Green Roof

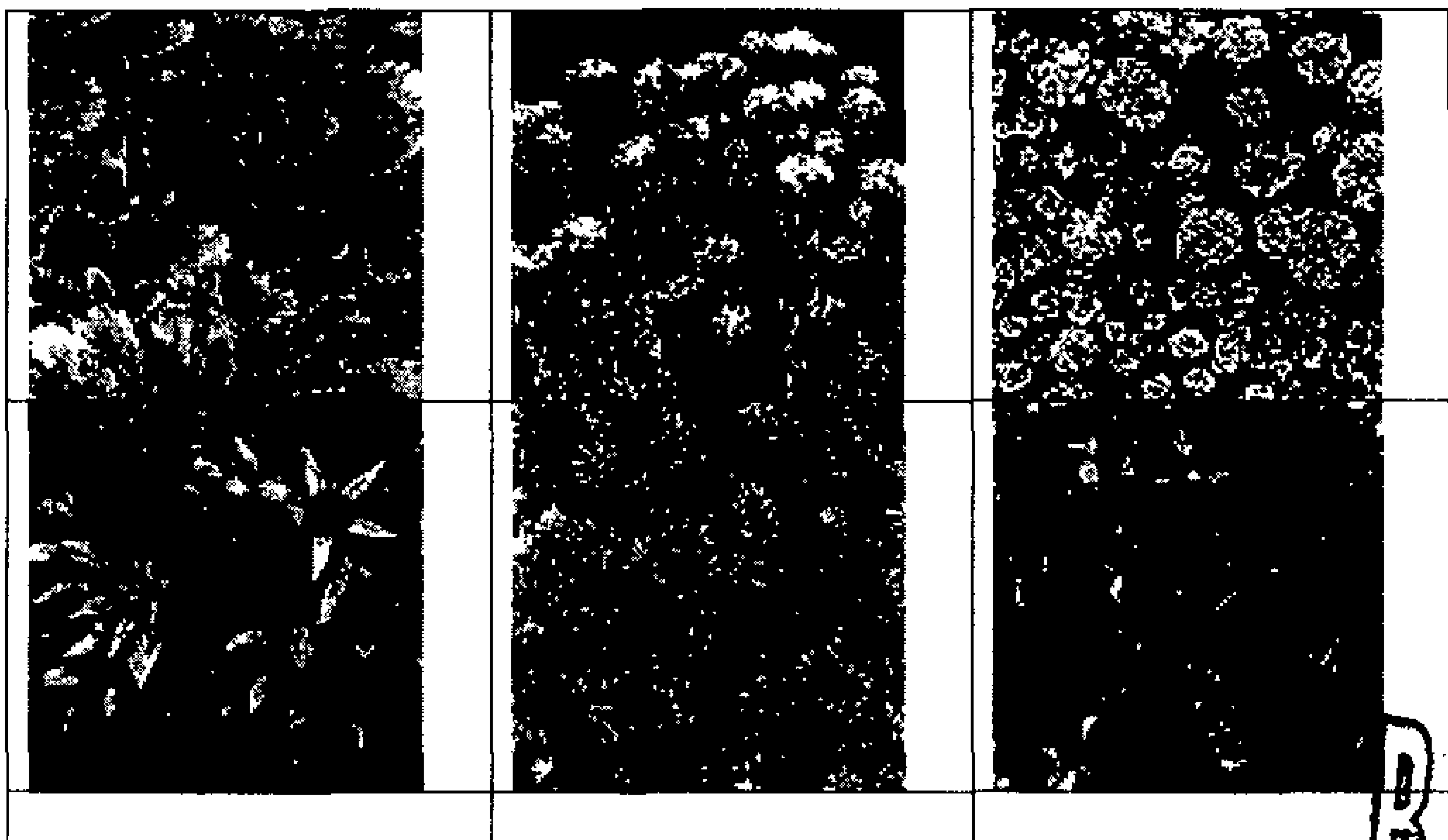
14a Redington Road

It is intended to use a green roof of sedum species by Blackdown Horticultural Consultants* on a waterproof membrane by Sarnafil**.

The method of planting will be 'plug and hydroplanting'. Rooted young plants (plugs) together with hydroplanting are used to establish the plant cover.

This process allows up to twenty species of Sedum to be planted – with varying flowering times this gives a consistent aesthetic to the roof.

Sedums which are commonly known as Stonecrops are the core species for BHC green roof systems in the UK. They are a versatile and attractive ground cover plant belonging to the Crassulacaea family. Sedums are evergreen, self-generating, drought resistant and capable of withstanding extremes of climate. They flower from early summer through to autumn in shades of pink, purple, yellow and white. Needing very little attention and no mowing or cutting back, they give excellent foliage colour and texture and are attractive to all kinds of insects and birds. Sedums are generally pest and disease free but,like most plants, can suffer from aphids, mealy bugs, thrips or vine weevil which can be controlled by biological means.



