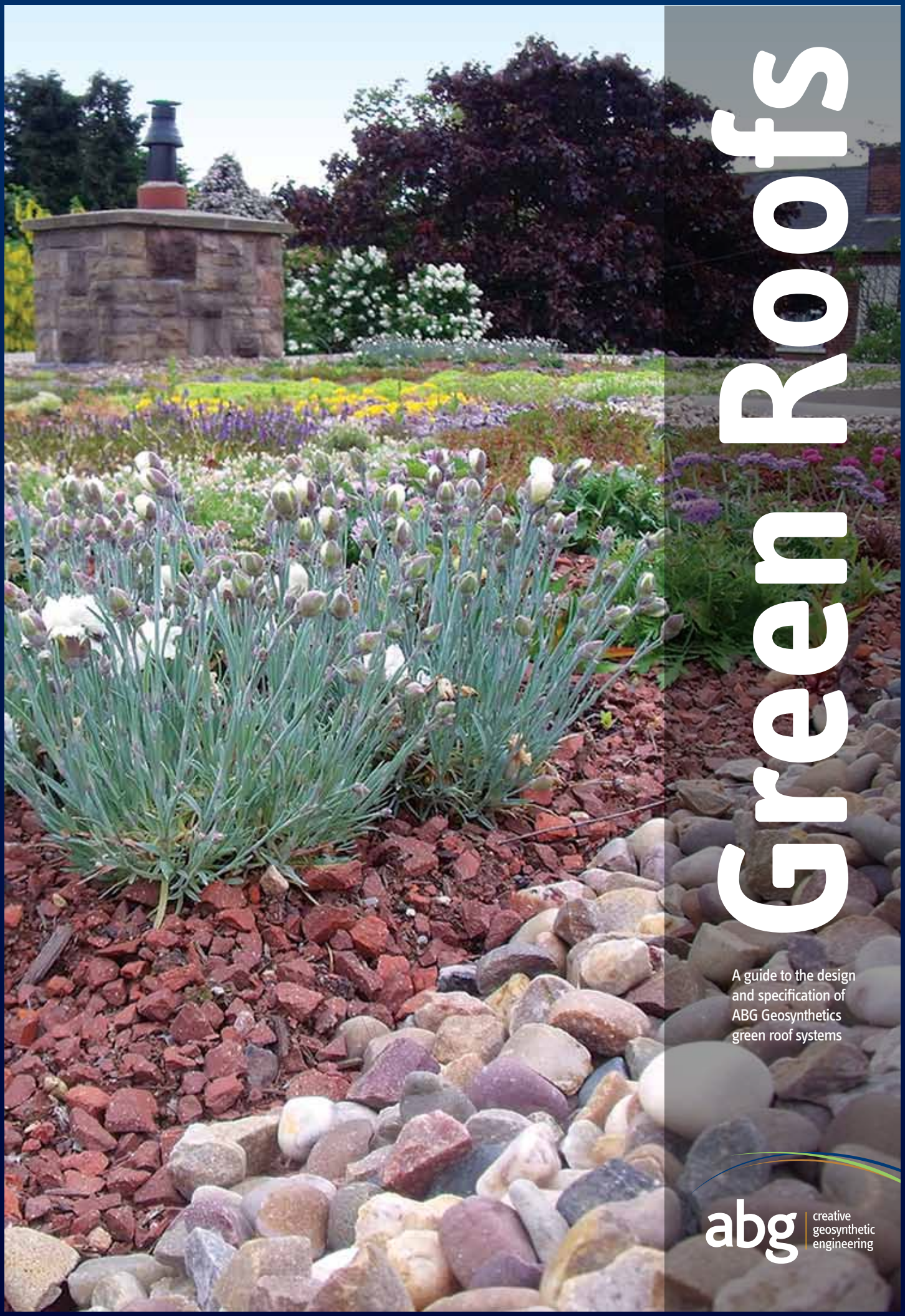


Green Roofs

A guide to the design and specification of ABG Geosynthetics green roof systems

abg creative geosynthetic engineering

Virtually any type of roof structure can accommodate a Green Roof, including domestic and commercial and on both new-build and retro-fit projects. The significant benefits of a Green Roof are wide ranging, such as helping to mitigate the effects of climate change, to whole-life cost benefits or by simply adding a natural aesthetic to an urban environment.

As much as 95% of rainfall on undeveloped land is naturally absorbed into the vegetated surface whilst the remainder runs off. Urbanisation and development of land creates hard impervious surfaces, which absorb only 5% of the rainfall leaving the remaining rainfall to run-off into both natural and man-made water systems which struggle to cope with the volumes. This has been highlighted in recent flooding events occurring all over the country.

Green roofs can play an important role in mitigating these events especially when designed as an integral element of a sustainable urban drainage system, also known as SUDs. In the future Green Roofs will be used to attenuate water, providing an alternative solution to SUDs tanks and helping reduce flooding in urban environments,

The next time you are thinking of incorporating a Green Roof system into a new or existing development don't hesitate to contact ABG Creative Geosynthetic Engineering directly and let us assist you through every stage of the process from design through to installation.

Contents

Intensive Green Roof on podium deck construction - Raithwaite Hall, North Yorkshire.

Added protection for the waterproofing layer

The build-up of a green roof helps reduce the impact of temperature fluctuations thereby reducing thermal stresses. A green roof protects the waterproofing by mitigating expansion and contraction whilst protecting the waterproofing from harmful UV rays and the effects of the freeze thaw cycle during winter months. This protection prolongs the life of the waterproofing to such an extent that many waterproofing companies will extended their warranties when an ABG green roof is installed.

Scoring BREEAM points

Improving the energy performance of buildings and embracing Green Roofs helps to meet standards such as the code for sustainable homes and BREEAM. It also helps to meet planning requirements and revisions in Part L Building Regulations. A development incorporating a Green Roof can earn up to 6.2 points on an Eco Homes score. It can also score substantial points for sections LE04 and LE05 using the ecology of the roof to enhance plant species, local biodiversity and water storage.

Reduces whole life costs

Typical roof installations have a life expectancy in the region of between 15 and 20 years. The building of a green roof system have been shown to have a life expectancy in excess of 50 years. The greatly improved life expectancy of a green roof means the costs over the whole life of the development are actually significantly lower than a traditional roof construction.

Green roofs as part of a SUDs solution

Urbanisation and land development creates hard impervious surfaces, which absorb only 5% of rainfall. The remaining 95% of the rainfall becomes run off. The result is that streams, rivers and ageing sewer systems cannot accommodate this huge influx, which in turn can cause severe flooding and erosion.

A Green Roof is an effective way to help attenuate rainfall as the vegetated surface allows infiltration into the roof build up. This solution benefits the environment by allowing developments to have a similar rainfall response to the natural land. In addition to this a Green Roof will function in areas where a SUDs tank will perform poorly e.g. clay, contaminated land, aquifers etc.

Aid planning consent

Although there are no regulations in place with regards to Green Roofs, many local authorities favour proposals that incorporate sustainable drainage systems.

Creates Amenity

A green roof can be used to create an amenity that the building occupiers can use and enjoy. Typical amenities within green roofs can include playgrounds and play areas, ornamental gardens or areas in which fruit and vegetables can grow.

Mitigating the Urban Heat Island effect

City centres are known to have higher temperatures than surrounding rural areas. This is due to a number of factors, many of which are linked to the specific heat and impervious nature of city surfaces such as concrete, tarmac and traditional membrane roofs. This is known as the Urban Heat Island Effect.

Including a Green Roof allows the heat generated by the building to be drawn into the cool roof construction and then dissipated more readily to the environment than with traditional roof constructions.

Creates Habitat

Green Roofs help create a living habitat for small wildlife and a wide variety of plant species. This is particularly useful when a development has taken some previous existing habitat, as the creation of new space on the roof can be used to offset the environmental impact of this. Also, whilst the formation of specific engineered habitat areas is possible, simple practices, such as including rocks and logs within the design, are often equally as effective in reaching the end result.

Insulation

It has been proven that Green Roofs have a cooling effect in summer, reducing air conditioning load and we are currently working with University of Sheffield on a research project to determine the level of insulation provided against heat loss in winter.

Green Roofs currently rely on an insulating layer to meet specification. This specification is on a project specific basis to ensure the building regulations regarding thermal insulation are met using the green roof. We work with leading UK insulation manufacturers to ensure the thermal requirements are met using the minimum thickness of material.

Noise reduction

A Green Roof is very good at reducing low frequency sounds, an extensive Green Roof can insulate up to 40dB and an intensive Green Roof can insulate up to 50dB. This can make a noticeable difference especially near airports.

