british council for offices

defining excellence in office space

CORPORATION OF LONDON

green roofs

research advice note

Introduction

Image 1

Green roofs may not at present be a familiar sight in our towns and cities. However, with successful examples in the UK, Europe, Japan and North America, evidence is accumulating to show they can make a unique contribution to the quality of our urban environment. The purpose of this note is to introduce planners, developers, architects and facilities managers to the concept of the green roof. Sources of further technical information are listed at the end of this note.

This is a joint publication by the British Council for Offices and the Corporation of London. It has been prepared in furtherance of the City of London Biodiversity Strategy.

contents

Printed on Revive paper made entirely from recycled stock. Design: michael@michaelhuntpublishing.co.uk

Benefits of green roofs

Image 2

Green roofs have a range of benefits. The larger the area of green roof coverage, either individually or cumulatively in an area, the more significant the benefits, but each roof can have local benefits.

Some of the benefits that green roofs may have include:

- value to biodiversity – providing habitat, shelter and feeding opportunities, providing a link in the urban network of green spaces
- assisting in meeting the targets of biodiversity action plans
- improving the view from nearby buildings
- offering an exciting, high-profile design opportunity that can boost the environmental credentials of a business
- providing extra insulation for a building
- reducing heating and cooling bills, depending on the building
- extending roof life by protecting it from weather conditions
- helping to cleanse the air of some dust and pollutants
- lowering temperatures in and around the building in the summer
- moderating the urban "heat island" effect. This will become increasingly important as climate change increases temperatures
- slowing storm water runoff by retaining moisture and moderating the discharge to street sewers which are then better able to cope in storms
- providing extra noise insulation
- creating new open space for relaxation

These benefits will depend on the building form and the detail of the particular green roof, although all green roofs are potentially beneficial to wildlife.

"Apart from our green roof creating a feeling of connectedness between our building and its surrounding gardens, it also provides an insulation layer to keep in heat in winter, and cool by evaporation in summer. It benefits the atmosphere by absorbing pollutants from the busy south circular road nearby, and its native wildflower meadow habitat provides a riot of colour in summer and an oasis for native insect and other invertebrate wildlife. The building's occupants greatly enjoy working in a building whilst being entertained by visiting squirrels and birds."

Lucy-Anne Bishop, Environment Projects Officer and office occupier at CUE Building Horniman Museum

Types of green roof

"Biodiversity is the variety of life forms we see around us"
The UK Biodiversity Action Plan, 1994

A green roof is composed of various layers that create an environment suitable for plant growth that does not damage the fabric of the building. Green roofs convert wasted roof area into viable green space for public benefit and for the benefit of biodiversity.

Green roofs are widespread in North America, Japan and Europe – particularly in parts of Germany and Switzerland where there are planning requirements to install them. There are several green roofs in London and more are being installed.

There are two types of green roof:

- intensive – a deep layer of soil to support a variety of plants such as flowers and shrubs, but requiring regular maintenance. Intensive roof gardens can grow a range of plants, even trees and shrubs, and with native species can provide a rich habitat for wildlife.

Image 3

- extensive – lightweight, often with shallower growing material, requiring little maintenance. The type of growing medium chosen affects the type of habitat created, which may reflect the building's natural surroundings. This type of roof is sometimes also known as a brown roof although not all extensive roofs, e.g. sedum roofs, are brown.

Image 4

Basic steps to planning a green roof

Pre-consider

pre-consider

Condition of the existing roof

An ideal time to consider building a green roof is when the existing roof needs to be replaced, or indeed when a new building is to be developed. This way, features such as a waterproof layer, and a protective root-resistant layer can be made an integral part of the new roof.

'Retrofitting' a green roof onto an existing roof is possible, but this will mean taking into account the roof's faults, such as existing leaks, damage and inability to resist roots.

Structural capacity of the existing/new roof

This will determine what type of roof can be installed.

Access to the roof

How will people access the roof? How will equipment and material be transported during construction and operation stages?

Purpose

What will be the prime function of the green roof? Is an amenity for staff or the public desired or will the function be more of an ecological one?

