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permeable paving projects

CONCRETE BLOCK
PERMEABLE PAVEMENT
CASE STUDIES
EDITION 3

Interpave

THE PRECAST CONCRETE PAVING AND KERB ASSOCIATION

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PERMEABLE PAVING PRINCIPLES

This document, first published in December 2005, covers a diversity of project case studies illustrating different applications of concrete block permeable paving (CBPP). It should be read in conjunction with Interpave's document *Understanding Permeable Paving* which provides essential information on all aspects of permeable pavements.

More, recent permeable paving case studies:

- **Permeable Paving for Amenity** – Robert Bray Associates
- **Adoption in Oxfordshire** – 15 years experience with permeable paving
- **Craigmillar Edinburgh** – the first permeable paving to be adopted in Scotland
- **PRP Architects Projects** – including concrete block permeable paving

PRINCIPLES

CBPP has a dual role, acting as the drainage system as well as supporting traffic loads. CBPP allows water to pass through the surface – between each block – and into the underlying permeable sub-base where it is stored and released slowly, either into the ground, to the next SuDS management stage or to a drainage system. Unlike conventional road constructions, the permeable sub-base aggregate is specifically designed to accommodate water. At the same time, many pollutants are substantially removed and treated within the CBPP itself, unlike attenuation tanks.

PRODUCTS

There is a growing choice of concrete blocks and flags available from Interpave manufacturers, designed specifically for permeable paving. Essentially they have the same impressive performance as conventional precast concrete paving products, including slip and skid resistance, durability and strength. The difference with CBPP is enlarged joints created by larger than conventional spacer nibs on the sides of each unit. These joints are subsequently filled with a joint filling material specific to each product, which is an angular aggregate, not sand. This arrangement ensures that water will continue to pass through the joints over the long-term.

SYSTEMS

There are three different CBPP systems, described as Systems A, B and C in all Interpave guidance. These systems were initially identified by Interpave and their designations have now been adopted in British Standards, The SuDS Manual (CIRIA 2007) and elsewhere. There is no difference between the surface appearances of the different Systems but each has unique characteristics making it suitable for particular site conditions.

SYSTEM A – FULL INFILTRATION

Suitable for existing subgrade (ground) with good permeability, System A allows all the water falling onto the pavement to infiltrate down through the constructed layers below and eventually into the subgrade (ground). Some retention of the water will occur temporarily in the permeable sub-base layer allowing for initial storage before it eventually passes through. No water is discharged into conventional drainage systems, completely eliminating the need for pipes and gulleys, and making it a particularly economic solution.

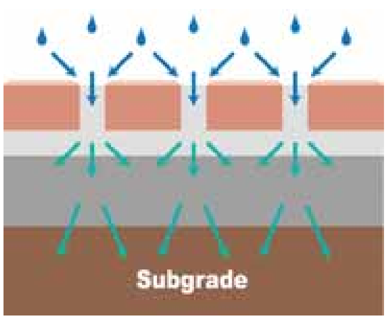
SYSTEM B – PARTIAL INFILTRATION

Used where the existing subgrade (ground) may not be capable of absorbing all the water. A fixed amount of water is allowed to infiltrate – which, in practice, often represents a large percentage of the rainfall. Outlet pipes are connected to the permeable sub-base and allow the excess water to be drained, via a flow-control device, to other drainage devices, such as swales, ponds, watercourses or sewers. This is one way of achieving the requirement for reducing the volume and rate of runoff and will most likely remove the need for any long term storage.

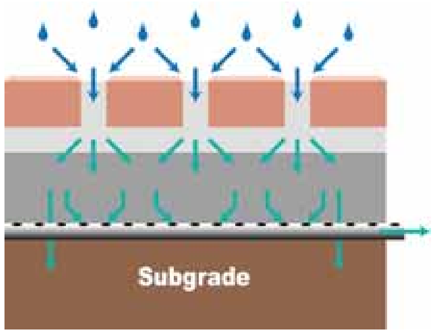
SYSTEM C – NO INFILTRATION

Where the existing subgrade (ground) permeability is poor or contains pollutants, System C allows for the complete capture of the water. It uses an impermeable, flexible membrane placed on top of the subgrade (ground) level and up the sides of the permeable sub-base to effectively form a storage tank. Outlet pipes are constructed through the impermeable membrane to transmit the water to other drainage devices, such as swales, ponds, watercourses or sewers. Importantly, the outlet pipes are designed to restrict flow so that water is temporarily stored within the pavement and discharge slowed.

