Testing of porous pavements performance on runoff and temperature control in Taipei City

Essai de performance de chaussées poreuses sur la maîtrise du ruissellement et de la température dans la ville de Taipei

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RÉSUMÉ

L'Université technologique de Taipei, sous contrat avec le gouvernement de la ville de Taipei, a lancé une étude sur les chaussées poreuses en asphalte et en briques de béton pour voies cyclables et piétonnes. L'objectif est d'évaluer la performance de ces chaussées en matière de réduction des eaux de ruissellement et de la température de surface, par rapport aux chaussées traditionnelles en asphalte et en brique de béton. De plus, la variation des taux d'infiltration de ces chaussées dans le temps a été surveillée. Le site d'essai comprend une piste cyclable en asphalte poreux de 200 mètres de long et une voie piétonne en béton poreux de même longueur, avec deux réservoirs de stockage des eaux pluviales de 70 mL x 2 ml x 0,5 mp en dessous. En décembre 2018, 20 tempêtes au total ont été surveillées. Les températures de surface pendant les tempêtes et les jours secs ont été mesurées. Les taux d'infiltration ont été mesurés sur une base mensuelle. Les résultats montrent que : 1) La réduction des pics de ruissellement varie de 16 % pour les tempêtes de grande intensité à 55 % pour les petites tempêtes de longue durée ; 2) Les taux d'infiltration diminuent de 25 à 50 % sur une période de surveillance de six mois ; 3) Température de surface : pendant les tempêtes, les briques poreuses de béton ont une température moyenne inférieure à celle du béton ordinaire avec un écart maximal de 7°C ; pour l'asphalte poreux, l'écart maximal était de 4°C. Pendant les jours secs, la température des deux chaussées poreuses a tendance à augmenter rapidement lorsque la température de l'air augmente, mais elle diminue également rapidement lorsque l'air se refroidit.

ABSTRACT

The Taipei University of Technology, under contract from the Taipei City Government, has initiated a study on asphalt and porous concrete bricks pavements for bicycle lanes and pedestrian walkways. The objective is to evaluate the performance of these pavements in stormwater runoff reduction and surface temperature mitigation, as compared to traditional asphalt and concrete brick pavements. Also, the variation of infiltration rates versus time of these pavements was monitored. The test site consists of one 200 meter long porous asphalt bicycle lane and an equal length of porous concrete walkway with two 70mLx2mWx0.5mD stormwater storage tanks underneath. As of December 2018 a total of twenty storm events were monitored. Surface temperatures during storm events and also dry days were measured. The infiltration rates were measured on a monthly basis. The results show that: 1) Runoff peak reduction ranged from 16% for large, intense storms to 55% for small, long-duration storms; 2) Infiltration rates decrease by 25% to 50% over a 6-month monitoring period; 3) Surface temperature: during storm events, porous concrete bricks averaged lower temperature compared to regular concrete with a maximum of 7 degrees C; for porous asphalt the maximum drop was 4 degrees C. During dry days, both porous pavements showed a tendency of rapid temperature increase as the air temperature rises, but also rapid temperature decreases as the air cools.

KEYWORDS

Field tests, infiltration rates, porous pavements, runoff control, temperature reduction,

1 THE FIELD TEST – BACKGROUND AND OBJECTIVES

The Taipei City Government has in recent years been implementing the “sponge city” approach in managing stormwater runoff. The approach, similar to that of the sustainable urban drainage (SUD), calls for the use of “natural, on-site” treatment of stormwater runoff through the processes of infiltration, detention, storage, etc. (Yu and Jia, 2016) The Taipei University of Technology was contracted in 2017 to conduct a demonstration study of the performance of porous pavement in order to provide design guides and maintenance information needed for a planned large scale implementation of bicycle lanes and pedestrian walkways throughout the City.

