

SECTION XXXXX – STONE COLUMNS

PART 1 - GENERAL

- 1.1 RELATED DOCUMENTS: Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 00 and Division 01 Specification Sections, apply to this Section.
- 1.2 DESCRIPTION: 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 [vibro stone columns](#).
- 1.3 WORK INCLUDED:
 - A. Provision of all equipment, material, labor, and supervision to design and install stone columns. Design shall rely on subsurface information presented in the project geotechnical report. Removal of spoils from the site (which result from stone column construction), removal of spoils off the working pad, footing excavation, and subgrade preparation following stone column installation is not included.
 - B. Drawings and General Provisions of the Contract, including General and Supplemental Conditions, and Division 1 Specifications, apply to the work in this specification.
- 1.4 APPROVED INSTALLERS:
 - A. Installers of stone column foundation systems shall have a minimum of 5 years of experience with the installation of stone columns and shall have completed at least 100 projects.
- 1.5 RELATED WORK:
 - A. Section 033000 – Cast in Place Concrete.
 - B. Section 312000 – Building Earthwork.
 - C. Geotechnical Report and Recommendations.
- 1.6 REFERENCE STANDARDS:
 - A. Design: The ground improvement installer shall be responsible for design of a vibro stone column ground improvement system that meets the allowable bearing capacity, and settlement requirements stated on the contract plans. 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 (if required).
 - C. Materials and Inspection:
 1. ASTM D-1241 – Aggregate Quality.
 2. ASTM STP 399 – Dynamic Penetrometer Testing (if applicable).
 3. ASTM D-422 – Gradation Soils.

- 1.7 CONFLICTS IN SPECIFICATIONS/REFERENCES: Where specifications and reference documents conflict, the Architect/Engineer shall make the final determination of the applicable document.
- 1.8 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 stone column engineer shall have Errors and Omissions design insurance for the work. The insurance policy should provide a minimum coverage of \$2 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 stone column installation to the General Contractor. The record shall indicate the pier location, length, average lift thickness and final elevations of the base and top of piers. 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 VIBRO STONE COLUMNS.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. Aggregate used for piers shall be selected by the Installer and successfully used in the modulus test.
- B. 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.
- C. 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 DESIGN:

- A. The stone column design stiffness modulus value shall be verified by the results of the modulus test, described in this specification.
- B. Stone Columns 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 Stone column Reinforced Soils: X,XXX psf.
 - 2. Minimum Stone column Area Coverage (for square Spread Footings): 20%.
 - 3. Estimated Total Long-Term Settlement for Footings: XX-inch.

4. Estimated Long-Term Differential Settlement of Adjacent Footings: XX-inch.
- C. The design submitted by the Installer shall consider the bearing capacity and settlement of all footings supported by stone columns, 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 stone column system shall be designed to preclude plastic bulging deformations at the top-of-pier design stress and to preclude significant tip stresses. The results of the modulus test shall be used to verify the design assumptions.
- 3.2 DESIGN SUBMITTAL: The Installer shall submit eight (8) sets of detailed design calculations, construction drawings, and shop drawings, (the Design Submittal), for approval at least three (3) weeks prior to the beginning of construction. A detailed explanation of the design parameters for settlement calculations shall be included in the Design Submittal. Additionally, the quality control test program for stone columns, 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.

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 PLAN LOCATION AND ELEVATION OF STONE COLUMNS: The center of each stone column 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.

- 4.3 REJECTED STONE COLUMNS: Stone columns 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.
- B. Stone column installation shall be monitored by an on board computer monitoring system. Monitoring system shall log stone column number, time of installation, depth, hydraulic pressure applied during the boring process and during the compacting process. Recorded data for each stone column 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.
- C. The QC procedures shall include the preparation of Stone Column Progress Reports completed during each day of installation and containing the following information:
 - 1. Footing and stone column location.
 - 2. Stone column length and drilled diameter (if pre-drilled).
 - 3. Planned and actual stone column elevations at the top and bottom of the element.
 - 4. Average lift thickness for each stone column.
 - 5. Soil types encountered at the bottom of the stone column 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. Proposed means and methods for verification that the installed stone columns 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.
 - 2. 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 or General Contractor 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 stone columns 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 stone columns 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 stone columns.
- 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 EXCAVATIONS:

- A. The General Contractor shall coordinate all excavations made subsequent to stone column installations so that at least five feet of horizontal distance remains between the edge of any installed stone column and the excavation. In the event that utility excavations are required at horizontal distances of less than five feet from installed stone columns, the General Contractor shall notify the stone column Designer to develop construction solutions to minimize impacts on the installed stone columns.
- B. Recommended procedures may include:
 - 1. Using cement-treated base to construct portions of the stone columns subject to future excavations.
 - 2. Replacing excavated soil with compacted crushed stone in the portions of excavations where the stone columns 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 stone columns 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 stone columns before pouring structural concrete, and (2) achieving direct and firm contact between the dense, undisturbed stone columns 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 stone columns 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 pier 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 stone columns, 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 stone columns designed for each footing have been exposed in the footing excavation.
 - 3. That immediately before footing construction, the tops of all the stone columns exposed in each footing excavation have been inspected and recompacted as necessary with mechanical compaction equipment, and that the tops of any stone columns 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 stone columns within horizontal distance of five feet from the edge of any pier, without the written approval of the Installer or Designer.

END OF SECTION XX XX XX

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