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Thinking Above the Box: *Green Roof History and Systems*

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Introduction

One of today's many new environmental buzzwords is "green roofs." While green roofs (sometimes written "greenroofs") can be important tools in environmental responsibility efforts, they are certainly not new, and they most definitely encompass more than a simple buzzword. A simplified definition of the term "green roof" is a roof with a covering, either full or partial, of live plant material. In their earliest years, green roofs were literally live plant material. However, green roofs and green roof technology have changed dramatically over the last 30 years.

The general public sometimes confuses green roofs with rooftop gardens. Although the benefits of each can be similar, there are significant differences between the two. Typically, rooftop gardens are characterized by containerized or built-up planting areas, either for aesthetic purposes or for the production of food, and may occupy only a small portion of a roof. A green roof usually consists of a layered system, most often completely covering the roof surface. The vegetation is almost always planted directly in a soil media, not in containers; however, this method of planting is changing with advanced technologies and applications.

History

The earliest green roofs can be traced to the hanging gardens of Babylon of the seventh and eighth centuries. Later, green roofs spread across portions of northern Europe, primarily in Germany, in rural and agricultural applications. Turf-covered roofs also have been used in areas throughout the Middle East for centuries. Their construction and use were purely functional (Dunnett and Kingsbury 2004; Getter and Rowe 2006). Protection from the elements involved placing thick layers of mud and sod on the roof. Benefits included a shaded living space and insulation from extreme heat, cold, water and wind. However, along with these benefits came leaks, falling soil and organic debris, and insect infestations.

In the late 1800s and early 1900s, the use of concrete in flat roof construction increased in Europe and the United States. This led to the development of several impressive "nature roofs" in Paris, Cologne, London and Chicago.

During the 1930s, green roof construction began on New York's Rockefeller Plaza, the most recognizable of the earliest installations in North America. However, long before that time, Native Americans and early European settlers used sod roofs and walls in the Great Plains for the same functional applications found in Europe. One million square meters of green roofs were in use in Germany by 1989. That number increased to 10 million square meters by 1996. Most recent estimates put 12 percent to 15 percent of all flat roofs in Germany under green roof (GRHC 2005; Snodgrass and Snodgrass 2006).

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As functional units, early roofs were simple constructs with relatively thin profiles. In more recent times, green roofs have become thicker, containing

Figure 1. Turf on roof of Icelandic structure. (Photo by John Oppermann)

more complex components. These changes have led to the categorization of specific green roof types.

Green Roof Types

While the basic elements remain the same, green roofs can be separated into two types: extensive and intensive. A third type, semi-intensive, has emerged as a hybrid between the two. The major differences between all three are found in the intended functions and profiles of each. Is the roof to be used actively by humans, or is it simply a vegetative cover for environmental or other benefits? Will a large amount of soil profile be required based on desired plant material, or will a minimal veneer suffice?

Extensive green roofs are characterized by thin soil profiles, contain smaller plant material, and usually are not meant for active human use. Typically, intensive green roofs have thicker soil profiles and large plant material and are suitable for active human use. Below are some of the physical differences between the green roof types:

Extensive

- Lower profiles, typically 6 inches (15.2 cm) or less.
- Low diversity of plants — succulents, grasses, etc.
- Soils: 20-30 percent organic/70-80 percent inorganic.
- Roof slopes up to 30 percent or more.
- Low saturated weight of 10-35 lbs/sf (.42-1.47 kg/m^2).
- Relatively low cost and minimal maintenance.

Semi-intensive

- Slightly higher profiles — 25 percent of the roof area above 6 inches.
- Slightly greater diversity of plants.
- Soils: 20-30 percent organic/70-80 percent inorganic.
- Roof slopes less than 30 percent.
- Saturated weight of 35-50 lbs/sf (1.47-2.10 kg/m^2).
- Slightly higher cost and maintenance than the extensive roof type.

Intensive

- High profiles, greater than 6 inches, sometimes several feet thick or more.
- Large plant diversity, pools, garden structures.
- Soils: 50 percent organic/50 percent inorganic (Snodgrass and Snodgrass 2006; GRHC 2006).
- Usually flat roof.
- Saturated weight can be 50-300 lbs/sf (2.10-12.65 kg/m^2).
- High cost and maintenance.

Advantages of Green Roof Types

While all three green roof types have advantages, many factors affect the viability and success of any roof installation. It should not be assumed that all of these characteristics and the advantages listed below will be realized with every green roof (Dunnett and Kingsbury 2004; GRHC 2005; GRHC 2006).

Extensive

- Lightweight.
- Suitable for large areas.
- Low maintenance costs and often designed for no irrigation.
- More suitable for retrofit projects.
- Lower capital costs.
- Easier to replace.

Intensive

- Greater diversity of plants.
- Best insulation properties and storm water management.
- Greater range of design.
- Usually accessible.
- Greater variety of human uses.
- Greater biodiversity potential.

Green Roof Systems

The technologies involved in green roof applications are changing and improving rapidly. However, the basic components have remained relatively the same.

It is important to understand that a green roof of any type or consisting of any number of components is not a replacement of a building's roofing

Semi-intensive roofs can combine the best features of extensive and intensive roofs.

system. Green roofs are additions to a conventional roof system. For any conventional roof, proper design and installation of the roof system are critical for the roof to remain viable. A green roof should never be considered a fix to or protection for an improperly installed or failing conventional roof.