Green roofs reduce rainwater run off by a number of processes:

* Retention of the rainwater in substrate and drainage layers.
* Uptake and release of water from the substrate by the plant layer. Water is transported from the root to the leaf and lost through the leaf surface - a process known as transpiration.
* Solar driven evaporation of water from the substrate.
* Wind disruption of the still, humid air layer (known as the boundary layer) over the plants and substrate increasing the rate by which water is lost to the atmosphere through evaporation and transpiration.

In addition, vegetation and substrate can absorb a range of pollutants including nitrogen, phosphorus and heavy metals such as cadmium, copper, lead and zinc.

In many cities around the world it has been recognised that the most significant ecological advantage of roof planting is storm water management. It is hard to come up with average figures of performance, however, roughly 50-60% of rainfall can be expected to be retained by an extensive green roof.

Although in the UK we lack any legislative drivers for roof planting, the pressures on development to accommodate it are increasing, if indirectly. The following is a section from an environment agency directive regarding a large commercial project:

'The discharge from the developed site should mimic that from the existing greenfield site as far as is practical. Thus in a 1 year event the discharge should be the same as for the greenfield site, and in a 10 year event, and similarly in a 100 year event. So across the range of return periods the natural greenfield runoff is simulated'.

The architects are concerned about the expense of ground based containment areas that will satisfy the directive. As discussed here, keeping the water on the roof and returning it to the atmosphere is a cost effective solution and an attractive one in the light of the directive.

Insulation

Although planted roof systems are widely acknowledged to offer both winter insulation and summer cooling benefits the advantages with regard to summer cooling are generally considered to be stronger. However, the information below indicates significant advantages for both effects. It should be made clear that we are dealing with a growing rather than engineered system and also one that can have varying water content. Consequently, even when direct analysis is carried out this will only be indicative of the type of performance that can be achieved.

A. Summer
The roof can suffer from huge thermal fluctuations on its upper surface throughout the day and through the year. In extreme cases these can range over 100 °C. (Papadopoulos and Axarli, 1992). Planting the roof surface dramatically reduces the amount of solar radiation absorbed by the roofs bare surface. The high daily thermal swings are neutralised and the annual fluctuations are decreased to between 20 and 25°C.(Eumorfopoulou and Aravantinos, 1998). Planting the roof reduces heat build up by the following mechanisms:

* Photosynthesis. This is the process by which plants use the sun's energy to turn water and carbon dioxide into sugars. Thus, some of the solar radiation is 'diverted' to drive the plant's growth rather than heat up the roof.
* Evaporative water loss from the plant tissues. Converting water from liquid into gas requires energy. Plants use this process to prevent over heating. The sun's energy is used to evaporate water rather than cause heat build up within the plants tissues. Evaporative water loss from plant tissue is termed evapo-transpiration. The solar radiation is therefore 'diverted' into evaporating water from the plant tissues rather than heating up the roof surface.

* Evaporative water loss from the soil or substrate. Much as for the plant tissue, solar radiation is 'diverted' into evaporating water from the soil or substrate rather than heating up the roof surface.

Studies carried out at Trent University under British climatic conditions, indicate that planted roofs can have markedly lower temperatures throughout the roof layers compared to the unplanted roof. With a mean daily air temperature of 18.4°C, the temperature below the membrane surface of an unplanted membrane roof typically reaches 32°C compared to 17.1°C for a roof with an extensive type green roof cover. These results indicate that bare roof surfaces can act as strong heat sinks and reach temperatures far above the ambient even under the quite mild climatic conditions of the UK. This makes it harder to control the ambient temperature within the building. Planting the roof surface can dramatically reduce the heat sink effect of the roof thus reducing the amount of energy needed to control ambient temperatures inside the building- a conclusion also reached by the administrative body of the City of Chicago! (see 'urban heat island effects'). As well as being economically advantageous as less energy would be spent on air conditioning, the reduced energy requirements of the building would mean less production of carbon dioxide (the main greenhouse gas contributing to global warming).

Looking to the future, global warming will mean that we will all have to cope with the elevated temperatures of our environment. Present government directives on building performance mean that many of us will be doing this in some of the best insulated buildings ever seen in this country. The accelerated need for energy expenditure (and therefore carbon dioxide production) to provide air conditioning for these, and all, buildings will increase and this will further fuel climatic change. Lightweight planted roof systems can only increase in importance as THE sustainable solution for keeping our buildings workable and liveable in the years ahead for two reasons:

* Reduced carbon dioxide production by the building less energy utilized by the building means less carbon dioxide produced.
* Removal of carbon dioxide by the roof plants The fixation of carbon dioxide by the roof plants to form sugars and the release of oxygen are two vitally important environmental benefits of roof planting.