Image 5

Basic steps to planning a green roof

Image 6

Determine

The type of roof

Having considered the above, what type of roof *(extensive or intensive)* is desired? An intensive roof requires regular maintenance but can provide similar amenity as a small urban park. An extensive roof is more lightweight, requires little maintenance (plants are chosen for their natural ability to survive); is not usually used as a public amenity but can provide a valuable natural habitat for local wildlife.

The weight of the roof

Soil, plants, equipment and users will add weight to the roof.

To determine the weight, the following should be taken into account:

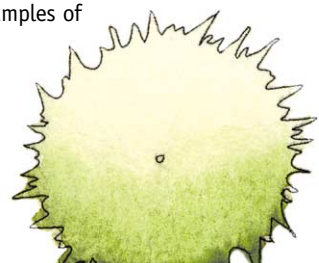
- the type of green roof to be installed
- the water storage system
- the type of growing medium and plants
- equipment for heating, ventilating and air conditioning
- volume of users

New buildings can be designed with adequate structural capacity for any type of green roof. Extensive green roofs are lighter and may be more suited to existing roofs with limited capacity.

Costs

Costs to be taken into account when building a green roof include design work and associated professional fees; any hard landscaping; structural work; costs for any irrigation systems; plant materials; and long term maintenance costs.

A basic extensive roof can be installed for minimal cost. This is because structural reinforcement becomes unnecessary; the installation of an irrigation system will not be required; and maintenance involved will be low. The schedule at the end of this document provides examples of costs of past projects.

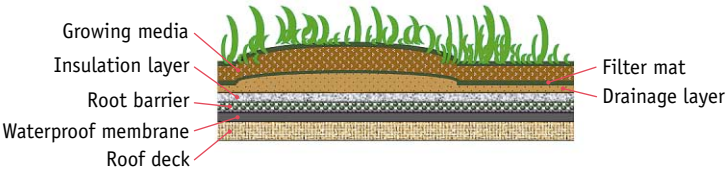


Basic steps to planning a green roof

Image 7

Design of the roof

The structural layout of a green roof may vary. Typically, however, the cross section of a green roof begins (starting from the bottom) with a waterproof membrane to protect the building from leaks, an insulation layer and a further protective layer which will prevent damage from any penetrating roots, or other structural movement. Some designs may incorporate the insulation layer as part of the protective layer. The option also exists for the insulation layer to be placed above the protective layer instead of below.



Over this, a drainage layer is put down. This can be made of lightweight gravel or light granulated clay. The drainage layer serves to keep the growing medium aerated and will release any excess water. It is important for maintenance purposes that drainage points are made accessible from above. On top of the drainage layer, a filter mat can be placed to allow water to soak through but will serve to prevent the erosion of fine soil.

The top layers of a green roof system include growing medium, plants, and a wind blanket. The growing medium consists of lightweight material (see below) and will assist with drainage as well as providing nutrients to the plants. The purpose of the wind blanket is to protect the growing medium until the roots of the plants take hold.

Irrigation

Ideally, extensive and intensive roofs should be designed to eliminate or reduce the need for watering, by planting drought-resistant vegetation. More formal types of planting may require an irrigation system or water connection to the roof. Rainwater can be collected from the roof's run-off, stored and reused for watering when required.

Basic steps to planning a green roof

Image 8

design of the roof

Drainage

Excess water that is not absorbed within the garden must be effectively drained from the rooftop. Failure to do so will result in water being held on the roof that could cause rot and add weight. A waterlogged green roof will also have little insulation effect.

Selection of plants and growing materials

The growing medium can be made up of high-quality compost and recycled materials. It should be based on locally occurring material so that the green roof is suitable to its location and reflects, as far as is possible, local wildlife habitats. The materials used need to be suitable for retaining water and air, resisting rot, frost and shrinkage.

On an extensive green roof, a good idea is to use crushed demolition waste, although other materials can also be used. This has environmental benefits including recycling of materials, and reducing the need for the transport and disposal of the waste. Crushed bricks, concrete etc form drainage and growing media that can support diverse plant and invertebrate communities, which in turn benefit higher forms of wildlife.

