Photo: ABG Limited

THE GRO GREEN ROOF CODE

Green Roof Code of Best Practice incorporating Blue Roofs and BioSolar Applications

Anniversary Edition 2021

(Incorporating June 2023 amendments).

FOREWORD

Back in 2008 when The Green Roof Organisation (GRO) was established, we were in the midst of a financial crisis, an event that had a profound effect on the world and particularly on the construction industry, as one of the first industries to head into a recession. Those events led to GRO being set up as a Special Interest Group totally reliant on the support of three roofing Trade Associations (NFRC, SPRA & LWRA) and the voluntary efforts of its members.

2021 sees us still in the midst of yet another major world changing event, the Coronavirus Pandemic. Coincidentally this latest global event has also been the backdrop to the biggest change to GRO in its history – the organisation has become a fully-fledged, not-for-profit Trade Association.

It is with great pleasure therefore, that I write this foreword to the 2021 edition of the GRO Green Roof Code of Best Practice (The Code). This latest edition marks our biggest step forward yet and is the product of 2 plus years work carried out by 3 special interest Working Groups (drainage boards, growing mediums and planting) and without their collective efforts, this update would not be as comprehensive, building upon the 2014 edition of The Code.

My thanks to everyone involved in these Working Groups and the subsequent updating of The Code.

With 'The Code' widely recognised as the key green roof guidance document in the UK, referenced by such key bodies as MHCLG and the British Board of Agrément, continuous updating to keep up with events and regulations remains one of the key drivers of GRO. Whether responding to tragedies such as the Grenfell Tower and the subsequent fire regulation changes, or the innovations of integrating solar panels and/or blue roofs with green roofs, GRO aims to be at the forefront of supporting building owners, architects, specifiers, suppliers and contractors.

With London now one of the greenest cities in the world, the regional mayors developing new city plans and the UK Government's plans for a greener country, the future of the green roof industry is looking more positive than ever.

I hope that this Code of Best Practice helps you, the reader, develop each and every one of your projects, so that they enhance the built and natural environment.

Mark Harris
Chair | Green Roof Organisation

Photo: Livingroofs.org

NOTES FOR USERS OF THIS CODE

The information contained in this document may be freely used by any interested parties.

This Code of Best Practice (The Code) has been prepared by the unpaid Technical Committee of the Green Roof Organisation (GRO), which comprises representation from all membership categories (Manufacturer, Supplier, Contractor and Associate). Based on extensive research and experience in the UK, it is the current industry view of best practice in the design, selection of materials, installation and maintenance of green roof systems and includes reference to all relevant European and British Standards as appropriate. Since Regulations and European and British Standards are under continuous review, the reader should confirm their status with the appropriate institutions before referring to them in specifications.

The GRO Code of Best Practice is intended to be recognised as a code of best practice and, as such, it should be used to guide behaviour relating to green roof design, specification, installation and maintenance. However, there will be special cases where additional considerations will need to be made.

Every user of the GRO Code of Best Practice is responsible for their own actions, and acts at their own risk.

GRO recognises that the FLL (Forschungsgesellschaft Landschaftsentwicklung Landschaftbau's (Landscape Research, Development and Construction Society)) guidelines for the planning, execution and upkeep of green roof sites is a sound base from which to establish a minimum recommendation for green roof specification, installation and maintenance. It is recommended that all parties using this Code and requiring greater technical detail should have a copy of the most recent version of the FLL Guidelines to hand, which can be purchased from www.fll.de.

The GRO Code of Best Practice does not seek to provide guidance, information or comment on waterproofing, falls and drainage, thermal performance or any other element of roof design and installation not related directly to green or blue roofing. What information it provides on blue roofing will be superseded by the ongoing development, at the time of publication, CIRIA guidance on blue roofing.

A list of relevant complimentary documents is contained in section 6 of this document.

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CONTENTS

1 Introduction to the Code 7

1.1 Scope 8

1.2 Who is this guidance for? 8

1.2.1 Lantra Training 8

1.3 Steering Group 8

1.4 Code review procedures 8

1.5 Acknowledgements 9

2 Roof types and benefits 11

2.1 Definition 12

2.2 Types 12

2.2.1 Extensive green roof 13

2.2.2 Extensive wild and meadow flower roof 14

2.2.3 Biodiverse roof 14

2.2.4 Intensive green roof 15

2.2.5 Blue roof 15

2.3 Benefits 16

2.3.1 Sustainable drainage/ attenuation/blue roofs 16

2.3.2 Biodiversity 17

2.3.3 Biodiversity Net Gain 17

2.3.4 Countering climate change & the urban heat island effect 17

2.3.5 Building performance and enhancements 18

2.3.6 Amenity, health & wellbeing 18

2.3.7 Financial 19

2.3.8 Policy / Planning consent 20

2.3.9 Improvement of air and water quality 20

2.3.10 Quieter buildings 21

2.3.11 Food production 21

2.3.12 Green roofs and solar power / biosolar 21

2.3.13 Green roofs – BREEAM & LEED 22

3 Design Considerations & Practical Implications 23

3.1 Configuration of a green roof 24

3.1.1 Root resistant material 24

3.1.2 Protection layer 24

3.1.3 Drainage/reservoir layer.....25

3.1.4 Filter layer 25

3.1.5 Substrate/growing medium 25

3.1.6 Substrate depth (Table 4) 28

3.1.7 Vegetation 29

Sedum blankets 29

Wild/meadow flower blankets/turf 29

Seed sowing 29

Establishment by cuttings .. 29

Establishment by plugs 30

Planting for Biodiversity 30

Watering 30

3.2 Structural design 30

3.2.1 Wind loads 31

3.2.2 Dead loads 31

3.2.3 Shear forces 31

3.3 Waterproofing 32

3.3.1 Waterproofing inspection 32

3.4 Drainage 33

3.5 Fire 33

3.5.1 Fire introduction 34

3.5.2 Substrate 34

3.5.3 Watering and irrigation 34

3.5.4 Fire breaks 34

3.5.5 Maintenance 35

3.5.6 Other systems i.e. cassette / modules 35

3.5.7 Intensive green roofs 35

3.6 Irrigation 36

3.7 Safety & access 36

4 Green Roof Installation 37

4.1 Site preparation & planning 38

4.2 Installation of systems components 38

4.2.1 Protection sheets, drainage layers and filter sheets 38

4.2.2 Substrate installation 38

4.2.3 Vegetation layer installation 39

4.3 Installation of perimeter & penetration details 39

5 Green Roof Maintenance 41

5.1 General maintenance actions 42

5.1.1 Irrigation 42

5.1.2 Fertilising 42

5.1.3 General vegetation maintenance 43

5.1.4 General clearance/removal . 43

5.2 Maintenance actions by roof type..... 43

5.2.1 Extensive roof maintenance 43

5.2.2 Biodiverse roof maintenance 43

5.2.3 Deeper extensive roof maintenance 44

5.2.4 Intensive roof maintenance 44

5.2.5 Blue roof maintenance 44

6 Relevant Complimentary Documentation 45

6.1 Building Regulations 46

6.2 British Standards – Building Design 46

6.3 British Standards – Structural Design 46

6.4 British Standards – Maintenance 47

6.5 British Standards – Health & Safety 47

6.6 British Standards – Workmanship 47

6.7 British Standards – Metal Roofing Specifications 48

6.8 British Standards – Bitumen Waterproofing Specifications 48

6.9 British Standards – Plastic & Rubber Waterproofing 48

6.10 British Standards – Mastic Asphalt Waterproofing 49

6.11 British Standards – Liquid Applied Waterproofing 49

6.12 British Standards – Single Ply Membrane Waterproofing 49

6.13 British Standards – Insulation Specifications 49

6.14 Green Roof Guidance 50

7 Glossary 51

1 INTRODUCTION TO THE CODE

1 | INTRODUCTION TO THE CODE

1.1 SCOPE

Green and blue roofs perform a vital role in helping cities adapt to the effects of climate change by reducing the need for artificial cooling in hot weather and attenuating or capturing rainwater runoff, as well as providing a range of habitats for wildlife.

However, green roofs can only provide these environmental benefits if designed and installed in a way that ensures that minimum performance criteria are met. This Code therefore highlights the important green roof design, installation and maintenance considerations and provides guidelines as to how they can be accommodated in a final green roof scheme.

1.2 WHO IS THIS GUIDANCE FOR?

This Code will help anyone who is designing, specifying, installing or maintaining a green or blue roof.

1.2.1 TRAINING

The year 2020 saw the launch of the full Lantra green roof training suite, which offers training and assessment in the installation and maintenance of green roofs. Topics covered include: blue roofs, biosolar, pitched, shaped and curved roofs as well as maintenance regimes and techniques. The training is open to architects, specifie s, estimators, installers, contractors or complete newcomers. This is the only training suite that allows candidates to work towards a LISS/ CSCS card in green roofi g. For more information, and to fi d national training providers, visit: www.lantra.co.uk and www.greenrooforganisation.org

1.3 STEERING GROUP

GRO constituted as a Trade Association in 2020, the Steering Group is drawn from its membership and wider interested parties. This most recent version of the GRO Code has been written and developed in partnership with national and European experts from industry, academia and specialist interest organisations such as Livingroofs.org, drawing on GRO members expertise and guidance to share current best practice.

1.4 CODE REVIEW PROCEDURES

On a regular basis, this document will be reviewed and updated by the relevant members of the GRO Technical groups and through consultation with the GRO Members. It is intended in the future to provide the latest version online.

GRO is a partnership of Industry green and blue roof manufacturers and installers and stakeholders, coming together to develop guidance for the specification, design, manufacturing, installation and maintenance of green and blue roofs – as well as their promotion more generally to the developers, property owners, central and local government and the wider public.

1 | INTRODUCTION TO THE CODE

1.5 ACKNOWLEDGEMENTS

GRO recognises that the FLL (Forschungsgesellschaft Landschaftsentwicklung Landschaftbau's (Landscape Research, Development and Construction Society)) guidelines for the planning, execution and upkeep of green roof installations is a sound base from which to establish minimum recommendations for green roof specification, installation and maintenance in the UK. The FLL document has been used as the foundation for green roof guidance documents around the globe, including: Switzerland; Austria; North America and Japan.

This UK Code of best practice will therefore refer to FLL guidance standards where appropriate.

Photo: Zinco

2 ROOF TYPES AND BENEFITS

Photo: Bridgman & Bridgman

2 | ROOF TYPES AND BENEFITS

2.1 DEFINITION

GREEN ROOFS

A green roof is created when a planting scheme is established on a roof structure. The roof can be at ground level, often with an underground car park beneath, or many storeys higher. Green roofs can be designed as recreational spaces to be enjoyed by people, as visual, sustainable or ecological features to support wildlife or a combination of both

BLUE ROOFS

Blue roofs are a way of controlling and reducing the speed of site rainwater run-off through roof level detention. Becoming a more common requirement to meet a specified SuDS flow rates, often required to meet planning policy requirements in areas of known flood risk.

