DEVELOPMENT AND CHARACTERIZATION OF PERVERIOUS CONCRETE MIXTURES FOR PAVEMENT APPLICATIONS

ABSTRACT

With the augmenting urbanization, the natural ground is being converted into man-made impervious pavement surfaces. The imperviousness reduces the rainfall infiltration into the soil and increases the frequencies of flash floods. Moreover, these pavement surfaces act as heat energy storage media that have resulted in increased temperatures in the surrounding environment. In order to reduce these changes in the environment, porous pavements have been gaining attention for various applications in roadway layers, and one amongst such systems is: pervious concrete pavements (PCPs).

Pervious concrete (PC) is a comparatively new pavement material compared to conventional and modified asphalt concrete as well as cement concrete materials. PC possesses unique interconnected pore structure that allows percolation of the stormwater, thereby reducing the issues of water stagnating on pavement surfaces. Several research gaps exist in the areas of structural, permeability, and functional domains of PC materials, which are essential in a complete understanding of the material as well as to advancing the state-of-the-art research and implementation.

The main objective of this study was to characterize several PC variants for their structural, permeability, and functional properties, and hence assess their potential applicability as pavement systems for low to medium volume roads. Over twenty PC mixture combinations encompassing 360 specimens of varying geometries were used to determine several PC properties. The scope of the effort encompassed a host of nondestructive and destructive tests on PC, including: determination of density, porosity and ultrasonic pulse velocity (UPV); 3-Dimensional image analyses of pore parameters using x-ray micro tomography; quantification of compressive and flexural strength; estimation of fatigue life and impact-abrasion resistance.

UPV tests indicated that the optimum gain of the ultrasonic signals for PC should be in the range of 50-60 dB. UPV technique was able to capture the effect of different mixture variables that could be used as a candidate quality control test for future investigations. Nonlinearity in Darcy’s law was observed due to the macropore structure of PC that eventually increased the momentum gain leading to turbulence in the flow. However, the Izbash’s
coefficients indicated that the flow was in the transition regime wherein the gradations with larger sized aggregates deviated significantly from the classic Darcy’s law.

Compressive strength of different PC mixtures was found to be ranging from 6-26 MPa, and the cylinders depicted shear-brittle type of fracture. The flexural strength was anywhere between 1.2 and 3.5 MPa, and the flexural stiffness varied from 8000-15000 MPa. Predictive models were developed to estimate flexural strength and stiffness that form the basic inputs in the rigid pavement design. Comprehensive investigations were performed on the fatigue properties of PC mixtures, and S-N curves were developed that best fitted the power function. The distribution parameters indicated infant-mortality type of failure characteristic, in which the fatigue life was very low at higher stress levels. Fatigue life was more dependent on pore parameters at the mid-span of the PC beam specimen. Fatigue models based on the laboratory testing were developed for different porosities, which are first-of-its-kind in the domain of PC paving materials.

The laboratory designed PC mixtures were successfully placed in the field encompassing eighteen slabs with three slabs per mixture type. Thermocouples were embedded within each representative slab for future monitoring purposes. These PCP test sections will serve as parking lots, walkways, and bicycle tracks. A set of guidelines was developed based on the extensive laboratory studies and pilot field test sections carried out as part of this research work. The practice guidelines included regression equations that were developed from the laboratory data, which will help in predicting different properties pertaining to PC performance. A mix design methodology for PC was developed and reported to determine the mixture variables required in attaining the targeted strength and permeability.

Overall, the construction practices followed while constructing PCPs in this research study will certainly encourage future engineers and designers to implementing green —pervious concretel pavement system in India and world at large making it more sustainable.

**Keywords:** Pervious Concrete; Porosity; Permeability; Compressive Strength; Flexural Strength; Fatigue; Image processing and analyses; Test Sections