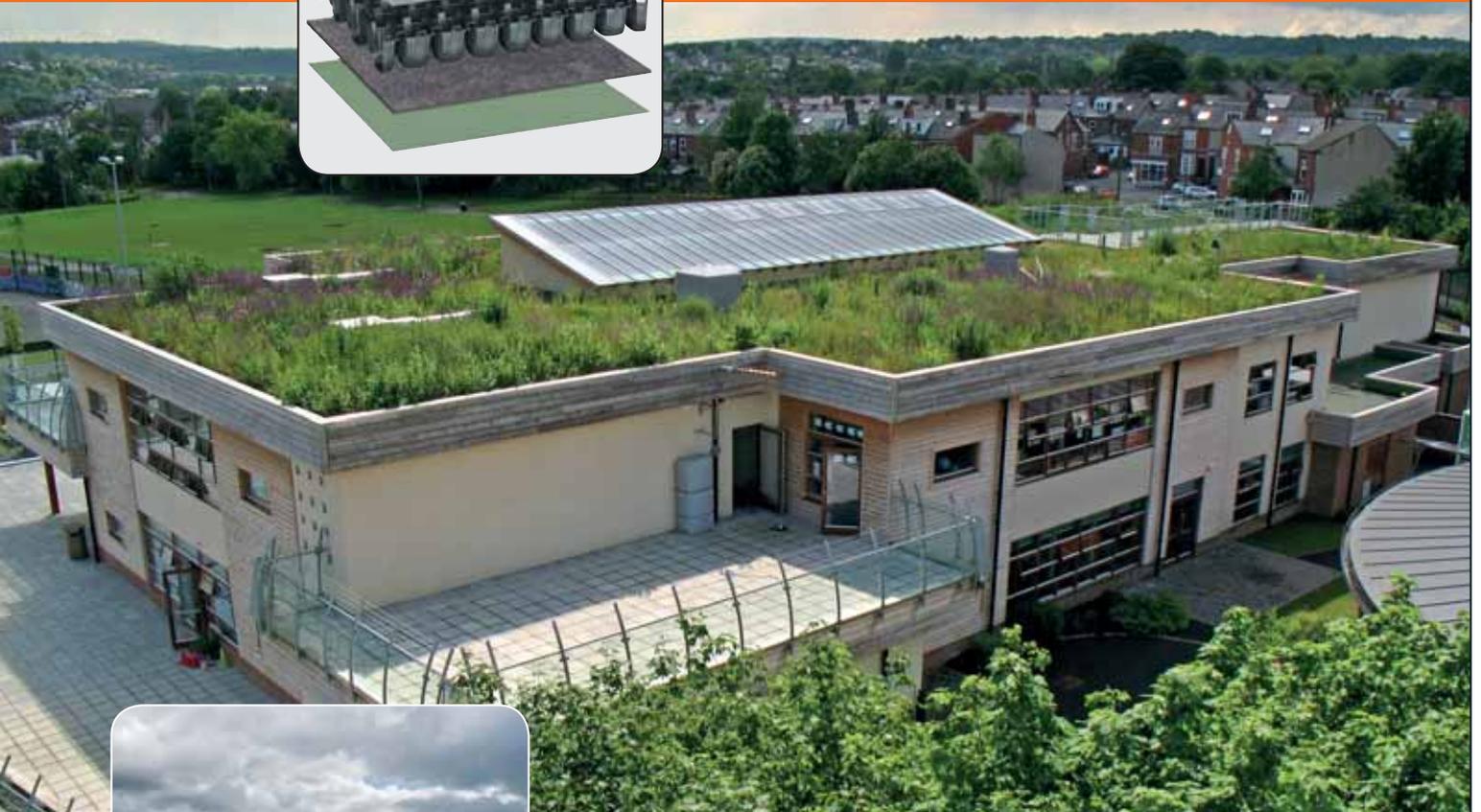


BAUDER



GREEN ROOF

**DESIGN
CONSIDERATIONS**



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1 PLANNING & CONSIDERATION

For a green roof to be successful, it is very important that all parties involved work together and fully understand what is to be achieved to avoid the risk of failure.

