

GREEN ROOF APPLICATIONS

INTRODUCTION

1. This bulletin is intended to be a basic primer on green roof applications.

2. Green roofs are not a new concept. They have been around in one form or another since ancient times. Even in the U.S. there are many examples of structures with planted areas on them (typically parking decks that could support the weight) which date back many decades. The difference today is that the technology and components utilized in green roofs have brought the weight of these assemblies down drastically. This reduction in weight has enabled the application of green roofs on many more building types and structures.

3. The light weight green roof technology originated in Europe back in the early 1970's to address various environmental and project specific needs. This technology finally found its way to the U.S. in the mid 1990's as some companies recognized the many benefits a green roof can provide made sense here too.

DEFINITIONS

Types of Green Roofs

1. The industry has typically classified green roofs as either Extensive, Semi-Intensive or Intensive, with some additional sub-categories. The basic difference between these two assemblies comes down to weight, as well as desired benefit. Extensive green roofs (also referred to as vegetative roofs or eco-roofs) are typically utilized where its environmental or technical benefits are the goal or simply to improve the esthetic appearance of the roof top. An Intensive green roof is considered by many to be like a garden on a roof where the emphasis may not be its environmental or technical benefits, but rather the creation of a beautiful useable space.

2. Extensive Green Roofs

characteristics are...

- Shallow soil depths (typically 2"-6")

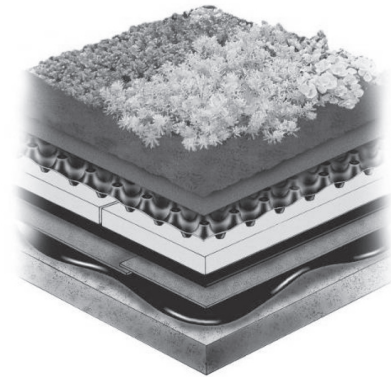
- Light in weight
- Limited plant selection of drought tolerant plants
- No or little irrigation required
- Low maintenance
- Non-recreational
- A complete Extensive green roof with 3"-4" of growing media can weigh between 22-30 lbs./SF (wet weight). As a general rule of thumb a typical growing media will weigh between 6-6.5 lb/SF per inch of depth (wet weight). Some lighter weight growing media blends are available in the marketplace.

3. A Semi-Intensive Green Roofs characteristics are...

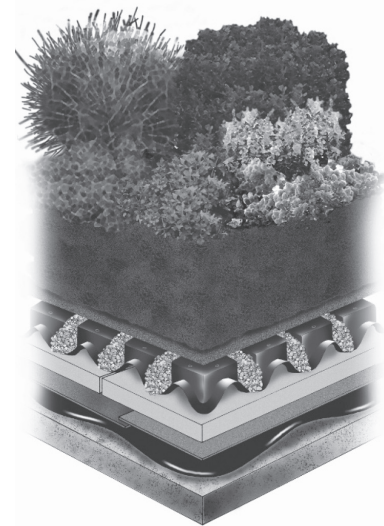
- Combination of deep soil media > 6" and areas < 6" depth
- Weight distributed with deeper areas over structurally sound areas. Weight varies from 25-200 lbs./ SF
- Greater plant palette
- Requires specialized irrigation
- Varies with maintenance required as necessary
- May provide partially accessible space

4. An Intensive Green Roofs characteristics are...

- Deeper Soil depths (typically 6"-36")
- Heavy in weight
- Greater plant palette
- Requires irrigation
- Requires regular maintenance
- Can become additional usable space
- An Intensive green roof at 6" would weigh around 43 lb./SF and



Extensive Green Roof Non-recreational



An Intensive Green Roofs can become additional usable space

go up from there as the depth of the growing media increases. As a general rule of thumb a typical growing media will weigh between 6-6.5 lb/SF per inch of depth (wet weight).

FEATURES AND BENEFITS

There are numerous benefits a green roof can provide.

Ecological Benefits

- Cleansing of airborne toxins (CO₂ reduction, O₂ production)
- Creation of wildlife habitat

- Mitigates the Urban Heat Island effects...

1. keeps urban areas cooler
2. reduces power demands
3. reduces smog

Technical Benefits

- Reduces temperature extremes on roof membrane
- Prevents mechanical damage to roof membrane
- Reduction of noise transmission into building
- Increased energy efficiency
- Storm water detention and retention

Owner Specific Benefits

- Additional usable space
- Reduction in operating costs for heating and cooling and sewage tax benefits (where applicable)
- Reduction in initial investment in HVAC equipment when incorporated into design criteria
- Aesthetics, beauty
- Increased longevity of roof membrane assembly
- Increases property value
- USGBC LEEDs certification

Despite their benefits, green roofs have certain disadvantages. Among those disadvantages are higher initial cost, higher repair costs, difficulty in diagnosis of leaks, and higher replacement cost.

