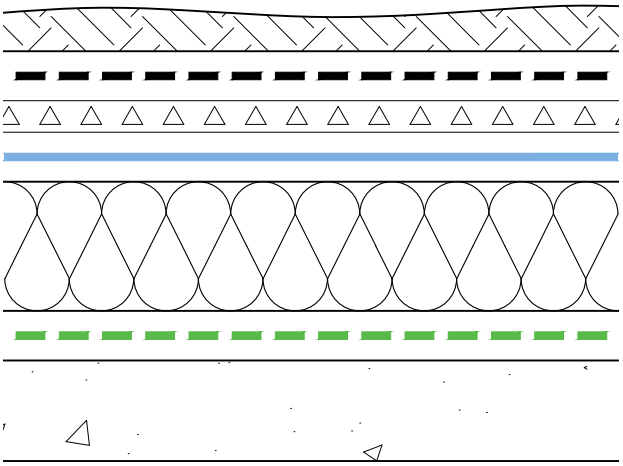
Introduction

This section provides guidance on meeting the performance requirements for green roofs.

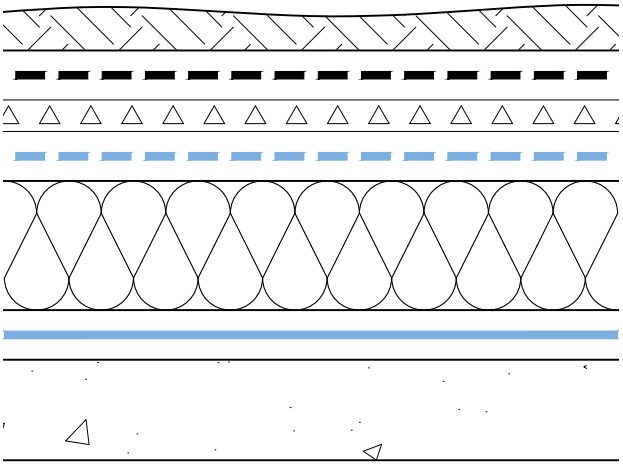
For the purposes of Warranty, a green roof comprises an organic vegetation layer and those components necessary to support its growth, which is placed over a membrane roof system. The following types of green roofs are covered within this section:

- Extensive green roof - a lightweight, low maintenance roof system, typically with succulents or other hardy plant species (often sedum) planted into a shallow substrate (typically less than 100 mm) that is low in nutrients. Irrigation is not normally required. A variant using Wildflower species will require a deeper substrate (typically 100mm to 150mm depending on species mix). Permanent irrigation is not required but it is advisable to include an option to irrigate in times of drought.
- Semi-intensive green roof - intermediate green roof type with characteristics of both extensive and intensive green roofs. Typically with a 100mm-200mm substrate depth, sometimes irrigated, occasionally managed and usually planted with a range of species.
- Intensive green roof - a version of a green roof often referred to as a roof garden that provides benefits akin to a small urban park or domestic garden. Designed primarily for recreational use, intensive roofs are typically configured with 200mm+ of substrate, and often require regular maintenance and irrigation.

Extensive green roof - warm roof system (section)



Intensive green roof - inverted warm roof system (section)



11.5.1 Compliance

Design, specification and installation of green roofs shall satisfy the performance requirements of this section.

The performance requirements of the ‘Roofs - Flat Roofs’ section shall also be satisfied.

11.5.2 Information to be provided

The Designer shall provide sufficient design details to demonstrate it meets the requirements of this section.

A full set of design drawings and specifications shall be made available to the Warranty provider and all other interested parties prior to the associated works starting on site. This may include:

1. A full set of detailed drawings including:
   a. Roof plan showing direction of falls and position of outlets and overflows.
   b. Sections showing roof build up and how falls are to be created. Section details should show all components to be used in the green roof build up (insulation type and thickness, vapour control layer, waterproofing membrane/layers etc.).
   c. Site specific detailing for all junctions, outlets and penetrations.
2. Details of all components to be used in the construction of the green roof.
3. Engineers drawings and calculations for the roof structure.
4. A third party product conformity certificate for the waterproofing membrane/layer. This must confirm the membrane can be used in a green roof build up.
5. Details of all fixings, their frequency and fixing method, including those for insulation and surfacing. Fixing methodology should be supported by appropriate wind uplift calculations.
6. Details of all fire stopping within structure and fire mitigation measures made within the green roof elements e.g. vegetation free zones. This should include specification and a detailed location layout drawings showing positioning.
7. Outline of method and plan for testing the integrity of the waterproofing layer.
8. A flat roof membrane manufacturer's approved installer must be used for all flat roof coverings. Evidence of the manufacturer's approval of the contractor to install their products should be provided to the Warranty surveyor.
9. A roof deflection analysis should be provided for medium to large roofs, those with complex roof layouts and for any roof areas that carry items of plant or are subject to access provisions beyond periodic maintenance of the roof area.

The Warranty surveyor, at their discretion, may also request supporting information that demonstrates suitability for use of any materials or systems contained within the above.

11.5.3 Structural design

Flat roof structures incorporating a green roof shall be designed and constructed so that all loads are sustained and transmitted to supporting structure(s) without causing instability, deflection or deformation. Factors to be considered are:

- Wind loading.
- Dead and imposed loading.
- Structural movement.
- Openings and penetrations.
- Fixing/attachment of ancillary structures and plant or equipment.

Statutory requirement

Design for loading should comply with current relevant Building Regulations. Further information can be found in the 'Roofs - Flat Roof' section of this Technical Manual.

Resistance to wind load

In all situations, including ballasted and inverted roofs, a calculation of wind load to BS EN 1991-1-4 should be undertaken by a suitably competent person. Wind load acting on a green roof will be affected significantly by the design of the perimeter and by the geometry and finishes on the elevations of the building. Any changes to these elements will necessitate a review of the calculation output.

In biodiverse, brown and extensive green roof systems, the dead load contribution from the growing medium should be calculated on an assumption of dry substrate conditions. Such loadings may be insufficient to restrain the green roof and certain types of waterproof membrane and insulation, necessitating the provision of supplementary ballast or netting restraint. Information on loading is available from horticultural suppliers.

Resistance to imposed loads

At the earliest possible stage, the employer should define the range of potential imposed loads for which the green roof is to be designed, such as seats, stand-alone planters, storage and public access. In the absence of such a performance requirement, the loading limits of the roof should be defined.

11.5.4 General design principles

The design, specification and installation of green roofs shall be suitable for the intended purpose.

Where green roofs are proposed, the design of the flat roof shall satisfy the performance requirements in the 'Roofs - Flat Roofs' section.

General

The guidance within this section should be read in conjunction with the 'Roofs - Flat Roofs'. The general build up and specification of materials for the green roof should satisfy the requirements within our 'Roofs – Flat roofs' section.

Green roofs must be designed in accordance with the GRO Code of Practice and CIRIA C753 SuDS Manual 2015.

Structural deck positioning within the flat roof build up

The roof system may be of warm deck or inverted warm deck configuration. The approach taken will be dependent on a number of variables which should be considered by the designer. The chosen approach should be discussed with the Risk Management Surveyor as early as possible to ensure all Warranty risks are mitigated.

For Warranty purposes, cold deck roofs are not suitable for green roof applications.

Weatherproofing

At an early stage in the design process, an audit of roof geometry should be carried out to establish what types of details will be required and whether they are to be weatherproof (incorporating an upstand/cover flashing arrangement) or waterproof (providing continuous waterproofing across the detail).

The following key principles should be followed in design of all details:

- Upstands to extend 150mm above the finished roof level i.e. top of growing medium.
- Downstands (of separate metal or other flashings) should lap the upstand by a minimum of 75mm.
- Reliance on sealant as the sole means of protection should be avoided.
- Consideration of the effect of vegetation growth on the integrity of the weatherproofing.

The total roof zone depth should be measured from the surface of the growing medium and assessed at critical points, such as the top of drainage slopes, to ensure that there is enough free upstand available to create the minimum required 150mm of waterproofing protection above finished roof level. It is important that this minimum 150mm upstand is maintained at all points around the area of the green roof, except at continuous water checks and at verges.

Protection layer

Protection layers should be provided to protect the waterproof membrane in accordance with the design.

