



Permeable Paving

DESIGN & CONSTRUCTION GUIDE

Permeable paving provides significant benefits over conventional pavements in terms of sustainability, environmental impact and long-term cost.

In the natural environments, the majority of stormwater is absorbed back into the ground, recharging the local groundwater table with minimal surface run-off entering local waterways. This is not the case in urban areas.

Large areas of impermeable surfaces result in the majority of stormwater being diverted to the local waterways and very little being absorbed into the ground.

As an alternative to conventional paving, permeable paving encourages water to infiltrate through the pavement surface and substructure to the ground below, easing the pressure on already overburdened or over-stressed stormwater systems.

Permeable paving was first developed in Europe and has been used extensively throughout the world. Adopted in Australia in 1997, it has been used in many projects including the Sydney Olympic Precinct.

The system has also been adopted locally by many local councils.

This guide is an introduction to permeable paving. For extensive and comprehensive detailed information and case studies please visit CMAA site www.cmaa.com.au.

Benefits of Permeable Paving

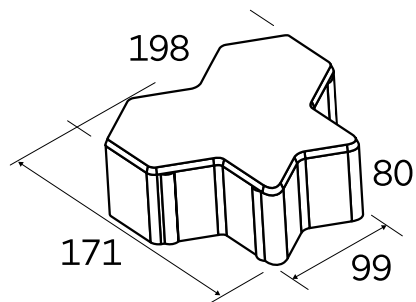
- Reduces the amount of rainfall run-off by infiltration, thereby eliminating or minimising the extent of stormwater drainage systems required.
- Reduces the risk of localised flooding and downstream flooding.
- Assists in recharging and maintaining aquifers and natural groundwater.
- Traps and treats pollutants that would otherwise contaminate groundwater.
- Assists in the biological decomposition of hydrocarbon contaminants.
- Reduces the size or need for rainwater retention facilities in roadworks by using the pavement itself for retention.
- Allows water and air access to roots of trees and plantings.
- Can be trafficked immediately following installation.
- Easy access to underground services if required, without damage to laid permeable paving.
- Surface gradients can often be minimised or eliminated.
- Enhanced aesthetic appearance.
- Paving can be recycled or re-used.
- Minimises tree root damage by directing root growth down instead of along the surface, picking up moisture caused by condensation under solid surfaces.
- Permeable paving provides a cost-effective alternative.
- Reduction of retention requirements in other parts of the drainage system.
- Slows the release of runoff.
- Reduction of downstream flows and bank erosion due to decrease peak flows and volumes.
- Possible reduction in overall project development costs due to a reduction in storm sewers and drainage.
- Very low maintenance requirements.
- Replace unsightly tree grates. Permeable pavers allow you to pave close to the base of the tree.

Aqua Tri-Pave Permeable Pavers

PRODUCT INFORMATION

Work Size (mm)	171x198x80
Dimensional Category	DPA2
CMAA Shape Category	Type B
Approximate Unit Weight (kg)	4
Approximate Pavers Per m ²	29
Approximate Coverage Per Pallet (m ²)	9.84
Pavers Per Pallet	384
Cold Water Absorption (%)	<2.6
Characteristic Breaking Load (kN)	>10
Mean Abrasion Index (Va)	<7
Slip Resistance Category	P5
Potential to Effloresce	Slight-Medium
Colours <i>Other colours made to order. Minimum quantities apply.</i>	Charcoal Pewter Heritage Red

A correctly designed subbase is critical to overall success of permeable paving.



Pewter



Charcoal



Heritage Red

Applications

- Carparks
- Government/Council projects
- Streetscape
- Footpaths
- Alleyways
- Industrial traffic
- Road infrastructure
- Residential driveways
- Schools
- Shopping Centres
- Paved areas/machine lay

Suitable for



Any outdoor entertainment area including alfrescos and patios.



Light traffic, Light Commercial and Unit Developments. Driveways.



Heavy traffic including trucks. Commercial projects.