Points to consider should be:

- Why is a green roof required and what performance is expected?
- Is the site suitable?
- Who should be involved in delivering the project?
- Essential and variable factors for consideration.

Why is a green roof required and what performance is expected?

There could be many reasons why a green roof is required. It may be to satisfy a planning constraint, in which case economic options will be considered; mitigate against storm water where the design will maximise rainwater attenuation; support a specific species of wildlife for a biodiversity solution; provide recreational space with public access; offer additional energy savings – photovoltaic units are up to 10% more efficient when used on a green roof; or for aesthetic reasons where the building needs to be masked into its surrounding environment.

Is the site suitable?

There are some fundamental considerations when planning a green roof and many factors which will influence its success.

Location factors

- Regional and local climate
- Volume of rainfall
- Amount of sunlight
- Exposure - strength of wind, amount of frost and snow

Structure factors

- Load capacity of the roof
- Pitch of the roof
- Shading and rain shadow from adjacent structures
- Hot/cold air emissions from air conditioning units and other equipment
- Height of parapet walls
- Safe access to install and maintain the green roofs

Vegetation

- Depth of substrate required by plants
- Drought tolerance of plants
- Shade tolerance of planting
- Other habitat creation and environmental issues



Who should be involved in delivering the project?

Everyone must be involved and fully support the project, regardless of the type of roof selected, from the building owner and client to the architect and main contractors. The planner should determine if the chosen roof is feasible at the location and make it clear in the planning constraint the wildlife which is to be targeted for a biodiversity roof. The architect's main objective is to specify the type of landscape and its support system to ensure the structure of the building is not placed at risk. On some projects it may also be appropriate to seek the services of an ecologist to advise on issues such as meeting a BREEAM or Biodiversity Action Plan requirement.

Essential and variable factors to be considered for all green roofs

One of the major factors to consider is the waterproofing, which should be robust and of high quality; the capping sheet can often be a root barrier to prevent penetration, though this is not always the case and any root barrier should meet FLL standards to ensure its integrity. The roof should be leak tested before the landscaping is installed. The drainage should always be capable of coping with intense rainfall and incorporate a filter sheet to prevent substrate being washed away. The growing medium will vary to suit the landscape required, and for biodiverse systems the vegetation and habitat materials selected to suit the habitats being created. Safe access for maintenance must be considered and planned for.

THE FIRST STEPS **2**

There are fundamental principals that apply to the design of a green roof, regardless of the proposed landscaping, location or climate. The specified solution must replicate nature within the build up and be able to support the vegetation.

The first step - What is the landscaping finish to look like?

The primary decision is the type of landscape required; what best suits the rationale behind the development, whether it is an intensive, extensive or biodiversity roof. Whatever the landscape chosen, the vegetation will have some basic requirements to sustain it; nutrients, a balance between moisture and drainage, and aeration to the root systems.

The next step - Planning the green roof to meet the needs of the vegetation

Once the vegetation finish has been determined the structural and design considerations and green roof components can be proposed.

It is vital that the protection of the building's fabric and in particular its waterproofing is considered in the green roof design. There is important information that the building's structural engineer will require:

- The height of the green roof system build up
- The maximum saturated load of the green roof
- The sheer force the green roof will exert when on a pitched roof
- Safe access for maintenance

Over the following pages, this guide will take you through.

Waterproofing system, structural loading and wind uplift

The structural design of the building will embrace the specification of the appropriate waterproofing system to meet the demands placed on it by the green roof and the effects of climate, especially with regard to performance against high-wind.

Configuration of green roof components

Green roofs typically reduce the run off from a roof by 50%. However, the green roof's drainage layer must allow excess water to be shed quickly from the roof surface, whilst holding sufficient to support the vegetation. Insufficient water storage means that either additional irrigation will be required or the vegetation will struggle to flourish.

Perimeters and vegetation barriers

Perimeter details have minimum requirements to comply with building regulations and vegetation barriers have important functions, one of them being to act as a fire break.

