Standard Test Method for Vertical Strip Drains Using a Large Scale Consolidation Test[1]

This standard is issued under the fixed designation D7498/D7498M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε1 NOTE—Units information and designation were corrected and editorial changes were made throughout in February 2014

1. Scope

1.1 This test method is a performance test, which measures the effectiveness of vertical strip drains on the time rates of consolidation of compressible soils from construction project sites.

1.1.1 It is expected that the design agency will be responsible for performing this test. It is not intended to be a manufacturer performed test.

1.2 This test method is applicable to all vertical strip drains.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4354 Practice for Sampling of Geosynthetics and Rolled Erosion Control Products(RECPs) for Testing

D4439 Terminology for Geosynthetics

3. Terminology

3.1 *Definitions*—For definitions related to geosynthetics, see Terminology D4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *vertical strip drains, n*—a geocomposite consisting of a geotextile cover and drainage core installed vertically into soil to provide drainage for accelerated consolidation of soils.

4. Summary of Test Method

4.1 This test method describes procedures for determining the effectiveness of vertical strip drains used under specified soil conditions to enhance the time rate of consolidation of compressible soils.

4.2 A specimen of the vertical strip drain is inserted in the test chamber and compressible soil from the project site is remolded around the vertical strip drain, such that the drain is in a similar position as it would be on the project site.

4.3 The top of the soil is sealed with a wax seal, such that drainage only occurs through the vertical strip drain. The vertical strip drain protrudes up through the seal.

4.4 A sand drainage blanket is placed on top of the wax seal, such that the vertical strip drain drains into the sand blanket.

4.5 A rubber cup seal provides the means of applying incremental loads in a similar manner to a standard soils consolidation test.

4.6 A similar setup is used, only with a 50 mm [2 in.] sand drain in place of the vertical strip drain.

4.7 The Coefficients of Consolidation are determined from the test results for both the vertical strip drain and the sand drain. Time rates of consolidation are then compared.

4.8 Persons performing this test shall have knowledge in the consolidation testing of soils.

5. Significance and Use

5.1 As this is a time intensive test, it should not be considered as an acceptance test for commercial shipments of prefabricated vertical strip drains.

5.2 Prior to the development of vertical strip drains, when it was desired to increase the rate of consolidation of a compressible soil on a construction project, large diameter sand drains were installed. Vertical strip drains can be installed in areas

[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.03 on Permeability and Filtration.

Current edition approved Jan. 1, 2014. Published February 2014. Originally approved in 2009. Last previous edition approved in 2009 as D7498–09. DOI: 10.1520/D7498_D7498M-09R14E01.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

where it is desired to increase the rate of soils consolidation in place of these large diameter sand drains.

5.3 This test method can be used to compare the performance of vertical strip drains to that of sand drains.

6. Apparatus

6.1 The apparatus for this test method is a specialty piece of equipment that must be capable of safely handling loads up to 206.8 kPa [30 psi] using compressed air.

6.1.1 As this is a time intensive test, it is recommended to have three test apparatus setups. This will allow simultaneous testing of three vertical strip drain specimens.

6.1.2 *Test Chamber*—A 254.0-mm [10-in.] diameter by 558.6-mm [22-in.] high by 12.7-mm [0.5-in.] wall thickness PVC pipe. (Fig. 1)

6.1.2.1 *Drainage Ports*—Six 3.18-mm [0.125-in.] drainage ports are located 152.4-mm [6-in.] from the top, and equally spaced around the perimeter of the cylinder.

6.1.2.2 On the outside of the cylinder, at 180° to one another, two 19.05-mm [0.75-in.] thick acrylic hooks are located 25.4 mm [1 in.] from the bottom of the test chamber for the purpose of fastening the test chamber to the base plate.

6.1.3 *Base Plate:*

6.1.3.1 A 361.95-mm [14.25-in.] diameter PVC flat plate, 38.1 mm [1.5 in.] thick.

6.1.3.2 The base plate has a 12.7-mm [0.5-in.] wide by 6.35-mm [0.25-in.] deep concentric groove, having an inside diameter of 254.0 mm [10 in.], located on the top side of the base plate.

