Designation: E2396/E2396M – 15

Standard Test Method for Saturated Water Permeability of Granular Drainage Media [Falling-Head Method] for Vegetative (Green) Roof Systems[1]

This standard is issued under the fixed designation E2396/E2396M; 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.

1. Scope

1.1 This test method covers a procedure for determining the water permeability of coarse granular materials used in the drainage layers of vegetative (green) roof systems.

1.2 This test method addresses water permeability under the low-head conditions that typify horizontal flow in vegetative (green) roof applications.

1.3 This test method is suitable for coarse-grained materials with 100 % of the material retained on the U.S. #8 [2.25 mm] sieve. It is not suitable for finer-grained materials.

1.4 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.

1.5 *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 to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C130 Specification for Lightweight Aggregates for Concrete (Withdrawn 1954)[3]

E631 Terminology of Building Constructions

E2114 Terminology for Sustainability Relative to the Performance of Buildings

3. Terminology

3.1 *Definitions:*

3.1.1 For terms related to building construction, refer to Terminology E631.

3.1.2 For terms related to sustainability relative to the performance of buildings, refer to Terminology E2114.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *water permeability*—the coefficient which when multiplied by the hydraulic gradient will yield the apparent velocity with which water (at 68°F) will move through a cross-section of media.

3.2.2 *wet density*—the density of coarse granular drainage course materials determined after immersion for 24 hours.

4. Summary of Test Method

4.1 This procedure involves measuring the water permeability of coarse granular materials under the low-head conditions that characterize the environment in vegetative (green) roof systems. A falling-head technique is used. Incidental to the procedure is the measurement of the wet density of the medium.

5. Significance and Use

5.1 This test method addresses performance characteristics for vegetative (green) roof systems with respect to the water permeability of the drainage media.

5.1.1 Water permeability of coarse materials is highly influenced by the head conditions under which it is measured. In vegetative (green) roofs, coarse materials are frequently used to create drainage zones for percolated rainfall.

5.1.2 This test method is intended to provide water permeability data that is relevant to this design condition that is characterized by horizontal flow under low-head. This will also allow the performance of granular drainage layers in vegetative (green) roof systems to be compared directly to alternative components, such as geocomposite drain layers.

5.2 Determining the performance characteristics of vegetative (green) roof systems provides information to facilitate the assessment of related engineering aspects of the facility. Such

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[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

aspects may include structural design requirements, mechanical engineering and thermal design requirements, and fire and life safety requirements.

5.3 Determining the performance characteristics of vegetative (green) roof systems provides information to facilitate assessment of the performance of one vegetative (green) roof system relative to another.

6. Apparatus

6.1 The apparatus consists of nested cylinders constructed from stainless steel or plastic:

6.1.1 *Inner cylinder*—inner diameter of 3.75 in. [9.53 cm], 32 in. [81.3 cm] long as shown in Fig. 1. Perforated at the bottom (50 % open area), with marks at 6 and 8 in. [15.2 and 20.3 cm] below the top of the cylinder,

6.1.2 *Outer cylinder*—inner diameter of 5.75 in. [14.6 cm] as shown in Fig. 1. This cylinder must be watertight,

6.1.3 U.S. #8 [2.25 mm] sieve disc, 3.55-in. [9.02-cm] diameter, and

6.1.4 Scale with accuracy of 0.005 oz [0.14 g].

6.2 The apparatus is mounted so that the 8-in. [15.2-cm] mark of the inner cylinder is level with the top of the outer cylinder.

7. Conditioning

7.1 Before conducting the tests, with the sieve in place, fill the apparatus with water and determine the elapsed time in seconds that it takes for the water level to fall 6 in. [15.2 cm] to the first mark. This value will be used to establish the upper limit on the measurement of water permeability using the apparatus.