Floatation

There should be measures in place to mitigate against the risk of flotation.

Permanent pedestrian access finishes

Pedestrian finishes should be designed to suit the purpose and frequency of access in the context of the intended planned maintenance regime. For example, paving on paving supports may be desirable to allow drainage and to level up the finish, but may be unsuitable if plants could spread beneath the paving. Generally, for amenity access, a finish of porous or hard concrete paving laid directly on a suitable protection fleece may be most suitable.

For service and maintenance access only, a flexible walkway tile may be sufficient (depending on the waterproof membrane and roof system type).

For further information regarding permanent protection during service, see the 'Roofs - Flat Roofs' section of this Technical Manual.

Temporary provision during construction

At the earliest possible stage, the anticipated loading of the roof system (prior to application of the green roof components) should be assessed in terms of:

- Load e.g. foot traffic, equipment.
- Frequency.
- Risk of impact.

If such usage is intense or long-lasting during the construction phase, consideration should be given to temporary works only, with completion occurring after all non-roofing usage has ceased as follows:

- Warm deck roof system: following the installation of vapour control layer, temporary protection is required to be overlaid until the remainder of the system is installed.
- Inverted warm deck roof system: overlay completed waterproof membrane with a geotextile and continuous temporary decking, such as plywood, Oriented Strand Board or compatible recycled thermoplastic board.

11.5.5 Rainwater drainage

Green roofs shall effectively drain rainwater from roof areas to a suitable drainage system. Green roofs shall have a minimum finished fall of 1 in 80 to facilitate rainwater drainage.

All flat roofs should be designed to collect, direct and discharge rainwater to a suitable drainage system by a suitably experience drainage designer prior to roofing work commencing.

The following guidance should be read in conjunction with the guidance provided in the 'Roofs – Flat Roofs' section on:

- Roof drainage
- Creation of falls
- Rainwater outlets
- Overflows
- Formed gutters

The following should also be read in conjunction with the 'Drainage' section.

Drainage design

Green roofs are likely to reduce the volume and rate of transfer of rain water-to-rain water goods. This effect is clearly dependent upon many factors, including depth and type of growing medium, type of drainage/reservoir layer, weather conditions prevailing prior to the rainfall event and fall in the waterproof membrane. Due to these variables, it is recommended that the design for rain water drainage in accordance with BS EN 12056 is as follows:

- Brown, biodiverse and extensive green roof systems: no allowance for rain water attenuation.
- Intensive green roof systems: attenuation as advised by the horticultural supplier. If no data is supplied, no allowance should be made.

The UK's National Annex to BS EN 12056 does permit the use of a coefficient to factor down the drainage infrastructure to account for factors such as the additional retention performance of green roofs. However the coefficient that is used to reflect this reduction should be based on average annual retention and not on responses to dynamic storm events.

Any drainage infrastructure designed to accommodate this reduced flow rate may not accurately account for seasonal differences or individual storm events. Any reductions in drainage capacity should be countered by alternative measures, e.g. appropriate detailing to ensure that any attenuation of water at the roof level will not be detrimental to the building structure or fabric.

Rain water goods from higher roof areas or adjacent roof areas should not be designed to discharge onto the green roof.

Falls

Falls are required for green roofs because:

- Standing water will inevitably result from design without falls, due to tolerances and deflection. Standing water, which may become stagnant, is not conducive to plant growth and should not be confused with the temporary retention of water in drainage/reservoir layers.
- Absence of falls will result in ponding, a potential slip hazard and the retention of mineral fines in vegetation-free zones, which in turn may encourage the growth of weeds.

Rainwater outlets

Rainwater outlets must be accessible and have a visible inspection hatch.

Rain water outlets should be readily accessible without disruption to the green roof or pedestrian finish. On finishes raised above the waterproof membrane (warm deck roofs) or Water Control Membrane (inverted roofs), this may be achieved by a suitably marked paving slab or demountable section of decking. Within the area of the green roof, a system approved vegetation-free inspection chamber and cover must be provided in order to avoid plant growth obstructing the outlet.

Design for irrigation

Rainfall is the typical source of water. However, complementary irrigation options may be required for semi-intensive and intensive systems or those where, for example, the appearance of a grass finish may be important.

