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Standard Guide for Vegetative (Green) Roof Systems[1]

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

2. Referenced Documents

2.1 *ASTM Standards:*[2,3]

C88 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 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 Method for Determining Apparent Opening Size of a Geotextile
D4759 Practice for Determining the Specification Conformance of Geosynthetics
D4873 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
D6637 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

[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.

E108 Test Methods for Fire Tests of Roof Coverings
E136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C
E631 Terminology of Building Constructions
E2114 Terminology for Sustainability Relative to the Performance of Buildings
E2396 Test Method for Saturated Water Permeability of Granular Drainage Media [Falling-Head Method] for Vegetative (Green) Roof Systems
E2397 Practice for Determination of Dead Loads and Live Loads Associated with Vegetative (Green) Roof Systems
E2398 Test Method for Water Capture and Media Retention of Geocomposite Drain Layers for Vegetative (Green) Roof Systems
E2399 Test Method for Maximum Media Density for Dead Load Analysis of Vegetative (Green) Roof Systems
E2400 Guide for Selection, Installation, and Maintenance of Plants for Green Roof Systems
E2432 Guide for General Principles of Sustainability Relative to Buildings
E2788 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)

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**).[5]

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 prolonged 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. Drain layers are not used in single-course vegetative (green) roof systems. See also *geocomposite drain layer* and *granular drain layer*.

3.2.7 *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.

3.2.8 *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 *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*.

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

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

3.2.11.1 *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 on their upper surfaces that will capture water. See also *granular drain layer*.

3.2.12 *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, Test Method D5617, and Practice D5818].

3.2.13 *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.

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

3.2.14 *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

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

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

sheet to provide a horizontal plane for free drainage of the vegetative (green) roof system.

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

3.2.16 *hardscape, n*—non-vegetated surfacing on vegetative (green) roof systems, used in place of soil at walkways, plazas, maintenance areas, or at staging areas for mechanical equipment and façade access.

3.2.17 *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].

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

3.2.18.1 *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.

3.2.19 *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.

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

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

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

3.2.21 *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.

3.2.22 *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).

3.2.23 *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.

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

3.2.24 *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.

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

3.2.26 *phytotoxic, n*—poisonous to plants.

3.2.27 *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.

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

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

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

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

3.2.30 *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.

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

3.2.32 *saturated water permeability, n*—for vegetative (green) roof media, the coefficient which when multiplied times the hydraulic gradient yields the apparent velocity with which water at 68°F (20°C) moves through a cross-section of fully submerged media.

3.2.33 *soundness, n*—for granular drainage media, the capacity to resist freezing without fracturing.

3.2.34 *thermal capacitance, n*—a property of a material that determines how readily it absorbs and releases thermal energy (3).

3.2.34.1 *Discussion*—Heat capacity, or specific heat, is the measure for thermal capacitance. Heat capacity of a material is determined by measuring the increase in temperature that attends the addition of thermal energy. In vegetative (green) roof systems, the material with the highest heat capacity is usually water.

3.2.35 *underflow, n*—water derived from rainfall or irrigation that percolates to the base of the vegetative (green) roof system profile and then flows horizontally through the drain layer toward roof discharge facilities such as area drains, scuppers, and gutters.

3.2.36 *vegetated (green) roof covering, n*—see *vegetative (green) roof system*.

3.2.37 *vegetative (green) roof media, n*—materials that fulfill the role that natural soil would fulfill in at-grade landscape.

3.2.37.1 *Discussion*—To achieve specified requirements for weight, drainage, fertility, saturated water permeability, density, etc. vegetative (green) roof media is typically prepared

as mixture of fine and coarse mineral aggregate, organic materials, and admixtures.

3.2.38 *vegetative (green) roof system weight, n*—see *dead load*.

4. Significance and Use

4.1 *Intended Use*—The intended use of this guide is to provide general information to practitioners in the fields of vegetative (green) roof design and construction. The guide encourages innovative but responsible vegetative (green) roof design, with a focus on performance and quality assurance. Numerical ranges, practical minimums, and benchmarks that are incorporated in the guide are intended for reference. Design requirements for specific projects vary and therefore qualified professionals may prepare designs with features that may vary from the recommendations contained in the guide. In all instances, vegetative (green) roof system designs shall conform to the applicable code requirements of Federal, State, Provincial or local agencies with jurisdiction.

4.2 *Users*—Users of this guide include: planners, developers, architects, landscape architects, engineers, general contractors, subcontractors, owners, facility managers, financial organizations related to building industry, building materials and product manufacturers, government agencies including building officials, and other building professionals.

5. Principles Relative to Vegetative (Green) Roof Systems

5.1 *Design Intent and Building Function*—Vegetative (green) roof systems should contribute or enhance, or both, a building's function/purpose. The design of the vegetative (green) roof system should be responsive to the project objectives.