8. Procedure

8.1 Place the sieve disc into the inner cylinder. Fill with the granular material. Take care to prevent segregation of finer particles within the column. Shake or vibrate the material vigorously to compact it into the cylinder. Fill to the 8-in. [20.3-cm] mark. If the specific gravity of the particles is less than 1.0, place a sieve disc on top of the sample and weigh down with glass marbles.

8.2 Begin introducing water into the inner cylinder. The water will fill the inner and outer cylinders and begin to overflow. Continue to introduce water for 30 min. As necessary, add more media to maintain the level of the media at the 8-in. [20.3-cm] mark. The temperature of the water should be 68 ± 5°F [20 ± 2.75°C]. Check the temperature by placing a thermometer in the annular space between the two cylinders.

8.3 Stop introducing water to the inner cylinder and note the elapsed time, in seconds, for the water level to descend to the 6-in. [15.2-cm] mark on the inner cylinder. Repeat three times and average the results.

8.4 Allow the material to stand overnight in the cylinder.

8.5 Weigh a graduated beaker.

8.6 After 24 hours, drain the cylinder.

8.7 After 15 min have elapsed, measure a portion of the granular medium into the graduated beaker. Weigh the beaker with its contents and subtract the weight of the beaker. Using the measured volume of the granular medium in the beaker, compute the wet density of the medium in units of lb/ft^3 [kg/m^3].

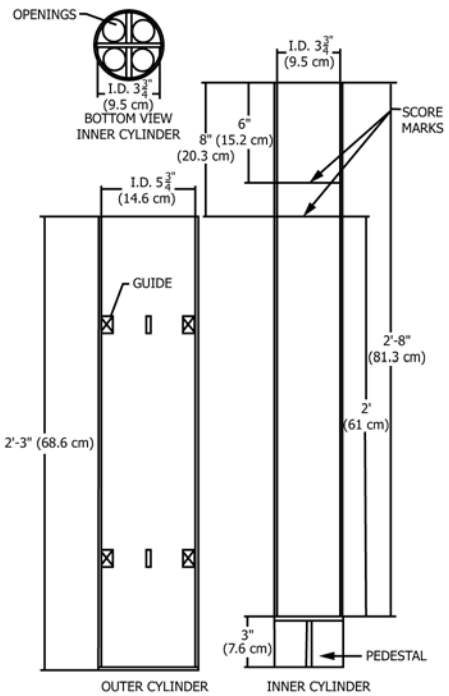

FIG. 1 Equipment Fabrication Detail

8.8 Conduct all tests in duplicate. If the results of two tests differ by more than 5 %, then repeat.

9. Calculation of Results

9.1 Compute the upper limit of the apparatus for determining water permeability as follows:

$$K_l = 0.5*1996/t \quad (1)$$

K_l = method limit for measuring water permeability [in./min], and
t = elapsed time measured when the apparatus contains only water [s].

9.2 Compute the water permeability, as follows:

$$K_f = 1996/T\ (\text{in.} - \text{lb}) \quad (2)$$

$$(K_f = 84.50/T)\ (\text{SI})$$

Kf = water permeability, in/min [cm/s]
T = Elapsed time, s

If $Kf > K_l$, then report $Kf \geq K_l$

10. Report

10.1 The report shall contain the following information:
10.1.1 Sample designation,
10.1.2 Grain-size distribution of the medium (Specification C130),
10.1.3 Dry density of the medium (Test Method C29/C29M),
10.1.4 Wet density of the medium,
10.1.5 Water permeability,
10.1.6 Upper limit of the method for measuring water permeability, and
10.1.7 Temperature of water in the outer cylinder.

11. Precision and Bias

11.1 *Precision*—The precision of the procedure for measuring water permeability is being determined. Parties interested in participating in interlaboratory test programs should contact Committee E60.

11.2 *Bias*—The bias for these measurements is undetermined because there are no reference values available for the materials used.

12. Keywords

12.1 granular, coarse aggregate; low-head; vegetative (green) roof; water permeability