Green Rooftops

Description

Green rooftops are veneers of living vegetation installed atop buildings, from small garages to large industrial structures. Green rooftops (sometimes called eco-roofs) help manage stormwater by mimicking a variety of hydrologic processes normally associated with open space. Plants capture rainwater on their foliage and absorb it in their root zone, encouraging evapotranspiration and preventing much stormwater from ever entering the runoff stream. What water does leave the roof is slowed and kept cooler, a benefit for downstream water bodies. Green roofs are especially effective in controlling intense, short-duration storms and have been shown to reduce cumulative annual runoff by 50 percent in temperate climates.

Key considerations for implementing green roofs include structural and load-bearing capacity, plant selection, waterproofing and drainage or water storage systems.

All green rooftops include the following basic component layers, listed from the bottom up:

- Waterproofing and root barrier
- Insulation (optional)
- Drainage and filter layer
- Soil and plants

Green rooftops can be built in a variety of ways, but the simplest involves a relatively light system of drainage and filtering components and a thin layer of soil mix (2 to 4 inches), which is installed and planted with drought-tolerant herbaceous vegetation. Roofs built this way are called *extensive* systems.

More complex green rooftops, or *intensive* systems, employ deeper soils to accommodate tree and shrub root systems and structures to support human use. They require higher structural load capacity as

Purpose

Water Quantity

Flow attenuation	■
Runoff volume reduction	■

Water Quality

Pollution prevention

Soil erosion	**N/A**
Sediment control	**N/A**
Nutrient loading	**N/A**

■ Primary design benefit
◧ Secondary design benefit
□ Little or no design benefit

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Source: Velazquez, 1999

well. For the purposes of this document, the information presented hereafter will be limited to the simpler *extensive* roof systems designed for lightweight overburden construction on flat and sloped roofs not meant for human use.

Despite centuries of use in Iceland and recent initiatives to encourage their use in Canada, Germany, France, Austria and Switzerland, green rooftops are relatively rare in this country and the market remains immature. However, several new and planned projects—including last year's retrofit of the Chicago City Hall and a 450,000-square-foot vegetated roof planned for a new Ford assembly plant in Dearborn, Michigan—are raising visibility and encouraging the nascent U.S. market for green roof technology. The Green Institute in Minneapolis is installing a vegetated roof; see Appendix B.

Advantages

- Green rooftops reduce and delay stormwater runoff.
- Help improve air quality by reducing CO^2 levels.
- Insulate buildings, reducing cost of both heating and cooling.
- Sound-absorbing and insulating properties can help make buildings and their surroundings quieter.
- Increase life expectancy of rooftop waterproofing due to protection from ultraviolet rays and mechanical impact.
- Reduce the urban heat island effect by cooling and humidifying surrounding air. They also help filter and bind airborne dust and other particles.
- Increase habitat for birds and butterflies, partially compensating for landscape lost to building development.
- Provide attractive views from other buildings.

Limitations

- Since water is being encouraged to remain on the roof, any damage to waterproofing materials may have serious consequences for a building. (At least one North American company offers an electronic leak detention system. See "Waterproofing," below, for other ways to reduce risk.)
- Can be expensive to design and construct, especially when retrofitting an existing building.
- Planting atop a sloped roof necessitates special erosion control structures.
- Maintenance for a green roof is likely to be higher than for a conventional roof.

