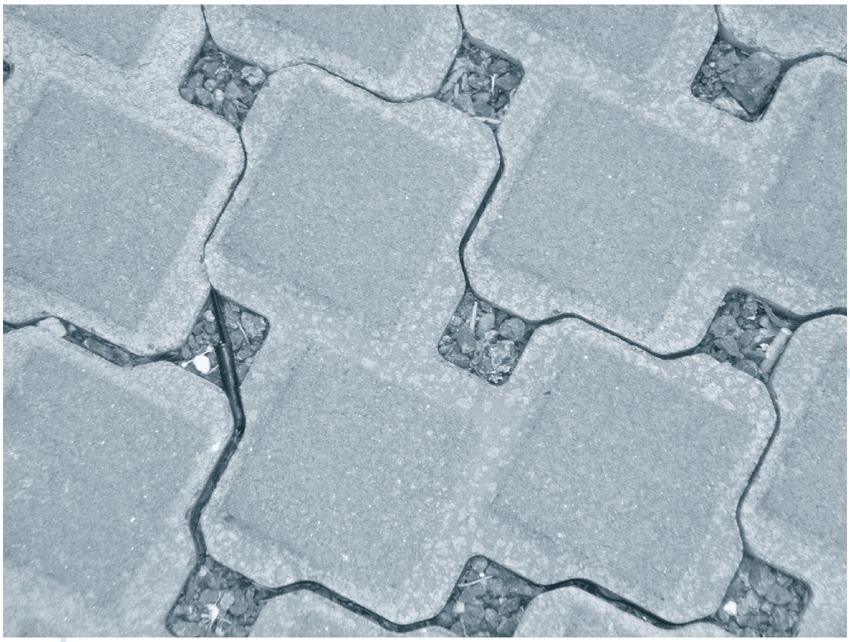
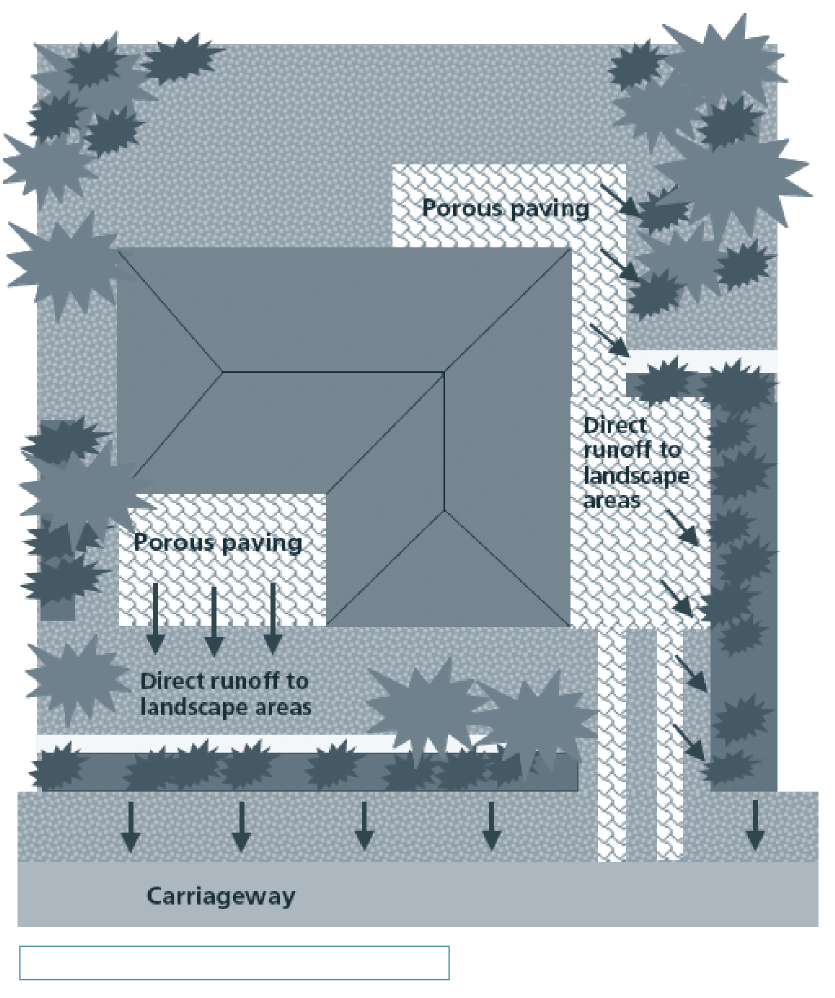
water sensitive urban design



Close up view of permeable paving. Gaps in pavers are filled with 'clean' gravel allowing water to infiltrate to the ground below.

