Permeable Pavements: Design and Construction Issues

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WSUD and Permeable Pavements

• One of guiding principle of WSUD is mitigating adverse effects of urban stormwater runoff such as:
  • *increased urban flooding*
  • *deteriorating receiving water quality*

• Permeable Pavements are known to be an effective source control measure to reduce stormwater flows and pollution loads
Permeable Pavement Types

There is a 5th type of permeable pavement namely grass-filled pavers but these are rarely used in Australia – too hot!
Typical PP Bed Cross Section
(Infiltration Type - after Boral)

- Pavers (typically 80mm)
- 2-5mm Aggregate Bedding (30mm thick)
- 10mm Single Sized Aggregate (100mm thick)
- 63-10mm Aggregate Sub-base (thickness generally based on storage volume requirements)
- Geotextile fabric or impermeable liner to suit
- Sub-grade

Storage Volume
Infiltration into Sub-grade Soil

On-site Detention

Harvesting and Re-use
Reduced Runoff and Peaks

Reduced Runoff and Peaks

Asphalt Runoff

PP Drain Discharge

Large Reduction in Runoff!

Fig. 8. Approximate 2-year storm hydrograph (63 mm)

Pollutant Removal Processes in Permeable Pavements

Dierkes et al., 2002
Infiltration through Pavers
Where are PPs Suitable?

Pedestrian Areas
Residential Streets
Carparks

Shackel, B. 2010
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Pedestrian Areas

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Where can PPs be installed?

- Permeable paving systems can be installed in a wide range of ground conditions as long as:

  - Subgrade - sustain traffic loading no excessive deformation
  - Subsoil - drainage conditions are suitable for infiltration
  - Infiltration - systems perform best on flat grades
  - Lined systems can be sloped at 10% or greater
Infiltration Systems

- When using un-lined, infiltration systems, there is a very low risk of contaminating groundwater, depending on pollution loads, soil conditions and aquifer susceptibility.

- To be sure, better not to use infiltration systems over shallow aquifers (<1.2m WT).

- In high water table situations use PE liner.

- Flow attenuation performance is still excellent even when the systems are lined.

Fassman and Blackbourne, 2010
Design Issues

- Permeable pavements can actually be cheaper to install than traditional paving when all construction and drainage costs are taken into account.

- When PP installed as part of an integrated water cycle management system they can be up to 3X cheaper than traditional road and stormwater management approaches (Melbourne Water Website).
Do Permeable Pavements Clog?

YES, they do.
What can we do about that?

Design for clogging.

Runoff from upstream surfaces.

Infiltration capacity through geotextile decreases with “age”.

Infiltration zone (infiltration capacity > Q_{peak})

Blockage front

Blocked zone

Even “Totally Blocked” System still functions and clears runoff
Design for Long-term Infiltration Rates

Research shows that infiltration rate decreases over time to a minimum of about 20% of new value (Borgwardt, 2006; Pezzaniti et al. 2009)

Use the long-term infiltration capacity (20%) to estimate capture rates

Overall trend of the infiltration performance
Clogging Front Performance
Construction Tips

- **Construct** PP system **last**!
- Finalise and stabilise **landscaping before PP construction** to avoid **contamination** by silt or soil **erosion**
- Keep **construction** vehicles **off** pavements!
- **Do not** use pavement areas for **storage**!
Structural and Hydrological Design

LOCKPAVE ® – PERMPAVE ®
Software Package for Concrete Segmental and Permeable Pavements

Developed by:
Concrete Masonry Association of Australia
University of South Australia

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Windows ® XP, Vista, Win 7

PERMPAVE® V2.1

- PERMPAVE® was developed to undertake a basic assessment of the hydrological performance of PPs and design inputs for flood mitigation, water quality improvement, and stormwater harvesting.

- The program incorporates methods outlined in ARR87 as well as Australian Runoff Quality documents.

### Analysis Conditions
- Type of Pavement Application: CAR PARKS - subject mainly to cars + very occasional emergency and service vehicle traffic
- Required Service Life (years): 10

### Pavement Details
- Type of Paver: Pavers with openings along narrow joints
- Jointing Material: Use 1 to 3 mm clean aggregate. Alternatively, if feasible, use bedding material in joints also.
- Bedding Material: Use 2 to 6 mm clean aggregate
- Type of Basecourse: Open Graded Granular Material
- Thickness of Basecourse required for Flood Control (mm): 110
- Geofabric: A permeable geofabric (filter fabric) must be installed between the pavement and subgrade

### Outputs
- Subgrade Permeability: 0.00000005 m/s
- Subgrade Class: ML
- Design Subgrade CBR: 5%
- Infiltration: 900 L/sec/ha
- THICKNESS:
  - 80mm Min
  - 25 mm
  - 110 mm
  - Voids: 40%
  - Permeable Liner
  - Discharge pipe

NOTICE: The PERMPAVE program only calculates the pavement thicknesses needed for Flood Control, Water Quality or Water Harvesting. You have chosen an application that may carry trucks or other heavy vehicles. Accordingly, you need to verify that the thicknesses given by PERMPAVE are also adequate to carry Vehicle Loads and Traffic. You should, therefore, run a structural analysis such as LOCKPAVE, for the conditions summarised above, to determine the thicknesses needed to resist traffic and then adopt the greater of the thicknesses given by PERMPAVE or the structural (LOCKPAVE) analysis.

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LOCKPAVE © V18.1

LOCKPAVE © was developed to assist professional engineers, landscapers and architects in the structural design of concrete segmental pavements for a variety of applications.

Now upgraded to incorporate design of permeable pavements

This is a similar type of program to Permpave but this designs the pavement for structural considerations

Use deepest subgrade design from both for final design

Download the program and use it for free!
Certainly not the Dutch!