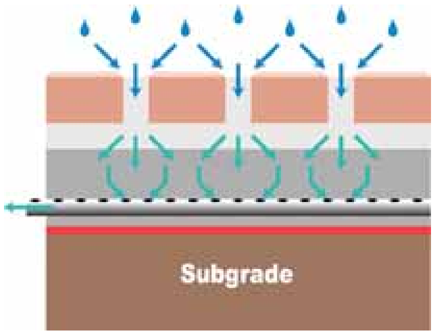
SYSTEM A **TOTAL INFILTRATION**



SYSTEM B **PARTIAL INFILTRATION**



SYSTEM C **NO INFILTRATION**



MARTLESHAM PARK AND RIDE, SUFFOLK

Designed by: Suffolk County Council Environment and Transport
Architects: Mouchel
Landscape Designers: The Landscape Partnership

PROJECT DESCRIPTION

The Park and Ride facility at Martlesham was one of Suffolk County Council's top priority transport schemes and the third park and ride to be built serving Ipswich, offering sustainable transport alternatives to the car. It was also the first large-scale concrete block permeable pavement (CBPP) project to be undertaken by the Authority. Following extensive public consultation the park and ride scheme formed part of Suffolk County Council and Ipswich Borough Council's Transport Strategy, which included plans for five park and ride schemes around the town aiming to dramatically reduce the level of traffic congestion within Ipswich.

The Martlesham site was chosen for its prime location on the eastern side of town and accessibility to the junction of the Ipswich eastern bypass. This choice followed extensive consultation and a detailed examination at a public enquiry. The location and access advantages of the site outweighed any potential adverse environmental effects that development might have had on the site and surrounding area: the site is part of a designated 'Special Landscape Area' and also part of a 'County Wildlife Site' with areas of acid grassland.

Since completion, the number of people using the park and ride scheme is gradually rising and there is already a high level of regular customers. The local residents are pleased with the new service and have been extremely complimentary about the site design and facilities.

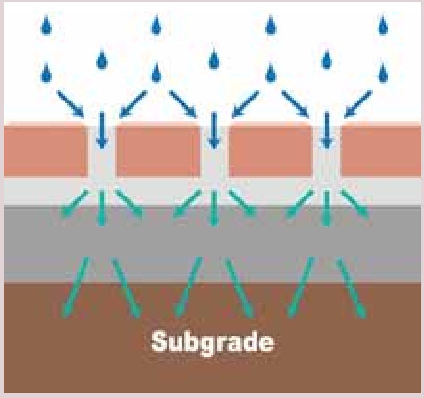
DESIGN PHILOSOPHY

The site occupies a total of 3.2ha with space for 530 cars. The key challenge for the project was to mitigate the adverse environmental and landscape effects of the development by incorporating SuDS techniques into the overall design to reflect the sustainability credentials of the Park and Ride concept. A complete paving solution was also required to create a surface of high industrial strength to withstand heavy vehicles, as well as attractive and accessible pedestrian areas.

Overall design objectives included:

- Visually attractive CBPP capable of full infiltration of rainwater to the ground
- A terminal building with a green roof for low-impact on the landscape and rainwater attenuation, feeding a reed-bed and pond to treat the water
- Effective car park lighting with minimum impact on surrounding landscape and wildlife habitats, and optimised energy use
- Landscaping with extensive planting of indigenous trees to complement local flora and habitats, and a layout to accommodate the existing trees
- Provision of bat and bird boxes to encourage colonisation within the site.

SYSTEM A
TOTAL INFILTRATION



The project utilised 14,000 square metres of CBPP for circulation, parking and pedestrian areas, and local conditions allowed for a 'System A' form of construction with total infiltration of surface water to the ground. Here, all rainwater falling on the CBPP, and adjacent impervious areas draining onto it, infiltrates through jointing material, the constructed layers below and eventually into the subgrade. This effectively eliminates the requirement for additional drainage systems whilst also recharging the natural groundwater.

Recent performance tests at the Martlesham Park and Ride replicated a 20-year in-service lifespan and demonstrated that the stability of the surface remained with CBPP construction. In addition to the CBPP, some 1,400 square metres of impermeable block paving for bus access areas and 1,300 square metres of flag paving for pedestrian areas were also installed.

KEY POINTS

This is a substantial and impressive example of CBPP forming part of a completely sustainable facility aiming for minimal impact on the local environment. At the same time, the large area of total infiltration (System A) permeable pavement does not need to form part of a SuDS 'management train' and operates in isolation. The project clearly shows:

- Elimination of traditional drainage components including pipes, gullies and soakaways
- Potential for total cost savings over other pavement types, including asphalt with traditional drainage
- Maintenance of stability of CBPPs under traffic and in different applications
- Ability for CBPP to replicate original drainage before intervention, therefore minimising impact on the environment
- Compliance with planning guidance (PPG25) and the Building Regulations, requiring local infiltration wherever possible.