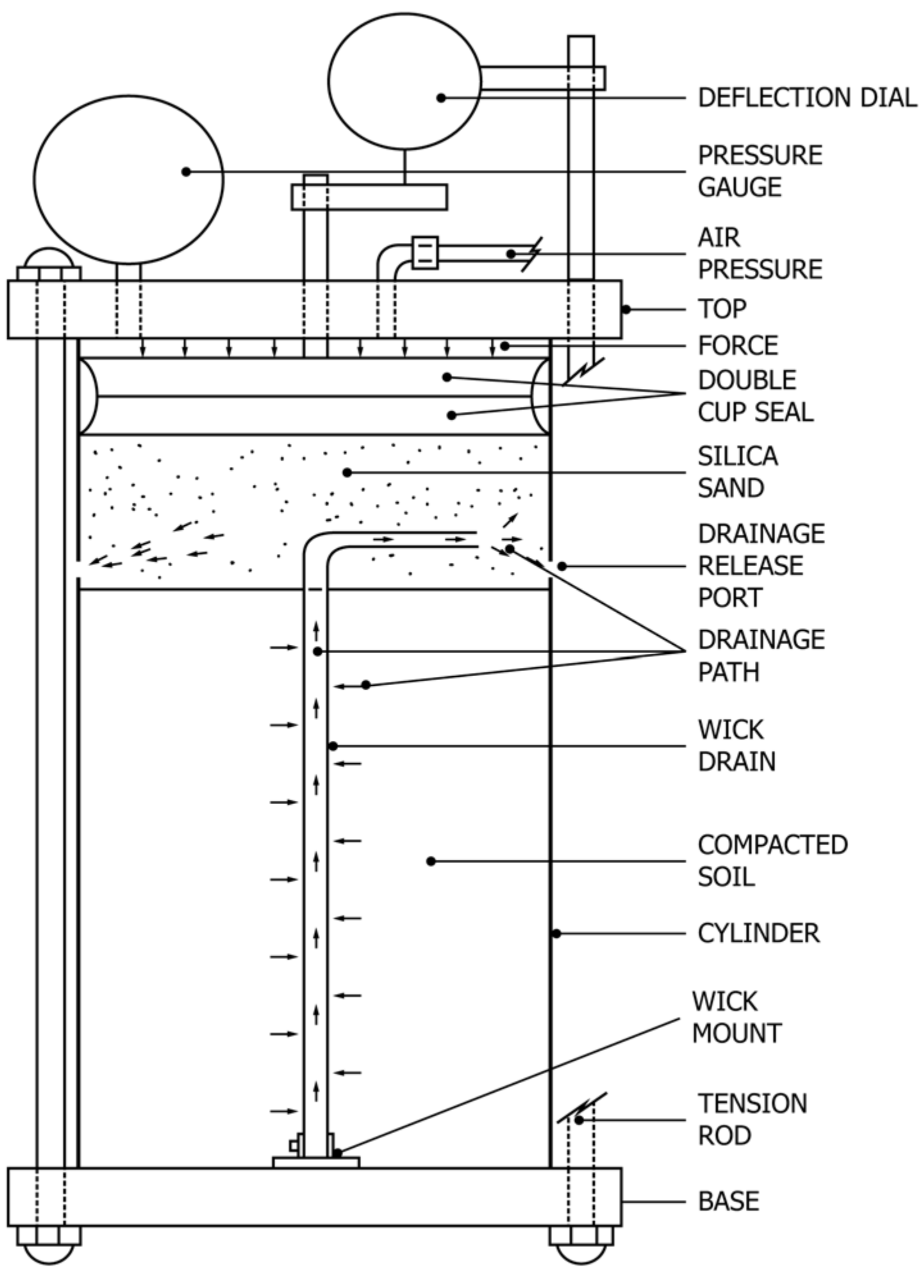

FIG. 1 Large Scale Consolidator

6.1.3.3 A 3.17-mm [0.125-in.] by 228.6-mm [9-in.] diameter rubber O-ring is stretched and placed in this groove.

6.1.3.4 The test chamber is seated into the groove on top of the O-ring.

6.1.4 *Tension Rods:*

6.1.4.1 Equally spaced around the base plate, 158.75 mm [6.25 in.] from the center of the plate, are six 0.952-mm [0.375-in.] diameter by 76.2-mm [30-in.] long threaded tension rods.

