

# RESEARCH SPOTLIGHT

## Project Information

**REPORT NAME:** Bridge Structural Analyses for Staged Construction and Constructability Reviews

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**TOTAL COST:** \$234,293

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

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## Structural analysis tools help streamline review of bridge construction plans

Highway bridges are designed to withstand a range of stresses, including traffic loading, heavy snow, high winds and crash impacts. But construction processes can expose bridge beams and other elements to additional stresses beyond those experienced by an in-service structure. To prevent damage or overstresses to bridge elements due to construction loads, contractors carefully plan each construction stage. For complex bridges and bridges with complex staging schemes, Michigan Department of Transportation (MDOT) engineers must approve these plans before construction can begin. This research project created tools to help MDOT efficiently conduct bridge constructability reviews and quality assurance (QA) assessments for a variety of bridge elements.

### PROBLEM

Bridge beams are subjected to an array of stresses as they are fabricated, transported to the construction site, erected, and loaded. Throughout the construction process, beams must be carefully stabilized, shored or stiffened, as excessive stresses could damage them and potentially impact the structural capacity, durability or longevity of the finished structure.

To ensure safety, contractors are required to perform erection analyses as they lay out plans for constructing the bridge according to a specific staging scheme. MDOT engineers then conduct a constructability review to ensure that the various bridge elements remain in static equilibrium at all stages of construction. MDOT also conducts QA reviews of all fabricated structural elements to check



During construction, a chain-down system (outlined in red) securely anchors this steel I-girder to the bridge substructure and provides resistance to wind loading stresses.

for manufacturing defects or other issues that could affect their performance in the completed structure.

(continued)

*“This project created powerful tools for analyzing situations during bridge construction that must be quickly and accurately assessed. The analysis forms and checklists create data transparency in a complex environment.”*

**Matthew Chynoweth, P.E.**  
Project Manager

At times, MDOT’s constructability reviews point to the need for more in-depth structural analysis. In the past, engineers made this determination on a case-by-case basis, which could result in inconsistent levels of analysis or duplicated efforts on similar projects in different regions. MDOT needed a more systematic approach to help engineers identify the level of analysis needed for various situations and efficiently perform calculations and inspections.

## RESEARCH

This project’s goal was to develop a comprehensive framework for conducting constructability reviews and erection analyses for bridge construction, including guidelines and tools for MDOT engineers and inspectors. Researchers sought to address all construction stages, beginning with the production and manufacturing of prefabricated bridge elements.

First, researchers reviewed relevant literature and current practices for conducting constructability reviews and erection analyses. They found that many state agencies used constructability review checklists to evaluate a wide range of staged construction issues, but none had a comprehensive approach evaluating all areas that could impact constructability and stability.

The research team also consulted with MDOT staff from the Bureau of Bridges and Structures, reviewing typical bridge construction plans and methods and examining

MDOT’s existing constructability review processes. Researchers also documented the methodologies engineers use to conduct QA testing of fabricated structural elements.

Next, researchers identified common design and construction review scenarios that require documented guidelines. They grouped these scenarios into five stages: 1) element production and manufacturing, 2) transportation and lifting, 3) erection, 4) deck placement, and 5) phased construction. The research team then developed a constructability evaluation framework showing the potential impacts of excessive stresses and component instability during these five stages.

## RESULTS

Based on their findings, researchers developed several tools:

- **A Quality Assurance Load Testing spreadsheet** for QA of prestressed concrete beams. The spreadsheet will help MDOT engineers more efficiently assess whether manufacturing irregularities could affect a beam’s load capacity.
- **A Constructability Analysis Cases Form** to help identify cases where bridge construction plans will require more in-depth analysis to assure constructability. This screening tool uses simple data inputs (bridge type, bridge geometry and construction type) and can be used during the design, checking and review processes.
- **Constructability Required Level of Analysis Selection Tools** to help identify the required level of analysis for cases identified by the previous form. These spreadsheet-based tools use more detailed inputs to recommend an analysis level and suggest appropriate structural analysis tools.
- **Structural Analysis Tools:** Through the literature review, the research team identified several structural analysis tools developed by other agencies that MDOT can use to evaluate constructability in specific situations. Researchers created eight

Mathcad analysis scripts to supplement these tools.

In addition, researchers updated MDOT’s existing constructability checklists for inspectors and developed a post-construction review form.

## IMPLEMENTATION

MDOT is working toward incorporating these tools into existing constructability review and design/QA processes. Special provisions addressing erection analysis requirements, Mathcad calculation tools and construction checklists are currently being implemented. By documenting the factors that engineers consider in their reviews, MDOT is creating transparency in decision-making and emphasizing the importance of constructability throughout all aspects of bridge design and construction.

## Research Administration

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**This final report is available online at**

[www.Michigan.gov/mdot/-/media/Project/Websites/MDOT/Programs/Research-Administration/Final-Reports/SPR-1691-Report.pdf](http://www.Michigan.gov/mdot/-/media/Project/Websites/MDOT/Programs/Research-Administration/Final-Reports/SPR-1691-Report.pdf)

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