Supplemental Technical Specification for

Stone Columns

SCDOT Designation: SC-M-205-2 (07/17)

1.0 DESCRIPTION

1.1 Furnish all necessary materials, labor, equipment, incidentals, and necessary submittals for the installation of stone columns in accordance with the lines, grades, dimensions, and designs shown on the plans, this Supplemental Technical Specification (STS), or as directed by either the Resident Construction Engineer (RCE) or the Geotechnical Engineer-of-Record (GEOR). Construct the stone columns using the dry bottom-feed installation technique. Prior written authorization by the GEOR with concurrence from the RCE to use water to install the stone columns is required.

2.0 MATERIALS

2.1 The stone backfill used for the stone columns shall consist of hard, durable crushed gravel or crushed stone with a gradation consistent with the following table:

Sieve Analysis	Percent Passing
2-inch	100
1.5-inch	90-100
No. 4	0-50
No. 16	0-6

2.2 The stone backfill shall be obtained from a source listed on *SCDOT Qualified Product List 2*. Marine limestone or recycled materials shall not be used.

2.3 The loose and compacted density of the stone backfill shall be determined in accordance with ASTM C29.

3.0 SUBMITTALS

3.1 Stone Material

3.1.1 At least 30 calendar days before beginning stone column installation; identify the proposed source of the stone materials and supply, to the RCE, the stone supplier's name and address. Suppliers not listed on *SCDOT Qualified Product List 2* will not be accepted or approved.

3.1.2 Provide the loose and compacted density of the stone backfill as determined by ASTM C29.

3.2 Stone Column Installation Plan

3.2.1 At least 30 calendar days before beginning stone column installation, submit to the RCE for review a Stone Column Installation Plan that includes as a minimum the following information:

a) The configuration of the installation equipment including size, type, weight, maximum pushing force, and vibratory hammer rated energy.

b) Dimensions and length of the vibro-probe.

c) Detailed description of proposed installation procedures.

d) Proposed methods and equipment for pre-augering or spudding, if required.

e) Provide a description of spoil disposal. If the use of water is allowed for installation, provide a detailed description for controlling and disposing of all water as well as any sediment.

f) Submit documentation of the successful application of the proposed stone column installation operations.

g) Determine the amount of stone anticipated per stone column and submit the method for determining the amount of stone installed per stone column (i.e. number of hoppers or skips).

h) Submit shop drawings showing the planned locations and bottom elevations of all stone columns and showing a unique identification number for each stone column. Include an installation sequence with the shop drawings. The shop drawings shall also show the location of all instrumentation, the location of all structures and utilities, and the limits of the final embankment.

3.3 Stone Column Installer

3.3.1 Provide proof to the RCE and GEOR of the experience of the Stone Column Installer for the work described at least 30 calendar days before beginning stone column installation. The Stone Column Installer shall:

a) Identify a full-time supervisor who has been in responsible charge of supervising stone column installation operations for at least 5 projects in the last 5 years. The supervisor shall be present at the work site at all times during stone column installation operations. Provide a detailed resume of the supervisor's experience and qualifications. Provide a detailed resume for the replacement supervisor, if required.

b) Identify a full-time stone column equipment operator who has been directly responsible for stone column installation for at least 5 projects in the last 5 years. The equipment operator shall operate the stone column installation equipment at all times during stone column installation operations. Provide a detailed resume of the equipment operator's experience and qualifications. Provide a detailed resume for the replacement equipment operator, if required.

c) Include in the resumes for supervisor and the equipment operator a list of referenced projects. List for each referenced project, the project start and completion dates, total quantity of stone columns installed, and a detailed description of the project, site conditions, and subsurface conditions. The project description shall include details of the stone column materials, the equipment and technique used to install the stone columns, the average and maximum length of stone column installed, the client name and address, the name and telephone number of the representative of the consultant and owner for whom the work was performed and who can attest to the successful

completion of the work, and any other information relevant to demonstrating the supervisor's or equipment operator's qualifications.

d) Identify the manufacturer and model of the stone column installation probe including the rated energy and centrifugal force of the probe. The probe shall be able to achieve the required diameter of stone columns as indicated on the project plans and shall be down-hole vibratory probe. Provide with the probe an appropriate metering device at a convenient location that inspection of amperage increase may be verified during the operation of the equipment. The metering device may be an ammeter directly indicating the performance of the probe tip.

