PERMEABLE ROAD PAVEMENT WITH SUBSURFACE PRECAST MICRO DETENTION POND: A GREEN PAVEMENT PRACTICE

-PhD Research in Stormwater Management

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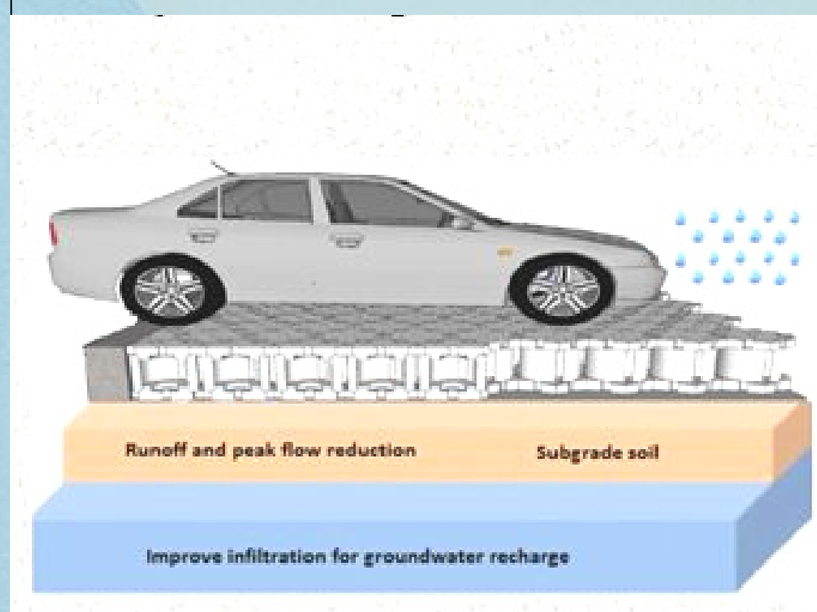
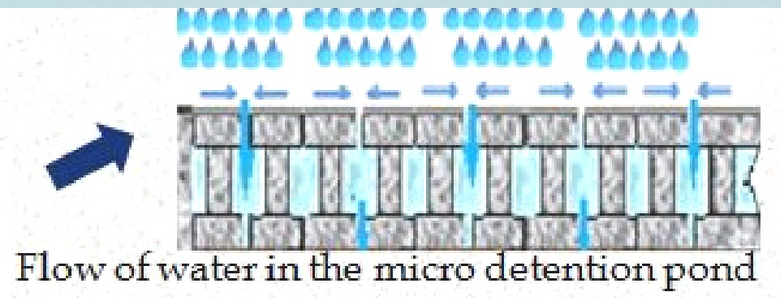
Acknowledgement: Exploratory Research Grant Scheme ERGS/TK03(02)/1009/2013(06

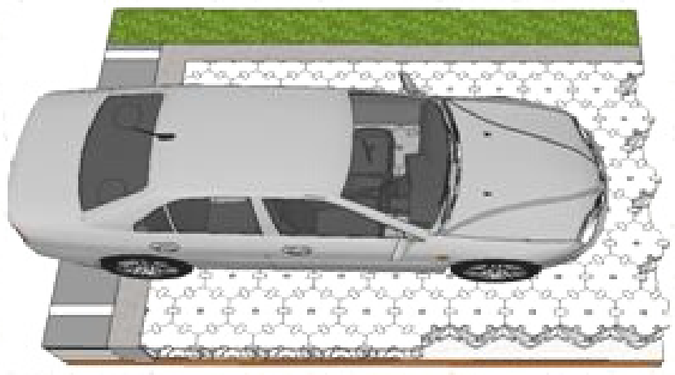
Related literature

1. Leming, M. L., Malcom, H.R., A., & Tennis, P. D. (2007). Hydrological Design of Pervious Concrete. Silver Spring, Maryland, USA.
2. Mannan, M.A., Bateni, N., Teo, D.C.L., Mah, Y.S., Putuhena, F.J., Ng, C.K., Bustami, R.A., Ibrahim, W.H.W., Lee, C.L.F., and Lim, H.L. StormPav, System and Method of Green Pavement. (2016). Application Number PI2016704420, Malaysian Intellectual Property Corporation, Kuala Lumpur.
3. Tennis, P. D., Leming, M. L., & Akers, D. J. (2004). Pervious Concrete Pavements. Maryland, USA: Portland Cement Association & National Ready Mixed Concrete Association.
4. UNI-GROUP. (2008). Permeable Interlocking Concrete Pavement: Design Guide and Research Summary. U.S.A.





