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Green Roofs: A Sustainable Strategy

Presented By: American Hydrotech, Inc.
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Description: Provides an overview of green roof systems including the types, benefits, components and related standards, as well as a discussion on how green roofs mitigate urban heat island effect and reduce stormwater run-off.

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Learning Objectives

At the end of this program, participants will be able to:

- explain how green roofs diminish the urban heat island effect: a major environmental issue
- describe how green roofs reduce stormwater run-off, dust/smog levels, and re-oxygenate the air
- explain how green roofs extend the life of the roof while providing a natural habitat for plants and animals
- list and define the types/components of green roofs, as well as the environmental, technical, and owner/occupant benefits of green roofs, and
- explain the design considerations and standards relating to green roofs.

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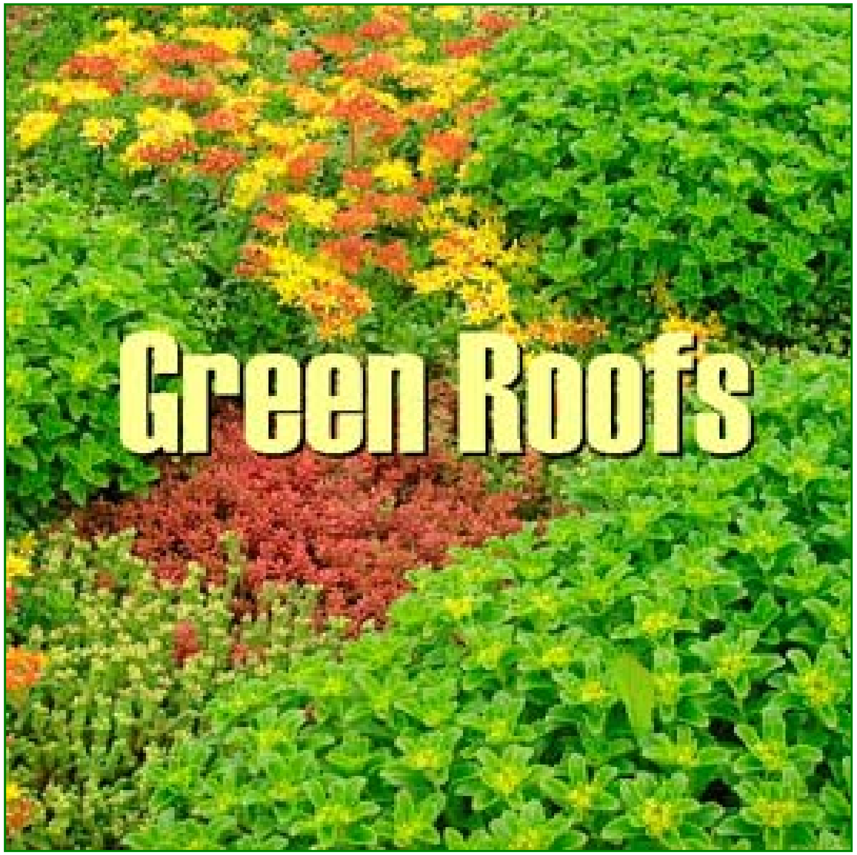


Introduction

What is a Green Roof?

A green roof — also referred to as a vegetative roof, or living roof — is a high-performance environmental statement. Not only do they provide building owners and occupants with several ecological, technical, and economic benefits (detailed in Section 3), but thanks to technological advances, today's green roofs present opportunities for the design professional to transform virtually any flat or sloped roof into a landscaped environment.

Green roofs include many of the same components as conventional roofs, such as insulation, waterproofing membrane, ballast, and flashing, but also contain components that provide moisture retention/drainage, as well as an engineered growing media to support the growth of plants.

Vancouver Public Library - Vancouver, BC

Church Street Station - Evanston, IL

History of Green Roofs

Though viewed as an emerging trend in North America, living roofs have a long and established history.

The ancient Babylonians incorporated elaborate vegetated roofs in the Hanging Garden's terraced structures, which were built around 500 B.C. and considered one of the Seven Wonders of the Ancient World.

Early 20th Century installations used conventional heavyweight soils and include Madison Square Gardens (1920s), the Rockefeller Center (1930s), and Frank Lloyd Wright's vision for the Guggenheim Museum (1950s).

Today, new technologies provide architects with interrelated roof components and allow for more efficient, lighter-weight green roofs.

The Essex Hotel - Chicago, IL

Types of Green Roofs

Introduction

There are three categories of green roofs:

1. Extensive
2. Shallow Intensive
3. Intensive

Each living roof type has different maintenance, structural, and performance criteriawhich will be discussed in subsequent slides.

Extensive

Shallow Intensive

Intensive

Extensive Green Roofs

The Extensive Green Roof is non-recreational and ideally suited for locations that will receive little maintenance, or where structural capabilities are a concern.

Although most green roofs benefit from irrigation during the first few months of establishment, extensive gardens do not generally require long-term irrigation systems.

The growing media mixture, composed primarily of mineral materials mixed with organic medium, can be very shallow (typically 3 - 4 inches) and the entire assembly can weigh as little as 15 pounds per square foot (2 inches of growing media), with typical weights between 20 – 30 pounds per square foot when wet. The entire system is very light, weighing little more than a traditional ballast roof, allowing for safe installation on almost any existing roof.

An Extensive Green Roof incorporates a simple design with a limited variety of plants. Recommended plants include colorful sedum, herbs, grasses and other vegetation that can withstand harsh growing conditions.

Extensive Green Roof Applications

The images below are examples of Extensive Green Roof applications.

Seattle City Hall - Seattle, WA

Coyne Institute - Chicago, IL
(one year after placement of sedum cuttings)

Extensive Green Roof Applications

Additional examples of Extensive Green Roof installations are presented below.

Ballard Library - Seattle, WA
(sloped application)

The Plaza at PPL Center - Allentown, PA

Shallow Intensive Green Roofs

The Shallow Intensive Green Roof is considered a lightweight assembly even though it is designed to support recreational use.

It has a slightly deeper soil depth (i.e., 6-12 inches soil depth), and typically weighs 40-70 pounds per square foot when wet.

Sod lawns and a wide variety of plants, shrubs, and even small trees can be incorporated into the landscape design.

Irrigation, care, and maintenance are dependent on the plant choices and climate.

UNC – Greensboro, NC

Greenwich Academy – Greenwich, CT

Shallow Intensive Green Roofs

Shallow Intensive Green Roofs are generally accessible by adjacent hardscape areas, such as a patio, enabling design professionals to create additional usable space on projects.

Church Street Station – Evanston, IL
(over a 5 story parking structure adjacent to a condominium)

Great Lakes Science Center – Cleveland, OH
(over a parking structure)

Intensive Green Roofs

Pedestrian-friendly Intensive Green Roofs may include walking paths, sod grass lawns, perennial and annual flowers, shrubs, and trees.

Typically, an Intensive Green Roof incorporates plants that require regular maintenance, such as watering, fertilizing, and mowing.

Soil depth is a minimum of 8 inches, weighing a minimum of 55 pounds per square foot when wet.

65 East Geothe Street – Chicago, IL

Sherman Plaza – Evanston, IL

Intensive Green Roofs

When used in conjunction with hardscape elements, such as architecturally finished pavers and precast items, an Intensive Green Roof system is ideal for roofs and plazas that will serve as pedestrian recreational areas.

