

PERMEABLE PAVING SYSTEMS



Nick van Diemen

ISS Institute/TAFE Fellowship

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Executive Summary

Permeable paving is a system of paving that provides a structural pavement allowing water to infiltrate the pavement construction for temporary storage prior to infiltration to the sub-grade. Alternatively it is a system to delay the water for discharge to stormwater systems or a combination of both the storage of water for later use and the filtering of contaminants via the stone aggregates of the bedding and base courses.

It is suitable for use in a wide range of applications and is particularly popular in car parks, residential streets, footpaths and bike paths. PPS is often used as a part of Sustainable Urban Drainage Systems (SUDS) but it can be used in isolation, especially where full infiltration into the soil is intended. The system is based on the same principles as traditional flexible pavements but uses a no-fines crushed rock and a fine granular bedding material.

Permeable paving in Australia is currently almost non-existent. In Germany PPS was first introduced in the mid 1980's and has been installed with increasing frequency since that time. Currently approximately 18,000,000 square metres of PPS is installed in Germany per annum. This is more than any other country in the world no matter how calculated – per capita or by area.

In Germany PPS is so widely accepted that it can be seen in many varied locations. It is most common in car parks and hardstand areas; even small car parks such as fast food outlets and motels are constructed using PPS. Industry figures in other European countries such as England, Scotland and Ireland are beginning to realise the enormous benefits of PPS and the number of projects is increasing rapidly.

Van Diemen's observation of overseas practices has helped him to realise that if PPS is to be successful in Australia, the following initiatives need to be taken:

- Federal, State and Local Governments need to be educated on the benefits of PPS and consequently specify PPS for appropriate Government projects.
- The benefits of PPS in regards to water quality need to be promoted to the entire community.
- Specifiers of SUDS projects in Australia need to be educated about the advantages of using PPS as opposed to traditional paving systems. Many of these specifiers know little about PPS.
- Paver manufacturers must promote PPS, not just permeable pavers. Most of the general population, including some in the paving industry, are not aware of the different specifications required for PPS projects.
- Suppliers of quarry products need to make materials needed for PPS more readily available.
- Paver manufacturers need to have permeable pavers available and in stock to allow PPS to be used on smaller projects as well as larger projects where they are made to order.
- Engineers, architects, designers and specifiers need to be educated in the application, design and specifications of PPS.
- Contractors need to be trained in the construction techniques and the materials used when constructing PPS.
- The general public need to know that PPS exists and the environmental benefits that can be achieved with its use.

The above skills and knowledge deficiencies can be addressed by designing a comprehensive and wide reaching educational initiative promoting the immediate and long term benefits of PPS as a stand-alone area of paving or as part of a SUDS project. This needs to be directed to the general public as well as all those involved in the paving industry:

Executive Summary

- Environmental designers and planners
- Architects and landscape architects
- Engineers
- Relevant Government departments
- Water authorities

If a better knowledge of the benefits of PPS can be disseminated throughout the community it would make the acceptance of the system quicker and benefits to the environment more immediate.

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Abbreviations and Acronyms

ACEA	Association of Consulting Engineers Australia
AILA	Institute of Landscape Architects
CCAA	Cement and Concrete Association of Australia
CBPAV	Clay Brick and Paver Association of Victoria
CBPP	Concrete Block Permeable Paving
CMAA	Concrete Masonry Association of Australia
ISSI	International Specialised Skills Institute
LIAV	Landscape Industries Association of Victoria
OTTE	Office of Training and Tertiary Education
PPS	Permeable Paving Systems
SUDS	Sustainable Urban Drainage Systems
TAFE	Technical and Further Education

Acknowledgments

Nick van Diemen would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide him throughout the Fellowship program.

Awarding Body - International Specialised Skills Institute (ISS Institute)

We know that Australia's economic future is reliant upon high level skills and knowledge, underpinned by design and innovation.

The International Specialised Skills Institute Inc (ISS Institute) is an independent, national organisation, which has a record of nearly twenty years of working with Australian industry and commerce to gain best-in-the-world skills and experience in traditional and leading-edge technology, design, innovation and management. The Institute has worked extensively with Government and non-Government organisations, firms, industry bodies, professional associations and education and training institutions.

The Patron in Chief is Sir James Gobbo AC, CVO. The ISS Institute Board of Management is Chaired by Noel Waite AO. The Board comprises Franco Fiorentini, John Iacovangelo, Lady Primrose Potter AC and David Wittner.

Through its CEO, Carolynne Bourne AM, the ISS Institute identifies and researches skill deficiencies and then meets the deficiency needs through its *Overseas Skill Acquisition Plan (Fellowship Program)*, its education and training activities, professional development events and consultancy services.

Under the Overseas Skill Acquisition Plan (Fellowship Program) Australians travel overseas or international experts travel to Australia. Participants then pass on what they have learnt through reports, education and training activities such as workshops, conferences, lectures, forums, seminars and events, therein ensuring that for each Fellowship undertaken many benefit.

As an outcome of its work, ISS Institute has gained a deep understanding of the nature and scope of a number of issues. Four clearly defined economic forces have emerged out of our nearly twenty years of research. The drivers have arisen out of research that has been induced rather than deduced and innovative, practical solutions created - it is about thinking and working differently.

