

SECTION 31 32 00
STONE COLUMN GROUND IMPROVEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work shall consist of designing, furnishing and installing Stone Columns for ground improvement to support foundations shown on the drawings and as specified herein.
- B. Stone Columns shall be in a columnar-type configuration and shall be used for support of foundation loads as shown in the drawings[OK1]. The Stone Column configuration shall satisfy the performance criteria in Section 3.1 herein.

1.2 DEFINITIONS

- A. Aggregate Piers: are columns of compacted aggregate used to reinforce the ground to increase bearing capacity and reduce settlement of the foundation. They also can serve to increase shear resistance, particularly when a load is placed immediately above them. The piers can either be constructed by means of a vibratory probe (vibrofloat or down-hole vibratory probe) or a down-hole tamper.
- B. Vibrofloat or Down-Hole Vibratory Probe: are specially-designed, high-energy depth vibrators. The horizontal vibrations are created by a motor and eccentric weight located near the tip of the vibrofloat. Extension tubes are bolted to the vibrofloat to allow it to be lowered to the necessary treatment depth.
- C. Bottom Feed Vibrofloats: are down-hole vibrators which are equipped with a tremie pipe through which the aggregate is fed to the tip of the vibrofloat. This equipment is most often used in soil conditions where a pre-drilled uncased hole may not remain open.
- D. Down-Hole Tampers: are high-energy impact apparatus. The vertical tamping energy is provided by a hammer which is connected to a round, beveled tamper. The apparatus is lowered into a pre-drilled hole to the required treatment depth.
- E. Independent Engineering Testing Agency: The firm employed by the Installer to perform laboratory quality control testing for the materials proposed for construction of Stone Columns.
- F. Installer: The person/firm employed by the Owner to install the Stone Columns.

- G. Geotechnical Engineer of Record: Schnabel Engineering Consultants, 1504 Woodlawn Drive, Baltimore, MD 21207 (410-944-6170).
- H. Designer: The person/firm employed by the Installer to design the Stone Column ground improvement system.
- I. Water Jetting: The use of water jets emitted from the bottom tip of the vibrofloat during Stone Column installation or vibrofloat penetration.

1.3 WORK INCLUDED

- A. Provision of all equipment, material, labor, and supervision to design and install Stone Columns. The Stone Column Designer may use the subsurface information presented in the project geotechnical report. The Stone Column Installer and Designer may perform any additional investigations necessary for the design and installation of the ground improvement system. Stakeout of stone columns, spoil removal (as required), footing excavations, and subgrade preparation following Stone Column installation is not included.
- B. The Stone Column 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 01 Specifications, apply to the work in this specification.
- D. The Installer shall warrant the performance of the foundations such that the total and differential settlement of any column shall not exceed the required design value indicated in Section 3.1.

1.4 APPROVAL OF INSTALLERS

- A. The Installer shall be approved by the Resident Engineer and the Geotechnical Engineer of Record prior to bid opening. No alternate installer will be accepted unless approved by the Resident Engineer at least 14 days prior to bid opening.
- B. Installers of Stone Column ground improvement systems shall have a minimum of 5 years of experience with the installation of Stone Column systems and shall have completed at least 15 projects of similar nature in the past 3 years.

1.5 REFERENCES

A. ASTM International (ASTM):

ASTM C88	Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	Test Method for Materials Finer than 75- μ m (No. 200) Sieve in Mineral Aggregates by
ASTM C127	Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C131	Test Method for Resistance to Degradation of Small- Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D422	Test Method for Particle-Size Analysis of Soils
ASTM D1143/D1143M	Test Methods for Deep Foundations Under Static Axial Compressive Load
ASTM D1557	Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³ (2,700 kN-m/m ³))
ASTM D2216	Test Method for Laboratory Determination of Water Content of Soil and Rock by Mass
ASTM D2974	Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM D4253	Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4254	Test Methods for Minimum Index Density and Unit
ASTM D4318	Test Method for Liquid Limit, Plastic Limit and Plasticity index of Soils

A. Geotechnical Reports of Subsurface Investigations titled "Addition to Warehouse Building 360 Veterans Administration Hospital, Perry Point, Cecil County, Maryland," by Schnabel Engineering Consultants.