The Solaire - New York, NY

Nasher Sculpture Garden – Dallas, TX

Intensive Green Roof Applications

Below are some examples of Intensive Green Roof applications.

LDS Conference Center – Salt Lake City, UT

M.D. Anderson Cancer Center – Houston, TX

29 Garden Street - Cambridge, MA

Benefits of a Green Roof

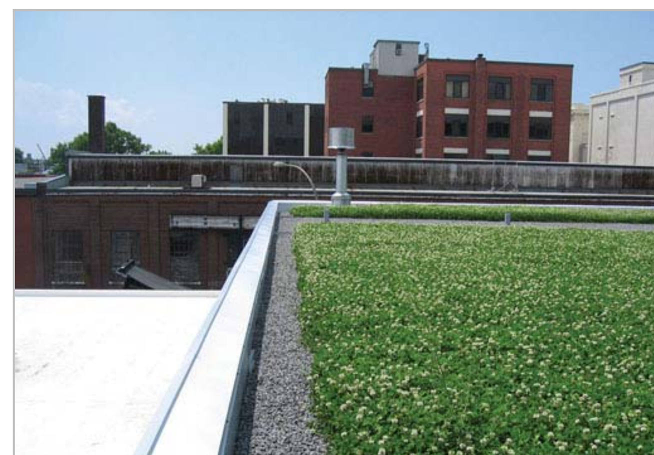
Introduction

Besides being aesthetically pleasing, a living roof can provide numerous benefits that, for the purposes of this course, have been grouped into three categories:

1. Environmental
2. Technical
3. Owner and Occupant Benefits

In this section of the course, we will review the many advantages that are included in each category, beginning with environmental benefits.

Federal Reserve Bank of Chicago – Detroit, MI



740 Bel-Air - Montreal, QC

Environmental Benefits

Green roofs directly address a major environmental issue: the urban heat island effect. Heat islands can result in urban temperatures that are 2°F to 12°F hotter than nearby suburban and rural areas. This phenomenon occurs due to roofs and roads made of dark materials that absorb the sun's rays, causing the temperature of the surfaces and the surrounding air to rise.

The consequences of the heat island effect include increases in peak energy demand such as air conditioning costs), air pollution levels, as well as heat related illness and mortality.

Designing with living roofs augments the amount of green space in urban areas, minimizing heat island effects. Evapotranspiration (refers to water loss from the soil by both evaporation and plant transpiration) can cool the surrounding air, which not only lessens demand for cooling, but also mitigates smog. Green roofs are heralded as an important solution to the urban heat island effect.

Environmental Benefits – Chicago City Hall Case Study

The following case study highlights the effectiveness of combating urban heat island effect via green roofs.

The city of Chicago initiated a program based on the principal that adding plants and trees to urban areas reduces urban heat island effect.

Since its completion in 2001, the living roof on the Chicago City Hall has been monitored. Test results indicate that when the air temperature is 90°F, the living roof temperature is also 90°F, whereas the asphalt roof on the adjacent building is 160°F.

The City of Chicago claims that it saves close to $3,600 annually in energy costs as a result of its green roof.

Environmental Benefits

Additionally, green roof vegetation reduces dust and smog levels and re-oxygenates the air. Airborne toxins, such as excess nitrogen compounds and aerosol contaminants, are absorbed out of the air and rainfall and bound into the plant tissue and soil.

Another environmental benefit: Living roofs change the nature of the built environment and add to its biodiversity by providing a natural habitat for birds and butterflies.

Reid R. Coffman, University of Oklahoma assistant professor of landscape architecture who researches green roof fauna and habitats states, “Longstanding living examples in Switzerland have shown green roofs can be viable habitats for threatened and endangered species.”

(Source: AIA/Architectural Record Continuing Education Series, Designing with Green Roofs: Maximizing Sustainability and Stormwater Management, 12.05 Architectural Record)

Technical Benefits

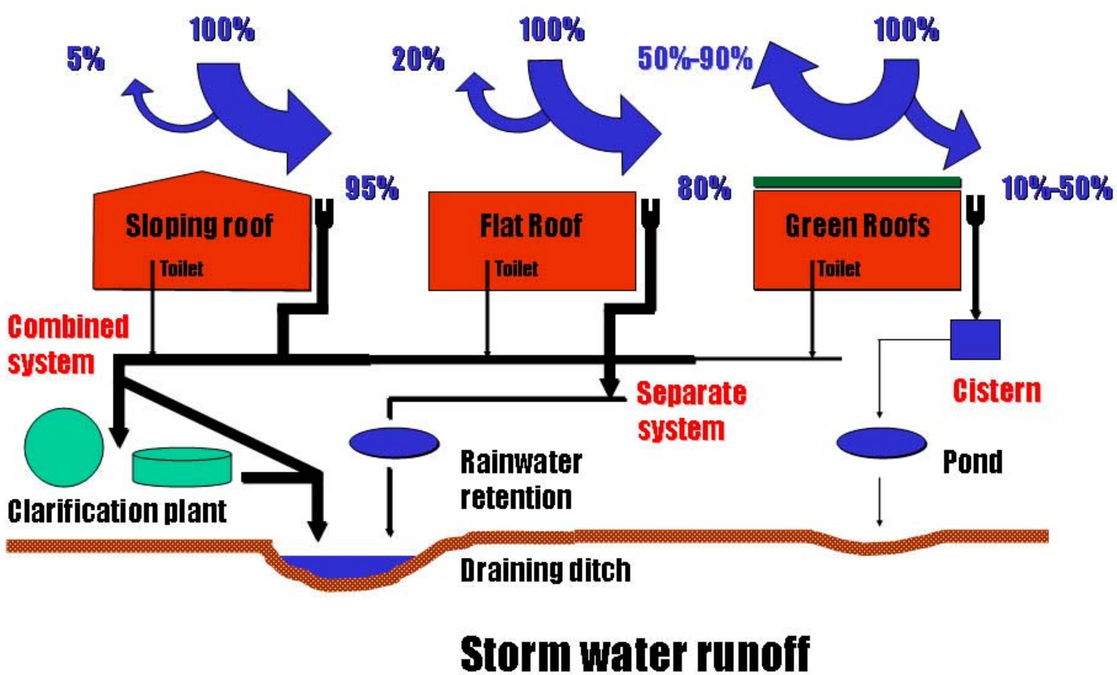
Green roofs are an effective management practice that can lead to a decrease in the cost of a municipality's stormwater infrastructure.

As land values rise, developers need to maximize building site potential. Small sites and large parking requirements leave little room for traditional stormwater storage.

The usual condition is for excess stormwater to run off into the city storm system. Newer solutions have included cisterns, large buried tanks for storage and filtration and, most recently, green roofs.

Technical Benefits

Inadequate existing stormwater infrastructures have placed more responsibility on developers to look at alternative ways to handle this challenge, thereby encouraging living roofs as viable solutions. Depending on the design, a green roof can typically reduce stormwater run-off by 50 to 90%. Additionally, the peak flow volume is greatly reduced and the peak flow period is delayed by as much as four hours, minimizing the impact on existing sewer systems. A comparison of stormwater runoff between a sloping roof, flat roof, and green roof is illustrated below.



Technical Benefits – JBG Case Study

The living roof at JBG Companies, finished in 2003, in suburban Maryland is an example of an extensive green roof designed for stormwater management.

One of a cluster of buildings, Woodland Park One was built on a site that had been completely paved.