B. Winter
Planted roofs do reduce the buildings heat loss through the roof during the winter months. This is achieved by a number of processes:

* The insulating effects of the added mass and individual properties of the system components.
* The biological activity in the root zone of the planted system which generates heat.
* The creation of a still layer of air (boundary layer) over the plants that reduces thermal loss.

It should be noted that the insulation effiency of a planted roof depends on the amount of water held in the substrate and plant layers. The water has a negative effect on thermal conductance. Thus, a saturated plant system will insulate less than a dry system. Should the water freeze in the substrate layer this will further increase thermal conductance and therefore reduce any insulatory effect. For this reason, it is not possible to provide absolute figures as to improvements in thermal performance.

In spite of this, benefits of planted roofs as insulation against heat loss have been recorded. Work at Trent University indicated that on a cold day in the UK with a mean temperature of 0°C, the temperature under the membrane of an unplanted roof system fell to -0.2°C. By contrast, the temperature directly under the membrane of a planted roof had a mean value of +4.7°C.

It can be concluded that roof planting will result in reduced thermal gradients between the interior and the exterior of the building through out the year. Reducing this thermal gradient means that roof planting lessens the driving force for heat loss from the building's interior to the exterior when external temperatures are low and for heat gain from the exterior to the interior when external temperatures are high. Roof planting means that energy requirements by heating or air conditioning systems to maintain acceptable ambient temperatures within the building, will be reduced.

Reduction in sound transmission

Adding mass to the roof structure by planting enhances acoustic performance of the roof. In a collaborative study with Corus Building Systems, we found that sound transmission (tested at 50 to 5000 Hz) through the planted Kalzip® aluminium standing seam roof system (Nature Roof®) was reduced by a mean of 40 percent compared with the bare Kalzip® roof.The figures represent a fully saturated plant system and acoustic performance will vary with the water content of the plant system; however, they do represent a minimum since the tests were carried out on a newly installed plant system. An established plant system would reduce sound transmission more effectively since its dense root and leaf mass would hold more water.Green roof installation could reduce the quantity needed of insulation products which carry much embodied energy and would therefore be more sustainable.

Improvement of air quality

Roof planting improves air quality because:

* Plants remove atmospheric carbon dioxide.
* Plants release oxygen.
* Plants and substrate release water vapour so humidifying the air.
* Airborne particulate pollutants are deposited in the substrate, on the leaf surfaces of the plant layer, and onto the moist internal surfaces of the leaf.
* Air borne heavy metals are absorbed onto plant and substrate surfaces.
* A range of organic volatiles including formaldehyde, xylene, toluene and benzene are removed from the atmosphere.
* Large scale roof planting will reduce the 'urban heat island effect' and improve the flow of cool fresh air into the city.

Information from thermal studies, carried out at Trent University in the UK, found that on a typical day where ambient temperature was 18.4°C, a bare membrane roof had a surface temperature of 32°C. An identical roof covered with a thin layer plant system had a surface temperature of approximately 15°C.

One has to conclude that conditions in built up areas could be improved by the use of more plant ground cover. A similar conclusion was reached by the scientists of NASA. The question is, how can a significant enough area of ground space be planted within our intensely developed cities? As with the search for sustainable methods of rainwater management, the solution may be to look to the roofs. Data indicates that the strong heat sink effects seen on roofs in the UK can be greatly reduced by planting. With a collective approach to the issue, planting existing roof space would have a very significant and positive effect on air quality and temperatures within our cities.

The City of Chicago seems to be convinced of the collective benefits of roof planting. As a direct result of problems with elevated city temperatures, the administration has committed over $1,000,000 to the quantification of the benefits of roof planting. The City of Chicago are now issuing 'green roof grants' under its 1999 Urban Heat Island Reduction Initiative.

As well as improving air quality, an energy study conducted by that city estimated that, with the greening of all city roof .ops, energy to the value of $100,000,000 could be saved each year because of the reduced demand for air conditioning. It was estimated that the peak demand for energy would be reduced by a colossal 720mW. This reduced demand for energy would also mean a massive reduction of carbon *dioxide production- especially significant for the world's greatest producer of this* 'global warming' gas.

