SECTION 31 2200

AGGREGATE PIER SUBGRADE IMPROVEMENT

PART 1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Section 31 2100 Earthwork Under Building

1.2 DESCRIPTION OF WORK

A. Work shall consist of designing, furnishing and installing materials, and constructing a ground improvement system at the locations noted on the drawings and as specified herein. Ground improvement system shall be either vibro stone columns or rammed aggregate piers. “Aggregate Pier” referenced in these specifications refer to both vibro stone columns and rammed aggregate piers.

B. 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. Removal of spoils from the site (which result from aggregate pier construction), removal of spoils off the working pad, footing excavation, and subgrade preparation following aggregate pier installation is not included.

1.3 APPROVED INSTALLERS

A. Installers of aggregate pier foundation systems shall have a minimum of 5 years of experience with the installation of aggregate piers and shall have completed at least 50 projects.

1.4 REFERENCE STANDARDS:

A. Design: The ground improvement installer shall be responsible for design of a vibro stone column or rammed pier ground improvement system that meets the global stability, allowable bearing capacity, and settlement requirements stated on the contract documents. Industry recognized standards or design methods specific to the installer’s equipment and construction methods shall be used.

B. Modulus and Uplift Testing:

1. ASTM D-1143 – Pile Load Test Procedures.
2. ASTM D-1194 – Spread Footing Load Test.
3. ASTM-D-3689 – Uplift Load Test.

C. Materials and Inspection:

1. ASTM D-1241 – Aggregate Quality.
2. ASTM STP 399 – Dynamic Penetrometer Testing.
3. ASTM D-422 – Gradation Soils.

1.5 CONFLICTS IN SPECIFICATIONS/REFERENCES:

A. Where specifications and reference documents conflict, the Architect/Engineer shall make the final determination of the applicable document

1.6 CERTIFICATIONS AND SUBMITTALS:

A. The installer shall submit detailed design calculations and construction drawings to the Architect and to the Geotechnical Engineer of Record for approval at least three (3) weeks prior to the start of construction. All plans shall be sealed by a Professional Engineer in the State in which the project is constructed (referred in this specification as “the Designer”).

B. The Aggregate Pier Engineer shall have Errors and Omissions design insurance for the work. The insurance policy should provide a minimum coverage of $1 million per occurrence.

C. Modulus and uplift test data - The Installer shall furnish the General Contractor a description of the installation equipment, installation records, complete test data, analysis of the test data and recommended design parameter values based on the modulus test results. The report shall be prepared under supervision of a registered Professional Engineer.

D. Daily Progress Reports – The Installer shall furnish a complete and accurate record of aggregate pier installation to the General Contractor. The record shall indicate the column location, length, average lift thickness and final elevations of the base and top of columns. The record shall also indicate the type and size of the densification equipment used. The Installer shall immediately report any unusual conditions encountered during installation to the General Contractor, to the Designer and to the Testing Agency.

1.9 BASIS OF PAYMENT:

A. This work will be paid for at the contract lump sum price for AGGREGATE PIERS.

PART 2. PRODUCTS

2.1 MATERIALS

A. Aggregate used for piers constructed above the water table shall be Type I Grade B in accordance with ASTM D-1241-68, or shall be other graded aggregate selected by the Installer and successfully used in the modulus test. It shall be compacted to a densification and strength, which provides resistance to the dynamic penetration test (ASTM STP 399) of a minimum average of 15 blows per 1.75-inch vertical movement

B. For aggregate used for piers constructed below the water table, the gradation shall be the same as Type I Gradation B, except that particles passing the No. 40 sieve shall be eliminated. Alternatively, No.57 stone or other stone selected by the Installer may be used. Dynamic penetration resistance testing is inappropriate for this material.

C. Potable water or other suitable source shall be used to increase aggregate moisture content where required. Access to water on site shall be provided to the Installer.

D. Installer to coordinate adequate and suitable marshalling areas on the project site for the use of the Installer for the storage of aggregate and equipment.

PART 3. DESIGN REQUIREMENTS

3.1 STONE COLUMN AND AGGREGATE PIER DESIGN

A. The Aggregate Pier design stiffness modulus value shall be verified by the results of the modulus test, described in this specification..

B. Aggregate Piers shall be designed in accordance with generally-accepted engineering practice and the methods described in Section 1 of these Specifications. The design shall meet the following criteria.

1. Minimum Allowable Bearing Pressure for Aggregate Pier Reinforced Soils: See Structural Drawings.

2. Minimum Stone Column Area Coverage (for spread footings): 30%.

3. Estimated Total Long-Term Settlement for Footings: See Structural Drawings.

4. Estimated Long-Term Differential Settlement of Adjacent Footings: See Structural Drawings.

5. Post-Seismic Event Differential Settlement Between Foundations (Liquefaction Mitigation): See Structural Drawings.

C. The design submitted by the Installer shall consider the bearing capacity and settlement of all footings supported by aggregate piers, and shall be in accordance with acceptable engineering practice and these specifications. Total and differential settlement shall be considered. The design life of the structure shall be 50 years.

