Executive Summary and Research Readiness Level Assessment

Detection of Flaws with Asphalt Overlaid Concrete Decks Using Ultrasonic Guided Waves

Research Objectives

The ultimate goal of the project was to expand the capabilities of the recently developed novel UGWL testing method to detect flaws in asphalt overlaid reinforced concrete bridge decks.

1. determined the effects of the asphalt overlay on the testing method
2. understood to what extent the research team detected the flaws in reinforced concrete decks when there is an asphalt overlay

Research Benefits

- Rendered the previously developed innovative UGWL method more applicable to Nebraska's bridges.
- Implementation during the construction of new bridge decks as well as during the repair of older bridge decks.
- Provided more insight regarding the deterioration times and patterns for reinforced concrete bridge decks with asphalt overlays.
- Presented a possibility for a relatively low-cost and simple to interpret non-destructive evaluation technique that can be utilized in-house by NOOT.
- In the long term, continuous monitoring and maintenance of bridge decks will provide increased safety and health of reinforced concrete bridge decks.
- In the long term, the methodology may help reduced maintenance costs on infrastructure.

Principal Investigator

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Background

In collaboration with NOOT, the research team has developed a novel NOT method that is capable of detecting the onset of rebar-concrete separation (mechanical delamination) and rebar corrosion (chemical delamination). This method utilizes a commercially available ultrasonic testing system; however, we developed innovative techniques for placing the transmitters and receivers, as well as for the analysis of the data. Due to the unique placement of sensors, instead of measuring the ultrasonic waves directly; we measure the leaked energy. The transmitter (T) is placed at the end of the steel rebar using the rebar as a waveguide. This allows the ultrasonic waves to propagate for longer distances within the boundaries of a linear element. The receiver (R) on the other hand is placed on the concrete's surface. As a result of this arrangement, the leaked energy from the ultrasonic guided waves propagating through the rebar are measured from the surface of the concrete. Using this technique, which we refer to as "ultrasonic guided wave leakage (UGWL) method", we were able to detect delaminations as small as 0.008" and record signals up to 10 and 14 feet away from the transmitter on a lab specimen and on an actual bridge deck, respectively. For the analysis/post-processing, we utilize the energy or the amplitude, instead of the typically measured velocity. This allows smaller changes in condition to be detected more clearly.

Conclusion

This feasibility study presents the results from laboratory experiments to determine the capabilities of a recently developed nondestructive testing (NDT) approach for detecting the flaws at the asphalt-membrane-concrete layers and rebar-concrete interfaces for asphalt-overlaid reinforced concrete bridge decks. The novel Ultrasonic Guided Wave Leakage (UGWL) method previously developed by University of Nebraska-Lincoln (UNL) and Nebraska Department of Transportation (NDOT) utilizes the steel rebar as a wave guide by placing an ultrasound transmitter at the rebar and measures the leaked energy from the top surface of concrete (or asphalt) with an array of ultrasonic receivers. This method has proved successful previously as a continuous monitoring tool in lab experiments, where early rebar-concrete delaminations as small as 0.008", and early corrosion in specimens soaked in salt-water (as early as 9 days) have been detected in various configurations and sizes of reinforced concrete specimens. Further, two proof-of-concept studies for instantaneous field testing has been carried out. First, on an existing bridge, concrete was cored to the top rebar level and a transmitter was attached to the rebar and an array of readings were taken from the concrete surface in 6 inch increments up to 14 feet from the transmitter. While the attenuation curve from this test was as expected based on theory of ultrasonic guided waves, without a baseline data from previous years, such data is difficult to interpret for accurate flaw detection. In the second field application, a transmitter was attached on a rebar during construction and embedded in concrete. Several months of testing showed no significant change, as expected, but this experiment proved that the attachment was secure and durable in field conditions. Future readings from this field implementation can reveal change in the condition of this bridge deck since baseline data does exist in this case. None of these systems (lab or field) included asphalt overlay, therefore this latest phase of the project aimed to explore the method's capabilities when the deck is overlaid with asphalt for wider spectrum of applications. Several asphalt-overlaid reinforced concrete laboratory specimens were tested in this study and the results showed that with careful placement of sensors and data analysis, flaws at the membrane level as well as the rebar level could be successfully detected. As stated before, the UGWL method's strength lies in continuous monitoring: change in amplitudes from a baseline data is more meaningful than instantaneous amplitude readings at this time. This method has the potential to answer an important need in infrastructure quality control and maintenance; namely *membrane inspections to detect construction flaws*.

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Interested in finding out more?
Final report is available at:
NDOT Research Website

NDOT Recommendations Based Off of Research Project

This feasibility study expanded on the capabilities of the recently developed novel Ultrasonic Guided Wave Leakage (UGWL) studied under Prototype System for Implementing the Ultrasonic Guide Wave Method on the Field project to detect flaws in asphalt overlaid reinforced concrete bridge decks. While this technology has its own potential in long term and structure health monitoring and is still evolving, Bridge Division is focusing in other technologies to detect instantaneous defects on waterproof membrane and asphalt overlays.

- *As provided by Fouad Jaber, Lead TAC Member*

Research Readiness Level (RRL) Assessment

RRL 2

Level : Applied Research/Proof Concept – Lab Level

-Research/Technology developed in a laboratory environment.

This brief summarizes Project SPR-P1 (20) M113
"Detection of Flaws with Asphalt Overlaid Concrete Decks Using Ultrasonic Guided Waves"
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