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E2DESIGNLAB

City of Melbourne

Permeability Testing of Permeable Pavement Systems

Version 01 / July 2017

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Document Control Sheet	
Project	Permeability Testing of Permeable Pavement Systems
Report Title	Permeability Testing of Permeable Pavement Systems
Version	01
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Signed	
Date	24/7/2017
Distribution	Candace Jordan, City of Melbourne

Revision	Date	Approved	Details of Revision
V1.0	05/07/2017	Dale Browne	Draft report
V1.1	24/7/2017	Dale Browne	Final Report

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Executive Summary

The City of Melbourne has constructed several trial permeable pavement assets at different locations across the City. In the future Council intends to construct larger areas of similar permeable pavements but needs to be confident that they are effective and have the necessary knowledge to maintain them effectively.

Council has become concerned that some of the trial assets are not infiltrating effectively. The failure of infiltration systems such as permeable pavements most commonly occurs due to clogging or to design and construction issues.

The purpose of this project was to build knowledge of the effectiveness of permeable pavements and how maintenance influences this. The project scope was to:

- assess four existing permeable pavement installations to determine whether they are functioning effectively and whether maintenance is required.
- confirm whether certain maintenance activities are effective in restoring functional performance.

Four locations with permeable pavement assets were assessed for their infiltration capacity before and after cleaning with water jetting. 14 sites across these 4 locations were tested, cleaned and tested again (only the test sites were cleaned, not the entire pavement asset).The four locations were

- Abbotsford Street, North Melbourne
- Eades Place, West Melbourne
- Harris Street North Melbourne
- Collins Street CBD

Two test methods were used for infiltration testing, the Simple Infiltration Test (SIT) proposed by Winston et. al. (2016) and the standard test method issued by the American Society for Testing and Materials (ASTM) - C 1701/C 1701M - 09.

The results for infiltration testing prior to cleaning showed that all 14 sites at the four locations were compromised by surface clogging (Figure 1,Figure 2, Figure 3 and Figure 4). The results suggest the assets in Abbotsford St and Harris St have failed and demonstrate minimal if any functional effectiveness and infiltration capacity. The systems at Eades Place and Collins St demonstrate some functionality but there is potential for this to be greatly improved.

The results for post-cleaning infiltration testing indicated much higher infiltration rates were achieved and conclusively demonstrated that the water jetting cleaning undertaken was effective in improving

functional performance. ***On this basis, it is recommended that full cleaning of the entire permeable pavement asset at all four locations is undertaken.*** The Abbotsford St and Harris St systems should be a priority due to their very low level of functionality.

It should be recognised that the very high infiltration rates observed immediately following cleaning will likely be short-lived with moderate to low infiltration rates being the normal mode of operation however this will still provide a much better level of functionality.

Council should ***immediately replace the infill media*** (quarter minus (2-5 mm) crushed rock) between the modular bluestone that was removed during cleaning at the location in front of 333 Collins St ***as this currently presents a potential trip hazard*** that needs to be rectified as a priority. Replacement of this material should be planned to occur immediately following future cleaning.

It is recommended that further trials could be undertaken during broader cleaning of the assets to confirm optimal water pressure to balance functional outcomes with potential damage to the assets due to dislodgement of the pavement matrix. Further trials of other potential cleaning mechanisms could also be undertaken (e.g. sweeping, vacuuming).

It is recommended that Council undertake further infiltration testing immediately following cleaning and then at scheduled intervals to establish a baseline and determine the rate of decline of pavement permeability. This will help to determine an appropriate frequency of cleaning that maintains an infiltration rate above a threshold that supports adequate function of the assets.

Infiltration test data collected over a number of points in time could be further used to develop an infiltration and clogging model to predict the change in infiltration rates over time and infer appropriate times for cleaning intervention for other or future assets. This could be calibrated based on the data collected (and ideally updated following subsequent cleans and testing) to allow Council to develop a more robust asset management model to support ongoing management of permeable pavement systems.

Figure 1
Modular paving, Collins St, Melbourne

Figure 2
Permeable asphalt, Eades Pl, West Melbourne

Figure 3
Permeable asphalt, Abbotsford St, North Melbourne

Figure 4
Permeable asphalt, Harris St, North Melbourne

1. Introduction

The City of Melbourne (Council) is undergoing a transition to align its urban water management practices with the natural water cycle and become a water sensitive city. Increasing the permeability of the Council's urban environments is one initiative the Council is trialling to provide stormwater quality treatment, reduce flood risks and increase soil moisture availability for trees. E2Designlab has been commissioned to test the effectiveness of several permeability trail projects and provide recommendations for future management.

1.1 Background

The City of Melbourne has previously constructed a number of trial permeable pavements and permeable interlocking concrete pavements (PICP), referred henceforth as permeable pavements. In the future Council intends to construct much larger areas of similar permeable pavements but needs to be confident that they are effective and that it has the knowledge and understanding to be able to maintain these effectively.

There is concern that some of the trial sites appear to not be infiltrating effectively and may have clogged. Failure of infiltration systems such as permeable pavements most commonly occur due to clogging or design and construction issues.

Clogging may occur at either the exposed infiltration surface or at the interface with the underlying and surrounding subsoil (or less commonly an internal interface). Clogging may be of a physical, biological or chemical nature and the processes are common for infiltration systems such as permeable pavements, infiltration basins and trenches, aquifer storage and recovery and media filtration systems. In stormwater treatment measures, physical clogging due to fine sediment (2-6 um) is the most common and likely cause as demonstrated in experiments at Monash University (Siriwardene, 2007) although biological clogging due to organic material from trees is sometimes possible.

Infiltration systems (including permeable pavements), infiltration and clogging processes are well researched internationally (Duchene, 1994, Fujita, 1994, Hamacher and Hausmann, 1999, Bouwer, 2002, Dierkes et. al, 2002, Dechesne, 2004, Le Coustumer and Barruad, 2007, Endo et. al., 2008, Aryal 2015, Winston et. al., 2016 as well as in Australia (Browne, 2007, 2008, 2009, 2011, 2012, Siriwardene, 2007, Argue et. al., 2004, Newton, 2005, Pezzaniti et. al., 2009, Pezzaniti and Shakel et. al., 2009. The research shows that clogging will occur over time with the longevity of systems ranging from very short (<1 year) to very long (>10 years) before clogging significantly constraining infiltration occurs. Clogging occurs as an exponential function with infiltration rates rapidly declining then

approaching an asymptote. This means that it may be preferable to clean systems more frequently to maintain infiltration rates within a moderate range.

Research into cleaning of permeable pavements and infiltration systems, Gerrits, 2002, Sansalone, 2012 and others has found cleaning can be quite effective in restoring infiltration capacity. Even sweeping or vacuuming can significantly restore infiltrative capacity while suction and water jetting has been found to be the best approach in other studies.

1.2 Permeable pavement locations

Permeable pavement systems at the following locations were assessed for this project:

- Modular paving - Collins St, Melbourne
- Permeable asphalt - Eades Place, West Melbourne
- Permeable asphalt - Harris St, North Melbourne
- Permeable asphalt - Abbotsford St, North Melbourne

Construction drawings for these systems, except for Harris St, are provided in Appendix D, E and F respectively. Construction drawings corresponding to the permeable asphalt works undertaken at Harris St were unavailable at the time of the project.