

SECTION 31 63 33 – DRILLED MICROPILES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Project Geotechnical Documents, for reference:
 - 1. Geotechnical Engineering Report, DFW Terminal C Expansion, by ECS Southwest, LLP dated April 14th, 2022. Report Number 63: 1603-C and subsequent Addendum dated July 12, 2023.
 - 2. Geotechnical Engineering Report, DFW Terminal A Expansion, by ECS Southwest, LLP dated April 14th, 2022. Report Number 63: 1603-A and subsequent Addendums dated February 5, 2023 and July 12, 2023.

1.2 SUMMARY

- A. Section Includes: Furnishing necessary engineering and design services, supervision, labor, materials, and equipment to perform work required to design, install, and test micropiles used to support freight elevator and adjacent structure, as indicated in Specifications and Drawings.
- A. Related Sections
 - 1. Shop Drawings Division 1
 - 1. Contractor Quality Control Division 1
 - 2. Cast-In-Place Concrete Section 03 30 00

1.3 REFERENCES

- A. Definitions:
 - 1. Admixture: Substance added to the grout to either control bleed and/or shrinkage, improve flowability, reduce water content, retard setting time, or resist washout.
 - 2. 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.
 - 3. Casing: Steel pipe introduced during the drilling process to temporarily stabilize the drill hole. Depending on the details of the micropile construction and composition, the casing shall remain partially or completely in place, as part of the final pile configuration.
 - 4. Centralizer: A device to centrally locate the reinforcing element(s) within the borehole.
 - 5. Micropile Contractor: The person/firm responsible for engineering and performing the micropile work.
 - 6. Core Steel / Center Bar / Tendon: Reinforcing steel used to strengthen or stiffen the pile, excluding any left-in drill casing.

7. Coupler: The means by which the load can be transmitted from one partial length of reinforcement to another.
 8. Design Load (DL): Anticipated final maximum service load in the micropile.
 9. 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 the exit the borehole via the annulus between rod and casing.
 10. Elastic Movement: The recoverable movement measured during a micropile test.
 11. Free (unbonded) Length: The designed length of the micropile that is not bonded to the surrounding ground or grout during testing.
 12. Micropile: A small diameter (typically less than 12 inches) drilled (bored) cast (grouted)-in-place pile, in which most of the applied load is resisted by the steel reinforcement. A micropile can be installed in a number of different grouting techniques typically defined as Type A, B, C, or D. Type A through D micropiles are defined as follows:
 - a. Type A: a micropile where grout (sand-cement mortar or neat cement grout) is placed by gravity head only.
 - b. Type B: a micropile where neat cement grout is placed under pressure as the temporary casing is withdrawn. Grout pressure is typically 0.5 to 1 MPa (72 to 145 psi).
 - c. Type C: a micropile where a two-step grouting process is employed, consisting of (a) initial neat grout placed under gravity head (as with Type A), and (b) prior to hardening of the initial grout, similar grout is injected one time through a sleeved grout pipe (without the use of a packer) at a pressure of at least 1 MPa (145psi).
 - d. Type D: a micropile where a two-step grouting process is employed, consisting of (a) initial neat grout placed under gravity head (as with Type A), and may be pressurized (as with Type B), and (b) after hardening of the initial grout, additional grout is injected via a sleeved grout pipe at a pressure of typically 2 to 8 MPa (290 to 1,160 psi). A packer may be used inside the sleeved pipe so that specific horizons can be isolated and treated several times.
 13. Reinforcement: The steel component of the micropile which accepts and/or resists applied loadings.
 14. Safety Factor: The ratio of the ultimate capacity to the working (service) load used for the design of any component or interface.
 15. Micropiles are contractor designed and shall meet the following requirements:
 - a. Corrosion protection per these Specifications.
 - b. Tested load-deformation performance per the Drawings and Specifications.
 - c. Requirements indicated on the Drawings.
 - d. Pile locations.
 - e. Pile required Design Loading.
 - f. Pile minimum dimensions.
 - g. Micropile shall be reinforced with a threaded bar. Final bar size and any additional rebar is to be added based on Contractor's final design.
 - h. Casing is to be designed by the Contractor and can be temporary or permanent based on Contractor's design and installation methods.
 - i. Any other requirements in the Drawings and Specifications.
- B. Building Code: Comply with requirements of the Building Code identified in the Structural General Notes, and OSHA requirements, except where more stringent conditions or criteria occur in the standards referenced below and the Contract Documents.
- C. The following publications form a part of this specification to the extent indicated by the references. The latest publication as of the issue date of this specification shall govern, unless indicated otherwise.
1. American Society for Testing and Materials (ASTM)