Green roofs perform many of the functions of a blue roof. The various layers of a green roof detain and slow down the speed of run-off, considerably reducing the total volume per annum (see Table 1 on page 17). Vegetation is often used as the upper most layer of a blue roof, however, they may also be paving and/or gravel ballast.

2.2 TYPES

Green roofs have risen in popularity due mainly to the positive impacts they have on the environment. Although there seem to be numerous categories of green roofs talked about in the market, they can be broadly broken down into intensive or extensive systems. Intensive systems are generally those types which are used as recreational spaces and often include similar features to traditional parks and gardens such as shrubs, trees, paving, lawns and even water features. These roofs require intensive care and maintenance.

Extensive green roofs are normally intended to be viewed from another location as visual or ecological features and are usually not trafficked. The more prevalent types of green roof which have hardier, more drought tolerant species of plants such as sedums, mosses and wildflowers fall within the extensive category.

Extensive green roofs designed specifically to create habitats for plants and animals can be termed biodiverse (or brown) roofs. These types of roofs are becoming increasingly specified in urban areas in order to recreate habitat lost by the development.

Photo: Dusty Gedge

2 | ROOF TYPES AND BENEFITS

As the green roof sector rapidly moves forward and systems continue to develop, there are now many design possibilities which could fall into both the intensive and extensive category. The level of planned maintenance should help to indicate if a roof will require 'intensive' and regular maintenance, or only occasional routine care, thereby being 'extensive'.

2.2.1 EXTENSIVE GREEN ROOFS

EXTENSIVE GREEN ROOF

Characteristics:

- Light weight (typically less than 250kg per m^2 saturated density),
- Low maintenance (1-3 visits per year),
- Shallow substrates (typically 80mm to 150mm),
- Not designed for public access.

Vegetation is limited to hardy, drought tolerant species for example:

- Sedums - a genus of succulent plants, some native species are available,
- Other small, hardy succulent plants,
- Wildflowers which thrive on low nutrient, free draining soils,
- Small herbs, bulbs and alpines which share the above characteristics,
- Grasses: unless a grass-dominated meadow habitat is required, grasses should be limited to selection from a small group of non-aggressive, slow-growing species.

For the purposes of this guide, we cover the installation of vascular plants, however mosses, fungi and lichens may sometimes establish themselves on a green roof and can add to the diversity of the plant community.

Extensive green roof systems generally provide a visual or biodiversity interest and are considered to be less suitable as an amenity or leisure space. They are generally designed to support plants with a lower maintenance requirement, e.g. sedums, grasses, mosses and some wildflower species. These planting types are able to survive on shallower substrate depths than other types of plants, require lower nutrient levels and little or no irrigation. When correctly designed and installed, irrigation is generally only required in the initial establishment phase and then very rarely afterwards.

SEDUM ONLY ROOFS

Characteristics:

- Light weight (typically less than 250kg per m^2 saturated density),
- Low maintenance (1-3 visits per year),
- Shallow substrates (60mm to 100mm),
- Not designed for public access.

Sedum species are well adapted for their use within extensive green roofs. They are drought tolerant, able to withstand extremes in climate and can grow on relatively shallow substrates. There are many species with a range of form and colour, generally flowering from early summer to autumn. Sedum can survive on shallow substrate depths, lower nutrient levels are very draught tolerant (when correctly designed and installed). Typical substrate depth of 60mm - 100mm is required for sedum, depending on planting method chosen and local conditions (geographic location, orientation, shading, exposure etc).

Sedum green roofs are generally planted using pre-grown mats or blankets containing mixes of sedum species and/or planted with species of young sedum plug plants and/or sedum cuttings.

2 | ROOF TYPES AND BENEFITS

2.2.2 EXTENSIVE WILD AND MEADOW FLOWER ROOFS

Characteristics:

- Light weight (typically less than 250kg per m^2 saturated density),
- Low maintenance (1-3 visits per year),
- Shallow/Medium substrates (minimum 100mm),
- Taller plants and flowers to support insect and bird life,
- Not generally designed for public access.

Typically requiring a substrate depth of 100mm – 150+mm, wild and meadow flower species provide an alternative to low and slow growing sedum planting. Pollinator invertebrates and other insects find many suitable habitats within the taller fast growing species that are also suitable for the rigors of a roof environment.

Wildflower and meadow planting is more seasonal in appearance than many sedum species. However, even when not in flower, the benefit to biodiversity is great. Wildflower or meadow style plants and sedum species can be combined on the same roof to good effect.

It is desirable to have watering facilities available at roof level, particularly for the installation stage of wild and meadow flower roofs. Watering of the vegetation may be required after long dry spells, typically more than 6 weeks without rain.

Extensive Roof
Image: Radmat

2.2.3 BIODIVERSE ROOFS

BIODIVERSE ROOFS

Characteristics:

- Light weight (typically less than 250kg per m^2 saturated density),
- Low maintenance (1-3 visits per year),
- Shallow substrates (up to 150mm),
- Inclusion of natural features to support insect and bird life,
- Not designed for public access.

Biodiverse roofs are a form of extensive green roofs, primarily designed for habitat creation to support particular flora and fauna. They typically combine wildflower and meadow type vegetation with varied substrate topography and materials, the addition of features designed to attract and sustain pollinators and invertebrates, and the fauna that forage for them.

A ‘Green’ biodiverse roof is generally created by broadcasting an appropriate seed mix (often wildflowers and grasses) and/or planted with species of plug plants (often wildflowers, sedums and grasses) to encourage specific plant types that will support certain bird and invertebrate species. Pre-grown mats containing mixes of drought tolerant wildflowers, grasses and herbs can also be installed to provide a more “instant” cover. A wider range of plants can be included compared to extensive green roofs, including shrubs and woody plants. Watering and maintenance requirements are dependent upon the plant species installed.

This category includes the ‘Brown’ biodiverse roof or “Brown Roof” which is not purposefully planted.

2 | ROOF TYPES AND BENEFITS

Substrate depths may vary (typically 80mm – 150+mm) across the roof deck to promote a diversity of both shallow and deep rooted plants and ones which are more and less drought tolerant. Undulating substrate depths also create differing habitats for a greater range of invertebrate species. Pebbles, boulders, gravels, sands, dew ponds, bare substrate, branches and logs may also be placed within the system to offer suitable habitats.

The "management" of a biodiverse type green roof very much depends upon what the client requires. It can be managed more heavily to produce a controlled "wildflower meadow" type environment. Less management input may lead to natural vegetation progression which relates to the prevailing conditions.

2.2.4 INTENSIVE GREEN ROOFS

INTENSIVE GREEN ROOF

Characteristics:

- Heavier in weight (typically over 250kg per m^2 saturated weight),
- Higher maintenance (Regular visits),
- Deeper substrates (over 150mm and up to 1000mm)
- Can be designed for limited or full public access or high visibility.

Deeper, richer substrates mean the range of vegetation is much broader including, but not limited to: lawn turf, shrubs, hedging, trees. Maintenance will vary according to the particular type of vegetation and the requirements of the site and client.

Intensive green roofs (also termed roof gardens) are principally designed to create recreational and amenity spaces for people to enjoy. They are generally accessible and contain features similar to traditional gardens including lawns, trees, shrubs and hard landscaped areas. Intensive green roof systems involve using greater substrate depths (usually above 200mm) and often create a larger weight loading on the roof. Intensive green roof systems require a higher level of maintenance, including regular irrigation.

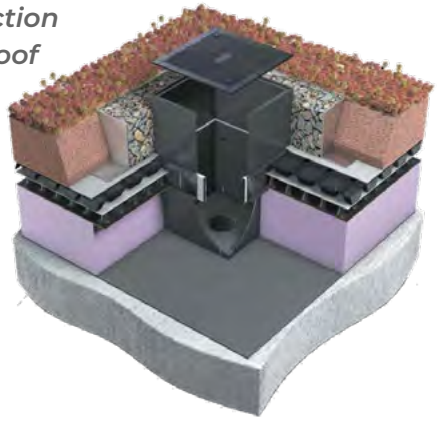
2.2.5 BLUE ROOFS

At the time of production, there is relatively little guidance on the specification for blue roofs. The NFRC have produced a Blue Roof Guide and CIRIA plan to publish more comprehensive guidance. However, there are now some established key design considerations:

- Blue roofs must be covered as open bodies of water can cause H&S issues. Typically, a blue roof is installed under a green roof.
- Any water held at roof level should be discharged in line with a site storm water management plan.
- The maximum depths of water held on the blue roof (H-Max) should not exceed the structural design tolerances of the roof.
- Blue roofs should only be installed over the most robust waterproofing systems.
- Blue roofs should be flat (with zero falls), as this is the only way to store large volumes of water at roof level.*
- There should always be adequate overflows to ensure the roof cannot exceed the H-Max (the maximum designed head of water).
- Where possible, parapet overflows should be fitted to act as a tell-tale to indicate that the maximum capacity has been reached.

***Note:** BS6229:2018 Flat roofs with continuously supported flexible waterproof covering. Code of practice and BBA Information No.4 Inverted roofs – Drainage and U value corrections provide clear guidance on the definition of a flat roof. "it should have a gradient of zero to 1:80 with no back falls". There are considerable design challenges around needing to form a surface that has little to no level changes and with no back falls.

2 | ROOF TYPES AND BENEFITS



Blue Roof Section with Green Roof Finish

Image:
ABG Limited

2.3 BENEFITS

Green roofs offer many advantages for building developers, owners and their users. Any of the benefits maybe the driver for the installation of a green roof, however, in many cases other positive outcomes are achieved as well.

2.3.1 SUSTAINABLE DRAINAGE (REDUCING FLOOD RISK)

More and more impermeable surfaces such as roads, footpaths, surface hardstanding and buildings are being constructed at the expense of permeable fields and meadows. Rain falling on hard surfaces runs straight off through the drainage systems into rivers. Therefore, in times of heavy or prolonged rainfall, existing drainage systems have to cope with large volumes of water which often, when built, they were not designed to do so. This can result in them backing up and subsequent flooding, especially during summer storm events.

The major flooding seen over recent years can be partly attributed to the increase in built up areas and reduction of vegetated areas. Therefore, developers are 'strongly encouraged' or required through planning policy by local authorities to employ Sustainable Drainage Systems (SuDS) on new developments.

SuDS are "A sequence of management practices and control structures designed to drain surface water in a 'more sustainable' fashion than some conventional techniques" (CIRIA 2000).

The Environment Agency can request that local authorities put conditions on planning permission such that the developer must restrict run off from the site to greenfield levels for a 100 year storm event plus allowance for climate change.

The 2019 National Planning Policy Framework (NPPF) recommends that SuDS should be considered for new developments and local authorities include them in their development plans particularly where there is identified flood risk

The inclusion of a green and/or blue roof system can be considered as one method of source control for SuDS (see Table 1):

- Water falling as rainfall onto a green roof is held within the pore spaces of the substrate.
- Water is taken up and used by the plants.
- Some of the water held within the plant is lost back to the atmosphere by evapotranspiration.
- Rain droplets are often trapped within the vegetation and can then evaporate back into the atmosphere.
- Water can be held within the drainage system of the green roof build up.
- The drain water run-off rate is very much reduced due to the time it takes for the water to percolate through the green roof build up and out via the drainage outlets. This, therefore, releases any excess water over a longer time period enabling the terrestrial drainage systems to cope better.

