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Standard Guide for Vegetative (Green) Roof Systems¹

This standard is issued under the fixed designation E2777; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope

1.1 This guide identifies terminology, principles, and fundamental concepts including those related to sustainability, technical requirements of construction, and types of vegetative (green) roof systems used on buildings.

1.2 The considerations for sustainable development relative to vegetative (green) roof systems are categorized as follows: environmental, social, and economic as consistent with Guide E2432. (See Appendix X1.)

1.3 This guide discusses technical requirements for vegetative (green) roof systems pertaining to the following categories: plants, media, wind scour resistance, soil reinforcement, separation or filter layers, drain layers, water retention layers, protection layers, and root penetration barriers.

1.4 This guide addresses intensive and extensive vegetative (green) roof systems for roofs up to 15 % slope. Roofing/waterproofing membranes and insulation are key components of vegetative (green) roof systems, but technical requirements regarding their role in such roof systems is beyond the scope of this guide.

NOTE 1—ASTM Technical Committees D08 and C16 have jurisdiction over the development of standards for roofing/waterproofing membranes and insulations, respectively. Some of their existing standards may be helpful in the evaluation of membranes and insulation used in vegetative (green) roof systems. As these two committees develop standards for such roofs, this guide will be revised appropriately.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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 determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standard-*

ization 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:^{2,3}

- C88/C88M Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
- D1079 Terminology Relating to Roofing and Waterproofing
- D1987 Test Method for Biological Clogging of Geotextile or Soil/Geotextile Filters
- D2974 Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
- D3786/D3786M Test Method for Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method
- D4354 Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
- D4439 Terminology for Geosynthetics
- D4491/D4491M Test Methods for Water Permeability of Geotextiles by Permittivity
- D4595 Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
- D4716/D4716M Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
- D4751 Test Methods for Determining Apparent Opening Size of a Geotextile
- D4759 Practice for Determining the Specification Conformance of Geosynthetics
- D4873/D4873M Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
- D5262 Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics
- D5617 Test Method for Multi-Axial Tension Test for Geosynthetics
- D5818 Practice for Exposure and Retrieval of Samples to Evaluate Installation Damage of Geosynthetics

¹ This guide 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 Whenever a specific version of a standard is not identified, the most recent edition of the standard shall apply.

- D6637/D6637M** Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method
- D7361** Test Method for Accelerated Compressive Creep of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method
- D7492/D7492M** Guide for Use of Drainage System Media with Waterproofing Systems
- D7877** Guide for Electronic Methods for Detecting and Locating Leaks in Waterproof Membranes
- E108** Test Methods for Fire Tests of Roof Coverings
- E136** Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C
- E631** Terminology of Building Constructions
- E2114** Terminology for Sustainability Relative to the Performance of Buildings
- E2396/E2396M** Test Method for Saturated Water Permeability of Granular Drainage Media [Falling-Head Method] for Vegetative (Green) Roof Systems
- E2397/E2397M** Practice for Determination of Dead Loads and Live Loads Associated with Vegetative (Green) Roof Systems
- E2398/E2398M** Test Method for Water Capture and Media Retention of Geocomposite Drain Layers for Vegetative (Green) Roof Systems
- E2399/E2399M** Test Method for Maximum Media Density for Dead Load Analysis of Vegetative (Green) Roof Systems
- E2400/E2400M** Guide for Selection, Installation, and Maintenance of Plants for Vegetative (Green) Roof Systems
- E2432** Guide for General Principles of Sustainability Relative to Buildings
- E2788/E2788M** Specification for Use of Expanded Shale, Clay and Slate (ESCS) as a Mineral Component in the Growing Media and the Drainage Layer for Vegetative (Green) Roof Systems
- 2.2 *ASCE/SEI Standard*:⁴
- ASCE/SEI 7** Minimum Design Loads for Buildings and Other Structures (latest edition)
- 2.3 *ANSI/SPRI Standards*:⁵
- ANSI/SPRI RP-14** Wind Design Standard for Vegetative Roofing Systems
- ANSI/SPRI VF-1** External Fire Design Standard for Vegetative Roofs
- 2.4 *CSA Standard*:⁶
- CSA A123.24** Standard Test Method for Wind Resistance of Modular Vegetated Roof Assembly

3. Terminology

3.1 Definitions:

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

3.1.2 For terms related to sustainability and buildings, refer to Terminology **E2114**.

3.1.3 For terms related to roofing and waterproofing, refer to Terminology **D1079**.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *apparent opening size (AOS), n*—for a geotextile, a property which indicates the approximate largest particle that would effectively pass through the geotextile.