Provision of habitat for native flora and fauna

A green roof cannot replace a ground-based habitat for the complexity and diversity of species supported. However, some provision of natural areas for wildlife can be sustained through the use of green roofs. They should be viewed as complimentary to the maintenance of 'green' corridors for flora and fauna within an urban setting. For certain species, green roofs could provide habitat stepping-stones in the city environment where any protected habitat is becoming increasingly island-like in nature. The advantages of green roofs are the following:

* They are undisturbed.
* They are free of predators - the main culprit being the domestic cat.
* They can be constructed to cater for selected species. This could include the type of vegetation planted on the roof and the plant and animal species being encouraged to colonise it. For example, the provision of bare areas for nesting and plenty of small areas of short vegetation can encourage the Black Redstart. This bird species is considered endangered in this country but has been found colonising green roof space in South East England.

The interaction of birds, beetles and spiders with European green roofs has been studied by Stephan Brenneisen at Basel University. The major findings were that:

* Appropriately constructed green roofs attract birds. These birds use the roof to *search for food (insects and seeds), preening and cleaning, searching for nesting* material, nesting and roosting. Wheatears, skylarks, crested skylarks, lapwings, common terns and mallard have been recorded as nesting on European green roofs. The pied wagtail requires open areas of ground with no vegetation. Goldfinchs require a varied plant layer to supply the range of seeds that it prefers. An integrated policy on green roof construction would allow linked areas of habitat to be created. This is vital to encourage dwindling bird species back into the cities.
* The capacity of certain material to retain water is vital as this encourages the beetle population BUT will also affect the plant layer. In this European study 172 different species of beetle were found on green roofs including many rare examples. The older roofs had the greatest species range. Small hills in the substrate allowed moisture retention and this encouraged the beetle population. Green roof relief, thickness and substrate had effects on the beetle population.

* In this study 60 different species of spider were found on green roofs.
* Natural soil incorporation into the substrate is good for the encouragement of biodiversity.
* Areas that retain water during dry periods are helpful. In Luzern, orchids have been found to have colonised certain roofs.
* The incorporation of larger stones and pieces of timber is beneficial as this provides localised humid sites for beetles and spiders and perching points for birds.

The encouragement of biodiversity by way of roof top planting is becoming more high profile, particularly in the highly urbanised South East of England. It has been a worrying trend that brown field sites around and within urbanised areas are viewed as easy prey for development. Brown field sites do provide valuable habitat for plant insect and animal species and the replacement of this habitat on the roof may be a solution.

A thorough understanding of how the 'habitat' green roof is to integrate with local flora and fauna is critical. At BHC, we are conducting trials with combinations of substrate formulation and plant species with particular regard to 'habitat' roofs being a subtle but distinct form of green roofing in the UK.

Government Policy

In the UK, there are no public policies that relate directly to green roofs, however policies encompassing urban renewal, construction, open space, nature conservation and drainage all have relevance. The Government's Urban White Paper (DETR 2000) emphasises the importance of good urban design and the value of open green spaces in cities. It is suggested that urban redevelopment should be on innovative, sustainable, well-designed, multifunctional schemes.

Until quite recently, the importance of green roofs in such schemes has been overlooked by policy makers but increasingly, their role in sustainable urban drainage schemes, promotion of biodiversity and building performance is being recognised at many levels.The Mayor of London, Ken Livingston and his chief advisor on architecture and urbanism, Richard Rogers, issued a statement in 2004 promoting the use of green roofs in London. The Greater London Authority (GLA) campaigns for green roofs through mayoral policies and strategies (the London Plan, the Mayor's Biodiversity and Energy Strategy, and planning guidance on sustainable design and construction) and is encouraging the Government to establish practical ways of supporting living roofs across the UK. The GLA is also one of the sponsors of a Biodiversity and buildings project run by CIRIA (the Construction Industry Research and Information Association).The objective is to provide guidance on the technical, structural and planning issues that should be considered in integrating ecological and sustainable drainage features (primarily green roofs) into building design.This guidance will be of interest to developers, RSLs, designers, consultants and planners and is scheduled to be made available in the summer of 2006.

CABE (the Commission on Architecture and the Built Environment) is a non-departmental public body set up by the government in 1999. Through public campaigns and supporting professionals it 'encourages the development of well-designed homes, streets, parks, offices, schools, hospitals and other public buildings'. In a new report Creating Successful Neighbourhoods, launched on 1 February 2005, the CABE highlights how the adoption of design innovation is leading to early success in the Government's nine Pathfinder areas. The Pathfinders were first announced in February 2003 as part of the Sustainable Communities Plan. The projects form the first phase in a 10- to 15-year programme of regeneration and housing improvement. The new report from CABE reflects on the progress of the Pathfinder programme. It highlights redevelopments such as that in St Mary's in

Oldham which puts sustainable urban design at the heart of the scheme, with the aim to achieve an EcoHomes excellent rating. Features such as green roofs, solar water heating and wind power are included in the proposals. Environmental Design Consultants are supporting the work of the architects.

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Construction of green roof

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