A36	Specification for Structural Steel
A252	Specification for Welded and Seamless Steel Pipe Piles
A615	Specification for Deformed and Plain Billet Steel Bars for Concrete Reinforcement
A722	Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete
C33	Specification for Concrete Aggregates
C144	Specification for Aggregate for Masonry Mortar
C150	Specification for Portland Cement
C494	Specification for Chemical Admixtures for Concrete
D1143	Standard Test Method for Piles Under Static Axial Compressive Level
D3689	Standard Test Method for Individual Piles Under Static Axial Tensile Load
D3966	Standard Test Method for Piles Under Lateral Load

2. American Association of State Highway and Transportation Officials (AASHTO):

T26	Quality of water to be used in concrete
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3. American Petroleum Institute (API)

5L	Specification for Line Pipe
5CT	Specification for Casing and Tubing

4. American Welding Society (AWS)

D1.1	Structural Welding Code - Steel
D1.2	Structural Welding Code – Reinforcing Steel

1.4 QUALIFICATIONS OF THE MICROPILE CONTRACTOR

- A. The Micropile Contractor shall have at least 5-years' experience in all aspects of micropile design and construction, and shall furnish all necessary plant materials, skilled labor, and supervision to carry out the contract.
- B. The Micropile Contractor shall provide the Engineer a complete list documenting the minimum experience listed above.
- C. The Micropile Contractor shall have a Civil Engineer or Geotechnical Engineer, registered in the State of Texas, to perform, stamp, and sign all design calculations and drawings.
- D. The superintendent shall have completed at least five micropile projects.
- E. The Micropile Contractor shall not sublet the whole or any part of this contract without the express permission in writing of the Engineer.

1.5 QUALITY ASSURANCE

- A. Pile Contractor shall monitor pile installation and maintain records of each pile installed.
- B. Inspection and testing will be performed by Owner's Geotechnical Engineer and Testing Laboratory under Part 3 "Field Quality Control" article of this Section.
 - 1. Owner's Representative will determine the acceptability of each pile, based on the observations and recommendations of the Owner's Geotechnical Engineer and Testing Laboratory.
 - 2. Acceptance shall not relieve Pile Contractor of their responsibility to provide piles that meet the requirements of the Contract Documents.

1.6 GROUND CONDITIONS

- A. The geotechnical study data as referenced in this Specification is provided For Information Only; however, factual (non-interpretive) data are believed to be representative of the conditions likely to be found on this site.
- B. If a manmade obstruction is encountered during installation of a pile that prevents the advancing of the hole while using rotary percussive eccentric duplex drilling methods, the hole shall be abandoned and filled with grout. A new pile shall be drilled at locations to be determined by the Engineer.
- C. Damage to existing structures and underground utilities or facilities shall be prevented during the installation of all micropiles. The Contractor shall be solely responsible for evaluating the need for, design of, and monitoring measures to prevent damage to adjacent structures, on or off the right-of-way. Mitigation measures shall include but are not limited to the following: selection of construction methods and procedures that will prevent caving of soils or inward movement of soils into excavations and excessive migration of grout through the ground; monitoring and controlling of the vibrations from construction activities, including placement of casings, sheet piling, soring, and similar ancillary features; and protecting utilities.

1.7 MICROPILE PERFORMANCE REQUIREMENTS

- A. The micropiles shall meet the minimum requirements presented in the following table.

Minimum Grout to Ground Bond Factor of Safety	Highest Toe Elevation Below Grade (ft)	Design Load Axial Compression (kips)
2.0	- 50	50

- B. The total length of an individual micropile should penetrate into material that will provide sufficient resistance to down-drag to avoid additional settlement of the pile.
- C. The structural capacity of the micropile shall be checked against the total load as the sum of down-drag force and load applied at the top of pile as indicated in the structural documents.

1.8 ADMINISTRATIVE REQUIREMENTS

- A. Pre-Activity Meeting: At least five days prior to commencing micropile installation, hold a pre-activity meeting at the site.