The managing principal of the architectural firm realized he had an opportunity to solve a stormwater problem and increase the value of the property to the developer.

Photos: Woodland Park One – Maryland

Technical Benefits – JBG Case Study

In 2003 the state of Maryland waived stormwater management quality requirements (to encourage redevelopment over green field development) when an architect increased the area that absorbed rainwater by 20% beyond the existing development footprint. For Woodland Park One, this meant that the building area would be increased if the stormwater detention was placed above ground, instead of burying it under the parking area.

Calculations proved that the costs were identical if a vegetative roof was placed on the building, instead of burying the stormwater in an underground tank. Additionally, the green roof had the advantage of being part of the scenery for office workers in the higher buildings, to be built in the next phase of the project.

The roof was completed in 2003 requiring no irrigation system and only minimal maintenance. The managing principal of the architectural firm demonstrated to his client, JBG, and to Montgomery County authorities that the vegetative roof would decrease the site's impervious area from 88% to 40%. These calculations, derived through the assistance of the green roof supplier, saved the owner permit time, reduced underground stormwater storage tanks, and complied with Maryland's Smart Growth initiative for green roofs.

Technical Benefits

Research studies at the Russell E. Larson Agricultural Research Center by Penn State University quantified a 50% reduction in runoff from a 3-1/2 inch green roof. Continuing studies are proving the stormwater retention capability of living roofs in many diverse climates, at various soil thicknesses, and with many types of plants.

Green roof providers can help design professionals calculate the amount of water storage available with various assemblies, based on climate data and required local stormwater codes, to create a design to meet their goals.

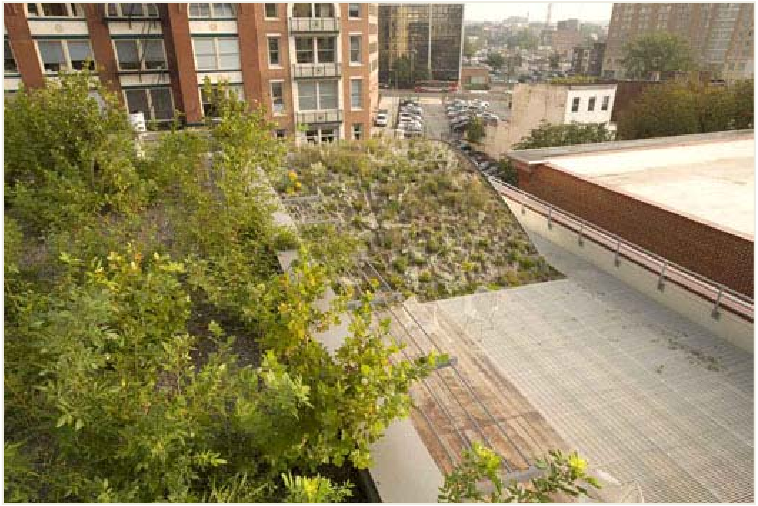
Along with addressing the issue of stormwater management, green roofs lower energy costs by adding insulation and extend the life of the roof by protecting it from climate extremes, ultraviolet rays, and physical abuse.

Furthermore, typical extensive green roofs (3 – 4 inches of growing media) have been shown to reduce reflective sound by up to 3 dB and improve sound insulation by up to 8 dB, important considerations for buildings situated near airports, factories, or freeways.

Technical Benefits – ASLA Case Study

When the American Society of Landscape Architects (ASLA) wanted a high profile location to best demonstrate how landscape architects play a key role in green roof design and construction, it needed to look no further than atop its own headquarters.

The previous black tar surfaced roof is now a landmark demonstration project, containing six distinct vegetative roof conditions, representing both flat and sloped extensive, semi-intensive, and intensive systems ranging in growing media depths of 3 - 18 inches.



Photos Courtesy of ASLA

Technical Benefits – ASLA Case Study

Two “waves” dominate the design and allow for the greatest green coverage possible for the 3,300 square-foot roof surface. Surrounding these is a third green roof system, covered by metal grating that allows visitors to walk over the planted material.

ASLA’s decision to install a living roof was based on the assembly’s stormwater management capabilities, as well as its ability to improve the building’s energy efficiency.

Photo Courtesy of ASLA

Owner and Occupant Benefits

Green roofs add quantifiable real estate value to projects and the built environment. They can be a good business decision for rooftops of mixed-use housing complexes and hotels with rooms facing the conventional tar and gravel roof landscapes.

More municipalities and other government agencies are providing incentives that can help off-set the cost of a green roof. Grants, tax credits, and assistance programs are offered to developers in an effort to encourage the utilization of living roofs for industrial buildings, as well as single family houses.

Gardens enhance the quality of life. Research demonstrates that human health is improved by exposure to nature, fresh air, and growing plants.

In hospitals and healthcare environments, views to natural landscapes enhance healing, and gardens have traditionally served as sources of respite, inspiration, and meditation.

Owner and Occupant Benefits – Schwab Project Case Study

The City of Chicago's Department of the Environment began to promote green roofs in the mid-1990s.

They provided grants for roofs, such as one for Schwab Rehabilitation Hospital, to reduce the heat island effect.

In July 2004, U.S. News and World Report named Schwab as one of the top U.S. hospitals, citing the therapeutic environment of the unique green roof as one of the reasons.

Photos: Schwab Rehabilitation Hospital - Chicago, IL

Owner and Occupant Benefits - Schwab Project Case Study

An integral component of the Schwab project is the walkway that flows around the garden perimeter, which is wide and gently graded for wheelchair accessibility.

The walkway is unique because it is made of concrete pavers with a highly reflective surface (meeting Energy Star® requirements) to reflect the heat of the sun. Set in an open joint assembly, the pavers dry quickly as water is directed to the roof drains below.

Photos: Schwab Rehabilitation Hospital - Chicago, IL

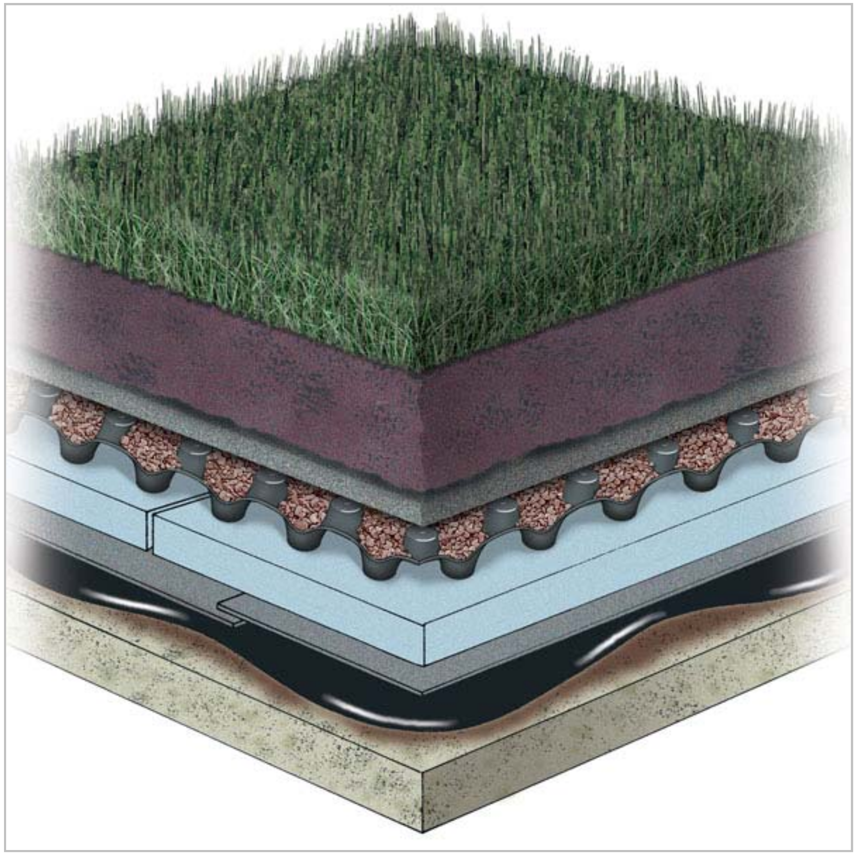
Owner and Occupant Benefits - Schwab Project Case Study

The roof has deep planting beds, trees, and a flowing stream built up above the roof deck, accessible from the therapy rooms.

