

SECTION 310100 – EARTHWORK – AGGREGATE PIERS

1.1 GENERAL REQUIREMENTS

A. Description

Work shall consist of designing, furnishing and installing aggregate pier ground support to the lines and grades designated on the project foundation plan and as specified herein. The aggregate piers shall be constructed by driving a hollow mandrel to the design depth, providing aggregate (compacted and grouted or un-grouted, as required) and withdrawing the mandrel to create the aggregate pier. The aggregate pier elements shall be in a columnar-type configuration and shall be used to produce an intermediate foundation system for support of foundation loads.

1.2 Work Included

- A. Provision of all equipment, material, labor, and supervision to design and install aggregate pier elements. Design shall rely on subsurface information presented in the project geotechnical report. Layout of aggregate pier elements, spoil removal (as required), footing excavations, and subgrade preparation following aggregate pier installation is not included.
- B. The aggregate pier design and installation shall adhere to all methods and standards described in this Specification.
- C. Drawings and General Provisions of the Contract, including General and Supplemental Conditions, and Division 1 Specifications, apply to the work in this specification.

1.3 Approved Installers

- A. The aggregate pier Installer (the Installer) shall be approved by the Owner's Engineer prior to bid opening.
- B. Installers of aggregate pier foundation systems shall have a minimum of 5 years of experience with the installation of aggregate pier systems and shall have completed at least 50 projects.

1.4 Reference Standards

A. Design

- 1. "Control of Settlement and Uplift of Structures Using Short aggregate piers," by Evert C. Lawton (Assoc. Prof., Dept. of Civil Eng., Univ. of Utah), Nathaniel S. Fox (President, Geopier Foundation Co., Inc.), and Richard L. Handy (Distinguished Prof. Emeritus, Iowa State Univ., Dept. of Civil Eng.), reprinted from *IN-SITU DEEP SOIL IMPROVEMENT, Proceedings of sessions sponsored by the Geotechnical Engineering Division/ASCE in conjunction with the ASCE National Convention held October 9-13, 1994, Atlanta, Georgia.*
- 2. "Settlement of Structures Supported on Marginal or Inadequate Soils Stiffened with Short aggregate piers," by Evert C. Lawton and Nathaniel S. Fox. *Geotechnical Special Publication No. 40: Vertical and Horizontal Deformations of Foundations and Embankments*, ASCE, 2, 962-974.

B. Modulus Testing

- 1. ASTM D 1143 - Pile Load Test Procedures

2. ASTM D 1194 - Spread Footing Load Test
 - C. Materials and Inspection
 1. ASTM D 1241 - Aggregate Quality
 2. ASTM D 422 - Gradation of Soils
 - D. Where specifications and reference documents conflict, the aggregate pier Designer shall make the final determination of the applicable document.
- 1.5 Certifications and Submittals
- A. Design Calculations - The Installer shall submit detailed design calculations and construction drawings prepared by the aggregate pier Designer (the Designer) for review and approval by the Owner or Owner's Engineer. All plans shall be sealed by a Professional Engineer in the State in which the project is constructed.
 - B. Professional Liability Insurance - The aggregate pier Designer shall have Errors and Omissions design insurance for the work. The insurance policy should provide a minimum coverage of \$3 million per occurrence.
 - C. Modulus Test Reports – A modulus test(s) is performed on a non-production aggregate pier element as required by the aggregate pier Designer to verify the design assumptions. The Installer shall furnish the General Contractor a description of the installation equipment, installation records, complete test data, analysis of the test data and verification of the design parameter values based on the modulus test results. The report shall be prepared under direction of a Registered Professional Engineer.
 - D. Daily aggregate pier Progress Reports – The Installer shall furnish a complete and accurate record of aggregate pier installation to the General Contractor. The record shall indicate the pier location, length, volume of aggregate used or number of lifts, densification forces during installation, the volume of grout use (if required), and final elevations or depths of the base and top of piers. The record shall also indicate the type and size of the installation equipment used, and the type of aggregate used. The Installer shall immediately report any unusual conditions encountered during installation to the General Contractor, to the Designer and to the Testing Agency.
- 2.0 MATERIALS
- 2.1 Aggregate
- A. Aggregate used by the aggregate pier Installer for pier construction shall be pre-approved by the Designer and shall demonstrate suitable performance during modulus testing. Typical aggregate consists of Type 1 Grade B in accordance with ASTM D-1241-68, No. 57 stone or other graded aggregate approved by the Designer.
 - B. Potable water or other suitable source shall be used to increase aggregate moisture content where required. The General Contractor shall provide such water to the Installer.
- 2.2 Cement
- A. Cement shall be Type II Portland Cement.
- 3.0 DESIGN REQUIREMENTS
- 3.1 Aggregate Pier Design

A. The design of the aggregate pier system shall be based on the service load bearing pressure and the allowable total and differential settlement criteria of all footings indicated by the design team for support by the aggregate pier system. The aggregate pier system shall be designed in accordance with generally accepted engineering practice and the methods described in Section 1 of these Specifications. The design life of the structure shall be 50 years.

