

JOINT TRANSPORTATION RESEARCH PROGRAM

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The Economic Impact of Implementing Nondestructive Testing of Reinforced Concrete Bridge Decks in Indiana

Introduction

Bridge decks require frequent maintenance and rehabilitation due to deterioration mechanisms such as corrosion of reinforcement and delamination of concrete. This makes the deck one of the most expensive components of a bridge over its lifetime. One major source of this damage is deicing salts applied in winter, which introduce chlorides to the deck surface and inevitably cause corrosion and cracking. Freeze-thaw cycles then exacerbate the cracks caused by corrosion, leading to delamination.

Currently the Indiana Department of Transportation performs inspections according to the federally prescribed two-year time interval for the state inventory of bridges. INDOT utilizes the findings from visual inspections as the main source of information regarding the condition of the deck, and the chain drag method occasionally is used in conjunction with the visual inspection. However, these methods do not provide a full picture of the condition. Due to this lack of quality data, INDOT has implemented a programmatic schedule for major work actions based on the age of the bridges in the network. Nondestructive testing (NDT) has been used extensively elsewhere to evaluate bridge decks, and it appears to be a more accurate alternative for deck inspections and programming decisions. This study was commissioned by INDOT to determine whether using the data from these methods will be cost-effective for the bridges in Indiana.

A thorough literature review and multiple interviews with INDOT personnel and NDT vendors provided the foundation for this study. The primary objective was to

investigate the economic viability of using NDT methods for evaluating bridge deck condition to inform the decision-making process for work actions. The NDT methods were first evaluated to determine if they are more effective than INDOT's current practices. A project-level comparison between various NDT methods was conducted to show which method and combination of methods were the best choices from a cost perspective. This combination then was used in the project-level analysis, wherein their use and the resulting effect on agency costs were compared to the costs incurred using INDOT's current practices. At the network level, a combination of rapid-screening NDT methods was implemented and compared in a similar fashion to the current INDOT practices. Utilizing a consultant was also considered in place of establishing an in-house NDT option.

The comparison between the various NDT methods considered the following costs: equipment and software, maintenance, personnel salary, and traffic control. A project-level analysis then compared the use of the NDT methods to INDOT's current practices for 30 randomly selected bridge decks. A deterioration curve was created based on factored INDOT chain drag data. Project- and network-level analyses were conducted for a 100-year period, and the deteriorative curve was used to model the deck conditions over time. A decision matrix was developed to trigger work actions based on the percentage of deterioration and an associated probability of that work action. This analysis concluded that utilizing the NDT methods will improve the deck condition overall. While the project-level analysis investigated only 30 bridge decks, the network level considered the

entire Indiana bridge inventory. The network-level analysis assumed a leader of an in-house NDT group called the NDT expert, but at the project level there was no group leader and the costs for personnel were calculated based on an established hourly rate.

Findings

The past literature indicated that NDT methods can provide more accurate corrosion and deterioration detection than can visual inspections. With regard to the combination of NDT methods, several past studies concluded that such combinations also could accurately locate corrosion and deterioration to provide a better understanding of the different types of deterioration occurring in a deck.

When the costs at the project level were compared, infrared (IR) thermography was found to be the best alternative because of its low purchase cost and rapid data collection. The best combination of NDT methods was determined to be IR, chloride ion penetration (CIP), and ground-coupled ground penetrating radar (GPR), which then was used in the project-level analysis. The costs of the condition-based NDT methods represented the net present cost, and the equivalent uniform annual cost (EUAC) proved to be significantly less than the costs using INDOT's current programmatic schedules. The least expensive schedule was 23% more costly than the NDT methods, and the most expensive schedule increased the EUAC by 54%. When expanded to the network level, the costs were almost 1.5 times more using INDOT's current practices than using NDT methods. Although the average percentage of delamination was lower using the INDOT programmatic schedules, the costs to achieve those results were exorbitant.

Based on estimates from two consultants, the use of in-house network-level NDT was compared to use of a consultant for this work, and the results indicated a break-even point of \$0.22 per square foot. Therefore, if a consultant offers services at less than \$0.22 per square foot, then it would be more cost-effective to contract with them than to perform in-house NDT collection and analysis.

The acquisition of more accurate data regarding the deck condition will allow INDOT to perform more appropriate work actions at the correct time, and thereby produce cost savings. This study therefore concluded that using NDT methods for bridge deck inspection would be cost-effective for INDOT in the long term.

Implementation

Based on the results of this study, it is recommended that INDOT establish and fund a new NDT work group for network-level bridge deck condition assessment. The estimate for the startup costs and first year of funding for the group is \$940,000. This estimate includes two sets of IR and air-launched GPR, two vans, two crews of two (four collectors), four analysts, and one NDT expert, as well as associated training, maintenance, and travel costs. High-priority bridges on the Interstates and NHS should be inspected first; if INDOT cannot afford to inspect every bridge in the state inventory, then these bridges should be the only ones inspected.

The crews will be able to inspect every bridge based out of the INDOT Research and Development Division in West Lafayette: Interstate bridges every two years, other NHS bridges every four years, and all other bridges every six years. INDOT should consider making use of a decision matrix similar to that of this study to aid in the decision-making process for bridge deck work.

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