Practice Note #4

POROUS PAVING

Water Smart design is the effective planning, design and building of homes, subdivisions, suburbs, towns and cities that are sensitive to the ecological needs of the waterways that are impacted by them.

Water Smart developments aim to mimic natural processes which reconnect neighbourhoods with local waterways and improve visual amenity and quality of life, make better use of all water within our urban areas, seek to protect the ecological health of urban waterways from the potential negative impacts of urban development, and to add value to our water and waterway management activities.

Each Practice Note in this series is designed to give greater detail and specific advice on different aspects of Water Smart developments and devices. The Practice Notes provide reviews of the main design features, advice on installation and maintenance issues, include diagrams and pictures to assist with implementation, and reference useful websites to assist with further research into Water Smart developments.

This Practice Note provides general guidance on the design and installation of porous paving to allow infiltration and stormwater treatment.

PAVING AND THE URBAN WATER CYCLE

Urbanisation typically involves an increase in the land area covered with paved (or 'impervious') surfaces, such as roads, driveways, pathways and courtyards. The installation of these impervious surfaces contributes to increased stormwater run-off resulting in increased downstream flooding and pollutant loads which impact on waterways and sensitive aquatic environments. Paved areas also reduce the volume of rainwater that infiltrates to the subsoil meaning less available water to recharge ground water systems and less water available for surrounding vegetation.

Urban areas fundamentally alter the natural water cycle by reducing infiltration and increasing runoff. This can be demonstrated by examining the Wyong Region on the Central Coast. Wyong on average experiences approximately 90 rainfall events per year. Under natural conditions stormwater would typically cause runoff in only up to ten of these events, with the rest of the rainfall infiltrating into natural soils. With urbanisation, runoff is generated under each one of these rainfall events with greater stormwater volumes of higher intensity reaching waterways and lakes.

This changes the natural condition of creeks and wetlands through bank erosion, loss of vegetation, increased pollutants and the alteration of ecosystem balance.

The greater use of porous paving in urban environments can contribute to reducing these impacts and promoting a variety of water management objectives, including:

- reduced (or even zero) peak stormwater run-off from paved areas by detaining stormwater within the pavement matrix
- increased groundwater recharge, as stormwater is allowed to infiltrate into the soil
- improved stormwater quality as porous paving filters contaminants from stormwater through adsorption, straining and (in some cases) biological processes.
- reduced area of land dedicated solely for stormwater management. If porous paving is used then rain gardens and other Water Smart treatment measures can be reduced in size

PAVING AROUND THE HOME

The impacts of hard paved surfaces on urban allotments can be reduced by:

- limiting the area of paved surfaces
- directing stormwater run-off from paved surfaces to landscaped areas, gardens and lawns rather than to the street drainage system, and
- using porous paving

The application of these methods to a typical residential allotment is shown in **Figure 1**.

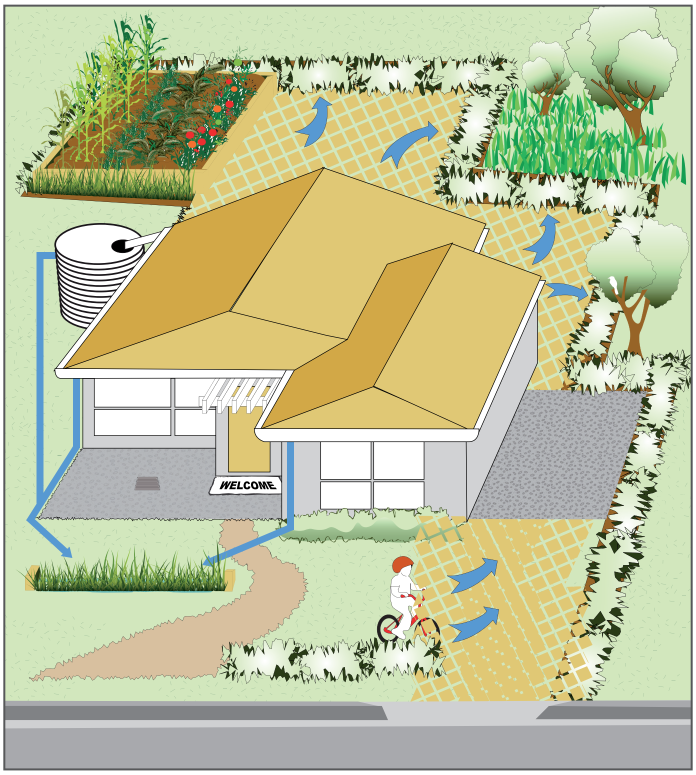


Figure 1: Paving strategy for a typical suburban lot. Hard surfaces like driveway, courtyard, patios can be substituted with porous paving.