2 | ROOF TYPES AND BENEFITS

Table 1. The table below highlights average reduction in annual rainfall run-off, as the depth of substrate increases.

Roof Type	Run-off Percentage
Standard	81%
Standard with 50mm of gravel	77%
Green roof with 50mm of substrate	50%
Green roof with 100mm of substrate	45%
Green roof with 150mm of substrate	40%

Source: Green roofs as a tool for solving the rainwater runoff problem in the urbanised 21st century? Mentens, J.; Raes, D.; Hermy, M. Revised 2005.

2.3.2 BIODIVERSITY

Green roofs help to create new wildlife habitats within urban environments or recreate habitats that were lost during development. The type of system chosen can be designed to provide a habitat to encourage a broad range of species to flourish. However, it could also be created to support more specific species of flora or fauna for conservation purposes. Green roofs, which are designed not to be trafficked and are therefore relatively undisturbed, can offer a very good habitat for plants, birds and insects Green roofs can create a “green corridor” through an urban environment, helping the movement and dispersal of wildlife.

2.3.3 BIODIVERSITY NET GAIN AND OFFSETTING

In March 2019 DEFRA announced that it was to mandate biodiversity net gain, stating that there was a clear government commitment to improving the environment. DEFRA’s 25 Year Environment Plan sets out the government’s goals for environmental improvement. The promise is to leave the environment in a better state than we inherited it. Therefore, all new developments within England will have an obligation to deliver measurable biodiversity net gain under the National Planning Policy Framework) and by law, with the introduction of the Environment Bill this year, which will mandate for 10% net gain. The aim being that developments should leave nature in a better state than before.

At present, the Biodiversity Metric 2.0 (available at www.naturalengland.org.uk) is used to calculate biodiversity net gain. The metric takes into account habitat type, distinctiveness, condition, size and connectivity to calculate biodiversity units pre- and post-development. The metric covers a range of habitats including biodiverse, intensive, and extensive green roofs meaning that there is an opportunity to use green roofs to score biodiversity units, particularly where creating habitats at ground-level is not feasible due to the size of the site or other constraints.

2 | ROOF TYPES AND BENEFITS

2.3.4 COUNTERING CLIMATE CHANGE AND THE URBAN HEAT ISLAND EFFECT

During the day, heat from the sun is absorbed by the hard surfaces within a city, which is then radiated back during the night, creating a hotter city microclimate. Therefore, urban temperatures are often many degrees warmer than the surrounding countryside, which can lead to a higher energy demand to cool city buildings through the night. This difference in temperature is called the urban heat island effect.

Rises in temperature can lead to increased levels of air pollution which may exacerbate health problems especially in the old, young and susceptible. However, evaporation of water from soil surfaces and the leaves of plants on a green roof create a cooling effect of the surrounding air leading to a reduction in the urban heat island effect. The many layers within a green roof system also prevent solar radiation increasing roof surface temperatures and therefore subsequently radiating any heat back at night.

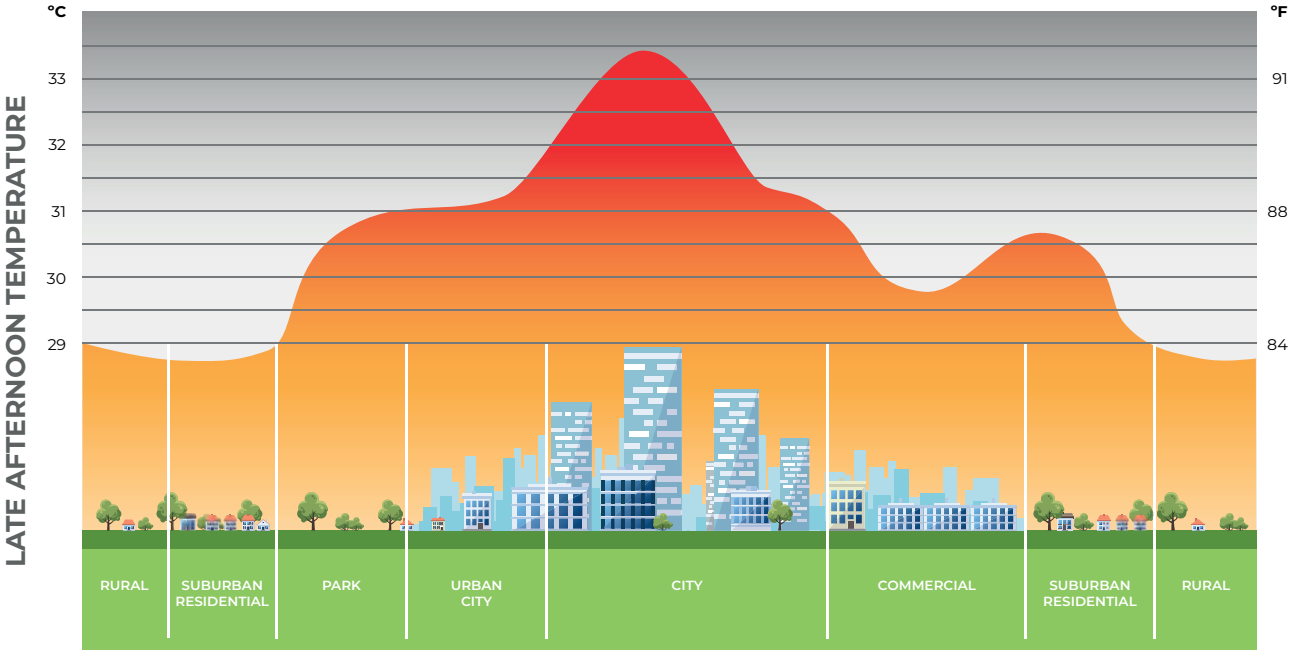
2.3.5 BUILDING PERFORMANCE AND ENHANCEMENTS

The evaporative cooling effect of green roofs, combined with the increased thermal mass of the build-up, can reduce the need for summer cooling through the use of air conditioning, with a resultant reduction in carbon emissions. This additional roof mass also serves acoustic purposes, providing additional sound attenuation benefits.

2.3.6 AMENITY, HEALTH AND WELLBEING

Green roofs can benefit building occupants, by providing valuable additional outdoor recreational areas for a variety of possible uses, including meeting places ,amenity and relaxation.. Indeed, research suggests that such green spaces can improve the productivity and well-being of workers and reduce hospital patients' convalescence times etc.

Urban Heat Island diagram:



2 | ROOF TYPES AND BENEFITS

Recreational Spaces - If the roof structure is able to take the weight of the proposed recreational system above it, then green roofs can play a very important role in providing useable spaces for people where there is little available at ground level. Green roofs designed as recreational areas have the advantage that access to them can be controlled, making the space less prone to vandalism and other anti-social issues which can be commonplace in public spaces at ground level.

Aesthetics - In many locations, the view looking across a series of city roofs can be very uninspiring. Green roofs, rather than hard flat roofs, are not only aesthetically pleasing; they are very likely to be seen as a positive selling point for developers wishing to sell or let property to potential buyers.

Health - It is known that people who live in high density urban environments are less susceptible to illness if they have a balcony or terrace garden. This is due to a number of associated benefits such as more oxygen, better air filtration and humidity control which plants can supply. There are also therapeutic benefits associated with the mixture of smells, colours, sounds and movement created by plants and their associated fauna which can reduce stress, lower blood pressure, relieve muscle tension and increase positive feelings.

2.3.7 ENERGY SAVINGS

Although the addition of a green roof cannot as yet be quantified to influence the thickness of insulation required for a building, its thermal mass can reduce the amount of solar heat entering a building through the roof. This is more pronounced when the building is poorly insulated. The various layers within a green roof system help to absorb the heat of the sun, reducing its transmission into the building below.

This, in turn, reduces the air-conditioning costs required to keep the temperature at a suitable level.

Longevity of Roofi g Membranes - Ultraviolet radiation falling upon certain waterproofing membranes can change its characteristics and accelerate the ageing process. However, as the membrane is buried below the green roof system, this premature ageing cannot take place.

During the day, an unprotected membrane heats up and then releases that heat back to the atmosphere during the night. This daily fluctuation of temperature causes the membrane to expand and contract which, over time, creates stresses within the membrane affecting its long-term performance. During the summer months exposed membranes could reach 50-60°C, and in winter, temperatures below freezing. A green roof acts as a buffer and reduces the severity of maximum and minimum temperatures, thereby extending the life of the membrane.

2 | ROOF TYPES AND BENEFITS

2.3.8 POLICY / PLANNING CONSENT

Some councils and local authorities e.g. the London boroughs have a planning requirement for green roofs for new major developments.

Living Roofs and Walls – Mayor of London – Planning Policy 5.1 Green roofs and development site environs
A Major development proposals should be designed to include roof, wall and site planting, especially green roofs and walls where feasible, to deliver as many of the following objectives as possible:

a adaptation to climate change (ie aiding cooling)
b sustainable urban drainage
c mitigation of climate change (ie aiding energy efficiency)
d enhancement of biodiversity
e accessible roof space
f improvements to appearance and resilience of the building
g growing food.

Other local authorities throughout the UK have or are moving towards implementing similar policies.

2.3.9 IMPROVEMENT OF AIR AND WATER QUALITY

AIR QUALITY

It is widely recognised that green roofs play a positive role in the improvement of air quality. In the process of photosynthesis, plants absorb carbon dioxide from the atmosphere and release oxygen back.

WATER QUALITY

Vegetation filter out airborne particulates as the air passes over the plants, settling on leaves and stems.

These particles are washed down into the growing substrate via natural rainfall or irrigation. They are then held within the green roof substrates and prevented from getting into water courses. Heavy metals such as lead, zinc and copper are recognized pollutants within urban areas, green roofs play a major role in limiting their potential to contaminate water supplies.

Photo: Livingroofs

2 | ROOF TYPES AND BENEFITS

2.3.10 QUIETER BUILDINGS

Hard roof surfaces tend to reflect sound, rather than absorb it. Green roofs absorb sound through the substrate, drainage and vegetation layers. This is especially significant in busy locations such as built up areas, near airports or flight paths and alongside busy roads. Buildings such as schools, hospitals and offices could benefit from the noise reduction properties of green roofs.

2.3.11 FOOD PRODUCTION

Green roofs can provide new opportunities for urban agriculture, however they need to be specifically designed for this application and require significant nutrition and irrigation.

There can be many benefits associa ed with growing and distributing food locally including:

- Support of the local economy in growing, processing and distributing
- Increased access to food by everyone
- Fresher produce
- Decreased travel time to market and related environmental costs
- Localised control of fertiliser and pesticides

2.3.12 GREEN ROOFS AND SOLAR POWER / BIOSOLAR

The demand for space on flat roofs is increasing. Often there is a requirement to have both Photovoltaic (PV) panels and green roofs on the new developments. It is not a case of an either-or situation, as PV panels can be combined with green roofs and both systems will function as they should if designed correctly.