HAZELEY SCHOOL, MILTON KEYNES

SuDS Consultant: Robert Bray Associates
Architects: Architecture MK

Further phases of this important SuDS project – including use of water harvested from permeable paving for toilet flushing – are covered in the Interpave case study:

- Permeable Paving for Amenity – Robert Bray Associates

PROJECT DESCRIPTION

The Hazeley School is a brand new, purpose-built state of the art secondary school on the Hazeley grid square in Milton Keynes. Located across the top of a hill, the school site as a whole can be considered as two distinct catchment areas divided by a ridgeline. The topsoil is shallow and sub-soils are heavy clays, regarded as impermeable by the drainage system designers. The site is a natural habitat for Great Crested Newts – a 'Protected Species' under National and European legislation.

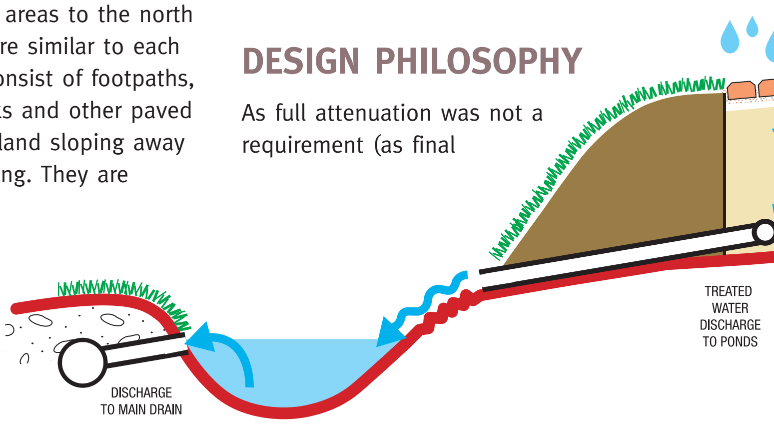
The western catchment, which consists of tennis courts and grass playing fields, drains via open detention basins/ponds and a linear wetland system to two outfalls on the north-west boundary and then to a natural watercourse. This case study concentrates on the eastern catchment area which includes the main building and three distinct external areas.

Immediately to the west of the school building, a large play area is constructed of impermeable asphalt and concrete block permeable pavements (CBPPs). Surface water from the asphalt drains on to the CBPP while rainwater down-pipes from the roofs also discharge into the permeable pavement sub-base which directly abuts the building. All the collected surface water travels through the CBPP jointing and laying course materials and into the permeable aggregate sub-base to be stored and slowly released into the next stage. The building acts as a dam except at its extreme ends and water is collected from the sub-base by perforated pipes for release under the building via control chambers. Storm water that exceeds the designed storage volume is allowed to flood around the ends of the building or through an overflow grating (with a protective inlet to prevent newt trapping) into pipes under the building once a level approximately 50mm above the block paving surface has been reached.

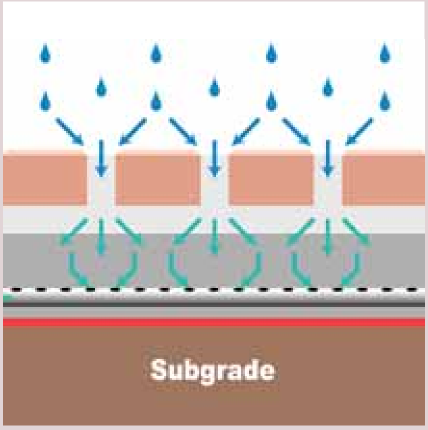
The two development areas to the north east and south east are similar to each other and generally consist of footpaths, car parking, cycle racks and other paved areas, terraced down land sloping away from the school building. They are surfaced in impermeable asphalt and CBPP with runoff from the asphalt draining onto the permeable pavement. Because the site slopes (approx 1:50), the permeable pavement sub-base is divided into compartments by walls extending up from a liner overlaying the subgrade to just below the surface block layer. Permeable collector pipes allow water to flow from each higher compartment to its lower neighbour via a chamber which can include a control device. This is repeated so that water progressively moves down the hill from compartment to compartment providing a controlled flow. Excess water is allowed to flow straight to the next compartment via overflows just under the block paved surface. Roof water in down-pipes is also added to the permeable pavement sub-base through filter chambers and then diffuser boxes. At the bottom of the terrace of compartments, water discharges into two separate retention basins (ponds) and finally runs into a new storm water sewer already installed as part of the Milton Keynes drainage infrastructure. Flood routes are provided by overflow swales and flush kerbs for extreme storm conditions.

