

# RESEARCH SPOTLIGHT

## Project Information

**REPORT NAME:** Capacity Prediction of Repaired and Unrepaired Bridge Beams with Deteriorated Ends

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**RESEARCH REPORT NUMBER:** SPR-1745

**PROJECT COST:** \$416,000

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

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## New tools for assessing and repairing bridge beam ends

Bridge inspectors across Michigan frequently encounter cracks, corrosion and other signs of deterioration at the ends of steel and concrete beams, which can reduce the structure's load-carrying capacity. To make the best possible repair decisions, the Michigan Department of Transportation (MDOT) needed more explicit guidance on when deterioration becomes a capacity concern and which repairs are most appropriate. This research project culminated in a range of practical tools, including a detailed decision-support matrix to help MDOT make more accurate and consistent repair decisions.

### PROBLEM

Bridge beam ends are particularly vulnerable to deterioration. Expansion joints, which are designed to act as watertight barriers, often break down long before the bridge itself does, allowing water and corrosive deicing salts to run directly onto the beam ends. Over time, this exposure causes corrosion, cracking and concrete spalling. Eventually, deterioration can lead to section loss, a reduction in the beam's cross section that lowers load capacity and undermines structural integrity.

Historically, MDOT inspectors and load-rating engineers had no uniform guidelines to help them interpret beam-end deterioration or determine how much loss of concrete or steel was too much. Decisions



New MDOT research provides more explicit guidance to assess deterioration at bridge beam ends and choose the most effective repairs.

about repairs or load restrictions were often based on judgment rather than quantitative capacity analysis. MDOT needed a systematic, evidence-based approach to help inspectors recognize when deteriorated beam ends required closer evaluation, when load capacity might be compromised and

*“The findings will help us understand when a beam end needs further evaluation or repair and when a bridge can safely wait. That’s going to help us distribute our limited resources more effectively.”*

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which repair techniques would best restore or extend service life.

## RESEARCH

The investigation of beam-end deterioration began with a review of national literature and a survey of state transportation agencies to understand common practices and knowledge gaps. An analysis of MDOT’s records for 431 steel beam ends and 267 prestressed concrete beam bridges examined deterioration patterns, repair histories and field performance.

During field visits, researchers examined deteriorated and previously repaired beams firsthand, gathering measurements, photographs and repair data. Detailed simulation models were developed for steel and prestressed concrete beams to understand how different types of deterioration affect load capacity. The ends of steel beams were evaluated for section loss, corrosion-induced holes and fatigue cracking potential. Simulations and analytical modeling of prestressed concrete beams were used to estimate load capacity under various deterioration scenarios.

To validate the models, researchers compared their calculations with experimental data from published studies. Then they used the validated models to establish capacity thresholds and develop

repair-selection matrices and user-friendly calculation tools to guide repair decisions.

Laboratory testing was also conducted to evaluate preservation and repair methods. The team assessed combinations of surface preparations, materials and reinforcement to determine which approaches perform best in Michigan’s challenging environment.

## RESULTS

Researchers established clear thresholds for section loss in steel beam ends to help inspectors determine when repairs are needed. These thresholds reflect real-world performance and will help prevent unnecessary repairs. The research team also evaluated fatigue performance of steel beams for Michigan’s 28 legal truck types and compiled the results into user-friendly tables to support load-rating decisions.

The research team produced a detailed matrix for prestressed concrete beam ends that outlined typical deterioration conditions, their likely effects on load capacity, and appropriate maintenance or repair strategies. This tool gives inspectors a straightforward, consistent method for determining whether repairs are needed and helps engineers determine the types of repairs that would be most effective based on how much capacity needs to be restored.

Together, these tools give MDOT a uniform approach statewide to evaluating beam-end deterioration, determining load restrictions and choosing appropriate repairs, which will improve safety and maximize maintenance resources.

## IMPLEMENTATION

The study delivered practical, capacity-based tools that MDOT inspectors, load raters and maintenance engineers can use immediately. MDOT is integrating the new guidelines into its inspection and maintenance workflows. Load-rating engineers will use the new tools to evaluate beam-end capacity and support decisions about

load restrictions. Repair details developed through the study will be available to MDOT’s special design unit to guide the selection of the most suitable repair methods. Implementation of this guidance will improve the accuracy and consistency of repair decisions across Michigan’s bridge system.

## Research Administration

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### The final report is available online at

[MDOTjboss.state.mi.us/TSSD/tssdResearchAdminDetails.htm?keyword=SPR-1745](http://MDOTjboss.state.mi.us/TSSD/tssdResearchAdminDetails.htm?keyword=SPR-1745).

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