Regardless of the type of conventional roof (modified bitumen, polymer-based single-ply, built-up, concrete, etc.) being considered for a green roof installation, the components of the green roof are fairly simple. The majority of green roof systems are called "built-up systems," consisting of various component layers constructed directly on the roof's structural deck and conventional roof system. This application can be installed either as part of the initial roof construction or added as a retrofit at a later time. Built-up systems are most often used in large-scale applications and for all three types of green roofs (GRHC 2005).

A root barrier, drainage material, filter fabric, growing medium and plant material comprise the main elements of green roofs. Waterproofing and insulation are usually components of the conventional roof; however, if they are not a part of the existing roof, they need to be included in the green roof construction. Other components sometimes found in green roofs include padding, support, irrigation, leak detection and pedestrian access elements.

Typically, the root barrier would be installed directly on the conventional roof's membrane. Above this is a drainage layer, topped by a filter fabric. Numerous products are available for use as a drainage layer, the simplest being lightweight gravel. Newer drainage

systems combine structural strength and shearing resistance along with wells for water storage during dry weather and drains for the removal of excess water. The function of the filter fabric layer is to prevent growing media and fine soil particles from migrating into the drainage system. However, it is possible for the filter fabric to become clogged over time with the fine soil particles, necessitating removal of the plant and media components so that the fabric can be replaced.

roof components and systems, a green roof will always add to the weight load imposed on a roof. This additional load will vary based on design and must be calculated for the structural impacts to the conventional roof.

Growing Media

A wide variety of materials are available for the soil growing media. The type of green roof, function, location and plant materials desired as well as the structural capabilities of the conventional roof all factor into choosing soil media. Some extensive roofs consist of 100 percent engineered soils containing no organic materials, while thicker intensive roofs can contain a 50-50 percent mix of inorganics and organics. Materials used in green roof media include sand, gravel, lava, shale, perlite, vermiculite, crushed brick and concrete, and various types of subsoils (Buist and Friedrich 2008; Dunnett and Kingsbury 2004).

The expected performance of the roof, desired goals and selected plant materials should guide the soil media mix decisions. Numerous sources caution against using clay soils or common topsoils as part of or solely as the growing media. Clay soils can become extremely heavy when saturated and may clog key components of the filtering system.

Topsoils and other highly organic materials can introduce pests and pathogens into the green roof system. The organic matter will decompose over time, potentially robbing the media of nitrogen. Research also has found that the leaching of nutrients, especially nitrogen and phosphorous, increases as the organic components of the soil media increase (Dunnett and Kingsbury 2004).

Figure 2. Simplified green roof system. *(Photo by Xero Flor America)*

The other basic green roof system is known as a modular system. Typically, modular systems are installed using preformed materials such as plastic or metal with support, drainage and filtering components built in. The sizes and shapes can vary, but the most common module is from 4 to 16 square feet (.37 to 1.49 m^2) with depths varying from 1 to 6 inches (2.5 to 15.2 cm). This type of system can be set in place on the roof and filled with a growing medium and planted or preplanted off-site and installed for immediate application.

While newer technologies are decreasing the weights of various green

Figure 3. Modular green roof system. *(Photo by LiveRoof)*

References:

A cathedral to green roof design. (2008). Living Architecture Monitor. 10(2):10-11.

A civic oasis: Nashville public square. (2007). Green Roof Infrastructure Monitor. 9(2):16-17.

A luxurious rooftop. (2008). Living Architecture Monitor. 10(3):22-23.

Berghage, R., D. Beattie, and A. Jarrett. 2007. Green roof runoff water quality. Green Roof Infrastructure Monitor. 9(2):26-27.

Buist, R. and C. Friedrich. 2008. The organic question. Living Architecture Monitor. 10(1):16-21.

Dunnett, N. and N. Kingsbury. 2004. Planting green roofs and living walls. Portland, Oregon, Timber Press.

Getter, K.L. and D.B. Rowe. 2006. The role of extensive green roofs in sustainable development. HortScience. 45(5):1276-1285.

Green Roofs for Healthy Cities (GRHC). 2005. Green roof design 101– Introductory course. Partcipant's manual.

Green Roofs for Healthy Cities (GRHC). 2006. Green roof infrastructure design and installation 201. Partcipant's manual.

Hewitt, T. 2003. Garden succulents. RHS Wisley Handbook. Cassell Illustrated Publications, London.

Retzlaff, B., M. Simmons, K. Forrester, E. Woods, and K. Luckett. 2008. Will my green roof reduce stormwater runoff? Living Architecture Monitor. 10(2):34-37.

Sherman, R. 2005. Compost plays key role in green roof mixes. BioCycle: Journal of Composting and Organic Recycling. March. 29-34.

Snodgrass, E.C. and L.L. Snodgrass. 2006. Green roof plants. Portland, Oregon, Timber Press.

Toronto and Region Conservation Authority (TRCA). 2006. Evaluation of an extensive greenroof. York University, Toronto, Ontario.

Worden, E., D. Guidry, A.A. Ng, and A. Schore. 2004. Green roofs in urban landscapes. ENH 984. University of Florida, Institute of Food and Agricultural Sciences.

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