The types of plants suitable for growing on a green roof will partly depend on the level of maintenance that will be available during its lifetime. It will also depend on whether the roof has an inbuilt irrigation and watering system or has areas of protection such as shade and shelter. Choosing local seed varieties will, however, enable both extensive and intensive green roofs to contribute to local biodiversity. The windy conditions typical of a rooftop will also mean that hardy drought-resistant vegetation, such as mosses and stonecrops, will establish itself and thrive more easily.

Image 9

Black Redstarts find it easier to establish habitats on extensive roofs and other brownfield sites where they do not face competition from the Robin

Basic steps to planning a green roof

Image 10

A typical extensive green roof may therefore consist of vegetation such as meadow-grass, mosses and stonecrops. Sedum mats can also be used but, in the short term, these will limit the variety of vegetation on the rooftop.

The possibilities for an intensive green roof are considerably greater. The roof can contain trees, shrubs, meadows, flowerbeds and even features such as a pond.

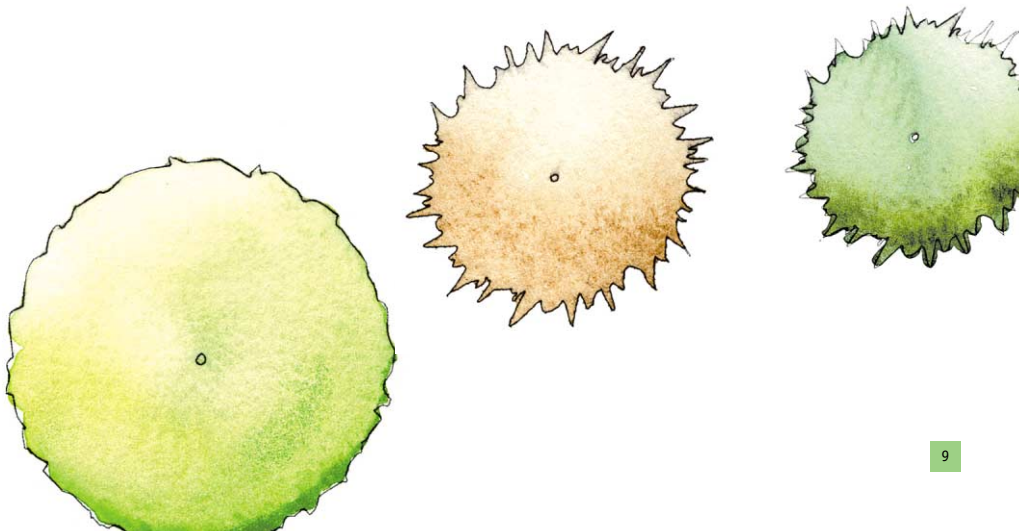
Further information on suitable plants for green roofs can be found in "Building Green" Johnston et al (1993) as referenced at the back of this note.

Maintenance

Extensive green roofs should be checked annually and any unwanted plants removed. Intensive green roofs must be watered and weeded similar to a conventional garden. Larger plants, shrubs and trees must be pruned to ensure safety during windy conditions. Drains and gutters must be inspected and cleared frequently to avoid plant material causing blockages.

Authorisation

Installation of a green roof may require planning permission and developers are recommended to check with their local planning authority.



Further methods of greening urban spaces

Image 11

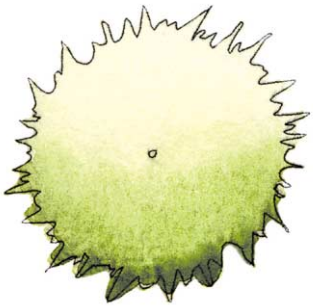
Installing a green roof is one of several ways in which plants and trees can be used to improve the quality of life in our urban environment. These include:

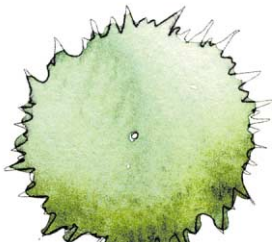
- incorporating trees and vegetation in courtyards
- creating balcony gardens
- creating vertical habitats alongside walls of buildings
- attaching bird boxes (different types and locations for different birds) to the sides of buildings

As well as some obvious benefits such as the positive visual impacts and the provision of habitats for wildlife, there are some other, perhaps less appreciated, benefits of having increased plant life and trees in the urban environment.