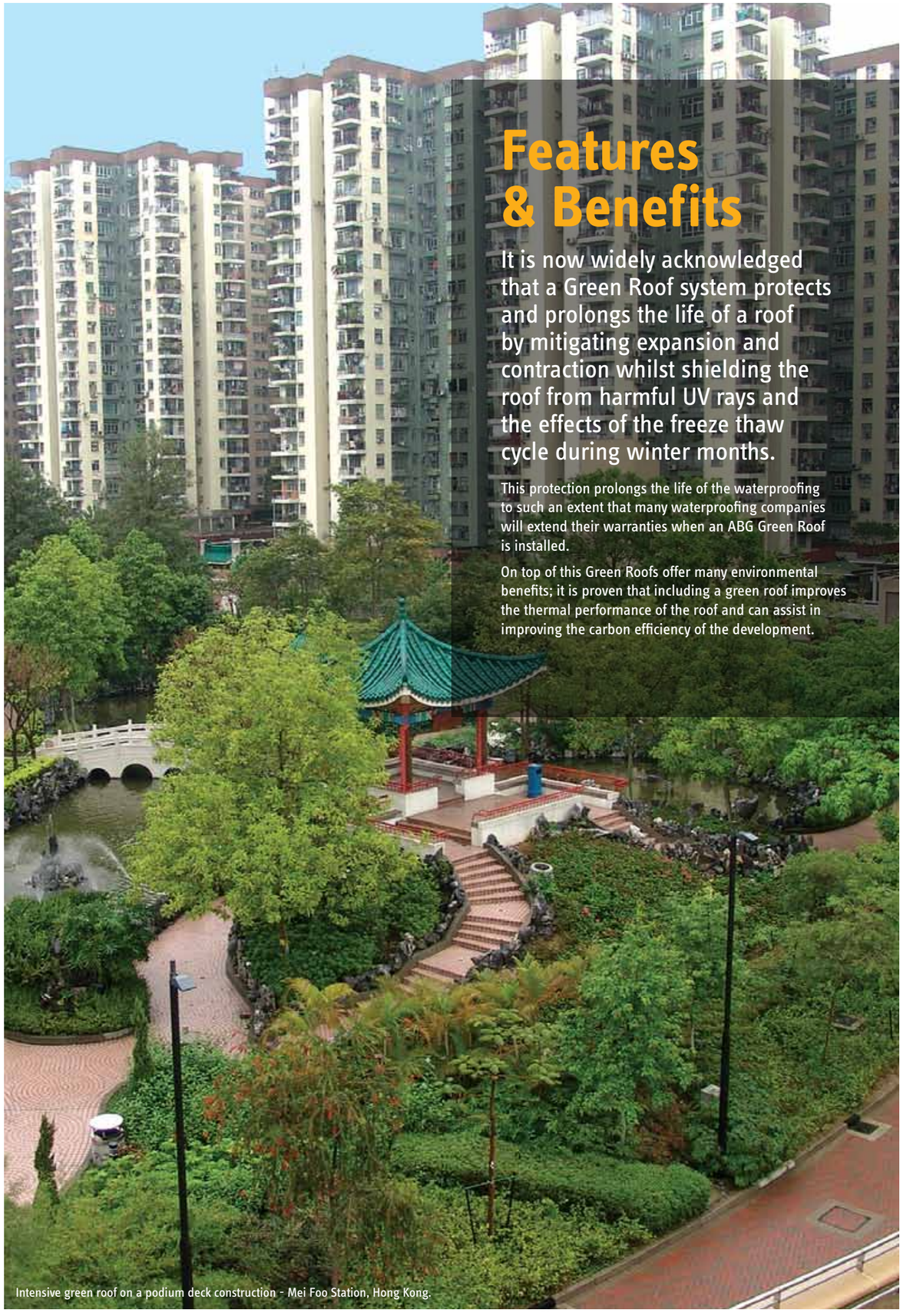
Extracts pollutants

The vegetation, growing media and filtration fabrics within the green roof construction helps filter dust and pollution from the air and rainfall thus reducing the amount of chemicals and pollutants that reach the river networks.

Water discharged from a green roof is proven to be cleaner than the precipitation from which it fell. In many cases the water is clean enough to be collected and used for irrigation and even for grey water applications such as toilet flushing.

Aesthetics

Green roofs can be used to allow the creation of a ‘green bridge’ through the built environment. This not only helps with the aesthetics of the area but also allows the natural flow of flora and fauna through urban developments.



Features & Benefits

It is now widely acknowledged that a Green Roof system protects and prolongs the life of a roof by mitigating expansion and contraction whilst shielding the roof from harmful UV rays and the effects of the freeze thaw cycle during winter months.

This protection prolongs the life of the waterproofing to such an extent that many waterproofing companies will extend their warranties when an ABG Green Roof is installed.

On top of this Green Roofs offer many environmental benefits; it is proven that including a green roof improves the thermal performance of the roof and can assist in improving the carbon efficiency of the development.

Intensive green roof on a podium deck construction - Mei Foo Station, Hong Kong.

Extensive Green Roofs

Extensive green roofs are the most common type and characteristically consist of a shallow layer of growing media; typically between 60mm and 120mm deep. This is planted with a variety of drought tolerant hardy plants.

This type of roof is relatively self-sufficient; they are not designed or constructed with the intention of being trafficked by pedestrians. Whilst not providing any kind of amenity area they do contribute to improving air quality, reducing the visual impact of the roof and assist in controlling rain water run-off/ harvesting as well as contributing to the acoustic and thermal properties of the roof.

Because access to the roof tends to be limited other than for annual maintenance, the choice of vegetation should be selected with this in mind with low maintenance planting such as sedums and indigenous species recommended.

Growing Media

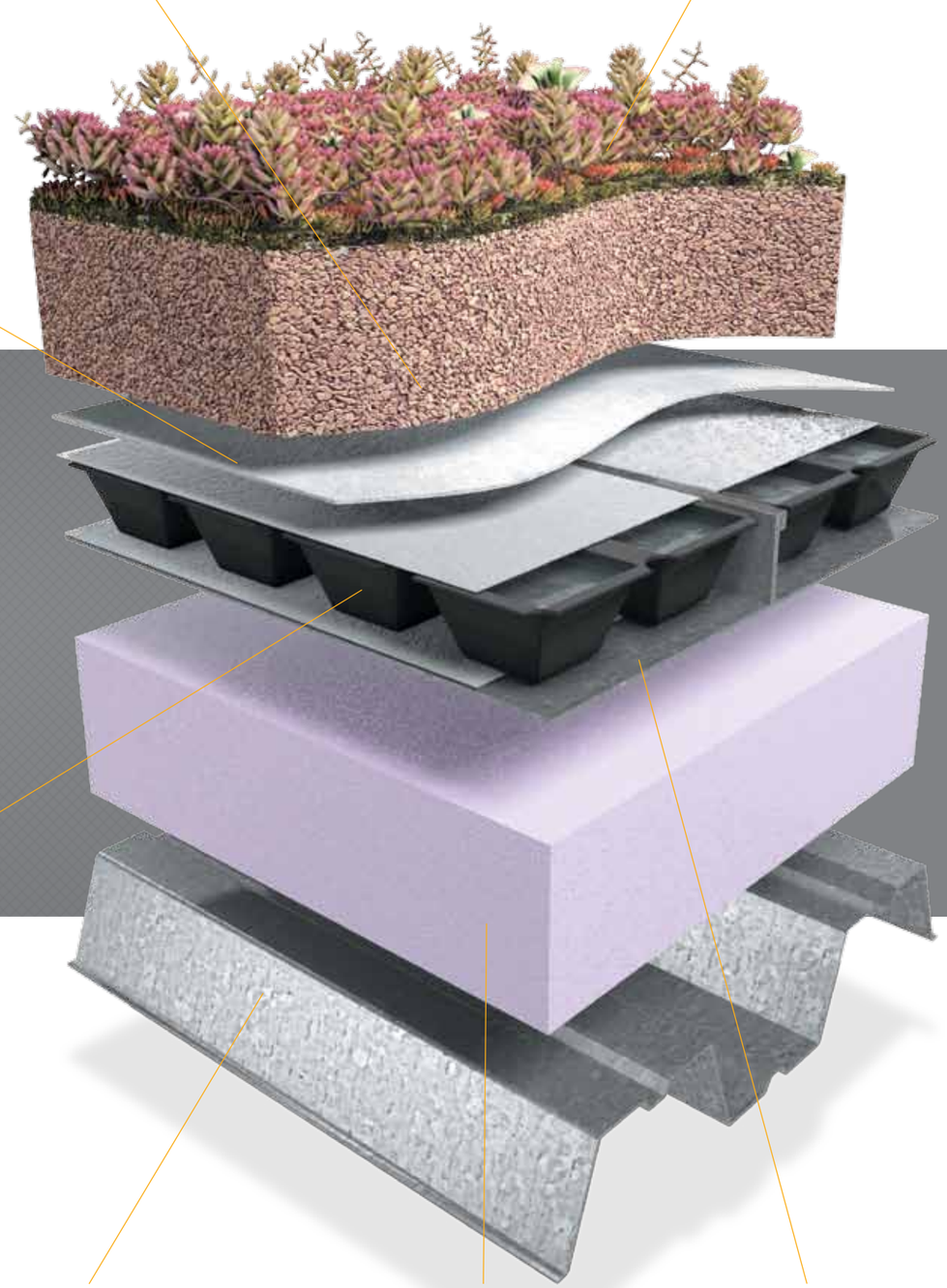
ABG peat free media derived from sustainable, 100% recycled, UK sourced materials. Using a specifically developed growing media can help provide the right growing environment for the selected vegetation and also reduce the load on the roof.