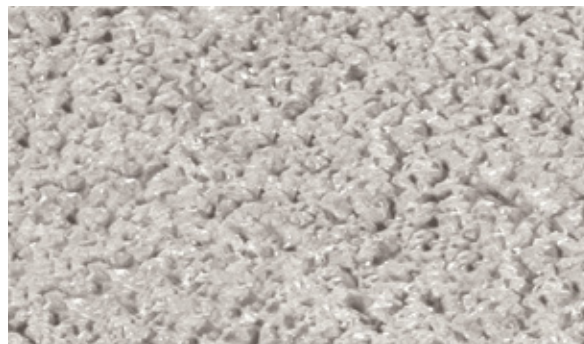
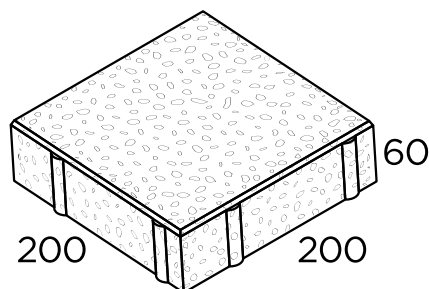
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Masterpave 60 Permeable Pavers

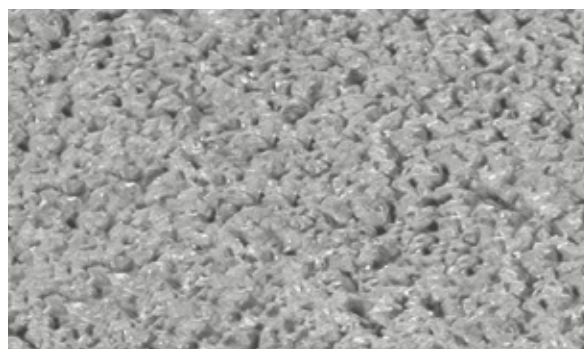
PRODUCT INFORMATION

Work Size (mm)	200x200x60
Dimensional Category	DP1
CMAA Shape Category	Type C
Approximate Unit Weight (kg)	4.4
Approximate Pavers Per m ²	25
Approximate Coverage Per Pack (m ²)	9.1
Pavers Per Pack	228
Leaves Per Pack	4
Nominal Pack Weight (kg) <i>inc. +3% moisture</i>	1003
Breaking Load (kN) <i>at 28 days</i>	>7
Slip Resistance Category	P5
Potential to Effloresce	Slight-Medium
Colours	Charcoal Pewter Silver

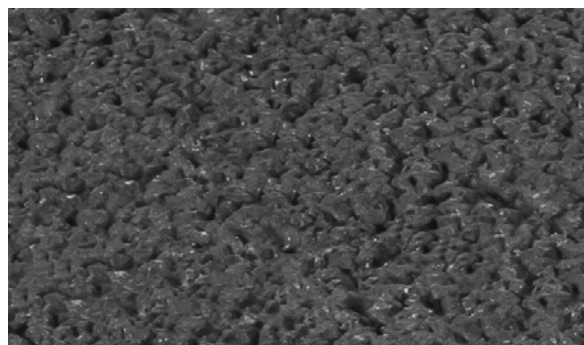
A correctly designed subbase is critical to overall success of permeable paving.



Silver



Pewter



Charcoal

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- Schools
- Shopping Centres

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Light traffic, Light Commercial and Unit Developments. Driveways.

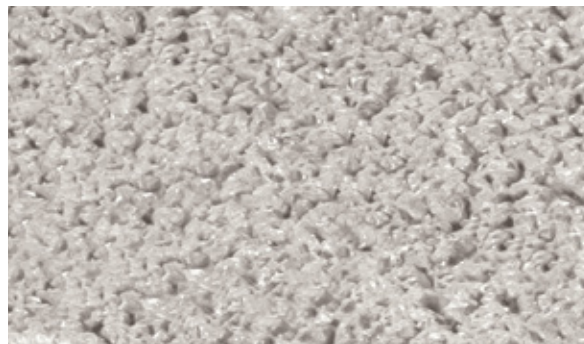
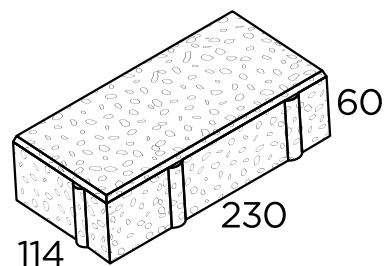
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Pavestone 60 Permeable Pavers

