles shall be installed a maximum of 2 percent of length from specified inclination.

#### **1.9 SUBMITTALS**

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. 30 days before beginning work, submit working drawings, a description of the proposed micropile system or systems intended for use, installation method and calculations sealed by a structural engineer in the state where the project is located, all of which shall be subject to the review and approval of the COR. The working drawings and design submission shall include the following:
  - 1. A drawing showing the location and orientation of each micropile.
  - 2. A micropile schedule showing:
    - a. Micropile number.
    - b. Micropile design loads
    - c. Type and size of Micropile

The COR shall approve or reject the contractor's working drawings and design submission within 20 working days after receipt of the submission.

- C. Contractor shall submit to the COR for review and approval mill test reports for the steel piling components.
- D. Shop Drawings shall comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures". Furnish complete shop drawings for the detailing, fabrication, bending, and placement of concrete reinforcement.
- E. Concrete mix design: Submit in accordance with Section 03 30 53, (SHORT-FORM) CAST-IN-PLACE CONCRETE.
- F. Certificates: The contractor performing the work described in the specification shall have installed micropiles for a minimum of five years. At the time of bid, the contractor shall submit a list containing at least five projects on which the contractor has installed micropiles. A brief description of each project and a reference shall be included for each project listed. As a minimum, the reference shall include an individual's name and current phone number.

Prior to the start of work, the contractor shall submit a list identifying the engineer, drill operators and on-site supervisors who will be assigned to the project. The list shall contain a summary of each individual's experience and it shall be complete enough for the COR to determine whether or not each individual has the satisfied the following qualifications.

The contractor shall assign an engineer to supervise the work with at least three years of experience in the design and construction of micropiles. The use of consultants or manufacturer's representatives does not satisfy the requirements of this section. Drill operators and on-site supervisors shall have a minimum of one year experience installing micropiles with the contractor's organization.

The COR shall approve or reject the contractor's qualifications and staff within 15 working days after receipt of the submission. Work shall not be started on any piling nor any materials ordered until approval of the contractor's qualifications is given. The COR may suspend the micropile work if the contractor substitutes unqualified personnel for approved personnel; the contractor shall be fully liable for additional costs resulting from the suspension of work and no

adjustment in contract time resulting from the suspension of work will be allowed.

G. Micropile Load Testing:

1. A schedule and sequencing plan for micropile testing and installation.
2. Micropile Load Test Work Plan:
  - a. At least two weeks before commencing micropile load testing work, the Contractor shall submit a micropile load test work plan describing the equipment, apparatus, procedures, and schedule for testing micropiles in accordance with ASTM D1143, ASTM D3689 and ASTM D3966 and as specified herein, to verify the design micropile capacity. The work plan shall also include the proposed instrumentation of the test pile indicating depth, location, and details of the micropile.
  - b. As part of the Micropile Load Test Work Plan, submit shop drawings and other information describing the loading and test monitoring arrangement for pile load tests, including the following:
    - 1) Structural design of the test load support/reaction frame.
    - 2) Details of equipment and apparatus to be used for the monitoring load and pile movements.
    - 3) Data on testing and measuring equipment including required jack, load cell and/or gauge calibrations.
    - 4) Sample field data recording sheets or examples of automated data acquisition records proposed for recording load test data.
  - c. Contractor guarantees that should the test pile fail to give acceptable results, he will modify his design and install and test another pile at his expense. He also guarantees that he will repair or replace at his own expenses all structural damage caused by inability of his piles to support the working loads satisfactorily for a period of two years.

- H. Independent Testing and Inspection Agency: The Contractor shall retain an Independent Testing and Inspection Agency (Agency) to document, monitor, and observe load test, probe pile, test pile, and production pile work. This Agency shall submit field reports and test results required for pile load tests, pile installations, and grout testing and

inspection. They shall submit a pile installation report for each pile no later than three days after the installation is complete.

- I. Qualification Data: For Installer, Land Surveyor, and Testing and Inspection Agency.
- J. Upon completion of micropile installations, the Contractor shall submit five copies of micropile installation reports. The Contractor shall pay for all surveying costs. Micropile installation reports must be submitted prior to beginning any pile cap or mat installation. One electronic copy of the reports shall be submitted on a CD-ROM. Drawings must be submitted in AutoCAD DWG format. The installation reports shall include the following:
  - 1. As-built drawings showing the locations of the Micropiles and the piles length.
  - 2. Steel manufacturer's mill test reports for the steel pile components incorporated in the installation.
  - 3. Detailed drilling records including depth to rock and rock quality.
  - 4. Grouting records indicating the cement type, and quantity injected.
  - 5. Micropile test results and graphs.
- K. Record drawings at Project closeout according to Division 01 Section "Closeout Procedures."