A Global Perspective. 'Skills Deficiencies' + 'Skills Shortages'

Skill deficiencies address future needs. Skill shortages replicate the past and are focused on immediate needs.

Skill deficiency is where a demand for labour has not been recognised and where accredited courses are not available through Australian higher education institutions. This demand is met where skills and knowledge are acquired on-the-job, gleaned from published material, or from working and/or study overseas. This is the focus of the work of ISS Institute.

There may be individuals or firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the IP to themselves; and over time they retire and pass way. Firms likewise come and go. If Australia is to create, build and sustain Industries, knowledge/skills/understandings must be accessible trans-generationally through nationally accredited courses and not be reliant on individuals.

Our international competitors have these capabilities as well as the education and training infrastructure to underpin them.

Addressing skill shortages, however, is merely delivering more of what we already know and can do to meet current market demands. Australia needs to address the **dual** challenge – skill deficiencies and skill shortages.

Acknowledgments

Identifying and closing skills deficiencies is vital to long-term economic prospects in order to sustain sectors that are at risk of disappearing, not being developed or leaving our shores to be taken up by our competitors. The only prudent option is to achieve a high skill, high value-added economy in order to build a significant future in the local and international marketplace.

The Trades

The ISS Institute views the trades as the backbone of our economy. Yet, they are often unseen and, in the main, have no direct voice as to issues which are in their domain of expertise. The trades are equal, but different to professions.

The ISS Institute has the way forward through its 'Master Artisan Framework for Excellence. A New Model for Skilling the Trades', December 2004. The Federal Government, DEEWR commissioned ISS Institute to write an Australian Master Artisan School, Feasibility Plan.

In 2006, ISS Institute Inc. set up a new ISS advisory body, the **Trades Advisory Council**. Members are Ivan Deveson AO; Martin Ferguson AM, MP, Federal Labor Member for Batman; Geoff Masters, CEO, Australian Council of Educational Research; Simon McKeon, Executive Chairman, Macquarie Bank, Melbourne Office; Richard Pratt, Chairman, Visy Industries and Julius Roe, National President Australian Manufacturing Workers' Union.

Think and Work in an Holistic Approach along the Supply Chain - Collaboration and Communication

Our experience has shown that most perceive that lack of skills is the principal factor related to quality and productivity. We believe that attitudes are often the constraint to turning ideas into product and a successful business; the ability to think laterally, to work and communicate across disciplines and industry sectors, to be able to take risks and think outside the familiar, to share – to turn competitors into partners.

Australia needs to change to thinking and working holistically along the entire Supply Chain; to collaborate and communicate across industries and occupations - designers with master artisans, trades men and women, Government agencies, manufacturers, engineers, farmers, retailers, suppliers to name a few in the Chain.

'Design' has to be seen as more than 'Art' discipline – it is a fundamental economic and business tool for the 21st Century

Design is crucial to the economic future of our nation. Australia needs to understand and learn the value of design, the benefits of good design and for it to become part of everyday language, decision making and choice.

Design is as important to the child exploring the possibilities of the world, as it is to the architect developing new concepts, and as it is to the electrician placing power points or the furniture designer working with a cabinet-maker and manufacturer. As such, design is vested in every member of our community and touches every aspect of our lives.

Our holistic approach takes us to working across occupations and industry sectors and building bridges along the way. The result has been highly effective in the creation of new business, the development of existing business and the return of lost skills and knowledge to our workforce, thus creating jobs - whereby individuals gain; industry and business gain; the Australian community gains economically, educationally and culturally.

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Acknowledgments

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In particular he would like to thank Carolynne Bourne for the professional way she conducted herself and the Fellowship process. Nick would also like to thank Jeanette McWhinney for the contribution she made to the planning and documentation of his overseas trip.

Fellowship Sponsor

The Victorian Government, Office of Training and Tertiary Education (OTTE) is responsible for the administration and coordination of programs for the provision of training and further education, adult community education and employment services in Victoria and is a valued sponsor of the ISS Institute. Nick would like to thank them for providing funding support for this Fellowship.

Fellowship Supporters

In Australia

Nick would like to acknowledge the support of Holmesglen Institute of TAFE for allowing him the time and providing administrative support required to undertake the Fellowship and associated activities.

Holmesglen Institute of TAFE

Earl Pike (Manager Horticulture)

Max Newton (Associate Director, Hospitality, Tourism, Recreation and Horticulture)

Graeme Eames (Timetable Co-ordinator)

Helen Georgiou (Secretary)

Concrete Masonry Association of Australia

Allan Pearson (CEO)

Landscape Industries Association of Victoria

Andrew Bright (Immediate past President)

Australbrick

Chris Kostas (Landscape Manager)

C & M Brick

Shane Sinnott (General Manager)

Claytek

John McNidder (Proprietor)

In England

Newcastle University

Professor John Knapton (PPS and Block paving consultant, and Visiting Professor)

Coventry University

Professor Chris Pratt (SUDS expert and retired Professor)

Brett Landscapes, Canterbury

David Marsh (Construction Manager)

Acknowledgments

Blockleys Pavers, Telford

Ian Cook (General Manager)

Interpave**Precast Concrete Paving and Kerb Association, Leicestershire**

John Howe (Development Director)

In Jersey Island**Jersey Airport Authority**

Andrew Durham-Waite (Engineer)

Andre Rabot (Engineer)