DESIGN PHILOSOPHY

As full attenuation was not a requirement (as final



SYSTEM C
NO INFILTRATION

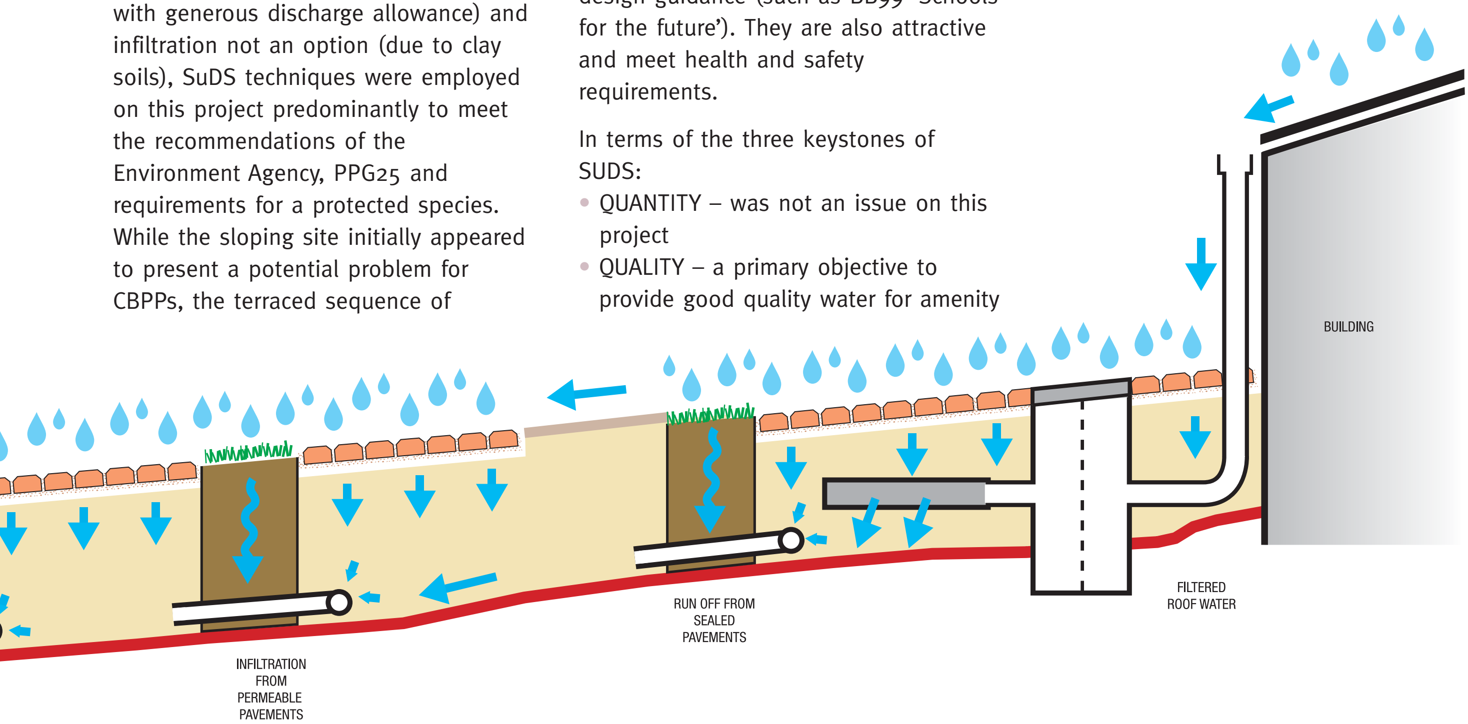


discharge is to a new storm water sewer with generous discharge allowance) and infiltration not an option (due to clay soils), SuDS techniques were employed on this project predominantly to meet the recommendations of the Environment Agency, PPG25 and requirements for a protected species. While the sloping site initially appeared to present a potential problem for CBPPs, the terraced sequence of permeable pavements provides a retention time enabling biological treatment of runoff with bio-remediation of organic pollutants like oils, milk and animal excrement. The resulting pollutant removal substantially improves water quality for the two ponds to encourage long-term population by wildlife – notably newts. The ponds themselves are highly vegetated and designed to filter the water, particularly during times of low flow, effectively acting as a 'polishing' feature or a second stage in the SuDS 'management train'. In addition to providing wildlife habitats, the ponds and related areas offer a valuable teaching and learning resource, recognised in the latest school design guidance (such as BB99 'Schools for the future'). They are also attractive and meet health and safety requirements.

In terms of the three keystones of SUDS:

- QUANTITY – was not an issue on this project
- QUALITY – a primary objective to provide good quality water for amenity

- AMENITY – high quality indigenous wildlife habitats including ponds.



HAZELEY SCHOOL, MILTON KEYNES

PROTECTING INDIGENOUS WILDLIFE

Assessments of the pollutants removed by the permeable pavements and their design were derived from CIRIA document C609: Sustainable Drainage Systems – Hydraulic, Structural and Water Quality Advice (of which the designer was a co-author). Apart from the wildlife ponds themselves, no other SuDS techniques were used in addition to the permeable pavements for pollutant removal in the eastern area.

