SCDOT

Research Summary

South Carolina Department of Transportation | Office of Materials and Research

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Feasibility Study for Rapid Evaluation of Bridge Decks

Degradation of concrete bridge decks is an ongoing challenge facing the South Carolina Department of Transportation (SCDOT). Different methods for concrete bridge deck evaluation are utilized by SCDOT including visual inspection and chain dragging. The current methods for concrete bridge deck evaluation are effective, but they require traffic control and many operators. To address these limitations, this project investigates rapid evaluation methods including vehicle mounted scanning (utilizing ground penetrating radar, infrared sensing, and high definition video scanning), pole mounted scanning (utilizing ultra-time domain infrared sensing), and deck acoustic response to identify which method, or combination of methods, is well suited for the evaluation of concrete bridge decks in South Carolina. Among the methods, deck acoustic response was found to be the most suitable for detection of delamination, with infrared and ultra-time domain imaging also providing good results. Ground penetrating radar was less effective for detection of delamination but showed promise for detection of chlorides and moisture intrusion. Benefit-cost analysis was performed to better understand the potential for implementation.

vehicle mounted | pole mounted | acoustic response

Evaluation Methods

Problem

The deterioration of concrete bridge decks presents a maintenance challenge for most transportation agencies and bridge owners. When a bridge deck exhibits a significant percentage of degraded area decisions must be made regarding approaches for repair. Potential methods include patching, hydro-blasting with subsequent partial depth overlay, and replacement of the deck. To aid in decision making, different methods for bridge deck evaluation have been employed by the SCDOT including visual inspection, chain dragging, and chloride sampling. While these methods are informative, they have the drawback of requiring traffic control, thereby increasing the cost of the evaluation and decreasing safety of workers during the evaluation.

Research

This project is motivated by a desire to identify a bridge deck evaluation method (or combination of methods) that would provide useful information and is similarly effective in comparison to current methods used by SCDOT while not requiring traffic control. Many approaches to this issue have recently

become commercially available and others are under development. These approaches vary in terms of traffic control requirements, cost, and fidelity of the results. Among the different approaches are a) vehicle mounted scanning (commonly utilizing ground penetrating radar, infrared sensing, and high definition video scanning); b) pole mounted scanning (utilizing ultra-time domain infrared sensing and high definition video scanning); and c) deck acoustic response enabled by a trailed device (utilizing trailed impactors in combination with acoustic detectors).

To assess the feasibility of different evaluation methods for South Carolina bridge decks in-service decks with differing damage levels were selected to serve as testbeds. Chloride sampling, chain dragging, and coring were performed in addition to rapid evaluation methods to enable assessment of the results. Bridge deck specimens removed from a bridge in South Carolina were also investigated under an accelerated aging protocol in the laboratory. Instrumentation was added to a new bridge deck during construction to aid in assessment of conditions potentially related to early degradation. It was found that many of the rapid evaluation methods offered levels of accuracy in a similar range to existing evaluation methods. Furthermore, vehicle mounted scanning is amenable to evaluation on a widespread basis, e.g. asset management.

Assessment of evaluation methods

Results

Bridge decks with differing damage levels were investigated using rapid bridge deck evaluation methods (ground penetrating radar, conventional and ultra-time domain infrared sensing, high resolution video, and deck acoustic response) to assess the efficacy of such methods for concrete bridge decks in South Carolina. It is envisioned that such methods may be used in the future either in place of, or in addition to, traditional evaluation methods for bridge deck evaluation (coring, chloride concentration testing, and chain dragging).

The rapid evaluation methods investigated varied in terms of cost, need for traffic control, type of traffic control when needed, and interpretation of results. To address accuracy, results gathered from each of the rapid evaluation methods were compared to results gained by sampling (referred to as 'ground truth' comparison, in this case gained through coring and/or chloride concentration testing).

Results related to the rapid evaluation methods (vehicle mounted, pole mounted, and deck acoustic response) are as follows:

1. Deck acoustic response demonstrated the highest accuracy for detection of delamination.
2. Vehicle mounted infrared and pole mounted infrared ultra-time domain sensing demonstrated promising results for detection of delamination.
3. Contour plots attained through vehicle mounted ground penetrating radar did not correlate well with detection of delamination. However, the most extreme contours did provide reasonable correlation with delamination. Because ground penetrating radar is sensitive to moisture conditions and chlorides in the bridge deck, ground penetrating radar is thought to be sensitive to conditions causing future degradation.

In addition to the field studies, a bridge deck specimen was subjected to an accelerated corrosion environment in a laboratory setting. Results are as follows:

1. Half-cell potential results indicate that corrosion initiated after 45 days of conditioning.
2. Impact echo and ultrasonic pulse velocity were used to detect a damaged area with minor wave velocity variation and evidence of damage.

To better understand the conditions that lead to degradation of bridge decks in South Carolina, instrumentation was installed in the deck of the Leaphart Bridge over I-26. Initial readings are within the expected range of behavior. It is recommended that the readings in this bridge deck be continued by SCDOT for a period of ten years.

Life cycle cost analysis indicates that most of the rapid evaluation methods investigated (vehicle mounted, pole mounted, and deck acoustic response) have similar cost when compared to chain dragging.

Value & Benefit

With a growing population and aging infrastructure, the SCDOT will require frequent monitoring of bridge health to ensure the continued safety of the public and to inform maintenance decision making. These goals can be met by the alternative inspection methods mentioned, which have similar cost, require less time, and yield inspection quality comparable to current methods. This study provides useful information related to promising bridge deck rapid evaluation methods to be implemented by SCDOT. The accuracy of these methods was compared to current traditional methods and specific recommendations are as follows:

1. For local evaluation, deck acoustic response (DAR) may serve as a reasonable replacement to chain dragging for detection and assessment of delamination.
2. For asset management, vehicle mounted infrared sensing proved to the most feasible means of evaluation as traffic control is not required with this approach.

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