1.6 SUBMITTALS

A. At least 30 days prior to start of Stone Columns installation, the following shall be submitted to the Resident Engineer:

1. Stone Column Installer Qualifications: The Installer for Stone Columns shall submit evidence of experience and competence to

construct the Stone Columns. The Installer shall have a minimum of 5 years of experience constructing similar Stone Columns. Furthermore, the Stone Column Installer shall have completed at least 15 projects in the last 3 years, in which the approved or similar structure has been used.

2. Design Calculations: The Installer shall submit detailed design calculation prepared by the Designer for review and approval by the Geotechnical Engineer of Record. A detailed explanation of the design parameters for settlement calculations meeting the design requirements in Section 3.1 shall be included in the design calculations. The design shall be completed by a Professional Engineer licensed in the State of Maryland.
3. Shop Drawings: Shop drawings showing the location of each Stone Column. Each Stone Column shall be assigned a reference number, which shall be indicated on the shop drawings. Shop drawings shall indicate the Stone Column nominal diameter, maximum tip elevation, cutoff elevation, load transfer mat (if needed) top elevation and thickness. All plans shall be sealed by a Professional Engineer in the State of Maryland.
4. Product Data: Product data for the proposed crushed stone (gravel) shall be submitted to the Geotechnical Engineer of Record.
5. Equipment Descriptions: The Installer shall submit complete descriptions and operating information for equipment proposed to perform the specified work.
6. Stone Column Installation Procedures: The Installer shall submit detailed Stone Column installation for constructing Stone Columns for review and approval.
7. Sample Stone Column Logs: The Installer shall submit a sample Stone Column log (record of installation form) for review and approval. As a minimum, the log shall include the requirements presented in Section 5.1 herein. The installation log shall also indicate the type and size of the installation equipment used.
8. The Vibration Monitoring Program shall be submitted 30 days prior to the start of installation of the Stone Columns, and shall be

subject to the approval of the Geotechnical Engineer of Record and the Owner.

- B. Resident Engineer At least 30 days prior to start of load testing, the following shall be submitted to the Resident Engineer:
 - 1. Load Test Equipment - Provide Load Test detail including testing devices and equipment along with the configuration to be used, as may be applicable for both modulus and full scale load test. In addition, load cell, jack, pump and pressure gauge calibration shall be submitted for review.
- C. Static Load Test Report - The Installer shall submit a complete report on each load test, within 7 days of completion, including a description of the installation equipment, installation records for the test of the Stone Columns, complete test data, analysis of test data, verification of the design parameter values based on the load test results, and other observations made during testing in general accordance with ASTM D 1143 - Procedure A - "Quick Load Test Method".
- D. Stone Column Production Logs: The Installer shall submit one copy of log and equipment computer record, if applicable, for each completed Stone Column, on a daily basis. Notations on any significant occurrences, obstructions, delays, unusual ground conditions, or difficulties encountered during column construction shall be indicated in the logs.
- E. Submittals shall be submitted electronically as well as one hard copy.

PART 2 - MATERIALS

2.1 Crushed Stone

- A. The crushed stone to be used in Stone Columns shall consist of hard, durable, clean, crushed rock, free of organic matter and other deleterious substances. When subjected to the magnesium sulfate soundness test ASTM C88, the percent weight loss shall be no more than 15 percent. When tested according to ASTM C131, the crushed stone shall have a maximum loss of 40 percent at 500 revolutions.
- B. Crushed stone shall consist of angular gravel having the following gradation limits when tested in accordance with ASTM C117 and ASTM C136:

U.S. Standard Sieve Size	Cumulative Percent Passing by Weight
2 inches	100
1 ½ inch	95-100
3/8 inch	0-5

- C. Specific Gravity Test Data: Provide specific gravity test data in accordance with ASTM C127.
- D. Maximum-Minimum Density: Provide three laboratory test results for maximum-minimum density of the crushed stone materials in accordance with ASTM D4253 and ASTM D4254.
- E. If the source of the crushed stone is changed during construction, submit additional test data for each new source in accordance with this Specification.

