



SURFACE INFILTRATION RATES OF PERMEABLE PAVEMENTS

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ABSTRACT

Impermeable surfaces have greatly increased runoff going into receiving waters. The purpose of permeable pavement is to allow water to infiltrate, reducing this effect. However, permeable pavement must be maintained to retain its permeability. This study tested the surface infiltration rate of 30 permeable pavement sites in North Carolina, Maryland, and Delaware. Seven different classifications of surfaces were tested with installation ages ranging from six months to 20 years. These included concrete block pavers with sand filled joints and pea gravel filled joints, permeable interlocking concrete pavements (PICP), grass pavers, porous concrete and porous asphalt. Twelve concrete block paver lots with sand filled joints were tested twice. The first test was under existing conditions and the second was run after the top layer 15 mm of residue was removed to simulate maintenance. The average "pre-maintenance" and "post-maintenance" infiltration rates were 5.4 cm/hr and 8.8 cm/hr, respectively. Two other final observations from this study were: 1) sites built near disturbed areas with loose fines had infiltration rates an order of magnitude or two less than sites built away from disturbed soil and 2) unless the site was constructed in a clay soil area, the infiltration rate was at least 2.5 cm/hr.



Turf Stone

SURFACES

Surface Type	No.
Turfstone™	13
Perm. Interconnecting Conc. Pavers	10
Porous Asphalt	3
Porous Concrete	2
Turfstone™ w/ Gravel Fill	1
Grassed Pavers	1

Thirty sites were selected in Maryland (7), Delaware (1), and North Carolina (22).



METHODOLOGY

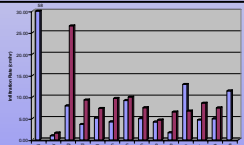
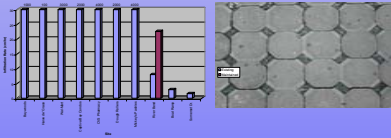
One of two methods were used to measure infiltration rates:

- The first method used double ring infiltrometers (DRI) for derived to test lower infiltration soils (<10 in/hr.). A DRI prevents horizontal migration by the water infiltrating from the inner ring. Thus, the inner water level can be measured to determine infiltration rates. At each site, three DRI tests were run for existing conditions. For nearly all concrete block paver sites, three DRI tests were also run after "maintenance" had been performed on the surface. Maintenance involved removing the top 13-19 mm (0.5-0.75 in) of material from void spaces. Most tests ran for 45 minutes, or until the rings were empty of water.
- The second method used was the surface inundation test, which was used for high infiltration sites. In this test, the inner ring from the DRI was sealed to the surface, while a ruler was taped inside the cylinder. Using a five gallon bucket, water was quickly poured into the inner ring. The infiltration rate was then determined by taking recording water levels every 30-60 s. This test is neither as accurate nor as precise as the DRI test; however, the surface inundation test does not prevent horizontal migration of the water.

DATA

Permeable Interlocking Concrete Pavers

Ten PICP sites were tested; seven in Maryland, two in North Carolina and one in Delaware. Seven of these sites were tested using the surface inundation test, due to their high permeability (mean infiltration rate of 2000 cm/hr). The remaining three PICP sites were located in adjacent to areas containing exposed fine soil particles (mean infiltration rate of 4.2 cm/hr) which were found to be statistically lower (at a 98% confidence) than sites away from fines.

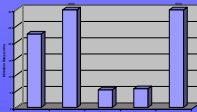


Concrete Grid Pavers

Infiltration rates were measured from 14 sites with Turfstone™; 12 also were tested after maintenance. Eleven of 12 sites had improved infiltration rates after maintenance. The site with the lowest surface infiltration rate, Town of Cary Public Works (1.0 cm/hr, 0.4 in/hr), could be the result of no maintenance, frequent heavy traffic, and clayey soil. The median average pre-maintenance surface infiltration rate was 4.8 cm/hr (1.9 in/hr); the median average post-maintenance surface infiltration rate was 7.5 cm/hr (2.9 in/hr). Maintaining the lots increased infiltration rates by 2/3.

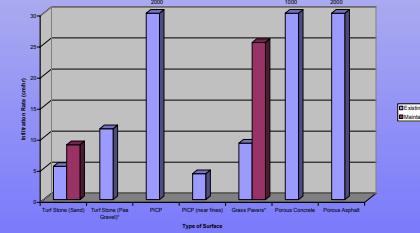
Porous Asphalt and Porous Concrete

Two sites in Chapel Hill, NC, had the highest surface infiltration rates: 6000 cm/hr, and 2000 cm/hr, asphalt and concrete respectively. These lots were recently constructed in 2002. A site in Wilmington (2001, porous concrete) had a comparatively lower infiltration rate, 23 cm/hr. Surface infiltration rates decline with time, as porous asphalt sites that are 7 and 17 years old maintained 5.7cm/hr and 5.4 cm/hr infiltration rates.



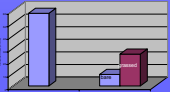
Averages

Comparisons among the different types of pavers are shown below. Note the significant difference between maintained and unmaintained sites as well as the significant difference between sites located near exposed fines and those free of fines.



Concrete Grid Pavers vs. Plastic Grid Pavers

Both Kingston TS and Kinston GP were designed and constructed at the same time. This offered a unique comparison between concrete and plastic grid pavers. A tighter soil (sandy loam) was used to fill the grass pavers. A sand was used to fill the concrete paver. Plastic grid pavers with grass coverage have a much higher surface infiltration rate (25 cm/hr) than the barren areas of plastic grid pavers (9.1 cm/hr).



KEY OBSERVATIONS & CONCLUSIONS

- Maintenance is a key factor to maintaining infiltration rates on pavements comprised of concrete block pavers filled with sand. Maintaining the sites increased permeability by 66%. A SASM analysis showed a statistically significant (97% confidence) difference between pre- and post-maintenance infiltration rates.
- Locating PICP away from fines is very important to maintaining high infiltration rates. Infiltration rates of newly installed PICP filled with gravel were not limited by their surface infiltration capacity in areas free of soil disturbances. The average infiltration rate was 2000 cm/hr (900 in/hr), while the PICP sites near disturbed soils with fines was 4.2 cm/hr (1.6 in/hr), a drop of over 99%.
- PICP sites away from fines also had rates similar in order of magnitude to those rates found for pervious concrete and pervious asphalt. However, all three surfaces show a strong tendency to have a highly decreased surface infiltration rates when they are either (1) substantially older and/or (2) located near exposed fines. Due to only a limited number of pervious concrete and pervious asphalt sites, it is difficult to make too many inferences from the data collected in this study.
- Almost all sites (27/30) had infiltration rates greater than 2.5 cm/hr (1 in/hr). These rates are equal to or greater than infiltration rates expected for grassed sandy loam.