Paved areas around the home are generally subject to light traffic loads and thus are ideally suited to the application of porous paving – an example of a good use of porous paving is shown as the hatched areas in **Figure 1.** Stormwater runoff from paved areas (shown as arrows) is reduced when porous surfaces are used, and the residual runoff can be more easily managed in landscaped areas resulting in reduced pits and pipes and possibly negating the need to connect to the street drainage system.

WHAT IS POROUS PAVING?

Porous paving is an alternative to traditional impermeable concrete and asphalt pavements. Porous paving allows water to percolate through a porous surface layer to the base and sub-base where it is stored until it infiltrates to the surrounding soil or drains at a slower rate to the stormwater system. Porous paving systems also function as a filtration system, removing many contaminants as the water passes through the granular matrix. An example of a typical porous pavement profile is shown is **Figure 2.**

A number of porous paving products are commercially available and the mechanism of infiltration can also vary – see following section for explanation.

Figure 2: Easydriveways block paving. (Source: AJ McCormack).

TYPES OF POROUS PAVING

Modular paving

Modular paving is similar to traditional paving with the exception there are voids (spaces) between the interlocking paver tiles **(Figure 3).** These voids are filled with gravel or coarse sand to allow water to pass through into the underlying pavement and soil.

Modular paving is generally made from concrete or clay and is available in various shapes and patterns. Modular pavers can be used on small jobs, such as footpaths, through to large hardstand areas like bus terminals.

Figure 3: Porous pavers. (Source: Toulatin River Keepers).

Monolithic porous pavement

Monolithic pavements are constructed to enable water to flow through the pavement structure (not through voids between pavers as in modular paving. See **Figure 4).**

This type of pavement incorporates voids into the entire pavement structure i.e. the paver unit or road surface layer itself is porous. The most common materials used are porous concrete and porous asphalt which are specially manufactured by removing the finest components from the matrix.

Figure 4: Monolithic porous pavers. (Source: Bahler Brothers).

Grid pavement

Permeable pavements can be constructed using grids made of various materials such as concrete and plastics ***(See Figure 5).*** These paver units contain many evenly spaced void areas that are filled with sand, gravel or grass. Similar preparation is required to modular paving with the grid units laid on bedding layers.

Figure 5: Propous paving grid system. (Source: CETCO contractor services).

DESIGNING POROUS PAVING

Porous paving is an excellent stormwater management measure for low-traffic surfaces such as driveways, access roads and car parks. To ensure the paving adequately manages the stormwater received and retains structural integrity, design and maintenance issues need to be carefully considered together with the site characteristics (slope, soil type, ground water and site needs (type of traffic, traffic loading). Guidance on site assessment is provided in Practice Note 1, and further explained below.

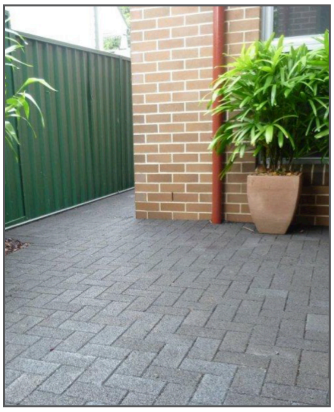
Porous paving functions by allowing rainfall and surface runoff to percolate through a porous surface layer to the road base and sub-base where it is stored until it infiltrates to the surrounding soil or drains to the stormwater system at a slower rate.

Common features of a porous pavement are shown in **Figure 6.** If infiltration to the surrounding soils is not appropriate then the under drains shown in the Figure are required to collect and convey treated water to the stormwater drainage system. Porous pavements can function as infiltration systems or detention systems. These functions can be implemented separately or together depending on the circumstance and requirements.

EXAMPLES OF POROUS PAVING

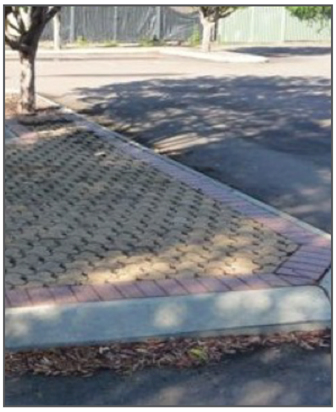
#1 DRIVEWAY

Porous paving driveway in Wyong Shire (source: M.Wierzbicki)



#2 AROUND THE HOME

Porous courtyard and footpath in residential setting in Sydney (Source: Hydrocon)



#3 CARPARK MEDIAN

Porous paving used in a carpark median in Wyong Shire (source: M. Wierzbicki)

#4 FOOTPATHS

Porous paving over the tree root zone at Honeysuckle wharf, Newcastle (source: M Wierzbicki)

Infiltration System

An infiltration system filters stormwater run-off as it passes through the granular filter media, and infiltrates to the surrounding soil. Infiltration is encouraged in areas where there are sandy, free draining soils with a deep water table. Care should be taken when locating porous paving in clayey soils near infrastructure such as roads or buildings as this may cause saturation and swelling of the soil. Porous paving systems can be sealed to minimise infiltration however the benefit on reducing runoff volumes is reduced. Guidance on Infiltration systems is provided in Practice Note 3 – Infiltration Devices.