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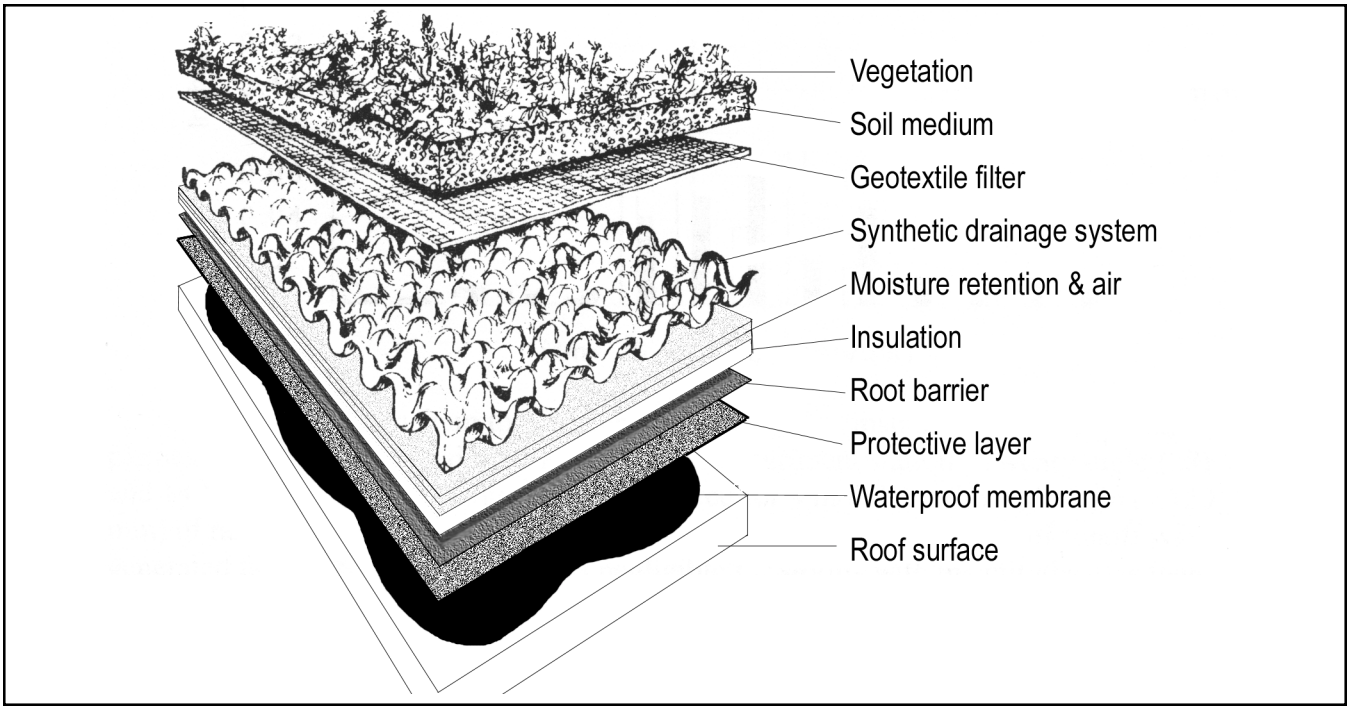

Figure 2: Monolithic Membrane Green Roof
Source: Adapted from Miller 1998 and American Hydrotech*

- Extreme sun and wind conditions present a challenge for plant survival.
- Weight of snow may limit applications to roofs with high-load-bearing capacity or where retrofit budgets are generous.

Requirements

Design

Roof Structure and Location Considerations

The load-bearing capacity of the underlying roof deck is a critical consideration in designing a vegetated rooftop. This means considering both dead load—the total weight of roof materials (including soil and plants) along with snow—and live load. For an extensive green roof, the live load includes people who will be atop the roof during maintenance procedures. Generally, green roofs weighing more than 17 pounds per square foot saturated require consultation with a structural engineer. Design of green roofs can circumvent some structural limitations by placing soil and plants over load bearing members. In retrofit applications, load capacities of existing roofs may be increased, but this is typically difficult and costly.

Flat roofs (or those with a pitch of up to 1.5 percent) are easiest to install and least complex. Those with steeper slopes usually require the addition of cross-battens to hold the drainage layers in place as well as more soil erosion control. With all rooftops, consider sun and shade conditions and

* *This mention does not constitute an endorsement of product.*

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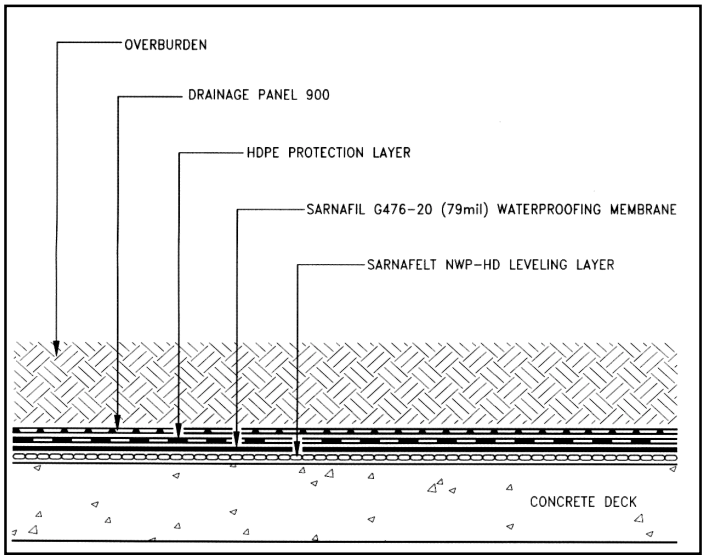

Figure 3: Sheet Membrane Green Roof
Source: Sarnafil*

Design (continued)

plan plantings accordingly; deeply shaded areas may not be suitable for extensive-roof plant species. The maximum slope for a green roof is about 25 percent.