3.2.2 *capillary potential, n*—of geotextiles, a property that indicates the ability of a geotextile to distribute moisture.

3.2.3 *cation exchange capacity (CEC), n*—the capacity of a soil to retain and exchange the cations of nutrients, defined as the sum of exchangeable cations that a media can retain per unit weight **(1)**.⁷

3.2.4 *clogging, n*—for geotextiles, the condition where soil particles move into and are retained in the openings of the fabric, thereby reducing the hydraulic conductivity.

3.2.5 *dead load, n*—for a vegetative (green) roof system, the weight of a mature vegetative (green) roof system from the structural deck up, following rainfall, during which retained and captured water attain maximum levels.

3.2.6 *drain layer, n*—horizontal layer, including one or more discrete components, that has been specifically designed to convey water toward the roof deck drains, gutters, or scuppers.

3.2.6.1 *Discussion*—Drain layers may be simple, consisting of a single component, or complex, combining multiple components including: geosynthetics, geocomposites, and coarse mineral aggregate. See also *geocomposite drain layer* and *granular drain layer*.

3.2.7 *eutrophication, n*—the process by which bodies of water or other aquatic systems become overly enriched with minerals and other nutrients.

3.2.8 *evapotranspiration, n*—the process by which water is released to the atmosphere by evaporation from the surface of media and plant foliage, and components of the vegetative (green) roof system.

3.2.8.1 *Discussion*—Potential evapotranspiration rates can be determined using local climatic data. Specific evapotranspiration rates may vary with plant type, plant foliage density, vegetative (green) roof media composition, and availability of irrigation.

3.2.9 *extensive vegetative (green) roof system, n*—a roof system that features plants that can be sustained in shallow media layers (with 6 in. or less of growing media), and typically utilizes non-woody, drought-tolerant herbs, grass, moss, and succulents.

3.2.10 *gap-graded, adj*—granular materials in which the particle size distribution curve is markedly discontinuous. Mixtures containing particles of both large and small sizes, in which particles of certain intermediate sizes are wholly or substantially absent. See *particle size distribution curve*.

⁴ Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, <http://www.asce.org>.

⁵ Available from Single Ply Roofing Industry (SPRI), 465 Waverley Oaks Road, Suite 421, Waltham, MA 02452, <http://www.spri.org>.

⁶ Available from Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, <http://www.csagroup.org>.

⁷ The boldface numbers in parentheses refer to the list of references at the end of this standard.

3.2.11 *geocomposite*, *n*—a product composed of two or more materials, at least one of which is a geosynthetic.

3.2.12 *geocomposite drain layer*, *n*—drain layer composed of a synthetic sheet, mat, or panel.

3.2.12.1 *Discussion*—Geocomposite drain layers may include absorptive drain mats whose principle function is drainage, but which will also contribute to water retention. Some geocomposite drain layers may incorporate reservoirs that will capture water. See also *granular drain layer*.

3.2.13 *geosynthetic*, *n*—a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical-engineering-related material as an integral part of a vegetative (green) roof system (as described in Practice [D4354](#), Practice [D4759](#), Guide [D4873/D4873M](#), Test Method [D5617](#), and Practice [D5818](#)).

3.2.14 *geotextile*, *n*—any permeable textile used with foundation, soil, rock, earth, or any other geotechnical-engineering-related material as an integral part of a man-made project, structure, or system.

3.2.14.1 *Discussion*—Geotextiles perform several functions in geotechnical engineering applications, including: separation, filtration, drainage, reinforcement, and protection.