6.1.4.2 Each tension rod is attached to the base plate by two hex nuts, one above the plate, and one beneath.

6.1.4.3 On two 180° opposing tension rods place a wing nut that is used to secure the test chamber to the base plate via the hooks referred to in 6.1.2.2.

6.1.5 *Double Cup Seal Assembly:*

6.1.5.1 This is used to evenly distribute the consolidation load over the soil in the test chamber. It consists of the following parts:

6.1.5.2 Two 254.00-mm [10-in.] diameter by 4.76-mm [0.3125-in.] thick rubber cup seals that are placed back to back. They are sandwiched between two 241.3-mm [9.5-in.] diameter by 12.7-mm [0.5-in.] flat PVC plates.

6.1.5.3 A 12.7-mm [0.5-in.] diameter by 228.6-mm [9-in.] long center rod centrally located on the cup seal assembly. It is attached to the assembly by a ball and socket device.

6.1.5.4 A removable PVC platform that is attached to the center rod after the test chamber is completely assembled. This is used to seat the deflection dial or transducer on.

6.1.6 *Top Plate:*

6.1.6.1 An identical plate to the base plate, including the groove for test chamber seating, and holes for tension rods to go through.

6.1.6.2 A 3.17-mm [0.125-in.] by 228.6-mm [9-in.] diameter rubber O-ring is stretched and placed in the groove.

6.1.6.3 A threaded 6.35-mm [0.25-in.] diameter hole going completely through the top plate into which a brass fitting is mounted. The air supply line is attached to this fitting. The consolidation loads are applied through this air line.

6.1.6.4 The double cup seal assembly is mounted through a hole in the center of the top plate. The cup seals are placed such that they will be inside the test chamber.

6.1.6.5 A pressure gauge for reading the applied air pressure is mounted to the top plate such that it reads the pressure inside the test chamber.

6.1.7 A deflection dial or electronic displacement transducer graduated in 0.0254-mm [0.001-in.] divisions.

6.1.7.1 The deflection measuring device is attached to the top plate by mounting it on a rod mounted to the outer edge of the top plate.

6.1.8 *Vertical Strip Drain Mount:* A flat PVC plate cut to fit the inside of the test chamber.

NOTE 1—See Fig. 1 and Fig. 2 for schematic diagrams of the test apparatus.

7. Materials

7.1 *Project Soil*—A quantity of in-situ compressible soil large enough to perform the number of required tests shall be obtained from the project site. This does not have to be undisturbed soil.

NOTE 2—The quantity of soil needed shall be figured based on filling the test chamber to a height of 381 mm [15 in.] at the desired density.

7.2 *Silicone Spray*—The spray is used to lubricate the inside surface of the test chamber to minimize friction between the soil and the chamber surface.

8. Hazards

8.1 There are no known hazards with the materials, or in performing the test.

9. Sampling, Laboratory Samples, and Test Specimens

9.1 *Lot Sample*—As a lot sample for acceptance testing, take the number of units as directed in Table 3 in Practice D4354. Consider rolls of the vertical strip drain to be the primary sampling units.

9.2 *Laboratory Sample*—Take for the laboratory sample a sample 1829 mm [72 in.] in length from each of the lot samples. Before taking the laboratory sample, remove the outer layer of drain from the sample roll to avoid testing any damaged material.

9.3 *Test Specimens*—From each laboratory sample cut three test specimens, each 508.0 mm [20 in.] long, making sure each end of the specimen is cut square.

9.3.1 At one end of each test specimen cut three notches 6.35 mm [0.25 in.] x 12.7 mm [0.5 in.] long. Each notch should line up with the mounting bolts in the specimen mount. See Fig. 1.

9.3.2 Place a 25.4-mm [1-in.] wide piece of masking tape around each test specimen, covering the area from 374.6 mm to 400.0 mm [14.75 to 15.74 in.] of the length of each specimen.

10. Test Set-Up

10.1 Compute the total wet mass of soil to be used in each chamber by multiplying the desired wet density by the volume the soil will occupy. This is the initial mass of soil.