D. The Aggregate Pier system shall be designed to preclude plastic bulging deformations at the top-of–column design stress and to preclude significant tip stresses as determined from the shape of the telltale test curve from telltales installed in modulus test columns. The results of the modulus test shall be used to verify the design assumptions.

3.2 DESIGN SUBMITTAL: The Installer shall submit detailed design calculations, construction drawings, and shop drawings, (the Design Submittal), for approval at least four (4) weeks prior to the beginning of construction. Electronic copies may be submitted if approved in advance by the Architect. A detailed explanation of the design parameters for settlement calculations shall be included in the Design Submittal. Additionally, the quality control test program for aggregate piers, 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 project is to be built.

PART 4. CONSTRUCTION

4.1 STONE COLUMNS

A. Install stone columns with a down-hole vibrator capable of densifying the aggregate by forcing it radially into the surrounding soil. The vibrator shall be of sufficient size and capacity to construct stone columns to the diameters and lengths shown on the installer’s approved construction drawings.

B. The probe and follower tubes shall be of sufficient length to reach the elevations shown on the installer’s approved construction drawings. The probe, used in combination with the available pressure to the tip jet, shall be capable of penetration to the required tip elevation. Preboring shall be permitted if it is specified in the installer’s approved construction procedure submittal.

C. The probe and follower shall have visible markings at regular increments to enable

measurement of penetration and repenetration depths.

D. Provide methods for supplying to the tip of the probe a sufficient quality of air or water to widen the probe hole to allow adequate space for stone backfill placement around the probe.

E. The probe shall penetrate into the foundation soil layer to the minimum depths required in the installer's construction plans.

F. Lift thickness shall not exceed 4 feet. After penetration to the treatment depth, slowly retrieve the vibrator in 12-inch to 18-inch increments to allow backfill placement.

G. Compact the backfill in each lift by repenetrating it at least twice with the vibrating probe to densify and force the stone into the surrounding soil.

H. Install stone columns so that each completed column is continuous throughout its length.

4.2 RAMMED PIERS

A. All Aggregate Pier elements shall be pre-augered using mechanical drilling or excavation equipment. Installation of piers without pre-augering shall not be allowed because this technique results in significant disturbance and remolding of the matrix soils surrounding the piers.

B. If cave-ins occur during excavation such that the sidewalls of the hole are deemed to be unstable, steel casing or a drilling slurry shall be used to stabilize the excavation.

C. If cave-ins occur on top of a lift of aggregate such that the volume of the caved soils is greater than 10 percent of the volume of the aggregate in the lift, then the aggregate shall be considered contaminated and shall be removed and replaced with uncontaminated aggregate.

D. Special high-energy impact densification apparatus shall be employed to densify the Aggregate Pier elements during installation. The apparatus shall apply direct downward impact energy to each lift of aggregate.

E. A minimum tamper energy level of 250,000 foot-pounds of force per minute shall be applied by the energy source.

F. The bottom of the excavation shall be densified prior to the placement of the aggregate. If wet, soft or sensitive soils are present, open-graded aggregate, such as ASTM No.57 stone or other, shall be placed at the bottom of the excavation and compacted to stabilize the element bottom and may serve as the initial lift.

G. Densification shall be performed using a beveled tamper. The beveled tamper foot is required to adequately increase the lateral earth pressure in the matrix soil during installation.

H. Downward pressure shall be applied to the tamper shaft during tamping.

I. Each lift of aggregate shall be tamped for a minimum of 15 seconds.

4.3 PLAN LOCATION AND ELEVATION OF AGGREGATE PIER ELEMENTS: The center of each pier shall be within six inches of the plan locations indicated. The final measurement of the top of piers shall be the lowest point on the aggregate in the last compacted lift. Piers installed outside of the above tolerances and deemed not acceptable shall be rebuilt at no additional expense to the Owner.

4.4 REJECTED AGGREGATE PIER ELEMENTS: Aggregate Pier elements improperly located or installed beyond the maximum allowable tolerances shall be abandoned and replaced with new piers, unless the Designer approves other remedial measures. All material and labor required to replace rejected piers shall be provided at no additional cost to the Owner.

PART 5. QUALITY CONTROL

5.1 QUALITY CONTROL REPRESENTATIVE

A. The Installer shall have a full-time Quality Control (QC) representative to verify and report all QC installation procedures. The Installer shall immediately report any unusual conditions encountered during installation to the Design Engineer, the General Contractor, and to the Testing Agency. The QC procedures shall include the preparation of Aggregate Pier Progress Reports completed during each day of installation and containing the following information:

1. Footing and Aggregate Pier location.
2. Aggregate Pier length and drilled diameter.
3. Planned and actual Aggregate Pier elevations at the top and bottom of the element.
4. Average lift thickness for each Aggregate Pier.
5. Soil types encountered at the bottom of the Aggregate Pier and along the length of the element.
6. Depth to groundwater, if encountered.
7. Documentation of any unusual conditions encountered.
8. Type and size of densification equipment used.