APPLICATIONS

1. Green roofs are capable of being installed on most roof structures that can support the weight (dead and live loads) of the green roof.
2. Most green roof assemblies can be installed on low sloped roofs with a maximum pitch of 3:12 (11°, 25%) (35% not 25%); however the green roof provider should be consulted as to the limitations of their assembly. Some green roof providers have the technology to install a green roof on

roof decks having a slope as much as 12:12 (45°, 100%). Green roof assemblies that exceed 3:12 would typically employ a means to retain the growing media (soil). This technical bulletin deals only with low sloped applications.

3. Most Extensive green roof assemblies are constructed on the roof, however, there are a few providers that offer a modular container or tray with growing media and plants. Another means used at the Ford Motors Project is vegetative mats (similar to sod) grown offsite. The pros and cons of each method must be weighed in order to determine their applicability for each green roof application.
4. Green roof applications can incorporate hardscape areas, such as, walkways of stone, gravel, pavers concrete topping, etc.

COMPONENTS/ASSEMBLIES

1. A green roof is an assembly of components, such as a roofing/waterproofing membrane, insulation layer, water retention/drainage elements, growing media (soil), vegetation and irrigation (if needed). There are many other components that can be utilized to help meet a projects specific needs.
2. There are companies that offer one or more components of a green roof assembly and others that can provide a complete single source green roof assembly. The typical components that can make up a green roof assembly are...
 - a. Roofing/waterproofing membrane – must be acceptable for use in a green roof application per the membrane manufacturer.
 - b. Protection Layer- optional but required in intensive applications as temporary or permanent protection from construction traffic or future excavation.
 - c. Root barrier - to protect the membrane from aggressive root growth
 - d. Insulation - to provide the required thermal value for the structure.
 - e. Drainage/Retention component(s) –

these two functions may be handled separately or together by one or more components. Drainage can be accomplished with a prefabricated drainage layer or an aggregate drainage base. Moisture retention is accomplished typically with fabric mats and/or prefabricated retention composites, (such as those that duplicate the shape of an egg carton). Some of these prefabricated composite components provide not only moisture retention but drainage too.

- f. Geotextile fabrics – for retaining or keeping the growing media in place.
- g. Engineered growing media (soil) – is a critical component to the success of a green roof application. Typically, engineered growing media consists of two primary components, mineral aggregate, often expanded aggregate of clay, shale or slate (of various gradations), and organic compost. Additional other components (such as sand, perlite, peat, etc.) can also be part of the blend.
- h. Irrigation – as required, to provide the vegetation with the moisture it requires that is not provided by Mother Nature. Drip or pop up sprinkler type irrigation methods are typically used.
- i. Vegetation – for Extensive applications very hardy drought tolerant plants such as sedums, herbs and some grasses are used. A much broader choice of plants is possible in Intensive applications where irrigation is a necessity.
- j. Stone or concrete pavers – typically used at roof perimeters, corners and at roof penetrations to form “vegetation free zones”.
- k. Metal work – such as inspection chambers (for drains) and edge restraints to define specific areas on the roof.
- l. Components – example of inspection chambers above OK most are stackable plastic coated galvanized steel however there are also plastic drain pipes, v-shaped drainage channels and bio-degradable erosion

blankets to secure media during grow-in period. Mesh fabric for temporary shading of sensitive plants...

- m. Safety Devices- built-in fall protection tie-off

DESIGN CONSIDERATIONS

1. A green roof is a “living roof” and therefore requires that all of its components work together to provide not only a watertight roof but also an environment capable of sustaining plant life.
2. The roof deck and building structure must be capable of supporting the dead load of the green roof and any anticipated live load. In new construction the additional loads can be easily accommodated in the design of the structure. An architect or engineer must be consulted to insure an existing structure is capable of handling the added loads of a green roof. Properly designed and constructed green roofs can be installed over all types of structures, concrete, wood or metal deck.
3. Local building codes must be adhered to.
4. Regardless of the height of a green roof it must be designed to resist the wind uplift forces that will affect it.
5. A green roof must be designed to resist fire. Intensive green roofs that are regularly irrigated are generally considered as being resistant to flying sparks and radiant heat. Extensive roofs, which are generally not irrigated, are usually accepted as fire resistant, provided that:
 - a. The growing media is at least 2” deep and contains no more than 20% organic matter by weight.
 - b. Vegetation breaks (of gravel or concrete pavers) occur every 100 feet with a minimum 4 foot width.
 - c. Vegetation free zones occur at all roof penetrations and at perimeter walls with openings.
6. Positive roof slope to promote good drainage is typically considered desirable. Roof drains should remain accessible so that they can be inspected and cleaned when needed.
7. The roofing/waterproofing membrane must be capable of functioning in a buried, wet environment. Ideally, it should have a long successful track record, be easy to detail and resistant to fertilizers. Roof membrane flashing heights should extend above the finished roof surface, 8” recommended. Metal-counter-flashings should be considered to protect otherwise exposed membrane flashing from physical abuse (shovels, rooftop traffic, etc.)
8. Insulation - must have sufficient compressive strength be able to take the weight of the green roof assembly as well as any anticipated live load.
9. The type and quality of the root barrier used will be determined largely by the aggressive and invasive nature of the vegetations roots.
10. The growing media must meet the physical, chemical and biological needs of the plants, as well as factor in climate. The mix and structure of the growing media will vary depending on the plants and their requirement for water, aeration and nutrients. Consult with the green roof provider to determine the growing media requirements specific to each green roof application. Most green roof providers have their own proprietary growing media blends that are designed specifically for their assemblies, to achieve the desired balance required.
11. The choice of vegetation hinges on numerous factors, such as, desired appearance, function of the green roof, growing media depth provided, irrigation, climate, etc. For Extensive green roofs typical sedum vegetation can be installed as seed, cuttings, plugs or pre-cultivated carpet (similar to sod). A number of factors will determine the best method to employ, such as desired initial vegetation coverage, desired grow-in period, plant material cost, installation cost, etc.
12. A source of water on the roof must be provided (even if a permanent irrigation system is not installed; common to Extensive green roofs) to