5.2 *Sustainability*—vegetative (green) roof systems should improve the sustainability of a building including: environmental, social, and economic impacts. Appendix X1 provides a review of potential contributions that vegetative (green) roof systems may make toward achieving sustainability objectives.

5.3 *Design Considerations:*

5.3.1 *Maintenance*—All vegetative (green) roof systems shall be accompanied by a detailed written maintenance procedures manual, provided by the design professional, vegetative (green) roof installation company or system manufacturer. Maintenance manuals should include instructions for operation of irrigation systems, where relevant, and directions for proper weeding and fertilization. These documents should also include methods for recognizing and dealing with commonly encountered problems, including: insect infestations, weed infestations, bare spots, wet spots or areas with perennial surface water ponding. Depending on the vegetative (green) roof system and site conditions, provisions for employing temporary irrigation should also be addressed. Manuals should also include instructions for inspecting exposed elements of the roofing/waterproofing membrane system, most notably the drains. Minimum requirements for site visitations should be provided.

5.3.2 *Performance*—The design professional working on a vegetative (green) roof system shall convey to the owner a written description of the system, showing conformance with the specified performance characteristics. Depending on the purpose of the vegetative (green) roof system and the provisions of the construction specifications, these descriptions include at minimum: *1*) maximum or minimum associated dead load, *2*) moisture retention capacity per hydrology study by the manufacturer, *3*) assurances of the longevity of the vegetative (green) roof system, *4*) assurances of the survival of the plant foliage cover, *5*) assurances that the roofing/waterproofing membrane is compatible with the selected vegetative (green) roof system and suitable for the application. Written descriptions of vegetative (green) roof system performance characteristics, typically emanate from, and will be supported by, the manufacturer or provider of the vegetative (green) roof system.

5.3.3 *Longevity*—The longevity of vegetative (green) roof systems can be limited by: *1*) degradation or loss of function of components of the vegetative (green) roof system, or *2*) premature failure of the roofing/waterproofing membrane system. Consideration should be given to locating leaks and repairing the membrane. For novel designs or large-scale projects, mock-ups of vegetative (green) roof systems may be advisable. Exposed surfaces of the roofing/waterproofing membrane system (for example, flashings and penetrations) may become the most important factor in determining the longevity of an installation. Consideration should be given to providing protection for all surfaces of the roofing/waterproofing membrane system. For instance, flashings should be protected with a durable and UV-resistant protection layer or counterflashing.

5.3.4 *Structural Loads*—The introduction of a vegetative (green) roof system to a new or existing structure has an effect on the live, dead and seismic loads. The addition of materials associated with vegetative (green) roof systems usually increases the dead load in varying amounts based on the number, composition and thickness of the layers of the system. Because of the transient water retention capacity of vegetative (green) roof systems, the live loads may increase as well. In accessible roofs, the live loads created by human occupants, should be taken into account. Minimum live load allowances for access by pedestrians, as well as by maintenance personal apply in most jurisdictions. Consideration of appropriate loads is the responsibility of the design professional and shall be addressed before the vegetative (green) roof system is designed.

5.3.4.1 Take into account all components in the vegetative (green) roof system profile and include the weight of matured plants and retained moisture.

5.3.5 *Roof Access*—Building maintenance and other personnel shall be provided with a safe means of accessing the roof.

5.3.6 *Equipment Access*—When mechanical equipment is located on the roof, accommodations shall be made to provide safe access to that equipment. Determination shall be made that the vegetative (green) roof system will not interfere with equipment operation. Allowances shall be made for required clearances for working around and under the equipment. Hardscape may be used in these spaces to provide working areas. Measures shall be included to prevent damage to the vegetative (green) roof system caused by wash-down, 'blow

down' or other discharges of fluids associated with operation or maintenance of mechanical equipment. Chemicals used in the operation or maintenance of mechanical equipment located in the field of a vegetative (green) roof system should not be phytotoxic to any of the designated plant varieties or damaging to the components of the vegetative (green) roof system.

5.3.7 *Facade Access*—In many instances, the roof serves as the primary point of façade access. Consideration should be given in vegetative (green) roof system design for access to façade rigging equipment including the use of temporary equipment (beams and weights). If walkways and staging areas for façade maintenance are not provided, damage to the vegetative (green) roof system may result. Chemicals used for window and façade cleaning and maintenance should be reviewed periodically to determine if they are phytotoxic and may inhibit plant growth in areas affected by façade maintenance. Materials that will be phytotoxic to plant varieties designated for the vegetated (green) roof system should be replaced by alternative materials that are benign toward these plants.