Jersey Municipal Council

Quintin Murfin (Engineer)

In Ireland**Tobermore Concrete**

Craig McBride (Sales Manager)

Hazel Hall (Specifications Sales Executive)

In Germany**SF-Kooperation, International Group of Paver Manufacturers**

Stephan Steffen (General Manager)

Stefan Sanders (Product Manager)

Jens Meinheit (PPS specialist)

Landscape Architect and PPS Expert

Soenke Borgwardt

Probst Handling and Laying Systems

Martin Probst (General Manager)

Manual de Rosario (Export Manager)

About the Fellow

Name: Nicolaas Adrianus van Diemen

Qualifications

- Certificate of Competency in Landscape Construction, Oakleigh Technical School (now Holmesglen TAFE)
- Fully qualified and registered teacher with the TAFE Teaching Board
- Diploma of Technical Teaching, Hawthorn Institute of Education (Melbourne University)
- Graduate Diploma in Graphic Communication, Hawthorn Institute of Education (Melbourne University)

Memberships

- Holmesglen Institute of TAFE (HIT) representative for the Landscape Industries Association
- Chairperson of the Segmental Paviers Training Program Consultative Committee
- Member of the Maryknoll Lawn Cemetery Trust

Nick van Diemen has been actively involved in the landscape and segmental paving industry for the past thirty-three years in the area of design, construction and training.

As a qualified landscape gardener he worked for some of Melbourne's leading landscape construction companies of the period as both a worker and foreman.

He conducted his own landscape construction business for many years, working for leading Melbourne architects and designers and was involved in all aspects of landscape design and construction as well as a broad range of segmental paving projects.

In the early 1980's he became involved in the training of landscape apprentices. During this period he obtained his teaching qualification, studying landscape design at Royal Melbourne Institute of Technology and plant science at Burnley Horticultural College, as part of the Diploma of Technical Teaching at Hawthorn Institute of Education.

The following list of achievements indicates his strong commitment to the landscape and paving industries:

- The development of the Landscape Apprenticeship course in Melbourne in 1987, which was the forerunner to the Certificate III in Landscape Construction course undertaken by landscape apprentices today.
- Principal architect and lecturer of the Landscape Design Certificate course that has run at Holmesglen TAFE since 1984.
- The development of the Clay Paviers Training Program in collaboration with the segmental paving industry and the Clay Brick and Paver Association. This program has since been updated to the Segmental Paviers Training Program. Since 1988 he has been the principal lecturer of this program and has been a member of the consultative committee that oversees the training program. He is the current chairperson of this committee.
- Nick was seconded in 1994 by Nubrik to conduct two one-day seminars and two three-day training programs in Tokyo and Kyushu, Japan.
- The organisation of five Segmental Paving conferences conducted at Holmesglen Institute of TAFE, along with presenting papers at these conferences.
- Judging the regional Worldskills Landscape Construction competition since 1990, and judging for the LIAV Awards of Excellence, paving category, since 1991.
- Lecturer in the Advanced Certificate of Landscape Design and Construction at Burnley Horticultural College from 1991 to 1994 (a campus of the University of Melbourne).

About the Fellow

Throughout his career van Diemen has built a strong relationship with the landscape and segmental paving industry and Government agencies. He has represented HIT at the LIAV meetings and was recently actively involved in the process of developing a list of competencies for the licensing of landscape contractors as Registered Building Practitioners in Structural Landscapes. He also conducted in-service training for many local paver manufacturers. In addition to this (and at times concurrently) he has had teaching commitments and involvement with industry. Nick also conducts a consultancy business in the area of landscape and paving.

Currently van Diemen is continuing to do all the things he has done previously. He is an Advanced Skills teacher at HIT and continues to run his small consultancy business. He is co-ordinating and developing the curriculum for the Landscape Licensing course and has just completed, with the help of some of his students, a do-it-yourself video on various landscape tasks for Cement Australia (Melcan). In November 2006 he presented a paper at the 8th International Conference on Block Pavements on the importance of education and training in flexible block pavements, in San Francisco, USA.

Away from work van Diemen enjoys bike riding, supporting the Melbourne Demons football team and the occasional game of golf. He also spends a substantial amount of time maintaining a one hectare block in Maryknoll, Victoria, where he lives with his family.

The Fellowship Program

The purpose of the Fellowship was to undertake an overseas study program in England, Jersey Island, Ireland and Germany to gain a comprehensive understanding of Permeable Paving Systems (PPS) in relation to design, construction and maintenance. The type of pavers used was investigated, along with the material specifications required. The benefit and possible applications of PPS under Australian conditions were also assessed.

Aim of the Fellowship

The aim of this Fellowship was to witness, research, and observe first hand the different types of PPS and how best to implement PPS in Australia. This Fellowship also offered an opportunity to assess the potential benefits and applications of PPS for Australian conditions in the commercial, industrial and residential sectors.

The Australian Context

Permeable Paving Systems (PPS) are not well established in Australia. In fact they are still at an embryonic stage compared to countries like Germany. Although there is an increasing awareness of the need to manage water and that water is a very valuable commodity, the connection between PPS and water management has not been widely recognised.