PV panels are most efficient within an operating temperature envelope. Once there is a deviation either above or below these levels, the electricity generation becomes less efficient. A green roof maintains a more constant temperature with less daily fluctuations, resulting in PV panels working more efficiently throughout the day.

PV panels create wind and sun shade at their rear if orientated to the south, thus improving vegetation diversity in the shade which in turn, increases the potential for increased biodiversity.

DESIGNING GREEN ROOFS WITH PV PANELS

Sometimes termed ‘Solar’ green roofs, the PV panels are mounted on, not integrated into the green roof system. In most cases, this means that PV array is either mounted to a metal frame on top of the green roof system and ballasted with non-green roof materials or it is fixed to the roof deck through the waterproofing layer.

Key design Issues:
The key issue when designing green roofs with PV panels is the distance between each array. Maximising the roof space to pack as many solar panels onto the roof can have a detrimental effect on both the green roof and the energy production of the PV panels.

Spacing between arrays should be at least 750mm if not 1000mm to ensure there is no negative impact on either the green roof or PV performance.

Timing of installation to ensure that the plants and green roof build-up are not damaged by the installation of solar panels and related hardware. Coordinate installation green roof programme with solar contractors.

Plant selection, the solar panel will cast shadows across some of the growing area, shade tolerant plants should be selected for these areas.

2 | ROOF TYPES AND BENEFITS

Maintenance on green roofs with solar panels is important. Due to condensation and rain falling from the panels onto the plants, growth can be more vigorous around the PV panels. If unmaintained, tall vegetation can grow and shade the panels. This can potentially have a negative impact on the energy production of the panels

BIOSOLAR

Biosolar roofs are systems where the PV mounting system is integrated into the green roof. In general, this is where the mounting is fixed to the drainage layer. The PV array is ballasted by the green roof and thus, other forms of ballasting or fixing are not required. In general, the maintenance of a Biosolar green roof is less than on Solar green roofs. An annual strim mid-summer of the area immediately beneath the vicinity of the panels is recommended, to ensure taller vegetation does not have a negative impact on the panel's efficiency.

GRO recommends that where PV is mounted on a roof, the application and area of green roof be maximised.

2.3.13 GREEN ROOFS – BREEAM & LEED

BREEAM - Building Research Establishment's Environmental Assessment Method is an assessment method based on performance to set standards for best practice in sustainable design. Credits are awarded in 10 categories and then added together to produce a single overall score, which is then given a rating of Unclassified, Pass, Good, Very Good, Excellent or Outstanding.

Green roof installation in general can directly assist in getting credits in the following categories:

1. **POL5: FLOOD RISK** - To encourage development in low flood risk areas or to take measures to reduce the impact of flooding on buildings in areas with a medium or high risk of flooding.
2. **LE4: MITIGATING ECOLOGICAL IMPACT** - To minimise the impact of a building development on existing site ecology
3. **LE5: ENHANCING SITE ECOLOGY** - To recognise and encourage actions taken to maintain and enhance the ecological value of the site as a result of development.
4. **LE6: LONG TERM IMPACT ON BIODIVERSITY** - To minimise the long term impact of the development on the site's and surrounding area's biodiversity.

Green roofs can also have a more indirect impact on other sections of BREEAM.

LEED - Leadership in Energy and Environmental Design and LEED certification provide a framework for healthy, highly efficient and cost-saving green buildings in the USA.

3 DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

3.1 CONFIGURATION OF A GREEN ROOF

All materials used within a green roof system or build-up should, where applicable, have been tested following the appropriate testing protocols (e.g. FLL, British Standards) and deemed to be fit for purpose by meeting the relevant performance criteria.

A green roof requires appropriate levels of each of the following in order to flourish:

- Daylight
- Moisture
- Drainage
- Aeration to the plant's root systems
- Nutrients
- Maintenance

The green roof system build-up should be configured to provide the appropriate balance of the above requirements to sustain plant life.

The geographical location, aspect, orientation and exposure to wind will all impact on the roofs ability to flourish. All these factors should be considered in the design stages of the green roof.

3.1.1 ROOT RESISTANT MATERIAL

A root barrier is a membrane that permanently protects the roof's waterproof covering by preventing plant roots or rhizomes from growing into or through it. It can take the form of an independent membrane or a monolithic root resistant version of a waterproofing membrane. The root resistant element may be a chemical or a physical barrier (tested in accordance with most current FLL, Section 7.1.2.5 or EN 13948 relating to root penetration of the membrane).

The important performance characteristics to evaluate suitability are:

- Density
- Tensile strength
- Elongation at break

The values for these parameters will vary, depending on the design of the roof and the characteristics required.

3.1.2 PROTECTION LAYER

A geotextile layer, available in varying thicknesses (typically between 2mm - 12mm), that performs the function of protecting the waterproof membrane during and after construction.

The following performance characteristics should be assessed for suitability:

- Water storage capacity (l/m²)
- Thickness (mm)
- Weight [dry] (kg/m²)
- Tensile strength (kN/m²)
- Durability measure as per EU Norm

The values for these parameters will vary, depending on the design of the roof and the characteristics required.

Note: in the case of inverted roofs, please consult the supplier as to the most appropriate product for this purpose.

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

3.1.3 DRAINAGE/RESERVOIR LAYER

Drainage/reservoir layers can be manufactured from a variety of durable materials fit for purpose and designed for the life of the roof, including geocomposite, polystyrene and foam. However, flow rates and water storage must be quantifiable. Demolition waste is not suitable. To function correctly the drainage/reservoir layer must allow excess water to drain away, thereby preventing the water logging of the substrate. Drainage/reservoir layers also incorporate water storage cells to retain additional water that can be diffused to the plants during prolonged dry periods (more than 6 weeks without rain).

Note: Coarse aggregates may also be used as drainage layer, however, additional reservoir capacity maybe required.

The important performance minimum characteristics to evaluate suitability are:

- Water storage capacity (l/m²)
- Fill volume for aggregates (l/m²)
- Flow rate (l/s/m²)*
- Weight [dry and saturated] (kg/m²)
- Compressive strength (kN/m²) Final design and construction loads must be considered.

The values for these parameters will vary, depending on the design of the roof and the characteristics required.

*** Note:** flow rate may be affected when used on a pitched as opposed to a flat roof. Check water storage capacity and flow rate when used at pitch.

3.1.4 FILTER LAYER

A woven or needle-punched non-woven geotextile that prevents fines and sediments from being washed out of the green roof into the drainage/reservoir layer so as to maintain permeability.

The important performance minimum characteristics to evaluate suitability are:

- Weight (90g/m² minimum)
- Tensile strength (7/7 kN/m minimum)
- Flow rate under hydraulic head of 50mm (EN ISO 11058) (minimum 70 l/m²/s)
- Effective pore size (EN ISO 12956) minimum 90 µm
- Penetration force (EN ISO 12236) minimum 1100N

3.1.5 SUBSTRATE/GROWING MEDIUM

The vegetation growing substrate (also referred to as growing medium) normally consists of a blended and engineered soil replacement that contains a specified ratio of organic and generally porous inorganic material. These are specifically designed to provide green roof plants with a growing media that holds the correct level of moisture, nutrient and air, and the correct particle structure, required for long term sustainable vegetation growth.

A green roof substrate should have a composition that provides the following properties:

- Lightweight to allow construction depth but to reduce the design load
- Resistance to wind and water erosion and chemically inert
- Substantially free from weeds; diseases; pests
- Ability to promote good plant anchorage to bind roots and reduce the risk of wind up-lift

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

- Fire resistance through avoiding high proportions of flammable organic matter (see section on Fire Risk)
- Contain no peat
- Adequate water retention and release characteristics to retain sufficient water for vegetation requirements
- Adequate permeability to prevent excessive retention of water
- Sufficient air porosity under wet conditions to prevent root damage
- Resistance to compaction in order to maintain sufficient substrate depth and adequate drainage
- Appropriate supply of nutrients to allow long term development in accordance with plant needs (Note: Generally extensive roofs have a low nutrient requirement while intensive roofs have higher nutrient needs)
- **No elements which have sharp points or edges which could damage the waterproofing.**

Photo: Dusty Gedge

BS 8616:2019 Specification or performance parameters and test methods for green roof substrates.

BS 8616:2019 establishes how the parameters of green roof substrates should be tested and their performance declared, it is not an approval or certification standard.

A current BS8616 specification sheet of substrate characteristics should be provided by suppliers. Substrate should be tested according to BS8616:2019 by an independent green roof substrate testing laboratory. If a supplier changes a substrate recipe, a new certificate is required. GRO have a set number of substrate parameters which should not be exceeded under any circumstance (Table 2.). GRO have a set of general guideline values for green roof substrate (Table 3.). Substrate characteristics may fall outside of the standard GRO ranges, but the substrate could still be appropriate for specific applications. GRO recommend that further information and evidence from the manufacturer/specifier is sought in order to determine if the substrate is appropriate for a specific application or geographical location.

Table 2. GRO substrate limits for extensive and intensive substrate (values should not exceed these limits)

Lead (mg l^{-1})	330
Nickle (mg l^{-1})	22
Copper (mg l^{-1})	55
Cadmium (mg l^{-1})	22
Zinc (mg l^{-1})	88

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

Table 3. GRO substrate recommendations (values may be above or below these recommendations in certain circumstances)

Water & Air	Extensive	Intensive
Field Capacity (% v/v)	≥ 20 - ≥ 65	≥ 30 - ≥ 65
Total Porosity (%)	> 22.5	> 22.5
Porosity at Field Capacity (%)	≥ 10	≥ 10
Saturated Hydraulic Conductivity (mm/min^{-1})	0.6-70	0.3-50
Chemical		
Organic Matter (% by weight)†	2.0 - 7.0	3.0 - 15.0
Organic Matter (% by volume)	5.0 - 20.0	20.0 -50.0
pH	5.8 – 8.5	5.8 – 8.5
Electrical Conductivity (mS cm^{-1})	1.8 – 3.5	2.0 – 4.0
Plant Available Nutrients		
Phosphate (mg l^{-1})	> 30	> 30
Potassium (mg l^{-1})	> 100	> 100
Total nitrogen (%)	< 2.0	< 3.5
Particle Size Distribution		
Particles ≤ 0.063 mm (% weight)	≤ 15.0	≤ 20.0
Particles > 8 mm (% weight)	< 60	< 30
Foreign bodies (% weight) i.e. not listed in substrate ingredients	<0.1	<0.1

Note: Bulk density of substrate is project specific and final decision is for structural engineers. Generic bulk density at field capacity for extensive substrate is 1.0-1.5 kg l^{-1} and for intensive substrate is 1.2-2.0 kg/l^{-1}.

† This figure may be below 2% by weight for bespoke mixes i.e. substrate for intentionally low nutrient input systems.

