THE PRACTICAL IMPLICATIONS OF INFILTRATIBLE (ECOLOGICAL) BLOCK PAVING

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ABSTRACT

Although well established in Germany, the recent introduction of infiltratible, also known as 'ecological', block paving to the UK has revealed new approaches to a number of important issues. This paper examines how infiltratible block paving fits in to current thinking on sustainable urban drainage systems, considering the needs for such systems and the techniques involved which include permeable pavements. Appropriate applications for infiltratible block paving are considered, related to the impact of pollution. The effects of silting up on long term performance are examined together with current design methodologies in use in the UK and the implications for structural performance of pavements. The importance of good site practices and early resolution of legal and management responsibilities for permeable pavements is stressed.

1. THE NEED FOR SUSTAINABLE URBAN DRAINAGE SYSTEMS

Continuing urbanisation and development results in a growing proportion of sealed up areas which stop rainwater passing directly into the soil. The consequences of this include:

*Concentration of surface water drainage
*Overloading of existing sewers and river flooding
*Direct channelling of pollution into watercourses
*Lack of water table replenishment
*Deprivation of water to local planting
*Substantial, ongoing further investment in drainage infrastructure

In the United Kingdom, the current governmental policy towards development of redundant inner city land (known as "brown-field" sites) for housing and other new development offers the additional challenge of building in areas generally with outdated drainage infrastructure unable to cope with additional loading. As a response to these problems, sustainable urban drainage solutions based on managed infiltration are growing in popularity, resulting in:

*Decentralisation of rainwater disposal
*Dispersal with little or no recourse to sewers and rivers
*Potential for natural pollution breakdown
*Replenishment of water tables
*Restoration or continuation of sustenance to local planting
*Real savings in drainage installation, upgrading, charges and maintenance costs

In the UK, a design manual recently published by CIRIA [1] recognises that sustainable urban drainage systems should:

*Deal with run-off close to where rain falls
*Manage potential flooding at source
*Protect water from point pollution and diffuse pollutants.

2. TECHNIQUES FOR SUSTAINABLE URBAN DRAINAGE SYSTEMS

Established sustainable techniques now being used in the UK include filter strips, swales, filter drains, infiltration devices (such as soakaways), basins and ponds, and permeable pavements. These permeable pavements simply allow some or all rainwater falling on the surface to pass through to be dealt with at source. By removing water from the surface where it falls, such pavements minimise ponding problems.

Permeable pavements have been used to provide a simple solution on their own for many smaller projects but a combination of these with other infiltration or drainage systems will usually be appropriate for larger areas. It is now recognised that an holistic approach should be taken with comprehensive development schemes, combining the various techniques, often including permeable pavements. Invariably, permeable pavements with infiltration systems provide a lower cost solution both in the short term and over a full design life than traditional concentrated drainage solutions, not to mention environmental benefits.

3. TYPES OF PERMEABLE PAVEMENTS USING BLOCK PAVING

There are three classifications of block paving used for permeable pavements. Porous paving blocks, manufactured with 'no fines' aggregate to create small voids within the pavers for the passage of water, have been used. However, the nature of the concrete material and its reduced strength limit the application of this category effectively to pedestrian areas following failure on trafficked pavements and there is evidence of comprehensive silting up of voids over time leading to ineffective drainage capability. Various designs of grass grid units - typically with 50% concrete load-bearing surface and 50% soil-filled with grass

growth (as shown in Photo 1) - have proved popular for emergency access roads and overspill car parks, combining the appearance of grass with structural capability. While these applications remain valid and such designs can play a part in sustainable drainage systems, the organic nature of the filling material results in poor drainage performance.

It is the third classification, infiltratible concrete block paving systems, which provides the best performance both in terms of drainage and structural performance, particularly under trafficking. Such blocks are manufactured in the same way as standard paving blocks to high compressive strengths but incorporating surface voids for water run-off generated by the block design. The surface voids result from the particular system's block design and can be generated by spacers, open areas between units (as shown in Photo 2) or enlarged joints (as shown in Photo 3).