All life depends on water but some animals and plants rely on aquatic habitats for daily survival. Amphibians – including frogs, toads and newts – return to water to breed, lay eggs and hatch tadpoles. They are particularly susceptible to water quality because of their permeable skins and, as tadpoles, use gills to breathe under water.

Recent research shows that tiny amounts of pollutants can disrupt immune systems in frogs causing deformities and population decline. They are the aquatic equivalent of 'canaries in cages' (historically used to detect gas in coal mines).

In addition, amphibians are threatened by man-made hazards along migration routes between breeding ponds and feeding habitats. Obstacles such as kerbs direct them towards drainage gratings and gulley pots used in traditional drainage systems, where they – along with other creatures including reptiles and small mammals – are trapped in lethal toxic liquids.

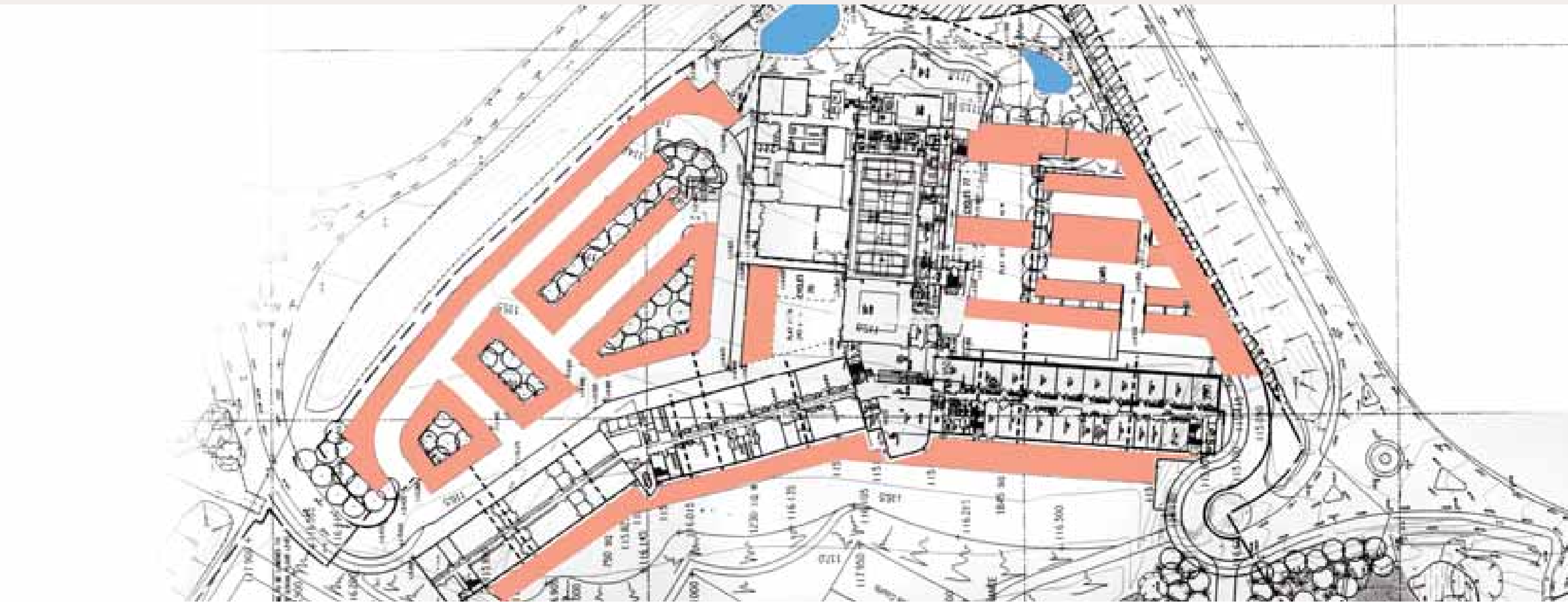
The protection techniques used on the Hazeley project include:

- Source control techniques at the head of the management train to protect ponds and other habitats further down the train from 'catastrophic' events
- Elimination of road gulleys by use of permeable pavements to collect runoff including roof drainage
- Open channels – both hard and soft – and short, direct pipe links without traps, allowing access out for wildlife
- Low flows characteristic of SuDS to avoid highly engineered outfalls
- Screening of outlets to prevent animals being swept into pipes and control structures.