3.2.15 *granular drainage media*, *n*—coarse aggregate applied in a layer at the base of the vegetated vegetative (green) roof system profile or filled into the upper face of a reservoir sheet to provide a horizontal plane for free drainage of the vegetative (green) roof system.

3.2.16 *granular drain layer*, *n*—a drain layer composed entirely of granular drainage media.

3.2.17 *hardscape*, *n*—non-vegetated surfacing on vegetative (green) roof systems.

3.2.17.1 *Discussion*—Hardscape is most often used in place of soil at walkways, plazas, maintenance areas, or at staging areas for mechanical equipment and façade access.

3.2.18 *hydraulic transmissivity*, *n*—for a geosynthetic or geocomposite, the volumetric flow rate per unit width of specimen per unit gradient in a direction parallel to the plane of the specimen; also referred to as in-plane flow and, for a granular drainage media, saturated water permeability multiplied by the layer thickness (as determined using Test Method [D4716/D4716M](#)).

3.2.19 *intensive vegetative (green) roof system*, *n*—intensive vegetative (green) roof systems feature large perennial plants or turf grass.

3.2.19.1 *Discussion*—The use of large plants generally requires media thicknesses in excess of 6 in. (15 cm), and in most instances, irrigation. Intensive vegetative (green) roofs will require levels of maintenance similar to onground gardens. See also extensive vegetated (green) roof system.

3.2.20 *maximum media density*, *n*—the density of a granular drainage media or vegetative (green) roof media determined after they have been subjected to a specific amount of compaction and hydrated by immersion to simulate prolonged exposure to both foot traffic and rainfall.

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

3.2.21 *module*, *n*—pre-manufactured unit containing some of the functional elements of a vegetative (green) roof system.

3.2.21.1 *Discussion*—Independent modules are designed to be placed adjacent, and sometimes linked to one another, in order to cover roof surfaces.

3.2.22 *open-graded*, *adj*—granular materials that contain relatively few fines in order to leave fairly large spaces between particles when compacted. See *particle size distribution curve*.

3.2.23 *organic matter*, *n*—material in a soil or vegetative (green) roof media that volatilizes from a dry sample when heated in an oven to 824 °F (440 °C).

3.2.24 *particle size distribution curve*, *n*—curve, based on sieve and hydrometer analysis, that describes the relative quantities of particles of different sizes in a mixture.

3.2.24.1 *Discussion*—For planting media, this descriptor is limited to the non-organic fraction.

3.2.25 *permeability*, *n*—see *saturated water permeability*.

3.2.26 *permittivity*, *n*—of geotextiles, the volumetric flow rate of water per unit cross-sectional area per unit head under laminar flow conditions, perpendicular to the plane of the geotextile.

3.2.27 *phytotoxic*, *n*—poisonous to plants.

3.2.28 *protection layer*, *n*—any continuous layer that is intended to protect the roofing/waterproofing membrane from damage and which is placed in direct contact with the roofing/waterproofing membrane.

3.2.28.1 *Discussion*—Agents for damage may include abrasion, puncture, UV exposure, and temperature fluctuation. Protection layers may include additional layers of material (as recommended by the membrane manufacturer), coatings, geosynthetic materials, geotextiles, geocomposites, tiles, and insulation.

3.2.29 *reservoir sheet*, *n*—a shaped plastic membrane containing receptacles on its upper surface to capture and retain water.

3.2.29.1 *Discussion*—In some vegetative (green) roof systems, these receptacles are filled with granular drainage media.

3.2.30 *root penetrability*, *n*—of a geotextile, a property that indicates the ease with which plant roots can penetrate a geotextile.

3.2.31 *root penetration barrier*, *n*—continuous layer incorporated in a vegetative (green) roof system to prevent damage to the roofing/waterproofing membrane system caused by root growth.

3.2.32 *root resistance*, *n*—ability of component to prevent penetration by roots as measured in a long-duration test that simulates field conditions (2).

3.2.33 *saturated water permeability*, *n*—for vegetative (green) roof media, the coefficient which when multiplied times the hydraulic gradient yields the apparent velocity with