Their existence serves to improve the air quality for the human population. Trees, for example, have the effect of filtering out dust in the air as their leaves absorb airborne particles. By photosynthesis, plant life absorbs carbon dioxide in our atmosphere, thus serving to maintain a healthier balance in our urban environment. Plants growing alongside building walls absorb pollutants from the air and serve to protect the structure from the effects of sun, rain and wind; it is a mistaken belief that plants will inevitably damage built structures.

Vegetation also works to absorb pollutants such as copper and lead from rainwater and therefore prevent them from being discharged into our groundwater, streams and rivers. Rainwater is retained for much longer with the absorbent surfaces provided by trees, soil and vegetation and this eases the pressure on sewers during periods of wet weather.





Schedule of costs of completed projects

Image 12

Project Name	Bennetts Associates – Offices, Rawstorne Place	A Zoo in the UK – Entrance Building	A Southern England Primary School	Wessex Water – Headquarters
Location	London, EC1	Devon	Devon	Bath
Type of roof	Extensive Sedum	Intensive Sedum	Intensive Sedum	Extensive Sedum
Design	Standard	Specialized	n/a	Standard
Basic cost	£150 per sq m	£100 per sq m	£100 per sq m	£82 per sq m
Additional cost	£35 per sq m	Included in basic cost	n/a	£18.66 per sq m
Total cost	£185 per sq m	£100 per sq m	n/a	£100.66 per sq m
Maintenance cost	Negligible	Negligible	n/a	n/a
Tangible benefits	Increased thermal mass	Provides highly insulated roof construction	n/a	Blending the building in with the surrounding lands

Source: BCO, 2003

Photocredits

Cover — Gateway House, Basingstoke
This building, formerly known as Gateway One, was completed in the late 1970s by Arup Associates
©Arup Associates, photographer Martin Charles

Image 1 — The CUE Building, Horniman Museum, 100 London Road, Forest Hill, SE23 3PQ
The CUE Building was completed in 1995. The architects are Architype. As well as having a grass (extensive) roof it is also built with other sustainable materials. Currently used as office space, the building is normally closed to the public. Occasionally, it is used for public lectures and architectural tours. Please contact the museum for further information
Photograph: Corporation of London

Image 2 — Rawstorne Place, London
Photograph: Bennetts Associates

Image 3 — No. 1 Poultry, London EC2. Intensive green roof
No. 1 Poultry was completed in 1997. It comprises shops, restaurants and offices. The architects are Stirling Wilford Association (now Michael Wilford & Partners)
Photograph: Corporation of London

Image 4 — Green roof in Basel, Switzerland
Extensive green roof incorporating solar panels, thus maximising the 'green' credentials of the building
Photograph: Stephan Brenneisen

Image 5 — 1, Finsbury Avenue, London
Photograph: Arup Associates

Image 6 — Courtesy of the Lovejoy Partnership

Image 7 — Courtesy of the Lovejoy Partnership

Image 8 — Landesbausparkasse, Mainz
Photograph: Erisco Bauder

Image 9 — Black Redstart
Photograph: Jim Lawrence

Image 10 — Extensive green roof in Basel, Switzerland
Photograph: Nigel Gedge

Image 11 — Marketing suite, Plantation Place, London
Photograph: Arup Associates

Image 12 — Greenfields Housing Development, Maidenhead
Extensive green roof incorporating solar panels
Photograph: Faber Maunsell

References and sources of further information

Useful publications

Building Green
Johnston, J. and Newton, J. (1993)
London Ecology Unit
1993 ISBN 1 871045 18 5
A useful guide with information on types of plants appropriate for green roofs

City of Chicago: Chicago's Green Rooftops
Available at: www.cityofchicago.org (April 2003)
A guide to rooftop gardening

Green Roofs: their existing status and potential for conserving biodiversity in urban areas
English Nature (2003) English Nature Research Report 498.
A technical report on green roofs including a schedule of intensive green roofs and extensive green roofs in England and Wales. For further information contact English Nature's Urban Advisor david.knight@english-nature.org.uk or in London pete.massini@english-nature.org.uk