Irrigation, maintenance and safe access

Every green roof will require access for maintenance and in the case of intensive green roofs access is continual. All access on green roofs should be safe for the user.



3 WATERPROOFING & DRAINAGE

Root Resistant Waterproofing

It is vital that the waterproofing is robust and proven to deliver long-term root resistance, preventing plant roots and rhizomes from growing in to or through it. Consideration must be given to the appropriate form of waterproofing so that it can meet the demands placed on it by the green roof, as such performance characteristics for durability and thickness of membrane (density), tensile strength (EN 12311-1) and elongation at break (EN 12311-1) need evaluation before appropriate selection can be made.

Bauder waterproofing membrane systems and liquid systems are manufactured in accordance with FLL guidelines for root resistance and carry BBA certification for green roof applications.

When designing the detailing (e.g. upstands, pipe penetrations, rooflight upstands etc) it is important that you take into account the increased build-up of the green roof construction. Building Regulations typically require the waterproofing detailing to finish 150mm above the finished roof surface i.e. the green roof surface not the surface of the waterproofing. Our technical team can work with you to produce the correct detail drawings for your green roof project.

Bauder Waterproofing For Green Roofs

Selecting the appropriate waterproofing system requires consideration so that its performance matches that required for the green roof.

Intensive green roofs would ideally use root resistant bituminous membranes or hot melt structural waterproofing systems as the nature of the access levels and maintenance regimes require a robust solution to ensure that the building is protected correctly. Extensive green roofs are generally possible on all forms of waterproofing that have root resistance including bitumen membrane systems, single ply, cold liquid applied and hot melt. The correct selection for waterproofing can often be determined because of the depth of substrate required to support the vegetation. The greater the depth of substrate, the more robust the waterproofing will need to be.



Creating Falls on a Green Roof

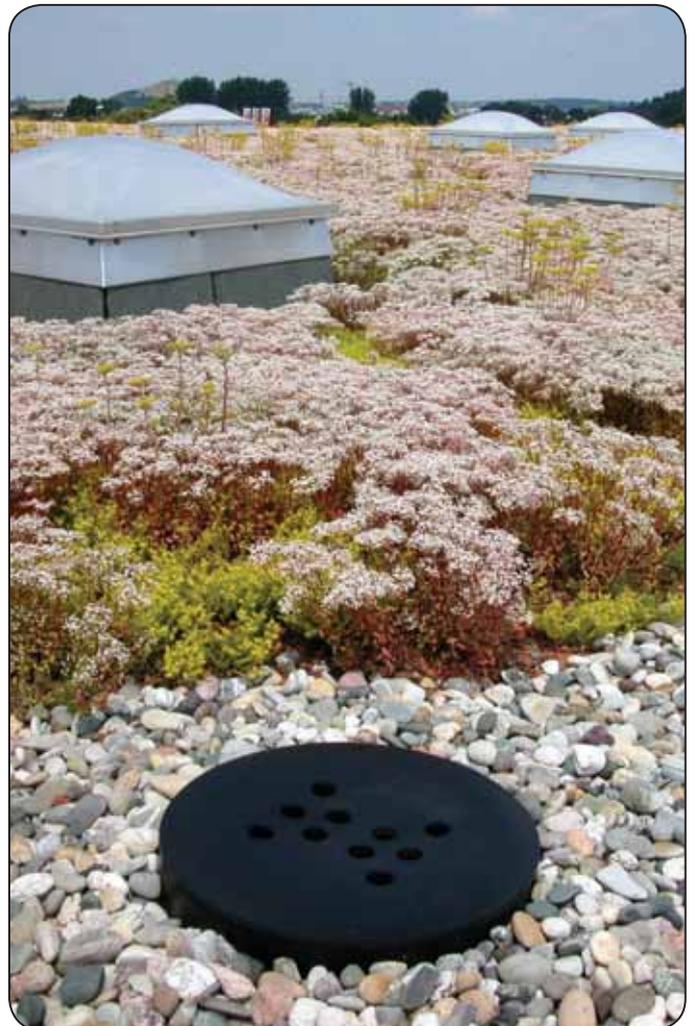
Intensive green roofs can be safely installed on horizontal decks, whereas with extensive green roofs minimum falls of 1:60 and above are preferred. The criteria is to have a depth of drainage layer deep enough to hold the landscape above any residual standing water that occurs on the surface of the deck, either by design or circumstance.