Water sensitive development involves simple design and management practices that take advantage of natural site features and minimise impacts on the water cycle. It is part of the contemporary trend towards more 'sustainable' solutions that protect the environment. This Water Sensitive Practice Note describes how to design and install paving so that it manages and treats stormwater.



Introduction

Urbanisation causes a significant increase in the area covered with paved (or 'impervious') surfaces, such as roads, driveways, courtyards, etc. Paved surfaces can have significant adverse impacts on the water cycle. They contribute to increased peak and total stormwater discharges, increased downstream flooding, streambank erosion, sewer surcharges, and the need for expensive drainage infrastructure. Paved areas also reduce infiltration to the subsoil which also can result in loss of groundwater, moisture for dependent vegetation, and downstream pollution of waterways and aquatic habitats.

Such impacts can be reduced by:

- Minimising the area of paved surfaces.
- Directing stormwater runoff from paved surfaces to landscaped areas, gardens and lawns rather than to the street drainage system.
- Using porous paving systems.

The application of these methods to a typical residential lot is shown in Fig. 1.

What is Porous Paving?

Porous paving is an alternative to conventional impermeable pavements with many stormwater management benefits. These surfaces allow stormwater to be filtered by a coarse subbase, and may allow infiltration to the underlying soil.

A number of porous paving products are commercially available including:

- Pavements made from special asphalts
- Concrete grid pavements
- Concrete, ceramic or plastic modular pavements.

Porous paving can be utilised to promote a variety of water management objectives, including:

- Reduced (or even zero) peak stormwater discharges from paved areas
- Increased groundwater recharge
- Improved stormwater quality.
- Reduced area of land dedicated solely for stormwater management.

Common Techniques

Asphaltic paving

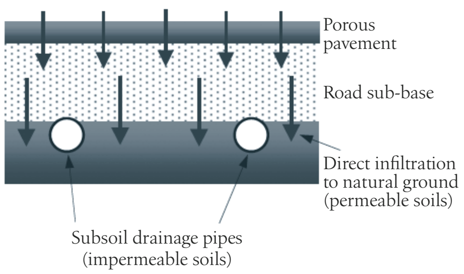


Fig 2: Asphaltic porous paving systems

Asphaltic porous paving is laid on a sand/gravel sub-base over natural soil (see Figure 2).

Rainfall percolates through a porous asphalt layer to the road sub-base, where it is stored until it infiltrates to the surrounding soil. When installed in impermeable soils (eg, medium to high clay content soils, like those formed on Jurassic Dolerite), subsoil drainage pipes are placed below the road sub-base to allow stormwater to overflow into the street drainage system.

Early porous paving, typically asphalt, relied on percolation of stormwater through the pavement and storage in the sub-base prior to infiltration to the soil. They were often subject to failure due to sediment clogging, and are less recommended than newer porous paving products.

Grid and modular paving

More recent porous paving designs overcome the deficiencies of the earlier asphalt porous paving products. They include:

- Concrete grids poured in-situ
- Precast concrete grids
- Concrete, ceramic or plastic modular pavers.

These products generally contain surface voids that are filled with sand or gravel. Stormwater filters through these voids to a sand or gravel sub-base, thereby cleansing the stormwater. Gravel retention trenches and geotextile fabric can also be installed, thereby creating a very effective stormwater treatment chain. During heavy rain, excess stormwater overflows to the street drainage system when the trench becomes full (see Figure 3).

Grass may also be grown in voids, but this is generally unsuccessful due to insufficient soil depth and nutrients, heavy wear and tear and retained heat in the pavers. In very low traffic areas, consider using turf rather than porous paving.

Plastic modular block pavers retain less heat than concrete ones, making them more suitable in hotter locations or climates.

Porous paving is an excellent stormwater management measure for low-traffic surfaces in driveways and car parks. Unfortunately history has shown many failures due to poor design, construction and maintenance practices.

Design Considerations

Consequently, the following design and maintenance issues need to be carefully addressed.

Clogging

Partial or total clogging with sediment and oil is a major potential cause of failure, and must be avoided. Clogging can occur during or immediately after construction, or through long-term use. The likelihood of clogging can be avoided by the following measures.

- Do not install porous paving in positions that are likely to receive large quantities of sediment and debris washed down by stormwater, or windblown sand or other material.
- Carefully protect porous paving from sediment inputs during construction.
- Do not use porous paving for accessways with high traffic volumes or

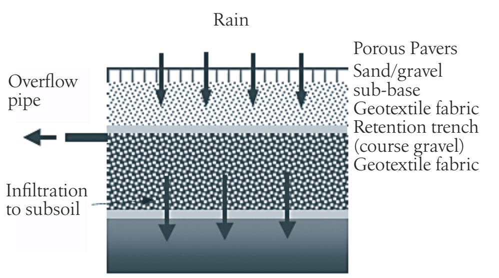


Fig 3: Grid and modular porous paving systems

with regular heavy vehicle traffic.

