CITY OF MADISON

Environmental Project Summary

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SUBJECT: **Permeable Concrete Field Test Summary**

In August 2011 I tested the effectiveness of 260 feet of permeable concrete installed in an Allied Drive neighborhood alleyway. The experiment addressed two questions:

1) Does water infiltrate the permeable pavement?
2) Does water then infiltrate into the underlying native soil?

The experiment results verified that the swath of permeable concrete does indeed infiltrate water and that it had successfully survived one winter. Unfortunately, due to not taking the slope of the entire alleyway into consideration, the storage capacity of the system was undermined by the elevation of the outflow pipe. The result is that the system can only store approximately one-fifth the volume of water it was originally designed to hold. The experiment underlines the importance of considering site topography when designing for the infiltration of stormwater using permeable concrete.

Permeable Pavement Design

The test site is an alleyway located between Dunns Marsh Terrace and Percy Julian Way, parallel to Allied Drive. Permeable concrete was laid in a 3.5-foot wide swath in the middle of the alley, running 260 feet long. This design minimizes the impact of vehicle traffic on the permeable concrete. The concrete was constructed with a slight 1% grade, so the north end is approximately 2.4 feet higher than the south end.

Below the 8 inches of permeable concrete is a perforated 6-inch PVC underdrain pipe, which connects to the storm sewer. Below the underdrain pipe are 18 inches of 3-inch clear stone overlying native sandy soil. Water infiltrating the concrete will saturate the clear stone before overflowing into the underdrain and exiting the system via the storm sewer. The purpose of the underdrain is to keep ponded water away from the permeable concrete, which could be damaged by freeze/thaw activity. The purpose of the clear stone is to store water long enough to allow it to slowly infiltrate into the underlying native soil.

Length of permeable pavement	264	ft
Cross-sectional area of clear stone below the underdrain pipe	19	ft2
Volume of 3-inch clear stone	5,037	ft3
Percent void space	30%	
Volume of clear stone void	**11,303**	**gal**

Based on the site plans, I calculated the approximate total volume of void space in the clear stone layer to be approximately 11,000 gallons. This means that the system should have enough space to store

11,000 gallons of water before overflowing into the underdrain.

Experiment Design

The water source for the experiment was the fire hydrant located at the corner of Allied Drive and Percy Julian Way. Eric Hopper of the Water Utility supplied the fire hose and a flow meter. With the flow meter installed, the maximum measurable flow rate was 43 CFM (322 gal/min).

The experiment consisted of using the fire hose to flood the alleyway with a known quantity of water at a known flow rate. The hose was placed at the top of the alley and the alley was flooded with predetermined quantities of water. One person watched the flow meter on the hydrant and a second person waited at the storm access structure (SAS) at the bottom to monitor for water overflowing into the storm sewer. Due to the weight of the steel grate, we were unable to remove it to directly measure the volume of any water exiting through the storm sewer. However, visual estimates of flow rates were noted.

Experiment Results

We conducted the experiment four times with the following results:

Date	Flow rate (gal/min)	Water Added (gal)	Results
8/12/2011	322	9,800	Water started flowing into the storm access structure (SAS) after 30 minutes. The flow exiting into the SAS was heavy and the volume was unknown.
8/16/2011	161	4,900	Water started flowing into the SAS after 45 minutes. The flow exiting into the SAS was moderate and the volume unknown.
8/17/2011	187	2,800	Water started flowing into the SAS 45 after 45 minutes. The flow exiting into the SAS was low and the volume unknown.
8/18/2011	52	2,500	Water started flowing into the SAS after 1 hr 5 min. The flow exiting the SAS was low and lasted for less than 3 hours. The volume was estimated between 270 and 720 gallons.

For all four experiments, we did not come close to saturating the infiltration capacity of the permeable concrete. According to the estimated volume of void space, the system should have been able to hold 11,000 gallons before overflowing into the storm sewer. However, water drained into the storm sewer when we added as little as 2,500 gallons at a relatively low flow rate (52 gal/min). On August 18, 2011, the estimated volume to leave the system was between 270 and 720 gallons, meaning the system had held 1,780 to 2,230 gallons of water, approximately 20% of the original design capacity.

Discussion

The reason the system did not hold 11,000 gallons of water is due to the slope of the alleyway. Due to the 1% slope, the elevation of the outflow of the underdrain pipe at the bottom of the alley is 2.4 feet lower than at the top of the alley. With only 18 inches of clear stone, this means that the majority of clear stone storage area is higher in elevation than the underdrain outflow elevation. Water entering the system can only be stored in clear stone below the elevation of the outflow. Water higher in elevation than the outflow will naturally exit into the storm sewer.

I estimated that the volume of clear stone void space below the elevation of the underdrain outflow to be approximately 2,800 gallons. Our test on 8/18/11 held between 1,780 and 2,230 gallons. Given the uncertainty associated with determining the volume of clear stone void space, the field results are within reason. (Post-construction measurements were not taken, so it is possible that less than 18 inches of clear stone were placed or that the pipe is more steeply sloped at the end than at the beginning.)

The experiment results verified that the swath of permeable concrete does indeed infiltrate water and that it had successfully survived one winter. Unfortunately, due to not taking the slope of the entire alleyway into consideration, the storage capacity of the system was undermined by the elevation of the outflow. The result is that the system can only store approximately one-fifth the volume of water it was originally designed to hold.

Site Photographs

Photo 1: Close-up of permeable concrete compared to regular concrete.

Photo 2: Eric Hopper of the Water Utility water flooding with a fire hose.

Photo 3: The end of wet pavement is visible, indicating all water has infiltrated.

Allied Drive Permeable Pavement Test