5.3.8 *Wind Resistance*—Damage by wind is a concern with vegetative (green) roof system installations, particularly along perimeters and corners, at obstructions such as mechanical equipment, and adjacent to penthouse structures. The potential for damage by wind will vary with building height, building geometry, geographic location, and local topography. Probability of wind damage is greatest with high winds immediately after installation and diminishes as the vegetative (green) roof matures. With many vegetative (green) roof systems methods for temporarily protecting the media prior to establishment of a mature plant ground cover may be advisable. This may include mats or mesh fabricated from organic fibers or geosynthetics, tackifying agents, or the installation of pregrown mats or modules. Various permanent stabilized leading-edge systems may be viable for a particular project, including: gravel or stone margins, unit pavers, strapped or bolted pavers, reinforced media layers, and buried ballasts in conjunction with reinforcing geotextiles. The width of stabilized leading-edge systems depends on the local wind environment, which is specific to each building and geographic setting. Measures shall comply with requirements of Federal, State, Provincial, or local entities with jurisdiction. Methodologies for determining ballast requirements often rely on estimates of wind velocities and uplift pressures based on ASCE/SEI 7. The dry weight should be used when evaluating the ballast weight of a vegetative (green) roof system In some jurisdictions upper limits on basic wind speed (3 s gusts) may apply to inclusion of gravel or stone ballast, due to the risk of these becoming windborne missiles.

5.3.9 In regions where brush fires are an identified threat, it is recommended that designs emphasize foliage cover consisting of succulent plants (for example, Sedum, Senecio, Delosperma, Graptopetalum, Echeveria, etc.), and the vegetative (green) roof system should be maintained to regularly remove dead or dormant grass and shrubs. Non-vegetated margins, consisting of coarse stone, gravel, concrete pavers, or stone pavers can be used to set back foliage-covered areas from critical surfaces. Specifically, setbacks for plant foliage are recommended in the following situations: *1*) walls immediately beneath the sills of operable windows, and *2*) adjacent to hatchways, thresholds, and mechanical equipment. Non-vegetated set-backs are recommended for boundaries with roofing/waterproofing membrane systems that are not classified Test Methods E108 Class A and from building surfaces constructed using materials that have not been successfully tested in accordance with Test Method E136. For vegetated (green) roof systems that are not rated Class A or B based on Test Methods E108, additional precautions are recommended, including providing breaks in the vegetative (green) roof system that will limit the area of any contiguous foliage-covered roof zone. Breaks may consist of concrete or masonry curbs that are taller than adjacent plant foliage or non-vegetated strips. Non-vegetated strips may consist of either: *1*) coarse stone, gravel, concrete pavers, or stone pavers, or *2*) Class A roof covering, as determined by Test Methods E108. All vegetative (green) roof systems should be provided with access to hose-bibs faucets, or an irrigation system that can provide sufficient to water to allow the entire vegetative (green) roof system to be thoroughly soaked within an elapsed time of 2 h. Provisions for introducing fire resistance measures shall comply with requirements of Federal, State, Provincial, or local entities with jurisdiction.

5.3.10 *Flashing*—To minimize the opportunity for water to gain entry through the roofing/waterproofing membrane system, minimum vertical isolation distances between the upper surface of the vegetative (green) roof cover and the top of the flashing is advised. These vertical isolation distances may vary with manufacturer and flashing type, some manufacturers require a minimum vertical isolation of 8 in. Vegetative (green) roof system profile thicknesses must be adjusted accordingly. If the recommended vertical isolation distance cannot be satisfied, then the vegetative (green) roof cover should be set back from the flashing using rigid edging.

5.3.11 *Leak Detection*—Design of the vegetative (green) roof system should include consideration of how leaks can be located and repaired. Expedients for consideration include: *1*) ensuring that both the roofing/waterproofing membrane system and other components of the system are compatible with use of low-voltage electrical methods of leak detection, and *2*) always using fully adhered membranes.

5.3.12 *Drainage*—Vegetative (green) roof systems can be adversely affected by either excessive or insufficient drainage capacity. The first concern of the designer when addressing drainage, should be to insure that the vegetative (green) roof system can efficiently percolate and discharge the underflow associated with mandated design storms. Unless specifically designed to generate surface runoff, vegetative (green) roofs systems should not experience ponding or surface flow when subjected to rainfall events that would be normal for a typical year. All drains and scuppers should be isolated by a filter fabric, or other appropriate means, to protect from clogging caused by the accumulation of foliage or debris. Conventional 'beehive' or 'bonnet' strainers are not suitable for this purpose. Chambers with removable lids are recommended for use at all drains and scuppers. Surrounding all drains and scuppers and along depressions where underflow concentrates, coarse stone

aggregate should be placed to facilitate percolation and horizontal flow toward the drainage facilities. The designer should avoid excessive drainage of the vegetative (green) roof system which may lead to perennially stressed conditions for the plants and, in extreme conditions, plant mortality.