Flow of water in the micro detention pond



Introduction

This research is the development of an innovative design of Permeable Pavement (PP) namely, Permeable Pavement with Micro-Detention Storage (PPDS). PPDS consists of three pieces precast concrete block with a top cover (acted as road pavement), a bottom plate (base plate/raft foundation) and a unique hydrological feature of a hollow cylinder (micro-detention storage) in the middle section. It works as a micro-scale dual system acted as a stormwater management control; a road surface and a sub-surface detention pond permeable pavement with benefits as follows:

- a microstructure, which exhibits the advantages of easy handling and lifting, as well as unique environmental benefits.
- designed in the shape of a hexagon prism, mimicking beehive to gain an interlocking honeycomb frame.
- In the middle part, it is equipped with a circular shape micro-detention pond, mainly for holding the rainwater.

OBJECTIVE

1. To construct a laboratory-scale rainfall simulator (RS) to test the PPDS
2. To measure the hydrological performance of the PPDS system.
3. To investigate the hydrological impact assessments of PPDS by comparing with other permeable pavements (PP) using Stormwater Management Model, SWMM software

METHODOLOGY

The study involved the methods as follows:

1. Construction of laboratory-scale rainfall simulator (RS) as a testing device for PPDS performances,
2. Experiments using a constructed rainfall simulator to test the hydrological performances of new develop PPDS
3. Comparison studies of previous PP hydrological properties Pervious Concrete (PC), Porous Asphalt (PA), Permeable Interlocking Concrete Pavement (PICP), and the newly developed system PPDS and Modeling using SWMM to create various scenarios and compare with existing PPs design.

RESULTS

- The development of RS meets the requirement of natural rainfall.
- PPDS properties include storage capacity about 70% (void porosity) and detention storage about 0.90m3/m2 (30 L/unit).
- The permeability rate of PPDS can handle the hydrological design requirements for 2-yr and 10-yr ARI
- Storage capacity 190L/m2 is sufficient to provide detention storage and release water within a duration of 48 hrs
- Utilize subgrade soil of hydrologic soil groups (HSG) A and B.

RESULTS

Assessment on Hydrological Impact with existing road condition of asphalt road pavement (AP), PC, PA, PICP & PPDS:

- PPDS shows the best runoff reduction as well as the lowest runoff coefficient and peak flowrate (Fig. 1).
- The PPDS demonstrates the lowest runoff flowrate (Fig. 2 and the fastest time taken for the infiltration process with the highest rate of infiltration loss.

Comparisoan of PPDS properties with existing PPs

PC Tennis et al. (2004)	PA Leming et al. (2007)	PICP (Block) UNI-GROUP, (2008)	PICP (Ecoloc) UNI-GROUP, (2008)	PICP (Aquaflow) UNI-GROUP, (2008)	PPDS Manan et. al. (2016)
35 L/m²	30 L/m²	40 L/m²	48.2 L/m²	140 L/m2	190 L/m²
Surface Permeable Concrete 100mm	Surface Permeable Asphalt 100mm	Surface Block Paver +sand, 110mm	surface Ecoloc pavers+ bedding, 110 mm	surface Aquaflow block + bedding 110mm	Top cover solid concrete (G50), with 40mm diameter centre hole Surface of 75mm
Base 200mm	Base 200mm	Base 200mm	Base 200mm	Limestone Subbase (no particles below 5mm) 400mm	Micro detention pond , cylindrical hollow tank 300 mm
Subbase 300 mm	Filter layer 50mm	Subbase 300mm	Subbase 200 mm		Bottom cover solid concrete (G50), with 40mm diameter centre hole 75mm

