Green roofs

Guidance on what green roofs are, why use them and and how they are constructed

What they are

The term 'green roof' is a generic name for a roof of a structure that has some variety of plants installed on it. Traditionally grass has been installed on pitched roofs in agricultural environments, but more commonly for urban locations the 'sedum' species of plant or roof gardens are installed on flat roofs.

Why use them

The primary reason for installing a green roof on a project is to increase bio-diversity for the site. This reduces the negative ecological impact of a project, and increases the points available on the BREEAM environmental scoring system. There are other benefits, which include good thermal performance, good sound insulation, air filtration, rain runoff reduction and attenuation.

Extensive and Intensive Roofs

Roofs fall into two categories:
Extensive roofs consist of a relatively shallow growing medium and are intended to be low maintenance, once planted they are left to grow except for occasional maintenance and are not intended for general access or recreation.

Intensive roofs require a deeper layer of soil, up to 450mm, and are more of an amenity or 'roof garden'. These roofs may include features such as lawns, flower borders or ponds. The additional weight of this planting has greater structural implications.
Brown roofs are a specific form of extensive green roof where locally sourced materials are laid on the roof. The roof is then typically left to self colonise with indigenous plants and insects.

This briefing note concentrates on extensive green roofs.

Make up

Roofs can be either insulated or un-insulated depending on the requirements of the building. See Figure 1 for the constituent parts. The most important layer is the waterproofing. This can take various forms:

- A membrane that is rolled out and welded along the seams.
- A hot-melt system that is poured on and spread out over the roof.
- Panelling system that is joined at the edges.

Some of the manufacturers of membranes include: Sarnafil, Bauder (membranes), Alcan Falzonal, Corus Kalzip (standing seams), Permaquick (hot melt system) and Kingspan (composite panels).

On top of the waterproof membrane is a drainage layer / moisture reservoir and a growing medium in which the plants are planted. The growing medium is similar to topsoil in its function, but the constituents are designed to be more absorptive than regular topsoil (Fig 4).

Loading

The total weight of the systems can vary between 70-310kg/m^2 or 0.7-3.1kN/m^2. Typically a greater depth of growing medium will increase the biodiversity potential of the roof. This will influence the points available under the BREEAM rating system.

Material	Thickness (mm)	Weight (kg/m^2)
Plants	20-100	30-80
Saturated Growing Medium	30-150	30-200
Root barrier / filter	3	3
Drainage Layer	50-60	3-10
Waterproof membrane	4-5	4-5
Insulation (warm roof)	50-150	3-10
Vapour control layer	3	3

Cost

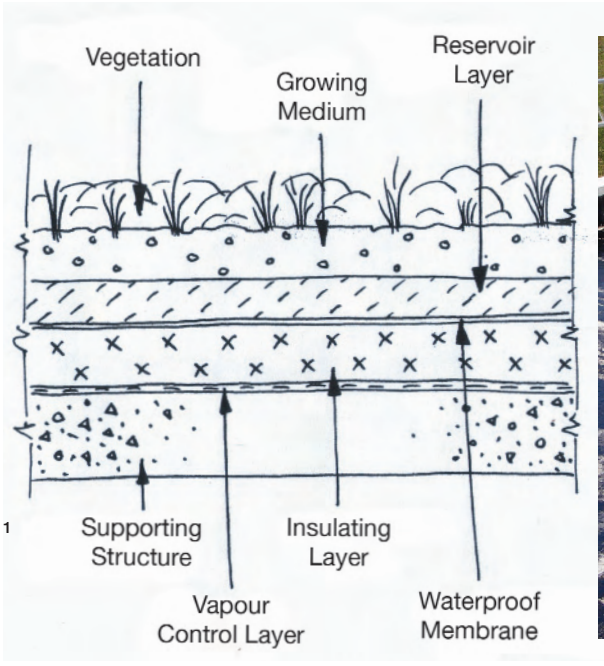
Costs will vary according to specific requirements for the roof geometry and plants required. Typically the supporting structure may need to be stronger to carry the extra load depending on the depth of growing medium used. As a running cost there will need to be maintenance, but there will be savings from the increased thermal performance.

Installation

The rate of installation of a green roof depends very much upon the complexity of the shape of it. All systems can be installed more quickly over large flat areas, and will take more time where lots of corners and details have to be accommodated. A waterproofing membrane may be laid at 10 to 50 to 150m^2/day for a team of two – depending on the amount of detailing that is to be incorporated and whether it is a large flat roof.

Details

Pitch / Gradient – 1:60 to 1:80 for 'flat roofs' – up to 20° roof pitch is fairly standard application. Above this pitch complexity (and cost) increases as measures need to be taken to ensure the growing medium does not slip down the gradient. In certain situations green roofs can be laid without a gradient.
Lightning protection – Surface mounted should be achievable but confirm with manufacturer.
– Perimeter mounted or mounted over green roof by way of mounting blocks placed on planted element surface.
Fall protection – Needs to be fixed through the waterproofing layer and back to the structure.
Edge protection – Needs to be fixed back to the structure.
Parapet details – Must ensure continuity of waterproofing.
Rain outlets / Overflows – Check with manufacturer if these are off the shelf, bespoke manufacturer off site with lead in times, or made on site. It is important that these are maintained and kept clear to prevent flooding of the roof which could potentially cause structural overloading.
Thermal performance – There is opportunity to tailor the amount of insulation installed and achieve very good U values – 150mm of foam glass insulation is typically enough on a membrane type roof. Manufacturers of different types of insulation will be able to provide specific data on thermal performance. Parapets need to be