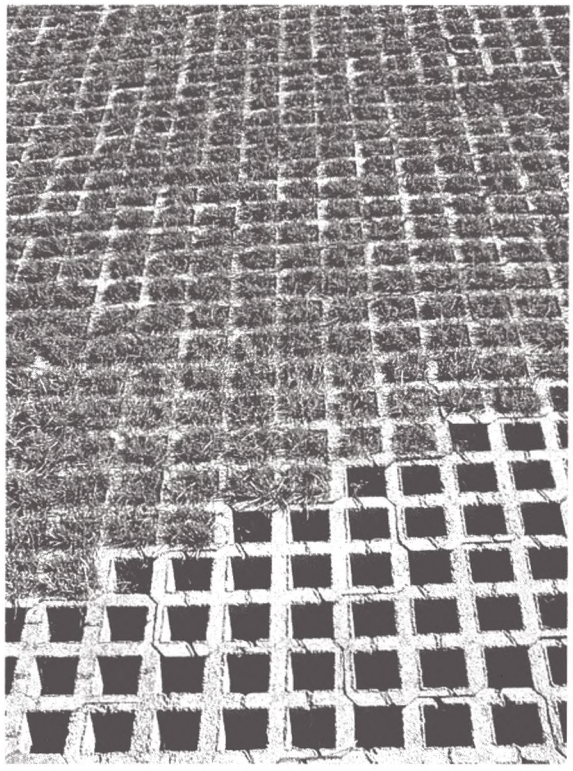

Photo 1. Cellular concrete paving with soil and grass infill



Photo 2. Infiltratible block paving with open areas between units

Blocks are laid on, and the spaces and joints between them filled with a granular material (as shown in Photo 4), containing a minimum of fine material, to allow the rapid passage of surface water through the pavement into an appropriately designed sub-base. Some designs are particularly suited to machine installation (such as shown in Photos 2, 3 and 4).

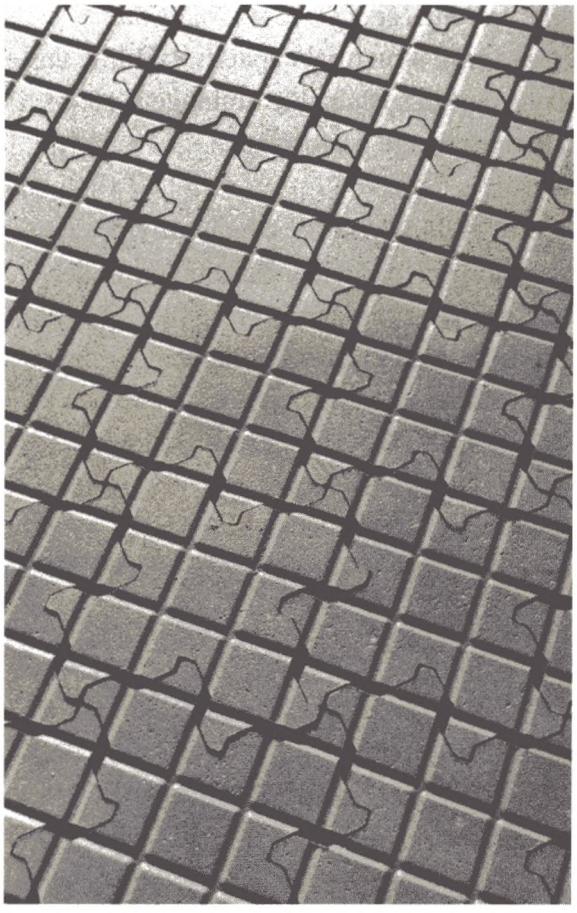

Photo 3. Infiltratible block paving before joint filling



Photo 4. Infiltratible block paving with joints and spaces filled

4. APPLICATIONS FOR INFILTRATIBLE BLOCK PAVING

Infiltratible concrete block paving can be used for a variety of different drainage approaches, dictated by a number of factors including the permeability of the ground (i.e. its ability to allow water to run through), sensitivity of location to pollutants (e.g. potable water extraction areas) and any requirement for water 'harvesting' (i.e. collection and storage for re-use as "grey water"). These can be summarised as follows:

4.1 Simple complete infiltration to ground water: good ground permeability; non-sensitive to pollutants; no storage requirement (Figure 1)

4.2 Infiltration with some surface run-off to an infiltration device or drain: less good ground permeability; non-sensitive to pollutants; no storage requirement (Figure 2)

4.3 Infiltration with some sub-grade drainage to infiltration device or drain: less good ground permeability; non-sensitive to pollutants; no storage requirement (Figure 3)

4.4 Impermeable membrane at sub-grade for collection and drainage to infiltration area or treatment plant: very poor ground permeability; sensitive to pollutants; storage requirement (Figure 4).

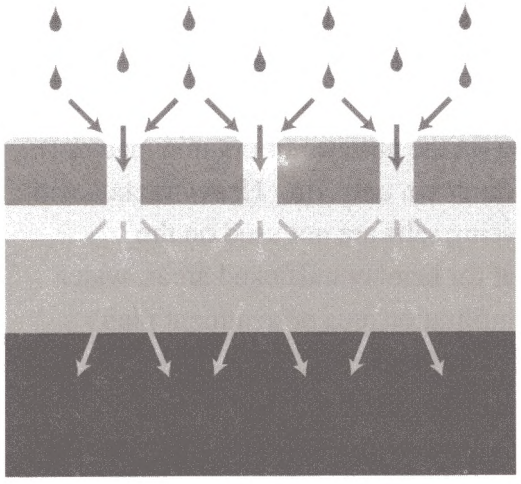

Figure 1. Infiltration direct to the ground

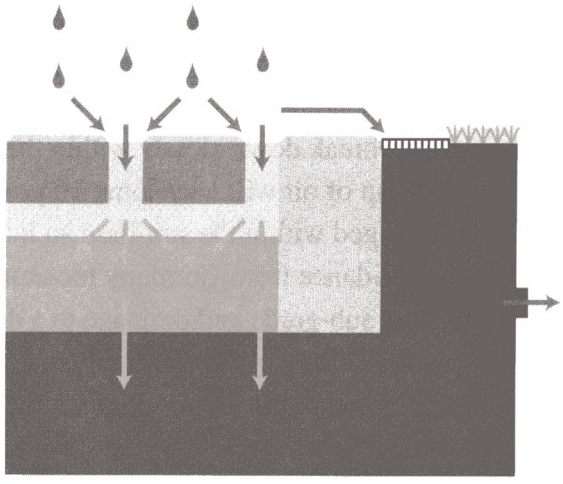

Photo 2. Infiltration with some surface run-off

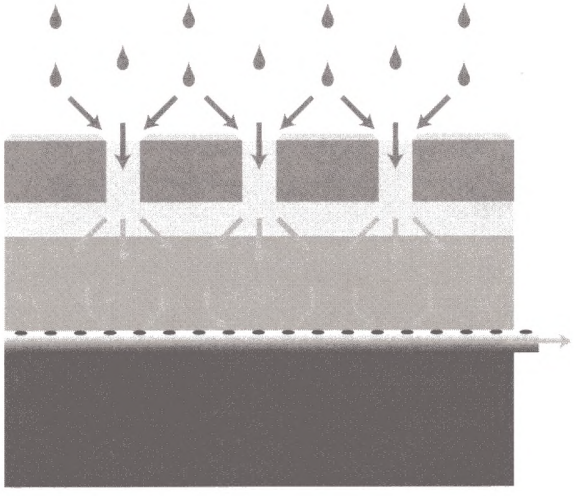

Figure 3. Infiltration with some collection/drainage at sub-grade

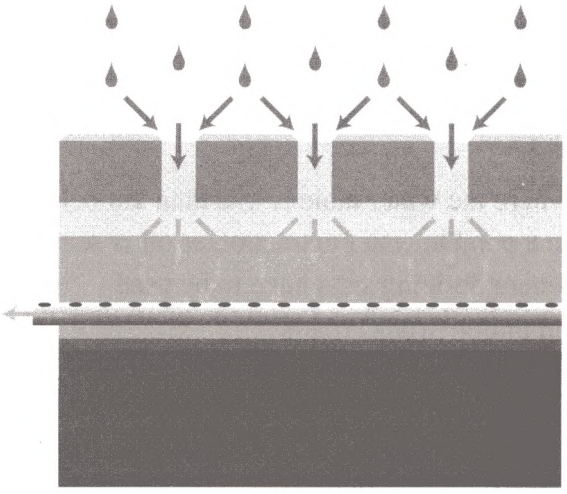

Figure 4. Containment for storage/ drainage by impermeable membrane

In the cases of 4.2 - 4.4 above, water can be drained or pumped out for re-use, for example to irrigate adjacent landscaping, or for secondary treatment if needed in basins or wetlands. It has been established that construction of infiltratible pavements can be both faster and less expensive than sealed pavements with concentrated drainage, with no requirements for complex gradients or gullies. In addition to surface water drainage, infiltratible block paving can be used to de-seal surfaces allowing migration of gases such as methane (particularly on land-fill sites) and radon which would otherwise cause health and safety problems. This technique has already been used in the UK.

5. POLLUTANTS AND INFILTRATIBLE BLOCK PAVING

Industry and traffic generated pollution falling on the pavement passes through into the sub-base, unlike traditionally drained paving where pollutants are concentrated into sewers and watercourses. Such pollutants can include sand, silts, organic particles, heavy metals, toxic compounds, materials in suspension, dissolved matter, oils, chemicals and litter.

Hydrocarbons break down slowly within the sub-base (in the absence of organic material): however, a drop of oil will take some 10 years to move down only 1m. Heavy metals will remain unchanged within the sub-base so long as de-icing salts are not used on the pavement. Guidance from Germany recommends that for heavily trafficked areas, water containment at sub-grade and drainage to a designed infiltration area or treatment plant should be considered. In the event of a major pollutant spillage, infiltratible paving allows this to be dealt within the immediate locality rather than channelled through sewer and watercourse systems. The CIRIA design manual [1] recognises three levels of potential pollution:

* Residential sites - where a single treatment stage should be sufficient