Detention System

A detention system reduces run-off from hard surfaces by detaining the water in voids within the granular bedding material, and then slowly releasing the water to the stormwater system. In other words the base and sub base materials act as a reservoir where the treated stormwater is temporarily stored. This system is appropriate if on-site detention is a specific objective, in this case the pavement matrix and void areas can be maximised allowing for greater storage.

IMPORTANT DESIGN CONSIDERATIONS

When designing porous pavement systems into your development, consider the following issues to ensure the system will provide the correct stormwater management services and function as designed. Typically, porous paving systems will be designed as depicted in **Figure 6** whilst considering issues of traffic, infiltration, clogging, geotextiles, ground water, conditions and maintenance.

Traffic Loading

For light duty traffic applications, such as pedestrian areas, courtyards, footpaths, off-street car parking bays and driveways, a single size (uniform) aggregate should be used in the base course (represented as the "retention trench" in **Figure 6**). The base course should be installed as per a standard pavement where the base material is placed in layers and compacted.

For heavy duty porous pavements, which are required to hold heavy vehicles and constant traffic, a precise pavement design will be required to meet the specific performance requirements of the site. Typically this will require the use of a specially graded permeable road base which provides the best compromise between load carrying capability, permeability and water storage. Please refer to the 'useful websites' section at the end of this for design of heavy duty pavements.

Infiltration

Once surface runoff percolates through the porous paving matrix, it can infiltrate to the surrounding soil, thus avoiding the need to be conveyed through a built stormwater management system. However, infiltration is not always appropriate either due to soil or ground water conditions, or the proximity to buildings and infrastructure.

Generally infiltration in heavy or reactive clays is not recommended, and in this case porous paving system should be lined to prevent infiltration beyond the pavement sub-base (under drains will be required to collect and direct water to stormwater drainage system). Saturation of soils near existing infrastructure such as roads and buildings is to be avoided. This can be overcome by locating the paving a minimum distance from them. Installing impermeable liners and other engineering solutions to reduce infiltration into the surrounding soil can be used to overcome this constraint.

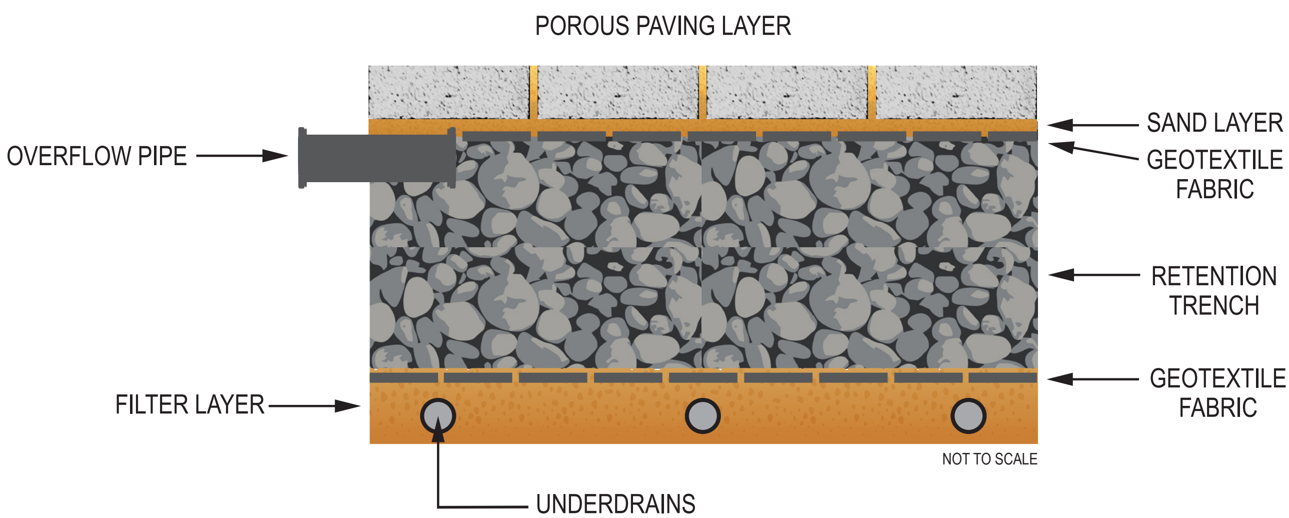


Figure 6: Typical porous paving section.