Vegetation

Specifically selected to suit the final finish requirements of the client/end user. On Extensive green roofs low maintenance varieties such as mosses, herbaceous plants, sedums wildflowers and grasses tend to be used.

Geotextile Filter Fabric

Laid beneath substrate to prevent fines filtering through to voids below.



Roofdrain

Forms a lightweight high performance drainage layer with integrated filter geotextile. Using Roofdrain allows for the collection and storage of water to irrigate the plants during low rainfall periods whilst providing a continuous drainage layer across the roof structure. In this system it is shown as strip specifically developed to be positioned between the standing seams.

Roof Deck

In this instance illustrated as a profile metal deck but other systems can be used.

Insulation

Specified to meet thermal requirements of the roof structure.

Waterproofing

Illustrated as a Standing Seam System.

Intensive Green Roofs

Sometimes referred to as roof gardens, an intensive green roof can be as simplistic or as complex as the client requires. Generally speaking an intensive green roof requires the same level of care as any traditional garden.

Intensive green roofs consist of a deep layer of engineered growing media, typically 150mm to 1500mm. As a result of this soil depth there is a greater scope of planting available and the roof can be viewed very much like a garden area and may be landscaped to include trees, lawns, flower beds and paved areas. With an intensive roof the only real limit to its scope is the weight of the system and the structure necessary to support it.

Many modern developments incorporate landscaped roofs at ground level, for example above basement areas and underground car parks. These are commonly referred to as podium decks. The decked areas themselves create additional usable space in urban developments. For large areas it is imperative that consideration is given to the provision of adequate sub-surface drainage.

Engineered Growing Media
ABG peat free media derived from sustainable, recycled, UK sourced materials. Using a specifically developed growing media can help provide the right growing environment for the selected vegetation and also reduce the load on the roof.

Vegetation/surfacing
Specifically selected to suit the final finish requirements of the client/ end user. On Intensive green roofs a wide variety of vegetation can be used from grasses to shrubs and trees as well as hard surfacing such as pavers and block paving.

Deckdrain
Forms a lightweight high performance drainage layer with integrated filter geotextile that eliminates clogging within the drainage structure that provides a continuous drainage layer across the structure.

Root Barrier
The GRO Best Practice Guide for Green Roof Construction recommends, for some roof types, the inclusion of Root Barrier above the waterproofing.

Waterproofing
Waterproofing layer specified according to project requirements and roof type.

Roof Deck
Roof deck specified by others to meet project requirements and roof type.

Biodiverse Roofs

A roof which is commonly used where the vegetation is intended to replace or replicate the existing site habitat. With an increasing number of developments being undertaken on brownfield land the use of biodiverse roofs can partly mitigate the loss of habitat on development sites.

This type of roof may be seeded like both the intensive and extensive varieties or can be allowed to self-colonise; however, seeding increases the biodiversity potential of the roof in the short term. Biodiverse roofs often include areas of logs and rocks to try and create habitat to suit colonisation by as broad a band of species as possible, because of this they are referred to as 'brown' or 'rubble' roofs.

Maintenance is similar to that of an extensive green roof; minimal maintenance is required. Aggregate and vegetation choice determined by the biodiversity objective the client would like to achieve.

Engineered Growing Media

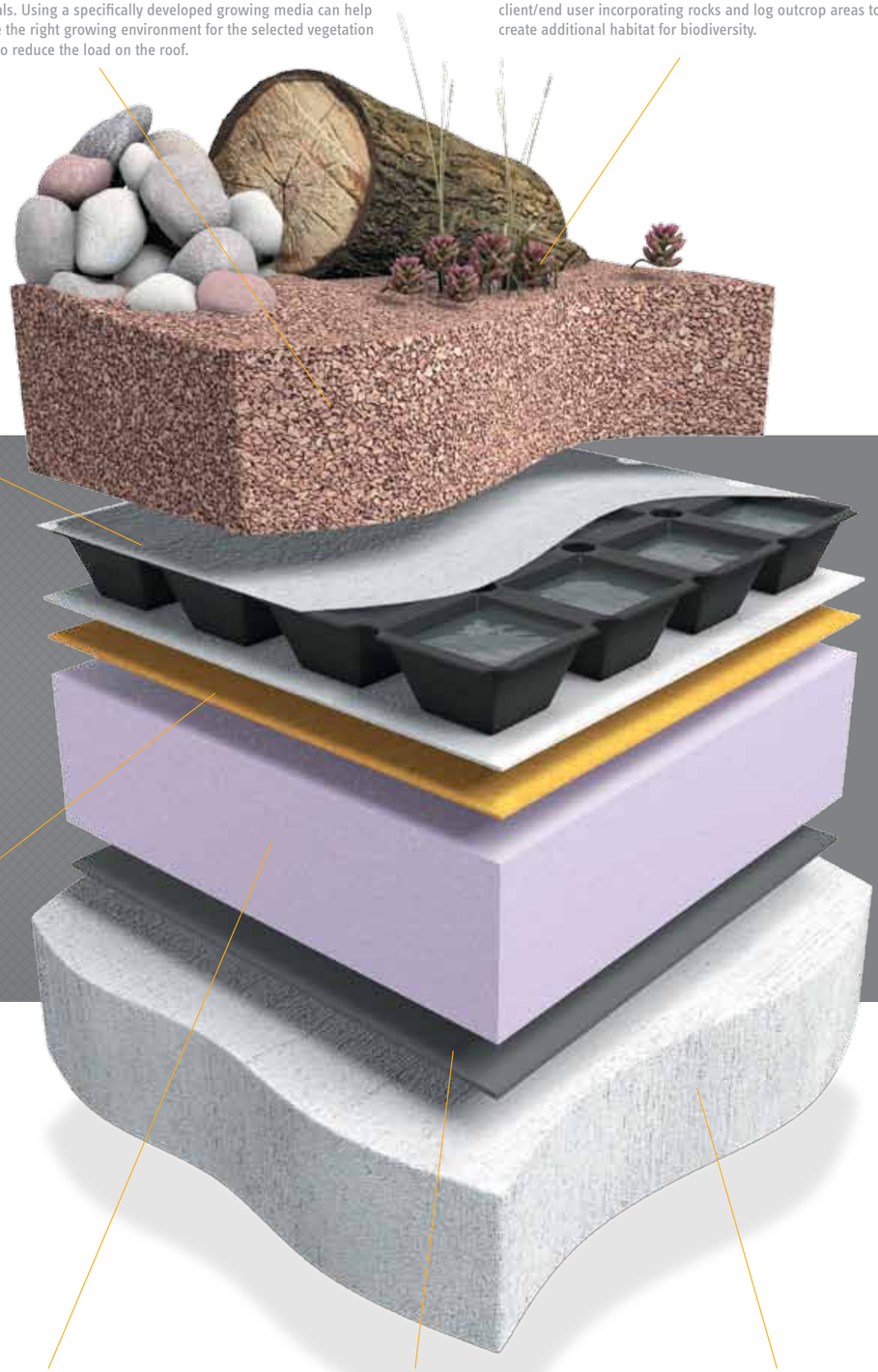
ABG peat free media derived from sustainable, recycled, UK sourced materials. Using a specifically developed growing media can help provide the right growing environment for the selected vegetation and also reduce the load on the roof.

Vegetation/surfacing

Specifically selected to suit the final finish requirements of the client/end user incorporating rocks and log outcrop areas to create additional habitat for biodiversity.