2.2 Water

- A. Only fresh water, free of all substances deleterious to the work, may be used.

PART 3 - DESIGN REQUIREMENTS

3.1 STONE COLUMN DESIGN

- A. The design of the Stone Column system shall be based on the service loads, bearing pressure and the allowable total and differential settlement criteria of all footings indicated by the design team for support by the Stone Column system. The Stone Column system shall be designed in accordance with generally-accepted engineering practice. The design life of the structure shall be 50 years.
- B. The design shall meet the following criteria.
 - 1. Minimum Allowable Bearing Pressure for Footings Supported by Stone Column Reinforced Soils: **3,000 psf**
 - 2. Maximum Estimated Total Long-Term Settlement for Footings: **1 inch**
 - 3. Maximum Estimated Long-Term Differential Settlement of Adjacent Footings: **½ inch**
- C. The Stone Column tip elevation shall be located a minimum of 1 foot into the natural soil (Stratum B).

PART 4 - EXECUTION

4.1 SITE PREPARATION

- A. Site preparation and pre-ground improvement operations shall be completed prior to commencement of Stone Column work. All working platforms shall be constructed of granular soils and compacted to provide a stable, level and safe surface that does not deflect under tracking of drilling equipment/ready-mix delivery trucks and does not turn into mud when wet. A working platform, consisting of a minimum of 12 inches thick compacted granular material, shall be used when required. The Installer shall inspect the working platform of each area prior to the start of the Stone Column operation in order to verify that the platform can safely support its equipment and operation and whether or not the granular material is required to improve the surface of the working platform.
- B. The General Contractor shall locate and protect underground and above-ground utilities and other structures at all times during installation of the Stone Column.
- C. The General Contractor shall be responsible for preparing and maintaining the work area at the existing grades and keeping the work area free from mud, water, and other debris. During installation, the working surface around the probe shall be kept reasonably clean and dry.

4.2 INSTALLATION PROCEDURES

Unless otherwise approved by the Geotechnical Engineer of Record, the installation method used for Stones Columns construction shall be that as used in the construction of the successful load test. Stone Columns shall be a minimum of 24-inch diameter.

- A. The following subsections provide general criteria for the construction of the Stones Columns.
 - 1. Stone Columns installed using augered (replacement) systems
 - a. Augered Aggregate Pier systems shall be augered using mechanical drilling equipment.
 - b. If cave-ins occur during excavation such that the sidewalls of the hole are deemed to be unstable, steel casing shall be used to

stabilize the cavity or a displacement Aggregate Pier system may be used.

- c. Crushed stone shall be placed in the augered cavity in compacted lift thicknesses as determined by the Designer, but not exceeding 14 inches.
- d. Should cave-ins occur on top of a lift of aggregate such that the volume of the caved soil is great 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.
- e. If a Down-Hole Tamper is used, a specially-designed beveled tamper and high-energy impact densification apparatus shall be employed to densify lifts of aggregate during installation. The tamper diameter shall be at least 80% of the pre-augered hole diameter. The apparatus shall apply direct downward impact energy to each lift of aggregate.
- f. If a Down-Hole Vibratory probe is used, the quantity of aggregate initially added shall be such that the vibrofloat tip is able to penetrate to within 12 inches of the design depth. The vibrofloat shall be raised and lowered repeatedly, such that on each re-penetration, the tip of the vibrofloat advances to within 12 inches of the previous penetration depth.

