Subsurface Temperature Properties for Permeable Pavements in Cold Climates

Recipient: US Geologic Survey
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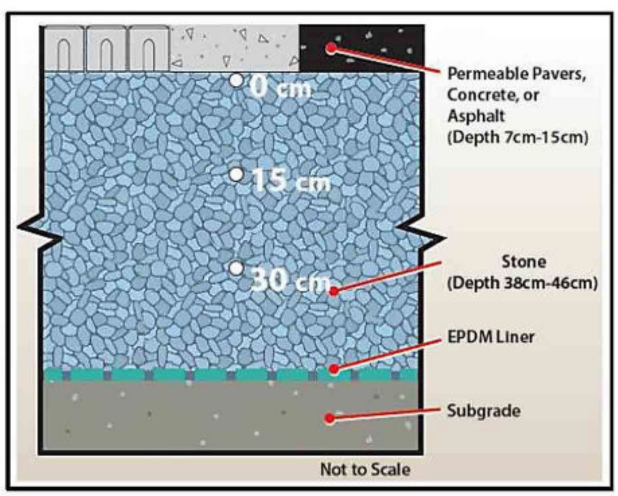
Background and Need

ICPI Foundation Project Fact Sheet 14 entitled "Wisconsin Permeable Pavement Evaluation" describes an area of permeable pavements constructed in 2014 in Madison, Wisconsin that received runoff from an adjacent asphalt parking lot. Monitoring was conducted over several years with various drainage areas contributing runoff and pollutants to the permeable pavement. The project demonstrated the ability of pervious concrete (PC), porous asphalt (PA), and permeable interlocking concrete pavement (PICP) to reduce pollutants. The unique aspect of this research was, unlike most permeable pavements, these were designed to not infiltrate water into the soil subgrade. The report notes that, "Each 500 sf (46.5 m^2) area of permeable pavement had a depth of approximately 21 in. (530 mm). Concrete walls were placed around the perimeter of each plot (subgrade) to prevent lateral exfiltration into underlying soils or between test plots. Similarly, rubberized berms were used at the surface to prevent cross contamination of surface flow between test plots above grade." The photos below illustrates this test site with PICP in the foreground, PC in the middle and PA at the far end.

Previous research papers authored by the principal investigator indicated substantial pollutant reductions from these no-infiltration permeable pavements. This expanded their use by the Wisconsin Department of Natural Resources. The papers indicated that the assemblies included sensors placed at the top, middle, and bottom of these three pavements to measure temperature. This provided an investigative opportunity. See the two figures below.

Installation of temperature sensors.



White dots indicate sensor locations.

Objectives

The US Geologic Survey collected temperature data over seven years which attracted an investigation into the thermal behavior of permeable pavements, especially internal freezing and thawing patterns while entering and leaving the winter season. The advantages to pollutant reductions and potential deicer use were explored upon analyzing the temperature data.

Outcomes

Not surprisingly, infiltration during freeze/thaw periods determines whether water can infiltrate into permeable pavements. Should there be little or no snowmelt to freeze or re-freeze into ice, that translates into reduced deicer use as well as reduce risk of slips and falls. For this study, PICP, PC, and PA were slow to freeze water on their surfaces and quickly thawed ice and snow. Likewise, subsurface temperatures rose above freezing on a most days with that saw surface melting and infiltration. The pavement interiors had consistently higher temperatures when ambient air temperatures were below freezing. This is likely due to warmth from the earth.

The research results pointed the thermal advantages of PICP compared to PA and PC. “Data show the PICP system surpassed PC and PA by having fewer days below freezing, higher temperatures on melt days, slower freeze and faster thaw times, and less penetration of freezing temperatures at depth.” This allows PICP to provide more pollutant processing time.

Specifically, during periods when daily average air temperatures were below freezing, PICP had the fewest number of days below freezing. This condition was observed at all depths in PICP. In other words, PICP remained completely below freezing for the *fewest* number of days for all depths compared to the PA and PC. The only exception was the near-surface of porous asphalt had similar thermal behavior to that of the PICP near its surface.

Similarly, PICP also remained above freezing at all depths for the greatest number of days as well as thawing faster than PC and PA. PICP showed more resistance to freezing and greater receptiveness to thawing. This has broader implications for enabling faster snow melt and subsequent reductions in deicer use.

Published as a peer-reviewed research paper, it affirms previous other PICP temperature studies such as that by Janet Attarian while implementing permeable “green” alleys and parking lots for the City of Chicago and Jennifer Drake (formerly with the University Toronto, see Fact Sheet 18) on the ability of PICP to melt snow (rather than refreeze). She found that deicers could be reduced as much as 50% on PICP compared to impervious asphalt pavement. Similar temperature studies confirmed similar thermal behavior from pervious concrete by John Kevern (University of Missouri at Kansas City) and by Kristopher Houle (University of New Hampshire) from porous asphalt. This USGS study demonstrated that PICP is *best equipped* to efficiently manage freezing and thawing temperatures, thereby extending pollution processing time while potentially reducing deicers.

The USGS research paper can be accessed here.