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

3.1.6 SUBSTRATE DEPTH

Greater substrate depth will give greater drought tolerance. However, excessive depth will enable undesirable plant species to establish and will increase roof loading. Consult a green roof specialist for projects where substrate depth greater than 400mm i.e. for large shrubs and trees, are being considered.

Design depth should allow for approx.10% settlement of the substrate.

*Table 4. **Recommended installation substrate depth to be not less than:***

Sedum pre-grown blanket/mat	60mm (+ blanket/ mat depth of min. 20mm)
Sedum established from cutting/plug plants	80mm
Wild / meadow flower blanket/mat	100mm (possibly deeper, depending on plant species)
Biodiverse	80mm to 150+mm in line with design
Herbaceous plants	150mm
Lawn (grass)	200mm
Medium shrubs	400mm

Intensive green roofs generally have a minimum installation substrate depth of 200mm. The depth of substrate depends on the planting scheme, with more complex and larger vegetation generally requiring deeper substrate (see Table 4). Guidance should be sought from a landscape architect or green roof specialist if clarification on specific species is required.

For applications where greater or lesser substrate depths are suggested, consult the manufacturer regarding the risks of reduced performance or increased care requirements.

3.1.7 VEGETATION

The following product guidelines are designed to enable professionals involved in green roofing to understand how to achieve the best possible performance in a wide range of green roof systems. They are not intended as a specification, but describe the principles agreed across the industry that will help reduce the incidence of green roof failures.

Photo: Optigrun

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

SEDUM BLANKETS

- Should be grown over a full growing season.
- Recommended minimum 9+ species.
- Minimum of 90% sedum coverage.
- Minimum of 20mm thick rooted substrate.
- Should be free from invasive weeds and grass.
- Should be ideally laid on a minimum of 60mm, giving 80mm in total.
- Note: There are alternative lightweight sedum systems which do not contain the recommended depth of substrate; where these are preferred, please refer to manufacturers recommendations.

WILD/MEADOW FLOWER BLANKETS/MATS

- Should be a minimum of 25mm thick.
- Should not be harvested until the root systems are mature and the blanket is well formed.
- Recommend minimum of 16+ species.
- If grasses are preferred, then these should be non-invasive.
- Minimum of 85% vegetation coverage.
- Should be free from invasive weeds and grasses.
- When harvested, the swath should be cut down to approx. 40mm to 150mm.
- Should be laid on a minimum substrate depth of 100mm.

SEED SOWING

- GRO do NOT recommend seed to establish sedum roofs.
- Wild and meadow flower roofs can be established by seed, however it is a slow route to achieving comprehensive vegetation cover.
- Only species suited to the roof environment should be used.
- Avoid invasive weeds and grasses.
- Should be sown at 3-4g per m^2.
- Should be sown with a wide species mix assuming not all species will germinate:15+ species are recommended.
- To maximise help to pollinators, please refer to RHS ‘Plants for Pollinators’.
- Sow seed in Spring or Autumn for best results.

ESTABLISHMENT BY CUTTINGS (UNCOMMON IN THE UK, ONLY SUITABLE FOR REMEDIAL VEGETATION REPAIRS)

- Only recommended for sedum roofs.
- Spread in spring or autumn.
- Spread at a rate of 50-150g per m^2.
- Always use fresh cuttings from 9+ species.

Photo: Frosts

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

ESTABLISHMENT BY PLUGS

- Size should be approx. 55cc with a small leaf area give the best stress tolerance against drought.
- Plugs should be planted at 16-25 per m^2. Where combined with seed, this can be reduced (12-16 per m^2 is recommended).
- Plugs should be saturated prior to planting and planted flush with the substrate.
- Plugs should not be grown in substrate containing peat.

PLANTING FOR BIODIVERSITY

- Substrate depths should vary, typically to achieve an average of 115mm (undulating 80-150+mm).
- Often include some areas of bare, unplanted substrate to recreate 'brownfield' sites.
- Broad range of flowering species used, minimum 15+ species.
- Ideally should contain other habitat features which help to support a wide range of invertebrate life. Features can include bare unplanted substrates and aggregates; native hardwood seasoned logs; rock; boulder and stone piles; sand-filled containers for burrowing insects, dead plant stems.
- Reference to local authority Biodiversity Action Plans (BAPs) and/or consultation with site ecologists is recommended.

WATERING

- All green roofs require a method of watering for periods of drought i.e. more than 6 weeks without rainfall.
- Newly installed green roofs will benefit from watering for at least 6 weeks after installation.
- Less drought tolerant planting and pitched green roofs will require regular watering during the summer months.

3.2 STRUCTURAL DESIGN

A green roof design must comply with all relevant structural design criteria, as per BS EN 1990:2002 'Eurocode - Basis of Structural Design.' As such, designs must be in accordance with all appropriate Eurocodes, with a notable emphasis on EN 1991 - Eurocode 1: Actions on structures.

On projects covered by NHBC / Premier Guarantee / LABC New Homes warranty, the structural design shall be undertaken in accordance with recognised standards. Please note, this maybe have requirements over and above the BS EN's.

Items to be taken into account include:

(a) Dead and imposed loads - these should be calculated in accordance with BS EN 1991-1-1, BS EN 1991-1-3 and BS EN 1991-1-4. Where a flat roof is to act as a roof terrace, roof garden or will have vehicle access, appropriate provision should be made for additional loading conditions. Intensive green roofs should only be used in conjunction with concrete decks.

General Actions:

- Densities, self-weight, imposed loads for buildings (BS EN 1991-1-1:2002)
- Snow Loads (BS EN 1991-1-3:2003);
- Wind Actions (BS EN 1991-1-4:2005 +A1:2010 Eurocode 1. Actions on structures. General actions. Wind actions)

The building structure and any loaded roof components (e.g. insulation, waterproofing) must be designed accordingly. In the case of a blue roof, the assumption for a storm incident (H-Max), should be classed as Live Load.

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

3.2.1 WIND LOADS

Wind loads should be calculated according to BS EN 1991-1-4:2005+A1:2010 Eurocode 1. Actions on structures. General actions. Wind actions. This states that the design should resist uplift from wind forces, either by anchorage to the main structure, or by having sufficient self weight to prevent the occurrence of uplifting in worst-case design conditions.

Where green roof elements are being used as ballast to provide the roofing system with resistance from wind uplift, (i.e. the roofing system is not mechanically fastened or adhered) sufficient weight must be incorporated into the green roof build-up. In these instances, the dry weights of the green roof components must be used to calculate the weight of the green roof system.

Subject to wind uplift loads, erosion control measures such as netting may be required whilst the plants establish.

With highest wind load areas occurring at roof perimeters and corners in particular, heavier materials, such as larger ballasting aggregates or paving slabs should be used to prevent wind scour of the green roof substrate.

3.2.2 DEAD LOADS

Dead loads must account for the saturated weight of the green roof, snow loads and any further imposed service loads such as pedestrian access loads and point loads from features such as water features and large trees. The underlying roofing system (deck, insulation, waterproofing, geotextile layer and drainage/retention layer) must all be capable of withstanding any point loads from the green roof installation and from any support elements included, such as decking or paving.

3.2.3 SHEAR FORCES

Green roof systems are suitable for flat and pitched (max 30°) roof applications. When used in pitched applications, the risk of substrates being exposed to excessive shear forces as a result of steep roof pitches and slipping down the slope, must be considered in the design. Anti-shear measures are typically required for roof pitches in excess of 10°; however, the waterproofing and (where different) the green roof manufacturer should be consulted for project-specific advice. The requirements of the anti-shear measures should be considered during the structural design phase.

The anti-shear measures should be designed to suit the individual waterproofing system employed and avoid imposing unintentional loads on the structure and waterproofing below. Common solutions include retention baffle systems and slip barriers. Where the attachment of the retention system penetrates the waterproofing, the retention measure itself should be waterproofed. It is important to refer to the waterproofing manufacturer for specific recommendations as failure to waterproof correctly, will impact the guarantee and/or waterproofing integrity.

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

3.3 WATERPROOFING

Waterproofing systems for use beneath green roofs should form part of a structure designed to BS EN 1991 Eurocode 1 and/or NHBC Standards Chapter 7.1. and/or EN 13948.

In all applications the primary waterproofing layer is critical to the successful performance of the roof as a whole. Therefore, its function and performance characteristics as well as its suitability for use within a green roof system must be assured.

As a minimum, the specified waterproofing system should be certified to FLL Guidelines against root resistance and/or be covered by British Board of Agrément (BBA) "Certification for green roof applications". A wide range of waterproofing options fall within these requirements including reinforced bitumen systems, hot melt monolithic systems, single ply systems, liquid applied systems and standing seam aluminium systems.

When designing and specifying the waterproofing system, it is important that the detailing (e.g. upstands, pipe penetrations, rooflight upstands etc) are designed to 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.

In all instances, the manufacturer of the waterproofing membrane should confirm the suitability of the waterproofing system for use in green roof applications and installation should be in accordance with the generic design and the waterproofing manufacturer's recommendations.

Where the roof covering does not provide the necessary root resistance, the installation of an independent root barrier is required (see Section 3.1.1).

During installation, consideration should be given to the action of wind loads (3.2.1). Where a loose laid waterproofing membrane is being installed, suitable temporary ballasting measures must be put in place. Where mechanical fastened or adhered waterproofing membrane is used, this will generally not be required but attention should be paid to the security of any overnight joints. Also, during installation, the waterproofing membrane should be protected from other trades and any other activity by means recommended by the waterproofing manufacturer. Sufficient storage and workspace should also be provided. The roof should not be used as a storage area or work platform.

3.3.1 WATERPROOFING INSPECTION

Completed roof waterproofing should not be used as a working platform for any trade other than those installing the green roof. In the event of damage to the waterproofing, causing ingress of water into the building post green roof installation, remedial works will require extensive investigations to locate the point of damage. Typically, this will require the removal (and subsequent replacement) of the green roof build-up, a process that is labour intensive and can lead to significant costs. The inspection and testing of the waterproofing integrity prior to the green roof installation is therefore imperative.

Testing and inspection can consist of electronic leak detection (if appropriate) and/or visual inspection. Regardless of which method(s) are used, the height of upstands, roof light flashings etc. should be thoroughly inspected to ensure correct

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

heights prior to installation of the green roof. Where an inspection of the waterproofing system is required by the manufacturer prior to the issue of a guarantee, this should be scheduled appropriately so as to minimise risk of damage of wind action. Where handing over to a specialist green roof contractor, there should be a noted handover of the area which recognises the change of responsibility between the waterproofer and the green roof installer.

3.4 DRAINAGE

Roof drainage designs should comply with the requirements of BS EN 12056-3:2000 Gravity drainage systems inside buildings and BS 6229:2018, Flat roofs with continuously supported flexible waterproof coverings.

Modelling of a green roof should be undertaken by an experienced hydraulic design specialist.

Professor Stovin's time/area calculation should be used to determine storage capabilities of 'Green Roofs' by auto-calculating the time area diagram with values representative of the depression storage and runoff lag. The time/area calculation for the catchment will allow the runoff rate to be calculated using appropriate hydraulic models to determine the size and number of roof outlets. A cascade analysis should be used to size the downstream or wider drainage system elements to allow for the benefits of the green roof to be realised due to the nature of the slowed flow rate from the inherent runoff lag and depression storage.