2. Stone Columns installed by displacement Aggregate Pier systems

- a. Displacement Aggregate Pier systems shall be advanced to the design depth by one of the following methods:
 - i. using a specially designed mandrel with a minimum 15 ton static force augmented by dynamic vertical ramming energy to the full design depth,
 - ii. using a closed ended steel pile, which is driven into the soil to the design depth; or
 - iii. using a hollow-shaft mandrel, which is advanced into the soil to the design depth
- b. The hole shall be filled with stone, while the mandrel/pipe is incrementally raised, permitting the aggregate to be released into the cavity, and then lowered by vertically advancing and/or ramming to densify the aggregate and force it laterally into the adjacent

- soil. The cycle of raising and lowering the mandrel or steel pipe, and ramming the aggregate shall be repeated to the top of pier elevation. The cycle distance shall be determined by the Aggregate Pier Designer.
- c. Densification shall be performed using a mandrel/tamper. The mandrel/tamper foot is required to adequately increase the lateral earth pressure in the matrix soil during installation.
 - d. Downward crowd pressure shall be applied to the mandrel during installation.
3. Vibro-Replacement Stone Columns installed by the wet, top feed method.
- a. The first 12-inch lift of stone shall be placed. The Vibrofloat shall then be lowered to the design depth while flushing water to facilitate penetrations.
 - b. Water is used to flush the soils around the vibrofloat, the hole is then filled with stone from the top, and the vibrofloat is incrementally raised, permitting the aggregate to be released into the cavity, and then lowered by vertically advancing and/or ramming to densify the aggregate and force it laterally into the adjacent soil.
 - c. The Vibrofloat will be repeatedly raised and lowered such that on each re-penetration, the tip of the Vibrofloat advances to within 2 feet of the previous penetration depth, or refusal (whichever comes first). The Vibrofloat will not be raised more than 4 feet at any time unless the stone stops flowing to the bottom of the vibrofloat.
4. Vibro-Replacement Stone Columns system installed by the dry, top feed method.
- a. Pre-augering shall be performed with an auger diameter equal to 75-100% of the finished column diameter.
 - b. The Vibrofloat shall then be lowered to the design depth. The crushed stone may be added to the hole either before or after insertion of the vibrofloat as long as the vibrofloat is able to penetrate to within 1 foot on the designed bottom of the Vibro Pier.
 - c. The Vibrofloat shall be repeatedly raised and lowered such that on each re-penetration, the tip advances to within 2 feet of the

previous penetration depth, or refusal (whichever comes first).
The Vibrofloat shall not be raised more than 4 feet at any time
unless the stone stops flowing to the bottom of the vibrofloat.

5. Vibro-Displacement Stone Columns installed by the dry, bottom feed method.
 - a. The vibrofloat shall be lowered to the design depth by vibration and air jetting action. The crushed stone is delivered through the tremie to the bottom of the probe as necessary.
 - b. The Vibrofloat is retracted in stages as crushed stone is added. The vibrofloat is repeatedly raised and lowered such that on each re-penetration, the tip advances to within 2 feet of the previous penetration depth, or refusal (whichever comes first). The Vibrofloat shall not be raised more than 4 feet at any time unless the stone stops flowing to the bottom of the vibrofloat.
- B. When constructing vibrated Stone Columns, the Installer shall continue to penetrate each lift of stone with the vibratory probe until the electric vibrofloat reaches the manufacturer's maximum recommended sustainable operating amperage (or, if a hydraulic vibrofloat is used, the recommended maximum sustainable hydraulic pressure) for at least three consecutive vibratory probe penetrations per lift except when a minimum design column diameter has been achieved by increasing the number of penetrations.
- C. The diameter of Stone Column lift shall be calculated by the Installer during column construction and verified by the Geotechnical Engineer of Record. The stone column diameter shall be calculated by the Installer using the moist weight of stone installed per lift, the in-place stone density (assuming 80 percent in-place relative density, as determined in accordance with ASTM D4253 and D4254), and the lift height. The moisture content and relative density of the stone shall be calculated by the Installer using the results of the laboratory tests described in Section 5.5.
- D. Air pressure may not be used to aid in the insertion of the probe and the feed of the gravel materials through the probe.

