Michigan Department of Transportation
RESEARCH Administration

RESEARCH SPOTLIGHT

Project Information

REPORT NAME: Concrete Deterioration of Prestressed Bridge Beams

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Remedies for concrete bridge beam deterioration

Prestressed concrete beams in Michigan's bridges can experience cracking and other deterioration from a variety of causes, including the state's harsh weather. Understanding the causes, both common and uncommon, and identifying where deterioration is occurring allows MDOT to effectively plan and prioritize bridge maintenance. New research addressed this need from several perspectives, including new bridge inspection guidelines, load rating calculations for damaged beams, and use of concrete coatings and sealants to protect and repair deteriorating concrete.

PROBLEM

Prestressed concrete beam bridges built in the 1970s and 1980s are experiencing varying amounts of deterioration. Some materials in concrete – aggregates containing silica and cement alkali – can produce a chemical reaction, creating a gel that causes expansion and cracking of the concrete. The reactivity between these materials is exacerbated by moisture and the concrete deterioration is promoted by Michigan's freeze-thaw cycles.

This particular type of deterioration generally results in longitudinal or alligator cracking along a fascia beam's bottom flange. As current bridge inspection procedures do not include documenting the condition of fascia beams, MDOT did not have a standardized process for recording and tracking the deterioration.

Before it could explore strategies for rehabilitating the distressed concrete, MDOT first needed to know the extent of the reactive damage among the bridges in its inventory. The agency could then improve its inspection methods for assessing the deterioration and better understand how the damage affects the state's bridges.

Longitudinal and alligator cracking may be caused by alkali-aggregate reactivity and generally occurs on beams exposed to direct sunlight.

RESEARCH

To identify bridges with concrete deterioration damage, researchers began by surveying MDOT's regional bridge engineers and reviewing inspection reports for all 1,136 prestressed concrete beam bridges in the state for indications of alkali-aggregate

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"MDOT was aware of this unique form of deterioration but didn't have good solutions. Now we have methods to identify it, understand the extent and implications of the damage and remedy not only this issue but other concrete deterioration as well."

Rick Liptak
Project Manager

reactivity and similar distress. Of this inventory, 136 bridges were found to have material-related deterioration on the beams.

A subsequent field inspection on a sampling of the bridges confirmed the damage and revealed similarities in where the deterioration generally occurred on the structures. With evidence of a relationship between crack characteristics and sun exposure, the research team conducted tests on the concrete to detect any gel produced by the materials' reaction.

Back in the laboratory, the gel was reproduced using reactive aggregates and different concrete mix designs, and experiments of two staining techniques were conducted to help MDOT choose a reliable method for identifying the substance on bridges in the field. Additionally, load rating procedures for bridges with deteriorated beams were developed, and the guidelines for the most accurate calculation of beam capacity by incorporating deteriorated concrete and prestressing strands were presented.

Next, researchers tested the performance of various protective coatings and penetrating sealants under extreme conditions. As heat from sunlight brings moisture to the concrete's surface, the breathable protective coatings and sealants must allow for evaporation to control the internal relative humidity of the concrete.

Finally, a review of MDOT's bridge inspection procedures, data recording formats and definitions of condition states revealed opportunities for improvement.

RESULTS

This project resulted in numerous findings and recommendations concerning several aspects of concrete deterioration:

Modified inspection guidelines: The updated condition descriptions and reference photographs digitally linked to inspection templates will help inspectors describe and document deteriorations consistently to identify bridges with material-related distress in fascia beams. A nondestructive procedure is presented for inspectors to calculate crack depth to evaluate the condition of prestressing strands for load ratings.

Alkali-aggregate reactivity screening: Using uranyl acetate to stain and identify areas of reactivity is the most reliable method for use in the field, though there are challenges. The fluorescence of the stains changes as the solution dries, potentially complicating interpretation. As a result, various improvements to these procedures could be further explored to enhance the reliability of the results.

Load ratings: While existing guidance excludes the strands adjacent to cracks in capacity calculations, a more accurate method incorporates the depth of the crack and the specific strand layout. The research results include guidelines and a calculation tool.

Concrete protective systems: This research resulted in specific product recommendations as well as cost estimates for applying concrete surface coatings and penetrating sealants on prestressed concrete beams to seal cracks and improve long-term performance. MDOT's product qualification process should be revised to ensure these coatings and sealers are applied to the appropriate concrete mixes.

Finally, an ArcGIS file was developed to help MDOT catalog and monitor the 136 bridges with fascia beam deterioration.

IMPLEMENTATION

MDOT plans to implement as many of the recommendations as feasible. Using the ArcGIS tool to prioritize bridges – and adding to the database as more are identified – the agency will test the updated inspection guidelines, assessing beams for the reaction-based damage and calculating load ratings using the new methods. Finally, MDOT will evaluate the protective coatings and sealants on many types of concrete deterioration.

Research Administration

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This final report is available online at

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