- Undertake regular vacuum sweeping or high pressure hosing to remove sediment (direct runoff to grassed areas).
- Install sediment traps, vegetated filter strips or specially designed gutter systems to pre-treatstormwater inputs to remove sediments.

Infiltration capacity

Porous paving sometimes has a poor reputation of having insufficient infiltration capacity. In most cases this can be attributed to sediment-induced clogging, soils with insufficient infiltration capacity and designs with insufficient storage volume. These problems can be readily overcome by using modern design practices to:

- Provide a retention trench below the sub-base.
- Provide an overflow to the street drainage system or other stormwater managementmeasure.
- Limit the runoff area contributing stormwater to the porous paving surface.

Aquifer contamination

Porous paving can, in some cases, result in a risk of contamination of shallow aquifers by toxic materials derived from asphalt, vehicular traffic and road use.

This risk can be minimised or eliminated by following these deign principles.

- Do not construct porous paving over shallow aquifers.
- Do not use porous paving on streets with high traffic volumes.
- Install a sand sub-base over a retention trench with geotextile fabric lining to capture contaminants.

Structural integrity

If properly installed, porous pavements have similar load bearing and design life performance to conventional pavements. Impairment of the structural integrity of porous paving by traffic loads or heavy vehicles can be avoided by adhering to relevant design and construction specifications.

Slopes

Porous paving should not be constructed on slopes greater than 5 degrees (10%) unless an engineering design is completed to assess the impact of the paving system on downstream environments and the stability of surrounding areas.

Unsuitable soils

Porous paving must be carefully designed in areas with:

- High water table levels.
- Wind blown or loose sands.
- Clay soils that collapse in contact with water.
- Soils with a hydraulic conductivity of less than 0.36 mm/hr.

Under such circumstances, soil assessment and permeability testing must be undertaken as part of the design process for porous paving. For details about suitable locations and hazard areas, contact your local council.

Rock

Porous paving should not be placed over rock that has little or no permeability. Studies have shown that infiltration is possible in severely weathered or fractured rock (for example, sandstone).

Engineering testing is essential in these circumstances to ensure that the rock will accept infiltration. In the case of shallow soil cover, testing is required to ensure that seepage does not cause any hazards or nuisance to downstream sites.

Suitable locations

Porous paving can be utilised in streets with low traffic volumes (such as cul-de-sacs), car parks and for paving within residential and commercial development. Acceptable performance can be achieved provided that the correct design and construction procedures are followed, including any manufacturer's recommendations.

Maintenance Issues

Concrete grid, ceramic and modular plastic block pavers require less maintenance than asphaltic porous paving as they are less easily clogged. They are also easier to repair.

Practice Notes

3 Paving

The performance and life of these pavements can be increased by regular vacuum sweeping or high pressure hosing (once every three months) to remove sediments.

As with traditional pavements, asphalt porous paving requires occasional resurfacing. Concrete grid, ceramic and plastic modular blocks require a maintenance schedule similar to that for conventional road surfaces. This involves retaining the pavers and replacing part of the sand layer to remove contaminants.

Indicative water quality

The contaminant removal processes in porous pavements include adsorption, straining, bioreaction and microbial decomposition. Correctly designed and maintained porous paving will retain approximately:

- 80% of sediment
- 60% of phosphorus
- 80% of nitrogen
- 70% of heavy metals
- 98% of oils and greases (with a sand sub-base).

Studies show that oils and greases are subject to microbial decontamination in porous paving. The addition of sand filters and retention trenches with geotextile fabric lining (see *Practice Note 2: Infiltration Devices*) further increases the effectiveness of porous paving as a stormwater treatment measure.

Costs

Construction cost of porous paving is similar to that of traditional pavement and is less than the cost of traditional paving when savings in stormwater infrastructure is considered. Research shows that porous paving can be up to three times less expensive than traditional road and stormwater management approaches.

Construction costs for porous paving are similar to that for traditional paving materials, and are less than the cost of traditional paving when savings in stormwater infrastructure are considered. When installed as part of an integrated stormwater management system, porous paving can be up to three times less expensive than traditional road and stormwater management approaches.

Useful websites

Atlantis: www.atlantiscorp.com.au

Rocla Products: www.rocla.com.au

University of South Australia: www.unisa.edu.au

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