6. Quality Assurance

6.1 *Specifications*—Specifications should clearly define the performance requirements for the vegetative (green) roof system, identify the relevant properties of constituent components, identify hazardous conditions, and include appropriate procedures to monitor construction, provide a safe working environment, and provide on-going maintenance.

6.1.1 *Performance Requirements*—Performance requirements may vary. However, where vegetative (green) roof systems have been selected with specific objectives in mind, these should be included in the specification. Where specific energy conservation or stormwater control objectives are important, civil engineering reports, supporting computations, field data, or computer simulations should be required of providers of vegetative (green) roof systems.

6.1.2 *Submittals*—Properties cited in specifications should be relevant to the successful performance of the vegetative (green) roof system. To the extent practical, specifications should provide ranges of acceptable performance, or design minimums and maximums.

6.1.2.1 For materials and components that are unique to vegetative (green) roofs, contractors should provide certifications by manufacturers that any tests have been successfully performed by an independent laboratory and that their products comply with the specification.

6.1.2.2 For vegetative (green) roof media, samples should be accompanied by certified statements by the manufacturer/blender – or recent tests by an independent laboratory -- demonstrating compliance with the specifications. Since the characteristics of feed stocks, such as ESCS and compost, may vary over time, tests for specific media formulations should be conducted on a periodic basis.

6.1.3 *Maintenance Program*—Contract documents should be specific concerning the maintenance requirements and responsibilities of the vegetative (green) roof system installer or system manufacturer. For example:

6.1.3.1 Procedures for leak detection and repair, as necessary, for the roofing/waterproofing membrane.

6.1.3.2 Requirements for minimum foliage cover prior to acceptance by the owner. Specify remedies if the cover requirement is not satisfied at the end of the designated establishment period.

6.1.3.3 Requirements for continued performance, including effective drainage, soil thickness, horticultural viability, etc., provided the maintenance program is followed.

6.1.4 Required longevity for constituent components.

6.2 *Project Check List*—The following project check list includes recommended activities to achieve successful outcomes with vegetative (green) roof system installations.

6.2.1 Determine the projects priorities, including sustainability goals.

6.2.2 Determine dead load and live load allowances.

6.2.3 Evaluate regional climate and microclimatic conditions.

6.2.4 Select vegetative (green) roof system(s) that can best achieve project priorities.

6.2.5 Coordinate vegetative (green) roof system details and requirements with the roofing/waterproofing membrane system manufacturer.

6.2.6 Prepare detailed specifications and address whether all components (membrane up to and including plantings) should be furnished by one manufacturer, or that the responsibility for same rest in one contractor.

6.2.7 *Implementation:*

6.2.7.1 Maintain the completed roofing/waterproofing membrane system in a protected condition.

6.2.7.2 Consider testing delivered vegetative (green) roof media in order to confirm compliance with the specification.

6.2.7.3 Monitor vegetative (green) roof system installation.

6.2.7.4 Document vegetative (green) roof system performance during the establishment period [typically two to three years are required for a vegetative (green) roof system to attain a stable condition].

6.2.7.5 Conduct regular on-going maintenance, as directed in the maintenance program, and document activities to the owner.

7. Technical Requirements

7.1 This section addresses technical requirements associated with plants, media, wind scour resistance, soil reinforcement, separation or filter layers, drain layers, water retention layers, protection layers, root penetration barriers, and membranes.

7.2 *Plants*—Refer to Guide E2400.

7.3 *Media*—Detailed specifications should be written around tests that can be conducted on samples of the final planting mixture. To ensure compliance with the performance requirements, testing of the final mixture should be considered. The purpose of the planting media is to sustain the life of the plants over an extended period of time, function as moisture reservoir, support efficient drainage during rainfall events, and protect the underlying components of the vegetative (green) roof system. Planting media is typically formulated from a mixture of component ingredients and is designed to satisfy specific performance requirements. In order to reduce dead load to roofs, many vegetative (green) roof systems utilize planting media that incorporate lightweight mineral aggregates as their principal constituent. Vegetative (green) roof planting media should exhibit a well-graded character. Gap-graded materials are not recommended for use as planting mixtures, as these tend to separate and lose saturated hydraulic permeability over time. In order to minimize the potential for compression over time, vegetative (green) roof planting media should contain a more or less continuous range of particle sizes that imparts a stable structure to the media layer. The choice of which ingredients to use in a planting mixture may depend on factors such as: performance specification, regional availability, cost and allowable dead load. Most mineral aggregates are provided in many gradations. The grain-size distribution curve for the mineral fraction should be selected with the goal of providing sufficient pore space for air, water,