The success of the roof depends on the specific build-up of the green roof, particularly in respect of its permeability and capacity for storage, as governed by the growing medium and drainage/ reservoir board, where installed. This should be accounted for in any modelling that is undertaken (See section 2.3.1 for details of sustainable drainage benefits of green roofs.). Inspection chambers are required to ensure that outlets are kept free of blockages and a robust maintenance regime should be put in place.

3.5 FIRE

In England, Wales and Northern Ireland Building Regulations Approved Document B (ADB) Volume 1 and 2 provided guidance on achieving compliance with the Statutory (legal) minimum requirements for the fire performance of buildings contained within the Building Regulations. In Scotland the Technical Handbooks perform this function.

Each of these documents references the Department of Communities and Local Government (DCLG) document *Fire Performance of Green Roofs and Walls* for guidance on achieving compliance with the requirements of Regulations B3 and B4.

Section 4.5.2 of DCLG *Fire Performance of Green Roofs and Walls* states that compliance with the requirements of Regulation B4 to achieving Broof(t4) to BS EN 13501-5 can be 'deemed to satisfy' when using a growing media of a minimum 80mm of settled depth with an organic content not exceeding 50% by volume. Alternatively, compliance can be demonstrated through specific testing to DD CEN/TS 1187:2012 Test Methods for External Fire Exposure to Roofs (Test 4) and classification to BS EN 13501-5:2016. Regulation B3 compliance is covered in section 3.5.4 of this document.

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

This document should be read in conjunction with:

- Building Regulations Approved Document B (2019) which can be downloaded for free at https://www.gov.uk/government/publications/fire-safety-approved-document-b
- Department for Communities and Local Government document "Fire Performance of Green Roofs and Walls". This contains more detailed help and design guidance and can be downloaded for free at https://www.gov.uk/government/publications/fire-performance-of-green-roofs-and-walls

GRO would strongly recommend that designers, contractors and building owners comply fully with all recommendations.

3.5.1 EXTERNAL FIRE PERFORMANCE

GRO recommends that the waterproofing manufacturer is consulted with regards to the fire performance of any exposed waterproofing used at parapet walls, upstand and penetrations such as rooflights; SVP's etc.

Green roof drainage/reservoir boards and filter fleeces should be completely buried beneath the growing medium and gravel margins to prevent potential exposure to fire risk.

GRO compliant growing media will provide a positive contribution to the resistance of penetration by fire due to the non-combustible nature of mineral/brick based growing media. Green roof systems can also resist the spread of flame provided they are correctly designed, installed and maintained.

Consideration must be given to any vegetation, whether at ground or roof level, to prevent the external spread of flame during prolonged periods of drought. Planting succulents such as sedum can help.

For all green roofs, the use of a temporary or permanent irrigation system to prevent drying out is recommended.

The ongoing maintenance of green roofs is important to ensure that the organic content of the roof does not significantly increase over time. The green roof system supplier should be consulted for maintenance/stewardship recommendations that will also ensure the health of a self-sustaining plant community.

3.5.2 SUBSTRATE

To ensure that there is no danger that fire can spread or penetrate the growing medium, GRO recommend that extensive substrates should be tested in line with BS 8616:2019 and contain no more than 20% organic content by volume (with no peat) and comply to GRO guidelines (Section 3.1.5).

3.5.3 WATERING AND IRRIGATION

Climate change and the increased likelihood of warmer, drier summers mean green roofs are likely to become more prone to droughting. It is recommended that all green roofs are designed with a means to water the roof in drought conditions. This may take the form of permanent irrigation or, for smaller roofs, a simple water point at roof level.

3.5.4 FIRE BREAKS

Section 4.5.1 of DCLG *Fire Performance of Green Roofs and Walls* states that compliance with the requirements of Regulation B3 which aims to prevent the spread of fire into, or from a building on to the green roof, recommends a fire break of 500mm width and 75mm deep is installed wherever the green roof abuts a vertical element i.e., at perimeters and penetrations such as rooflights, soil pipes, etc. Additionally, on large roofs, a one-metre-wide fire break should be installed at 40 metre intervals across the roof.

To help maintain the fire break, a retention angle should be included between the growing medium and the pebble margin/paving.

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

There is no guidance on pebble margins around rainwater outlets or at roof verges but GRO recommend the installation of a minimum 300mm gravel margin at 50mm depth around rainwater outlets to prevent vegetation blocking the outlets. At roof verges it may be possible to take the green roof to the verge but consideration should be made as to the risk of wind scour due to the building height. Where a gravel margin is installed at the verge GRO recommend it is a minimum 300mm gravel margin at 50mm depth.

3.5.5 MAINTENANCE

All green roofs require maintenance to ensure they remain healthy and do not represent a fire risk.

Importantly, fire breaks should be maintained regularly and kept clean of encroaching vegetation.

The regular removal of leaves, rubbish, old flowers and seed heads reduces the risk from dry organic matter. Tall grasses and/or wildflower species die back seasonally and can produce large volumes of organic material on the roof which can increase the fire risk if the correct maintenance regimes are not followed.

3.5.6 OTHER SYSTEMS I.E. CASSETTE/ MODULES

This GRO guidance focuses on site assembled extensive green roof construction incorporating non combustible growing medium.

This guidance does not neccessarily apply to systems that incorporate/use substitute for a non-combustible growing medium such as foam; mineral wool or pre-grown cassettes/ modules. Where a client or specifier is considering using an alternative such as these, they should satisfy themselves that the as built roof construction will achieve the requirements of Approved Document B in particular. This is typically achieved via a full system assessment to TS1187 Test 4. In turn this will provide fire test certification to BS EN 13501-5. This information should be sought from the manufacturer and where not available a fire assessment should be made by a suitably qualified person, or the product should not be used.

3.5.7 INTENSIVE ROOFS

Intensive green roofs which are irrigated, regularly maintained and have a thick substrate layer (typically 200mm as a minimum) are regarded as a “hard roof”, implying that it has no greater fire risk than a conventional roof finish. On this basis, GRO believes that Intensive Roofs should be deemed to meet Broof (t4). For Extensive and Biodiverse green roofs, the manufacturer/ supplier should be consulted, as should Agrément Certification or other relevant test certification. Fire breaks should comply with guidance set out in Section 3.5.4.

Photo: Sempergreen

3 | DESIGN CONSIDERATIONS & PRACTICAL IMPLICATIONS

3.6 IRRIGATION & WATERING

Irrigation is typically required for the initial establishment of the green roof for a period of 6 - 8 weeks depending on natural rainfall during this time. Once vegetation cover is achieved, irrigation can be reduced. However, all green roofs will need watering in periods of extended draught i.e. more than 6 weeks without any rain.

The requirement for irrigation depends on several factors, particularly:

- The plants chosen
- The depth of substrate
- Water storage capacity of substrate and drainage layer
- Rainfall
- Exposure of the site
- Pitch of roof

In all instances advice should be sought from the green roof system supplier.

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 7562-3:1995 “Planning, design and installation of irrigation schemes - Part 3: Guide to irrigation water requirements”.

Standards relevant to the design of specific irrigation systems include BS EN 15099-1:2007 - Irrigation techniques. Remote monitoring & control system, BS EN 15097:2006 - Irrigation techniques. Localised irrigation hydraulic evaluation and BS EN 13742-1:2004 - Irrigation techniques. Solid set sprinkler system - selection, design, planning & installation.

3.7 SAFETY & ACCESS

Legislation requires, amongst other things, edge protection, safe working platforms and protection against falls to be provided for roof installation works.

The principal reference statutory documents are:

- The Construction (Design and Management) Regulations - requiring risk assessments to identify and mitigate potential risks during the construction and post-construction phases leading to the preparation and implementation of safe working practices;
- The Construction (Health, Safety & Welfare) Regulations - requiring safe access and egress, including fall prevention measures;
- The Health and Safety at Work Act - generally placing an onus on employers and employees to ensure safe workplaces, including requirements for measures to protect against the risk of falling when working at height.

In addition, the need to have full perimeter upstand (minimum hight of 1.1m from top of substrate surface) and/or fall restraint and/or fall arrest systems for post installation maintenance is universal for all green and blue roof systems. However, the type of system required varies depending on the type of roof and the resultant requirement for maintenance. The fall arrest specification should account for the guidance provided within BS 7887: 2005 - Code of practice for the design, selection, installation, use and maintenance of anchor devices conforming to BS EN 795.

4 GREEN ROOF INSTALLATIONS

Photo: Bridgman & Bridgman

4 | GREEN ROOF INSTALLATIONS

Contractors should be trained in the installation of green roofs and must have a specialist understanding of the green roof system as well as general roof care and construction knowledge. Incorrect installation may result in a variety of failures including, but not limited to, the loss of plant life, damage to the waterproofing, slippage from the roof, failure to achieve BREEAM ratings, failure to meet planning requirements, failure to perform as designed etc.

4.1 SITE PREPARATION & PLANNING

Project Management is critical to delivering successful green roof installations:

- The installation of the green roof elements should be the last operation on the roof, after all other trades have completed their works.
- Scheduling works to comply with the project programme (the waterproofing installation in particular) and close collaboration with the green roof materials delivery and installation will be essential to ensure that materials arrive on site in a timely fashion whilst minimising the storage time of plant materials on site.
- Consideration must be given to selecting the method of installation for the substrate and planting layer that is most appropriate to the roof layout and the planned objectives of that particular roof.

Before commencing installation works, the integrity of the waterproof covering must be tested and approved (see 3.3.1). All drainage works, flashings etc should be finished prior to the application of the green roof covering.

4.2 INSTALLATION OF SYSTEM COMPONENTS

4.2.1 PROTECTION SHEETS, DRAINAGE LAYERS AND FILTER SHEETS

Protection sheets, drainage layers and filter sheets should be installed edge to edge across the entire roof area to be greened to ensure the waterproofing is protected and the drainage layer functions consistently. Due to the diversity of products available from the various green roof manufacturers/suppliers, it is recommended that specific installation advice is sought from the specified system provider to ensure compliance with manufacturer's recommendations.

4.2.2 SUBSTRATE INSTALLATION

Typically supplied in either small sacks (containing 25 litres and weighing 20 to 25kg each) or larger bulk bags (containing 1.25 m^3 and weighing 1.25 tonnes), the selection of one or the other or a combination of both packaging methods will depend on the roof size and/or access and lifting limitations. Generally, smaller projects suit sacks and large projects and/or multiple roof spaces suit bulk bags.

When supplied in bulk bags, the bags certification and fitness for purpose should be checked with the project's Health & Safety officer.

Care should be taken not to overload any area of the roof while uploading.

The choice of method for lifting the substrate up to the roof level and the subsequent dispersion across the roof has significant access, budgetary and scheduling implications. Typically, a crane is required for the duration of the installation of the substrate. Each project should be assessed for its specific conditions (i.e. access, hard

4 | GREEN ROOF INSTALLATIONS

standing, roof area, slope, structure, access, plant/ equipment availability, loading limits etc) to determine the safest and most timely/ cost effective installation method.