* Non-residential sites - requiring two levels of treatment
* Industrial and Major Commercial sites - which need special attention

Infiltratible concrete block paving without full containment should not generally be used:

*where the water table is less than 2m below the paving
*in a potable water extraction or other sensitive area
*where de-icing salts have to be used
*on major (trunk) roads

6. LONG TERM DRAINAGE EFFICIENCY

It is now well-known that voids in the top 20mm or so of the jointing material start to clog with silt and organic matter over time, affecting potential flow rates. In Germany, studies by Borgwardt [2] consider that drainage capability is ultimately reduced to only 10% of the newly constructed value and additional run-off drainage is often provided for the future. In the UK, design engineers consider this value to be more in the order of 50% and actual experience endorses this view, while research demonstrates that the rate of reduction stabilises over time to a value which, ideally, would form the basis of design. Maintenance regimes to try to prevent or reverse silting up, for example by jet washing joints, are considered expensive, ineffective and problematic.

7. PERMEABLE PAVEMENT DESIGN

Although prescribed design standards are used in some countries, such as RStO in Germany, there are currently no such standards in the UK. British Standards for the manufacture of block paving, pavement designs and installation make no reference to permeable pavements, as is the case with trade association guidance. The CIRIA design manual [1] is a new departure from this but recommends a non-prescriptive, holistic approach for designers with the natural drainage pattern of each site as its starting point. British pavement designers therefore use models based on experience, supported by extensive weather statistics.

UK rainfall statistics, for example as shown in BRE Digest 365 [3] indicate that a rainfall intensity of 180 l/s/ha (litres per second per hectare) offers a conservative design criteria for all but the most extreme conditions throughout the country. This relates to a 10 minute storm returning every 5 years (known as M5-10). Infiltratible block paving systems should be able to accept at least this level throughout design life. Trials by Shackel [4] have shown that a 2-5mm granular material provides optimum drainage capacity while maintaining good structural performance of the pavement surface. This material should be clean and as free of fines as possible.Taking into account the potential silting up of voids, a reduction to only 10% of original levels could be considered an absolute worst case, giving a requirement of 1800 l/s/ha. Recent tests of one paver design with approximately 10% of open area to surface area (shown in Photo 2), with the bedding and jointing material described above, have given a capacity of 3550 l/s/ha, almost double this requirement.

