

3.0 Survey of types of green roofs and their standards

This section will provide a generic description of green roofs then it will provide and describe a few of the existing available systems. Then it will provide information on green roof standards, and finally the green roof performance requirements that have been adopted by some European municipalities as part of their green roof policies.

3.1 Green roofs described

The term "green roof" is generally used to represent an innovative yet established approach to urban design that uses living materials to make the urban environment more livable, efficient, and sustainable. Other common terms used to describe this approach are eco roofs, and vegetated roofs. Green Roof Technology (GRT) is the system that is used to implement green roofs on a building

Green roofs are constructed using components that

- have the strength to bear the added weight;
- seal the roof against penetration by water, water vapour, and roots;
- retain enough moisture for the plants to survive periods of low precipitation, yet are capable of draining excess moisture when required
- provide soil-like substrate material to support the plants;
- maintain a sustainable plant cover, appropriate for the climatic region;
- offer a number of hydrologic, atmospheric, thermal and social benefits for the building, people and the environment;
- protect the underlying components against ultraviolet and thermal degradation.

In describing Green Roof Technology of the last 10 to 15 years, Dunnett and Kingsbury (2004) find two approaches: extensive and intensive.

Intensive green roofs generally require more effort for the tending of plants, whereas the term extensive roofs call for a more passive approach. Intensive green roofs also emphasize the use of space and therefore raise higher aesthetic expectations than more functional extensive green roofs. Intensive green roofs generally need deeper substrate, more diverse plants including trees and shrubs, and proper watering schedules. Thus they involve higher costs (Dunnett and Kingsbury 2004; Peck et al. 1999). As in many design classifications, however, there are actually degrees of intensiveness in the approach to rooftop greening.

3.2 Currently available green roof technology

Green roof systems can be categorized as follows:

- complete systems where all different components including roof membrane are an integral part of the whole system;

- modular systems that are positioned above the existing roofing system;
- precultivated vegetation blankets that consist of a growing medium and plants that are rolled onto the existing roofing system with drainage mats and root barriers as required.

Variations between systems are generally found in the manner in which growing medium and drainage layers are treated.

The following are the common green roofing systems used in recent years in North America:

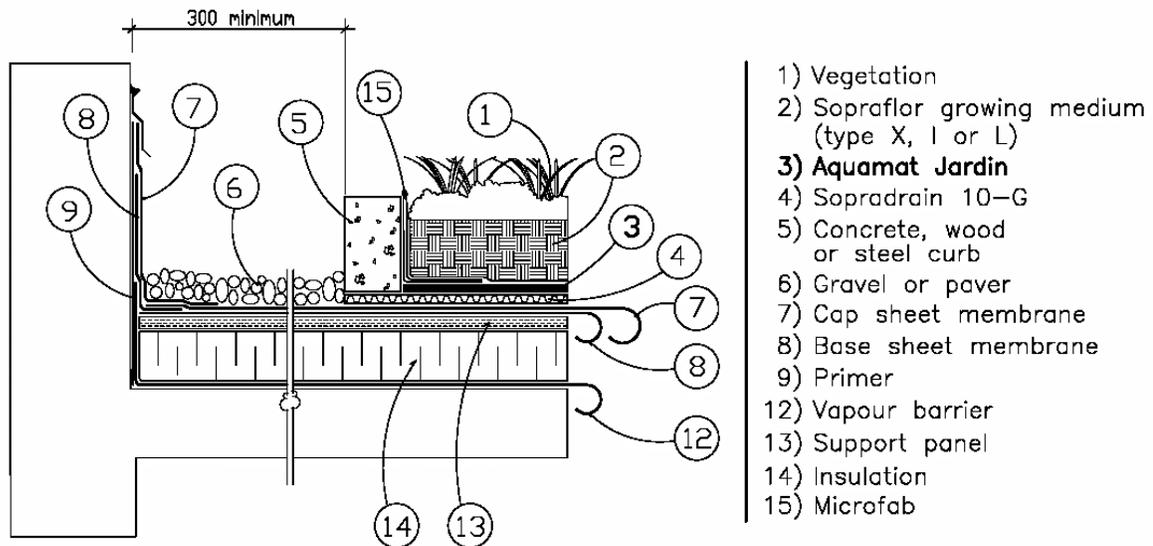
1. Sopranature by Soprema
2. Garden Roof by Hydrotech developed in conjunction with ZinCo GmbH
3. Easy Green by Elevated Landscape Technologies
4. Pre-cultivated vegetation blankets by Xero Flor Canada
5. Roofmeadow assembly by Roofscapes Inc. adapted from Optigreen of Germany
6. GreenGrid System by Weston Solutions Inc. and ABC Supply Co. Inc.
7. Green Roof Blocks by St. Louis Metalworks Company

In addition there are several green roof technologies available in Europe. Suppliers of these green roof technologies include: GDT Systems International in Germany, APP's Roof Garden Sets in Germany, Bauder's Green Roof System in the UK, and Kalzip's Nature Roof in UK.