Drainage

Roof drainage designs should comply with the requirements of BS EN 12056-3:2000 Gravity drainage systems inside buildings. The soft landscaping on a green roof will retain a large percentage of the average annual rainfall, as for example an intensive green roof can retain up to 90%. However, the UK's National Annex to BS EN 12056 does not permit the use of a coefficient to factor down the drainage infrastructure to take account for factors such as the retention performance of green roofs.

When specifying internal outlets, we would always recommend a minimum of two outlets per roof, regardless of roof size, as a precaution against accidental blockage.

All outlets should be protected by an inspection chamber with removable covers to allow access for maintenance, and be surrounded by a pebble vegetation barrier to prevent encroachment.



Most roof deck constructions are suitable for some form of green roof provided that they can support the dead and imposed load, though intensive green roofs should only be constructed on concrete decks.

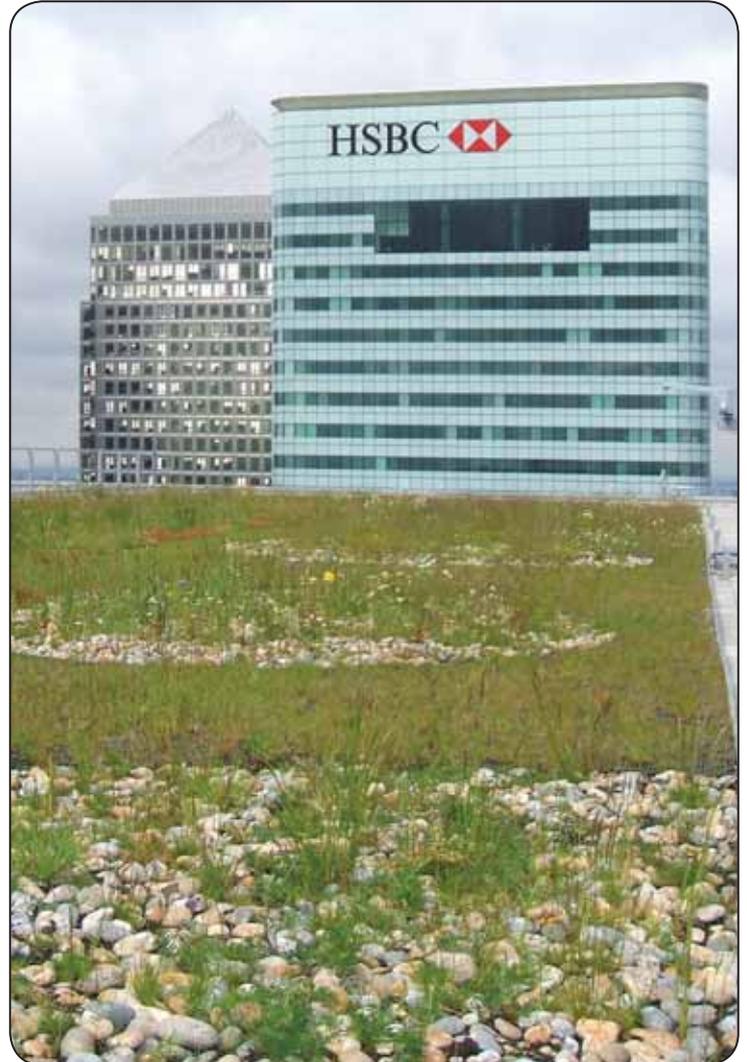
Dead and imposed loads - should be calculated in accordance with BS EN 1991-1-1, BE EN 1991-1-3 and BS EN 1991-1-4 and should include the weight of the waterproofing system, saturated weight of the green roof components and substrate, vegetation, snow loads, and imposed loads such as access by people and vehicles as well as point loads for items such as water features and trees.

