0-5220: Investigation of Stormwater Quality Improvements Utilizing Permeable Pavement and/or the Porous Friction Course (PFC)

Background

Permeable friction course (PFC) is an overlay of porous asphalt placed in a 2-inch layer on top of regular impermeable pavement. During rain events water enters the porous layer and seeps to the side of the road by gravity. By removing water from the road surface, the pavement improves visibility and reduces splash and spray. This increasingly popular pavement contributes to a sustainable transportation infrastructure by providing numerous benefits: mitigating hazards of wet weather driving, reducing vehicle noise, and producing cleaner runoff than conventional pavement. The material has been used widely in Europe. Our study focused on the hydraulic and water quality aspects of the pavement and represents some of the first documentation of the American experience with PFC.

What the Researchers Did

The researchers performed a variety of tasks related to the hydraulic and water quality benefits of PFC. Runoff from PFC and conventional pavement was collected at three different monitoring sites in the Austin area over a four-year period. One site measured the runoff hydrograph from PFC in addition to collecting water samples. The stormwater samples were analyzed for solids, nutrients, and metals. The economics of using PFC for stormwater treatment were compared to conventional practices such as sand filters and vegetated filter strips. With TxDOT's assistance, core samples were extracted from PFC highways during each year of the study. The cores were tested to determine their porosity and hydraulic conductivity. A conventional falling head permeameter could not be used to measure the hydraulic conductivity because the impermeable base course could not be separated from the PFC layer without damaging it. To overcome this difficulty, a new test based on cylindrical flow geometry was developed to measure the hydraulic conductivity. An extension of this test was developed for use in the field, facilitating in-situ, non-destructive testing of PFC layers. The researchers also developed models to predict the water depth within and on top of the PFC layer during rain events. Analytical models were developed for steady state conditions and simple roadway geometries; a comprehensive numerical model was developed for unsteady conditions and complex geometry.

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What They Found

The researchers found that the quality of runoff from PFC was substantially better than conventional pavement. Total suspended solids were reduced by 90% compared to conventional pavement. Significant reductions were also observed for total copper, total lead, and total zinc, though concentrations of dissolved constituents were not significantly different. Clogging of the PFC layers was a phenomenon of interest, but measurements of porosity and hydraulic conductivity were fairly constant over the study period, suggesting that any clogging is occurring slowly. With regard to cost, PFC is competitive with sand filters for treating runoff in urban areas but vegetative filter strips are more economical where land is available. The biggest variable influencing the relative cost effectiveness was the cost to acquire right-of-way.

For the purposes of testing to determine hydraulic conductivity, Darcy's law was found to inadequately describe the flow physics so the use of Forchheimer's equation was necessary. Drainage modeling efforts showed good agreement with field measurements and provided some of the first predictions of water depth on the surface of PFC. Modeling also showed that PFC layers have little effect on the hydrology of large storm events, but delay and attenuate the peak flow for smaller events. PFC layers dramatically reduce the duration of sheet flow conditions on highways and this phenomenon was quantified for the first time.

What This Means

The research conducted under this project has several direct and immediate implications. Based on the water quality monitoring in this study, the Texas Commission on Environmental Quality approved PFC as a Best Management Practice (BMP) for stormwater treatment in the Edwards Aquifer region. This approval means that TxDOT can forgo, at great cost savings, structural stormwater controls such as sand filters for roads where PFC is installed. The field test for determining the hydraulic conductivity can be used for acceptance testing on construction projects, providing direct evidence that design objectives for the PFC layer were met. The field test can also be used to monitor the performance of PFC layers as they age. The modeling tools developed on this project can be used by highway designers to select the thickness of a PFC layer to convey a design storm. Such an approach represents an advance beyond current practice and should improve driver safety.

For More Information:
0-5220-1 State of the Practice: Permeable Friction Courses

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