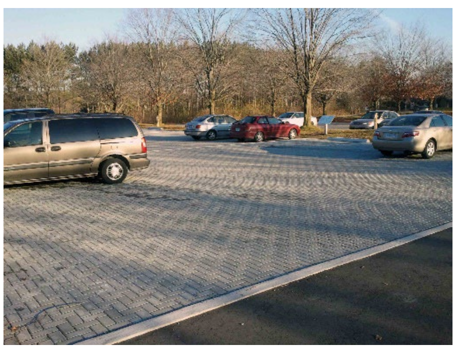
Long-term Permeable Interlocking Concrete Pavement (PICP) Performance in Ontario

Recipient: Toronto and Region Conservation Authority (TRCA)
Grant: $10,000* PI: Tim van Seters
Completion: 2016
Project Summary: 10

icpi Foundation for Education and Research

Background and Need

This study of permeable pavements was conducted over five years at a research facility constructed by TRCA in 2009 at the Kortright Center visitor's center parking lot in Vaughan, Ontario. The site consists of four 230 to 233 m2 pavement cells. Two cells are constructed with PICP, one with narrow joints and another with wider joints filled with open-graded aggregates. Another cell was constructed with pervious concrete (PC) and another with impervious asphalt. The purpose of the study was evaluating the long-term volume and pollutant reductions, geotextile performance, surface clogging and cleaning. Each permeable pavement cell is drained by a perforated pipe. The asphalt cell is surface drained via a catch basin in the center. Concrete curbs between cells prevent inter-mixing of flows.



Narrow-jointed PICP

Wide-jointed PICP

Pervious concrete

Objectives

The infiltration rate through the surface of the three permeable pavements was initially very high but declined rapidly over the first two years as sediment accumulated in the surfaces. Vacuum cleaning in June 2012 partially restored permeability. However, by December 2014, infiltration rates on the narrow and wide PICP had declined below thresholds established to avoid surface runoff during intense rain events (15 cm/h). The PC had a surface infiltration rate over 30 times that of the PICP surfaces, partially due to later PC construction. At the end of five years, the PC continues to infiltrate well. However, vacuum maintenance would be need in the future and its effectiveness would require evaluation.

The permeable pavements reduced runoff volumes consistently over the course of the study, despite the presence of fine-grained native soils. Annual warm season volume reduction rates compared to asphalt averaged 45% over the study period. This finding suggests that native soils below the pavements retained their capacity to infiltrate and that the geotextile below the subbase layer did not inhibit the movement of water into the underlying soils. The first 5 mm of most rain events was almost completely retained and infiltrated despite of the perforated pipe location at the bottom of the permeable pavement structures.

Permeable pavement effluents had lower concentrations of most pollutants compared to asphalt runoff. Reductions in median total suspended solids event mean concentrations (EMCs) by the permeable pavements over the study period were between 88% and 89%. Mass load reductions of pollutants would be greater than concentration reductions because, as noted earlier, 45% less stormwater was discharged from the permeable pavements than from the asphalt pavement.

The water quality of outflows from the different permeable pavements was comparable, but the PC pavement showed higher levels of pH, phosphate and potassium than the concrete pavers. Concentrations of these constituents in PC outflows stabilized at levels like the PICP between two to four years. Effluent quality from the two PICP surfaces were very similar and joint size made almost no difference in pollutant reductions.

Outcomes

Underdrains were placed in the base and below a 0.5 to 1.0 m layer of native soil to evaluate potential effects on groundwater in areas with high water tables. Results showed that effluent from the upper and lower underdrains had similar concentrations of pollutants with little change over time. Except for salt (NaCl), pollutant concentrations in the lower underdrain were rarely at concentrations that would pose a health threat to the use of groundwater for drinking water. Lead exceeded the guideline in 2% of samples from the lower underdrain, suggesting that a separation distance between the base and seasonally high-water table would need to be greater than 0.5 m to prevent lead contamination. Iron and total dissolved solids were also above the aesthetic objective for drinking water in up to 40% of samples.

There were no substantial differences in pollutant reductions between two PICP systems as one had geotextile beneath its bedding layer and other did not. This confirmed that interstitial placement of geotextile within aggregates renders little if any pollutant reduction benefits. Research in the United Kingdom also confirms this. In addition, permeable pavements take longer to freeze in the early winter and are the first to thaw in the late winter. These delays in freezing added about two months of additional pollutant reduction while the surrounding ground was frozen.

Runoff from Impervious surfaces can pose a threat to aquatic life in receiving waters by increasing temperatures. Results of this study showed that permeable pavement generated lower thermal loads to receiving waters than the asphalt pavement during hot summer days, primarily due to lower outflow volumes. While the permeable pavement had lower maximum temperatures than asphalt, event mean temperatures (EMT) were higher than asphalt during two of the four events analyzed. During these two events, runoff from the asphalt occurred during the cool night hours, while the permeable pavement drained more gradually (up to 36 hours) and was therefore subject to greater daytime solar heating.

TRCA plays a key role in advising Ontario municipalities on environmental policies. The deliverables from this project helped establish PICP as a viable pollution and volume reduction practice for municipalities in Ontario. The complete research report is available online.

*ICPI members donated permeable paving materials. This project leveraged over $200,000 in materials and labor from many other donors.