Sheer forces - need to be combated generally on roof pitches in excess of 10 degrees, though this depends on the levels of substrate being installed and the vegetation used. Anti-shear measures should suit the individual system and on a Bauder sedum blanket system this comprises a simple mechanical retention strip with spikes that hold the blanket onto the waterproofing.

Our technical team can provide information and advice so relevant data can be passed to the structural engineer.

Wind Uplift and Erosion

The need for stability of the system is increased because the negative pressure forces that can develop during high wind conditions are counteracted by the weight of the green roof system. Wind can also lead to erosion problems on exposed sites, especially if plant establishment is in the early stages.



SPECIFICATION SUPPORT



TECHNICAL DOWNLOADS

www.bauder.co.uk/technical-centre



TECHNICAL HELPLINE

T: 0845 271 8800

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GREEN ROOF COMPONENTS

When designing a green roof, the components required will depend on the type of vegetation specified and how the balance between water retention and drainage is achieved to meet the demands of the vegetation.

The general principle is to recreate the conditions nature provides in a shallower system. In all green roof scenarios, substrate depths are completely dependent on the vegetation specified and the different drainage / water retention layers are selected according to the levels of water required to be held within the construction.

Vegetation and Substrates

The different vegetation options will require different depths of substrate (growing medium) in order to support the plants and their root structures. Intensive roofs require careful design considerations and the desired planting scheme will reflect that of a ground level garden or recreational space.

Substrates

Generally the depth of substrate is dependant on the type of vegetation being installed. Low growing sedum will need a shallow, low nutrient, free draining substrate. Wildflowers will require deeper substrate (100-150 mm). Herbaceous plants, shrubs and trees on intensive green roofs will require greater depths (300-450 mm+). As planting becomes more substantial it is likely to require a higher organic content within the substrate.

Extensive Vegetation

Pre-grown vegetation mats – will establish quickly and give high aesthetic finish immediately after installation.

Plug plants – enable a particular selection of species to be planted with establishment reached in 1+ year. They require thorough attention and maintenance during establishment as plugs are quite delicate.

Seed – offers a lower establishment cost but will take a couple of growing seasons to fully establish.

For an extensive green roof the vegetation options can be combined and information on extensive vegetation plants and indicative substrate depths can be found on our website where we also have an extensive vegetation brochure that you can download.

Filter Layer

This layer is a polypropylene geotextile fleece that prevents substrate fines and sediment from being washed in to the water storage or drainage component. The pore size is around 0.13mm.

Water Storage / Drainage Layer

This layer helps to maintain the balance between the levels of water to be held on the roof to support the vegetation whilst allowing the surplus amount to drain away so that the substrate doesn't become waterlogged. The water storage cells can be filled with coarse gravel or crushed brick to increase the compressive capabilities of the build up. The components can be manufactured from a variety of materials such as high density polyethylene (HDPE) or polystyrene; each having their own reservoir capacity.

Protection Layer

This layer delivers protection against damage to the waterproofing system that lies beneath the green roof. The layer can be of varying thicknesses, selected and specified to cope with possible levels of mechanical damage that the waterproofing could be subjected to. This is fundamentally in relation to the intensity of the vegetation scheme. For example, extensive green roofs would generally experience much lower levels of mechanical damage during maintenance and therefore only require a protection layer to meet those expectations. The Bauder protection layers are manufactured from the following materials:

- Eco Mat - recycled polyester and polypropylene
- FSM 600 and FSM 1100 - polyester and polypropylene fibre mix
- Pro Mat - recycled shredded rubber

Separation Layer

This layer ensures that the building structure and its waterproofing can move independently of the green roof so allowing for movement such as thermal expansion without shear forces created by the weight of the green roof restricting it. The Bauder separation layer, PE Foil, is a polyethylene foil manufactured from recycled granules.



GREEN ROOF CONFIGURATIONS

6

Here are some green roof component build ups that are typically specified for different green roof scenarios.

