
Supplemental Technical Specification for

Earthquake Drains

SCDOT Designation: SC-M-205-1 (1/19)

1.0 DESCRIPTION

1.1 Provide all necessary materials, labor, equipment, submittals and incidentals for the installation of Earthquake (EQ) drains in accordance with the details shown on the plans and the requirements of these Supplemental Technical Specifications. The EQ drains consist of a corrugated pipe with slot type perforations encased by a geotextile filter fabric (jacket material). The space within the pipes above the ground water table provides a reservoir for water expelled from the ground for liquefaction mitigation. Construct additional reservoir space, if required, in accordance with details shown on the project plans. Install the EQ drains at the locations shown on the project plans, unless otherwise directed by the Resident Construction Engineer (RCE) and the Geotechnical Engineer-of-Record (GEOR). Install the EQ drains to full length without splicing. Contact the Department for instructions and additional requirements, if splicing is required.

2.0 TESTING STANDARDS

2.1 Use the latest edition of the testing standards indicated in this specification. Substitution of standards will require the prior written approval of the Materials and Research Engineer (MRE) with concurrence of the GEOR. The Contractor is to provide copies of all substituted standards to the RCE. The RCE will provide the copies to the MRE and GEOR for acceptance.

3.0 MATERIALS

3.1 General

3.1.1 The EQ drains shall consist of newly manufactured materials and shall consist of a continuous high-density polyethylene pipe (core) with slot type perforations wrapped in a nonwoven geotextile filter fabric (jacket). The jacket shall allow free passage of pore water to the core without loss of soil material or piping. The core shall provide continuous vertical drainage and shall provide drainage through slot type perforations with a reservoir available in the space above the ground water table. Additional reservoir space may consist of an artificial reservoir provided at the top of the EQ drain as indicated on the plans. The artificial reservoir may range from a layer of stone bridge lift material (see *Bridge Lift Materials* (2007 Supplemental Specifications)) applied over the area receiving EQ drains, to individually constructed reservoirs at each drain location as specified in the plans.

3.2 Jacket Materials

3.2.1 The jacket components shall conform to the following:

- a) Be a synthetic nonwoven polymeric geotextile material capable of resisting bending, punching and tensile forces imposed during installation and during the design life of the EQ drain meeting the requirements indicated in Table 1.
- b) The jacket material shall not be subject to localized damage (e.g., punching through the filter by sand/gravel particles).

- c) The jacket material shall be flexible enough to bend smoothly during installation and during any induced consolidation settlement without damage.
- e) The jacket material shall not undergo cracking and peeling during installation of the vertical drain.

Table 1 – Jacket Material Properties

PROPERTY ¹	TEST METHODS	UNITS	REQUIREMENTS
Mass	ASTM D5261	oz./yd ²	≥ 3.5
Grab Elongation	ASTM D4632	%	≥ 50
Grab Strength	ASTM D4632	lbs.	≥ 95
Tear Strength	ASTM D4533	lbs.	≥ 50
Puncture Strength	ASTM D6241	lbs.	≥ 35
Permittivity	ASTM D4491	sec. ⁻¹	≥ 0.5
AOS	ASTM D4751	Sieve Size (mm)	#70 (≤ 0.15)
Ultraviolet Stability (Retained Strength)	ASTM D4355	%	≥ 50 after 500 hrs. of exposure

Notes:

¹All numeric values represent Minimum Average Roll Value (MARV) in the weaker principal direction. Provide geotextiles whose average test results from any roll sampled in a lot for conformance or quality assurance testing meets or exceeds minimum values provided in this Table.

3.3 Core Materials

3.3.1 The core materials shall conform to the following:

- a) The core shall be continuous high-density polyethylene (HDPE) annular-corrugated interior and exterior pipe with slot type perforations to promote drainage along the axis meeting the requirements of Table 2.
- b) The HDPE shall meet the requirements of ASTM D3350 Cell Classification 424420C. The carbon black content for this pipe shall range from 2 to 4 percent.