1. Provide for the Specialty Subcontractor's project manager and on-site supervisor to attend the meeting and explain the work plan and safety considerations.
2. Invite the Owner's Inspector, the Engineer, and the applicable testing personnel.
 - a. Coordinate the scheduled meeting time with the Owner's Inspector and testing personnel and the Engineer, and provide written notice at least three days in advance of the meeting.

1.9 SUBMITTALS

- A. Submittal procedures and administrative provisions are established by Division 01 Section, "Submittal Procedures".

B. Pre-Construction Submittals

1. The Micropile Contractor shall prepare working drawings and relevant structural design calculations for the micropile system for submittal to the Engineer for review and acceptance. The submittal shall be stamped and sealed by a Registered Professional Engineer in the State of Texas. The Micropile Contractor shall allow the Engineer two (2) weeks to review the working drawing submittal after a complete set has been received. Work shall not begin until the appropriate submittals have been received, reviewed, and accepted in writing by the Engineer.
2. The working drawings and design calculations submittal(s) shall include the following:
 - a. Micropile fabrication and installation details for each pile type (load) showing:
 - 1) Micropile design load
 - 2) Type, size, and arrangement, and extents of permanent casing and reinforcing steel.
 - 3) Minimum total bond length
 - 4) Total micropile length
 - 5) Micropile top attachment
 - b. Structural calculations and analysis data.
 - c. Micropile numbering system for records.
 - d. Grout mix designs, and the procedure for placing the grout.
 - e. Detailed description of the construction procedure and sequence.
 - f. Detailed plans for the method proposed for the testing of the micropiles prior to beginning the tests. This shall include all necessary drawings and details to clearly describe the method.
3. Product Data: For each type of micropile product and accessory indicated.
4. Pile load testing information shall include location, type, and depth of anchor piles; testing frame and jacking equipment details; and details of the strain gauge system.
5. Load test frame and equipment shall be designed by a licensed Civil or Structural Engineer registered in the State of Texas. Provide stamped and signed submittal for load test frame design and calculations.

C. Construction Records Submittals

1. The Micropile Contractor shall submit the following information during construction:
 - a. Certified mill test reports, properly marked, for the reinforcing steel showing the ultimate strength, yield strength, elongation, and material properties.
 - b. Calibration reports for each test jack, pressure gauge and master pressure gauge to be used. The calibration tests shall have been performed within 60 calendar days of the date submitted.

D. Installation Records

1. The Micropile Contractor shall prepare and submit to the Engineer installation records for each pile installed. The records shall be submitted within 24 hours after installation is completed for the pile. The records shall include the following minimum information:
 - a. Pile drilling duration
 - b. Final toe elevation
 - c. Total micropile length
 - d. Description of unusual installation behavior or conditions
 - e. Grout quantities pumped
 - f. Pile materials and dimensions
 - g. As-built location
 - h. As-built inclination

E. Testing Records

1. The Micropile Contractor shall prepare and submit to the Engineer all submittals required in Section 3.6, Pile Load Testing, below. The records shall be submitted within 24 hours after each pile load test is complete.

PART 2 - PRODUCTS

2.1 WATER

- A. Water for mixing grout shall be potable, or shall be tested to evaluate its adequacy for use with the cement, with test results submitted for approval.

2.2 ADMIXTURES

- A. Admixtures shall conform to the requirements of ASTM C494. 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 Engineer. 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.

2.3 CEMENT

- A. All cement shall be Portland cement conforming to ASTM C150, Type I, Type II, or Type III, and shall be the product of one manufacturer.

2.4 GROUT / CONCRETE

- A. Grout shall be 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.

2.5 REINFORCEMENT

- A. Unless indicated otherwise, all reinforcing steel shall be threaded bars conforming to ASTM A615 Grade 75 or ASTM A722 Grade 150.
- B. Bar couplers, if required, shall develop the ultimate tensile strength of the bars without evidence of any failure.

2.6 PIPE / CASING

- A. Permanent steel casing / pipe shall be new product (unused and free from defects) conforming to API 5L Grade B or API 5CT Grade J55.

2.7 PLATES AND SHAPES

- A. Unless indicated otherwise, structural steel plates and shapes for pile top attachment shall conform to ASTM A36 or ASTM A572 Grade 50.

2.8 CENTRALIZERS

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

2.9 POST-GROUT TUBES

- A. Where required, a separate sleeved PVC pipe shall be installed for post-grouting. The pipe outside diameter shall not exceed 1 ¼ inches. The sleeved interval in the bond length shall not exceed 5 feet.