There are very few projects in Australia constructed from PPS. The Olympic site in Sydney has an area of permeable paving and there is an area in Carlton (Melbourne) that has only recently been completed by the Melbourne City Council using a form of permeable stone paving. There are also some types of paving in Melbourne that resemble permeable paving. The bluestone pitcher streets constructed in the 1940's were of a semi-permeable construction. Even though this was probably accidental, the fact is that at least 50% of the water collected under average rainfall intensity infiltrated the paving, which reduced the strain placed on the drainage systems substantially.

One of the initial problems is the availability of the materials needed to construct PPS. Currently there are no paver manufacturers that stock permeable pavers. The pavers are only available if they are pre-ordered and this would require a substantial amount of pavers to be ordered to make it worthwhile, interrupting the production line to manufacture the permeable pavers. Ideally paver manufacturers should stock permeable pavers as they do other lines, so that if a project was proposed, the pavers would be available. This would also make it possible to do small jobs in PPS.

At present the base materials used for PPS are also not available as a standard line. This also contributes to the difficulty in getting the system started. As with other pavers, when materials have to be specially ordered and production lines have to be interrupted many companies take the short term view that it is not financially viable to produce these materials, and rather wait until demand increases to do this. If PPS are to be as successful in Australia as they are overseas, it is essential that all industries involved make some short term sacrifices and be prepared to invest in the system and gamble on its likely success.

The promotion of PPS will also affect how successful it will be. Manufacturers of permeable pavers will be the main companies that will promote it on a commercial basis. It is imperative that these companies promote PPS as a system and not just as a paver. The general public, and even some people involved in the industry, are not aware of the material differences in the construction of PPS as opposed to traditional pavements.

It is to be expected that initially the cost of PPS will be greater than that of traditional segmental paving. But overseas research indicates that, apart from the environment benefits, there are also financial advantages to PPS. The main reason being the reduction of the need to construct large or additional storm water systems.

There is also an opportunity to construct PPS from granite or bluestone setts, as this type of paving is already being done in Australia and is widely accepted and popular. The only thing that would need to change is the gradings of the base, bedding and jointing materials.

Peak Organisations and Key Representatives

Federal Government

- Commonwealth Department of Resources and Environment
- Depart of Water and Sewerage
- Water Ministry

State Government

- Department of Sustainability and Environment

The Australian Context

Local Government

- Melbourne Water, consisting of Southeast Water, Citywest Water and Yarra Valley Water

Paver Manufacturers

- Australbrick
- BAM Stone
- Boral Brick
- Boral Masonry
- C & M Bricks
- Selkirk Bricks and Pavers
- Hanson Quarries

Suppliers

- Boral Quarries
- FRH Quarries
- Pioneer Quarries
- Ready-mix Quarries

Professional Associations

- Association of Consulting Engineers Australia (ACEA)
- Clay Brick and Paver Association of Victoria (CBPAV)
- Concrete Masonry Association of Australia (CMAA)
- Cement and Concrete Association of Australia (CCAA)
- Institute of Landscape Architects (AILA)
- Landscape Industries Association of Victoria (LIAV)

Education/Training Institutes

- Chisholm Institute of TAFE
- Holmesglen Institute of TAFE
- Northern Melbourne Institute of TAFE
- Swinburne Institute of TAFE

Media

- Earthstyle, Helen Schwab, Ph: (03) 9397 3499, Email: schwab@mira.net.au
- Greenworld, Jo Lidgerwood, Ph: (03) 9544 2233, Email: jo@glenv.com.au
- Landscape Australia (Magazine)

Identifying The Skills Gaps

Specific Areas of Study and Development

- Identification of the advantages of PPS and who would benefit
- Examine the design considerations relevant to the installation of PPS in Australia
- Research the ability of PPS to filter contaminants from water run-off
- Examine the relationship between PPS and Sustainable Urban Drainage Systems (SUDS)
- Investigate the long term financial benefits of PPS to the Australian economy
- Determine the water saving potential of PPS in commercial and residential situations
- Investigate the benefits of returning water to the water table to assist plant growth
- Examine the potential benefits to existing drainage systems by the use of PPS
- Investigate the types and shapes of pavers used in the construction of PPS
- Develop an understanding of the hydraulics of PPS
- Research the importance of having a thorough knowledge of sub-grade conditions and infiltration rates
- Determine the methods used to calculate the infiltration rates of existing sub-grades
- Investigate the base, bedding and jointing material gradings used in PPS
- Identify the potential application of PPS to Australian conditions
- Explore the environmental and economic potential of PPS in Australia

Ongoing Areas for Development

The need to:

- Persuade paver manufacturers and stone quarries to have materials and products available as standard lines and not by special order only
- Lobby Government departments on the benefits of PPS in terms of water saving and management
- Create a marketing and promotional strategy for PPS usage
- Explore options of the use of PPS and SUDS to improve our management of water
- Investigate additional ways of recycling water via the use of PPS
- Convince the stone quarrying industry of the long term environmental and economical advantages of producing stone aggregate that is appropriate to be used in the construction of PPS
- Develop an education and training program on all aspects of PPS

The potential of PPS in Australia is so great, especially in the drier southern states, that it would be a wasted opportunity not to use PPS wherever appropriate. This can only be possible if the right people know of its existence and how to design and construct PPS.

International Context

The purpose of the overseas study program in England, Jersey Island, Ireland and Germany was to identify and explore the skills and knowledge gaps and to obtain the information necessary to enable the Fellow to return to Australia and implement a realistic education and training program to promote the benefits and improve the overall acceptance of Permeable Paving Systems in Australia.