#### **1.10 QUALITY CONTROL**

- A. Contractor's Quality Control Responsibilities: Contractor is solely responsible for quality control of the Work.
- B. A Quality Control Program shall be submitted by the Contractor at least two weeks prior to the commencement of work. The implementation of a Contractor Quality Control Program does not relieve the Contractor from the responsibility to provide work in accordance with the Contract Documents, applicable codes, regulations, and Governing Authorities.
- C. Contractor's Independent Testing and Inspection Agency (Agency): The Contractor shall retain at his own expense, the services of a qualified Independent Testing and Inspection Agency, licensed in the state of the project, to provide testing and inspection services during the installation of all foundation piling involved in this Work. This firm shall also provide consultation services to the Contractor if problems are encountered during the execution of the Work. The Agency shall be primarily concerned with the testing and construction methods which will result in finished foundation piling of the required quality and

strength. The Agency shall also be concerned with preventing settlement and/or damage to surrounding structures, roads, utilities, embankments, etc., both within the property lines and on adjoining properties during the construction.

- D. The Agency shall be experienced in the testing and installation of micropile foundations. It shall have been involved in at least 8 different micropile projects in the last 5 years, and shall have experience in recommending, testing, and specifying micropiles for similar subsurface conditions.
- E. Survey Work: The Contractor shall engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for micropiles. The surveyor shall record actual measurements of each micropile's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.
- F. Welding Standards: Qualify procedures and personnel according to the following:
  - 1. AWS D1.1
  - 2. AWS D1.4
- G. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, State and Municipal authorities having jurisdiction. Obtain necessary approvals from all such authorities.

#### **1.11 QUALITY ASSURANCE**

- A. The Owner shall retain the services of a Geotechnical Engineer (Consultant) to provide general observation of all micropile operations and to provide technical advice to the Owner with regard to micropile operations and performance.
- B. The Consultant shall have been involved in at least 8 different micropile installation projects in the last 5 years, and shall have experience in recommending, testing, and specifying micropiles for similar subsurface conditions.

#### **1.12 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
- A283/A283M-03 (2007).....Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
- A615/A615M-09b.....Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
- A929/A929M-01 (2007).....Standard Specification for Steel Sheet, Metallic Coated by the Hot Dip Process for Corrugated Steel Pipe
- A996/A996M-09b.....Standard Specification for Rail Steel and Axle Steel Deformed and Bars for Concrete Reinforcement
- C33-11a.....Standard Specification for Concrete Aggregates
- C94/C94M-12.....Standard Specification for Ready Mixed Concrete
- C150-C50M-11.....Standard Specification for Portland Cement
- C494/C494M-11.....Standard Specification for Chemical Admixtures for Concrete
- C618-12.....Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
- C989-C989M-11.....Standard Specification for Slag Cement for Use in Concrete and Mortars
- C1017/C1017M-07.....Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
- D1143-81 (1994)e1.....Standard Test Method for Piles Under Static Axial Compressive Load
- D3689-90 (1995).....Standard Test Method for Individual Piles Under Static Axial Tensile Load
- D3966-90 (1995).....Standard Test Method for Piles Under Lateral Loads
- C. American Concrete Institute (ACI):
- 211.1-91 (2009).....Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
- 301-10.....Specifications for Structural Concrete
- 315-99.....Details and Detailing of Concrete Reinforcement
- D. American Welding Society (AWS):
- D1.1/D1.DM (2010).....Structural Welding Code - Steel



D1.4 (1998).....Structural Welding Code - Reinforcing Steel

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS**

- A. Steel Reinforcement: ASTM A615, Grade 60, deformed.
- B. Portland Cement: ASTM C150, Type I or II.
- C. Water: Potable, complying with ASTM C94/C94M requirements.
- D. Steel Casings: All casing shall meet ASTM A283, Grade C; or ASTM A36, carbon-steel plate, with joints full-penetration welded according to AWS D1.1, or ASTM A929/A929M, steel sheet, zinc coated corrugated steel. The Contractor shall design shells to withstand drilling forces and earth pressures and reinforce the bottom cutting edge as required for proper drilling and sealing of the shells into the rock. The cutting edge shall be capable of coring through at least 3000 mm (10 ft) of broken or solid rock. A minimum of 2% out of roundness of the diameter shall be considered in the design of the shell. All seams shall be welded and watertight.
- E. Grout Mix: Prepare design mixes according to ACI 211.1 and ACI 301 for each type and strength of grout determined by either laboratory trial mix or field test data bases. Use a qualified testing agency for preparing and reporting proposed mix designs for laboratory trial mix basis. Proportion mixes according to ACI 211.1 and ACI 301 to provide normal-weight grout with the following properties:
  - 1. Compressive Strength (28 Days): 27.6 MPa (4000 psi).
  - 2. Slump shall be as indicated below +/- 1" (tested in accordance with ASTM C143):
    - a) No water reducing admixture: 4 inches
    - b) With mid-range water reducer: 5"
    - c) With high-range water reducer: 7"
  - 3. Do not air entrain grout for micropiles.
  - 4. Limit water-soluble, chloride-ion content in hardened grout to 0.15//0.3 percent by weight of cement.
  - 5. Grout-mix design adjustments may be considered if characteristics of materials, project conditions, weather, test results, or other circumstances warrant. Resubmission and approval of proposed changes to grout-mix proportions is the responsibility of the Contractor.
- F. Grout Mixing: Measure, batch, mix, and deliver grout according to ASTM C 94/C 94M, and furnish batch ticket information. Do not add water

to grout mix after mixing, unless a procedure per ACI 301 is submitted to and approved by the COR. Maintain grout temperature less than 32 degree Celsius (90 degree Fahrenheit).