Roofdrain

Forms a lightweight high performance drainage layer with integrated filter geotextile. Using Roofdrain allows for the collection and storage of water to irrigate the plants during low rainfall periods whilst providing a continuous drainage layer across the roof structure.



ABG Slimline Membrane

High performance non-woven polyethylene barrier that resists the passage of water but is vapour permeable.

Insulation

Specified to meet thermal requirements of the roof structure.

Waterproofing

Waterproofing layer specified according to project requirements and roof type.

Roof Deck

Roof deck specified by others to meet project requirements.

Access & Maintenance

The British Standards Institution state that all new builds must provide access to the roof area to enable a minimum of two inspections per year, so working at height regulations must be considered. If a building is of a height which can cause an injury from a fall, including roofs under 2m, then edge protection is required.

Even though extensive Green Roofs are relatively self-sustaining, they still require some form of maintenance. ABG recommend this should be dealt with in the form of a maintenance contract. Maintenance for extensive roofs will typically be required twice in the first 12 months, then once annually thereafter. Therefore the overall cost of maintaining a Green Roof can be relatively minimal.

Drainage & Water Retention

Drainage and water retention are key elements to consider when designing a Green Roof. The specific type is entirely dependent upon the proposed landscaping element. Ensuring adequate water retention/drainage requirements are met aids the long-term survival of the vegetation and prevents pooling.

Geographical Location

Geographical location and orientation are also an important part of designing the roof. Which area of the country, the amount of average rainfall in that area and the prevalent wind direction determines the type of uses and needs for the Green Roof. Biodiversity and drainage are then designed into the roof from these requirements. The direction in which the roof faces and amount of sunlight the roof receives helps to determine the types of vegetation for a successful roof.

It is worth noting that green roofs in coastal locations require particular attention in order to ensure any vegetation specified is hardy enough to withstand the specific conditions.

Structural Loadings

The introduction of a Green Roof will have loading implications for the building. It is vital to consult a structural engineer at an early stage especially when designing for a SUDS solution where water may be stored within the roof structure. This will enable you to determine any constraints you may be under and in turn help decide which type of Green Roof system to implement.

Compressive strength

A design consideration more prevalent in podium deck applications is the compressive strength of the drainage layer. The structural requirements of these systems are commonly misinterpreted with erroneous descriptions such as 1000kPa are sometimes mentioned. This is significantly greater than the requirements of the roof and indeed most roofs do not need anything over 150kPa.

Roof Angle

Contrary to popular believe Green Roofs can be constructed on sloping roofs. It is worth bearing in mind that once the angle is over twenty degrees both installation and maintenance may start to become increasingly complex.

Cost

When taking into account factors such as the whole life cost of the building, the reduction in other infrastructure such as stormwater tanks, and the extension in the life of waterproofing membrane, extensive Green Roofs typically provide a positive cost benefit.

As opposed to having a 'one system fits all' approach, our supply chain enables us to put forward bespoke systems to help meet the needs of the client, on time and within agreed budget.

Green roofs and food production

It is becoming increasingly common on a local and domestic scale for the green roof to be utilised for the cultivation of fruit and vegetables. This can be done without affecting the structure of the green roof beneath and can yield good results.

Thermal Performance

Any green roof needs to meet the building regulations required to achieve the thermal performance. At the moment the green roof build up cannot be considered as part of the roof build up when calculating thermal performance so insulation specification must be done as per a standard roof.

However, research shows that the introduction of layers of drainage, growing media and vegetation have an impact on the thermal performance and can offer additional benefits on the development including cost benefits and reducing the carbon footprint.

Sound Insulation

Including a green roof can reduce noise levels inside the development by providing additional acoustic protection against rainfall, wind noise and low decibel frequencies.

Water Attenuation

A Green Roof can be designed to provide rainwater storage and form part of the SUDs requirement on the site. This can replace the below ground storage tank of particular interest on sites with tight land use (See pages 18-19).

Fire

There is a misconception about the risks of fire and how this affects the design of a Green Roof. There is less risk of a green roof catching fire than a standard roof.

A minimum firebreak of 300mm is required round penetrations and edges and for continuous runs a maximum length of 20m is permitted followed by a 500mm break.

Aesthetics

It is important to consider the appearance of the selected Green Roof system both in the short term & long term. Planting should be tailored to suit the desired end result.

A wide variety of plants are suitable for green roof planting schemes; mosses, sedums and grasses for Extensive though to deeper rooted shrubs and trees and even fruit and vegetables for Intensive Roofs. The decision is entirely dependent on the roof finish required.

Design Considerations

A Green Roof is a complex structure that requires careful consideration throughout the design process in order for it to exist both as a waterproof roof and a complex living ecosystem.

Function, location and aesthetics all have a direct effect on the design of the roof with the final solution varying from development to development to meet the clients exact requirements

Beneath the green element the roof still has to fulfil its primary role in keeping the elements out of the building throughout its design life. Careful design of the structural elements is required to ensure the Green Roof survives all that the natural world can throw at it.

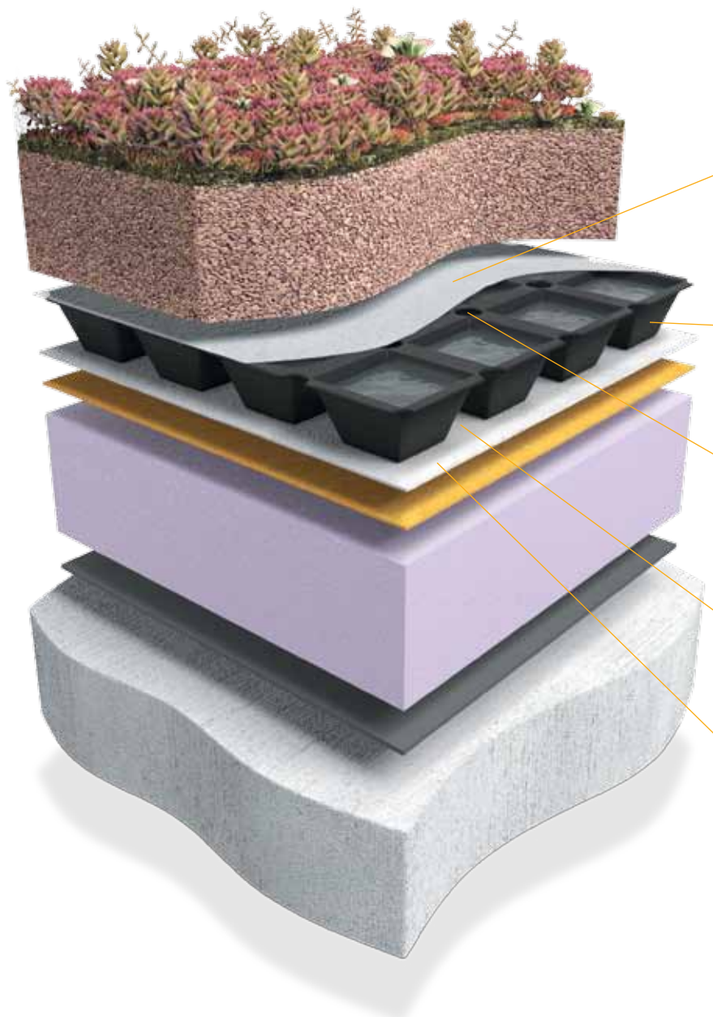
Biodiverse Roof on Staffordshire County Council Offices - Staffordshire.

Roofdrain

The design of intensive green roofs requires a structural drainage layer (Deckdrain); by contrast the modern method of an extensive green roof requires a combination of efficient drainage and water attenuation in order to allow the ecology to flourish.

Roofdrain allows the storage of water within the nodes of the of the HDPE core whilst facilitating the efficient drainage of any excess water away from the roof. This helps prevent the root growing media from drying out during dry periods and from becoming waterlogged during wet periods.

When used within a roof construction Roofdrain provides a versatile system for the collection of surplus seepage water at the base of the growing medium and for the prevention of water pressure on the structural waterproofing.



Filter Geotextile
Filter geotextile allows free drainage of water into the core.

Attenuation Void
Wells formed by cuspates of core allow for water storage to feed plants during periods of low rain fall.

Perforations
Perforations in core allow free passage of surcharge water into drainage channels.

Drainage Channels
Channels in core allow free lateral drainage of water to discharge outlets.

Protection Geotextile
Protects underlying elements from damage.

	Thickness	Reservoir Capacity (l/m²)	Typical Applications
Roofdrain 20	20mm	5.5	Below substrate layers 75mm down including extensive and brown roofs.
Roofdrain 25	25mm	4.3	Standard grade product. Below substrate layers 150mm down including extensive and brown roofs. It is particularly useful on pitched roofs due to the profile of the cone shaped cuspates.
Roofdrain 40	40mm	12	Used to store additional rainwater allowing greater diversity of vegetation.
Roofdrain 60	60mm	23	Used to store large volumes of rainfall and significantly reduce run-off.