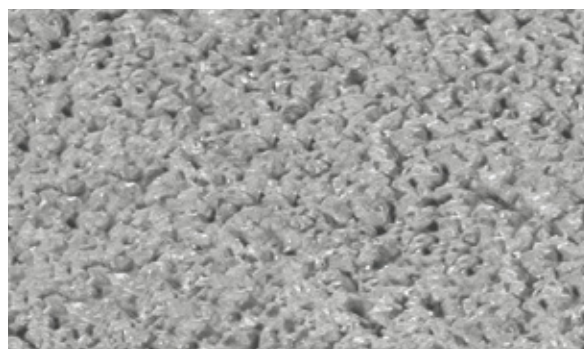
PRODUCT INFORMATION

Work Size (mm)	230x114x60
Dimensional Category	DP1
CMAA Shape Category	Type C
Approximate Unit Weight (kg)	3.4
Approximate Pavers Per m ²	38.1
Approximate Coverage Per Pack (m ²)	8.7
Pavers Per Pack	330
Leaves Per Pack	5
Nominal Pack Weight (kg) <i>inc. +3% moisture</i>	1156
Breaking Load (kN) <i>at 28 days</i>	>7
Slip Resistance Category	P5
Potential to Effloresce	Slight-Medium
Colours	Charcoal Pewter Silver

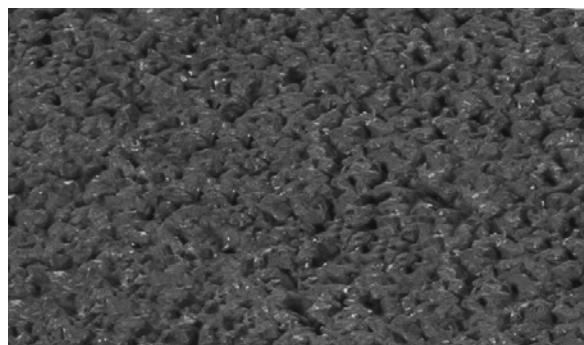
A correctly designed subbase is critical to overall success of permeable paving.



Silver



Pewter



Charcoal

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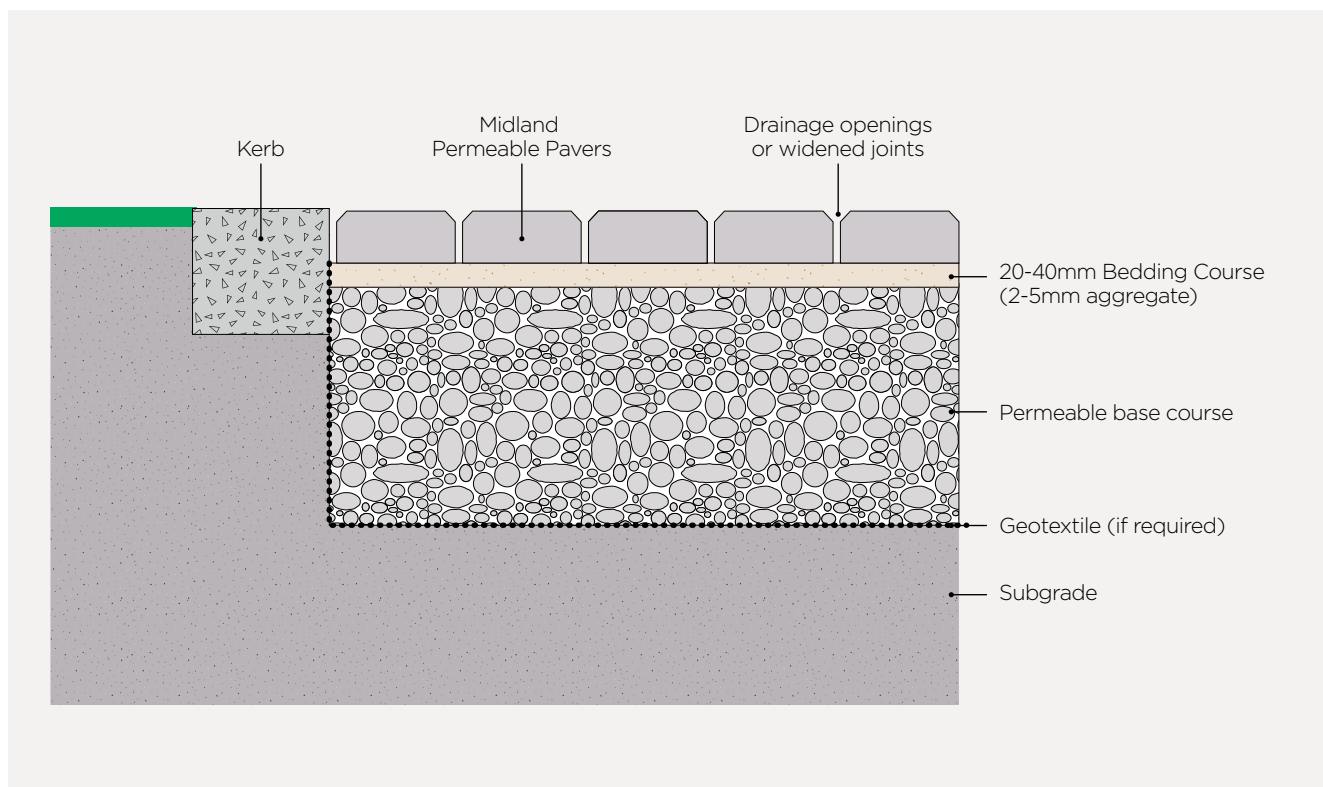
Light traffic, Light Commercial and Unit Developments. Driveways.