Some suppliers offer bulk deliveries via silos or tippers, which can offer economies of scale on large projects or overcome access restrictions. Deliveries made via silos allow the substrate to be immediately pumped onto the roof. Tipper loads can be pumped to the roof in stages.

Substrate should be applied to the required depth (including the appropriate settlement volume) using grading bars. Depth checking should be undertaken throughout the installation.

4.2.3 VEGETATION INSTALLATION

See Section 3.1.7 for Vegetation design considerations

The optimum periods to install green roofs are late September/early October or late March/early April as the cooler and wetter conditions will typically reduce the need (and cost) for irrigation to keep plants moist. Planting in late March/early April matches the natural growth periods for plants, facilitating the establishment of the green roof eco-system in harmony with nature.

Establishment watering

- Surface watering is required for all green roofs during the establishment period.
- Establishment watering is required until the plants or blanket have fully “rooted in” to the substrate.
- Plug planting and seeding is best carried out during the spring and autumn (in milder conditions).
- Installation at other time of the year is possible, however careful consideration should be given to the likely weather conditions and the higher risk of failure.
- Planting during periods of frost or drought should be avoided.
- Remember the plants used for green roofing are affected by the seasons in the same way as ground level plants.

4.3 INSTALLATION OF PERIMETER & PENETRATION DETAILS

Waterproofing details for perimeters (e.g. eaves, verge, ridge), drainage outlets, fire breaks, fall arrest system incorporation and penetrations (e.g. rooflights, flues) should be installed as per the relevant standard detail specific to the manufacturer’s system

To comply with Building Regulations and prevent the spread of fire into, or out from the building onto the green roof, a fire break of 500mm width is required around all vertical abutment’s i.e., higher storeys, parapet walls, rooflights, soil pipes, lift overruns etc. The fire break must consist of 20 - 50mm size rounded pebbles (fines free) to a minimum depth of 75mm placed directly onto the drainage board, or concrete paving stones that are minimum 40mm thick. There should be no growing medium/ substrate within the fire break area. To help maintain the fire break, a retention angle should be included between the growing medium and the pebble margin/ paving

At rainwater outlets GRO recommend a gravel margin is installed around the outlet consisting of 20 – 40mm rounded pebbles to a width of 300mm and a depth of 50mm together with an inspection chamber included to facilitate maintenance checks.

5 GREEN ROOF MAINTENANCE

5 | GREEN ROOF MAINTENANCE

All green roofs will require maintenance; it is important that access is considered at the design stage. Maintenance, should be conducted by qualified personnel This will help ensure the initial establishment and continued health of the green roof system. It is strongly recommended that the installing contractor remains responsible for the maintenance of the green roof during this establishment stage (between 12 - 15 months) and prior to the assignation of maintenance duties to the building owner's representative. Maintenance contractors, with specialist training in green roof care from organisations such as GRO, should be used where possible.

When designing a green roof, it is important that the green roof system is specified accounting for any budgetary constraints. The costs of roof maintenance should therefore form part of the life cycle cost analysis for the building, allowing the most appropriate green roof specification to be realised.

5.1 GENERAL MAINTENANCE ACTIONS

All maintenance actions carried out at roof level must be in full compliance with the appropriate health and safety regulations, and particularly those specifically dealing with working at height. BS 4428:1989 - Code of practice for general landscape operations (excluding hard surfaces) and BS7370-4:1993 Grounds maintenance - Part 4: Recommendations for maintenance of soft landscape (other than amenity turf) provide guidelines for maintenance actions.

5.1.1 IRRIGATION & WATERING

Irrigation is typically required for the initial establishment of the green roof for a period of 6 - 8 weeks depending on natural rainfall during this time. However, once vegetation cover is achieved, irrigation can be reduced.

All green roofs will need watering in periods of extended drought i.e. more than 6 weeks without any rain.

Care should be taken not to overwater green roofs, as this may harm the plants or overload the roof.

(See Section 3.6 and 4.2.3 for details).

5.1.2 FERTILISING

GRO does not recommend regular or high use of fertiliser on the low-nutrient growing mediums used on green roofs as they can encourage invasive weeds and grasses and may leach into the watercourse. Each green roof should be assessed prior to any addition of fertiliser.

Note: Fertiliser should be slow and long release, and only be applied if downpipes are isolated from mains sewage system.

Intensive and simple intensive roofs are based on a more fertile growing medium and the planting installed will require regular fertilisation.

5 | GREEN ROOF MAINTENANCE

5.1.3 GENERAL VEGETATION MAINTENANCE

- Always remove species with large growth habits or aggressive root systems.
- Any wind-blown seeds or cuttings should be removed before they have the opportunity to take root.
- Many grass species can be invasive and should be removed from extensive green roofs, unless designed into the planting scheme.
- The ecological and aesthetic requirements of the site should guide the management of dominant species and habitat over time.
- Cut back taller flowering species to approx. 150mm above substrate surface in autumn/ winter after seeding.
- Excess dead plant matter should be removed to avoid encouraging fungal disease. However, for maximum wildlife support, care should be taken not to remove all vegetation straight after flowering as many insects over-winter in hollow plant stems. For this reason, rotational cutting (where not all vegetation is cut simultaneously) and removal is advised.

5.1.4 GENERAL CLEARANCE/REMOVAL

Generally, the removal of dead material is desirable as it allows plants the space to develop a greater coverage, improving the finished appearance of the roof, whilst also reducing the risk of fungal disease forming and spreading. However, in some biodiverse applications, removing plant debris could be counter-productive in creating habitat.

5.2 MAINTENANCE ACTIONS BY ROOF TYPES

5.2.1 EXTENSIVE ROOF MAINTENANCE - < 100MM LOW NUTRITION SUBSTRATE

Irrigation: Post-establishment, irrigation is not generally required for extensive green roofs. However, the facility to water should be in place, if possible.

Fertilisation: Extensive green roofs typically have low nutrient requirements. If required, they can be fertilised on an annual basis, each spring, using a slow-release fertiliser.

Plant management: Removal of undesirable plant species and fallen leaves should take place twice each year. General: Drainage outlets (including inspection chambers) and shingle/gravel perimeters to be cleared of vegetation, twice yearly

5.2.2 BIODIVERSE ROOF MAINTENANCE – 80MM – 150+MM VERY LOW TO LOW NUTRITION SUBSTRATE

Irrigation: Typically, not required.

Fertilisation: Generally not required, particularly where indigenous species are being encouraged to replicate native habitats. Whilst a low vegetative density is common, zero vegetation is generally undesirable.

Plant management: A maintenance programme should be drawn up to follow the intended biodiversity objectives

General: Drainage outlets (with inspection chambers) and gravel/shingle perimeters should be inspected twice yearly and cleared of any living or dead vegetation.

5 | GREEN ROOF MAINTENANCE

Maintenance should take account of the intended wildlife support, in addition to standard green roof maintenance procedures. Care should be taken not to remove all vegetation after flowering as many insects over-winter in hollow plant stems.

5.2.3 DEEPER SUBSTRATE EXTENSIVE ROOF MAINTENANCE - 100MM TO 200MM LOW TO MEDIUM NUTRITION SUBSTRATE

Irrigation: Periodic irrigation/watering is expected, depending upon the plant specification and the climatic and microclimatic conditions prevailing at roof level.

Fertilisation: With a wider range of planting, using a more fertile growing medium, more regular fertilisation maybe required.

Plant management: Removal of undesirable vegetation on the greened area twice yearly.

General: Drainage outlets (including inspection chambers) and shingle/gravel perimeters to be cleared of vegetation, twice yearly.

5.2.4 INTENSIVE ROOF MAINTENANCE - 200MM + MEDIUM NUTRITION SUBSTRATES AND TOP SOILS

Irrigation: Regular irrigation is often required, subject to the plant specification and the climatic and microclimatic conditions prevailing at roof level.

Fertilisation: With a wider range of planting, using a more fertile growing medium, more regular fertilisation maybe required.

Plant management: The intensive maintenance of lawns, hedges, borders etc is required on a regular basis, so as to maintain the roof aesthetics. Undesirable vegetation should be removed from the green areas at least twice yearly. Failed plants should be replaced.

General: Drainage outlets (including inspection chambers) and shingle/gravel perimeters to be cleared of vegetation, twice yearly. Where excessive substrate settlement has occurred, this should be replenished.

5.2.5 BLUE ROOF MAINTENANCE

Inspection: Restrictor chambers; orifices & roof outlets.

Filtration: Particle filter cleaning/ replacement as required.

General: Observation or general roof condition and report of any remedial works required.

6 RELEVANT COMPLEMENTARY DOCUMENTATION

6 | RELEVANT COMPLEMENTARY DOCUMENTATION

6.1 BUILDING REGULATIONS

- The Building Regulations Approved Document B (2006 edition) Fire safety
- The Building Regulations Approved Document F Ventilation (1995 Edition, amended 2006) (F1-Means of ventilation, F-2 Condensation in roofs)
- The Building Regulations Approved Document Part H (2002 Edition) Drainage and waste disposal
- The Building Regulations Approved Document Part L1 (2010 Edition) Conservation of fuel and power in dwellings
- The Building Regulations 2001 Approved Document Part L2 (2010 Edition) Conservation of fuel and power in buildings other than dwellings
- The Building Standards (Scotland) Regulations 2004

6.2 BRITISH STANDARDS - BUILDING DESIGN

- BS EN ISO 6946:2007 - Building components and building elements. Thermal resistance and thermal transmittance. Calculation method.
- BS 8233:1999 - Code of Practice for sound insulation & noise reduction for buildings
- BS 5250:2002 - Code of practice for control of condensation in buildings
- BS EN 12056-3:2000 - Gravity drainage systems inside buildings. Roof drainage, layout and calculation.
- BS 7543:2003 - Guide to durability of buildings & building elements, products & components
- BS 8207:1985 - Code of practice for energy efficiency in buildings
- BS 8210:1986 - Guide to building maintenance management
- BS 8207:1985 - Code of practice for energy efficiency in buildings
- BS 476-3:2004 - Fire tests on building materials & structures. External fire exposure roof test
- BS EN 1363-1:1999 - Fire resistance tests. General requirements
- BS EN 62305-1:2006 - Protection against lightning. General principles

6.3 BRITISH STANDARDS - STRUCTURAL DESIGN

- BS EN 1990:2002 - Eurocode 0: Basis of structural design
- BS EN 1991-1-1:2002 - Eurocode 1: Actions on structures. General actions : Densities, self-weight, imposed loads for buildings
- BS EN 1991-1-3:2003 - Eurocode 1: Actions on structures. General actions : Snow loads
- BS EN 1991-1-4:2005 - Eurocode 1: Actions on structures. General actions : Wind actions
- BS EN 1991-1-6:2005 - Eurocode 1: Actions on structures. General actions : Actions during execution
- BS EN 1991-4:2006 - Eurocode 1: Actions on structures. General actions : Silos and tanks
- BS EN 1993-1-3:2006 - Eurocode 3: Design of steel structures. General rules. Supplementary rules for cold formed members and sheeting.
- BS EN 1995-1-1:2004 - Eurocode 5: Design of timber structures. General. Common rules and rules for buildings (and Appendix A1, 2008)
- BS EN 1997-1:2004 - Eurocode 7: Geotechnical design. Part 1: General rules.
- BS 6915: 2001 - Design & construction of fully supported lead sheet roof & wall coverings