For further information of Roofdrain visit www.abgltd.com/roofdrain

Deckdrain

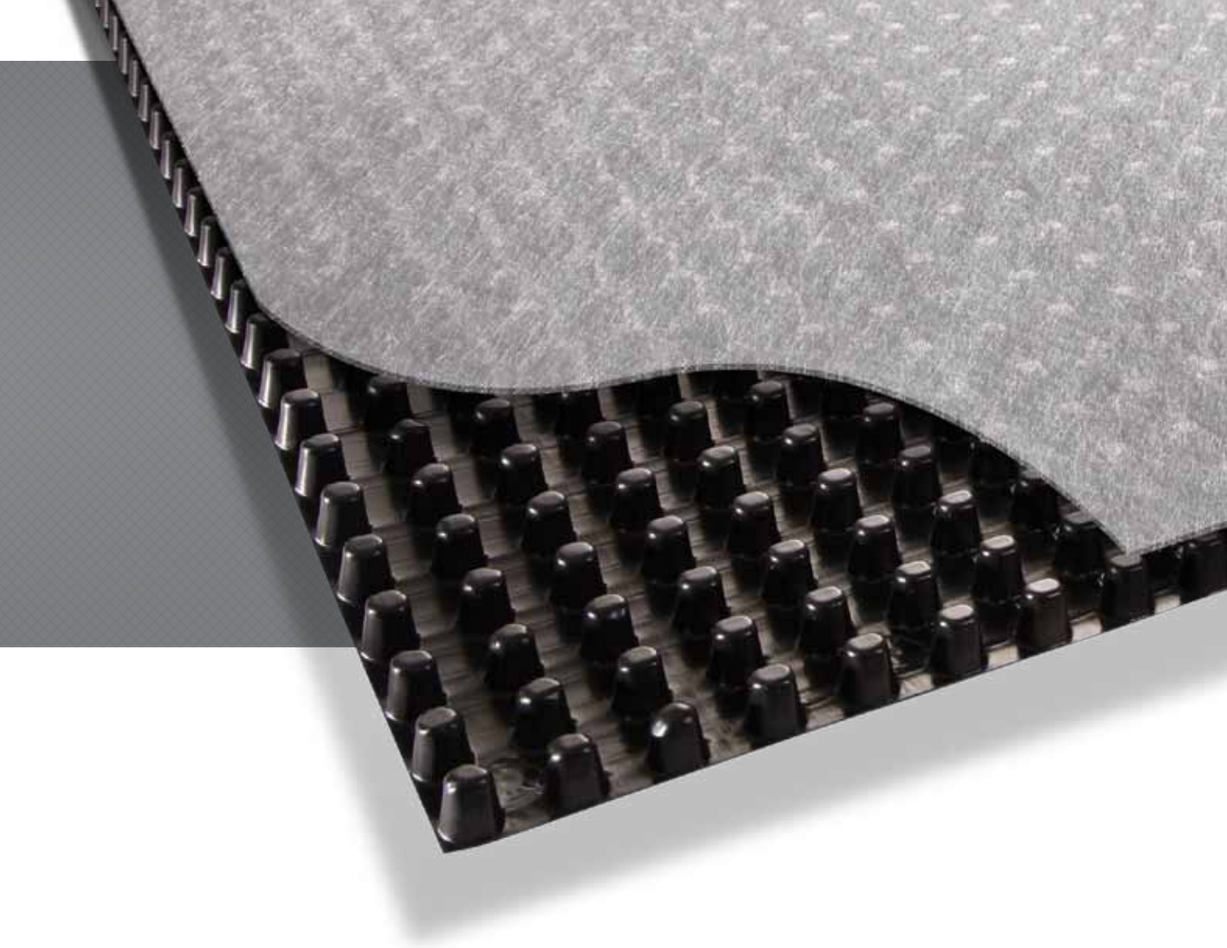
Deckdrain consists of a combination of a cuspated core with a geotextile fleece bonded to the upper face.

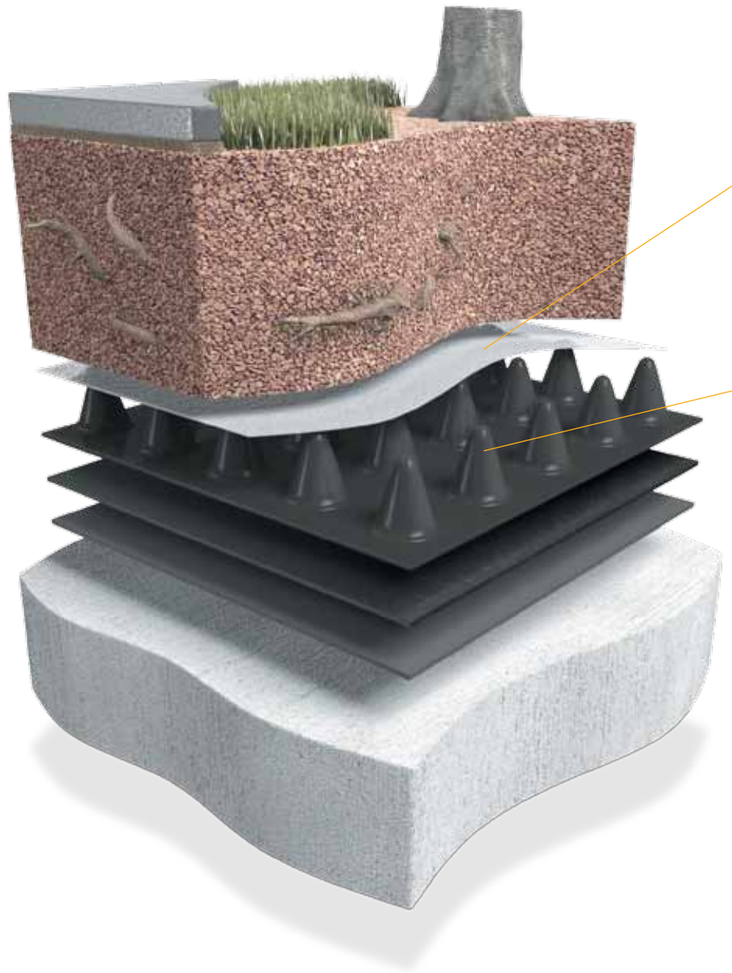
Deckdrain is manufactured from up to 95% recycled material bonded to the upper face. Deckdrain is manufactured within the UK, making it an environmentally sound choice.

Deckdrain provides excellent drainage over the whole base area of the soil layer as well as providing additional waterproofing protection. With more emphasis on reducing the amount of carbon used in construction, recycled materials can provide additional environmental benefits.

Intensive Green Roofs have a deeper layer of growing medium than extensive roofs. This increased depth has a greater capacity to retain water making it less likely to dry out. Utilising a drainage composite such as Deckdrain, reduces the risk of over saturation of the plants during periods of heavy rainfall.

The high strength core used in Deckdrain allows the product to be used in high load areas such as on podium decks with vehicular traffic.





Filter Geotextile
Filter fabric allows free drainage into core whilst preventing intrusion of over fill materials.

Drainage Core
High strength drainage core allows factory constant drainage capacity and protects waterproofing layer.

	Thickness	Flow Rate*	Puncture Resistance	Typical Applications
Deckdrain 700	7mm	0.67	2400N	Smaller podium decks and car parks where outlets are closely spaced.
Deckdrain 1200	12mm	1.25	2300N	Larger podium decks and car parks where outlets are less frequent.
Deckdrain 2500	25mm	4.30	4800N	Applications where large volumes of water will be travelling over large distances in podium deck and green roofs.
Deckdrain 5000	50mm	29.00	N/A	Used as part of the SUDS attenuation system detailed on page 19.

*Flow rate determined at HG=0.1 and under 20kPa load which represents the hydraulic gradient typical to a horizontal roof construction. For further flow figures, including at HG=1 - vertical, please contact technical sales for the latest Deckdrain datasheet.