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Permeable Pavement Components

Components of a Permeable Pavement

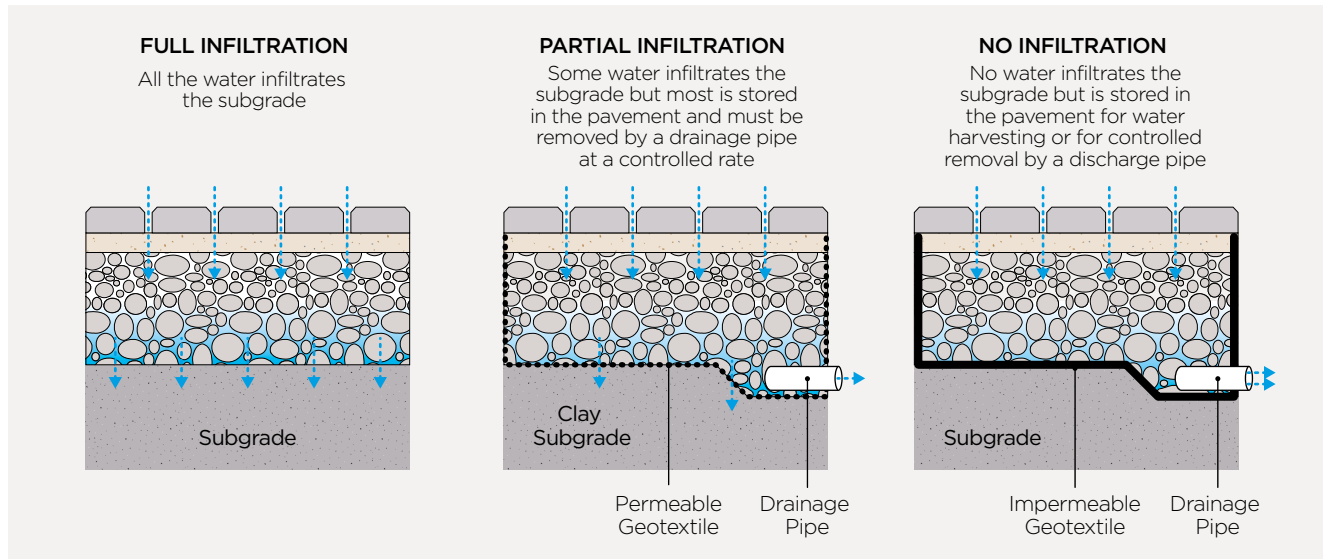
- Midland Brick Permeable Pavers are designed to permit rapid infiltration of rainfall.
- The voids between in Aqua Tri-Pave pavers should be completely filled with uniform aggregate 2-5mm. If voids are not correctly filled the system becomes less effective over time as it allows a greater build-up of debris and silt. Sand must not be used in joints.
- Permeable pavers should be laid on a 20-40mm bedding course of uniform aggregate typically 2-5mm in size.
- A permeable geotextile may be installed beneath the bedding layer. This option is required to mobilise biological controls of hydrocarbons etc. Installation of geotextile may not be suitable where pavements are subjected to heavy vehicular traffic as it can cause or create a failure plane. Consult with a qualified engineer.
- A permeable base course, typically consisting of compacted unbound granular materials, provides the main loadbearing layer. The thickness of this layer must be sufficient to resist traffic loads and to provide adequate water storage. Composition of the aggregate and size will depend on the intended use of the permeable pavement.
- On cohesive subgrades, a filter fabric must be provided under the base course to prevent clay migrating into the pavement. This is not needed where the subgrade is granular such as sandy or gravelly soils.
- Where the subgrade is contaminated (saline or expansive) an impermeable membrane must be provided under the base course to prevent water from entering or leaving the pavement. The standard practice is to run the membrane along the sides of the pavement.
- There may be a need to include drainage pipes to remove water from some pavements.
- The in-situ soil at the pavement site is known as the subgrade. The type of subgrade determines what type of permeable pavement cross-section is achievable and how thick the pavement needs to be to resist traffic and control stormwater.