KEY POINTS

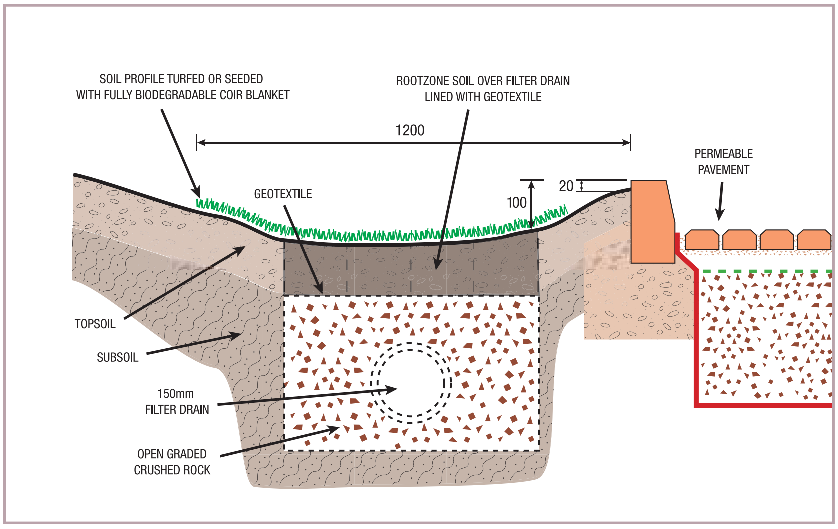
This is an unusual project which focuses on water quality and wildlife, where hydraulic and structural engineering requirements are employed to enhance these objectives. It is carefully thought through, taking an holistic approach, and offers an impressive demonstration of:

- Protection of wildlife with an absence of gulleys and other traps – an important benefit of concrete block permeable paving
- Removal of pollution within permeable pavements by controlling retention times to enable biological treatment to occur naturally
- Effective water treatment generally without the need for other SuDS techniques such as swales or filter strips, other than a final stage such as amenity pond, minimising land-take
- Application of CBPPs on sloping ground with terraced compartments
- Acceptance of roof water and runoff from adjacent sealed paving into permeable pavements – eliminating the need for other drainage means
- Problem-free use of permeable pavements close to buildings – an important lesson for urban areas.



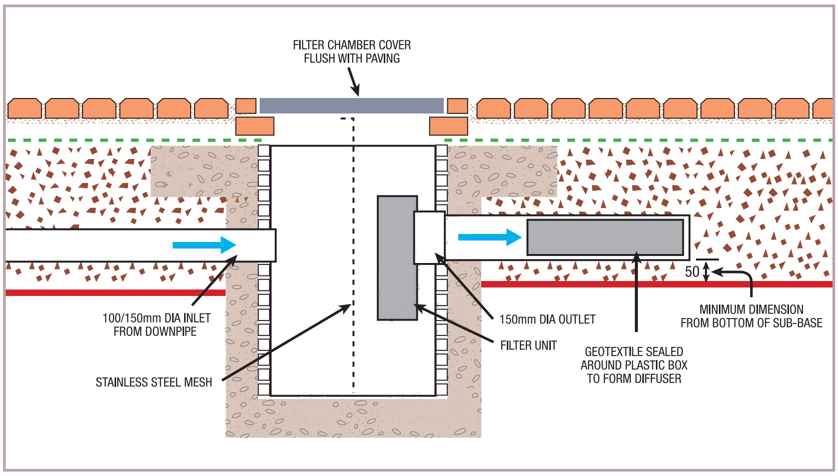
WORKING DETAILS

Protecting Permeable Paving



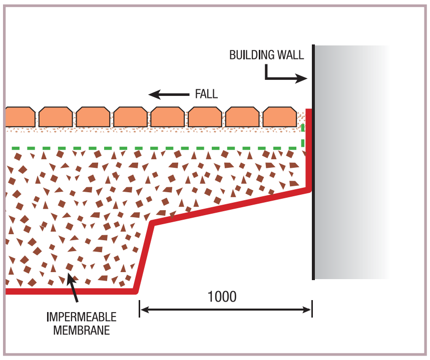
Under-drained, profiled verges are provided at the foot of banks and higher ground near permeable pavements to prevent silt and debris from being carried onto the pavement where blockage might occur.

Downpipe Connection



Roof water is piped into filter chambers which remove rubbish and silt, then dissipated through diffuser boxes into the permeable sub-base under the CBPP.

Building Abutment



Concrete block permeable paving runs right up to the school building but the permeable sub-base is curtailed 1 metre away from the building with a clay protection to the foundation. Water is contained within the sub-base and provision made for excess storm water runoff so that it cannot enter the building.