Therapists at Schwab Rehabilitation Hospital have designed programs for sensory stimulation and for learning relaxation techniques. Patients in wheelchairs can plant flowers in wheelchair accessible flowerbeds. The tasks of planting, weeding, and watering improve motor coordination and manual dexterity.

Staff and patients appreciate the ability to go outside, in a safe, therapeutic environment.

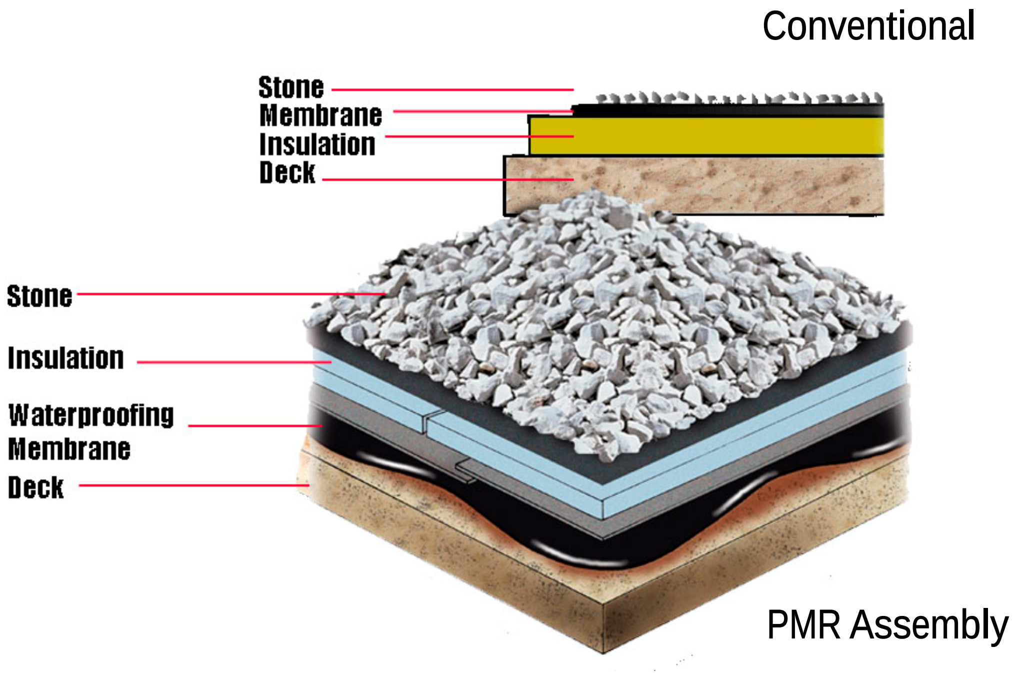
Schwab Rehabilitation Hospital - Chicago, IL



Components of a Green Roof Assembly

Introduction

A logical approach to building a green roof is to think of it as another form of ballast for a Protected Membrane Roof (PMR). A PMR consists of (from the roof deck up) a waterproofing membrane, moisture-resistant insulation, and ballast, and is commonly referred to as an Insulated Roof Membrane Assembly (IRMA). With this design, the membrane's temperature range and rate of temperature change are drastically reduced. In fact, the PMR system provides a thermally protected environment with conditions far superior to those endured by membranes in conventional assemblies wherein insulation is placed between the decking and waterproofing.

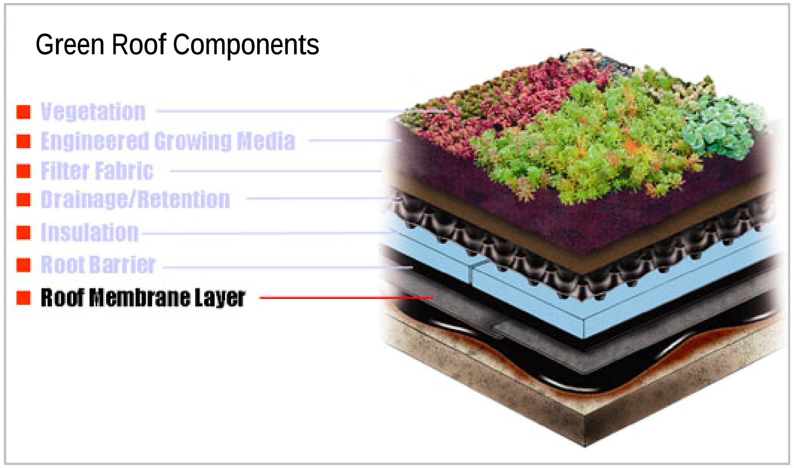


Roof Membrane Layer

Of the various components that make up a green roof, there is none more important than the roof membrane, because no matter how great a green roof looks, if it leaks, the owner will not be happy.

There are a number of roof membranes and assemblies available, including built-up, single-ply, and fluid applied.

It is critical that the membrane manufacturer be consulted to ensure their product is adequate for use in a green roof assembly.



Roof Membrane Layer

Ideally, the membrane for a green roof assembly should have the following attributes:

- Capable of performing in a continuously wet environment
- Long lasting
- Fully bonded to the substrate
- Monolithic or seamless
- Easy to detail
- Fully warrantable (labor and materials)
- Successful, proven track record

To ensure a successful installation, the membrane should be installed by an authorized, trained applicator.

Roof Membrane Layer

One type of roofing membrane which has performed well, with a successful 45-year track record in buried wet applications, is a fluid applied rubberized asphalt membrane.

This type of membrane is applied in a fabric reinforced assembly 215 mils. thick, directly to the substrate with no seams (monolithic).

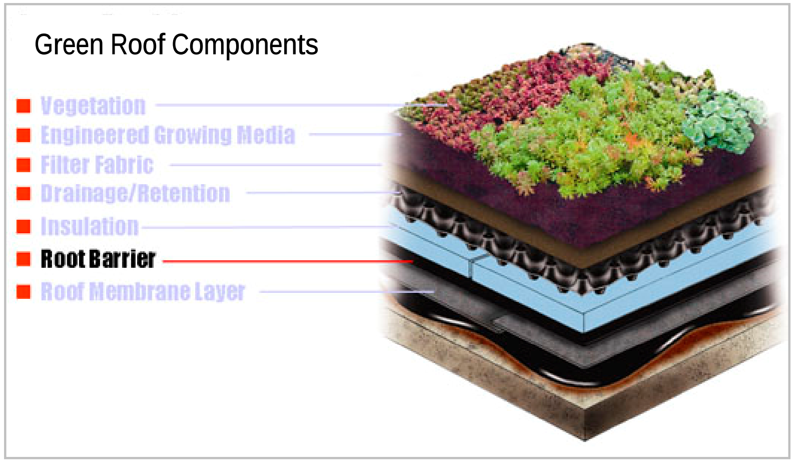
This facilitates the location and repair of the membrane should damage occur, making it ideal for green roof applications.