Provision may include hoses, sprinklers, overhead irrigation and automated systems that pump from some reservoir storage. The establishment of a need for an irrigation system, and the design of an irrigation scheme, should be in accordance with the principles of BS 7562-3. Where irrigation is required, a frost-protected water supply, rain water or grey water storage facility should be provided at roof level.

11.5.6 Material specification

Materials and components for the green roof system shall be suitable for the intended purpose.

The waterproofing system shall have a third party product conformity certificate which confirms it can be used in a green roof build-up.

The material specification of the flat roof components under the waterproofing system should satisfy the performance requirements of the 'Roofs - Flat Roofs' section.

Insulation

Insulation material should have adequate compressive strength to withstand likely applied loads and the designer should taken account of differing loads applied across the surface between the green, margin and paved areas.

Roof barrier

A root resistant element is required above the waterproofing layer. Alternatively, an approved root resistant waterproofing layer can be used. If the waterproof membrane is also intended to provide root resistance, suitable certification of testing in accordance with BS EN 13948 should be available.

Consideration should be given to the potential for large roots to enter and disrupt inverted warm roof insulation, the system provider should be consulted for advice.

11.5.7 External fire performance

Where green roofs are proposed, they shall satisfy the relevant Building Regulations in relation to external fire performance.

Design for resistance to external fire

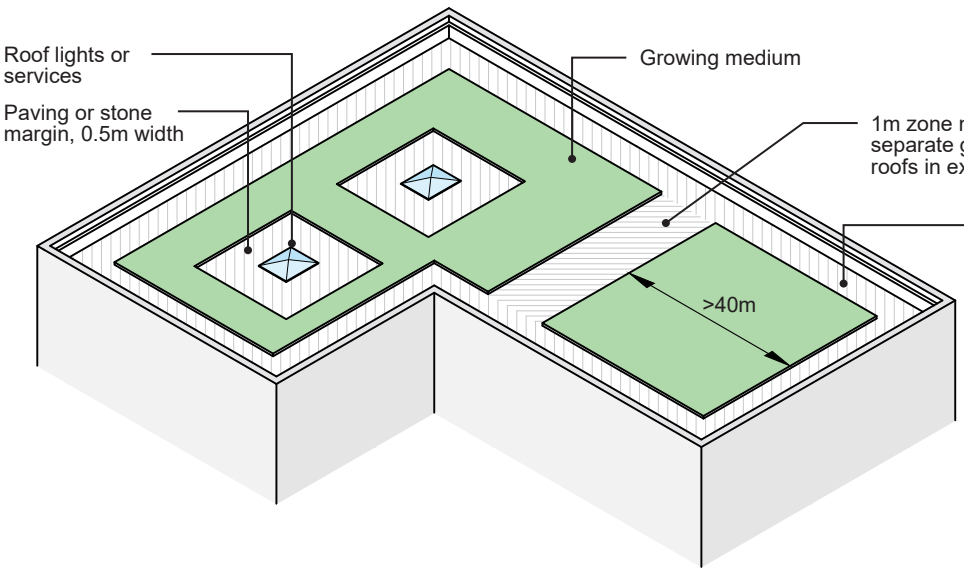
The design of green roof systems can influence the fire performance of the overall roof system. The rate of growth and moisture content of natural vegetation is unpredictable and determined by irregular weather conditions. The substitution of planted species with others is also unpredictable. Design to minimise fire risk cannot be based on an assumption of regular maintenance or of irrigation during drought. The latter is not relevant with sedum species, which die back, but is important for intensive roof gardens or extensive systems planted with wildflowers and grasses.

The design should not allow the vegetation to grow or propagate towards adjoining elements, such as abutments, eaves or pitched roofs. It should also be kept away from openings, such as roof lights and smoke vents.