Current approaches to design in the UK are pragmatic and dependent upon use and anticipated risk. For example, an event return factor of 1 in 2 years might be consider acceptable for open car parking while 1 in 100 years is used close to housing. For footpaths, cycle ways, drives, smaller car parks and other modest sized projects, it can generally be assumed that drainage requirements will be met by a properly constructed infiltratible pavement without additional drainage measures except emergency run off. In the UK, this could consist of clean 'Type 3' granular material (replacing 'Type 1', often used in road construction) which contains sufficient voids to allow drainage. For un-trafficked areas, a 100mm thickness should suffice while well known standards such as Road Note 29 recommend specific thicknesses for minor residential roads. Care should be taken to ensure that cellars, embankments or other structures will not be affected by drainage from the pavement.

For some years infiltratible block paving has been used on large, major projects as part of unified managed infiltration designs. For example, some 120,000 m2 is now installed for bus parking at the Hanover World Fair site (Photo 5). It is recognised that each project needs to be considered on an individual basis taking an holistic approach using any combination of sustainable urban drainage system techniques which is appropriate.



Photo 5. Infiltratible block paving in use at the Hanover World Fair site with emergency run-off to infiltration areas

8. STRUCTURAL PERFORMANCE IMPLICATIONS

Research by Shackel [4] demonstrates that one particular design tested(shown in Photo 2), laid with the recommended bedding and jointing material, gave good load-bearing characteristics similar to conventional, fully interlocking paving blocks of a similar L-shaped format. Recent comparative trials by Knapton [5] of four pavers for mechanised installation provides a useful insight into the effects of paver shape on performance in heavy duty situations. Where an infiltratible equivalent of such pavers is available (such as those shown in Photos 2 and 3), a similar structural performance can be anticipated.

9. SITE PRACTICES

Experience with permeable pavements has clearly demonstrated the importance of quality control. It is essential for the long term success of a project that the materials which form part of the drainage and structural design are carefully graded, supplied and installed as specified. To ensure this, appropriate testing programmes should be set up and site procedures closely followed. In particular, organic matter such as soil installed after paving for landscaping purposes must be kept off infiltratible block paving. Similarly, the paving must be protected from other construction, waste or other bulk material stored on it, or such practices avoided completely. Unlike other surfaces on construction sites, permeable pavements cannot successfully be cleaned after abuse during construction.

10. DELINEATION OF RESPONSIBILITY AND MANAGEMENT

There is no question of the potential for sustainable urban drainage systems to play a growing part in acceptable development for the future. However, management issues form a major initial barrier which must be resolved early. Traditional legal responsibilities and demarcations are not well suited to this relatively new technology. However, in the UK initiatives are being taken by statutory authorities to simplify the process: for example, in Scotland and Northern Ireland it has been established that local authorities will be responsible for maintenance of public sustainable urban drainage systems (including permeable pavements) above ground and water authorities below ground. It is anticipated that new standards will be established soon allowing use of infiltratible block paving to grow rapidly.

REFERENCES

1. Sustainable Urban Drainage Scottish Working Party (2000) Sustainable Urban Drainage Systems - Design Manual for Scotland and Northern Ireland, CIRIA, UK.

2. Borgwardt, S. (1995) Suitable Beddings for Paving Blocks Permeable to Water, Betonwerk + Fertigteil-Technik BFT, Germany.

3. BRE Digest 365 (1991) Soakaway Design, Building Research Establishment, UK.

4. Shackel, B. Water Penetration and Structural Evaluations of Permeable Eco-Paving, University of New South Wales, Australia.

5. Knapton, J. (2000) A Report on the Performance of Pavers for Mechanical Installation, University of Newcastle upon Tyne, UK.