Program Content

During the course of the Fellowship the visits encompassed many individuals and companies involved in the PPS/segmental paving industries in England, Ireland and Germany. Though these appointments were all confirmed prior to departure, the Fellow did anticipate that there would be additional information presented during the course of the Fellowship that would alter the program. Though these changes were minor, these impromptu visits and meetings were advantageous to the study program.

The following site visits and meetings proved to be the most significant in providing information and inspiration.

Meetings and Site Visits

Haseley Secondary School, Milton Keynes, England

This is a 'purpose-built state of the art' school that has used PPS and SUDS to overcome the problem of impermeable heavy clay soils and the presence of the Great Crested Newt, which is a protected species under English and European legislation.



Professor John Knapton, PPS and block paving consultant and Visiting Professor at Newcastle University, Whitley Bay, North-East England

Professor John Knapton is England's leading expert on PPS and has written and presented many papers on PPS at conferences worldwide. Professor Knapton is involved with the specifications, especially in heavy traffic areas, of PPS all over the world.

International Context

Professor Chris Pratt, SUDS expert and retired Professor at Coventry University, Leicester, England

Professor Chris Pratt was one of the pioneers of PPS in England. He was involved in the design of the first permeable paver to be manufactured in England by Formpave.

Oxford Service Centre, Oxford, England

This is one of the best examples of the relationship between PPS and SUDS in regards to addressing the issue of reduced runoff. Due to the use of a PPS and a series of SUDS techniques the water discharge has been reduced from up to 200 litres per second to one litre per second.



Madley Park, Witney, England

Phase one of a three-phase housing development to build 140 affordable houses was underway. A key requirement was to incorporate innovative and environmental sustainable construction techniques to achieve eco-homes ratings and to benchmark these techniques to assess their suitability for later stages. The project incorporated 1,360 square metres of Concrete Block Permeable Paving (CBPP).



International Context

Jersey Airport, Jersey Island

- Andrew Durham-Waite, Head of Engineering, St Helier, Jersey Island
- Andre Rabot, Project Engineer, St Helier, Jersey Island
- Quintin Murfin, Public Services Department Principal Engineer, St Helier, Jersey Island
- Ian Cook, Managing Director of Blockleys Bricks and Pavers, Telford, England
Blockleys are the only manufacturer of clay permeable pavers in the UK and supplied the paver for the airport project on Jersey Island.

This is one of the best known permeable paving projects in England. It was designed to cater for an increasing problem of contaminated water entering existing agricultural bores. The project used PPS techniques to totally manage the discharge of water within the site.



South Hill Primary School, Jersey Island

- Quintin Murfin, Public Services Department Principal Engineer, South Hill, Jersey Island

This project is an excellent example of how a PPS can be used when there is no other means of discharge. The water collected by the permeable paving is totally infiltrated and absorbed by the existing sub-grade.



International Context

Aldi Supermarket, Ireland

- Hazel Hall, Specification Sales Executive, Tobermore Concrete, Dublin, Ireland.

Designed and specified by John Knapton this is the perfect example of how PPS could, and should, be used in Australia. Estimates of the project showed that it was cheaper to construct with permeable paving than to use traditional asphalt.



Brett Landscape, Canterbury, England

- David Marsh, Construction Manager

Brett Landscape is one of England's leading manufacturers of concrete permeable pavers. They have designed an interlocking permeable paver, called the T-flow block, due to its interlocking characteristics. It is one of the best permeable pavers on the market. Brett Landscape is also one of the largest producers of stone aggregate in the UK.

SF-Kooperation, Bremen, Germany

- Stephan H Steffen, Managing Director
- Stefan Sander, Product Manager
- Jens Meinheit, PPS expert and CAD expert

SF-Kooperation is a research and development institute that provides technical support and advice to its shareholders/members. They have been researching PPS for 20 years. C & M Bricks, an Australian company, is a member of the SF-Kooperation.

Dr Soenke Borgwardt, Landscape Architect and leading German authority on PPS, Hamburg, Germany

Dr Soenke Borgwardt is one of Germany's most respected and well known experts on PPS. He has been involved in the design and specification of PPS since its introduction to Germany in the mid 1980's. He was the PPS consultant to the Hanover World Expo site, one of the largest PPS projects in the world. Though the project was supported and approved by the local council it was specified that it must have zero water discharge into existing drainage systems.

International Context

Hanover World Expo Site, Hanover, Germany

- Dr Soenke Borgwardt, Landscape Architect and leading German authority on PPS

The site for the World Expo 2000, in Hanover, Germany, is one of the largest PPS and SUDS projects ever undertaken in the world. The huge car and bus parking areas have been constructed using a PPS which allows the majority of water to be stored and infiltrated into the sub-grade. The excess water is channelled to a large swale that contains a rubble filled trench 2m wide and 1.8m deep. This swale does have an overflow but to date this overflow has not been needed.



Probst, Stuttgart, Germany

- Martin Probst, General Manager
- Manuel de Rosario, Export Sales Manager

Probst handling and laying systems are one of the world's leading manufacturers of equipment designed to mechanically lay segmental pavers. They also manufacture a range of lifting and handling devices associated with the installation of segmental paving.

