FHWA-NJ-2022-001
March 2022

New Jersey Department of Transportation Bureau of Research

Research at a Glance

Technical Brief

Implementation of Porous Concrete in Sidewalks In New Jersey

Principal Investigator

Husam Najm. PhD, SE
Professor of Civil Engineering
Rutgers, The State University of New Jersey

In this project a pervious (porous) concrete sidewalk was implemented in the field to evaluate porous concrete construction practices and its short and long term performance. The sidewalk was monitored periodically through visual inspections for raveling and infiltration rate measurements for potential clogging. The implementation project also developed and life cycle analysis tool of pervious concrete sidewalk. The implemented sidewalk was part of the Skillman Road Pathway project.

Research Problem Statement

Pervious (or porous) concrete has been gaining popularity as a potential solution to reduce the amount of impermeable surface area associated with sidewalks, reduce puddling, and potentially slow storm water surface high flow rates. As important as these benefits are to surface runoff mitigation, there are concerns with the ability of pervious concrete mixes to provide sufficient structural support and longevity for the expected service life of the sidewalks as well as life cycle costs. The composition of pervious concrete creates limitations to its mechanical strength and challenges in its implementation and maintenance. There were also concerns about construction practices and potential for raveling and clogging. The This implementation project addressed several of these concerns.

Water draining through porous concrete

Severe raveling and clogging can occur if not maintained

Research Objectives

The objectives of this research were the following: 1) evaluate existing porous concrete sidewalks in New Jersey, 2) improve porous concrete mix designs for flied applications, 3) build a porous concrete sidewalk as a pilot project in New Jersey, and 4) collect data on its short and long term performance through periodic monitoring, and 5) develop life cycle analysis tool for porous concrete sidewalks.

Methodology

We evaluated several exiting sidewalks in Camden County using visual inspection and infiltration tests. We conducted a survey for stakeholders on implementation of porous concrete sidewalk. We developed several mixes that that would give higher strength while maintaining the required void ratio for acceptable infiltration. The traditional porous concrete mix has cement, coarse aggregates, and sand. In this research, we added smaller amounts of fine aggregates (sand) to increase strength while maintaining acceptable void ratios. Sand ratios used were 5%, 10%, and 15%. The mix with 10% sand added to the mix showed about 20% - 25% increase in strength and about 25% reduction in voids which is still good for acceptable infiltration. This mix was used in Segment II of the implementation project and will be compared to standard porous concrete mixes with no sand used in Segments I and III. The pilot sidewalk was about 1200 ft^2 and was of part of the Skillman Road Pathway project in Montgomery Township. The sidewalk was monitored and evaluated overtime to assess their performance. Monitoring of the built sidewalk included: 1) visual inspection for surface texture, clogging, and raveling; 2) periodic infiltration tests to measure variation of infiltration rates overtime, and 3) coring of cylindrical cores to measure in situ void ratio and compressive strength in the lab. The proposed implementation of porous concrete for sidewalks in the field is needed to evaluate their short term and long term performance over time. This will help provide information on their performance, service life, life cycle costs, and environmental benefits.

Results

1. NJDOT specs were found to be consistent with other specs from other DOT's agencies, counties and worked well for our implementation project. We only needed to make minor modifications to the mix design to make it applicable to filed implementation. The compressive strength and void ratio were consistent with earlier research and were within the recommended values published by the NRMCA (2014) and the ACPA (2012)
2. Certified suppliers who have experience with porous concrete mix design and transportation to construction sites are required.
3. It is important the contractor be certified and has workers on site who are skilled in placement and finishing of porous concrete.
5. Field supervisors need to be also skilled and experienced with porous concrete delivery, placement and finishing.
6. Field sample should be taken and tested in the lab for compressive strength and void ratio.
7. Coring is also recommended to get as built strength and void ratio, but coring should be discussed with the owner to make sure they allow it (poor coring and poor filling or core locations can have adverse effects on durability)
8. It is recommended to build a nearby test pad or test slab prior to construction of the sidewalk. This will help to practice discharging, placement and finishing of porous concrete to avoid unforeseen issues with mixes during real construction. It will also help train inexperienced field crew with this type of concrete ahead of time. The test pad can also be used to get cores and run infiltration tests and other field tests in the future as long as it is kept on site.
9. The sidewalk should be visually inspected regularly for raveling, debris, sediments, and clogging. This can be done by routine inspection of Township bi-monthly or when needed.

Research Project Manager

Priscilla U. Ukpah
Bureau of Research
New Jersey Department of Transportation

U.S. Department of Transportation
Federal Highway Administration

Results (cont'd)

10. It is recommended to do bi-annual cleaning of the surface using 'walk behind' vacuuming machines. Air blowers maybe used but should have sufficient power to clean well. Vacuum cleaning is much more effective than air blowers.
11. If the sidewalk is severely clogged, it can be cleaned using power washing. Water pressure between 3000 to 3500 psi should be sufficient to remove moderate to severe clogging. Periodic vacuuming, however, should prevent clogging and the need for power washing.
12. If minor raveling and small cracks are detected from visual inspection, the sidewalk should be inspected more frequently to monitor these defects. When the raveling becomes severe and the cracks are wider, the locations that has severe raveling and cracking should be removed and replaced. These locations can be replaced by porous concrete. They can also be replaced by conventional concrete is the are to be removed is small and does not compromise permeability requirements.
13. Porous concrete can resist freeze and thaw cycles as long as the pores are free from clogging. Previous studies have shown enough resistance to freeze and thaw and less demand for dicing salts due to the presence of pores.

Placement and finishing operations

Finished porous concrete surface

Recommendations

1. For locations where there is traffic that can do slow turns or where snowplows are used, the scaling and abrasion resistance is important. For the sidewalk it is not as critical. However, we will reach out to the asphalt lab at Rutgers and check if they have an abrasion test machine that we can use to test sample porous concrete for loss weight versus number of cycles (ASTM C944, *Standard Test Method for Abrasion Resistance of Concrete or Mortar Surfaces by the Rotating-Cutter Method)*
2. The addition of some sand to pervious concrete can improve its strength and may improve its resistance to raveling. There is a need to evaluate the effects of adding sand to mix and its effects on strength and porosity. Establishing an optimum sand content for pervious concrete is worth investigation.
3. There is a need for research to evaluate the raveling resistance and factors than can influence this resistance (such as aggregate type, addition of sand, cement content and chemical additives). The resistance to raveling is very important for the long-term performance of pervious concrete especially for parking lots were braking and turning can lead to raveling.
4. The sidewalk was monitored during winter 2021-2022 no adverse effects were observed from snow removal and application of deicing salts. However, this is a very short period to make any observations. We will continue monitoring the sidewalk to evaluate freeze thaw effects and deicing salts.

U.S. Department of Transportation
Federal Highway Administration

This brief summarizes **FHWA-NJ-2022-001**, "Implementation of Porous Concrete in Sidewalks in New Jersey," produced through the New Jersey Department of Transportation Bureau of Research, 1035 Parkway Avenue, P.O. Box 600, Ewing, NJ 08625 in cooperation with the U.S. Department of Transportation Federal Highway Administration.