CENTER FOR
PORTLAND CEMENT CONCRETE
PAVEMENT TECHNOLOGY

IOWA STATE UNIVERSITY

RESEARCH PROJECT TITLE
Development of In Situ Detection Methods for Materials-Related Distress in Concrete Pavements: Phase II

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PRINCIPAL INVESTIGATOR
Scott Schlorholtz
Department of Civil, Construction and Environmental Engineering
Iowa State University

PCC CENTER / CTRE IOWA STATE UNIVERSITY
2901 South Loop Drive, Suite 3100
Ames, IA 50010-8634
515-294-8103

MORE INFORMATION
www.pcccenter.iastate.edu

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Detecting Materials-Related Distress in Concrete Pavements

tech transfer summary

Objectives

- Advance the in situ detection of materials-related distress in portland cement concrete (PCC) pavements
- Perform proof-of-concept trials and evaluation of two nondestructive test methods: (1) ground penetrating radar (GPR) and (2) visual inspection via the pavement profile scanner (PPS).

Problem Statement

Materials-related distress (MRD) in PCC pavements includes concrete failures caused by the materials' properties and their interaction with the environment. Materials and construction techniques can be combined to detect, analyze, and treat these distresses. Effective methods are needed for evaluating and quantifying the amount of distress or deterioration present in existing pavement slabs. Since materials-related distress might begin at the base of the slab, evaluation is difficult and often subjective. Currently, petrographic examination of core sections is a commonly used technique. However, it is time consuming and often opinion-based, and site selection depends on observations of surface features. The goal of this research was to evaluate and advance nondestructive testing methods that can enhance the in situ detection of materials-related distress.

Research and Technology Description

Several GPR systems and a pavement visual inspection system were evaluated.

GPR Evaluation

For GPR proof-of-concept testing, four sites were selected. Two sites exhibited aggregate-related distress, one site exhibited paste-related distress, and one site (a control section) exhibited no distress.

Three GPR systems and seven antenna configurations (all ground-coupled, with frequencies ranging from 400 to 1,500 MHz) were evaluated. One state-of-the-art GPR system (Geophysical Survey Systems, Inc., SIR-10 A+) allowed data to be collected at highway speeds, while the other two systems (Sensors & Software, Inc., pulseEKKO 1000A and Geophysical Survey Systems, Inc., SIR-20) were commercially available and less sophisticated. See Figure 1.

Because the GPR systems failed to detect distress in the Webster County site, which exhibited extensive cracking, laboratory experiments were conducted to isolate the reason(s) for the failure.

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Visual Inspection System Evaluation

For proof-of-concept testing of the visual inspection system, 11 sites were selected. Four locations match the sites used in the GPR proof-of-concept trials, and all sites had been evaluated via field survey and petrographic examination during prior research.

The visual inspection system used a PPS developed by Mandli Communications, Inc., that can collect distress symptoms, such as the fine cracking common to materials-related distress, while traveling at highway speeds (see Figure 2). Data are processed after the information has been collected and saved to fixed storage, and calculations include the standard pavement engineering information (e.g., International Roughness Index, rutting, etc.). For this research, the Mandli PPS was integrated into an Iowa Department of Transportation (Iowa DOT) van equipped with a downward imaging system and standard video log system, which is a more robust system than the PPS alone.

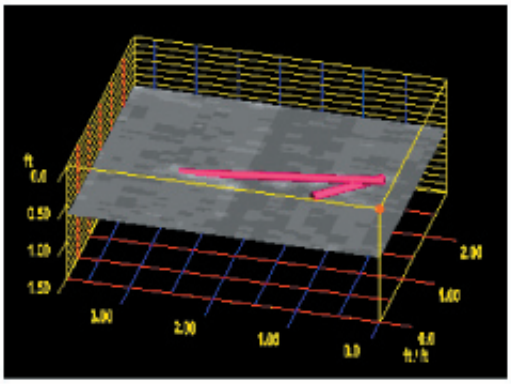

Figure 1. Three-dimensional visualization of GPR data, rebar indicated in red

Figure 2. PPS device mounted on Iowa DOT video log van

Key Findings

- While both the GPR and visual inspection systems passed the proof-of-concept trials, neither method can diagnose the presence of materials-related distress. Rather, both techniques detect the symptoms of materials-related distress.
- Diagnosis of materials-related distress still relies on coring and petrographic examination.
- Higher frequency GPR antennas were capable of detecting subsurface distress in two of the three sites investigated, which indicates that GPR was successful during the proof-of-concept testing in three out of the four sites evaluated.
- GPR scans failed to detect pavement distress at a site in Webster County, Iowa, and exhibited similar difficulties during subsequent laboratory testing. This indicates that GPR scans may not measure uniform mortar bar expansion in PCC pavements, and more experimentation is needed before firm conclusions can be made.
- Laboratory results indicate that moisture conditions in the cracked pavement site probably explain the failure of GPR to identify distress at the Webster County site.
- The downward imaging system integrated into the Iowa DOT video log van provided excellent information about pavement distress.
- Combining the results of GPR testing with the visual inspection system is quite complex, due to data collected using different operating systems (Apple OS vs. Windows), the difficulty of data exchange, and the significant amounts of time and processing to produce exact agreement in the data stream.

Implementation Benefits

- Both the GPR and visual inspection systems enhanced the ability of pavement engineers to detect distress, and thus both were considered to have passed proof-of-concept testing.
- PPS surveys conducted on five different PCC pavements showed an excellent capability of detecting surface cracking on pavement slabs, and post-processing of the data has improved dramatically in the recent version of the analysis software.

Implementation Readiness

Both technologies are in a rapid state of development and the future for these technologies appears bright. The limitations noted are expected to be overcome as the technologies advance and mature.