4.3 PLAN LOCATION AND ELEVATION OF STONE COLUMNS

- A. The as-built center of each pier shall be within 3 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.
- B. The depth of treatment shall be selected by the Designer of the Stone Column system to satisfy the performance requirements presented herein. Installer shall construct each column to be continuous for the entire depth of the Stone Column (vertical interval of treatment).
- C. The axis of the Stone Column shall not be inclined from the vertical y more than one percent as indicated by the tilt of the vibrator/tamper and followers.

4.4 REJECTED STONE COLUMNS

- A. Stone Column elements installed beyond the maximum allowable tolerances shall be abandoned and replaced with new piers, unless the Stone Column Designer demonstrate otherwise to the Geotechnical Engineer of Record 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.

4.1 OBSTRUCTIONS

- A. The Installer shall be prepared to encounter occasional locations in the sub-surface materials where penetration of the Stone Column probe is difficult or obstructed. In the event probe penetration cannot be achieved, the Installer shall use the following procedure:
 - 1. A 12-inch maximum horizontal deviation from indicated column location will be allowed without prior authorization from the Resident Engineer when an obstruction is encountered; the presence of any obstruction shall be reported to the Geotechnical Engineer of Record and the Resident Engineer and be described in the records. When a deviation greater than 12 in. is caused by an obstruction, the Installer shall stop work, move to another location, and immediately notify the Geotechnical Engineer of record and the

Resident Engineer. The Geotechnical Engineer of Record may, at his option, authorize one or several of the following:

- a. relocation of the Stone Column a short distance away from the original position,
- b. installation of additional Stone Columns to bridge the obstruction,
- c. removal of the obstruction and replacement of removed soils followed by installation of the Stone Column in the original indicated location, or
- d. other removal or relocated operations.

The Owner will pay the Installer for authorized work to remove obstructions or for performing directed relocation operations, except shifting the column location point.

PART 5 - QUALITY CONTROL AND QUALITY ASSURANCE

5.1 CONTROL TECHNICIAN

A. 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 Stone Column Designer, the Resident Engineer, and the Geotechnical Engineer of Record. The quality control procedures shall include the preparation of Stone Column Progress Reports completed during each day of installation containing the following information:

1. Name of installer and inspector
2. Date of installation
3. Footing and Stone Column location.
4. Pre-drilling diameter and soil conditions encountered during drilling (if required).
5. Planned and actual Stone Column elevations at the top and bottom of the Stone Column.
6. Average lift thickness of each Stone Column.
7. Volume of crushed stone placed with depth.
8. Calculated Stone Column diameter with depth

9. Documentation of any obstructions or unusual conditions encountered.
10. Type and size of densification equipment used.
11. Penetration and Compaction time and energy with depth.
12. Vibroflot Amperage with depth and time.
13. Estimate of ground heave or subsidence.
14. Jetting pressure (if used).

5.2 STONE COLUMN LOAD (MODULUS) TEST

- A. A minimum of two Stone Column Load Tests shall be performed at locations agreed upon by the Stone Column Designer and the Geotechnical Engineer of Record to verify or modify Stone Column design. The Stone Column Installer shall conduct and monitor the column load test installation and testing. The Installer shall provide and install all dial indicators and other measuring devices, conduct the test, and prepare the load test report. Load Test Procedures shall be performed in general accordance with ASTM D 1143. Stone Columns shall be tested to 150 percent of the maximum design stress. The modulus tests shall be of the type and installed in the manner specified herein.
1. A telltale shall be installed at the bottom of the test pier so that bottom-of-pier deflections may be determined. Acceptable performance is indicated when the bottom of the pier deflection is no more than 30% of the top of pier deflection at the design stress level.
 2. ASTM D-1143 general test procedures shall be used as a guide to establishing load increments, load increment duration, and load decrements. As a minimum, the following loading increments, decrements and duration shall be used.