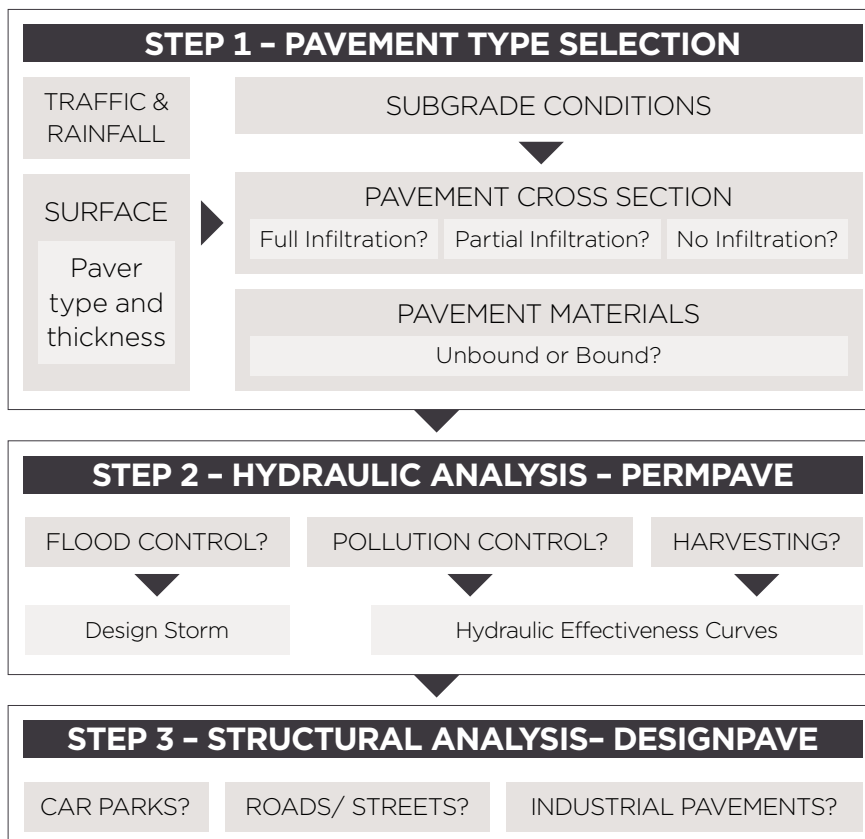
Design Considerations

Permeable pavements must be designed not only to carry traffic but also to manage run-off, infiltration, pollutant treatment, and where appropriate water harvesting.

There are three principal types of cross-sections to consider when designing permeable pavements.



Three-Step Design Process – cmaa.com.au



The DesignPave 2.0 software package is provided as a tool to aid design and to give general guidance about the construction of concrete block pavements.

The software is not intended as a replacement for engineering skill and judgement, and users should consult with suitably experienced and professionally qualified civil engineers to finalise and validate designs.

(Shackel 2010)

Materials and Construction Guide

Base course and Subgrade Materials

The subgrade soil determines the type of pavement cross-section that is required to manage both the structural response to traffic and water management. Where the subgrade is of granular material, it is usually possible to infiltrate all the design rainfall fully. This is the most widely used base for permeable pavements.

However, for a cohesive clay subgrade, only a small fraction of the stormwater run-off can be expected to infiltrate the soil, i.e. only partial infiltration is possible. In some cases, where the subgrade soil is contaminated (expansive or saline) or where local regulations do not permit infiltration, an impermeable liner must be placed between the pavement and subgrade to ensure that no infiltration is possible. In the cases of either partial or no infiltration, the pavements main function is to capture the water temporarily and then to allow it to efflux via a carefully sized outlet pipe to stormwater sewers at a rate chosen not to overload these facilities.