Mercedes Benz Museum, Stuttgart, Germany

This visit was not planned to be part of the study tour, as the visit was merely to see the recently opened museum. Such is the frequency of use of PPS in Germany that there was approximately 5,000 square metres of permeable paving using a granite paver. This paver was not specifically manufactured for use as a permeable paver, but just laid on the correct base materials and with a 10mm joint filled with a stone grit.

International Context



City Mall, Stuttgart, Germany

This site visit was also unplanned, but highlighted the wide-spread use of PPS in Germany. The large format granite pavers have been laid with a 6mm joint filled with a 2-3mm grit.



Findings

PPS is being used in all the countries visited (England, Jersey Island, Ireland and Germany) to achieve a wide range of water management objectives. These objectives can vary from very basic water management techniques such as returning water to the water table, to complex water storage and decontaminating systems used for fire fighting training.

Key Issues

The two main areas visited were the UK (England, Ireland and including Jersey Island) and Germany, and they have slightly different philosophies and practices in relation to PPS. The philosophy in Germany is very simple. As stated by Dr Soenke Borgwardt, the main reason for PPS is to return as much water back to the sub-grade and to relieve the strain being placed on the existing out-dated stormwater systems. This means that the majority of PPS in Germany is 'System A' or 'System B' (see below). The UK philosophy is far more complex and in the United Kingdom 'System C' (see below) is also practiced and there is a far greater emphasis placed on the filtering of contaminants as outlined by Professor Chris Pratt.

The use of PPS is not as widespread in England as it is in Germany. Permeable paving is a system of flexible concrete, clay or stone segmental or flag paving that allows for the water to infiltrate the pavement rather than the water running off the paving surface. This is achieved by using a specific grading of crushed rock that does not contain any fines. Permeable paving can be laid in isolation where the amount of water discharge needs to be delayed, reduced or controlled, or as is often the case, it is installed as part of a Sustainable Drainage System, also known as Sustainable Urban Drainage Systems (SUDS).

There are three categories of PPS:

- 1) **System A** where all the water is eventually absorbed into the sub-grade. This system is used where there is no outlet and the soil infiltration rate is suitable for the amount of water the paving is expected to accumulate. Soil infiltration tests need to be done to establish the infiltration rates and duration.
- 2) **System B** where the water is partly absorbed into the sub-grade and the excess water is discharged into a drainage system. This greatly reduces the amount of water that is discharged and is probably the most common method of PPS and a very efficient way of reducing, delaying or controlling discharge into the stormwater system.
- 3) **System C** where all the water is directed to a specified area for storage or to be treated if the water is contaminated. This method of PPS can be effectively used to store water for later use on gardens and lawns.

PPS in Germany is extremely common and some form of permeability is incorporated with nearly all flexible segmental and flag paving projects. The philosophy is simply that any of the following outcomes will benefit either the environment or the drainage infrastructure.

Key issues and observations include the following:

- The return of water to the water table to assist in the growth of plants and to help maintain soil structure.
- The delay and reduction of water flow to maximise evaporation (where desirable) and assist storm water systems to cope with peak storms.
- Reducing the amount of contaminants that enter streams and rivers. Research has shown that if we can catch the first 20% of the initial runoff we will eliminate 90% of the contaminants. This would be very beneficial to our waterways.
- The elimination of sub-surface drainage and storm water systems where the infiltration rates of the sub-grade is sufficient to accommodate the water catchment.
- The use of PPS as part of a SUDS to greatly reduce the discharge to existing overloaded stormwater systems. In both England (Oxford Service Centre) and Germany (Hanover World Expo) all the environmental and infrastructure benefits already mentioned exist. In Germany these systems are not unusual as it is common law in many municipalities that new developments, such as the Hanover World Expo site, must manage the discharge of water within the development.

International Context



- The storage of water under the pavement for later use. This storage can be increased by the use of plastic cells that are 92% permeable (eg: Jersey International Airport fire fighting training facility). The water can then be pumped from the water storage area for use at a later stage or sprayed onto the pavement to be evaporated if the storage is full.
- The frequency of maintenance to ensure that the PPS continues to function to its optimum capacity. This frequency varies between the UK and Germany due to the different gradings of the jointing material. The finer gradings used in Germany, (1-3mm), clog up more quickly than the coarser gradings (2–5mm) used in England. The reason for the finer material used in Germany is that the finer material is easier to get into the joints creating a better interlock and a more stable paving.



International Context

- The storage capacity of the pavement is critical to the efficiency of the system. The most common type of PPS uses coarse graded stone that allows the voids to be filled with water. This system is approximately 30% permeable, ie 300 litres of water can be stored per cubic metre of base material.

There are other key issues that relate to the materials used and the paving unit selected. These aspects influence the structural, aesthetic and functional capabilities of the pavement:

- The type (concrete, clay or stone) and shape of the paver can greatly affect the permeability of the pavement. 6-8% of the total surface area needs to be permeable. This can be increased for vehicular traffic but needs to be maintained for pedestrian use, where the large holes or gaps can make walking uncomfortable. Clay and stone pavers tend to be visually more pleasing but more difficult to manufacture or process to a shape necessary to create a structurally sound pavement suitable for heavy vehicular traffic. The use of porous pavers, where the water permeates through the pavers, has been found not to be as efficient as a pavement where the water infiltrates through the paving joints or holes that have been created by the paver shape and the laying pattern.



