OFFICE OF RESEARCH & BEST PRACTICES
Michigan Department of Transportation

Research Spotlight

Project Information

REPORT NAME: ECR Bridge Decks: Damage Detection and Assessment of Remaining Service Life for Various Overlay Repair Options, Part I

START DATE: September 2006

REPORT DATE: January 2011

RESEARCH REPORT NUMBER: RC-1549

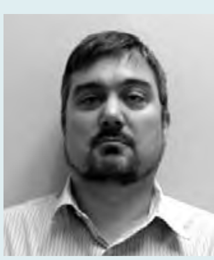
TOTAL COST: $334,908, includes Part I (this research) and Part II (see separate Research Spotlight)

COST SHARING: 20% MDOT, 80% FHWA through the SPR, Part II, Program

MDOT Project Manager

Steve Kahl, P.E.

Construction and Technology Division
Michigan Department of Transportation
8885 Ricks Road
Lansing, MI 48917
kahls@michigan.gov
517-322-5707



Moving toward electronic testing for invisible bridge deck damage

The standard methods for testing subsurface damage on bridge decks are low-tech and time-tested, but they depend on significant operator expertise. Modern technology afforded MDOT the opportunity to develop an electronic system for nondestructive bridge deck evaluation that could at once speed the testing process and produce easy-to-interpret results.

Researchers aimed to replace traditional tests of bridge deck subsurface damage (such as the chain drag test above) with a system that electronically interprets sound readings (an early prototype is shown at right).

Problem

MDOT closely monitors bridge deck delamination - the internal cracking and separation between the top concrete layer of a bridge deck and the upper reinforcing steel bars. The department uses nondestructive testing methods to assess the amount of delamination for entire decks and bridges and to help inform rehabilitation decisions. Testing typically involves closing one or more lanes of traffic and using acoustic sounding techniques. By tapping the deck surface at short intervals with a steel rod or by dragging chains along the concrete surface, an inspector with a trained ear can recognize the characteristic "hollow" sounds associated with delamination.

The process is time-consuming and requires significant training for inspectors to learn to interpret these sounds and detect damage. With advances in electronic

(continued)

> *"This research shows the real potential for automating and improving upon existing methods for evaluating deck delamination."*
>
> **Steve Kahl, P.E.**
> Project Manager

sound filtering and processing, MDOT saw the potential benefit of using technology to automate the detection process and quickly collect results in a manner less dependent on subjective interpretation and user expertise.

Approach

Investigators undertook a project to develop a device that would impact a bridge deck surface, receive the resulting sound and then automatically determine whether delamination is present beneath a given location. The plan called for development of a prototype device that integrated testing hardware, electronics and software.

A particular challenge was the creation of algorithms to process and correctly interpret the sounds received by the testing device. The software needed to be able to cancel extraneous noise, both from traffic and from the ambient environment, to isolate the sound from the deck subsurface. The system also needed to be able to interpret the sounds from the subsurface, extracting features of the sounds and recognizing patterns characteristic of delamination.

Research

Working within these parameters, researchers developed the necessary sound processing algorithms. The final research report details the mathematics underlying the filtering techniques required for the system to cancel dynamic and unpredictable noise. It also addresses the various mathematical models that researchers considered and adapted for processing sound readings to extract features that most consistently denote bridge deck delamination.

Working from these algorithms, researchers built a prototype testing cart, which included a sounding rod, measuring devices and a computerized sound processing system. Verification tests of the prototype cart began in the laboratory on a concrete slab constructed with artificial delamination. Trials followed in the field on two bridges along US-127 near Mason, Mich. Field testing included a comparative evaluation of the test methods, with data collected and delamination readings made both with traditional methods and with the electronic system.

Results

Testing in the lab and the field showed that the system works in principle and validated the noise cancellation, feature extraction and pattern recognition algorithms underlying the hardware and software. This represents significant steps toward a field-ready device.

Currently, however, the prototype remains unready for regular service on Michigan's bridge decks. Given the high noise levels in field use, it remains necessary to perform site-specific field calibration of the device to collect meaningful results. Until more data are collected and the device is further refined, the traditional testing methods continue to be the most time- and cost-effective.

Value

The experience from this project has helped MDOT better understand the challenges in developing an electronic nondestructive evaluation tool for bridge decks. These results will prove extremely valuable for follow-up efforts that are already under way in the region. The same investigators are working with Indiana DOT and Purdue University to collect more data from different bridges to make the system more robust and universally valid.

If investigators reach the end goal of developing a system that can replace today's methods for detecting delamination, MDOT will have played a critical role in the process. It will also have access to an easy-to-use detection system that will save time and money while producing more accurate results.

RBP

Principal Investigator

Ronald Harichandran, Ph.D., P.E.

Department of Civil and Environmental Engineering
Michigan State University
East Lansing, MI 48824
harichan@egr.msu.edu
517-355-5107

Contact Us

PHONE: 517-241-2780

E-MAIL: mdot-research@michigan.gov

WEB SITE: www.michigan.gov/mdotresearch

This final report is available online at

https://mdotjboss.state.mi.us/SpecProv/getDocumentById.htm?docGuid=c6bdc983-b9c8-46ae-9b76-083f1608ae8b.

Research Spotlight produced by CTC & Associates LLC.