Root Barrier

The primary goal of a root barrier is protecting the watertight integrity of the roof membrane and keeping root growth from spreading to unintended areas.

Root barriers can vary, depending on the type of plants. For species with aggressive root systems, asphaltic sheets with an embedded repelling agent, or heavy duty thermoplastic sheets with taped or overlapping seams are used to prevent root penetration.

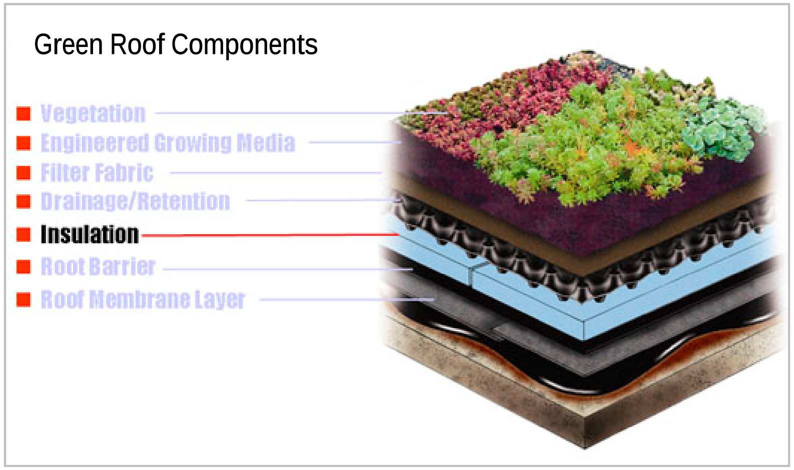
For plants with less aggressive root systems, standard duty thermoplastic sheets are installed, again overlapped at the seams.

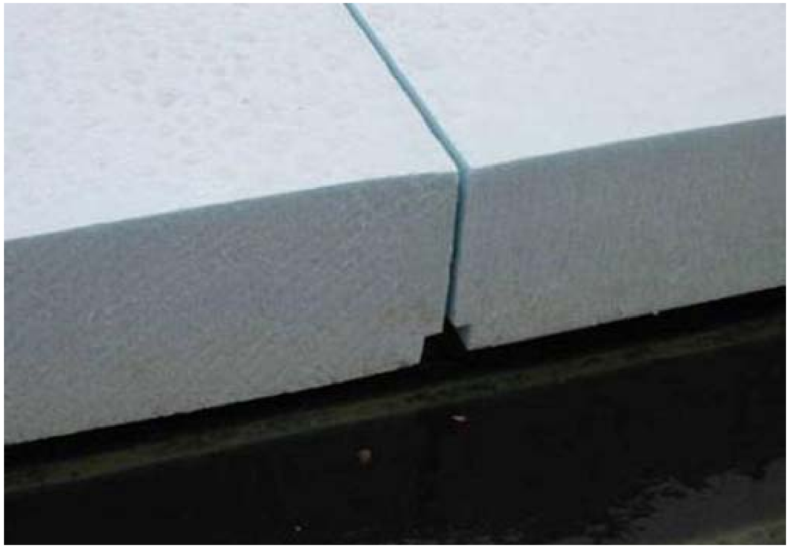


Insulation

The insulation of choice for a green roof in a protected membrane assembly is Extruded Polystyrene Insulation due to its many favorable features and benefits including:

- Excellent performance in wet applications
- Dimensionally stable
- High thermal value
- Good compressive strength
- Environmentally friendly





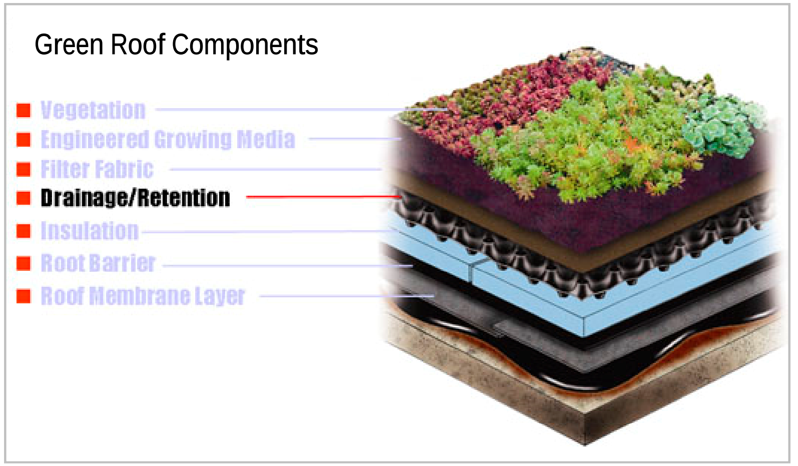
Extruded Polystyrene Insulation

Drainage / Retention Elements

The delicate equilibrium between over-watering and not providing enough water can be challenging enough with common houseplants.

The scale is greater on a roof top, but the issue is the same.

Moisture retention and drainage panels that incorporate both a reservoir system and drainage channels are located beneath the soil, under a filter fabric, in a well-designed green roof.



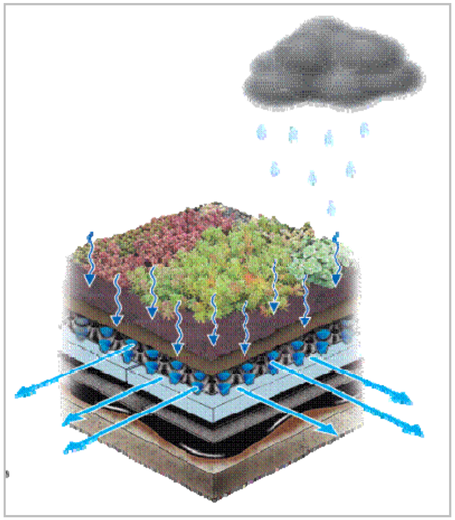
Drainage/retention elements provide water retention, drainage, and aeration.

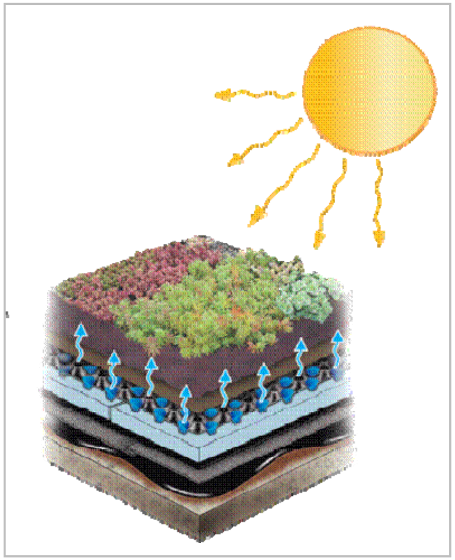
Drainage / Retention Elements

The drainage and moisture retention layer plays an essential part in storing rainwater that filters through the growing media.

One component, which looks like an egg crate (lower image, previous slide), works as follows: drainage channels above and below ensure that excess water is free to drain out of the system (top image). The profile of the components also provides water storage troughs that retain (or store) additional water for use by the vegetation. Diffusion holes through the panels allow air circulation and water vapor to move up into the root zone of the soil (bottom image).