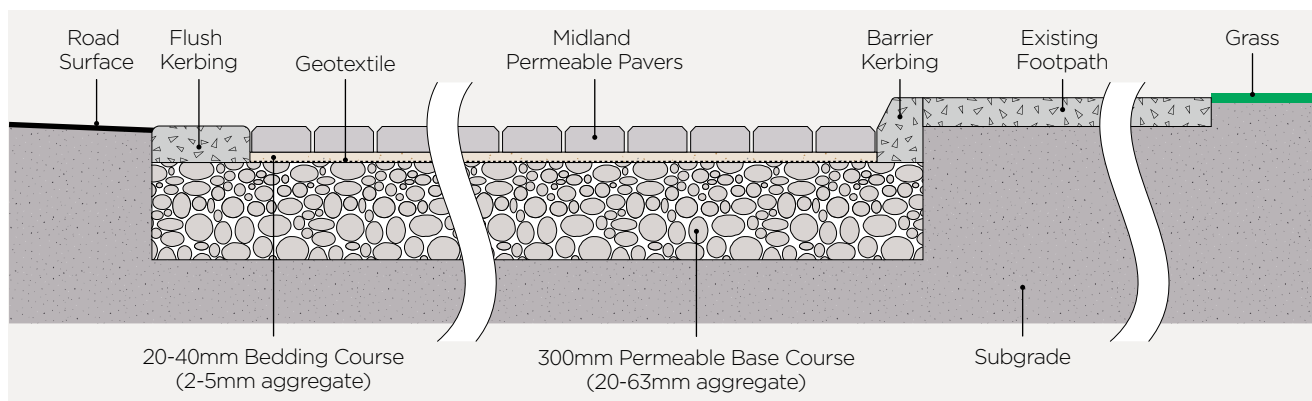
The aggregate base thickness is determined by the need to store and infiltrate a certain amount of stormwater and the need to carry traffic. The material is compacted to the planned specifications, which will depend on the expected loadings.

Typically, varied sizes of granular material are used to allow water to flow through. Larger sized particles are placed at the bottom, medium in the middle and smaller sized granular on top. These size combinations can be specified by a suitably qualified engineer to meet the design and loadbearing requirements.

Please consult with a qualified engineer for the required aggregate size base thickness and design specifics. Software such as PermPave and DesignPave are available and very useful in designing appropriate pavement systems.

Subbase: an optional layer of soil placed between the excavated subgrade and base course to provide additional load bearing strength. Mainly used for low-strength subgrades.

TYPICAL CONSTRUCTION



Geotextiles and membranes

Geotextiles and membranes are used to prevent water movement between the pavement and subgrade. They are also installed as filters to separate materials and provide the right environment for beneficial microbes and bacteria to breakdown hydrocarbons and other pollutants.

For pavement designed to **fully infiltrate** rainfall to the subgrade, the use of geotextiles is generally unnecessary. The exception is where bioremediation of hydrocarbons is a design objective. In such cases, a permeable fabric may be placed below the bedding course to host microbial action.

Where water is required to drain to the subgrade, the use of a permeable filter fabric helps prevent the migration of colloidal particles into the subbase. This maintains the integrity of the structural and hydraulic characteristics of the system.

*Permeable geo fabrics are particularly important where a system operates above a clay subgrade, where only **partial infiltration** of water is possible.*

The use of filter fabric is mandatory in permeable paving with **partial infiltration** and should be installed along the sides of the pavement as well.

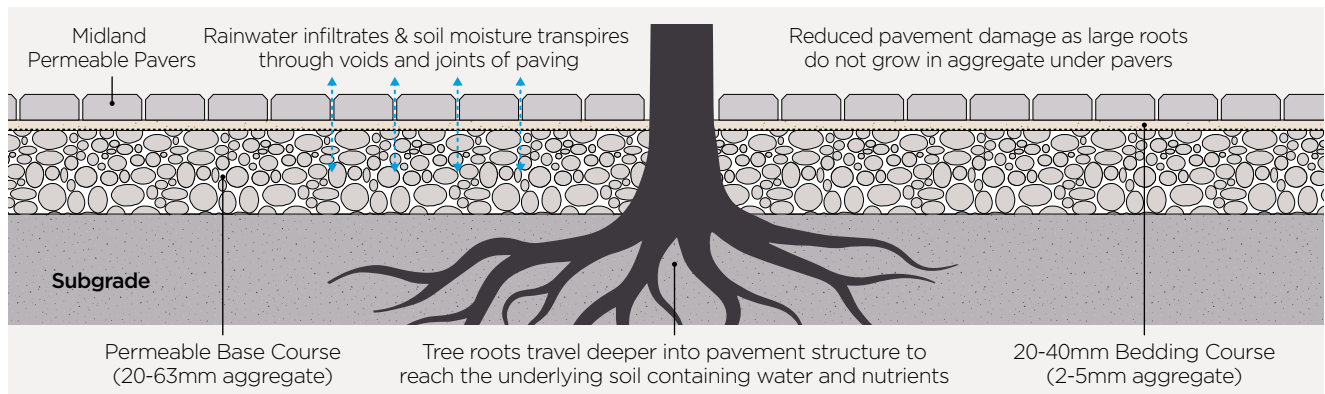
Where heavy vehicular traffic is likely, the installation of a geotextile layer in a pavement will need particular attention to determine the possibility of surface water creating a failure plane. In these instances, we recommend a suitably qualified engineer be consulted.