3.4 Submittal Reviews

3.4.1 Verification that the stone supplier is on *SCDOT Qualified Product List* 2 will be made by the Materials and Research Engineer (MRE). The equipment, construction sequence, and method will be accepted by the GEOR. Verification and acceptance of the source of material or acceptance of the equipment, construction sequence, or installation method does not relieve the Contractor or the Stone Column Installer of its responsibility to install the stone columns in accordance with the plans and specifications. Acceptance by the GEOR of the method and equipment to be used to install the stone columns shall be contingent upon satisfactory demonstration of stone column installation at the project site. If, at any time, the RCE or the GEOR considers that the method of installation does not produce satisfactory stone columns, alter the method and/or equipment as necessary to comply with this STS. The RCE or the GEOR will be the sole judge in determining the adequacy of the Contractor's methods and equipment.

4.0 CONSTRUCTION REQUIREMENTS

4.1 Prior to commencing work, examine the following: existing site conditions, drawings, records of existing utilities and other existing subsurface structures, and Geotechnical Subsurface Data Reports. This data will be made available by the RCE to help determine stone column installation conditions.

4.2 Data on indicated subsurface conditions is provided solely for convenience of the Contractor. It is expressly understood that neither the Department nor the GEOR are responsible for interpretations or conclusions drawn by the Contractor or the Stone Column Installer. The Department and the GEOR expressly encourages the Contractor and/or the Stone Column Installer to perform soil test borings or other subsurface explorations to determine whether the Stone Column Installer's proposed installation method is capable of installing the specified stone columns. If the Contractor and/or Stone Column Installer need additional test borings and other exploratory operations, the boring or other exploration operations are to be conducted at no additional cost to the Department. Acceptance by the GEOR of the installation method, does not imply that the installation method is appropriate for the site.

4.3 Construct a test section at the location indicated on the plans. The test section shall be used to verify the Stone Column Installer's equipment and procedures achieve the requirements contained in the project plans. At the completion of the test section supply the information indicated in Section 5.5 of this STS to the RCE and GEOR for evaluation. Based on the results of the test section the RCE and GEOR will determine whether the Stone Column Installer's proposed procedure meets the requirements of this STS.

4.4 Construct the stone columns in such a manner to not interfere with bridge foundation

installation. Establish positive site drainage prior to construction of the stone columns. Control all spoils generated during stone column construction and prevent spoils from flowing offsite. Dispose of all spoils generated by stone column construction properly. No additional compensation shall be made for handling or disposing of spoil.

4.5 Construct stone columns at the locations shown on the project plans and in accordance with this STS or as directed by either the RCE or GEOR.

4.6 Construct the stone columns to the depths required, using the methods necessary to penetrate to the required depth, including but not limited to pre-augering through stiff and dense layers that may be present, as well as obstructions from existing construction.

4.7 At all times, protect structures (new or existing), underground utilities and other construction from damage caused by stone column installation. Damaged materials or structures shall be replaced or repaired to the satisfaction of the RCE at no additional cost to the Department.

4.8 Install the stone columns to the minimum required Area Replacement Ratio (α_s) with the minimum α_s indicated on the plans. The α_s is based on the spacing between the stone columns, the shape of the layout of the stone columns (e.g. triangular or square) and diameter of the stone columns.

4.9 Verify the location of existing underground utilities by excavation before starting stone column installation operations. If utility lines are to remain in place, provide protection from damage during installation operations.

4.10 Consult with the RCE and the GEOR immediately for directions as to the required procedure if uncharted or incorrectly charted piping or other utilities are encountered during excavation or execution of work. Cooperate with Department and public or private utility companies in keeping their respective service and facilities in operation. Repair damaged utilities to satisfaction of utility Department at no additional cost to the Department.

4.11 Ensure that existing utilities serving facilities occupied by Department or others are not interrupted, except when permitted in writing by the RCE and then only after temporary utility services have been provided.

4.12 To ensure that stone columns are not installed at locations designated for future structural elements, install the stone columns only at the locations shown on the plans. Advanced written authorization from both the RCE and the GEOR is required prior to relocating any stone column. The request to relocate a stone column shall indicate the stone column number, the proposed stone column location, the revised stone column location and why relocating the stone column is necessary.

4.13 A pre-installation conference is required between the RCE, the GEOR and the Contractor and the Stone Column Installer, to review special requirements for work. Arrange the pre-installation conference sufficiently in advance of work to allow required attendees adequate notice (5 work days minimum) to make arrangements to attend. Discuss at the pre-installation conference the individual equipment capabilities and expectations.

4.14 Use a down-hole vibrator capable of providing the horsepower and force as indicated on the plans.

4.15 Specific equipment and procedural specifications are left to the Contractor and/or the

Stone Column Installer to achieve the specified criteria. However, the following general guidelines are identified:

a) After penetration to the treatment depth, the vibrator should be slowly retrieved in 12-inch to 18-inch increments to allow stone placement.

b) The vibrator should be re-driven through each increment into a recently treated depth interval to observe amperage buildup or increase (or equivalent pressure increase for hydraulic vibrators).

c) Amperage buildup and backfill quantities are contingent to the type of vibrator, type of backfill, in situ soil conditions, and the Stone Column Installer's procedure.

