GENERAL CHARACTERISTICS OF GREEN ROOF STORAGE

Green roofs introduce vegetation on unavoidably impervious surfaces and offer a number of environmental advantages including:

- improving air quality
- providing habitats for insects and birds
- helping to retain higher levels of humidity in urban areas
- reducing roof stormwater runoff and associated contaminants such as nutrients and bacteria from bird droppings. Up to 50% of all rainfall might be retained by an extensive green roof whilst for 3mm to 23 mm rainfall events, greater than 85% of the rainfall might be retained.

Figure 1 illustrates a simplified section through a green roof showing the three principal components; waterproofing, soil and plants. The insulation layer in an optional component and may be included to prevent the water stored in the system from extracting heat energy from the underlying building. Usually some form of biodegradable wind blanket such as a jute or coco liner type mesh, may be placed over the new plants to stabilize the establishing root system.

![Figure 1. Section through a standard green roof](image)

In Europe, installers mainly use 60 to 80 mm PVC single-ply roof systems although reinforced PVC also works well for waterproofing because it is heat-seamed which reduces the risk of leaks. Other suitable material materials for waterproofing and root protection include rubber membrane (EPDM) or hypolan (CSPE) although the former needs to be bonded. Thermoplastic polyolifins (TPOs) are also used and are often considered more environmentally acceptable. An asphalt-based roofing system must be covered with a high-density polythelene (HDPE) membrane to prevent root penetration since asphalt is anorganic product and thus would act as a food source for soil organisms.

For new green roof projects, using on-site, stockpiled quality topsoil can be very cost-effective but needs to be mixed with expanded clay to improve water retention capacity. However, the structural loading capacity will normally determine the type of substrate; at
least 70 kg/m² beyond snow load is the minimum critical loading. Intensive green roofs require a minimum of 300 mm of soil depth to create a viable roof garden with large trees and shrubs. Such multi-layered constructions with elaborate irrigation and drainage systems add considerable load (400 – 700 kg/m²) to a structure and require intensive maintenance. These types of roof gardens are designed to be accessible and often used as parks or building amenities by corporate city companies.

Even thin soil systems of 20 – 25 mm depth can work optimally with two layers separated by a geotextile fabric; the lower level is commonly very lightweight mineral matter (usually a fired clay). Plant roots will penetrate the geotextile and concentrate along the bottom of this layer where they find the best conditions for survival i.e cool and moist. When roots are encouraged to grow higher up in the profile, they are much more vulnerable to the effects of varying temperature and moisture. Consequently, if irrigation is used, water is introduced into this granular layer. If the substrate is chosen to have good water retention qualities, the green roof will support a variety of plants without irrigation.

Generally the construction effort and cost of green roofing increase with slope. Minimal slopes slow down water flow and above 5 degrees or more, it is necessary to prevent rapid runoff by increasing the retention capacity of the substrate. Light soils and water retaining substrates make it possible to vegetate sloping roofs up to 30 degrees. However, roof slopes above 15 degrees require:

- steps to prevent soil slippage and erosion
- possible additional support with cross-battens
- a raised grid structure to secure the plant’s growing substrate.

The additional load of materials comprising plants, soil and water held in a green roof must be taken into account when accommodating the structural loading of the building. Calculations must be based on the saturated state and a structural loading in the order of 70 – 150 kg/m² is likely to be required. Wind, insulation and evapotranspiration can create extreme drying conditions on roof surfaces which mean that runoff from a green roof is often negligible and suspended solids capture can be as high as 75% or more. On average, a 25 mm deep sedum layer over a 50 mm gravel bed will retain about 58% of water and a 100 mm layer including herbaceous vegetation can retain up to 70%.

Correct application and testing of the waterproof membrane (preferably a liquid-applied form), is essential to the viability of the green roof, and since plant roots secret humic acids, the membrane should be able to withstand these conditions as well as being root resistant. Vulnerable areas where leakage can occur include:

- abutting vertical walls
- roof vent pipes
- rainwater outlets
- air conditioning units
- perimeter areas
The gravel, rockwool or plastic drainage layer carries away excess water and on shallow roofs, may be combined with the filter layer. Drainage capacity must increase closer to rainwater outlets, so a separation barrier some 500 mm wide of large rounded pebbles should be installed along the eaves and near outlets. Additionally, a shallow layer of gravel or pebbles placed about 400 mm from the outside perimeter of the roof is recommended, providing additional drainage, fire control and access to the roof for maintenance.

Lightweight soil mixes of high quality compost and recycled materials comprise the plant growth medium and it desirable to have as large a volume and depth of media as possible to contribute to wind stability, offset drying rates and protect the roots from frost damage. The plants should have shallow root systems, good regenerative qualities be drought tolerant and resistant to direct radiation and wind. The closest natural environmental conditions which match these found on green roofs are succulents including coastal plant or arid/alpine communities. Plants successfully used in shallow soil beds on roof surfaces include species of sedum, sempervivum, creeping thyme, allium, phloxes, antnenaria and aubretia. Sod is not used for green roof applications because it is highly maintenance intensive requiring constant irrigation and cutting and providing only limited ecological benefits. Mosses are also best avoided as they can pose serious fire hazards. Some detail of a sedum-planted green roofs located in Malmo, Sweden is illustrated in Figure 2 which is used as an educational facility and which shows that they can also provide aesthetic features within the built-up environment.

Figure 2. A Green Roof Garden in Malmo, Sweden.