ECO COURT, SHERWOOD ENERGY VILLAGE

Architects and Environmental Engineers: LEDA Ltd
Engineers: Capita Symonds
Landscape Architects: Technical Exchange

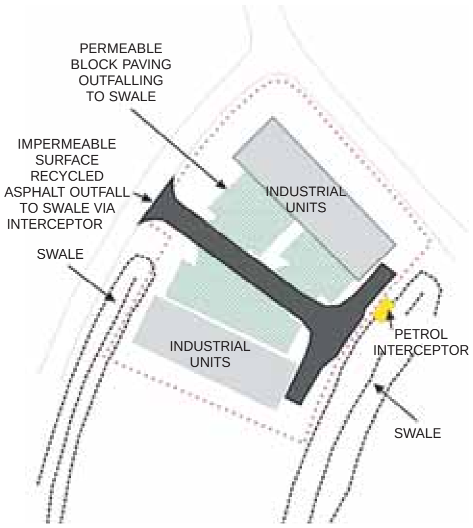
PROJECT DESCRIPTION

Sherwood Energy Village (SEV), Ollerton, is a unique initiative transforming a 91 acre former colliery into an environmental enterprise comprising industry, commerce, housing, education, recreation, tourism and leisure. The design ethos adopted by the SEV organisation is for the promotion of the highest energy efficient and environmental standards for the whole site development. It is therefore the perfect location for the Eco Court pioneering best practice project incorporating concrete block permeable pavements as part of the SuDS management train. The Sustainable Drainage System within Sherwood Energy Village is the largest in the UK.

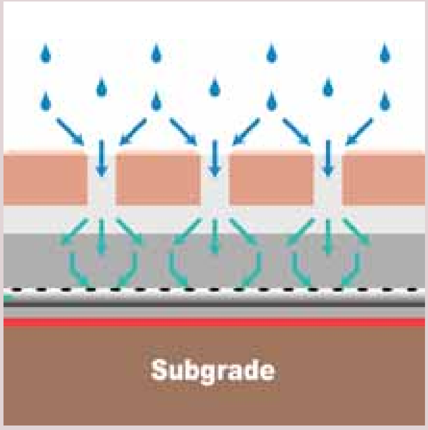
Eco Court is the result of the particular interest of the client, East Midlands Development Agency, to develop a sustainable prototype for the humble speculative industrial unit. The idea is to demonstrate the potential for applying a range of sustainable principles to the building design with a view to improving the overall performance of a building type whose creation has hitherto been overwhelmingly driven by requirements for very low cost and maximum speed in construction. The project is to be monitored for a period of 30 months after completion and the results disseminated in the public domain to maximise learning potential.

The scheme provides six units, arranged in two blocks responding to the radial geometry adopted by the site master plan. The challenge for the design team was to create a new vision of the industrial unit that looked forward to the needs of small developing industries today and in the future while encompassing:

- Flexible design enabling a variety of uses and comfortable internal environment to maximise productivity
- Minimal running costs, very high levels of insulation throughout and airtight construction
- Maximum use of glare-free daylight, effective natural ventilation for all year round comfort and simple, highly efficient heating systems
- High quality, low maintenance landscape to enhance local ecology based on native species and local sourcing
- Embracing and enhancing SEV site design principles with high quality external areas for customer confidence incorporating CBPP
- Use of low-embodied energy, local and recycled materials including UK sourced Douglas fir boarding, soil amelioration on site to create topsoil, UK sourced recycled cellulose insulation and recycled aggregates.



SYSTEM C
NO INFILTRATION



DESIGN PHILOSOPHY

Parking areas and footpaths in front of the new units were constructed in CBPP to act as a natural attenuation and filtration medium, and first stage in the SuDS management train, before discharging into the swale system that serves the whole of the SEV site. The impermeable asphalt access road, selected to facilitate construction access, drains onto the CBPP.

Originally, the designers wanted to keep the water in the immediate vicinity for planting sustenance – notably willow screens – with localised infiltration. But site conditions consisted largely of made-up ground following reclamation, with contaminated soils and groundwater levels within 2 metres of the subgrade. As a result, regulators required a sealed base with no infiltration (CBPP 'System C'). The designers also wanted to provide additional pollutant removal within the CBPP for runoff from adjacent impermeable asphalt pavements to protect swales and avoid oil spillages causing damage, without resorting to oil separators (with their potential maintenance problems). However, regulators eventually insisted on a small interceptor between asphalt and swale.

The designers gave considerable thought to the construction process and its potential impact on the CBPP. Initially, use of the sub-base as a construction platform was considered, although this could have clogged the sub base, and alternatively putting down a sacrificial layer and then removing. Eventually, it was decided to install a recycled asphalt access road and use this for construction access to maintain the drainage capabilities of the CBPP.

KEY POINTS

This pilot project is a good example of CBPP forming one stage in the SuDS management train and a demonstration of:

- Use of CBPP to enhance the external working environment
- Effective application of CBPP and SuDS to a difficult brown-field site
- The role of CBPP in projects demonstrating the highest environmental and sustainability credentials
- Careful consideration of construction implications and amendment as required
- CBPP adding value – particularly on a 'Whole of Life' basis – to developments.