This is achieved may be achieved by:

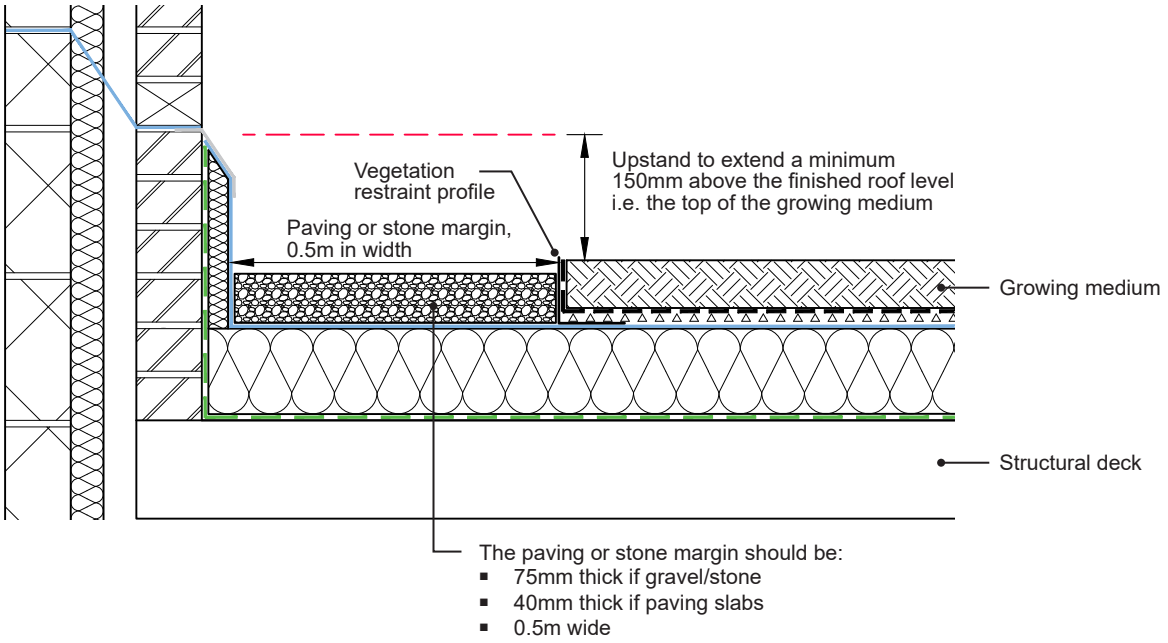
- A vegetation-free zone of minimum 0.5m width consisting of either 20 – 50mm rounded gravel at 75mm depth or 40mm thick paving slabs at all vertical perimeters, vertical abutments and vertical openings. This zone should be extended to 1m to separate large roof zones in excess of 40m in length.
- Design of flexible walkways, hard paving and ballasted areas so as to minimise root and plant spread.

Green roofs: Vegetation-free zones (Plan, zone width: not to scale of building)



Notes:
1. 0.5m zone around openings, along abutments, and at perimeters.
2. 1.0m zone may be required to separate green roof areas on roof in excess of 40m length.
3. Vegetation-free zone to comprise non-combustible stone or paving on suitable protection.

Green roofs: Vegetation-free zones: Warm roof (section)



Notes:
1. Vegetation restraint profile should be secured with ballast as necessary. Additional restraint will be required on sloping roofs to stop creep of the vegetation zone.
2. Protection of waterproof membrane should be extended under ballast zone.
3. Paving or stone should not simply be added to the growing medium at the perimeter as this:
   a. May reduce the available height of upstands, **and**
   b. Will not stop plants growing in the zone.

11.5.8 Testing of the waterproofing integrity

Waterproofing systems shall be tested prior to any green roof components being laid and at completion of the green roof to prove and demonstrate resistance to the passage of moisture.

Testing shall be completed in accordance with the ‘Roofs - Flat Roofs’ section and the following guidance.

No reliable method is available for testing the integrity of a green roof following application of the green roof components. Therefore the roof covering should be tested at completion to demonstrate waterproofing integrity before application of the green roof components. For guidance on testing of flat roof membranes, please refer to the ‘Roofs – Flat Roofs’ section.

Care should be taken to ensure that damage to the waterproof membrane does not occur during installation.

With extensive greening on certain warm roof systems, it may be feasible to use low voltage earth leakage, but any defects recorded will in any case involve removal of the green roof components. Therefore, it is strongly recommended to ensure the very highest possible standards of protection of the water proof membrane during the application of the green roof components.