5.0 QUALITY CONTROL

5.1 Notify the RCE and GEOR no later than 48 hours prior to commencement of the stone column installation operations.

5.2 Various production columns shall be evaluated by the Engineer on the basis of volume stone installed per column location. Perform Cone Penetration Testing (CPTu) to explore specific areas within the production columns, if required. The project plan sheets will indicate if the testing is to be performed. The test locations will be determined by the GEOR and will be provided on the project plan sheets. Inform the RCE and GEOR 30 calendar days prior to the installation of the first production column so that the GEOR may schedule personnel to be available on-site during field testing.

5.3 The RCE and GEOR reserve the right to request additional tests if in the opinion of the RCE or GEOR the stone columns do not appear to be achieving the required results.

5.4 The RCE will make continuous inspections of stone column installation operations to determine that the depth of penetration is obtained

5.5 Furnish a complete log for each stone column on the project daily or as directed by either the RCE or the GEOR, to include the following:

a) Column identification
b) Date of installation
c) Recording of probe number
d) Start/finish time of stone column
e) Approximate backfill quantities
f) Loose and compacted density (ASTM C29)
g) Number of hoppers or skips used for each 5-foot interval and the total used
h) Weight or volume of each hopper or skip used
i) Amperage per foot
j) Diameter of column (see Section 5.6)
k) Location of column
l) Existing ground surface elevation
m) Top and bottom elevation of each column
n) α_s based on the actual spacing and estimated installed column diameter

5.6 The estimated installed diameter of the column shall be determined for every 5 feet of depth. The loose and compacted densities of the stone backfill shall be used. The density of the stone backfill in the column shall be either measured in the field or shall be assumed to be

80 percent of the compacted density. Contact the RCE for a spreadsheet developed by SCDOT for determining the estimated installed column diameter.

5.7 The acceptance criteria for the stone columns shall be the estimated installed diameter and spacing to create the required minimum α_s. No stone column shall have an estimated installed diameter less than 90 percent of the theoretical stone column diameter provided in the project plans. For groups of 50 consecutively installed stone columns, the average diameter over the total length shall not be less than the diameter specified in the project plans. This same criteria shall be used on all fractions less than 50 consecutively installed stone columns.

5.8 The Stone Column Installer must have sufficient production capacity to produce the required work without causing delay to the project.

5.9 Using a baseline and benchmark established by the Contractor; number, locate, and stake out all stone columns. All other construction staking, preserving the stake locations, and re-staking if necessary, is the responsibility of the Contractor. The as-installed locations of the stone columns shall not vary by more than 12 inches from the locations designated on the plans or approved shop drawings.

5.10 Provide the RCE with "As-Built" plans of the stone column installation. Include in the plans the location, the date installed, and the length of each stone column below the fill soil surface elevation. In addition, include on the "As-Built" stone column plans the fill soil surface elevation at each location, the "As-Built" stone column bottom elevation, and identify any rejected or abandoned stone column installations. Submit "As-Built" plans at least weekly during stone column installation operations. Submit a final "As-Built" stone column plan within 7 calendar days of the completion of stone column installation in all embankment locations. The final "As-Built" plans will be subject to the approval of the RCE.

6.0 METHOD OF MEASUREMENT

6.1 Furnish all supervision, materials, equipment, crews, tools, required permits, survey stake out of stone column locations, and other equipment and materials as necessary to properly execute the work.

6.2 Measure the length of acceptably installed stone columns to the nearest 1/2 foot. The quantity of stone columns measured for payment shall be the actual length of the installed stone columns acceptable to the RCE. No payment will be made for stone columns beyond the limits required by the Contract Documents, unless such increases in the specified area are ordered by the RCE in writing.

6.3 The GEOR may vary the depths, spacing, or numbers of stone columns to be installed and may revise the stone column installation limits shown on the plans based on the actual subsurface conditions encountered. Such changes or revisions may increase or decrease the total quantity of the stone columns estimated based on the plans. In the event of such changes in required stone column quantity written authorization will be provided by the RCE.

7.0 BASIS OF PAYMENT

7.1 Payment will be for the cost of furnishing the total length of the stone column material, installing the stone column, altering of the equipment and methods of installation in order to produce the required end result in accordance with the contract documents, and including the cost of furnishing all tools, materials, labor, equipment, supervision, survey stake out of stone column locations, an all other costs necessary to complete the required work.

7.2 No payment will be made for stone columns, or for any delays or expenses incurred through changes necessitated by improper material or equipment. No payment will be made for stone columns placed deeper than the tip elevation designated on the plans unless authorized in writing by the RCE.

7.3 Payments shall be made under:

Item No.	Pay Item	Pay Unit
2051112	Stone Columns	Linear feet