RESEARCH ADMINISTRATION
Bureau of Field Services
Michigan Department of Transportation

Research Spotlight

Project Information

REPORT NAME: Evaluating Prestressing Strands and Post-Tensioning Cables in Concrete Structures Using Nondestructive Methods

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Nondestructive bridge evaluations guide repair decisions

Nondestructive evaluation (NDE) methods show promise for obtaining detailed data on steel corrosion and concrete deterioration in bridges without requiring core samples. MDOT evaluated three of these methods by using them on laboratory specimens and existing structures in the field. All three were successful and will provide MDOT with valuable information for making maintenance and repair decisions.

Problem

Typically, concrete bridge beams are constructed with steel reinforcements, such as prestressing strands and post-tensioning cables, to increase their strength. However, these reinforcements are susceptible to corrosion caused by contact with air, water and deicing chemicals. This corrosion can lead, in turn, to the deterioration of the surrounding concrete, such as cracking, delamination and spalling.

Consequently, bridge inspectors visually evaluate bridges for concrete deterioration indicative of reinforcing steel corrosion. However, this method means the damage has already become obvious and doesn't give inspectors a good way to quantify the degree of corrosion and deterioration. While inspectors can evaluate concrete beams by taking core samples, this destructive method can weaken them further and so is not always an option. As a result, engineers have been developing NDE methods to gain more information about the conditions of structures than they can by visual inspection alone without requiring coring. NDE methods are continuously advancing, and research was needed to evaluate current and emerging NDE methods for MDOT's use in the field.

Researchers found that MFL assessment was a good way to detect and quantify changes in the cross-section of steel reinforcements (an indicator of corrosion) and to estimate the reduced flexural capacity of beams.

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"Nondestructive evaluation methods provide critical data for engineers trying to make informed decisions concerning structures, which can otherwise be very challenging."

Beckie Curtis, P.E.
Project Manager

Approach

The goal of this study was to assess the effectiveness of several NDE methods to detect and quantify concrete bridge beam deterioration due to the corrosion of steel reinforcements. These methods are used as an alternative to coring in cases where visual inspections have revealed that structures are showing signs of deterioration. The NDE methods used in this study were:

- **Ultrasonic assessment**, in which inspectors analyze the properties of multiple sound waves propagated through a structure to detect signs of concrete deterioration.
- **Electrochemical half-cell potential assessment**, in which electrodes and a voltmeter are used to detect electrochemical indicators of corrosion.
- **Magnetic flux leakage (MFL) assessment**, in which a magnetic field is passed through a structure to detect changes in the cross-section of reinforcements, which cause a disturbance in this field called a flux leakage.

Research

Researchers used NDE methods to assess both laboratory specimens and existing structures in the field, including:

- Three specimens consisting of box beams designed in the laboratory to simulate signs of corrosion, including voids around prestressing strands and changes in their cross-section, as well as grouting defects in post-tensioned ducts, which leave voids between the concrete and post-tensioning cables.
- Three beams salvaged from the Kent County Road Commission, decommissioned after being in service for 39 years.
- Three bridges in Michigan.

For the first two experiments, researchers compared the results of NDE testing to the actual interior defects of beams. Field testing allowed researchers to cross-check these methods against each other and visual inspection.

Results

Results showed that the three NDE methods offer useful information for detecting and quantifying steel corrosion and concrete deterioration in bridges.

Ultrasonic Assessment

Ultrasonic assessment was able to detect debonding of the steel reinforcement, internal voids, cracking and delamination. It was also able to estimate the thickness of beams with great accuracy and quantify the depths of defects and the area of delamination. However, it was not able to determine the length of debonding around strands unless cracking and delamination had reached an advanced stage. Other methods are needed to more specifically quantify the loss of reinforcement material and the extent of corrosion.

Electrochemical Assessment

In the laboratory, electrochemical testing was able to isolate the areas in beams with a high chance of corrosion. It is an excellent tool to monitor areas prone to corrosion and to isolate areas with a high chance of corrosion.

MFL Assessment

MFL assessment was able to detect changes in the cross-section of steel reinforcements in both the laboratory and the field. The correlation is strongest when the loss is spread out over a longer area than when it is concentrated.

Value

Making the right decisions is essential to the safety and performance of bridges in Michigan. As part of this project, MDOT piloted the use of the NDE methods to study a bridge with corroded prestressing strands. The NDE methods provided critical information about the condition of inaccessible reinforcement features. MDOT engineers used this information to confirm their decision to restrict the shoulder and then used the information to determine the scope of work required to repair the structure. In the future, MDOT may use NDE methods as an alternative to coring on structures that show early signs of deterioration.

Research Administration

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