Follow state and/or local standards with respect to wind resistance of rooftop elements. Since uplift pressures tend to be higher at roof corners and perimeters, these areas may be designed as "vegetation-free zones." Substrate soil can be protected from wind via erosion control mats anchored on or near the soil surface.

Fire resistance can be attained by installing soil as specified and, on larger structures, creating firebreaks/barriers a minimum of 130 feet apart. Non-vegetative materials, such as stone or pavers must be installed around all rooftop openings and at the base of all walls that contain openings.

Waterproofing

Monolithic membrane, a rubberized asphalt product applied as a hot liquid, is generally thought to provide superior waterproofing and easier maintenance. Since it is installed directly on the roofing deck, existing roofing must be completely removed.

Thermoplastic sheet membranes are typically installed over a vapor barrier and insulating layer. With certain limitations, sheet membranes may be installed over existing roofing, although manufacturers prefer that existing roofing be removed.

Protective layers are placed atop both types of waterproofing: a modified bituminous protective sheet for the monolithic membranes and high density polyethylene (HDPE) over sheet membranes.

To discourage roots from interrupting the waterproofing, a physical or chemical root barrier is installed over the protective layer. For extensive systems, with their relatively shallow-rooted plants, a thin physical layer is usually sufficient.

On monolithic membranes, a Styrofoam insulation layer may be installed above the root barrier.

Moisture Retention and Drainage

The drainage system, often consisting of recycled-polyethylene elements resembling egg crates, creates a series of small depressions that retain rainwater for plant uptake during dry periods and allow drainage of surplus water. Depth of the drainage layer varies, depending on level of runoff management desired and roof-deck load-bearing capacity.

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Source: Velazquez, 1999

Above the drainage system and below the soil, a geosynthetic filter mat prevents fine particles from being washed out of the overlying soil and compromising the drainage layer.

Soil

Soils for green roofs are lighter weight than typical soil mixes; they generally consist of 75 percent mineral and 25 percent organic material. They must be carefully formulated to meet oxygen, nutrient and moisture needs of plants as well as offer the appropriate pH level.

Plants

The range of plants suitable for use in rooftop landscapes is limited by the extremes of the rooftop microclimate, including high wind, drought and low winter temperature due to lack of ambient heat (normally retained in the ground). As a result, alpine or subalpine species are best suited to rooftop applications. These include a variety of sedums, wildflowers and grasses, some of which are listed below. All have shallow root systems, grow no higher and a foot tall and tolerate shallow soils.

3 Inches Soil Minimum	2 Inches Soil Minimum
Dianthus carthusianorum	Sedum album
Dianthus deltoides	Sedum floriferum
Dianthus plumarius	Sedum hybridum
Hieracium pilosella	Sedum reflexum
Koeleria glauca	Sedum sexangulare
Petrorhagia saxifrage	Sedum spurium
Sempervivum hybriden	
Thymus serpyllum	

In more elaborate schemes, infrastructure such as irrigation, increased insulation and venting from interior heat sources can be employed to overcome microclimate stressors.

Construction

- Correct and meticulous application of the waterproof membrane is essential to the viability of the rooftop. Special care must be taken to waterproof areas around flashings, walls and roof perimeter.
- It is essential to mark the position of the roof outlets before installing the protection layer, so that they can be located easily and the root barrier and protection mat cut out accordingly.
- A test for watertightness is usually conducted after membrane and before protective layer is installed.
- Temporary ballasting of individual components and erosion control may be necessary to avoid wind uplift during installation.

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Requirements

Maintenance

- Weed at least twice annually. This will usually mean pulling any plants taller than a foot—typically tree seedlings.
- Some companies will conduct annual surveys of green roofs to verify that the waterproofing system remains watertight below the vegetated cover.

Sources

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