assist during the establishment period of the vegetation, if Mother Nature does not cooperate.

13. All green roofs must be maintained. Therefore it is advisable to provide ease of access to the roof (roof hatch, stairs, ladders, etc.) and storage area for any gardening/maintenance tools required. Safety equipment and anchorage points (or tie-offs) should also be provided (where required) to keep people safe during the installation of the green roof, as well as for maintenance after.
14. Warranty availability. Verify what warranty(s) will be available to the owner from the green roof provider. Some green roof providers offer a range of warranty options. Some can even provide a single source warranty that covers all of the green roof components, including removal and replacement of the overburden to access the membrane, as well as vegetation coverage and maintenance. In a retrofit application where the green roof components are to be installed over an existing roof membrane, verify if an existing warranty from the membrane manufacturer may be jeopardized.
15. Quality Assurance Program – possibly more important than manufacturer’s warranty. Program should designate a person or consultant firm during construction and offer “chain of custody” rollover to Owner based facility maintenance. Commercially available and RCI / NRCA recommended asset management software systems can be used to coordinate inspection documentation, punch lists, photographs, roof commissioning and follow-up maintenance scheduling in a continuous database that begins during bidding and construction.

APPLICATION CONSIDERATIONS

1. An ever expanding variety of green roof assemblies and components are available in the marketplace. Their installation or application can vary widely from one to another. The following points attempt to address general application considerations that most assemblies would subscribe to. The specific green roof component of

assembly provider must be consulted to insure the successful application of their component/assembly.

2. Accessibility of the roof to provide for the delivery of the green roof components and equipment necessary to install them must be determined.
3. Loading of the roof deck with materials and equipment must be done with caution so that the dead/live load limit of the deck is not compromised.
4. All safety precautions must be employed during the installation of the green roof assembly to safeguard the installers.
5. Coordination between all parties on a project is critical to the success of the installation. It is not uncommon to have a waterproofing/roofing installer and a landscape contractor involved on the same project. The scope of responsibility and coordination between contractors must be pre-defined and established.
6. The roofing/waterproofing assembly installation should be done in accordance with the manufacturer's guidelines and details for a green roof application. The application of the roofing/ waterproofing assembly should be done by a manufacturer approved or authorized installer. Typically the roof assembly will also include the roof insulation.
7. All flashing height must be determined

to insure they extend above the finished roof surface, where possible.

8. It is strongly recommended that prior to the installation of the overburden (green roof components, growing media and vegetation), the waterproofing/ roofing membrane be leak tested. Any breach in the watertight integrity of the membrane must be properly repaired.
9. Protection of the completed waterproofing/roofing membrane assembly must be provided during the installation of the green roof components and growing media.
10. The root barrier, whether an integral part of the roof membrane assembly or a separate component must be properly installed (per the manufacturer's guidelines) and free of any punctures. Typically, they should extend up the full height of the membrane flashings to protect the roof membrane assembly from root damage.
11. During the installation of the green roof assembly temporary ballasting may be required to keep some of the components in place until the growing media installation is completed.
12. Many green roof installations can be phased. The waterproofing/ roofing assembly can sometimes be installed separate from the green roof components to dry in a structure

early in construction, provided the membrane assembly is properly protected from physical abuse and it doesn't require the overburden to keep it in place. Phasing the installation can also consist of completing everything on the green roof up through the growing media, but not the vegetation. This is typically done so that the vegetation can be planted at the proper time of the year. In this case the growing media must be protected from the wind and contamination from unwanted seeds, pollution and contamination from construction chemicals (i.e. brick cleaning) to keep it safe until the vegetation is planted.

13. The best time to plant the vegetation on an Extensive green roof is typically in the spring or fall. Planting in the summer time comes with risk with respect to excessive heat and lack of natural moisture there by making it difficult to establishing the vegetation.

SPECIAL CONSIDERATIONS

The green roof owner should be encouraged to obtain a maintenance agreement with the green roof installer/ landscape contractor. The first two years are critical to the success of the green roof with respect to plant establishment and sustainability.

Other valuable resources available from the Sealant, Waterproofing & Restoration Institute

SWR Institute *Applicator*, a technical journal

Applying Liquid Sealants: An Applicator Training Program

Below Grade Waterproofing Manual

Clear Water Repellent Handbook

A Practical Guide to Waterproofing Exterior Walls

Sealants: The Professional's Guide

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