Clay permeable pavers



Stone permeable pavers



Concrete permeable pavers



Concrete permeable pavers

- The engineering philosophies (in regard to the drainage) of the bases used for traditional pavements and permeable pavements are diametrically opposed. Historically water was directed away from the pavement base, due to the fact that traditional crushed stone bases were weakened by the retention of water in the fine particles. The crushed stone used in PPS has no fine particles (see graph below). The fact that water is encouraged to enter the pavement structure rather than being drained away, without loss of strength to the structure, is a difficult concept for some specifiers to comprehend. The compaction and/or cement stabilisation of this type of crushed stone base is still paramount to the structural integrity and longevity of the pavement.

International Context

- The quality of the installation of the paving, be it manual or mechanical, is critical to the performance of the pavement. It is vital that all design tolerances are strictly adhered to and that the joints are thoroughly filled to ensure complete interlock and prevent shunting.

sieve size, mm	percentage passing	
	coarse aggregate 4/40	coarse aggregate 4/20
80	100	–
63	98-100	–
40	90-99	100
31.5	–	98-100
20	25-70	90-99
10	–	25-70
4	0-15	0-15
2	0-5	0-5
1	–	–

Aggregate gradings for sub-base materials to BS EN 12620

Key Observation

The problem associated with the introduction of PPS to Australia is not so much one of deficiencies in the skill of installing the pavement but more to do with the lack of knowledge in the design and specification of PPS. A concerted effort needs to be made to educate all parties associated with and benefiting from the use of PPS in Australia.

Knowledge Transfer

The transfer of the knowledge Nick van Diemen has gained from the Fellowship is to be addressed in the following ways, including presentation to a range of industry groups on the benefits of PPS. Some of these have already been completed and more are planned for the future. These include:

- Presentation to contractors for Australbrick, November 2006
- Presentation at the Sustainable Paving Conference, Holmesglen Institute of TAFE, August 2007
- Presentation to C & M Brick executives, April 2007
- Presentation to the LIAV, August 2008
- Proposed presentation on the Fellowship findings at the 9th International Conference on Concrete Interlocking Pavement in Buenos Aires (Argentina), late 2009
- PPS workshop for installers in late 2008

Other methods of distribution of the knowledge gained include:

- The writing of articles for trade magazines. One article has already been completed and published in the LIAV magazine 'Earthstyle' in the Autumn/Winter issue 2007.
- Proposed article in Landscape Australia in 2008
- Placing the report on the CMAA, HIT and LIAV websites

Recommendations

The following are recommendations to Government, Industry, businesses, professional associations, education and training providers, our community and the ISS Institute.

If Australia is to take full advantage of the environmental and water conservation benefits of PPS there must be an extensive education and awareness campaign directed to the community as a whole, as well as those directly involved with the permeable paving industry along the Supply Chain, from initial design of pavers to installation and maintenance. This campaign would need to be specifically designed to cater for the needs of different sectors.

Government

It is now an established fact: in overseas countries PPS has major benefits to the environment. In line with the directives now being addressed by Government at all levels, it is strongly recommended that legislation is required to make it compulsory to manage all, or part of the discharge of water and run-off of specific developments. Permeable paving is an effective system which can directly contribute to creating a solution to water management.

Other initiatives that Governments can take that would assist the increase of PPS systems are:

- The incorporation into environmental studies units at primary and secondary schools of the long and short term benefits of PPS.
- Provide financial incentives to developers that install PPS as part of a SUDS or as stand alone projects to reduce the volume and increase the water quality of the water discharge.
- Legislation to reduce the amount of contaminants that can legally be discharged into waterways.
- Local Governments to include in permit applications strict guidelines on water management techniques including the use of PPS.
- Government departments such as the Department of Sustainability and Environment need to realise the benefits of PPS and be proactive in the promotion and implementation of PPS projects.

The success of water management strategies in Australia, which includes PPS, is largely the responsibility of the Government. Therefore, involving the key Government bodies is of great importance. Along with air, water is our most valuable asset. The quality and quantity of water will depend on how well Governments plan for the sustainability of this asset. There is now indisputable proof that PPS can play a major role in how Governments manage this scarce resource.

Industry

The paving industry in Australia is well established. It has the expertise and experience to adapt existing manufacturing plants and production lines to successfully manufacture pavers and to produce the materials required to accommodate the introduction of PPS to Australia. The main consideration of PPS for Australia must focus on the necessity to utilise the benefits rather than the initial short term costs. There are three main industry sectors that would be affected by, and profit from the introduction of PPS to Australia. It is recommended that these industries consider the following initiatives and be proactive in campaigns to help establish PPS in Australia.

- Once the industry has been informed of the benefits of PPS the manufacturers of concrete and clay bricks and pavers need to promote permeable paving as a pavement system and not just promote the paving unit. The latter would be disastrous for the numerous

Recommendations

customers who are not aware of the complex nature of PPS. The technical divisions of these companies must also be proactive in helping the companies' marketing and sales divisions understand the complexity of PPS and the need to promote it as a pavement system. Most manufacturers of segmental pavers have already put in place the necessary equipment to produce permeable pavers. One local manufacturer is a member of the German SF-Kooperation who has considerable expertise in PPS.