In an extensive roof located in drier, hotter climates, a moisture mat can be added to the system assembly to absorb and store additional usable water.



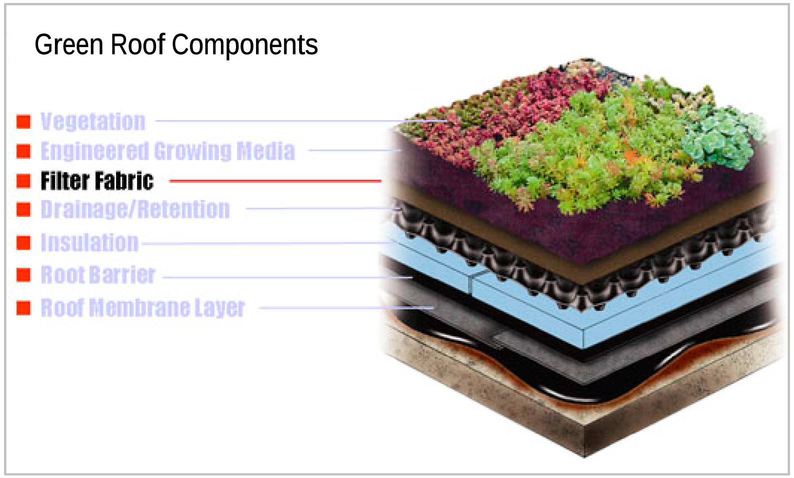


Filter Fabric

In a properly designed green roof, a filter sheet should be placed between the growing media and drainage/retention panels.

A geotextile filter sheet is made of non-rotting, non-woven polypropylene fibers.

Properties of a filter fabric include high resistance to all natural acids and alkalis, and it should be chemically neutral.



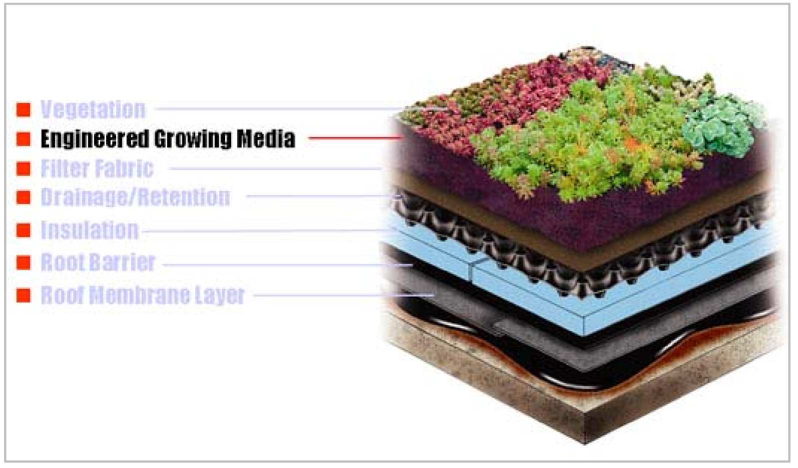
Engineered Growing Media

Conventional green roofs (old technology) used ordinary soil, a common material that is heavy and often contains clay that reduces water penetration. Furthermore, it is prone to compaction which translates to a loss of oxygen, moisture, and nutrient availability for plant growth.

Growing media designed for green roof assemblies is 30-50% lighter than ordinary soil and provides optimal moisture retention, nutrient availability, and provides good drainage.

They are blends of sand and organic matter, along with lightweight aggregates such as expanded shale, slate, clay or naturally occurring aggregates like pumice or scoria.

Conventional Green Roof



Versus Green Roof Engineered Assembly

Engineered Growing Media

These lightweight engineered media provide a stable structure for the anchorage of the plants' root systems, while remaining as light as possible to prevent excess loading of the roof structure.

The climate of the site and plants selected for the green roof dictate the appropriate chemical, physical and biological properties required for the growing media.

Plant Selection

A self-sustaining, well-designed green roof should adhere to the standards of good ecological design. Appropriate plant selection is a crucial part of this process.

Since roof landscapes mimic nature, plants should be long lived and self-propagating.

Vegetation should be selected based on their size; tolerance to drought, frost, direct radiation, and wind; maintenance requirements; and climate conditions. Native plants are often the most favorable choice for shallow-intensive and intensive applications.

Turner Entertainment - Atlanta, GA

Plant Selection

Succulent plants and sedums require little soil, can withstand long periods without water, and thrive in difficult climates. They are usually less than one foot tall and come in a variety of attractive colors and shapes. For these reasons, sedums are considered the ideal plant for an extensive green roof.

Plant Selection – Intensive Roof

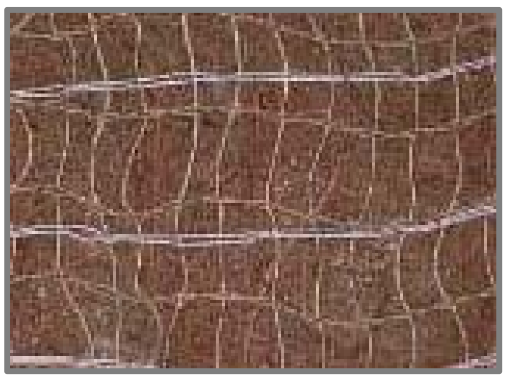
Intensive roofs are typically landscaped for diversity and aesthetics. To provide variety and encourage long-term plant viability, combine annuals and perennials, cool and warm season plants, and shallow-rooted wildflowers and grasses.

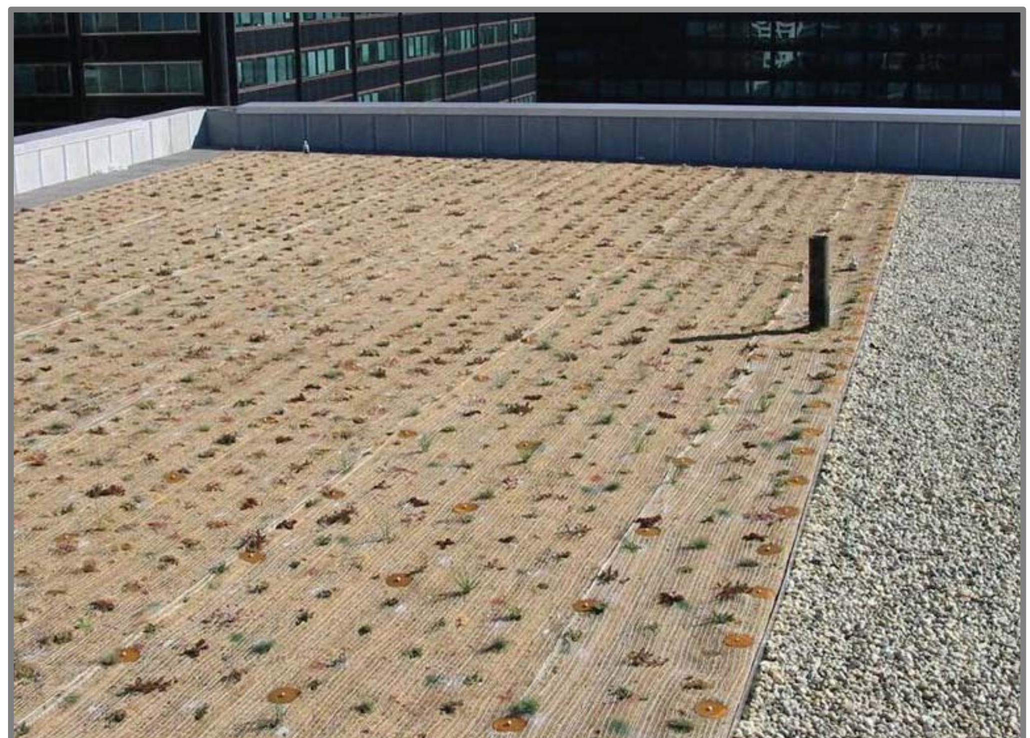
Prior to installation, a plant list should be prepared by a qualified landscape architect.

