Guide to Green Roofing

Facility Management Journal
November/December 2009

A properly-installed green roof allows building owners and managers to achieve long-term cost savings and counter climate change factors. A green roof is beneficial, both economically and environmentally, when the design is properly integrated into the building's overall function. Each project is unique and various factors must be considered when selecting the proper green roof system. Although the design and specification of a green roof is the designer's role, it is important for the building owner and/or facility manager to understand the basic design principles.

System Types

Extensive green roofs are low-profile roofs that require minimal external input for maintenance after initial growth. They have a shallow growing medium (3 to 6 inches) with a specialized mix of vegetation that can thrive in harsh, dry, high-temperature conditions. Plant types can include mosses, sedum, succulents, herbaceous plants and grasses.

- Intensive green roofs are high-profile roofs that incorporate a wide variety of plant material. The growing medium depth starts from 8 inches and can range up to 5 feet in depth. Vegetation may include perennials, bulbs, annuals, shrubs and even trees.

- Intensive green roofs are usually accessible to pedestrians and can include elaborate architectural accents such as waterfalls, ponds or gazebos. They require regular maintenance, including trimming, mowing and weeding. These roofs may require complex irrigation and drainage systems resulting in higher costs.

- Semi-intensive green roofs combine features of both intensive and extensive green roofs.

Green roofs are becoming increasingly popular in the United States, especially in urban areas. A green roof is defined as an area of plantings or landscaping installed above a waterproof substrate over habitable space1. Green roofs provide many benefits, including:

- Increased building energy efficiency;
- Storm water retention;

- Extended service life of waterproofing;
- Reduction of urban heat island effect;
- Improved air quality;
- Noise reduction;
- Aesthetic improvement; and
- LEED® (Leadership in Energy and Environmental Design) points.

A correctly-planted, site-built green roof will reach maturity in approximately two growing seasons. Another option is to install a pre-grown or modular roof system. Green roof modules are composed of a series of trays, which hold engineered soil and plants independent of the waterproofing. The modules are pre-planted to a client's specification. The vegetation arrives on the roof with established roots and a mature appearance. These systems are typically more expensive than a comparative site-built green roof.

Factors to Consider

Structural limitations

A conventional roof system weighs around 5 pounds per square foot; a green roof system ranges from 20 pounds per square foot (extensive) to more than 100 pounds per square foot (intensive). Therefore, the roof structure's load-carrying capacity can be a limiting factor when considering a green roof installation. In new construction projects, this is typically not an issue since the roof deck can be engineered to support the increased loads. For retrofit projects, the facility manager should plan a structural engineering analysis to determine allowable roof-load capacities in accordance with present day building code requirements—including dead, live and seismic load requirements. Building code load values have changed over time. Thus, older structures may be over- or under-designed based on present day requirements, impacting green roof options.

Climate

The regional climate will impact the selection of plantings and landscaping. The facility manager should work with a landscaping consultant to determine which plants are appropriate for their building. Several factors—including soil types, rainfall, wind, humidity and heat—will contribute to vegetation survival. It is also important to consider how the building's orientation and layout will affect a roof garden. Ideally, the roof deck should be oriented to receive sunlight from the east, south and west as much as possible. The shading patterns of adjacent façades should be reviewed to determine average exposure to sunshine.

Wind

The roof system must be designed to withstand uplift pressures as required by the building code and the facility's insurance provider. A roofing professional should be consulted to determine if the green roof system has sufficient uplift capacity. There are currently no green roof assemblies that are Factory Mutual (FM) approved. FM sets the standard for third-party certification. The FM-approved mark is backed by scientific research and testing. FM has issued a data sheet with recommendations for green roof assemblies. In high-wind areas—such as roof corners and perimeters—it might be necessary to install additional ballast or concrete pavers to achieve adequate uplift resistance.

Structure-specific factors

It is recommended that green roof systems incorporate structurally-sound perimeter containment, such as a parapet walls. The parapet wall should extend at least 6 inches above the growth medium, stone ballast or pavers. For intensive roof gardens with pedestrian access, the height of the parapet wall must adhere to building code requirements for fall protection or safety railings need to be installed. The presence of mechanical conditioning units on a roof can be detrimental since exhaust gases—such as sulfur dioxide—can damage vegetation. Incorporating a vegetation-free zone around rooftop mechanical units can help. However, if the roof has multiple adjacent roof top units, it might be impractical to install a green roof.

Fire protection

The green roof system should meet Underwriters Laboratories Inc. (UL) requirements for external and internal fire resistance. UL is the trusted source across the globe for product compliance. Incorporating vegetation-free zones adjacent to rising walls, perimeters and openings will minimize fire risk posed by combustible plant materials.

Warranty

The warranty for a green roof system is also important. There is a greater opportunity for a leak to occur due to increased number of trades working on the roof. Leaks are more difficult to address due to the overburden. Most green roof manufacturers will only provide a warranty if all of their specific system components are used. Some waterproofing manufacturers may require a specific landscaping consultant to be used for the growing medium and plantings. If multiple warranties or no warranties are acceptable, then various components from different manufacturers can be used.