5.2 QUALITY CONTROL VERIFICATION PROGRAM

A. The installer shall be responsible for design of a verification program to assure the quality of the construction. The program shall verify that the installed ground improvement system satisfies the performance requirements noted on the contract plans and the design requirements determined by the ground improvement system designer. As a minimum, the verification program shall include the following

1. Program to monitor performance of the ground improvement system during and after construction of the proposed structure or embankment to be supported. This program may include installation of settlement plates, monitoring points, inclinometers, piezometers, or other instrumentation.
2. Aggregate pier installation shall be monitored by an on board computer monitoring system. Monitoring system shall log aggregate pier number, time of installation, depth, hydraulic pressure applied during the boring process and during the compacting process. Recorded data for each aggregate pier shall be plotted depth/pressure versus time. Installation records for each shall be made available upon request in electronic format within 24 hours of installation.
3. Proposed means and methods for verification that the installed aggregate piers meet the strength and/or stiffness criteria required by the design. This may include, but shall not be limited to, modulus or load tests on individual elements

and/or groups, soil borings, and other methods as approved by the Engineer.

4. Quality control program to verify that the ground improvement system is installed in accordance with the designer's specifications and the requirements in this special provision. The quality control program shall include testing and observations by qualified personnel employed by the ground improvement installer or an independent testing laboratory.

PART 6. QUALITY ASSURANCE

6.1 INDEPENDENT ENGINEERING TESTING AGENCY: The Owner is responsible for retaining an independent engineering testing firm to provide Quality Assurance services. The Testing Agency should be the Geotechnical Engineer of Record.

6.2 RESPONSIBILITIES OF GEOTECHNICAL ENGINEER & INDEPENDENT ENGINEERING TESTING AGENCY

A. The Geotechnical Engineer of Record shall review and approve the Installer's Design Submittal.

B. The Testing Agency shall monitor the installation of Aggregate Pier elements to verify that all work is performed in accordance with the approved Design Submittal.

C. The Testing Agency & Geotechnical Engineer of Record shall observe footing excavations and densification of Aggregate Piers and provide written reports per section 7.3.D.

D. The Testing Agency shall report any discrepancies to the Installer and General Contractor immediately

PART 7. RESPONSIBILITIES OF GENERAL CONTRACTOR

7.1 PREPARATION

A. The Installer shall locate and protect underground and aboveground utilities and other structures from damage during installation of the Aggregate Pier elements.

B. The General Contractor will provide the site to the Installer, after earthwork in the area has been completed.

C. Site subgrade shall be established by the General Contractor within 6 inches of final design subgrade, as approved by the Design Engineer.

7.2 UTILITY EXCAVATOINS

A. The General Contractor shall coordinate all excavations made subsequent to Aggregate Pier installations so that at least five feet of horizontal distance remains between the edge of any installed Aggregate Pier and the excavation. In the event that utility excavations are required at horizontal distances of less than five feet from installed Aggregate Piers, the General Contractor shall notify the Aggregate Pier Designer to develop construction solutions to minimize impacts on the installed Aggregate Piers.

B. Recommended procedures may include:

1. Using cement-treated base to construct portions of the Aggregate Piers subject to future excavations.

2. Replacing excavated soil with compacted crushed stone in the portions of excavations where the Aggregate Piers have been disturbed. The placement and compaction of the crushed stone shall meet the following requirements.

   (a) The crushed stone shall meet the gradation specified by the Designer.

   (b) The crushed stone shall be placed in a controlled manner using motorized impact compaction equipment.

   (c) The aggregate should be compacted to 95% of the maximum dry density as determined by the modified Proctor method (ASTM D-1557).

   (d) The Testing Agency shall be on site to observe placement, compaction, and provide density testing. The test results shall be submitted to the Designer and the General Contractor. The subcontractor shall provide notification to the Testing Agency and the Designer when excavation, placement, and compaction will occur and arrange for construction observation and testing.

7.3 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 workmanlike manner, and shall be protected until concrete placement, with procedures and equipment best suited to (1) prevent softening of the matrix soil between and around the Aggregate Pier elements before pouring structural concrete, and (2) achieving direct and firm contact between the dense, undisturbed Aggregate Pier elements and the concrete footing.

C. 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 (“Wacker Packer,” “Jumping Jack,” or similar). Sled-type tamping devices shall not be used. Compaction shall be performed over the entire footing bottom to compact any loose surface soil and loose surface column aggregate.

   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 expansive or sensitive soils.

   4. If same day placement of footing concrete is not possible, place a minimum 3-inch thick lean concrete seal (‘mud mat”) immediately after the footing is excavated and approved.

D. The following criteria shall apply, and a written inspection report sealed by the project Geotechnical Engineer 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 Stone Column 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 all the Aggregate Pier elements exposed in each footing excavation have been inspected and recompacted as necessary with mechanical compaction equipment, and that the tops of any Aggregate Pier elements which may have been disturbed by footing excavation and related activity have been recompacted to a dry density equivalent to at least 95% of the maximum dry density obtainable by the modified Proctor method (ASTM D-1557).

4. That no excavations or drilled shafts have been made after installation of Aggregate Pier elements within horizontal distance of five feet from the edge of any pier, without the written approval of the Installer or Designer.

END OF SECTION