For further information of Deckdrain visit www.abgltd.com/deckdrain

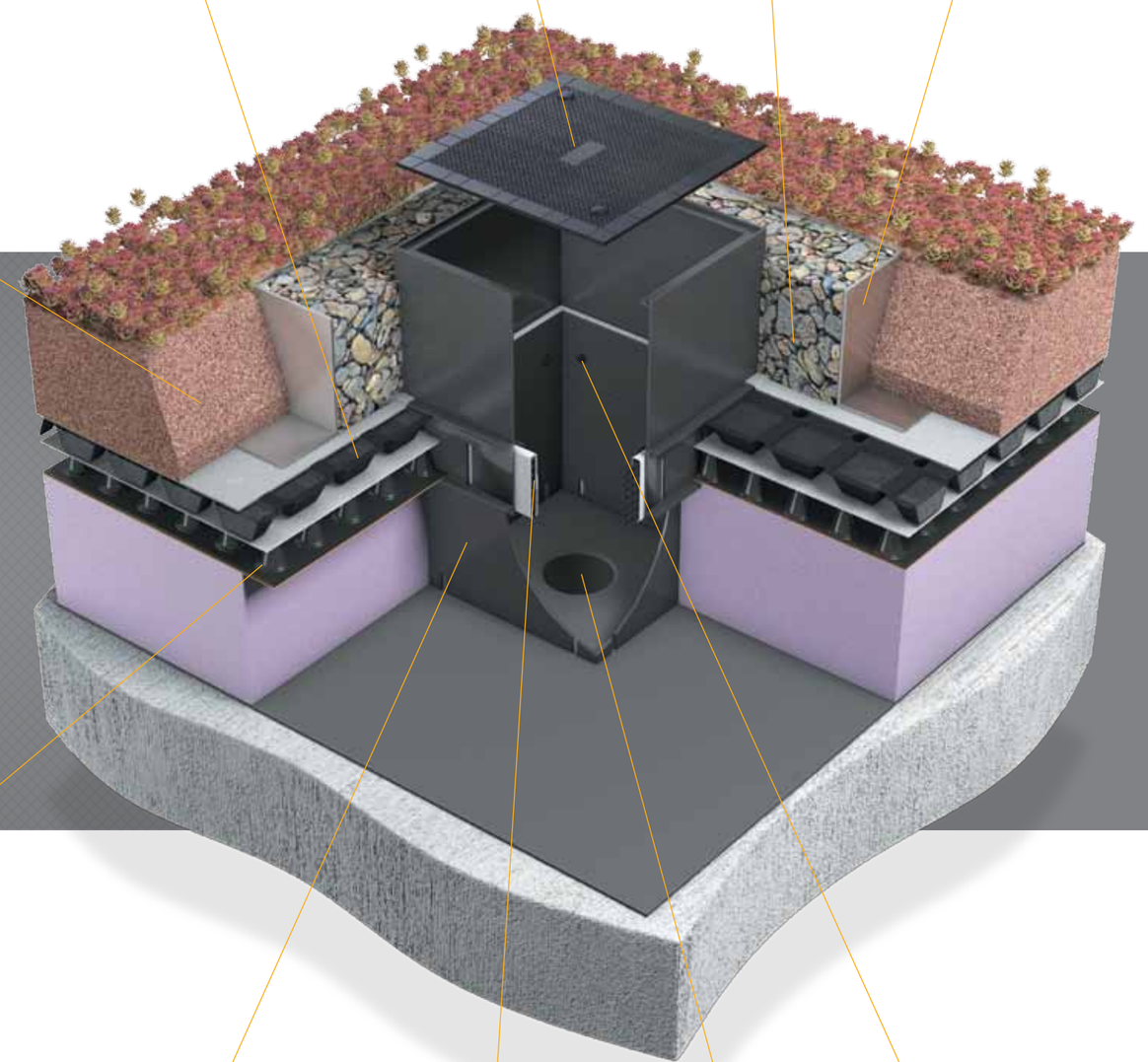
Blue Roof System

ABG Blue Roof System has the ability to provide a SUDS attenuation solution for a development. The geocomposite, water attenuation and substrate layers are specifically designed with enhanced water storage capacity in built and the discharge is controlled using a patented outlet designed specifically for this function. Designing a green roof in this way allows storage capacities suitable for a one in a hundred year storm event to be achieved. This stored water, as with a 'traditional' storage system, can be released at controlled rate or even used as grey water or irrigation for the vegetation across the development.

The ABG Blue Roof System consists of 3 key components. A 2 tier drainage geocomposite system, comprising layers of Deckdrain and Roofdrain, integral filter geotextiles and a series of Restrictor Chambers.

Excess water not absorbed by the vegetation, filters through the green roof and builds up in to the drainage void formed by the geocomposite layers below. This water is gradually dispersed through the system to the Restrictor Outlet Chamber and discharged to the roof outlet at the rate permitted for the site.

The storm water attenuation requirements are met within the roof construction, therefore the need for underground storage can be eliminated. The benefits to the overall project include the removal of the disruption, time and cost of installing an underground tank. Placing the storage within the footprint of the building also has advantages in heavily urbanised developments where external space is at a premium and on site working space and materials storage is limited. This reduction in material movements also helps reduce the carbon footprint of the project.



Growing Media

ABG Sedum Roof Mix

Based on 5-14mm grade brick/tile and 10-25mm green compost. It has very low nutrient content and is engineered specifically for sedums, alpines and low growing drought tolerant plants.

ABG Lawn Roof Mix

Based on a 2-5mm brick/tile and a 0-10mm green compost and sterilised soil. It is a medium nutrient mix designed to support lawn turf and garden shrub planting.

ABG Meadow Roof Mix

Based on a 2-5mm grade brick/tile and 0-10mm green compost. With enough nutrients to support a broader range of plant species ranging into wildflowers and meadow grasses.

ABG Sedum Lite Mix

Light-weight green roof media based on Vitag, an ultra-light, durable, granular clay aggregate manufactured in the UK to an exacting specification.

Vegetation

Pre-grown Mat

A vegetation layer where the material is grown to maturity, rolled up and supplied in the form of a mat. This can be either sedum, turf or meadow plants to create an instant green effect.

Plug Planting

Ideal for smaller projects, involving planting species like sedum & wildflower; typically 10–20 per m^2. For fuller cover, incorporate cuttings or simply increase the number of sedums per m^2.

Self-vegetated

The roof structure is left to vegetate via natural processes. The plant species will be uncontrolled and need checking to ensure no species appear that may damage the underlying structure.

Food

Green Roofs can be used for the cultivation of fruit and vegetables including lettuce, onions and strawberries. Below is a picture of fruit and vegetables grown on our own warehouse roof.

Growing Media & Vegetation

The growing media used in Green Roof projects can be designed specifically to suit each project and this can be varied to meet the requirements of the vegetation and surrounding ecosystem.

The growing media can range from low nutrient site specific medium, such as a limestone mix for calcareous grasses and plants, to a composted nutrient mix to support geophytes such as snow drops, daffodils, herbaceous plants and other native perennials.

Plant choice should take into account factors such as air pollution levels, location, structural limitations of the building, and the level of maintenance required. The choice is also dependent upon what the client wants to achieve.

The most common mix for extensive Green Roofs is a free draining formulated layer consisting of organic, inorganic, mineral and recycled components. Sometimes sintered clay, leca or slate is added to aid the absorption of rainwater. This material is lightweight and helps minimise weight on the roof structure.

The most common mix for intensive Green Roofs is a denser and slower draining substrate. This consists of both organic and synthetic materials, which simulate a topsoil type material; this can support a wider variety of vegetation.

Extensive Green Roof - Student accommodation, Oxford

Erosion Control

These products cover a broad section of erosion control requirements including biodegradable or non-biodegradable and pre-seeded varieties. ABG erosion control products can help with both the surface protection and the structural stability of soil slopes.

Silt laden run-off from exposed soil slopes is a major concern or the Environment who consider it to be a pollutant; ABG erosion control products help ensure that the slope is protected from through construction to the final vegetation being established.

As with all ABG products design advice on which materials are best for your individual application and their specification is available from our experienced technical department.

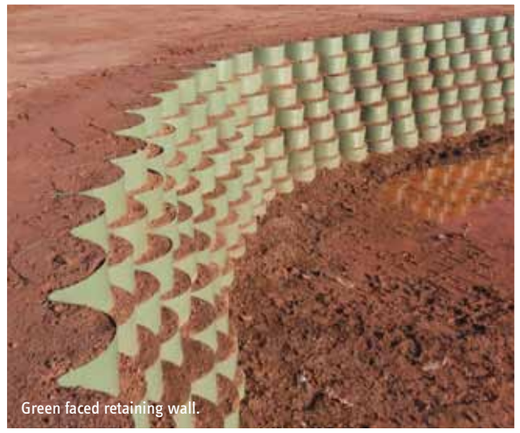
Installing Erosaweb for top-soil retention on steep embankment.

Retaining Walls

We first became involved in designing retaining walls through reinforced earth over twenty years ago when we developed and launched our own range of ground engineering solutions.