Erisco Bauder, 2000 Waterproofing Systems for Landscape Roofs
Available at: www.erisco-bauder.co.uk (April 2003)
A booklet demonstrating the products of the manufacturers Erisco Bauder in various green roof systems

Roofscapes Inc, 2002, Roof Benefits
Available at: www.roofmeadow.com (May 2003)
A summary of the potential benefits associated with green roofs

Useful contact points

James Farrell, Biodiversity Team
Greater London Authority (GLA)
City Hall, The Queen's Walk, London, SE1 2AA.
Tel: 020 7983 4990 James.Farrell@London.gov.uk
The Biodiversity Team members specialise in a range of biodiversity topics including green roofs

William Morenc, The London Biodiversity Partnership
c/o The London Wildlife Trust, Harling House,
47–51 Great Suffolk St, London SE1 0BS. Tel: 020 7921 5479
The members of the London Biodiversity Partnership (LBP) represent a broad spectrum of interest groups and expertise in London. The LBP is responsible for producing the Biodiversity Action Plans for London

Lucy-Anne Bishop, Education and Environment Project Officer
The Horniman Museum, Forest Hill. Tel: 020 8699 1872
Lucy-Anne Bishop will be able to provide information on the environmental aspects of the CUE Building

Gyongyver Kadas, g.kadas@btinternet.com
Gyongyver has carried out an MSc study of "invertebrates on green roofs: how roof design can maximise biodiversity in the urban environment". She is currently working on long term research, the purpose of which will be to inform planners and designers about the biodiversity benefits of green roofs

Gary Grant, Eco-Schemes Ltd
7 Lea Combe, Axminster, EX13 5LJ
Tel: 01297 34552 gary.grant@ecoschemes.com
Gary Grant is an ecologist and designer of green roofs. He is also the principal author of English Nature's Green Roof Study (English Nature Research Report 498)

Useful websites

www.blackredstarts.org.uk *Provides advice on designing roofs to benefit black redstarts*

www.architype.co.uk *Architype specialise in ecological and sustainable architecture and building practices. They have designed a number of green roofs in the UK*

www.uncommonplants.com *Provides advice on plants suitable for rooftop gardens*

www.zedfactory.com *Website for the Bill Dunster architectural practice which specialises in designing Zero (fossil) Emissions Developments*

www.greenroofs.ca *A Canadian website made up of four divisions all dedicated to implementing technologies which support environmentally and economically sustainable developments*

www.greenroofs.com *Website dedicated to sharing and exchanging information on green roofs*

www.lbp.org.uk *Website for the London Biodiversity Partnership*

http://fesweb.ntu.ac.uk/staffwebs/greenroofs/aboutGRandESB.htm *Interesting website set up by the School of Property and Construction, The Nottingham Trent University*

www.roofmeadow.com *This is an American based website for 'Roofscapes Inc', whose services include design consultation, specifications, construction management, installation and lifetime services and maintenance*

Manufacturers specialising in products for green roofs

www.alumasc-exterior-building-products.co.uk Alumasc
Manufacturer of various building products including green roof systems

www.greenroof.co.uk Blackdown Horticultural Consultants
Horticulturists who specialise in design, supply, installation and maintenance of lightweight roof planting systems

www.ram-rgc.co.uk Ram Roof Garden Consultancy Ltd
Consultancy specialising in green roof systems

www.erisco-bauder.co.uk Erisco Bauder
Manufacturer specialising in roof systems, including green roofs

www.green-roof-systems.co.uk Roof Garden Consultancy Ltd
Consultancy specialising in green roof systems

www.americanwick.com The American Wick Drain Corporation
Produce prefabricated soil sheets and strip drain materials, and have recently developed products for roof gardens

www.hydrotechusa.com American Hydrotech
Specialise in waterproofing and roofing systems, including green roofing systems

Further information on the Corporation of London can be found at www.cityoflondon.gov.uk.
Queries regarding this advice note can be made to Rachel Hughes Tel: 020 7332 1148