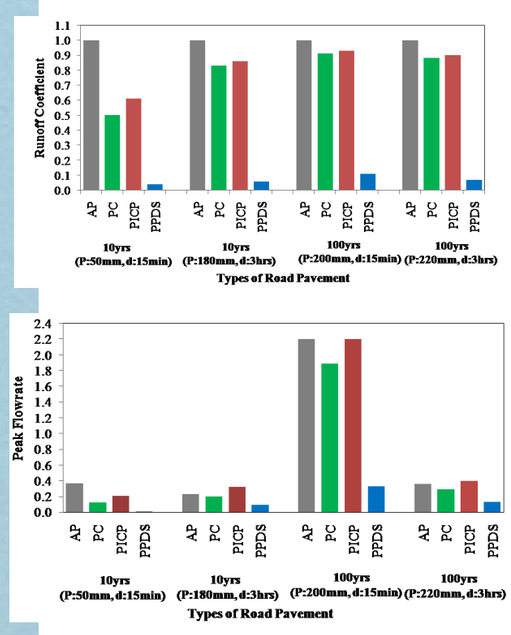
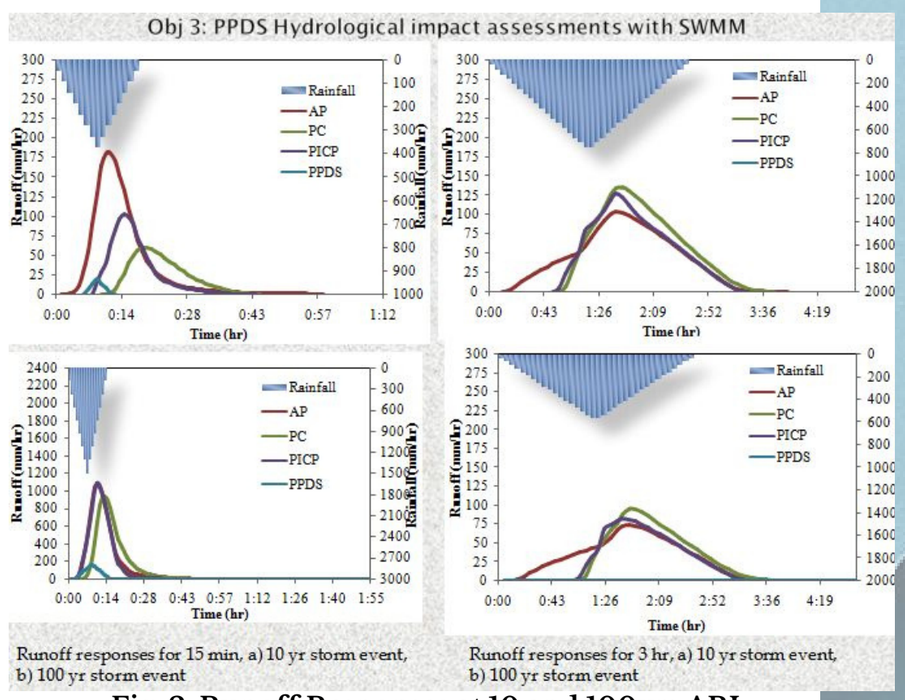


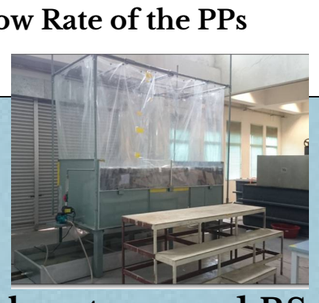
Fig. 1. Runoff Coeefficient and Peak Flow Rate of the PPs



Runoff responses for 15 min, a) 10 yr storm event, b) 100 yr storm event

Runoff responses for 3 hr, a) 10 yr storm event, b) 100 yr storm event

Fig. 2. Runoff Responses at 10 and 100yrs ARI



Novelty

1. New medium-scale for laboratory used RS with properties size of; 3.16m x 1.47m and adjustable height of (1.55m to 3m) and a green pavement box; 3.0m (width) x 1.305m (length) x 1.5m (height) equal to half of the road system size.
2. New design of PP with subsurface micro-detention pond storage with new hydrological properties at a void capacity of 70%, and 0.19m3/m2 storage.

Conclusion

Stormwater management evaluation of PPDS shows significant achievement in runoff reduction, infiltration rate and peak flow attenuation. The PPDS appears as an alternative to stormwater management control, which can be served as a component in the road system. The system is currently, investigated for environmental performance and field study as well as the maintenance and life span.