In Northern climates, the garden should be planted early enough to become established before winter dormancy.

Additional Components - Erosion Control Mats

In some applications it may be necessary to help prevent wind and water erosion of the soil. There are several different varieties, including recycled, non-rotting, polypropylene fibers stitched through a polyethylene carrier sheet or fully biodegradable materials that disappear after a growing season or two. Erosion control mats are rolled out over the growing media to help keep it in place.





Macallen Building - Boston, MA

Design Considerations

Introduction

The first step when planning a green roof is determining the design intent. What is the purpose of the vegetative roof? Will it be pedestrian accessible? Selecting the design intent will determine if the garden should be extensive, semi-intensive, intensive, or a combination.

Other planning and design issues that should be considered include:

- Standards/LEED®
- Structural Requirements
- Slope
- Wind Uplift
- Fire Resistance
- Drainage
- Vegetation-Free Zones
- Hardscape
- Cost and Maintenance
- Supplier
- Manufacturer's Warranty

An exploration of the above issues is presented in this section of the course.

Standards

Currently, new building codes are being developed for vegetative roofs and testing standards are being written by the ASTM International Green Roof Task Group.

Mashantucket Pequot Museum - Mashantucket, CT

LEED

Certain organizations, like the U.S. Green Building Council (USGBC) have come forward as strong proponents of living roofs.

Through its Leadership in Energy and Environmental Design (LEED) certification program, architects/engineers can pursue sustainable design and earn points towards project certification. Green roofs can contribute towards 8-16 points with LEED 2009 for New Construction (refer to table on next slide).

Points are awarded for numerous benefits including stormwater management, since the effect of a green roof is that it decreases the impervious surface of a site. A specific credit addressing reduction of heat islands is available and green roofs qualify as long as they cover at least 50% of the roof surface. In addition, some green roof manufacturers use recycled content in the waterproofing membrane and other components that contribute to the granting of additional points towards certification.

Vegetative roofs can contribute to providing points for supplying materials within a 500-mile radius of the site, and also count for the reduction of site disturbance.

LEED

LEED 2009 NC

LEED RATING SYSTEM CREDIT	AVAILABLE POINTS
SS 5.1 and SS 5.2 Restoring Habitat and Maximizing Open Space	1-2 points
SS 6.1 and SS 6.2 Stormwater Design Quality and Quantity	1-2 points
SS 7.1 and SS 7.2 Heat Island Effect Non-roof and Roof	1-2 points
WE 1 Water Efficient Landscaping	2-4 points
EA 1 Optimize Energy Performance	1-2 points
MR 4 Recycled Content	1-2 points
MR 5 Local/ Regional Materials	1-2 points
TOTAL POINTS POSSIBLE (project specific)	8 - 16 points

Structural Requirements

Green roofs add weight, or dead load, to the roof of a structure that must be factored into its design. Besides the weight of the roof membrane and insulation, the weight of the living roof components, growing media (soil), and plants must be taken into consideration. The weight of the components is typically expressed as a saturated or wet weight.

Some extensive green roofs can weigh little more than a traditional roof with ballast; however, this weight can increase substantially as the thickness of the soil is increased to accommodate the wider variety of plants that can be placed in an intensive green roof.

The soil for a green roof typically weighs between 5.0 to 7.0 pounds per square foot per inch of depth (wet or saturated weight), so on a typical extensive green roof, a 3 inch depth of soil would add 15.0 to 21.0 pounds per square foot. This spread in weight is largely dependent on the composition of the soil and can vary between green roof providers. You should typically plan for an additional 3 – 5 pounds per square foot of load for the remaining components in a complete assembly.

Slope

Along with considering the maximum loadbearing capacity of the roof, other structural requirements include reviewing the height, size, and slope of the roof.

Typical garden roof systems are designed for a maximum slope of 2:12 inches.

Extensive systems can handle steeper slopes, including gable/hip, convex, concave, and complex slopes (some have been installed up to a 12:12 or 45 degree slope). Steeper green roofs require soil stabilization components and are offered through limited green roof providers.

Photos: Tyner Center - Glenview, IL
(max. 6:12 slope)

Wind Uplift

A green roof must be able to withstand wind loading. Keep in mind, wind pressures can vary across a roof, depending on location.

At the center of the roof, a thin layer of soil (15 pounds per square foot) may be adequate. At perimeters and corners, high winds may necessitate the use of large stone ballast or multiple rows of precast pavers to prevent uplift.

Taller structures have a greater risk of wind uplift. Ballasting requirements vary by building height, parapet height, and wind design speed.

Wind Uplift

A host of standards provide wind design guidelines specifically for green roofs. These include:

Factory Mutual

- FM Global: FM Property Loss Prevention Data Sheet 1-28, Wind Loads to Roof Systems and Roof Deck Securement
- FM Technical Advisory Bulletin 1-29, Loose-Laid Ballasted Roof Coverings
- FM Property Loss Prevention Data Sheet 1-35, Green Roof Systems

American Society of Civil Engineers (ASCE)

- ASCE-7-95, Minimum Design Loads for Building and Other Structures

American National Standards Institute (ANSI) and Single-Ply Roofing Institute (SPRI)

- ANSI/SPRI RP-14, Wind Design Standard for Vegetative Roofing Systems

Fire Resistance

Regularly irrigated green roofs are regarded to be resistant to sparks and radiant heat.

Roofs that are not irrigated are typically considered fire resistant provided they meet the following criteria:

- The growing media is 2 inches deep, with no more than 20% by weight of organic matter
- Gravel or concrete breaks occur in the vegetation every 100 feet, at least 4 feet wide
- Vegetation-free zones occur at all roof penetrations and at perimeter walls with openings
- Safety strips are kept free of flammable vegetation

Fire resistance guidelines are available from Underwriters Laboratories (UL) Inc. 790, Tests for Fire Resistance of Roof-Covering Materials; the International Conference of Building Officials (ICBO); and FLL (a German Landscape Research, Development and Construction Society who created the Guideline for Green Roofs).

Drainage

Green roofs retain a high percentage of rainwater; excess water must be drained from the roof by surface roof drains, gutters, or scuppers.

Proper roof drainage design should incorporate a minimum of two outlets, or an outlet and an overflow.

Outlets should be kept clear of vegetation by installing a vegetation-free zone around the outlet (shown at right) and a cover that excludes light from entering the drain area.

★ Please remember the **exam password GARDEN**. You will be required to enter it in order to proceed with the online examination.

Vegetation-Free Zones

Vegetation-free zones should be installed at all perimeters and penetrations. These areas generally consist of a recommended 18 inch-wide path of gravel or architectural pavers.

The purpose of a vegetation-free zone is to protect the roof flashings from the plants roots, as well as provide fire break, wind lift protection, and ease of access to the flashings (if needed).