This included Webwall, our own cellular retaining wall system developed as a sustainable green wall solution.

As the number of Webwall projects grows in both number and physical size so does our knowledge on utilising the system. Today ABG are in position to offer full PI covered design, material specification and supply, including advice and specification of the drainage works and then, through carefully selected partner businesses, the installation of the Webwall right through to planting the face with the right plants for your project environment.



Green faced retaining wall.

Structural Drainage

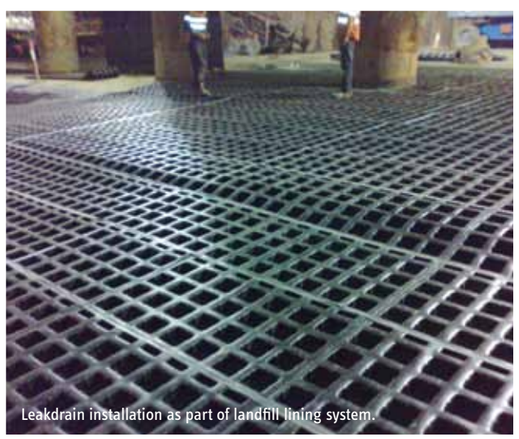
ABG have vast experience in drainage solutions and the systems have been used globally on major projects in a wide range of sectors including infrastructure, energy, water, waste and many other sub-surface structures.

Using preformed drainage systems we offer sub-surface drainage with higher performance, lower environmental impact and lower cost than traditional granular filters. ABG systems have been specifically designed to be compatible with waterproofing systems whilst withstanding the high loads associated with backfilling to give optimum performance over the whole life of the structure.

Applying Fildrain for structural drainage application.

Other Systems

Our fin drains (Fildrain) offer a high performance, economic alternative to traditional stone groundwater drainage solutions and are used extensively in a wide range of applications from highway edge drainage through to landscape drainage. Sports pitch drainage can be tackled using Pozidrain Sport which is suitable for both retrofit and new build applications. Basement drainage problems can be addressed using Cavidrain below ground Cavity drainage system. ABGs range of cellular confinement systems are proven solutions for use in slope stabilisation, for creating access roads and tree root protection. Root Barriers to prevent the spread of invasive roots to unwanted areas and pond liners are available for all projects.



Leakdrain installation as part of landfill lining system.

About ABG

ABG are a market leader in the development, manufacture and technical support of high performance geosynthetic solutions for use in a wide range of building and environmental projects.

Formed in 1988, based in Meltham, in the heart of the Pennines, ABG has developed an excellent reputation for developing quality products and outstanding service. The ability for rapid product development ensures that the most innovative, up to date and cost effective solution can be found for many engineering problems including Green Roofs, SUDs, irrigation, reinforced earth and drainage.

Our involvement with Green Roofs goes back over twenty years and we now have a complete range products developed specifically for green roof applications. During this period we have supplied products to projects throughout the UK, Ireland and globally including over 1,000,000m² of geocomposite drainage into both extensive and intensive green roof projects.

Technical support is provided by our trained and experienced staff, many of whom are Chartered Civil Engineers. This extensive support includes design, design confirmation, feasibility study, cost advice and meeting regulatory requirements including BREEAM and CFSH.

As part of this technical support much work is Undertaken in developing knowledge within our active markets including working with organisations such as CIRIA (Construction Industry Research and Information Association) on a number of guidance documents and working closely with leading universities on a number of research projects, including the installation and monitoring of our very own Green Roof with The University of Sheffield and work with The University of East London on developing biodiversity in Green Roofs and also management of storm water.

To complement this product range and knowledge base ABG have recently created an installation business allowing a complete package solution to be offered from design to installation to on-going maintenance, all working in partnership with the client to deliver bespoke project solutions.

Biodiverse Green Roof on ABG distribution centre - Meltham, West Yorkshire.

Further reading

The GRO Green Roof Code
Green Roof Organisation, Groundwork Sheffield, 2011

Building Greener.
Guidance on the use of green roofs, green walls and complementary features on buildings (C644), Early P, Gedge D, Newton J & Wilson S, CIRIA, 2007

Living Roofs and Walls
Technical Plan, Supporting London Plan Policy, Design for London, Greater London Authority, 2008

Planting Green Roofs and Walls
Dunnet, N, & Kingsbury, N, Timber Press, Oregon, 2004

Building Green
Johnston, J & Newton, J, Greater London Authority, 2004

Green roofs
their status and potential for supporting biodiversity in urban areas English Nature Research Report 498, English Nature, Peterborough, 2003.

The International Green Roof Journal
Published by the International Green Roof Institute, Sweden

The Green Roof Infrastructure Monitor
Published by Green Roofs for Healthy Cities, Canada

Work at Height Regulations, 2005

Useful Websites

www.livingroofs.org
www.thegreenroofcode.co.uk
www.thegreenroofcentre.co.uk
www.groundwork-sheffield.co.uk
www.greenroof.se
www.greenroofs.org
www.ciria.org/buildinggreener
www.uel.ac.uk/erg/BarkingRiversideGreenRoof.htm

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Appendix I – Maintenance Strategy

GENERAL DESCRIPTION

The responsibility for the performance and maintenance of SuDS components will depend on the nature of the component and the number of properties it serves. Areas of permeable paving will become the responsibility of the individual homeowner, while shared features such as the detention basins, ponds etc will become the responsibility of either Local Water Authority (subject to a Section 104 agreement) or a Management Company, following completion of the development.

The SuDS scheme is designed to accommodate a 100 year rainfall event plus a 40% allowance for the effects of climate change, with no on-site flooding, plus a 10% allowance for 'Urban Creep' (future extensions).

Flood routes (exceedance routes) – indicate the direction which overland flows will travel IF the surface water system fails or water volumes exceed the capacity of the system. These routes must be kept clear of obstructions at all times, to prevent damage to property.

SuDS techniques include landscape features and control structures will manage runoff as it flows from site.

The following lists the SuDS features included in the design for this site:

Blue Roofs – a blue roof is designed to attenuate storm water within a void which sits directly above the waterproofing layer and beneath a surface finish surface. All outlets should be visually inspected and be clear of debris and free draining.

Green Roofs – a green roof or living roof is a roof that is partially or completely covered with vegetation and a growing medium, planted over a waterproffing membrane. It is designed to absorb heat, C02 and a large proportion of surface water. They also provide a degree of insulation together with providing a wildlife habitat.

Existing Attenuation Tank - Attenuation tanks can help reduce flow rates from a site by providing attenuation storage. The available storage volume is provided by the void space in the tank structure:

GENERAL OPERATION AND MAINTENANCE REQUIREMENTS

- Collect all litter or other debris and remove from site at each visit;
- Avoid use of weed killers and pesticides to prevent chemical pollution;
- Avoid de-icing agents wherever possible to allow bio-remediation of pollutants in permeable
- surfaces;
- Protect all permeable and infiltration surfaces from silt, sand and other fine particles.

SPILLAGE – EMERGENCY ACTION

Most spillages are of compounds that do not pose a serious risk to the environment if they enter the drainage in a slow and controlled manner with time available for natural breakdown. Therefore, small spillages of known organic substances should be removed where possible using soak mats as recommended by the Environment Agency with residual spillage allowed to bio-remediate in the drainage system.

In the event of a serious spillage, either by volume or of unknown or toxic compounds, then isolate the spillage and block outlet pipes from chamber(s) downstream of the spillage with a bung(s).

Contact the Environment Agency immediately.

SPECIFIC OPERATION AND MAINTENANCE REQUIREMENTS
Maintenance activities & frequencies associated with the site drainage are outlined in the following tables.

TABLE 21.3 Operation and maintenance requirements for attenuation storage tanks

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action	Monthly for 3 months, then annually
	Remove debris from the catchment surface (where it may cause risks to performance)	Monthly
	For systems where rainfall infiltrates into the tank from above, check surface of filter for blockage by sediment, algae or other matter; remove and replace surface infiltration medium as necessary.	Annually
	Remove sediment from pre-treatment structures and/ or internal forebays	Annually, or as required
Remedial actions	Repair/rehabilitate inlets, outlet, overflows and vents	As required
Monitoring	Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed	Annually
	Survey inside of tank for sediment build-up and remove if necessary	Every 5 years or as required

Table Operation and maintenance requirements for blue roofs

Maintenance schedule	Required action	Typical frequency
Monitoring	Inspect outlet structures, and storage areas fro trash and sediment accumulation.	Monthly in the first year and then 6 monthly/annually dependant on general leaf litter
Cleaning	Remove debris from drainage outlets and outlet screens to prevent clogging. Remove debris from secondary drainage/overflows. Remove excessive build-up of sediment around the outlet controls or within the storage cells	During inspections or as needed
	Break up ice formation around outlets and overflows.	As needed during the winter months.