	Configuration 1	Configuration 2	Configuration 3	Configuration 4
Intensive Green Roofs	Flat roofs soft &/or hard landscaping	Flat roofs soft &/or hard landscaping	Sloped roofs soft landscaping	Drainage only for soft landscaping
Substrate and Vegetation				
Filter Layer	Filter Fleece	Filter Fleece	Filter Fleece	Filter Fleece
Water Storage / Drainage Layer	DSE 40	DSE 60	Reservoir Board	Drainage Board
Protection Layer	FSM 1100	FSM 1100	FSM 1100	FSM 1100
Separation Layer	PE Foil	PE Foil	PE Foil	PE Foil
Extensive Green Roofs	XF301 sedum blanket system	Plug planted or wildflower blanket	Biodiverse	Seeded roof
Substrate and Vegetation				
Filter Layer		Filter Fleece	Filter Fleece	Filter Fleece
Water Storage / Drainage Layer	SDF Mat	DSE 40	DSE 20	DSE 40
Protection Layer	Not required	FSM 600	FSM 600	Eco Mat
Separation Layer	Not required	PE Foil	PE Foil	PE Foil

7 PERIMETERS & SAFE ACCESS

Perimeters

The minimum required upstand height for the waterproofing at abutments, parapets or pipe work penetrations etc, is 150 mm above the completed landscape surface. The only exceptions are at perimeter kerbs where the waterproofing extends fully to the outer edge finishing in a traditional welted drip, edge trim or at access doorways, where a linear drain is incorporated. Flush threshold access doorways can normally be accommodated, and the design of the waterproofing detail at the threshold will vary dependant upon the components to be sealed to.

Vegetation Barriers

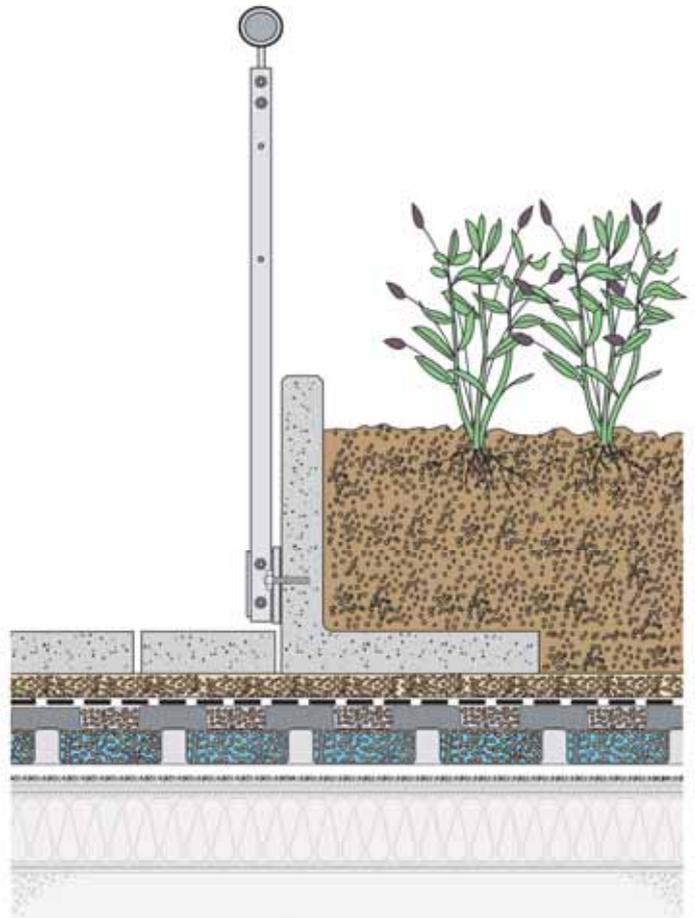
These are created with round washed pebbles or paving slabs and provide several important functions on extensive green roofs:

- Prevent vegetation from encroaching on roof elements such as rainwater outlets.
- Protection of the vegetation layer from water running down vertical upstand surfaces or from higher level rainwater downpipes.
- Provide rapid surface drainage during heavy rainfall.
- Protection of the waterproofing from mechanical damage during maintenance.
- Fire break, where the pebbles are installed in accordance with GRO guidelines of at a minimum margin of 500 mm x 50 mm.
- Wind uplift resistance by increasing the imposed load at roof perimeters.