Increment	Approximate Load (percent design)	Minimum Duration (min)	Maximum Duration (min)
Seat	5	0	N/A
1	17	15	60
2	33	15	60

3	50	15	60
4	67	15	60
5	83	15	60
6	100	15	60
7	117	60	60
8	133	15	60
9	150	15	240
10	100	N/A	N/A
11	66	N/A	N/A
12	33	N/A	N/A
13	0	N/A	N/A

- B. With the Exception of the load increment representing approximately 150% of the design maximum top of Stone Column stress, all load increments shall be held for a minimum of 15 minutes. Loads shall then be maintained until the rate of deflection reduces to 0.01 inch per hour or for the minimum of 1 hour, whichever occurs first.
- C. The load increment that represents approximately 150% of the design maximum stress on the Stone Column shall be held for a minimum of 15 minutes. That load shall then be maintained until the rate of deflection reduces to 0.01 inch per hour or for the minimum of 4 hours, whichever is occurs first.
- D. A seating load equal to 5 percent of the total load shall be applied to the loaded steel plate prior to application of load increments and prior to measurement of deflections to compensate for surficial disturbance.

5.3 BOTTOM STABILIZATION TESTING (BSTs)/CROWD STABILIZATION TESTING (CSTs)

- A. Bottom Stabilization Testing (BSTs) and Crowd Stabilization Testing (CSTs) shall be performed for augered Aggregate Pier System and displacement Aggregate Pier system, respectively, by the Control Technician during the installation of the modulus test.
- B. Bottom Stabilization Test shall be performed for augered Aggregate Pier System as follows:
 - 1. Apply tamper energy to the bottom lift of aggregate and compact aggregate for the same duration and number of passes as in the load test pier.

2. Turn off the energy source, place a reference bar over the cavity for the Aggregate Pier element and mark the tamper shaft at the reference bar.
3. Restart the energy source for 15 seconds.
4. Stop the energy source and mark the tamper shaft again at the reference bar.

Bottom Stabilization Tests shall be performed on the first five production Aggregate Piers. Additional testing as required by the Aggregate Pier Designer (at least 10% of the production Aggregate Piers) shall be performed on selected production Aggregate Pier elements to compare results with the modulus test pier.

- C. Crowd Stabilization Test shall be performed on displacement Aggregate Pier System as follows:

Crowd Stabilization Tests shall be performed for displacement Aggregate Piers during the installation of probe piers and the modulus test pier to establish quality control criteria during construction of the production Aggregate Pier elements. The Crowd Stabilization Tests shall be performed in general conformance with the following procedures:

1. The impact energy of the hammer shall be turned off after completion of a compacted lift at a depth specified by the Aggregate Pier Designer.
2. A reference mark shall then be made on the mandrel. Crowd pressure from the installation machine shall be applied to the top of the compacted lift of aggregate.
3. The vertical mandrel movement at the maximum crowd pressure shall be recorded.
4. The maximum crowd pressure shall be applied for an additional 15 to 180 seconds following the initial crowd pressure readings. The duration of the test shall be determined by the Aggregate Pier Designer.

Crowd Stabilization Tests shall be performed on the first five production Aggregate Piers. Additional testing as required by the Stone Column Designer (at least 10% of the production Aggregate Piers) shall be performed on selected production Aggregate Piers elements to compare results with the load test columns.

5.4 MONITORING PROGRAM^[QK2]

- A. The Stone Column Installer shall be responsible for submitting a Vibration Monitoring Program in accordance with Specification Section 31 32 00. This Vibration Monitoring Program shall monitor ground vibrations caused by the installation of the Stone Columns immediately adjacent to the site and the existing building.

5.5 INDEPENDENT ENGINEERING TESTING AGENCY

- A. The Independent Engineering Testing Laboratory shall perform quality control tests of each type of material required on the Project from the sources proposed by the Installer.
- B. Crushed Stone (gravel) proposed to be used in the work shall be tested in the laboratory for compliance with specified requirements as follows:
 - 1. Moisture-Density Relationship: ASTM D1557.
 - 2. Moisture Content: ASTM D2216.
 - 3. Liquid Limit: ASTM D4318.
 - 4. Plastic Limit and Plasticity Index: ASTM D4318.
 - 5. Percentage of Wear: ASTM C131.
 - 6. Sulfate Soundness Test: ASTM C88.
 - 7. Sieve Analysis: ASTM D422, and ASTM C136, as applicable.
 - 8. Percent Passing No. 200 sieve: ASTM C117.
 - 9. Organic Content of Soils: ASTM D2974.

