JOINT TRANSPORTATION RESEARCH PROGRAM

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Early Detection of Joint Distress in Portland Cement Concrete Pavements

Introduction

Midwestern states have observed premature joint deterioration in jointed plain concrete pavements. It has been proposed that this deterioration occurs when the joint sealants fail, allowing fluid to collect in the saw-cut joint. Problems of joint deterioration (caused by water ingress, freezing, and/or salt reaction) have emerged that can shorten the life of the pavement, requiring expensive and invasive repairs. To effectively apply low cost corrective actions early, detection of fluid in the joints is needed. Concrete pavements can be expected to provide a relatively long service life. This project investigated the use of electrical resistivity and ground penetrating radar (GPR) as two techniques to detect premature joint deterioration.

Findings

The electrical response was measured for mortars subjected to a temperature cycle from 23°C to -35°C with varying degrees of saturation and varying salt concentrations. The resistivity increased as the degree of saturation was reduced due to the reduction in the volume of the conductive medium and increase in tortuosity. The resistivity decreased as the concentration of NaCl increased due to the increased ionic concentration. The resistivity gradually increased as temperature was decreased until the phase transformation temperature (i.e., ice formation), after which time the resistance increased more rapidly. The increase in resistivity can be described using an Arrhenius law for conduction from 23°C due to the phase transformation temperature; however, at temperatures lower than the phase transition temperature, the responses are more complex due

to a reduction in conducting fluid and a change in solution concentration. The influence of the degree of saturation and salt concentration on the amount of activation energy seemed relatively small. Changes in resistivity were detected when cracking occurred in the sample, and the magnitude of these changes was similar to that detected using changes in the ultrasonic wave speed.

GPR was used effectively to detect fluid accumulation in the saw-cut joint behind the joint sealant. The typical GPR waveforms are difficult and time consuming to interpret. Features of the wave form (amplitude and derivative) indicate the presence of fluid; however, the XX antenna configuration with the 400 MHz antennas was the most promising due to proportionality with the fluid present in the joint. A signal processing approach referred to as the complexity-invariance distance (CID) approach, was used to obtain a single number that reflects the potential for fluid in the joint. Scalar waveform

Illustration of the experimental setup

features and the computed CID can be used to estimate which joints may contain fluid, thereby providing insights into which joint sealant sections may need to be repaired or when a sufficient number of joints may contain fluid, which suggests that a larger joint maintenance effort be performed to seal the joints or the concrete.

Implementation

Ground penetrating radar is the most promising method that can be used to gain a general understanding of the fluid level in the joint without requiring the removal of the backer rod and silicone sealant. Currently, this process provides only a binary solution to identify whether or not fluid exists in a joint beyond a certain depth. However, refinement of the process and a statistical analysis of the differences between maximum amplitudes of regular and cross polarized scans on a variety of pavements could provide the ability to determine the depth of fluid in a joint.

Direct measurement of electrical resistivity of the concrete from the surface can also be used to identify whether fluid exists in a joint beyond a threshold determined to be indicative of susceptibility to joint deterioration. Like the GPR process, this method will be

influenced by many factors independent to each specific pavement. However, this method is not recommended for use in the field due to the increased time required for performing the test.

When joints contain fluid, the potential for joint deterioration occurs. In cases in which fluid is identified, we recommend that a larger investigation be performed to determine the extent of the damage and whether a larger maintenance effort is needed to reseal the joints or the concrete.

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