2.10 CORROSION PROTECTION

- A. Bars need not be additionally protected where encased by permanent steel casing and grout.
- B. In the bond zone below the permanent casing, and corrosion specialist should review the corrosivity results provided in the geotechnical report to determine if additional corrosion protection measures are required to protect the bar. If necessary, encapsulation shall be factory installed by bar manufacturer or their licensed fabricator. Splices shall be protected in accordance with manufacturer's instructions.

PART 3 - EXECUTION

3.1 DESIGN

- A. Design micropiles and pile top connections in accordance with Federal Highway Administration Report No. FHWA-NHI-05-039 or CBC 2019 (whichever is more stringent), except as modified herein.

1. Design micropiles to meet or exceed the required loads provided on the structural foundation plans, including all applicable safety factors, and the load-displacement criteria specified below:
 - a. Design the micropiles to limit vertical displacements between the micropile grout body and the surrounding soil to approximately 0.1 inch when loaded at 40% of the ultimate capacity, and approximately 0.4 inch when loaded to 80% of the ultimate capacity, unless otherwise approved by the Engineer.
- B. Design micropiles for the locations and spacing shown on the Drawings.
- C. Design micropiles for the lengths and elevations shown on the Drawings.
- D. Design calculations and drawings prepared by the Micropile Contractor shall be submitted to the Engineer for review and acceptance prior to installation.

3.2 INSTALLATION

- A. The drilling equipment and methods must provide a cased borehole to the defined nominal diameter in all soil. Temporary casing to be removed within bonded zone.
 1. Equipment used shall be compatible with existing site conditions including available overhead and side clearance distances. Contractor is responsible for verifying site conditions in the field.
 2. Equipment and material used to install the Micropile testing program shall be the same as those used for the production micropiles.
- B. Centralizers shall be provided on central reinforcement. The uppermost centralizer shall be located two (2) feet maximum from bottom of footing. Centralizers shall permit the free flow of grout without misalignment of the reinforcement.
- C. 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.
- D. Unless indicated otherwise, the pipe casing and borehole shall be filled with specified grout without voids by tremie method from bottom to top of micropile, withdrawing any temporary casing during grouting operations.
- E. The Micropile Contractor shall check pile top elevations and adjust all installed micropiles to the planned elevations.
- F. No injection bore piles are allowed. An injection bore pile is defined as an uncased pile advanced through the ground by injected grout originating from the tip of the drill rods to create an annular space between the drill steel and the borehole wall.
- G. Begin installation of production micropiles only after verification load test has been evaluated and approved by the Engineer.
- H. Do not drill holes for piles until the adjacent piles have been grouted and the grout has hardened for at least 24 hours.

3.3 GROUTING

- A. The Micropile Contractor shall have means and methods of measuring the grout quality and quantity during the grouting operations. The Micropile Contractor shall keep records showing the quantities and test data for inspection by the Engineer.
- B. The grouting equipment shall produce a mixed grout free of lumps and undispersed cement. The grouting equipment shall be sized to enable the grout to be pumped in one continuous operation. The mixer shall be capable of continuous agitation of the grout.
- C. Grout piles during drilling or as soon as possible after drilling is completed. Do not leave pile hole open overnight.
- D. Post-grouting, if approved, shall be sequenced in such a manner that it does not interfere with the grouting or installation of nearby piles or cause a hydraulic connection between the post-grouting of one pile and a nearby pile.
- E. Grout within the micropiles shall be allowed to attain adequate strength and no fewer than ten days of age prior to load testing.

3.4 PILE THREAD

- A. Piles shall be machine threaded to develop the required design strength of the pile section. Welded splices are not allowed for permanent (underpinning) micropiles.

3.5 ALLOWABLE TOLERANCES

- A. Stake locations of all micropiles and mark micropile identification number on stake.
- B. Centerline of piling shall not be more than 3 inches from indicated plan location.
- C. Pile vertical alignment (plumbness) shall be within 2 percent of design alignment.
- D. Top elevation of pile shall be within 2 inches of the design vertical elevation.
- E. Centerline of core reinforcement shall not be more than $\frac{3}{4}$ inch from the centerline of micropile.