5.6 RESPONSIBILITIES OF GEOTECHNICAL ENGINEER OF RECORD

- A. The Owner shall retain the Geotechnical Engineer of Record to provide Quality Assurance services
- B. The Geotechnical Engineer of Record shall observe the installation of Stone Column to verify that the production installation practices are similar to those used during the installation of the load test of the Stone Column elements and that the production columns have been installed to the required tip elevation.
- C. The Geotechnical Engineer of Record shall observe the excavation, compaction and placement of the foundations. Dynamic Cone Penetration testing may be performed to evaluate the footing bottom condition as determined by the Geotechnical Engineer of Record.

PART 6 - RESPONSIBILITIES OF THE GENERAL CONTRACTOR

6.1 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 Stone Columns.
- B. The General Contractor shall locate in the field the locations of each Stone Column as shown on drawings prepared by the Designer.
- C. Site grades at the time of Stone Column installation shall be at least 1 foot above the bottom of footing elevation. Ground elevations and bottom of footing elevations shall be provided to the nearest tenth of a foot at each foundation column location.
- D. The General Contractor shall 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 Stone Column installation.
- E. Prior to, during, and following Stone Column installation, the General Contractor shall provide positive drainage to protect the site from wet weather and surface ponding of water.
- F. If spoils are generated by Stone Column installation, spoil removal from the aggregate pier work area in a timely manner to prevent interruption Stone Column installation is required.

6.2 STONE COLUMN LAYOUT

- A. The location of Stone Column-supported foundations for this project, including layout of individual Stone Column elements, shall be marked in the field by the General Contractor using survey stakes or similar means at locations shown on the shop drawings.

6.3 UTILITY EXCAVATIONS

- A. The General Contractor shall coordinate all excavations made subsequent to Stone Column installations so that excavations do not encroach on the piers. Protection of completed Stone Column is the responsibility of the General Contractor. In the event that utility excavations are required in close proximity to the installed Stone Column, the General

Contractor shall contact the Stone Column Designer immediately to develop construction solutions to minimize impacts on the installed Stone Column elements.

6.4 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 Column shall be made in a workmanlike 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 Stone Column before pouring structural concrete, and (3) achieve direct and firm contact between the dense, undisturbed Stone Column and the concrete footing.
- C. All excavations for footing bottoms supported by Stone Column 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 Stone Column shall be performed using a motorized impact compactor ("Wacker Packer," "Jumping Jack," or similar). Sled type tamping devices, such as plate tamper, shall only be used in granular soils and when approved by the Stone Column Designer. Loose or soft surficial soil over the entire footing subgrade shall be recompacted or removed.
 - 3. Place footing concrete immediately after footing excavation is made and approved, the same day as the excavation. Footing concrete must be placed on the same day. If same day placement of footing concrete is not possible, the exposed footing subgrade shall be protected from surface water accumulation. A minimum of 3-inch thick lean concrete mud-mat shall be used to accomplish this. Other methods must be pre-approved by the Designer.

PART 7 - MEASUREMENT AND PAYMENT

- A. Measurement: The accepted quantity of Stone Columns, including test columns, shall be measured in total linear feet of all columns

completed in-place. Measurement shall be from the bottom of each column to the proposed bottom of footing. Measurement of each column shall be to the nearest one foot.

- B. Mobilization and demobilization shall be a separate lump sum item.
- C. Stone Columns shall be paid at the contract unit price per linear foot.
- D. Load testing may be priced as a lump sum or unit price based on the Stone Column specified.

END OF SECTION 31 32 00