2 METHODS

A stretch of pedestrian walkway and a bicycle lane, each of 200 m long, were constructed in front of the Taipei Municipal Da-An Vocational High School by using porous concrete bricks and porous asphalt pavement, respectively. The bicycle lane is parallel to a high-traffic road constructed with regular asphalt and concrete. Underneath the walkway, two runoff storage tanks, each with dimensions of 70m long, 2m wide and 0.5m depth were constructed. The following data were collected at the site:

- Rainfall - One rain gage (HOBO-ON SET) on the roof of a campus building at the site
- Runoff stored at the two underground runoff storage tanks
- Flow measurements at four locations by weirs
- Infiltration rates at seven locations on monthly basis
- Surface temperature at six locations during storm events and dry periods
- Ground water level at one location

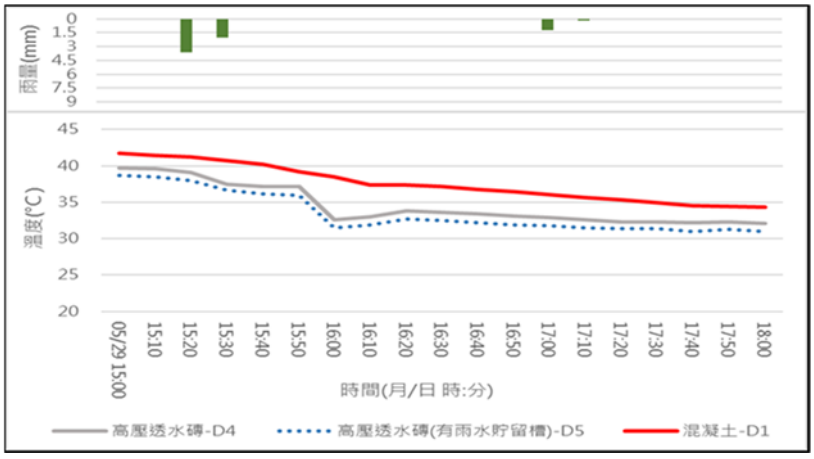
Below is a picture showing the site after the porous pavements construction was completed.

On the left – porous asphalt bicycle lane, on the right – porous concrete brick pedestrian walkway

3 RESULTS AND DISCUSSION

Monitoring was started in early 2018. From April 2018 to December 2018, a total of 20 storm events were sampled. Certain samples, i.e., surface temperature, were also taken during prolonged dry periods. In addition, infiltration rates at 7 locations were taken on a monthly basis. The rainfall events ranged from 17mm to 152 mm in total depth, with a maximum intensity of 94 mm/hr. The following is a summary of the performance results obtained thus far:

- Runoff peak reduction – from 16.5% for short duration, high intensity storms to 54% for long duration and low intensity storms
- Infiltration rates – for porous asphalt, a decrease of roughly 40% over 6 months; for porous concrete bricks, a decrease of roughly 30% over 6 months
- Surface temperature – for porous asphalt, during storm events the temperature could drop to a maximum of 4 degrees C, compared to that of the regular asphalt pavement. For porous concrete bricks, the drop was larger, about 7 degrees C. (See Figure below) During dry periods, both porous pavements showed a rapid increase in temperature when the air temperature rises, but showed faster decrease when the air temperature cools.



Red line – regular concrete bricks, grey and blue lines – porous concrete bricks

4 CONCULSIONS

The results from monitoring twenty storm events and also during dry periods at the porous pavement site show that porous pavements are effective in reducing runoff peaks, especially for low intensity storm events. Porous pavements help reduce the surface temperature significantly compared to traditional pavements. Porous pavements need to be maintained in order to keep their designed infiltration rates.

LIST OF REFERENCES

Lin, Jen-Yang, Chen Chi-Feng and Kang, Shyh-Fang, (2018) *Assessment of Porous Pavement Stormwater Runoff Reduction Effectiveness and Infiltration Capability.* Report to Taipei City Government, Taipei, Taiwan