3.2.1 Complete systems

Complete systems provide the most flexibility in terms of the type and nature of growing medium and drainage, and protection layers that can be used. These have direct impact in terms of the type of vegetation that the green roof can support. They also generally contribute the greatest amount the structural design load. Sopranature by Soprema, Garden Roof by Hydrotech, and Roofmeadow by Roofscapes fall into this category. Figure 3.1 shows a Sopranature system on a conventional roof assembly

Figure 3.1
A typical Sopranature green roof assembly on conventional roof
(Adapted from Soprema Inc.)



The Soprema system is typically used with its proprietary waterproofing membrane. The Hydrotech system is essentially similar in concept to the Soprema system, but also uses its own proprietary roofing membrane.

The Roofmeadow system by Roofscapes offers several options of varying thicknesses and weights from as low as 50mm to 75mm (2 to 3 inches) and 60 to 90 kg per sq. m, (12 to 18 lbs per sq. ft.). Roofmeadow systems can be installed with a variety of waterproofing membrane types, Roofmeadow will, however, take a single source responsibility for the performance of the whole roofing system. Their low thickness system is similar to the precultivated vegetation blanket system.

3.2.2 Modular systems

Modular systems are essentially trays of vegetation in a growing medium that are grown off site and simply placed on the roof to achieve complete coverage. They are available in different depths of growing medium typically ranging from 75mm to 300mm (3 to 12 inches). GreenGrid and Green Roof Block systems are examples of modular systems shown in Figures 3.2 and 3.3.

Figure 3.2
Photograph showing Green Roof Block System
(Adapted from St. Louis Metalworks Company)



Figure 3.3
Photograph showing GreenGrid System
(Adapted from Western Solutions Inc.)



3.2.3 Precultivated vegetation blankets

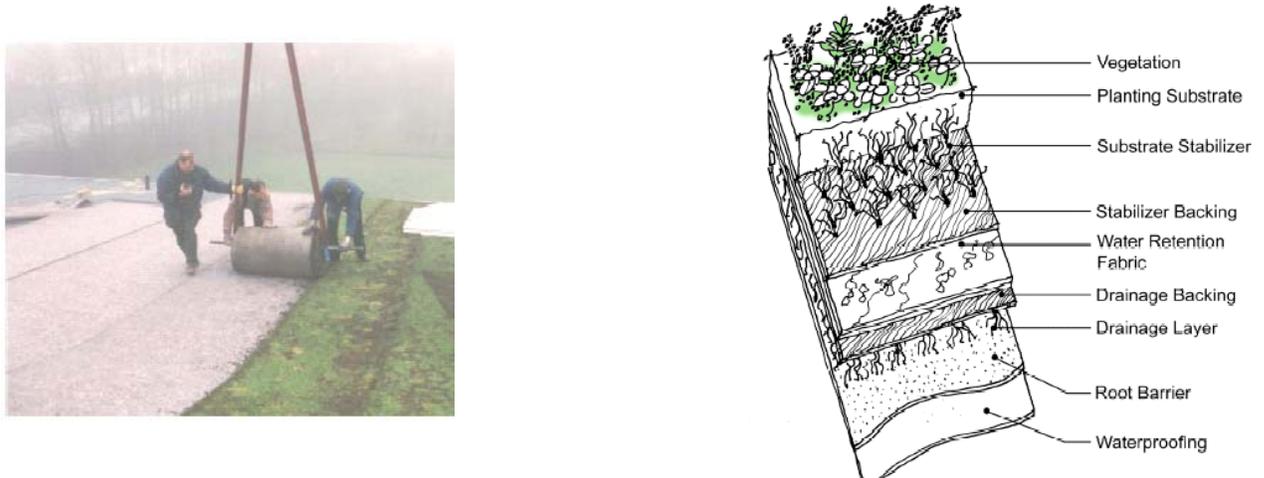
Xero Flor Canada and Elevated Landscape Technologies (ELT) offer precultivated vegetation blankets. Figure 3.4 shows photographs of the system offered by ELT. It is a pregrown interlocking green roof tile and in that respect it could be viewed as similar to the modular system. But its thickness categorizes it as a blanket system. It is available in one thickness of about 45mm (1.75 inches)

Figure 3.4
Photograph showing ELT system
(Adapted from Elevated Landscape Technologies)



Xero Flor primarily offers extensive green roof systems. A variety of system designs are available, but perhaps the most versatile system contains 25 mm (1 inch) of planting substrate. The result is a lightweight system ranging in weight from 40 to 60 kg per sq. metre. The majority of the vegetation is made up of several varieties of sedum – a succulent plant (8.0 to 13.0lbs per sq. ft.) that is tolerant of extremes in temperature and that survives with little or no irrigation while requiring very little maintenance. Most Xero Flor systems are cultivated at ground level, then rolled-up and transported as a complete system on pallets or by crane.