Providing water and air to trees and vegetation

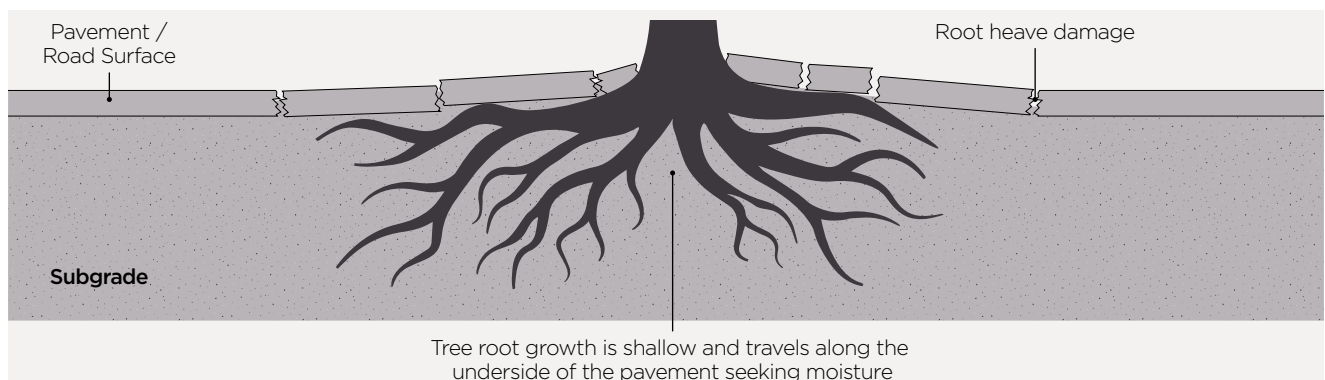
Permeable pavements support sustainable development and liveable green communities. Permeable pavement systems are extremely useful where the proximity of trees and other planting is in close contact with the hard surface as it allows water and airflow to continue back into the roots of the surrounding area.

The City of Belmont is at the forefront of permeable paving to benefit trees and planting.

TYPICAL ROOT GROWTH PATTERN WHEN PERMEABLE PAVING AND AGGREGATE BASE USED



TYPICAL ROOT GROWTH WHEN PAVEMENT IS LAID DIRECTLY ON SOIL



Below is an extract from a research paper by T. Lucke and S. Beecham, *“An Infiltration Approach to Reducing Pavement Damage by Street Trees”*

In this study, it was found that the growth of street trees can be influenced by using permeable pavement surround laid on a sufficiently deep gravel base course layer.

This influence was limited to root growth with no significant effect on tree height. The permeable pavement supplied the underlying subgrade soil with sufficient oxygen, nutrients and moisture to promote woody growth deeper in the soil profile, eliminating shallow woody root growth near the pavement surface.

In particular it was found that:

- The asphaltic concrete control pavement was severely damaged by shallow woody root growth that sought out the observed condensate forming on the underside of the pavement surface.
- Even in the permeable pavements without a gravel base course layer, there was some dislodgement of the paver surface by shallow roots.

- Permeable pavements with a 100mm deep gravel base course layer suffered minimal paver dislodgement.
- No dislodgement was observed in permeable pavements with a 300mm deep gravel base course layer.
- Excavation of the pavements, after 4.5 years of operation, showed that the 300mm deep base course layer encouraged woody root growth to adopt a downward trajectory away from the pavement surface, with an absence of either shallow woody root growth or non-woody feeder roots.

The results of this study will help engineers, arborists and landscapers to improve street tree planting design and to reduce pavement damage and repair costs for local municipalities.

(Lucke & Beecham 2019)

Pollution Control

There is evidence that a properly designed permeable pavement system will effectively manage stormwater hydraulically and improve water quality.