Safe Access

Provision should always be made for safe access to the roof for routine maintenance, which may include man-safe systems with harness and attachment points, internal access hatches or an externally mounted bracket to secure a ladder.

As all green roofs will need to be accessed at least twice a year for routine maintenance, it is a fundamental requirement of the design of the roof structure that safe access is provided for. The two important points are; safe access on to the roof by people and maintenance equipment and the safety of individuals once on the roof, ie handrail balustrades at the correct height, stable surfaces that are slip resistant etc



Establishment Watering

Establishment watering is particularly important during the first 6-12 weeks following installation (depending on rainfall and the vegetation being established) and differing system finishes will require different watering practices. It is important to make provision for establishment care and watering even if the installation takes place in the spring or autumn.

For extensive and biodiversity landscaped roofs, the ongoing watering needs are dictated by the type of vegetation, location, aspect, roof slope and exposure of your roof. Substrate based roofs with sedum plants rarely need artificial watering, whereas wildflower vegetation needs occasional watering during prolonged dry spells. Expectations regarding appearance is also an important factor, as some clients wish to maintain or enhance the visual appearance, whereas others may prefer to leave it to nature.

Every roof is different and levels of irrigation depend entirely on the water demands of the vegetation as well as the levels of water storage on the roof and local micro climate.

Irrigation

The more intensive a roof finish, the more likely irrigation will be required. The plants must have sufficient levels of water to ensure they remain healthy during prolonged dry periods. An automated system is generally the best option in the long-term and the frequency at which it is applied will depend on the plant species. These are designed and supplied by specialist irrigation companies who will offer a specific system to meet your requirements.

General Maintenance

All roofs require a minimum of two inspections a year to ensure that the outlets etc are maintained, regardless of the type of green roof. An intensive green roof will require the regular maintenance associated with the planting scheme and landscape design, whereas an extensive green roof will need only minimal maintenance to ensure that any unwanted species do not become established.

We strongly advise the inclusion of the cost for an initial post-installation maintenance program within the tender documents for a period to be agreed with the client's representative. This ensures that the green roof is handed over in a healthy and fully established condition.



Bauder Maintenance Service

Bauder's experienced team provide a tailor-made maintenance programme which is normally carried out in spring and autumn. This work is undertaken by our experienced engineers who will carry out the necessary risk assessments and comply with all current health and safety legislation throughout the duration of the work.

A full inspection and evaluation is carried out and a bespoke report provided with photographic verification outlining the condition of the planting and any areas requiring on going treatment.

Common items for inclusion in the service are:

- Fertilising – application of a granular, organic slow-release fertiliser is essential to provide the plants with nutrients enabling them to become hardy enough to resist extreme cold, heat and drought.
- Debris – removal of all debris and leaves from the roof surface, rainwater outlets, chutes and gutters.
- Plant encroachment – removing excess vegetation that is encroaching into areas surrounding rainwater outlets, walkways, pebble barriers, gutters etc.
- Weeding – removal of unwanted vegetation, especially saplings etc either by hand or using a 'weed wipe'.
- Repairing bare patches – once weeding has occurred, bare patches can remain which are covered using remaining sedum vegetation from cuttings.
- Monitoring colour and growth – the vegetation will naturally change colour depending upon the time of year and prevailing weather conditions. Monitoring growth vigour and colour will identify how healthy the vegetation is or if it is in need of additional support.
- Vegetation barrier – settlement of the pebbles can occur and may need additional application.
- Promenade tiles or paving slabs – ensuring they are in good condition and secure in their original position.
- Rainwater pipes – free from blockages to enable water to flow freely through them.

Contact the Bauder Green Roof Maintenance Team

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