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Standard Test Method for Maximum Media Density for Dead Load Analysis of Vegetative (Green) Roof Systems[1]

This standard is issued under the fixed designation E2399/E2399M; 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 maximum media density for purposes of estimating the maximum dead load for green roof assemblies. The method also provides a measure of the moisture content, the air-filled porosity, and the water permeability measured at the maximum media density.

1.2 This procedure is suitable for green roof media that contain no more than 30 % organic material as measured using the loss on ignition, as described in Test Methods E177, Test Method C. The test specimen should be a bulk oven-dried sample prepared according to Test Methods E177, Test Method A.

1.3 The maximum media density and associated moisture content measured in this procedure applies to drained conditions near the saturation point.

1.4 The test method is intended to emulate vertical percolation rates for water in green roofs.

1.5 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.

1.6 *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, health, and environmental practices and to determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2325 Test Method for Capillary-Moisture Relationships for Coarse- and Medium-Textured Soils by Porous-Plate Apparatus (Withdrawn 2007)[3]

D2947/D2947M Test Method for Screen Analysis of Asbestos Fibers

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E631 Terminology of Building Constructions

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

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 *air-filled porosity*—the air-filled porosity, also known as void ratio or non-capillary porosity, is a measure of the air volume remaining in a sample after it has been compacted to the maximum media density and when the moisture content

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[1] This test method is under the jurisdiction of ASTM Committee D08 on Roofing and Waterproofing and is the direct responsibility of Subcommittee D08.24 on Sustainability.

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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.

equals the maximum media water retention. In this method, the air-filled porosity does not include closed-cell particle porosity or porosity that is unavailable to be filled by water when the sample is immersed.

3.2.1.1 *Discussion*—This property has two important applications:

(*1*) It is an indicator of the viability of media to support plants when it is wet. Materials with low air-filled porosity may tend toward anoxic conditions when wet, and

(*2*) This is the volume available for water to fill after the maximum media water retention is satisfied. This volume of water may contribute to the live load of the green roof system.

3.2.2 *maximum media density*—the density of a mixed media material determined after it has been subjected to a specific amount of compaction and hydrated by immersion to simulate prolonged exposure to both foot traffic and rainfall.

3.2.2.1 *Discussion*—The maximum media density applies to drained conditions.

3.2.3 *maximum media water retention*—the quantity of water held in a media at the maximum media density, measured in volume percent.

3.2.3.1 *Discussion*—This is useful measure of the capacity of a media to hold water under drained conditions.

3.2.4 *saturation point*—the moisture content at which the soil tension in the mixed media is zero, but a free water surface has not developed.

3.2.4.1 *Discussion*—The saturation point represents the theoretical maximum moisture content that a material can contain in a drained state.

3.2.5 *water permeability*—the coefficient, which when multiplied by the hydraulic gradient will yield the apparent velocity with which water, at 68°F [20°C] will move through a cross-section of media.

3.2.5.1 *Discussion*—The conditions created in this method apply to freely-drained media where the free water surface is level with the upper surface of the media layer (such as, impending accumulation of water above the surface of the media).

4. Summary of Test Method

4.1 This test method involves compressing a moist sample of a media into a perforated mold using specified compaction developed using a Proctor hammer. The sample is subsequently immersed in a water bath for 24 hours to promote full hydration of the material. After allowing the sample to drain briefly, its density and moisture content are determined using standard gravimetric procedures. This procedure also includes methods for estimating: (*1*) the water permeability using a pseudo-constant head procedure, and (*2*) the air-filled porosity.

4.2 This test method involves measuring the density of the media after the sample has been allowed to drain for 2 h. This measurement is the maximum media density. The 2-h measurement is valuable to the green roof designer, since it is directly comparable to media densities determined using the most common international procedures for establishing green roof dead load values.

5. Significance and Use

5.1 This test method describes simple laboratory methods that provide reproducible measurements of critical media properties, and permit direct comparisons to be made between different media materials.

5.2 The density of mixed media materials will vary depending on the degree to which they are subjected to compaction and the length of time that the material is allowed to hydrate and subsequently drain. Most green roof media materials have a large capacity to absorb and retain moisture. Furthermore, moisture will drain gradually from the media following a hydration cycle. The maximum media density measured in this procedure approaches the density at the theoretical saturation point.

5.3 Existing methods for measuring the capillary-moisture relationship for soils (Test Method D2325) rely on sample preparation procedures (Test Methods D698) that are not consistent with the conditions associated with the placement of green roof media materials. This procedure is intended to provide a reproducible laboratory procedure for predicting the maximum media density, moisture content, air-filled porosity, and water permeability under conditions that more closely replicate field conditions on green roofs.

5.4 The value of this test method to the green roof designer is that it provides an objective measure of maximum probable media density (under drained conditions) for estimating structural loads. It also provides a method for estimating the lower limit for the water permeability of the in-place media. This latter value is important when considering drainage conditions in green roofs. Finally, the maximum media water retention has been shown to be a useful indicator of the moisture retention properties of green roof media.

6. Apparatus

6.1 *Apparatus*—contains the following:

6.1.1 Cylindrical stainless steel container: inside dimensions 6.5 in. [16.5 cm] high with a 6-in. [15.2 cm] inside diameter and 125 3⁄16-in. [4.75-mm] perforations in the bottom. The hole pattern is not significant, provided the holes are distributed evenly across the bottom of the cylinder. The tolerance for the cylinder dimensions shall be plus or minus 0.1 in. [2.5 mm].

6.1.2 U.S. #30 [0.6 mm] sieve disc, 5.8-in. [14.7-cm] diameter.

6.1.3 Steel disk plate, 5.8-in. [14.7-cm] diameter.

6.1.4 Proctor hammer: 10 lb [4.54 kg], with fall height of 18 in. [45.7 cm].

6.1.5 Scale, accurate to 0.0035 oz [0.1 g] and capacity of at least 11 lb [5 kg].

6.1.6 Drying dish.

6.1.7 Plastic water immersion bath with minimum immersion depth of 8 in. [20.3 cm].

6.1.8 Drain stand.

6.1.9 Filter fabric disk, 5.8-in. [14.7-cm] diameter, for covering the upper surface of the sample within the test cylinder.

6.1.10 4-in. [10-cm] concrete cubes (for use as weights).