Figure 3.5
Photograph showing Xero Flor System installation and cross section
(Adapted from Xero Flor Canada)



3.3 Survey of green roof system standards and performance requirements

The only comprehensive green roof guidelines in existence today are produced by Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (FLL) a landscape industry organization in Germany. An English version entitled "Guideline for the Planning, Execution and Upkeep of Green Roof Sites" was issued in 2002. The document covers design, construction and maintenance of green roofs, with detailed sections on stormwater considerations, planting medium requirements, and drainage and layer requirements. It also provides information on testing of some of the green roof components.

In North America, ASTM, a standards development organization has struck a committee to formulate standards. Some standards relating to the performance of components of green roof system components and determination of structural loads from green roofs will be published in Fall, 2005.

In addition to green roof standards, many European jurisdictions have established green roof performance requirements. These performance requirements are different from standards. They build on and rely on standards for green roof specifications to meet specific policy or incentive requirements in a municipal jurisdiction.

3.3.1 FLL guidelines

The FLL 2002 Guidelines in English contain very detailed information pertaining to the planning, execution and upkeep of green roofs. The following paragraphs describe some of the key elements of the document

The first section of the document deals with applicability and relationship to other standards. It is important to note that the same standard applies to greening of roofs, roof terraces, and underground parking garages.

The second section of the document describes the types of green roofs: intensive, simple intensive and extensive. It further provides guidelines on the type of vegetation that each of type of green roof may be able to support and the factors that contribute to the successful growth of the vegetation.

The third section provides general information on the benefits of green roofs. This is followed, in Section 4, by a discussion of the nature of building and roof construction on the design of green roofs. It identifies the slope of the roof as a key factor in the success of a green roof. Roofs with slopes less than 2% (which would include many flat roofs in the Toronto area) will need special precautions with respect to drainage and preventing water from clogging the roots. Other issues that are discussed in this section include: roof designs and their suitability to accept green roofs, consideration of structural roof loads, compatibility of materials, watering, drainage from roof areas, fall protection, and ensuring that green roofs do not accidentally contribute negatively to the environment

Section 5 provides technical construction requirements for green roofs. Details are provided for protection from: root penetration, mechanical damage, corrosion, emissions and effluents, and slipping and shearing. Details are also provided for drainage facilities, construction of joints, borders and parapets, wind load considerations, fire prevention, provision of furnishings and trafficable areas.

Section 6 introduces the various components of the vegetation area such as the growing medium, filter course, drainage course, protective layer, root-penetration layer, separation layer and the anti-bonding layer. It provides general construction guidelines for these components. Detailed requirements for some of these components are provided elsewhere. This section also provides general guidelines relating to water retention and watering requirements. Of particular interest is the chart titled "Standard course depths for different types of roof-greening" and the chart that provides reference values relating depths of growing medium and annual average water retention. Tables 3.1 and 3.2 below summarize this information.

Sections 7, 8 and 9 provide detailed information about the materials, their requirements and construction of the drainage course, filter course, and the vegetation support course (growing medium). Sections 10 and 11 provide detailed information pertaining to the planting of vegetation, its cultivation and maintenance. The guidelines also include requirements for quality control and assurance. Section 12 provides details of the tests that should be conducted to ensure components meet the requirements set out in the guidelines. Finally, Section 13 provides useful reference data related to weight of materials that can be used to determine structural loads.

The FLL guidelines in general would be applicable to green roofs in the City of Toronto as long as the plant requirements are replaced by those of local plant species.