### **PART 3 - EXECUTION**

#### **3.1 GENERAL**

- A. Size: Micropiles shall be provided as 6" to 12" diameter. Depths shall be as required to achieve scheduled loads.
- B. Changes: Requests for change in size or type of micropile from those shown shall be accompanied by calculations and other documentation necessary to show that proposed changes will meet load requirements. Do not proceed with changes before receiving written approval from the COR.
- C. Defective Casings: Do not install buckled, distorted or otherwise damaged casings. Replace casings damaged or disturbed during construction, casings that are not mud-tight or otherwise not in accordance with drawings or specifications, at no additional cost to the Government.
- D. Survey: Registered Professional Land Surveyor or Registered Civil Engineer, specified in Section 01 00 00, GENERAL REQUIREMENTS, shall establish lines and levels and stake micropile locations.

#### **3.2 EXCAVATION**

- A. Excavation and construction methods shall result in minimum disturbance of surrounding material and full lateral support of micropiles by surrounding material.
- B. Remove boulders and rock in micropiles such as rock seams underlain with soil seams, sloping rock or rock otherwise unsatisfactory for bearing.
- C. Test Drilling: As requested by the Geotechnical Engineer monitoring drilled micropile installation.
- D. Maintain sidewall stability during drilling. Excavate holes for closely spaced micropiles, and those occurring in fragile strata, only after adjacent holes are filled with grout and allowed to set. Micropile drilling equipment shall have the minimum torque capacity and downward force capacity for the contract site conditions. Bottoms of micropiles shall be cleaned of loose or soft materials and leveled.
- E. Excavations for utilities, support of excavations, or other purposes shall be kept a minimum distance of three shaft diameters away from the outer edge of the micropile.

### **3.3 PLACING GROUT**

- A. Before placing grout, the tip of the micropile shall be observed and approved by a qualified testing agency registered and licensed in the state. The testing agency shall be retained by the Contractor and approved by the COR. The shaft shall be inspected, cleared of mud, water, loose material and debris.
- B. The grouting equipment shall produce a grout free of lumps and undispersed cement. The pump shall be equipped with a pressure gauge to monitor grout pressures. The pressure gauge shall be capable of measuring pressure 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 mixer should be capable of continuously agitating the grout.
- C. The grout shall be injected from the lowest point of the drill hole. The grout may be pumped through grout tubes, casing, hollow-stem-augers or drill rods. The quantity of the grout and the grout pressures shall be recorded. The grout pressures and grout takes shall be controlled to prevent excessive heave in cohesive soils or fracturing of rock formations. The entire Micropile shall be filled with grout. Upon completion of grouting, the grout tube may remain in the hole but it shall be filled with grout.
- D. Strike finished top surface of grout to true plane at required elevation.
- E. Grout placement in each micropile shall be one continuous operation. If placing operation has to be stopped, leave surface approximately level. If grout has hardened, clean surface and slush with a 1 to 1 cement-sand grout before placing operation is resumed. Grout pours shall not begin within one hour of darkness. In the event that this type of continuous sequential operation cannot be performed, the Contractor shall submit for approval by the COR a method of securing the open excavation. The Contractor shall not leave excavations open overnight without receiving prior written approval from the COR.
- F. When water is present, control water level to within 25.4 mm (1 inch) of bottom of the micropile by pumping. If impossible or impractical to control water, secure written permission from COR to place concrete through water by means of a watertight tremie.

1. When placing concrete under water, discharge end of tremie shall be submerged in fresh concrete and shaft of tremie maintained full of concrete to point above water level.

2. Increase cement content of concrete required to be placed in water by one sack per cubic yard of concrete.

G. Vibrate top 1524 mm (5 feet) of concrete.

H. After grouting, the Micropile shall not be loaded for a minimum of three days.

### **3.4 MICROPILE RECORD**

A. For each micropile placed and before superstructure framing is placed, submit to COR for approval a certified report recording following information prepared by Registered Professional Land Surveyor or Registered Civil Engineer.

B. Micropile number, length, and bearing material.

C. Location.

D. Grout and steel reinforcement properties.

E. Plumbness.

F. Dates:

1. Excavation completed.

2. Grout placed.

G. Diameters:

1. Top of shaft.

2. Bottom of shaft.

H. Elevations:

1. Top of ground.

2. Top of grout.

3. Top of rock.

4. Bottom of micropile.

I. Steel manufacturer's mill test reports for the steel pile components incorporated in the installation.

J. Detailed drilling records including depth to rock and rock quality.

K. Grouting records indicating the cement type, and quantity injected.

L. Micropile test results and graphs.

### **3.5 CLEAN UP:**

A. All debris from excavation of objectionable material, removal of obstructions, and any material not to remain as part of the

construction are to be removed and disposed of by the Contractor in a legal manner at no additional cost to the Owner.

- B. The site shall be cleaned at frequent intervals and no material shall be stored on the site in a manner, which would obstruct the easy access of equipment and personnel.

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