10.2 Taking a small portion of the wet soil from 10.1, determine and record the initial moisture content of the soil to be placed in the test chamber using Eq 1:

$$w_i = [(W_T - W_S)/W] \times 100\,\% \tag{1}$$

where:

w_i = Initial Moisture Content (%)
W_T = Total Wet Mass of Soil (g)
W_S = Dry Mass of Soil (g)

10.3 Secure the test chamber to the bottom base making sure that the O-ring seal is in place in the base plate.

10.4 Draw a line around the inside of the test chamber 381.0 mm [15 in.] up from the top surface of the base plate. This is the height to which the soil will be placed, and is the initial height of soil in the test chamber.

10.5 Spray non-stick silicone spray around the inside surface of the test chamber. This will reduce sidewall fiction between the soil and the test chamber as consolidation takes place.

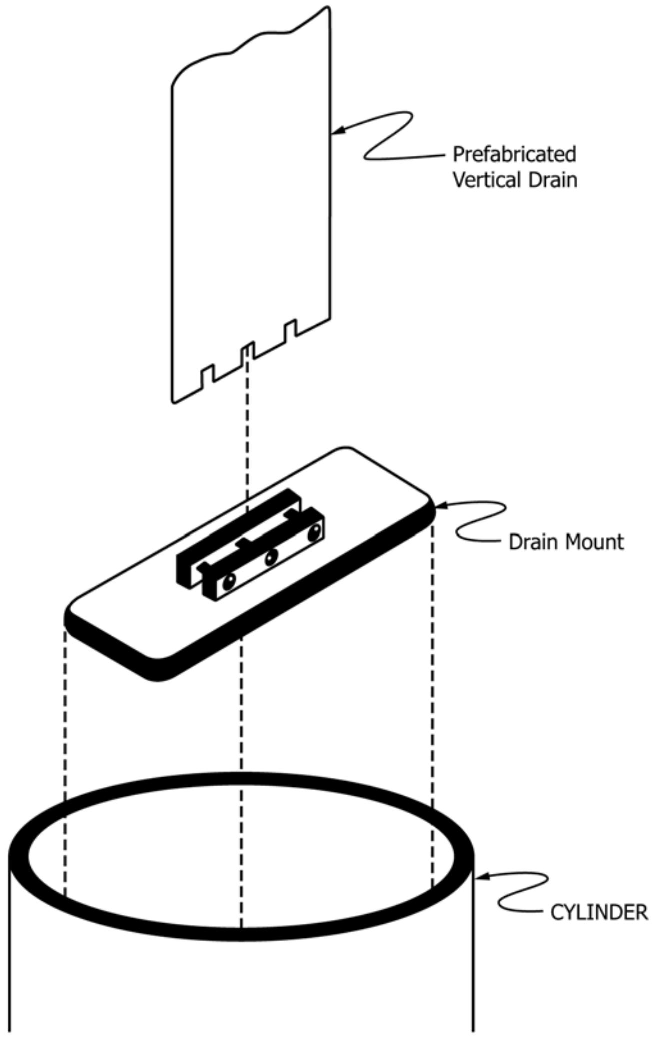

FIG. 2 Prefricated Vertical Strip Drain Mount

10.6 Assemble the test specimen to the specimen mounting plate by placing the three pre-cut notches over the assembly bolts and tightening these bolts. Place the assembly in the test chamber.

10.7 Weigh and record the test chamber, bottom base plate, prefabricated vertical strip drain and holder, and assembly rods weight.

10.7.1 Leaving the items in 10.6 on the scale, tare the scale out.

NOTE 3—If the scale can be locked, lock the platform in place after taring out. Then set the scale for the desired mass of soil to be added in the next step.

10.8 *Soil Placement*—Holding the prefabricated vertical strip drain in a vertical position, start placing the soil into the test chamber. Distribute evenly around the drain using hand pressure and kneading to eliminate voids and achieve a uniform density. Add soil in layers of equal thickness until the final placed layer reaches the line drawn in 10.4. Be sure to keep the test specimen in a vertical position as the chamber is filled with soil.