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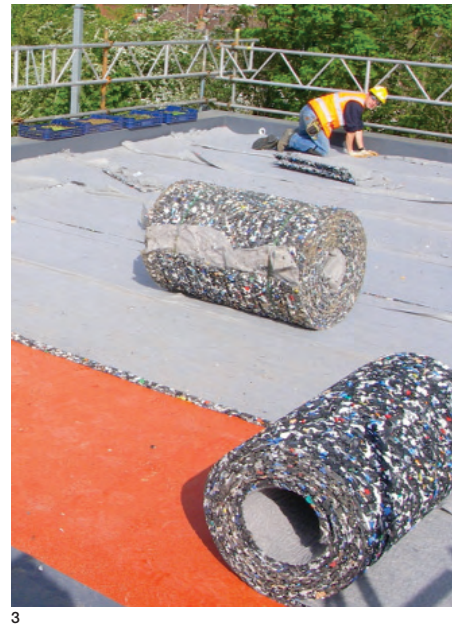

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Fig 1 Constituent parts of a green roof
Fig 2 Application of vapour control layer
Fig 3 Reservoir layer installation in progress
Fig 4 Growing medium being added
Fig 5 Green roof one year after installation

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designed accordingly to avoid cold bridging. The growing medium has a tendency to contribute to thermal lag, keeping the building warm at night and reducing heat build up from solar radiation by day.

Rain attenuation and runoff reduction – The storage capacity of the drainage layer and the growing membrane affects the rain water runoff in two ways. Firstly there is an attenuation effect, whereby the maximum runoff occurs after a greater delay than for a smooth roof, this can reduce the maximum capacity requirement of the drainage system. The second effect of a green roof is that not all of the water runs off the roof. For a nominally flat roof in the region of only a quarter to a third of the annual rain that lands on the roof may run off into the drains. It must be verified that the weight of the roof system quoted by the manufacturer is based on saturated figures. Attenuation and runoff reduction is most pronounced for roofs that are nominally flat.

Sound Insulation – Green roofs are good at reducing noise transmission into the building. The plants contribute to absorbing high frequency sounds and the soil and lower layers absorb low frequency sounds.

Time to settle in

A grass roof can be green from the day it is planted if pre-grown turf is used, but this will be more susceptible to dry spells, require back up irrigation and deeper layers of growing medium. Sedums take approximately a year to fully take root (see Fig 5) and do not require irrigation provided they are not installed in mid-summer. For non-sedum varieties of plants a backup irrigation system may be installed.

Pre-grown sedum mats are available and can provide almost total cover at completion of installation. Alternatively an onsite planted option will improve the creation of habitat and diversity of planted species either using seeds or plug in plants.

Sedum roofs are low maintenance but not 'no maintenance'. It is important to ensure that drainage and overflow points are kept clear and plants do not encroach on exclusion zones or fire strips around the perimeter. Periodic addition of fertiliser will also help maintain the biodiversity. Clients may choose to engage in a periodic maintenance contract to ensure the roof is kept in good order.

Wind loading performance

The roof is similar to that of a ballasted roof in that it has loose parts (typically the stones to the perimeter). Plants may be blown away initially, or pecked out by birds, but once the plants have taken root the growing medium is knitted together.

Guarantees

As with all other roofs, green roofs need to keep all the water out. It is strongly advised that all manufacturers and contractors provide adequate guarantees and carry sufficient insurance to cover repairs. An established quality assurance regime is also recommended. As an example the Sarnafil system is both visually inspected and also electronically tested to check for any potential leakage sites. Typical guarantees available range from 15-25 years. However, due to the plants and soil protecting the waterproof membrane from sunlight, the membrane does not suffer degradation from UV radiation.

Further Information

This briefing is prepared by the IStructE Sustainable Construction Panel. Contact: Berenice Chan (email: Berenice.chan@istructe.org).

Reference: R Chudley and R Greeno, Building Construction Handbook, Butterworth-Heinemann Ltd
Acknowledgement: Blackdown Horticultural Consultants
www.greenroof.co.uk
Bibliography: (www.bauder.co.uk)
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Comment from reader:

The problem with the arrangement of the constituent parts of the green roof shown in Figure 1 is that it makes it difficult to trace the source of a leak arising from the waterproof layer becoming damaged during construction or in service, perhaps by someone 'maintaining' the vegetation. Ultrasonic and pressure tests were found to be ineffective in this situation. The difficulty occurs because the waterproof layer is above the insulation resulting in leaks below. The water can track laterally in between the layers below so the area of visibility from underneath may not match the location of the damage above. A simple solution is to place the waterproof layer on the structure and physically bond it in place rather than loose lay. There are a number of proprietary products which will perform this way. The insulation can then be placed above. This may need some degree of enhancement to ensure it maintains 'waterproof' and thereby maintains its defined R value. This bonded system has the advantage that any leak visible below will be caused by damage directly above thereby simplifying the repair. This system has been used extensively in a number of roof gardens in schools and courtyard developments over car parks and has so far been problem free.

Response from Panel:

The issue of tracing the source of a leak can present a significant problem. Clearly, the membrane on top of the insulation is more vulnerable to penetration than a waterproof membrane at a lower level. As a preventative measure it is important that the maintenance company is well aware of what they are working with. Also, it is advisable for both the manufacturer and the maintenance company to have adequate insurance. However, it is worth noting that the system described in the briefing does have quite a lot of redundancy regarding waterproofing built in. Another option to consider is to corrugate the surface of a covered concrete roof laid to falls; this helps to simplify the process of tracing any leaks, but incurs additional installation costs.