Green roof construction

Protected membrane

The preferred approach for green roof construction is a protected membrane configuration—the waterproofing membrane is adhered directly to the deck and covered by the green roof components. The long-term performance of a waterproofing membrane is significantly affected by exposure to ultraviolet radiation, heat and thermal cycles— eventually leading to a breakdown of the membrane's chemical composition. In the protected membrane configuration, the overburden components shield the waterproofing membrane from these elements as well as mechanical damage, thus substantially prolonging the system's life. Although green roofs in North America are a relatively new phenomenon, data from Europe shows that protected green roof assemblies have a service life in excess of 40 years.

The protected membrane configuration is recommended by most industry standards, but green roof components can also be installed on top of a conventional roof system. In a conventional roof system, insulation, cover board and other components are located underneath the waterproofing membrane. Although this is acceptable for new roof construction, the facility manager should not install a green roof on top of an existing roof system. An existing roof membrane is more prone to defects as a result of wear and exposure, making it difficult to pinpoint and costly to remedy once the membrane is covered in an overburden.

Waterproofing membrane

Selecting and designing a high-quality waterproofing membrane is essential since the membrane will be buried underneath layers of overburden and cannot be economically repaired or maintained. The facility manager should select a system with proven performance characteristics that incorporates multiple redundancies to reduce the possibility of leaks.

The waterproofing membrane can be a fully-adhered, mechanically-attached or loose-laid system. It is recommended to use a waterproofing membrane that is fully adhered directly to the deck substrate as it minimizes the potential for water migration if a leak occurs. For a fully-adhered membrane, the structural deck must provide adequate slope to drain.

The waterproofing membrane should have low-water absorption, low-vapor transmission, puncture resistance, chemical resistance and high-tensile strength. The following systems are recommended:

- Hot-fluid-applied, polymer-modified asphalt membranes consist of mopped asphalt reinforced with fabric, creating a continuous monolithic membrane without seams. When properly designed and installed, these systems have

longevity. It solidly bonds to a properly-prepared deck substrate and has crack bridging properties. Hot asphalt used in installation can produce strong fumes and possibly create a fire hazard. Cold-process built-up systems avoid temperature application of asphalt and have fewer odors. The base coat should be 90 mils, with fabric reinforcement between a second coat of membrane at 125 mils, for a total thickness of 215 mils. A root barrier is required due to the organic (asphalt) nature of the membrane.

- SBS-polymer-modified bitumen sheet membranes are composed of overlapping sheets of polymer-modified asphalt between one or multiple reinforcing material layers. The asphalt acts as the waterproofing material while the fabric and felts provide the strength. The SBS sheet membrane should be a minimum of two layers for a green roof system. SBS membranes can be applied with hot asphalt or cold mastics. These membranes exhibit excellent puncture and impact resistance. A root barrier is required due to the organic (asphalt) nature of the membrane.

- Polyvinyl chloride (PVC) membrane consists of factory-fabricated sheets of reinforced PVC. A minimum thickness of 60 mil fabric-reinforced PVC membrane should be used for green roof waterproofing. The PVC membrane seams are thermally fused (hot air welded) to form a monolithic sheet that does not rely on adhesives for a watertight bond. These systems have a lower puncture resistance compared to the asphalt systems reinforced with felt. PVC is made from inorganic material and therefore does not require a root barrier.

Additional system components

Green roof systems incorporate several layers in addition to the waterproofing membrane. Functional components include a root barrier, drainage layer, separation layer, moisture resistant insulation, aeration layer, moisture retention layer, reservoir layer, filter fabric layer and growth medium with plantings. In some systems, a single component can perform more than one function; in this case, the manufacturer should be consulted for specifics. Materials must have appropriate compressive strength for the desired green roof system. If different manufacturers are used to mix and match various components, it must be confirmed that all materials have mutual chemical compatibility.

Electric field vector mapping (EFVM) leak detection systems can also be installed within the roof system. The EVFM leak detection method consists of a stationary impulse conductor wire installed directly on top of the waterproofing membrane. The EFVM test creates an electrical potential difference between the non-conductive waterproofing membrane and the conductive structural deck. An electric field is created by applying water to the surface of the membrane.

A breach in the membrane will create a vector or a ground fault connection. This helps to pinpoint defects and avoid fully removing the overburden to perform repairs. Some manufacturers require EFVM to receive their warranty.

Installation and maintenance

During construction, the waterproofing membrane will be trafficked by workers. It is important to install protection layers immediately after installation of the membrane to prevent waterproofing damage. Wind uplift of partially-completed roof components can occur. During construction it must be specified that contractors provide adequate ballast on components not attached to the roof deck. If plantings are installed before the remaining roof components, a wind scour protection blanket over the growing media may be required.

If budget permits, full-time observation of a green roof system installation should be commissioned. Construction monitoring will document that the installation is in accordance with the details and specifications, greatly increasing the likelihood of a long-lasting system.

Regular inspection of drains, sealants and flashings is also recommended. An extensive green roof requires significantly less attention than its intensive counterpart. However for both roof systems, regular removal of dead plants and weeds is necessary. The landscaping consultant should provide the facility manager with projected maintenance requirements for the specific roof system.

Making a green roof a reality

As a result of the increasing popularity among the facility management community, industry professionals now have many options when implementing a green roof system. By following these design guidelines, achieving the full environmental, economic and aesthetic benefits of a green roof is possible.

1 The NRCA Vegetative Roof Systems Manual, Second Edition. The National Roofing Contractors Association. (Rosement: NRCA, 2009) pg 11