3.6 MICROPILE LOAD TESTS (VERIFICATION)

- A. Micropile ("pile") load tests shall be performed to assess the load carrying capacity of the pile system and the construction procedures prior to installing production piles. A minimum of one verification test pile (with any reaction piles or anchors) shall be constructed and tested prior to the commencement of the installation of the production micropiles.
- B. The location proposed for verification test pile shall be at the location as identified in the Drawings. Revision to the location shall be approved by the Engineer. The verification test pile shall be sacrificial and may not be a production pile.
 - 1. Locate verification test pile and reaction piles to avoid damaging existing foundations, new or existing utilities, or existing slab to remain.

2. At the conclusion of the testing, remove load test piles and anchor piles to a minimum of 5 feet below finish grade or any subsequently placed concrete. Neither test piles nor anchor piles shall be used to support load in the completed structure.
- C. Verification load test results shall verify the design and installation methods for the micropile and will be reviewed and accepted by the Engineer prior to beginning production micropiles.
 1. Begin installation of production micropiles only after verification load testing has been evaluated and approved in writing.
- D. If pile load test fails to meet design performance requirements, establish cause and modify micropile design and/or installation methods. Retest new system as directed by the Engineer.
- E. The Micropile Contractor shall submit for review and acceptance the micropile load-testing program. The testing program submittal shall be provided two weeks prior to starting the load testing. This micropile verification load testing proposal shall indicate the following information, at minimum:
 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, as applicable
 5. Hydraulic jack calibration report
- F. The drilling and grouting methods, casing diameter, and depth of embedment of the verification test pile shall be identical to the production piles.
- G. 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.
- H. A minimum of two dial gauges having a precision of 0.001 inches shall be used to determine average movement.
- I. The verification test pile shall be instrumented with strain gauges at each major soil transition layer, a minimum of four per load test pile, to provide stress and strain values along the entire length of the pile. Strain gauges shall be vibrating wire type attached to the center bar. A report shall be prepared by the subcontractor providing strain results during load testing.
- J. Design and provide a testing reaction frame sufficiently rigid and of adequate dimensions so that excessive deformation of the testing equipment does not occur.
 1. Testing apparatus shall not impose load on existing structure, for verification tests.
- K. It is permissible to use a larger center reinforcement element for load tests, provided all other pile dimensions and installation procedures are the same.
- L. Test micropiles as specified in the applicable ASTM standards, except as modified in this specification,
 1. ASTM D 1143 for axial compression
- M. Verification Test Load Schedule

1. Conduct verification axial pile load tests by incrementally loading the micropile in accordance with the following schedule and recording the head movement at the beginning and end of each step. AL = alignment load = applied load of less than $0.1 \cdot DL$, and DL = design load.

Step	Loading	Applied Load	Hold Time (min.)
1	Apply AL	AL	2.5
2	Cycle 1	0.15 DL	2.5
		0.30 DL	2.5
		0.45 DL	2.5
		AL	1
3	Cycle 2	0.15 DL	1
		0.45 DL	1
		0.60 DL	2.5
		0.75 DL	2.5
		0.90 DL	2.5
		1.00 DL	2.5
		AL	1
4	Cycle 3	0.15 DL	1
		1.00 DL	1
		1.15 DL	2.5
5	Cycle 3	1.30 DL	Varies
6	Cycle 3	1.45 DL	2.5
		AL	1
7	Cycle 4	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

1. At 1.30 DL, Step 5, Cycle 3, perform creep test; hold load for at least 10 minutes while recording movement at times specified below. At end of creep test load increment, demonstrate a creep rate not exceeding 0.04 inch per log cycle time (1 to 10 minutes) or extend test for up to 60 minutes to demonstrate less than 0.08 inch per log cycle time (6 to 60 minutes) and linear or decreasing creep rate. Then continue to next applied load increment (Step 6).
2. Load hold periods shall start as soon as the test load is applied.
3. Pile movement, with respect to a fixed reference, shall be measured and recorded at 1, 2, 3, 4, 5, and 10 minutes (creep test interval and load cycle maximum load only).
4. Support and sustain pile resistance at $1.0 \cdot DL$ test load increment with no more than $\frac{1}{2}$ inch total vertical movement at the top of the pile.
5. Support and sustain pile resistance at $2.0 \cdot DL$ test load increment without failure, where failure is defined as the load at which the slope of the load versus head displacement first exceeds 0.03 in/kip.

END OF SECTION