B. The design shall meet the following criteria.

Maximum Allowable Bearing Pressure for Footings supported by aggregate pier Reinforced Soils	3,000 psf
Estimated Total Long-Term Settlement for Footings:	≤ 1-inch
Estimated Long-Term Differential Settlement of Adjacent Footings:	≤ ½-inch

C. The aggregate pier elements shall be designed using a aggregate pier stiffness modulus to be verified by the results of the modulus test described in Section 5.2 of these specifications.

3.2 Design Submittal

The Installer shall submit detailed design calculations, construction drawings, and shop drawings, (the Design Submittal), for approval at least **3** week(s) prior to the beginning of construction. A detailed explanation of the design parameters for settlement calculations and a Finite Element Model demonstrating satisfactory support and anticipated uncracked performance of the slab-on-grade floor slab under service loading of shall be included in the Design Submittal. Additionally, the quality control test program for aggregate pier system, meeting these design requirements, shall be submitted. All computer-generated calculations and drawings shall be prepared and sealed by a Professional Engineer, licensed in the State or Province where the piers are to be built. Submittals will be submitted electronically only unless otherwise required by specific submittal instructions.

4.0 EXECUTION

4.1 Approved Installation Procedures

The installation procedures of the aggregate pier elements shall be submitted with the calculation submittal to provide general criteria for the construction. Unless otherwise approved by the Designer, the installation method used for aggregate pier construction shall be that as used in the construction of the successful modulus test.

4.2 Plan Location and Elevation of aggregate pier Elements

The as-built center of each pier shall be within 6 inches of the locations indicated on the plans. Piers installed outside of the above tolerances and deemed not acceptable shall be rebuilt at no additional expense to the Owner.

4.3 Rejected Aggregate Pier Elements

Aggregate pier elements installed beyond the maximum allowable tolerances shall be abandoned and replaced with new piers, unless the Designer approves the condition or provides other remedial measures.

All material and labor required to replace rejected piers shall be provided at no additional cost to the Owner, unless the cause of rejection is due to an obstruction or mislocation.

5.0 QUALITY CONTROL

5.1 Control Technician

The Installer shall have a full-time, on-site Control Technician to verify and report all installation procedures. The Installer shall immediately report any unusual conditions encountered during installation to the Aggregate Pier Designer, the General Contractor, and to the Testing Agency.

5.2 Aggregate Pier Modulus Test

As required by the Designer, an Aggregate Pier Modulus Test(s) will be performed at locations agreed upon by the Designer and the Testing Agency to verify or modify aggregate pier designs. Modulus Test Procedures shall utilize appropriate portions of ASTM D 1143 and ASTM D 1194, as outlined in the aggregate pier design submittal.

6.0 QUALITY ASSURANCE

6.1 Independent Engineering Testing Agency (Owner's Quality Assurance)

The Aggregate Pier Installer shall provide full-time Quality Control monitoring of aggregate pier construction activities. The Owner or General Contractor is responsible for retaining an independent engineering testing firm to provide Quality Assurance services.

6.2 Responsibilities of Independent Engineering Testing Agency

- A. The Testing Agency shall monitor the modulus test pier installation and testing. The Installer shall provide and install all dial indicators and other measuring devices.
- B. The Testing Agency shall monitor the installation of aggregate pier elements to verify that the production installation practices are similar to those used during the installation of the modulus test elements.
- C. The Testing Agency shall report any discrepancies to the Installer and General Contractor immediately.
- D. The Testing Agency shall observe the excavation, compaction and placement of the foundations as described in Section 7.5 and preparation and compaction of floor slab areas and placement of fill above constructed elements.

7.0 RESPONSIBILITIES OF THE GENERAL CONTRACTOR

7.1 Site Preparation and Protection

- A. The General Contractor shall locate and protect underground and aboveground utilities and other structures from damage during installation of the aggregate pier elements.
- B. Site grades for aggregate pier installation shall be within 1 foot of the top of footing elevation or finished grade elevation to minimize aggregate pier installation depths. Ground elevations and bottom of footing elevations shall be provided to the Aggregate Pier Installer in sufficient detail to estimate installation depth elevations to within 3 inches.