6 | RELEVANT COMPLEMENTARY DOCUMENTATION

6.4 BRITISH STANDARDS - MAINTENANCE

- BS 7562-3:1995 - Planning, design & installation or irrigation schemes. Guide to irrigation requirements.
- BS EN 15099-1:2007 - Irrigation techniques. Remote monitoring & control system
- BS EN 15097:2006 - Irrigation techniques. Localized irrigation hydraulic evaluation
- BS EN 13742-1:2004 - Irrigation techniques. Solid set sprinkler system - selection, design, planning & installation
- BS7370-4:1993 - Grounds maintenance - Part 4: Recommendations for maintenance of soft landscape (other than amenity turf)
- BS 4428:1989 - Code of practice for general landscape operations (excluding hard surfaces)

6.5 HEALTH & SAFETY

- The Construction Safety and Welfare Regulations 1966 statutory no.1592 Regulation 6
- The Construction Design and Management Regulations 2007 (CDM)
- Fire Precautions (Workplace) Regulations: 1997 (As amended 1999)
- Control of Substances Hazardous to Health Regulations 2005 (COSHH)
- Work at Height Regulations 2005.
- BS EN 12811-1:2003 - Temporary works equipment. Scaffolds. Performance requirements and general design.
- BS EN 363:2008 - Personal fall protection equipment. Personal fall protection system
- BS EN 795:1997 - Protection against falls from height. Anchor devices. Requirements & testing
- BS 7887:2005 - Code of practice for the design, selection, installation, use and maintenance of anchor devices conforming to BS EN 795
- BS EN 516:2006 - Prefabricated accessories for roofing. Installations for roof access. Walkways, treads and steps
- BS EN 517:2006 - Prefabricated accessories for roofing. Roof safety hooks
- BS EN 1263-1 & 1263-2:2002 - Safety nets. Safety requirements, test methods and positioning

6.6 WORKMANSHIP

- BS 8000-4:1989. Workmanship on building sites. Code of practice for waterproofing
- BS 6229:2003. Flat roofs with continuously supported coverings. Code of practice
- BS 8217:2005. Reinforced bitumen membranes for roofing. Code of practice
- SPRA Design Guide 2020 Edition (SPRA 2020)
- LWRA Design Guide for Specifiers (2020)
- Code of Practice: Specification and Use of Liquid Applied Waterproofing Systems for Roofs, Balconies and Walkways (LRWA 2010)
- Code of Practice: Specification and Use of Hot Melt Monolithic Waterproofing Systems for Roofs, Balconies and Walkways (LRWA 2014)
- NHBC Technical Requirements, Chapter 7.1 (2020)

6 | RELEVANT COMPLEMENTARY DOCUMENTATION

6.7 BRITISH STANDARDS - METAL ROOFING SPECIFICATIONS

- BS 5427-1:1996 - Code of practice for the use of profiled sheet for roof and wall cladding on buildings - Design
- BS EN 501:1994 - Specifications for fully supported roofing products of zinc sheet
- BS EN 502:2000 - Specification for fully supported roofing products of stainless steel sheet
- BS EN 504:2000 - Specification for fully supported roofing products of copper sheet
- BS EN 505:2000 - Specification for fully supported products of steel sheet
- BS EN 506:2008 - Specification for self-supporting roofing products of copper or zinc sheet
- BS EN 507:2000 - Specification for fully supported products of aluminium sheet
- BS EN 508-1:2008 - Specification for self supporting products of steel, aluminium or stainless steel sheet - Steel
- BS EN 508-2:2008 - Specification for self-supporting products of steel, aluminium or stainless steel sheet - Aluminium
- BS EN 508-3:2008 - Specification for self-supporting products of steel, aluminium or stainless steel sheet - Stainless steel
- BS EN 988:1997 - Zinc & zinc alloys. Rolled flat products for building
- CP 143 - Code of practice for sheet roof & wall coverings
- BS 4868:1972 - Specification for profiled aluminium sheet for building

6.8 BRITISH STANDARDS - BITUMEN WATERPROOFING SPECIFICATIONS

- BS EN 13707:2004+A2 Flexible sheets for waterproofing. Reinforced bitumen sheets for roof waterproofing. Definitions and characteristics.
- BS EN 1928:2000 Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Determination of water tightness.
- BS EN 13583:2001 Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Determination of hail resistance
- BS EN 13416:2001 Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Rules for Sampling

6.9 BRITISH STANDARDS - PLASTIC & RUBBER WATERPROOFING SPECIFICATIONS

- BS EN 13956:2005 Flexible sheets for waterproofing - Plastic and rubber sheets for roof waterproofing. Definitions and characteristics
- BS EN 1928:2000 Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Determination of water tightness.
- BS EN 13583:2001 Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Determination of hail resistance
- BS EN 13416:2001 Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Rules for Sampling

6 | RELEVANT COMPLEMENTARY DOCUMENTATION

6.10 BRITISH STANDARDS - MASTIC ASPHALT WATERPROOFING SPECIFICATIONS

- BS 8218:1998 - Code of practice for mastic asphalt roofing
- BS EN 13948:2007 Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Determination of resistance to root penetration.

6.11 LIQUID APPLIED WATERPROOFING SPECIFICATIONS

- Code of Practice: Specification and Use of Liquid Applied Waterproofing Systems for Roofs, Balconies and Walkways (LRWA 2010)
- Specification and Use of Hot Melt Monolithic Waterproofing Systems for Roofs, Balconies and Walkways (LRWA 2014)
- Code of Practice: Design Guide for Specifiers issue 1, 2020 (LRWA 2020)

6.12 SINGLE PLY MEMBRANE WATERPROOFING SPECIFICATIONS

- BS EN 313-1:1996 - Plywood Classification
- BS EN 313-2:2000 - Plywood Terminology
- BS EN 636:2003 - Plywood Specifications
- BS EN 300:2006 - Oriented Strand Board (OSB): Definitions, classification and specifications
- Code of Practice: Design Guide for Single Ply Roofing (SPRA 2012)

6.13 BRITISH STANDARDS - INSULATION SPECIFICATIONS

- BS EN 13162:2008 Thermal insulation products for buildings. Factory made mineral wool (MW) products. Specification
- BS EN 13163:2008 Thermal insulation products for buildings. Factory made products of expanded polystyrene. Specification
- BS EN 13164:2008 Thermal insulation products for buildings. Factory made products of extruded polystyrene foam (XPS). Specification
- BS EN 13165:2008 Thermal insulation products for buildings. Factory made rigid polyurethane foam (PUR) products. Specification
- BS EN 13166:2008 Thermal insulation products for buildings. Factory made products of phenolic foam. Specification
- BS EN 13167:2008 Thermal insulation products for buildings. Factory made cellular glass (CG) products. Specification
- BS EN 13168:2008 Thermal insulation products for buildings. Factory made wood wool (WW) products. Specification
- BS EN 13169:2008 Thermal insulation products for buildings. Factory made products of expanded perlite (EPB). Specification

6 | RELEVANT COMPLEMENTARY DOCUMENTATION

6.14 GREEN ROOF GUIDANCE

- NHBC Chapter 7.1 2021
- British Standard BS EN 8616: 2019 Specification for performance parameters and test methods for green roof substrates
- Green Roof Organisation – GRO Fire risk guidance document 2018
- Green Roof Guidelines: 2011 Guidelines for the Planning, Construction and Maintenance of green roofs.
- Green Roof Guidelines: 2008 Guidelines for the Planning, Construction and Maintenance of green roofs.
- The SuDS Manual C753F – CIRIA 2015
- FFL (Forschungsgesellschaft Landchaftsentwicklung Landschaftsbau e.V.)

Photo: Bauder

7 GLOSSARY

Photo: Bridgman & Bridgman

7 | GLOSSARY

Biodiverse roof

A roof designed to create a desired habitat that will attract a particular flora and fauna.

Biosolar roof

A system of using green roof materials to hold solar photovoltaic panels in place.

Blue roof

A build-up of engineered layers to detain water on a roof.

Broof (t4)

Classification for roofs / roof coverings exposed to external fire.

Brown roof

Refers to a self-established green roof. No longer considered best practise (see Biodiverse Roof).

BS

British Standards formulated by the British Standard Institute (BSI).

Drainage layer/reservoir board

A layer of material to aid water removal or detention.

DIN Standards

Deutsches Institut für Normung which means “German Institute for Standardization.” DIN Standards are the published results of DIN’s work.

Extensive green roof

A lightweight, low-maintenance roof system.

Filter flee e/ fi es layer

Prevents fines and sediments from being washed out of the green roof into the drainage system.

FLL

Forschungsgesellschaft Landschaftsentwicklung Landschaftbau’s (German Landscape Research, Development and Construction Society).

Green roof

A roof or deck onto which vegetation is intentionally grown or habitats for wildlife are established, including: extensive, intensive and biodiverse roofs; roof gardens; biodiverse roofs; brown roofs; public and private amenity spaces.

Green roof plants

Plants chosen and cultivated for their resistance to the harsh conditions of a roof environment.

Green roof system

The component layers of a green roof build-up.

GRO

Green Roof Organisation: The Trade Association for green roof, blue roof and biosolar roof development and promotion in the UK.

Growing medium/substrate

An engineered lightweight soil replacement specifically designed for green roof.

HSE

Health and Safety Executive.

Hydro seeding

Spraying a specially designed blend of seeds and growing medium.

Inspection chambers

Enclosed container that allow access for inspection and maintenance.

7 | GLOSSARY

Intensive green roof

High maintenance version of a green roof sometimes called a roof garden.

Modular green roof

Green roof system consisting of off-site constructed and grown identical tray/panels/cassettes, which can be laid directly onto suitable waterproofing.

Protection layer

Layer designed to protect the waterproofing during construction and function of green roof.

Root barrier

A layer (membrane) designed to prevent roots from penetrating the waterproofing layer and building fabric.

Sedum

A genus of about 400 species of low-growing, leafy succulents that are wind, frost and drought tolerant and found throughout the northern hemisphere. Not all species are suitable for roofs.

Standard/traditional/conventional/grey roof

Un-vegetated and non-absorbent roofs i.e. asphalt, single ply, mineral felt, liquid applied, metal deck etc.

Stewardship

The long-term care of a green roof as an environmental asset.

Substrate/growing medium

An engineered lightweight soil replacement specifically designed for green roof.

SuDS

Sustainable Drainage Systems

Vapour barrier

A layer, typically a plastic or aluminium foil covered bituminous sheet, that resists diffusion of moisture through the building fabric.

Photo: Jenn Baxter

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