Designation: E2400/E2400M – 19

Standard Guide for Selection, Installation, and Maintenance of Plants for Vegetative (Green) Roof Systems[1]

This standard is issued under the fixed designation E2400/E2400M; 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 guide covers the considerations for the selection, installation, and maintenance of plants for green roof systems.

1.2 This guide is applicable to both extensive and intensive green roof systems.

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

1.5 *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]

E631 Terminology of Building Constructions

E2114 Terminology for Sustainability Relative to the Performance of Buildings

E2777 Guide for Vegetative (Green) Roof Systems

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

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.

3.1.3 For terms related to vegetative (green) roof systems, refer to Terminology E2777.

4. Summary of Guide

4.1 This guide covers the selection criteria for plants to be used on green roofs. Primary considerations are as follows:

4.1.1 Design intent,

4.1.2 Aesthetics,

4.1.3 Climate; including both macroclimate and microclimate,

4.1.4 Plant characteristics, including the rate of establishment, longevity, and disease and pest resistance, and

4.1.5 Media composition and depth.

4.2 This guide covers the installation of plants for green roofs. Installation methods include:

4.2.1 Pre-cultivation, and

4.2.2 Direct planting on roof (seeds, root cuttings, and plugs).

4.3 Guidance is also provided for the maintenance of plants for green roofs.

5. Significance and Use

5.1 This guide addresses performance characteristics for green roof systems with respect to the planting. A rooftop is an extreme environment with strong and variable wind patterns and little or no protection from the sun's intense heat and ultraviolet radiation. Selection of plant material can be crucial for success of the green roof system.

5.1.1 This guide provides general guidance only. It is important to consult with a professional horticulturist, green roof consultant, landscape architect, or work with similar professionals that are knowledgeable, experienced, and acquainted with green roof technology and plants.

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

Current edition approved Jan. 1, 2019. Published February 2019. Originally approved in 2006. Last previous edition approved in 2015 as E2400/E2400M – 06 (2015)ε1. DOI: 10.1520/E2400_E2400M-19.

[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.

5.2 Determining these performance characteristics of green roof systems provides information to facilitate the assessment of engineering aspects of the facility. Such aspects may include structural design requirements, mechanical engineering and thermal design requirements, and fire and life safety requirements.

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

6. Selection

6.1 In general, green roofs can be categorized into two types, intensive or extensive, depending on the plant material and planned usage for the roof area.

6.1.1 *Intensive green roofs*—Intensive green roofs utilize a wide variety of plant species that may include trees and shrubs and are generally limited to flat roofs. Use of large plants requires deeper media layers, possibly 25 cm [10 in.] or more, which results in more weight and a need for an increased structural load capacity of the building. Intensive green roofs usually have higher requirements for water, labor and other resources than extensive green roofs.

6.1.2 *Extensive green roofs*—Extensive green roofs use a narrow range of species limited to herbs, grasses, mosses, and drought tolerant succulents such as *sedum*, a succulent plant known for its tolerance for extreme conditions. These types of plants can potentially be sustained in a media layer as shallow as 2.5 cm [1.0 in.] and, therefore, they can often be installed on buildings without the cost of major structural alterations. Extensive green roofs generally require less maintenance and are generally less expensive to install than intensive green roofs.

6.2 *Criteria for Selecting Species:*

6.2.1 *Design Intent*—The design intent will impact plant selection. Aspects of design intent that may influence plant selection include: accessibility and use of the roof, stormwater management objectives, xeriscaping objectives, and thermal insulation objectives. Considerations for wildlife, such as establishing connections with a wildlife corridor or providing habitat for wildlife of local ecosystems may also impact the plant selection. Considerations for wildlife should be coordinated with a knowledgeable consultant and the regional Extension Service to verify anticipated wildlife in that climate at the rooftop elevation.

6.2.1.1 The design intent and available installation and maintenance budgets are key factors is determining media depths and plant selection.

6.2.2 *Aesthetics*—Aesthetics often drive green roof design and plant selection. Combinations of evergreens and flowering plants with a long blooming season work well together. However, flowering perennial plants may recede into the ground during winter or long, hot, dry periods in the summer. If they survive roof environmental conditions, they will usually regenerate themselves from the root system, but periods of drought can leave a mass of browned-out, dead looking plants that could be a fire hazard. Similarly, grasses are difficult to keep green throughout the summer. One can allow grasses to grow until June and then cut them back to approximately three inches in height, but this practice requires extensive labor. Plants may look fantastic early in the year, but most cannot withstand summer heat and drought conditions when growing in shallow extensive roof media depths. In order to grow most annuals, perennial flowering herbaceous plants, and grasses, either irrigation must be present or the media must be deeper. If irrigation is not available, then succulent species such as *sedum*, *sempervivum*, and *delosperma* are considered good choices because of their ability to withstand extended drought and other adverse environmental conditions often present on a rooftop. Unlike most perennials and grasses, succulents are not considered fire hazards because of the large percentage of water that is stored in their leaves. The aesthetic value of the roof will continually change throughout the growing season and over time. Plant competition and succession will occur as in any landscape, therefore intended patterns may lose symmetry. Similarly, identical plant palettes will look and behave differently depending on the local environmental conditions. In many cases extensive vegetative green roofs can be planned and maintained to allow natural succession to take over. In some climates the conditions are right to allow for the natural re-vegetation to become a natural meadow which requires minimum maintenance such as removing invasive plants and winter cleanup of dead vegetation.

6.2.3 *Climate*—Climate has a major impact on plant selection. Typically, the microclimate of the roof will be different than the microclimate in the same location at grade. Microclimates on a rooftop can dramatically affect plant health and appearance and contribute to the failure of a green roof system.

6.2.3.1 In particular, average high and low temperatures, extreme hot and cold temperatures, wind, and the amount and distribution of rainfall throughout the year will determine what species can survive in a specific area. Drought tolerance is important because high levels of solar radiation and low media moisture are usually the norm, especially in shallow extensive systems. Climatic conditions, especially the amount and distribution of rainfall and temperature extremes, will eliminate the use of certain species or will dictate the need for irrigation.

6.2.3.2 Microclimate specific to the location must also be considered. Surrounding structures may shade a portion of the roof, thus altering the evapo-transpiration rate of the plants. Drying winds will be stronger the greater the elevation of the building and a roof built with different levels can cause changes in wind and sun patterns, leaving some areas hot and dry and other areas relatively cool and moist. Roof slope and orientation will influence the intensity of the sun, as south-facing slopes will be drier and warmer than north-facing slopes. Slope also affects water-holding capacity, as sloped roofs will drain faster due to the laws of gravity. Plants growing near the bottom of a slope will likely be greener because of higher media moisture content relative to the top. This could be a factor in choosing plant species that will be successful. One must also consider the exhaust from air vents for heating and air conditioning units as well as chemical exhaust from industrial buildings. Reflective heat from adjacent windows will be directed onto the green roof and will then heat up that portion of the roof. This creates hot spots that will kill or damage certain plants. To avoid this scenario, shade