- C. The General Contractor will provide site access to the Installer, after earthwork in the area has been completed. A working surface shall be established and maintained by the General Contractor to provide wet weather protection of the subgrade and to provide access for efficient operation of the aggregate pier installation.
- D. Prior to, during and following aggregate pier installation, the General Contractor shall provide positive drainage to protect the site from wet weather and surface ponding of water.

7.2 Aggregate Pier Layout

The location of aggregate pier-supported foundations for this project, including layout of individual aggregate pier elements, shall be marked in the field using survey stakes or similar means at locations shown on the drawings.

7.3 Contractor's / Owner's Independent Testing Agency (Owner's Quality Assurance)

General Contractor is responsible for acquiring an Independent Testing Agency (Quality Assurance) as required. Testing Agency roles are as described in Part 6 of this specification. The aggregate pier Installer will provide Quality Control services as described in Part 5 of this specification.

7.4 Excavations of Obstructions

- A. Should any obstruction be encountered during aggregate pier installation, the General Contractor shall be responsible for promptly removing such obstruction, or the pier shall be relocated or abandoned. Obstructions include, but are not limited to, boulders, timbers, concrete, bricks, utility lines, etc., which shall prevent placing the piers to the required depth, or shall cause the pier to drift from the required location.
- B. Dense natural rock or weathered rock layers shall not be deemed obstructions, and piers may be terminated short of design lengths on such materials.

7.5 Utility Excavations

The General Contractor shall coordinate all excavations made subsequent to aggregate pier installations so that excavations do not encroach on the piers as shown in the aggregate pier construction drawings. Protection of completed aggregate pier elements is the responsibility of the General Contractor. In the event that utility excavations are required in close proximity to the installed aggregate pier elements, the General Contractor shall contact the Aggregate Pier Designer immediately to develop construction solutions to minimize impacts on the installed aggregate pier elements.

7.6 Footing Bottoms

- A. Excavation and surface compaction of all footings shall be the responsibility of the General Contractor.
- B. Foundation excavations to expose the tops of aggregate pier elements shall be made in a workman-like manner, and shall be protected until concrete placement, with procedures and equipment best suited to (1) avoid exposure to water, (2) prevent softening of the matrix soil between and around the aggregate pier elements before pouring structural concrete, and (3) achieve direct and firm contact between the dense, undisturbed aggregate pier elements and the concrete footing.
- C. All excavations for footing bottoms supported by aggregate pier foundations shall be prepared in the following manner by the General Contractor. Recommended procedures for achieving these goals are to:

1. Limit over-excavation below the bottom of the footing to 3-inches (including disturbance from the teeth of the excavation equipment).
 2. Compaction of surface soil and top of aggregate pier elements shall be prepared using a motorized impact compactor. Sled-type tamping devices shall only be used in granular soils and when approved by the designer. Loose or soft surficial soil over the entire footing bottom shall be recompacted or removed, respectively. The surface of the aggregate pier shall be recompacted prior to completing footing bottom preparation.
 3. Place footing concrete immediately after footing excavation is made and approved, preferably the same day as the excavation. Footing concrete must be placed on the same day if the footing is bearing on moisture-sensitive soils. If same day placement of footing concrete is not possible, open excavations shall be protected from surface water accumulation. Methods must be pre-approved by the Designer.
- D. The following criteria shall apply, and a written inspection report sealed by the project Testing Agency shall be furnished to the Installer to confirm:
1. That water (which may soften the unconfined matrix soil between and around the aggregate pier elements, and may have detrimental effects on the supporting capability of the aggregate pier reinforced subgrade) has not been allowed to pond in the footing excavation at any time.
 2. That all aggregate pier elements designed for each footing have been exposed in the footing excavation.
 3. That immediately before footing construction, the tops of aggregate pier elements exposed in each footing excavation have been inspected and recompacted as necessary with mechanical compaction equipment.
 4. That no excavations or drilled shafts (elevator, etc) have been made after installation of aggregate pier elements within the excavation limits described in the aggregate pier construction drawings, without the written approval of the Installer or Designer.
- E. Failure to provide the above inspection and certification by the Testing Agency, which is beyond the responsibility of the aggregate pier Installer, may void any written or implied warranty on the performance of the aggregate pier system.

END OF SECTION 310100