Table 2 – Core Material Properties

PROPERTY	TEST METHODS	UNITS	REQUIREMENTS
Nominal Inside Diameter	ASTM F667	in.	As shown on plans
Minimum Average Wall Thickness	Measured with caliper	in.	0.042
Minimum Pipe Stiffness @ 5% Deflection	ASTM F667	psi	30
Elongation	ASTM F667	%	≥ 5 to ≤ 10
Minimum Drainage Slot Area	ASTM F667	ft ² /ft	0.013

3.4 EQ Drain Assemblies

3.4.1 Label or tag the component materials used to manufacture the EQ drains in such a manner that the information for sample identification and other quality control purposes can be read from the label. As a minimum, identify each roll of material whether jacket or core material

used to manufacture the EQ drains by the manufacturer of the material as to lot or control numbers, individual roll number, date of manufacture, manufacturer and product identification. The jacket materials shall be free of defects, rips, holes, and/or flaws. The core materials will be free of defects, crimps, kinks, crushed sections and/or other flaws. Do not use any materials in the work which are damaged during shipment, unloading, storage, or handling, or do not otherwise meet these Specifications. The jacket and core materials shall be wrapped in a protective covering during shipment to the project site.

3.4.2 Wrap the EQ drain component materials as well as the assembled EQ drains in burlap or similar heavy duty protective covering during the storage of the EQ drain. Protect the EQ drains from sunlight, mud, dirt, dust, debris, and other detrimental substances during on-site storage. The assembled EQ drains shall be resistant against wet rot, mildew, bacterial action, insects, dissolved salts, acids, alkalis, solvents, and other ingredients in the site ground water.

4.0 SUBMITTALS

4.1 Earthquake Drain Material

4.1.1 Acceptance of the sample of EQ drain component materials by the MRE will be required prior to delivery of the component materials to the Project. At least 30 calendar days before beginning EQ drain assembly, the Contractor and the EQ Drain Installer shall:

- a) Identify the proposed source of the component materials prior to delivery to the site. Supply, to the RCE, a manufacturer's material certification that the component materials meet or exceed the requirements of this specification. The manufacturer's literature shall document the physical and mechanical properties of the component material. The component material manufacturers shall each be a specialist in the manufacture of the component material and shall have produced a minimum of 5,000,000 linear feet of the component material proposed for the Project that have been used in successful EQ drain applications within the past 5 years, including details on prior performance on these projects.
- b) Submit to the RCE for review and visual inspection 3 samples of the EQ drains, as manufactured/assembled by the EQ Drain Installer. The samples of EQ drains shall be at least 5 feet long. Label the samples of the EQ drains to indicate the manufacturer of each component material as being representative of the component EQ drain material having its specified trade name. In addition, indicate on the label the EQ Drain Installer that assembled the EQ drain.
- c) Submit to the RCE for review and visual inspection 3 samples of the proposed anchor plate to be used to anchor the EQ drains at the design depth shown on the plans.

4.2 Earthquake Drain Installer

4.2.1 Provide proof to the RCE and GEOR of the experience of the EQ Drain Installer for the work described at least 30 calendar days before beginning EQ drain assembly and installation. The PVD Installer shall:

- a) Document successful assembly and installation of at least 5,000,000 linear feet of EQ drains during the last 5 years.
- b) Document at least 5 successfully completed projects within the last 5 years of similar size and complexity to that of the Project. Document the EQ Drain Installer's experience by providing a project summary that includes for each referenced project, the project

start and completion dates, total quantity of EQ drains installed, and a detailed description of the project, site conditions, and subsurface conditions. Include in the project description details of the EQ drain component materials, the technique used to assemble the EQ drains, the equipment and technique used to install the EQ drains, the average and maximum length of EQ drain 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 EQ Drain Installer's qualifications.

- c) Identify a full-time supervisor who has been in responsible charge of supervising EQ drain 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 EQ drain assembly and installation operations. Provide a detailed resume of the supervisor's experience and qualifications. Provide a detailed resume for the replacement supervisor, if required.

4.3 Earthquake Drain Installation Plan

4.3.1 At least 30 calendar days before beginning EQ drain installation, the Contractor and the EQ Drain Installer shall submit to the RCE for review an EQ Drain Installation Plan that includes as a minimum the following information:

- a) Describe the EQ drain assembly procedures/process.
- b) The configuration of the installation equipment including size, type, weight, maximum pushing force, and vibratory hammer rated energy.
- c) Dimensions and length of the mandrel.
- d) Details of the EQ drain anchorage.
- e) Detailed description of proposed installation procedures.
- e) Proposed methods and equipment for preaugering or spudding.
- f) Documentation of the successful application of the proposed EQ drain installation operations.
- g) Provide shop drawings showing the planned locations and bottom elevations of all EQ drains, a unique identification number for each EQ drain, the proposed installation sequence, the location of all potential conflicts with the locations of the EQ drains.