10.8.1 The moisture content, percent saturation, and placement density shall be as required by specifier.

10.8.2 Clean any excess soil from the walls of the test chamber and then unlock the scale and check to see that the desired mass of soil has been placed in the chamber.

10.9 Apply another coating of non-stick silicone spray to the inside exposed test chamber wall.

10.10 Place a 9.52-mm to 12.7-mm [0.375 to 0.5-in.] layer of molten wax on the entire top surface of the soil, allowing it to seal against the taped section of the test specimen. Make sure that wax does not splash on exposed portion of test specimen or the walls of the test chamber.

10.11 With a thin bladed spatula carefully cut around the perimeter of the test chamber between the wax seal and the wall to break any bonding of the seal to the wall.

10.12 Place a uniform 25.4-mm [1-in.] layer of moist silica sand on top of the hardened wax seal. Fold the test specimen which extends up through the sand layer over on top of the sand. Place an additional 76.2-mm [3-in.] layer of moist silica sand over the test specimen. Level and smooth the surface of sand.

NOTE 4—Be careful not to crimp the test specimen or break the wax seal when bending the specimen over the sand.

10.12.1 Record the height of the sand layer.

10.13 Place the double cup seal assembly inside the cylinder. Be sure that it is level and in contact with the sand layer.

10.13.1 Place the top plate down over the center rod of the cup seal assembly and tension rods on the cylinder. Be sure that the O-ring seal is in place in the top plate.

10.14 Connect an air line from the air supply to the fitting in the top plate.

10.15 Attach the deflection dial or transducer platform to the center rod.

10.15.1 Attach the deflection dial or transducer to the top plate, being sure that the follower of the dial or transducer is contact with platform in 10.14.

10.15.2 Set up remaining two test chambers in the same manner.

11. Test Procedure

11.1 With the air supply valves in the off position, adjust the air regulators to read 103.42 kPa [15 psi], or as otherwise specified, but within the safe operating limits of the air supply system.

11.2 Record the initial, or zero load, deflection dial/transducer readings.

11.3 Open air supply valves so that the air pressure from 11.1 is applied to the test soil.

11.4 Take the following timed deflection readings:

11.4.1 Day 1: 1,2,5,10,30,45,60,90,120,150,180,210,240, then hourly;

11.4.2 Day 2: Morning; Mid-day; End of the work day.

11.4.3 Remainder of the test: Morning; End of the work day.

NOTE 5—If electronic timing and data collection are used, after the first day, readings every 6 h are suggested.

11.5 The following plots are constructed during the test phase: *1*) Deflection readings versus the log of elapsed time; and *2*) Deflection readings versus the square root of time.

NOTE 6—These plots will be used to determine the ending of each loading phase.

11.6 When the plots from 11.5 show that there are a least three data points beyond the 100 % primary consolidation phase for the soil, proceed to the next loading phase.

11.7 With the air supply valves in the off position, adjust the air regulators to 206.84 kPa [30 psi], or as otherwise specified, but within the safe operating limits of the air supply system.

11.8 Repeat 11.2 – 11.6.

11.9 When the plots for the second load meet the condition of 11.6, the test is complete.

11.10 Shut off the air supply and release the load from the soil.

11.10.1 Remove the top plate assembly and remove the cushion sand from the top of the chamber.

11.10.2 Weigh and record the cylinder base assembly and soil. This is the final wet weight of soil in the chamber. (W_F)

11.10.3 Remove the soil cylinder from the chamber intact.

11.10.4 Slice the soil cylinder down along the edge of the vertical strip drain. Photograph and record the condition of the vertical strip drain. If necessary, apply a coloring to the edge of the vertical strip drain so that there is a noticeable color contrast between the drain and the soil. Be sure to place a test identifying card in the photograph.

11.10.5 Take a representative soil sample from the center of the soil cylinder, approximately 1 kg [2 lbm]. Weigh and record the mass of the sample.

11.10.6 Dry the soil sample in an oven at 110 ± 5°C for a minimum of 16 h. Weigh and record the mass of the dried soil sample.

11.11 Repeat 11.1 – 11.10.6, only in place of the prefabricated vertical strip drain insert a 50-mm [2-in.] diameter sand drain.