Apart from showing environmental benefits, Eco Court seeks to demonstrate to developers that sustainability pays. Chris Blankley of East Midlands Development Agency explains, "Whilst there may be a higher initial cost, we aim to show by means of this project, that this is outweighed by the reduced running costs, combined with greater rental and capital growth returns, thus encouraging these principles elsewhere".

Swales serve the whole SEV site

Superstore, Exeter

Engineers: White Young Green

Drainage Design: Interpave Member

Subgrade (ground) conditions: Rock

Particular constraints: a discharge restriction into a sewer was applied by the Environment Agency demanding additional storage on site

Constructed in: 2006

Techniques: Optimisation of gradients to create additional storage within the CBPP and elimination of conventional drain run excavation within rock

Special interest: CBPP avoided the need to excavate into rock for conventional drainage runs and storage facilities.

In this situation, the use of an impermeable conventional pavement with drainage gulleys, pipe connections and petrol interceptors would have been prohibitive due to the time, cost and unpredictability of excavation in rock.

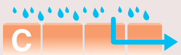
The scheme involved an extension to an existing superstore car park. The new parking area joined the existing car park at a gradient of approximately 1:50.

Due to the slope of the site and the discharge restriction imposed, the usual hydraulic design depth was not adequate for the entire site. Therefore a system was designed so that the lower edge of the car park had additional sub-base material for water storage. To achieve this end, the subgrade gradient was slackened to 1:125 whilst keeping the CBPP surface at 1:50, making it visually consistent.

Sixfields Development, Northampton

Designers: Halcrow

Subgrade (ground) conditions:
Polluted brownfield site with clay capping



Particular constraints: no discharge permitted to subgrade (ground)

Total area of CBPP: 52,000m²

Constructed in: 2005

Techniques: CBPP used to attenuate and treat runoff to watercourses

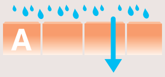
Special interest: The largest CBPP project started in Europe during 2005. Also adopted by the local authority.

The Northampton Brownfield Initiative, a collaboration between English Partnerships and Northampton Borough Council, is transforming various sites to create new homes and leisure facilities. At Sixfields a 2,235 car and coach park with access roads forms an essential part of this development. It was constructed over old gravel pits previously filled with household waste and capped off with a clay capping layer many metres thick. In order to minimise future settlement it was necessary to reduce the clay capping layer to half a metre thick and apply high-energy ground compaction techniques. One of the strengths of CBPP is its ability to accommodate differential settlement anticipated in situations such as this.

Because of the capping layer, the CBPP could not allow any water to infiltrate into the existing ground. CBPP used for parking areas and roads allows for the complete capture of all water, as well as attenuation and treatment within the pavement, before discharge into drainage ditches or directly into the River Nene. Due to the pollution removal characteristics of CBPP it was not necessary to provide oil separators. The CBPP roads are being adopted by the local authority.

Hoylake Park and Ride, Wirral

Designed by: Wirral Borough Council



Subgrade (ground) conditions: good permeability

Particular constraints: potential flooding issues for the local area, linked to restrictions on discharge into the existing drainage system

Total area of CBPP: 1,756m²

Constructed in: 2006

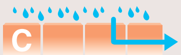
Techniques: CBPP used in isolation

Special interest: the CBPP also handles runoff from adjacent impermeable areas.

This 137-space car park was constructed next to Hoylake station as part of a package of transport improvements associated with the 2006 Open Golf Championship. Taking into account restrictions on discharge into the existing drainage system, investigations showed that using impermeable surfaces with piped drainage would increase the risk of flooding in the local area after medium rainfall. Instead, the 4,217m² area comprises impermeable roadways draining onto CBPP car parking areas which reduce, attenuate and clean up runoff, replicating natural infiltration to the ground and watercourse.

The Dings Home Zone, Bristol

Drainage Design: Interpave Member



Particular constraints: The existing combined sewer system in the area was already working at full capacity and the drainage authority did not want to increase flow into these sewers

Constructed in: 2005

Techniques: Retrofitted CBPP used for attenuation and treatment before discharge to watercourse

Special interest: Retrofitted CBPP adopted by a local authority. The CBPP avoids barriers to mobility – such as channels, kerbs and gulleys – in shared surfaces within this Home Zone.

Bristol City Council has been at the forefront of developing Home Zones for some time and this example is one of the first retrofitted permeable paving schemes in the UK which was also adopted as a ‘highway’ by the local authority. The Dings Home Zone was developed in partnership with the charity Sustrans – along with other stakeholders – which led the community involvement process whereby residents are involved at each stage of the design of the new streets. A Sustrans spokesman said: ‘The initial phase of the project has been awarded a Bristol Civic Society Environmental Award, which is a great credit to the work undertaken by the local community, Bristol City Council, and other stakeholders whose input has been invaluable and helped shape this scheme.’

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