4.4 Submittal Reviews

4.4.1 Acceptance of the proposed component materials will be by the MRE. The equipment, construction sequence, EQ drain assembly procedures and installation method will be accepted by the GEOR. Acceptance of the EQ drain component materials, equipment, construction sequence, assembly procedures or installation method does not relieve the Contractor and EQ Drain Installer of its responsibility to install the EQ drains in accordance with the plans and specifications. Acceptance by the GEOR of the assembly procedure or the method and equipment to be used to install the EQ drains is contingent upon satisfactory demonstration of EQ drain installation at the project site. If, at any time, the RCE or the GEOR considers that the method of assembly or installation does not produce satisfactory EQ drains, alter the assembly procedure, the installation method and/or equipment as necessary to comply with this

Supplemental Technical Specification. The RCE or the GEOR will determine the adequacy of the Contractor's methods and equipment.

5.0 CONSTRUCTION REQUIREMENTS

5.1 Install EQ drains as indicated on the plans or as directed by the RCE and GEOR and install in stages coinciding with construction stages.

5.2 Install the EQ drains using a mandrel or a sleeve to advance through the soils to the bottom elevations shown on the plans. Size the equipment to minimize the disturbance of the subsoil during the installation operation. Install the EQ drains using equipment that will maintain the mandrel in a vertical position. The mandrel or sleeve shall protect the drain material from tears, cuts, and abrasion during installation and shall be retracted after each earthquake drain is installed. Fit the mandrel with 3 symmetrically spaced fins for transmitting vibrations to the soil during installation. The mandrel or sleeve shall be sufficiently stiff to prevent wobble or deflection during installation. In no case will alternative raising and lowering of the mandrel during advancement be permitted. Permit the raising of the mandrel only after completion of the EQ drain installation to the EQ drain bottom elevation shown on the plans or as otherwise authorized by the GEOR.

5.3 Consider the subsoils at the site when selecting equipment and developing the EQ Drain Installation Plan. On the EQ drain installation rig, utilize a vibrator with an eccentric moment sufficient to generate vertical vibration to the mandrel during installation. The equipment shall also generate sufficient vertical force (static crowd) to the mandrel to install the earthquake drains through all existing subsurface materials to the depths shown on the plans. The equipment shall have sufficient power to penetrate into the materials underlying the potentially liquefiable stratum. Use equipment having the capability of installing the EQ drains to at least 5 feet deeper than the maximum EQ drain depth shown on the plans. Select equipment that will not force the fill soil into the existing soil, nor disturb the fill soil, nor cause any bearing capacity problems with the subgrade soils due to the weight of the equipment.

5.4 Install EQ drains using a continuous push using static weight and vibration. Jetting or the use of an impact hammer will not be allowed to install the EQ drains.

5.5 Provide the EQ drain with an "anchor" plate or similar arrangement to anchor the bottom of the drain at the required depth during mandrel removal and to prevent soil from entering the bottom of the mandrel during EQ drain installation. The anchorage shall be adequate to keep the bottom of the EQ drain at the required depth subject to approval and field verification by the RCE. The corresponding dimension of the anchor shall conform as closely as possible to the breadth dimensions of the mandrel to minimize soil disturbance.

5.6 Notify the Department at least 3 working days prior to installation of the initial EQ drains at the location(s) shown on the plans to allow the Department sufficient time to provide the necessary inspection for the initial EQ drain installation. Do not begin installation of the initial EQ drains at the location(s) indicated without the presence of the RCE or his/her representative. During the installation of the initial 10 EQ drains at the indicated location(s), demonstrate that the equipment, method, and material produce a satisfactory installation, as determined by the RCE. Following completion of the initial EQ drain installations at the indicated location(s), do not proceed with the installation of the remaining EQ drains until authorized by the RCE.

5.7 Since foundations may have been previously installed, install the EQ drains in a manner to minimize the impact to these foundations. The location of the EQ drains relative to the foundations shall be determined and staked out prior to the installation of the EQ drains. In addition, take precautions to preserve the stake locations and re-stake EQ drains locations as necessary.

5.8 Using a baseline and benchmark determined by the Contractor, locate, number, and stake out the EQ drains. All other construction staking, for taking precautions to preserve the stake locations, and for re-staking, if necessary, is the responsibility of the Contractor. Do not vary the as-installed locations of the EQ drains by more than 12 inches from the locations designated on the plans or approved shop drawings.

5.9 EQ drains that deviate from the plan locations by more than 12 inches, that are damaged, or improperly installed will be rejected. Abandon in place rejected EQ drains. Place replacement EQ drains as close as possible to the correct original locations.