Between 1999 and 2001, the Urban Water Resources Centre at the University of South Australia carried out a series of laboratory and field tests to establish the retention of pollutants through permeable pavements located in Port Adelaide.

The results from the field tests were compared with data from a comparable conventional pavement and indicated that permeable pavements could reduce up to 50% of pollutant concentrations – when compared to the conventional pavement. (Zhang 2006)

A field study of four types of porous paving, installed in a parking area, found no oil, fuel or lead had infiltrated into

the water, even though these pollutants were present in the surface run off from the impermeable asphalt control sample. (Brattebo and Booth 2003)

A Review of Stormwater Sensitive Urban Design in Australia acknowledged improvements to water quality through interception and biological treatment when comparing porous pavement to impervious pavement. The report also raises the importance of not allowing the permeable pavement system to clog up. (Fletcher, Deletic and Hatt 2004)

Porous pavers should be swept regularly to remove debris and sand, etc.

Maintenance

Surface infiltration rates

Tests in Australia have shown that even permeable pavements that had received little routine maintenance, the infiltration rates 8 to 10 years after construction remained at serviceable levels.

Published Infiltration Measurements for permeable pavements in service for periods of 8 and over 10 years located in Australia range from 70 to 1080mm/hr/m² (Beecham et al. 2009).

Midland Brick test results from local case studies confirmed the high infiltration rate of newly laid permeable pavement.

According to a study (Borgwart 2006) Infiltration rate in new pavements can be as high as 1548mm/hr/m².

However, over time the infiltration performance is affected due to the age of the pavement and particulate pollutants becoming trapped within the upper 20-40mm of the materials filling the drainage openings and joints, slowing the infiltration rate. It is important to completely fill all voids so that the debris and silt can be easily removed from the surface.

Clogging

Clogging of permeable pavement is a natural ongoing process which must be considered in the planning and design.

Despite clogging over periods of 8 to 10 years, test results have shown that pavements continued to exhibit good infiltration rates.

In the eventuality of the permeable pavement clogging up because of particulate pollutants, it has been shown that simply replacing the top 10-25mm of the drainage material within the voids and joints can largely restore the infiltration capacity. (Beecham et al. 2009)

Clogging can be minimised by regular maintenance such as using conventional street vacuum cleaning.

The percolation rate will decrease from the newly laid value but will stabilise with age, usually within 8 to 10 years.

The recommended infiltration rate over a 20-year design life, without regular maintenance, will be approximately 10% of the initial value. Therefore, it is recommended that a clogging factor be applied in the design of permeable pavements allowing for incremental clogging that naturally occurs.



Midland Brick

For more information about Midland Brick

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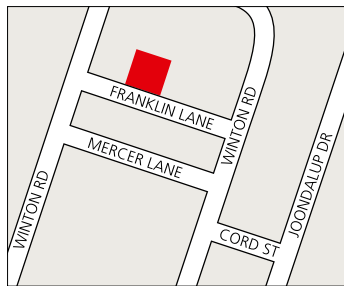
 Visit our website at **midlandbrick.com.au**

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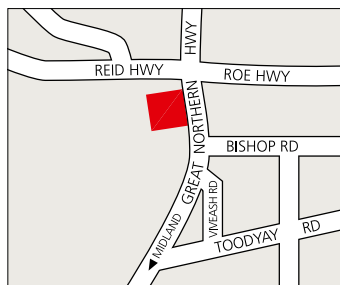
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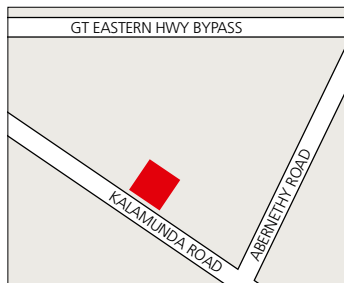
Selection Centres Selection Centre & Yard Selection Centre



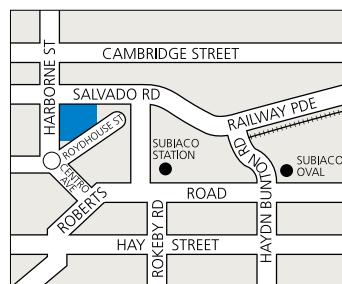
Joondalup
16 Franklin Lane



Middle Swan
321 Great Northern Hwy



South Guildford
1/260 Kalamunda Road



Subiaco
Home Base, 55 Salvado Road

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