- The producers of stone products will also play a role in the establishment of PPS in Australia. Currently the crushed stone gradings required for PPS are not readily available in Australia. The stone quarry industry must be prepared to invest time and expertise into the range of products that are required to install PPS to maximise the infiltration rates and storage capacity without compromising the base strength.

Paving contractors need to educate themselves and their staff in the complex workings of PPS. Because permeable paving is so different to traditional flexible paving in so many ways it is vital that the installer fully understands the system eg: the storage of materials (sand, soil, etc) on completed paved areas is commonly practiced with traditional flexible and rigid segmental and flag pavements. If this is done with permeable paving the joints would clog up and the paving would be impermeable. Paving contractors can also play an important role in the promotion of PPS by suggesting it as an option, where applicable, to their clients. They can, however, only do this if they have a thorough knowledge of the applications of the system.

Business

Water is big business in Australia, especially in Melbourne at the present time. Businesses both large and small need to find innovative ways to make a profit from water saving devices, recycling and storage methods. The opportunity to make a profit from such innovations exists because Governments are prepared to pay large sums for water. Some of the following business concepts are not beyond the realms of possibility:

- A business that advises and consults on ways of storing, recycling, decontaminating or filtering water. PPS can do all of this.
- A business could subsidise the installation of PPS in return for the water collected and sell it for industrial use.
- Developers that design subdivisions using PPS to collect water and store it within the development to use for gardens, building projects, toilets and cleaning purposes.

Corporate businesses have a moral responsibility to support community issues that have the capacity to cause hardship to families and communities. These businesses should do more in the way of offering grants, Fellowships and support to other businesses and/or individuals that invent and create ways of managing water more efficiently. Some of these ideas could include PPS.

Professional Associations

- Association of Consulting Engineers Australia (ACEA)
- Clay Brick and Paver Association of Victoria (CBPAV)
- Concrete Masonry Association of Australia (CMAA)
- Cement and Concrete Association of Australia (CCAA)
- Institute of Landscape Architects (AILA)

Recommendations

- Landscape Industries Association of Victoria (LIAV)
- Master Builders Association of Victoria (MBAV)
- Royal Australia Institute of Architects (RAIA)

The above associations and their members will be the people most directly involved in the design, installation and maintenance of PPS in Australia. It is imperative that these associations are educated in the design specifications, trained in the correct installation techniques and advised on the maintenance requirement and frequency of PPS. These associations need to be proactive in the development and implementation of education and training programs through the various universities and TAFE institutes and the conducting of seminars, workshops and conferences.

Education and Training

Education and training in the understanding and benefits of PPS is vital and should start as early as possible in the education system.

- Most primary schools are now teaching the fundamentals of sustainability and the need to consider the environment especially in relation to water conservation. PPS needs to be included in these programs so that there is a basic understanding of how the system works and the benefits that can be gained.
- Environmental studies is taught at practically all secondary colleges in Australia. PPS should be included at an intermediate level so as to whet the appetite of students that may wish to pursue a career in SUDS/PPS. This would also give an appreciation of the environmental management of water in relation to hard surface areas and help them make informed decisions on these issues throughout their lives.
- There is a tremendous opportunity for TAFE, tertiary institutions and private providers to develop training programs in the design, installation and ongoing maintenance of PPS. PPS also needs to be incorporated into the curriculum of existing degree courses such as engineering, architecture and landscape architecture. It also needs to be included in existing training programs such as Certificate III in Landscape Construction (Landscape Apprenticeship) and various landscape design and environmental study programs that exist throughout the system. The need to educate people on the benefits of PPS is paramount to its success and educational institutions are in the best position to do this. Government funding to achieve this must be provided.

If these recommendations are to be successful it will also be necessary to organise in-service activities for teachers at all levels of education to ensure that these teachers have the knowledge to competently deliver these programs. This is something that could be organised through the TAFE system with the assistance of the International Specialised Skills Institute.

Community

The community is possibly the most important sector in the endeavour to introduce PPS into Australia. If the community (consumers) can be made aware of the huge financial and environmental benefits this would probably be the most efficient method of ensuring the success of PPS in Australia. This could be done with the aid of a wide-spread public awareness program targeting the following media outlets and other forms of marketing.

Recommendations

- Lifestyle and do-it-yourself television programs.
- Environmental magazines
- Articles in newspapers' weekend magazines
- Talk-back radio
- Displays at gardening and lifestyle shows, for example 'The Melbourne International Flower and Garden Show', 'Tilex' and 'Designex'.

How ISS Institute can be Involved

The International Specialised Skills Institute has the potential to utilise its many contacts to attract funding and work with TAFEs and certification groups to assist in the introduction of PPS to Australia. In most cases, the lack of funding is the main obstacle that needs to be overcome.

Further Skill Gaps

There are some additional skill gaps that, if addressed would assist in the introduction and continual use of PPS in Australia. These skill gaps may be able to be addressed in the awarding of future Fellowships. These are as follows:

- The lack of consistent information about the use of geofabric between bedding material and the base and its ability to remove contaminants.
(There were several papers on this subject presented at the '8th International Conference on Concrete Block Pavements' that were inconclusive and lacked the appropriate comparative tests to make an informed decision).
- Additional information on the maintenance of PPS and, in particular, joint clogging
- The silting up of geofabric if it is being used
- Additional information on the amount of contaminants that are removed via the PPS and how this is done

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