Executive Summary, Research Readiness Level Assessment and Technology Transfer

Early Detection of Near-Surface Void Defects in Concrete Pavement Using Drone-Based Thermography and GPR Methods

Research Objectives

- Further validated the effectiveness of the proposed approach in different environmental situations on detecting and locating near-surface void defects through both lab and field studies.
- Further validated the effectiveness of the proposed approach in different environmental situations on detecting and locating near-surface void defects through both lab and field studies.
- Identified the best timing of detecting these defects in different seasons.
- Developed a field detection procedure which is practical, fast, and low-cost for a coverage of 2,000-4,000 feet of pavement per day (approx. Width = 48 ft.).

Research Benefits

- Enhanced quality control during construction and reduced cost of repair work of concrete pavement projects.
- Fast, minimal-interference, and low-cost assessment of large pavement areas.
- Minimized field time of locating voids by using accurate location mapping technology.

Background

Near-surface (i.e., less than 4 in deep) voids that are 1/2" or larger in diameter (in both horizontal and vertical directions) is a common consolidation issue during the construction of concrete pavements. This issue was observed by NDOT in concrete pavements constructed by different contractors, on different roads (highways and local roads), and with different thicknesses (9-14 in). These voids can be caused by improper vibration, overly dry mix, and/or long wait time between concrete batches (Legg 1974). These large voids or concentrations of smaller voids can be detrimental to the durability and/or strength of the pavements (Freeman and Zollinger 2008). Being able to detect these voids at an early stage will enable NDOT to direct timely correction orders during the construction process. As a result, costlier repair and maintenance actions can be avoided.

Non-destructive testing (NDT) methods, including GPR and Thermography have been used in detecting concrete defects for a long time, including the detection of pavement delamination, deterioration, spalling and pumping issues (Sebest and Scullion 2005; Morcous and Sekpe 2010) with varying levels of success. However, very few reports were found on using these two NDT approaches to detect defects during the hydration time due to many constraints and challenges, including weak compression strength during the early hydration process for heavy inspection vehicles or equipment.

Conclusion

In this project, both laboratory and field tests were conducted with both methods, and coring samples were used for validation of results. The results from multiple specimens and multiple experiments suggested that both technologies performed well in detecting the subsurface voids in the concrete pavement's initial set stage. Despite some limitations discussed in the report, the outcomes of the project provided evidence that these technologies can be used separately or together on the field as efficient and economical quality control tools in concrete pavement construction.

Principal Investigators

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Interested in finding out more?

Final report is available: HERE

NDOT Recommendations Based Off of Research Project – 2020 – RRL4

The research has shown the use of thermography is not a solution for detecting voids in concrete. Thermography does work, but there are too many limitations on timing of the day, environment, the use of cure compound, etc. Thermography is not a solution.

Ground Penetrating Radar (GPR) also has limited use but will work in a small area. The department will propose the GPR to be used in an area and verify with a core. GPR could be used the next day in areas that may be questionable in nature. Coring requires a minimum of three days before any testing can be performed.

Depending on the Materials and Research equipment budget, a purchase may be made for a GPR device in the next year for forensic purposes.

- *As provided by Wally Heyen, Lead TAC Member*

NDOT Recommendations Based Off of Research Project – 2025 – RRL5

The NDOT has chosen to use MIRA Ultrasonic Pulse Echo Imaging rather than Ground Penetrating Radar techniques for detecting near-surface voids within concrete pavement. MIRA concrete tomograph pulses low-frequency ultrasonic shear waves to determine the pavement structure by measuring reflectivity within the pavement. This technology can measure voids ranging from 30 mm to 400 mm. Beyond void detection, MIRA can also measure slab thickness, test tile/panel bonding, confirm grouting, and even determine coverage of steel reinforcement. NDOT considers MIRA as its best tool for void detection, due to its consistency regardless of weather conditions. Additionally, the other properties of MIRA enable its use on a broader range of projects compared to GPR. The Department is currently in the learning phase with MIRA, capturing scans and taking cores to understand better the relationship between the MIRA scan and concrete quality. To accomplish this, MIRA has become standard equipment taken out on projects. While GPR is used for detecting voids in pavements, the Department will not be moving forward with it, instead focusing on MIRA.

- *As provided by Wally Heyen, Lead TAC Member*

MIRA Ultrasonic Pulse Echo (FHWA)

Executive Summary, Research Readiness Level Assessment and Technology Transfer

Technology Transfer

PUBLISHED JOURNAL PAPERS AND THESES/DISSERTATION

- Shen, Zhigang, Cheng, Chongsheng. "Semi real-time detection of subsurface consolidation defects during concrete curing stage", submission to the ScienceDirect website - https://www.sciencedirect.com/science/article/abs/pii/S0950061820334930?via%3Dihub

JOURNAL PAPERS SUBMITTED FOR REVIEW

- McCabe, T.*, Erdogmus, E., Morcous, G., Kodsy, A. "Early Detection of Honeycomb in Concrete Pavements Using GPR," submitted to the ASCE Journal of Performance of Constructed Facilities. Submitted on 5/5.

Research Readiness Level (RRL) Assessment

Level 5: Fully Understood

No further evaluation necessary. Moved up from RRL4, assessed in 2020.

RRL 5

This brief summarizes Project SPR-P1 (19) M082
"Development of an NDT Tool for In Situ Assessment of Prestress Loss"
Nebraska Department of Transportation Research Program