Table 3.1
Growing medium depth required for various types of vegetation
on different types of green roofs and
Annual average water retention as percentage of rainfall
for selected types of green roofs

Type of green roofs and vegetation	Depth required for growing medium (cm)	Water retention – annual average (% of total rainfall)
Extensive green roofs		
Moss-sedum	2 to 6	40 to 45 %
Sedum-moss-herbaceous plants	6 to 10	50 %
Sedum-herbaceous-grass plants	10 to 15	55 %
Grass-herbaceous plants	15 to 20	60 %
Simple (semi) intensive green roofs		
Grass-herbaceous plants	12 to 35	See note below
Wild shrubs, coppices	12 to 50	
Coppices and shrubs	15 to 50	
Coppices	20 to 100	
Intensive green roofs		
Lawn	15 to 35	See note below
Low-lying shrubs and coppices	15 to 40	
Medium height shrubs and coppices	20 to 50	
Tall shrubs and coppices	35 to 70	
Large bushes and small trees	60 to 125	
Medium-size trees	100 to 200	
Large trees	150 to 200	

Notes to Table 3.1: Water retention for semi-intensive and intensive green roofs will depend on area coverage. For individual areas of greening retention will be greater than that for extensive roofs and as high as 90% or more. The retention percentages are based on an average rainfall of between 650-800 mm. The City of Toronto average annual rainfall falls into this category. In drier regions the retention percentage will be higher and in wetter regions the retention percentage will be lower.

3.3.2 Green roof requirements⁵

In Europe performance rating systems have been developed for green roof technology. The rating systems help municipalities stipulate requirements that are tied to various programs related to green roofs on specific projects. They help ensure that the performance goals, which form the basis of municipal support programs, are met and continue to be met.

An example of such a system is the one developed by the FLL in 1998, specifically for the rating of green roofs in land-use planning, building permit approvals, and construction acceptance. Ten base points are assigned for each cm. of depth of green roof available for plant root penetration per sq. m. of green roof coverage. So, a 10 cm design will earn a building 100 (10 points x 10 cm) points per sq. m. coverage of green roof. In order to qualify for these points, the roof construction should meet certain minimum requirements in the following categories:

- water retention capacity of the growing medium;
- water retention capacity of the drainage layer;
- number of plant species for extensive green roofs; and
- plant biomass or volume for intensive green roofs.

In addition to these above quantitative elements, the FLL system identifies qualitative characteristics according to type of roof construction. These are typically used to judge whether a project is suitable for ecological compensation according to the local conservation requirements. Each natural function parameter is deemed “possible to fulfill completely”, “possible to fulfill partially”, or “slightly or not possible to fulfill.” The qualitative parameters are

- quality of soil;
- improvement in surface water quality;
- reduction in load of the sewer system;
- improvement in groundwater recharge;
- purification of stormwater;
- filtering of air;
- contribution to oxygen production;
- contribution to urban temperature levelling;
- contribution to establishment of flora and fauna habitat;
- contribution to landscape and urban scenery; and
- contribution to amenity for people / leisure / healing.

⁵ The discussion on green roof performance requirements is adapted from “Green Roof Policy: Tools for Encouraging Sustainable Design” by Goya Ngan, 2004 last accessed at <http://www.gnla.ca/library.htm>.

Another example of performance rating is the Karlsruhe Performance Rating System for green roofs. It rates green roofs according to five natural functions. Each of these functions, or categories is assigned a weight based on its importance. The five functions with their weights are as follows:

1. Type and depth of soil used (Soil) – 15%
2. Impact on climate due to evapotranspiration (Climate) – 15%
3. Type and variety of vegetation (Flora) – 30%
4. Impact on zoological biodiversity (Fauna) – 30%
5. Average annual stormwater retention (Water Balance) – 10%

Each type of green roof is assigned a rating in percentage for each of the above five functions. The sum of the weighted rating for each of the five functions is used to compare different green roofing systems and stipulate minimum requirements. In one example an extensive roof with 3-5 cm growing medium is rated at 0.14 on a numerical scale compared to 0.48 for a roof with a 15 cm growing medium.

In addition to these examples of specific requirements for green roofs to meet program requirements in specified jurisdictions are provided in Table 3.2:

Table 3.2 Green roof requirements in selected European jurisdictions

Name of jurisdiction	Requirements specific to green roofs
North Rhine Westphalia, Germany	Runoff coefficient as tested for specific green roof systems to be less than 0.3 or have a minimum depth penetrable by roots of 15cm.
City of Cologne, Germany	<p>No specific requirements for runoff coefficient or minimum depth. However a stormwater fee discount is applied on a sliding scale, with 90% discount for roofs with a runoff coefficient of 0.1 or less decreasing to a discount of 30% for a runoff coefficient of 0.7.</p> <p>In addition each applicant is required to submit a stormwater infiltration data form providing details of the runoff characteristics of the green roof and the drainage management of the building and the site.</p>
City of Berlin, Germany	Green roofs should meet industry standards such as FLL guidelines
City of Linz, Germany	<p>For underground parking garages, green roofs are to have a root penetrable growing medium of at least 50 cm. with plant coverage of 80% of the designated green roof area.</p> <p>Other parts of new and existing buildings with an area more than 300 sq. m. and slopes of 20° or less are required to have green roofs with a root penetrable growing medium of 12 cm.</p>