11.12 After placing the test soil in the chamber, push a 50-mm [2-in.] diameter soil sampling tube down through the soil in the center of the cylinder.

11.12.1 Withdraw the tube with soil in it leaving a 50-mm [2-in.] diameter hole down the center of the cylinder of test soil.

11.13 Fill the 50-mm [2-in.] diameter soil with 20-30 silica sand.

11.14 Finish setting up the test equipment as for the prefabricated vertical strip drain.

11.15 Perform the loading and data collection as with the prefabricated vertical strip drain.

12. Calculations/Data Reduction

NOTE 7—The following information is calculated for the tests performed with both the prefabricated vertical strip drain and with the sand drain.

12.1 Compute the final moisture content (w_f) of the soil. Use Eq 1 only using the masses as determined from 11.10.5 and 11.10.6.

12.2 Compute the dry weight of soil in the chamber using Eq 2:

$$W_S = W_F/(1+w_f) \quad (2)$$

where:

W_F = Final Wet Mass of Soil from 11.10.2 (g)
W_S = Final Dry Mass of Soil in Test Chamber (g)
w_f = Final Moisture Content of Soil from 12.2

12.3 Compute the final height of the soil sample in the test chamber using Eq 3:

$$H_F = H_I - (C_1+C_2)/K \quad (3)$$

where:

H_I = Initial Height of Test Soil in Chamber from 10.4
H_F = Final Height of Test Soil in Chamber (mm)

$(C_1 + C_2)$ = Total Consolidation for the Two Applied Loads (mm)
K = 1 if using SI units, or 12 in./ft if using English units.

12.4 Compute the initial and final volumes of soil in the test chamber using Eq 4:

$$V = A \times H \tag{4}$$

where:

For the initial volume H = the initial height of soil in the test chamber (mm)
For the final volume, H = the final height as computed with Eq 3 (mm)
A = Cross-sectional Inside Area of the Test Chamber (mm^2)
V = Initial and/or Final volumes of test soil in (mm^3)

12.5 Compute the initial wet density of the test soil using Eq 5:

$$\gamma_w = W_T / V_1 \tag{5}$$

where:

γ_w = Initial Wet Density kg/m^2 [lbm/ft^2]
W_T = Initial Wet Weight of Soil from 10.1
V_I = Initial Volume of Test Soil

12.6 Compute the initial dry density of the test soil using Eq 6:

$$\gamma_D = \gamma_w / (1 + w_i) \tag{6}$$

where:

γ_D = Initial Dry Density kg/m^2 [lbm/ft^2]
γ_w = Initial Wet Density kg/m^2 [lbm/ft^2]
W_I = Initial Moisture Content (%)

12.7 Compute the final dry density using Eq 6 and the final moisture content in place of the initial moisture content.

12.8 Using the plots from Section 11 and the graphical procedures for determining the coefficients of consolidation (c_v); determine the c_v for 50 % and 90 % consolidation for each load applied to the soil.

12.9 The information calculated and determined in this section can be used to compare performance of different prefabricated vertical strip drains and/or;

12.9.1 To determine the prefabricated vertical strip drain field spacing requirements. This will be covered in a Standard Practice under development.

13. Report

13.1 The test report shall include the following for both the prefabricated vertical strip drains and for the sand drains:

13.1.1 The test was performed according to ASTM Test Method D7498;

13.1.2 Any variations from the test method as described herein;

13.1.3 Provide a description of the soil used including a visual description and initial moisture content;

13.1.4 Identify the prefabricated vertical strip drain tested providing the manufacture and specific identifying information such as style number or other appropriate information to differentiate materials tested;

13.1.5 The test results including initial and final moisture contents, initial and final dry densities, and the final height of the test soil following completion of the loading;

13.1.6 The plots of deflection versus square root of time and deflection versus the logarithm of time;

13.1.7 The coefficients of consolidation as determined from the plots in 13.1.6.

14. Precision and Bias

14.1 *Precision*—The precision of the procedure in this test method is being determined.

14.2 *Bias*—This test has no known bias because the results are defined in terms of the test method.

15. Keywords

15.1 coefficient of consolidation; large scale consolidation; prefabricated vertical strip drain