5.10 Provide the RCE with a means of verifying the plumbness of the mandrel and determining the depth of the EQ drains. Check the equipment for plumbness prior to installing each drain. A deviation from the vertical of no more than 2 percent (2%) during installation is allowed.

5.11 Install EQ drains from the working surface to the EQ drain bottom elevations shown on the plans or to refusal. Refusal is defined as the point where the soils resist a reasonable effort at further penetration of the EQ drains. The GEOR will establish refusal criteria based on the existing soil borings and the initial EQ drain installations to be performed by the EQ Drain Installer in the presence of the RCE or his/her representative, as specified herein. Terminate no EQ drains above the design EQ drain bottom elevations shown on the plans without the approval of the GEOR. The GEOR may vary the depths, spacing, and/or number of EQ drains to be installed, and may revise the plan limits for this work based on the actual subsurface conditions encountered.

5.12 Cut off the EQ drains neatly approximately 6 inches above the working surface, unless otherwise shown on the plans. The filter fabric shall be knotted at the top of the drain to prevent soil from entering the drain.

5.13 Provide the RCE with a means of determining the depth of the advancing EQ drain at any given time and the length of the drain installed at each location. Submit a summary tabulation of the number and length (to nearest 1/2 of a foot) of acceptable EQ drains daily to the RCE.

5.14 Where obstructions are encountered below the working surface, install a new drain within an 18-inch radius of the original location of the obstructed EQ drain. As directed by the RCE make a maximum of 2 additional installation attempts for each obstructed EQ drain. If the EQ drain still cannot be installed to the design bottom elevation, abandon the EQ drain location and install a new EQ drain at a location determined by the RCE in consultation with the GEOR. Clearly mark in the field the locations where EQ drains do not meet the depth criteria due to obstructions. The RCE in consultation with the GEOR has the right to waive the replacement EQ drain requirement upon written notice to the Contractor and EQ Drain Installer.

5.15 Preaugering or spudding for the EQ drain installation shall be allowed to advance the EQ drains through compacted fill material or other obstructions. Penetrate the overlying fill material or any dense layers or obstructions when encountered to satisfactorily install the EQ drains. Obstructions are defined as any man-made or natural object or strata that prevents the proper insertion of the mandrel and installation of the EQ drain.

5.16 The Contractor may use augering, spudding, or other approved methods to loosen the soil and obstructing material prior to the installation of the EQ drains. The obstruction clearance procedure is subject to the approval of the RCE; however, such approval shall not relieve the Contractor or the EQ Drain Installer of the responsibility to clear obstructions in accordance with the specifications.

5.17 If augering is the selected method, the augers shall have a minimum outside diameter equal to the largest horizontal dimension of the mandrel, shoe, or anchor, whichever is greatest.

The maximum outside diameter of the auger shall be no more than 3 inches greater than the maximum dimension of the mandrel.

5.18 Limit the use of obstruction clearance procedures and use only when approved by the RCE. Penetrate no more than 3 feet beneath the obstruction when using augering or other obstruction removal techniques.

5.19 Provide the RCE with "As-Built" plans of the EQ drain installation. Include in the plans the location, the date installed, and the length of each EQ drain below the fill soil surface elevation. In addition, include on the "As-Built" EQ drain plans the fill soil surface elevation at each location, the "As-Built" EQ drain bottom elevation, and identify any rejected or abandoned EQ drain installations. Submit "As-Built" plans at least weekly during EQ drain installation operations. Submit a final "As-Built" EQ drain plan within 7 calendar days of the completion of EQ drain 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 materials, supervision, equipment, mobilization, crews, tools, required permits, survey stake out of EQ drain locations, and other equipment and materials as necessary to properly execute the work. In addition, this item includes clearing of obstructions and the proper disposal of surplus materials brought to the ground surface by obstruction clearance, if required.

6.2 Measure the length of acceptably installed EQ drains for liquefaction mitigation to the nearest 1/2 foot. Do not include in the length of drains that are not anchored to the required depth, unless previously approved by the GEOR and the RCE in writing.

6.3 The GEOR may vary the depths, spacing, or numbers of EQ drains to be installed and may revise the EQ drain 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 EQ drains estimated based on the plans. Measure the length of the acceptably installed addition EQ drains.

7.0 BASIS OF PAYMENT

7.1 Payment will be based on the sum total length of all acceptably installed EQ drains.

7.2 No payment will be made for EQ drains, or for any delays or expenses incurred through changes necessitated by improper material or equipment. No payment will be made for EQ drains 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
2052210	Earthquake Drains	LF