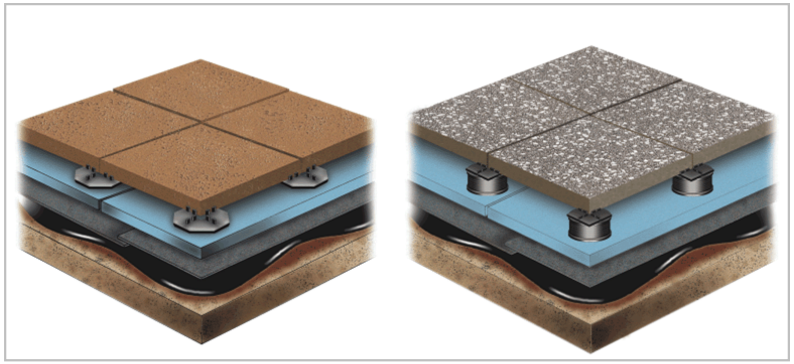
Inspection chambers over all roof drains are recommended to preclude plant growth in the drain.

Hardscape

For intensive green roof applications, there are a number of hardscape paving materials that can be used to provide a walkway or sitting area.

Precast concrete architectural pavers are commonly used and are installed in an open joint assembly (supported at the four corners on spacer tabs or pedestals).

This method of installation allows for water to drain below the wearing surface rather than pond on it, thus eliminating the likelihood of dangerous pedestrian conditions, as well as possible heaving resulting from trapped moisture. In addition, the open joint assembly provides easy access to the assembly components and structure below, facilitating maintenance and future deck alterations.

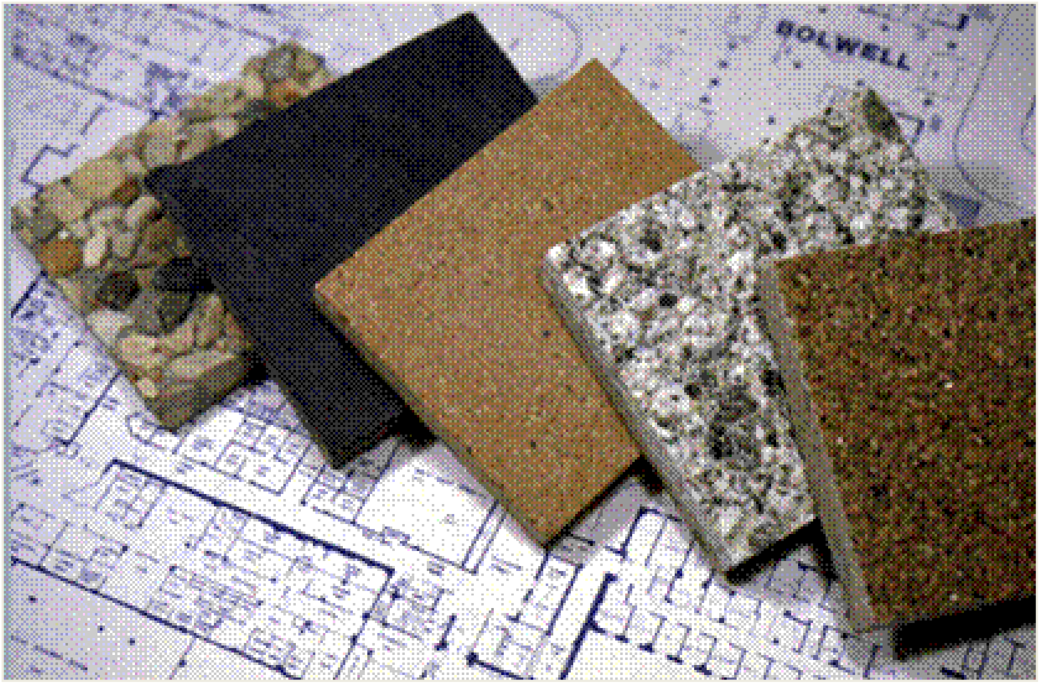


Pedestals

601 Congress - Boston, MA

Hardscape

Architectural Pavers are available in a variety of finishes, colors, and sizes (typically ranging from 12 inches to 36 inches square). Check with the manufacturer for custom colors and sizes to meet specific project requirements.



Hardscape

When designing a green roof, combining the color and beauty of plants with architectural pavers can yield aesthetically pleasing results.

4th Ward Lofts - Madison, WI

North Park 400 – Atlanta, GA
Extensive and Intensive with Pavers

Cost and Maintenance

Cost and maintenance requirements are key considerations when evaluating green roof systems. The cost of a green roof system will vary based on size, complexity, and location.

Living roofs are initially more expensive than traditional systems; however, both short- and longer-term owners reap rewards in several important ways, such as increased property values, improved building performance, and in the case of intensive green roofs, added usable space. Hence, when all of the benefits are considered the payback of green roofs usually makes economic sense.

While the return on investment (ROI) for different building varies, one principle is universal: a long-term owner will spend less on building operation and maintenance over time than on a comparable building without a vegetative roof.

Cost and Maintenance

In terms of maintenance, extensive systems require minimal maintenance, some as little as one annual weeding/watering; intensive systems require regular maintenance including mowing, weeding, watering, and fertilizing.

Intensive: Sherman Plaza - Evanston, IL

Intensive: Millennium Park – Chicago, IL

Single-Source Supplier

Ideally, a green roof system should come from a single source; that is, a single manufacturer whose components are engineered to work together from the membrane up through the plants.

Compiling individual components from different manufacturers is a potentially risky proposition that can take more time to design and build a system.

The manufacturer should be able to provide architectural/engineering support from the initial planning stage to installation.

As well, the manufacturer should have an established history of working with experienced contractors who know the systems involved.

Manufacturer’s Warranty

Manufacturers typically provide warranties for green roofs, and guarantee that their products will last with proper installation. A reliable green roof supplier should provide the following:

- All of the components of the entire system, from waterproofing membrane to the growing media and plants (if provided on the project)
- Proper considerations for wind loading and fire safety
- Material data proving that the system conforms to applicable ASTM standards
- The total weight of the system
- Stormwater calculations for the site location
- Plant recommendations, especially for extensive roofs
- Specifications for all products
- A single-source warranty for all components from the deck up
- Authorized trained installers
- A portfolio of successful projects

In Summary…

Progressive or environmentally-conscious architects, owners, and contractors have been embracing green roofs. They help the environment by mimicking the natural vegetated surface of the earth, while adding new outdoor spaces in dense urban environments. Vegetative roofs lower heating bills by adding insulation, and extend the life of the roof by protecting it from ultraviolet rays.

They have been praised for their ability to manage stormwater, diminish heat island effect, reconnect people with nature, and have even been credited for helping heal patients in healthcare facilities.

As well as minimizing noise transmission, they provide visual excitement and a natural habitat for plants and animals.

Designing with green roofs affords design professionals opportunities to plan projects with exciting new elements, added value, and significant, tangible benefits, thereby enhancing the built environment with newly-created landscapes.

Additional Information

Other sources of information pertaining to Green Roofs include:

- USGBC
  http://www.usgbc.org/education-at-usgbc
- PENN State Center for Green Roof Research
  http://plantscience.psu.edu/research/centers/green-roof
- Green Roofs for Healthy Cities: Your Green Roof Infrastructure Industry Association
  http://www.greenroofs.org
- The Greenroof Directory
  http://www.greenroofs.com/resources.htm

Conclusion

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