Michigan Department of Transportation
RESEARCH
Administration

RESEARCH SPOTLIGHT

Project Information

REPORT NAME: Evaluation of Camber and Deflections for Bridge Girders

START DATE: March 2019

REPORT DATE: March 2021

RESEARCH REPORT NUMBER: SPR-1697

TOTAL COST: $271,598

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

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New MDOT design tool predicts how bridge beams will flex and settle over time

The bump drivers often feel as they approach or leave a bridge reflects a common and complex engineering challenge. Unevenness at these transition points can occur over time as the beams supporting the bridge deck adjust to their surrounding environment differently than designers had estimated. To improve ride quality and minimize the need for costly on-site realignment, the Michigan Department of Transportation (MDOT) reevaluated its existing design procedures, developing a new methodology that allows bridge designers to more accurately predict how beams will behave at any stage of their service life.

PROBLEM

Prestressed concrete beams stored in a fabricator's yard display a slightly arched shape, or camber.

Beams used in modern bridge designs are typically made of either steel or prestressed concrete. Both beam types are naturally prone to changes in curvature over time as they age and bear loads: Beams that take on an upward curve are referred to as cambered, while beams that curve downward are deflected. Engineers consider the current and anticipated curvature of each beam when designing or repairing a bridge; however, a range of issues can arise when a beam behaves differently than predicted.

Drivers traveling over the bridge may feel a bump where the road and bridge sections meet, which can cause minor discomfort. For vehicles passing under the bridge, beam deflections greater than estimated can affect the vertical clearance between the bridge and the roadway beneath it, potentially resulting in traffic restrictions.

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"The methodology developed through this project will help us accurately predict camber and deflections in bridge beams over time, allowing us to make any needed adjustments during the design phase and avoid delays and added expense during construction."

Kyle Kopper, P.E.
Project Manager

The challenge of unplanned deformations can be addressed during the construction phase or with repairs during the bridge's service life, but fixes in the field increase project costs and require additional time. Recognizing that improved prediction accuracy would provide the most cost-efficient solution and improve ride quality for all travelers, MDOT sought to reevaluate the calculation methods its bridge designers use to estimate camber and deflection and minimize the need for design-related corrections on-site.

RESEARCH

Predicting camber and deflection accurately presented a complex endeavor for project investigators, largely because of the quantity and variety of factors that must be understood and considered. In addition to specific data such as the size, age and precise composition of each beam, the entire bridge's geometry, additional components and surrounding environment also affect how the beams will behave independently and collectively over the bridge's service life.

An additional complicating factor is that beams can rebound when weight is removed, such as when a bridge deck is replaced. How much each beam rebounds varies, depending on factors like material composition and the amount of weight it had been supporting, and this affects how the replacement deck is designed and constructed.

Investigators began by reviewing literature on cambered and deflected beams. They found that while studies have been done to improve the accuracy of camber predictions involving individual beams, the long-term changes to the beams and how they affect the bridge structure as a whole – including the impact of beam rebound – are not as well understood.

Next, the research team made note of seven methods commonly used in the concrete industry for calculating camber, as well as the drawbacks of each method. The team then conducted a national survey to learn more about the practices used by other state departments of transportation (DOTs).

Drawing from existing methods, the researchers developed and fine-tuned a mathematical framework for calculating long-term camber and deflections. The researchers' methodology was validated by comparing the predicted measurements against actual data for 17 MDOT projects and a bridge under construction in Canada. To further improve the proposed methodology, the team identified additional data that should be collected and worked with fabricators to refine their specifications for creating, storing and measuring camber in concrete beams.

RESULTS

The new methodology performed very well, accurately predicting camber and deflection about 94 percent of the time – a significant improvement over the 70 percent accuracy rate MDOT experienced with previous methods.

As a final step, the team created a computer program that allows engineers to enter data and receive an accurate prediction of the curvature changes of any prestressed concrete or steel bridge beam, individually or as part of a larger structure with a concrete deck, at any time in its service life.

IMPLEMENTATION

For MDOT, the benefits of this research are immediate; the prediction tool has already been adopted into everyday practice as engineers have been trained to use it in their bridge designs.

As new bridges are built in the state and older bridges are repaired, MDOT will realize significant savings in both time and costs. More accurate bridge designs will minimize the need for on-site alterations, and travelers will experience a smoother ride when they cross over bridges in Michigan.

Research Administration

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This final report is available online at

https://www.michigan.gov/mdot/-/media/Project/Websites/MDOT/Programs/Research-Administration/Final-Reports/SPR-1697-Report.pdf.

Research Spotlight produced by CTC & Associates LLC, October 2021.