Clogging

Limit the opportunity for the system to become 'clogged' resulting in stormwater bypassing the system through:

- Installing porous paving in positions that are unlikely to receive large quantities of sediment and debris washed down by stormwater, or windblown sand or other material
- Avoid locating near native trees that may produce blossom which is a common cause of clogging
- Ensuring appropriate sediment controls are in place to stop sediment inputs during construction
- Undertaking periodic maintenance, such as vacuum sweeping or high pressure hosing, to remove sediment (and direct run-off to grassed areas)

Geotextile layer

Figure 6 shows the common practice of positioning a geotextile fabric at various layers within the pavement. The geotextile layer prevents migration of finer bedding sand down through the pavement profile and it also adds strength to the pavement.

Clogging at the surface and at the geotextile layer has been known to occur in porous paving requiring periodic replacement of sand bedding and geotextile. This can be avoided by undertaking appropriate maintenance (surface cleaning), and by monitoring impervious areas connected to the porous pavement which can generate sediment.

Groundwater contamination

Porous paving can, in some cases, increase the risk of contamination of shallow groundwater by toxic materials derived from asphalt, vehicular traffic and road use. This risk can be minimised or eliminated by adhering to the following design principles.

- Do not construct porous paving over shallow or sensitive aquifers
- Do not use porous paving on streets with high traffic volumes
- Install a sand sub-base over a retention trench with geo-textile fabric lining to capture and treat contaminants prior to infiltration to surrounding soil. i.e. maximise the treatment potential of the system.

For further information on contamination of groundwater see Practice Note 8.

Unsuitable conditions

Porous paving should not be placed:

- On saline, acid sulphate, sodic (high sodium) or very shallow soils
- Over shallow groundwater (high water table)
- In areas that will have high sediment loads which will cause clogging
- On roads with high traffic volumes or heavy loads
- On slopes in excess of 5%
- On areas subject to persistent wind blown or loose sands
- On clay soils that collapse in contact with water or have high shrink/swell characteristics
- On soils with a hydraulic conductivity of less than 3.0 mm/hr (heavy clay)
- Over rock that has little or no permeability
- In the vicinity of trees and shrubs that produce excessive blossom which will clog the pavement surface.

Maintenance

Maintenance of porous paving will enable the system to continue operating as designed and extend the life of the pavement. This will reduce the need for major maintenance activities such as pavement replacement and it will also reduce traffic and pedestrian hazards created by excessive ponding.

Routine inspection of permeable pavement should be undertaken annually or after each major storm event and regular maintenance will typically comprise:

- Annual cleaning by sweeping or high pressure hosing to remove sediment and clogged surfaces. Depending on the size of area there are different methods for cleaning porous paving.
- Periodic replacement of infill aggregate, sand bedding and geo-textile layers. The frequency may range from 5 to 20 years depending on the above maintenance regime and sediment inputs.

USEFUL WEBSITES

For general information on Water Sensitive Urban Design and some specific information on porous paving refer to http://www.wsud.org/tools-resources/

Concrete Masonry Association of Australia for permeable paving: www.cmaa.com.au

A comprehensive coverage on porous and permeable paving is provided in the technical paper Technologies and opportunities for permeable segmental paving in Australia. Brian Shackel & Alan Pearson http://www.cmaa.com.au/html/CMAA_TechInfo.html

Design Guidelines prepared by Gold Coast City Council. – Planning Scheme 2003 Policy 11 - Land Development Guidelines Volume 3 – Section 13.11 - Porous & permeable paving. Go to link http://www.goldcoast.qld.gov.au/gcplanningscheme_policies/policy_11.html#specs

Technical publications and software in relation to paving and permeable paving and design of permeable pavements is available from the Concrete Masonry Association Australia. http://www.cmaa.com.au/html/CMAA_TechInfo.html

Computer aided software used to design heavy duty permeable pavements is available at; http://www.cmaa.com.au/html/CMAA_TechInfo.html

National Guidelines for Evaluating Water Sensitive Urban Design— Appendices for porous paving: http://www.environment.gov.au/water/publications/urban/water-sensitive-design-national-guide.html

Design Guidelines and examples for porous paving — Hydrocon Australasia www.hydrocon.com.au

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