TABLE 12.5 Operation and maintenance requirements for green roofs

Maintenance schedule	Required action	Typical frequency
Regular inspections	Inspect all components including soil substrate, vegetation, drains, irrigation systems (if applicable), membranes and roof structure for proper operation, integrity of waterproofing and structural stability	Annually and after severe storms
	Inspect soil substrate for evidence of erosion channels and identify any sediment sources	Annually and after severe storms
	Inspect drain inlets to ensure unrestricted runoff from the drainage layer to the conveyance or roof drain system	Annually and after severe storms
	Inspect underside of roof for evidence of leakage	Annually and after severe storms
Regular maintenance	Remove debris and litter to prevent clogging of inlet drains and interference with plant growth	Six monthly and annually or as required
	During establishment (ie year one), replace dead plants as required	Monthly (but usually responsibility of manufacturer)
	Post establishment, replace dead plants as required (where > 5% of coverage)	Annually (in autumn)
	Remove fallen leaves and debris from deciduous plant foliage	Six monthly or as required
	Remove nuisance and invasive vegetation, including weeds	Six monthly or as required
	Mow grasses, prune shrubs and manage other planting (if appropriate) as required – clippings should be removed and not allowed to accumulate	Six monthly or as required
Remedial actions	If erosion channels are evident, these should be stabilised with extra soil substrate similar to the original material, and sources of erosion damage should be identified and controlled	As required
	If drain inlet has settled, cracked or moved, investigate and repair as appropriate	As required

MAINTENANCE RESPONSIBILITY

The maintenance required by all unadopted, but shared drainage features maintenance will be undertaken by a management company who will coordinate the maintenance on behalf of the Client.

Appendix J – SuDS Designers Risk Assessment

SuDS Risk Assessment

Based on CIRIA RP002 – The SuDS Manual

SITE/SYSTEM OVERVIEW		
Location	Travelodge, Drury Lane, Covent Garden, WC2B 5RE	
SuDS Component	Blue/Green Roofs	
	Into existing attenuation tank in basement	
Date of Assessment	23 March 2023	
Date of next assessment	Prior to construction	
ESTABLISH CONTEXT		
General description of component and its operation	1 No. green/blue roofs at differing heights attenuating surface water	
IDENTIFY POTENTIAL HAZARDS	**Yes/no**	
Drowning through ice in winter	No	Blue roof/ Green roof
Slips, trips and falls	Yes	Blue roof/ Green roof
Entry into pipes/confined spaces (note this is for inadvertent public access. Follow relevant legislation and guidance for worker access)	No	Blue roof/ Green roof
Water Quality – health risk	No	Blue roof/ Green roof

DROWING OR FALLING THROUGH ICE IN WINTER - N/A		
Consider factors that might affect: (a) the likelihood of people entering the water/accessing the ice (b) the potential consequence of entering the water/accessing the ice	Summary of influence of factor on likelihood of entry/access, including justification (Consider for children < 5 years, children ≥ 5 years, adults)	Summary of influence of factor on consequence of entry/access, including justification (Consider for children < 5 years, children ≥ 5 years, adults)

SLIPS TRIPS & FALLS		
Factors that might affect likelihood of people slipping/tripping/falling	Summary of influence of factor on likelihood of Slip/trip/fall including justification (Consider for children < 5 years, children ≥ 5 years, adults)	Summary of influence of factor on consequence of Slip/trip/fall including justification (Consider for children < 5 years, children ≥ 5 years, adults)
DESIGN FACTORS – SURFACES		**RISK**
Level changes	***Suitable edge protection/Fall arrest system designed by others***	***Low***
Surfacing materials	***Possible slips or trips in icy weather***	***Low***

SUMMARY OF RISK ASSESSMENT FOR SLIPS TRIPS AND FALLS

Group	Likelihood of slips/trips/falls/other injury	Likely consequence of slips/trips/falls/other injury	Overall level of risk posed by the design	Additional mitigation measures required	Action date	Final level of risk
Children under 5 years	Rare	Minor	Low Risk	None		Low
Children over 5 years	Rare	Minor	Low Risk	None		Low
Adults	Occasional	Major	High Risk	Edge protection/fall arrest system		Low

Appendix K – Camden Drainage Proforma v2019.02

Camden

GREATERLONDONAUTHORITY

LoDEG

1. Project & Site Details

Project / Site Name (including sub-catchment / stage / phase where appropriate)	Travelodge,
Address & post code	10 Drury Lane, High Holborn, London WC2B 5RE
OS Grid ref. (Easting, Northing)	E 530273
	N 181320
LPA reference (if applicable)	
Brief description of proposed work	The proposal will create an additional 55 bedrooms replacing the existing service yard and undercroft areas together with reception area over 4 floors, which will be linked into the existing Travelodge Hotel.
Total site Area	3900 m^2
Total existing impervious area	3900 m^2
Total proposed impervious area	3900 m^2
Is the site in a surface water flood risk catchment (ref. local Surface Water Management Plan)?	The site is not on the Historic flooding and Local Flood Risk Zones Map within Camden Policy CC3 Water and flooding
Existing drainage connection type and location	Pumping station discharges to combined sewer via restricted rate
Designer Name	Robin Crowther
Designer Position	Director
Designer Company	J P Chick & Partners Limited

2. Proposed Discharge Arrangements

2a. Infiltration Feasibility

Superficial geology classification	Lynch Hill Gravel Member - Sand And Gravel
Bedrock geology classification	London Clay Formation - Clay, Silt and Sand
Site infiltration rate	0 m/s
Depth to groundwater level	0 m below ground level
Is infiltration feasible?	No

2b. Drainage Hierarchy

	Feasible (Y/N)	*Proposed (Y/N)*
1 store rainwater for later use	N	N
2 use infiltration techniques, such as porous surfaces in non-clay areas	N	N
3 attenuate rainwater in ponds or open water features for gradual release	N	N
4 attenuate rainwater by storing in tanks or sealed water features for gradual release	Y	Y
5 discharge rainwater direct to a watercourse	N	N
6 discharge rainwater to a surface water sewer/drain	N	N
7 discharge rainwater to the combined sewer.	N	Y

2c. Proposed Discharge Details

Proposed discharge location	SW into existing within Short's Gardens FW into existing within Drury Lane
Has the owner/regulator of the discharge location been consulted?	No

Camden GREATERLONDONAUTHORITY LoDEG

3. Drainage Strategy

3a. Discharge Rates & Required Storage				
	Greenfield (GF) runoff rate (l/s)	*Existing discharge rate (l/s)*	*Required storage for GF rate (m^3)*	*Proposed discharge rate (l/s)*
Qbar				
1 in 1		2.244		0.6
1 in 30		4.713		0.6
1 in 100		6.13		0.6
1 in 100 + CC				0.6
Climate change allowance used		40%		
3b. Principal Method of Flow Control		Restrictor valve within blue roof		

3c. Proposed SuDS Measures			
	Catchment area (m^2)	*Plan area (m^2)*	*Storage vol. (m^3)*
Rainwater harvesting	0		0
Infiltration systems	0		0
Green roofs	see below		
Blue roofs	106	92	5.7
Filter strips	0	0	0
Filter drains	0	0	0
Bioretention / tree pits	0	0	0
Pervious pavements	0	0	0
Swales	0	0	0
Basins/ponds	0	0	0
Attenuation tanks	0		0
Total	**106**	**92**	**5.7**

4. Supporting Information

4a. Discharge & Drainage Strategy	*Page/section of drainage report*
Infiltration feasibility (2a) – geotechnical factual and interpretive reports, including infiltration results	N/A - page 15
Drainage hierarchy (2b)	page 24
Proposed discharge details (2c) – utility plans, correspondence / approval from owner/regulator of discharge location	Appendix D - COMMERCIALDDW report Appendix G -CCTV Survey
Discharge rates & storage (3a) – detailed hydrologic and hydraulic calculations	Appendix H - Pre & post runoff rates
Proposed SuDS measures & specifications (3b)	Section 6 -

4b. Other Supporting Details	*Page/section of drainage report*
Detailed Development Layout	Appendix B
Detailed drainage design drawings, including exceedance flow routes	Appendix I
Detailed landscaping plans	n/a
Maintenance strategy	Appendix I
Demonstration of how the proposed SuDS measures improve:	
a) water quality of the runoff?	Section 6.03
b) biodiversity?	Section 6.04
c) amenity?	Section 6.05