RESEARCH ADMINISTRATION
Bureau of Field Services
Michigan Department of Transportation

Project Update

Project Information

TRANSPORTATION POOLED FUND: Evaluation and Analysis of Decked Bulb T-Beam Bridge

START DATE: September 2011

END DATE: September 2014

TRANSPORTATION POOLED FUND NUMBER: TPF-5(254)

TOTAL COMMITMENTS: $380,000

MDOT Project Manager

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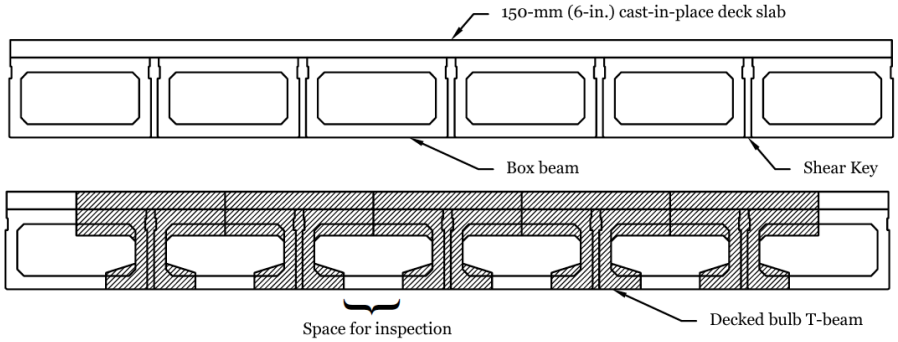
New beam design may double bridge service life

In Michigan's winter climate, traditional box-beam bridges are susceptible to concrete cracking, deterioration and corrosion of their steel reinforcements. They also are difficult to inspect. To address these problems, MDOT is partnering with four other states to investigate an innovative new bridge design that uses decked bulb T-beams, carbon-fiber prestressing and post-tensioning strands, and mild reinforcement, and ultra-high-performance concrete for joints. These bridges could last more than 100 years and require far less maintenance, leading to significant cost savings for Michigan taxpayers. The bridges also are easy to construct, inspect and repair.



Researchers propose modifying traditional side-by-side box-beam bridge superstructure (top) with decked bulb T-beams (bottom).

Problem

To build short to medium-length bridges, many state DOTs use prestressed concrete box beams—girders with rectangular cross-sections that better resist torsion and can carry greater loads than beams with I-shaped cross-sections. These beams are prestressed longitudinally, or cast around stretched steel strands that are released after the concrete hardens to compress the concrete and so make it stronger. The beams are then placed side by side and transversely post-tensioned by running steel strands through hollow ducts within the beams and applying tension with a hydraulic jack, squeezing the beams together to increase the structural integrity of the bridge as a whole.

Bridges built using side-by-side box-beams have the advantage of being simple designs that are low-cost and easy to rapidly construct. However, the steel reinforcement used in these bridges is susceptible to corrosion from moisture and

(continued)

> *"Our goal is to build bridges that can be rapidly constructed, require less maintenance and have a service life exceeding 100 years."*
>
> **Dave Juntunen**
> Project Manager

chlorides in salt used to deice roadways in winter. The corrosion leads to concrete cracking and deterioration. This process is accelerated by freeze-thaw cycles that occur in northern climates, so that many of these types of bridges are reaching the end of their service lives in Michigan. Furthermore, routine inspections that might help mitigate such problems are made difficult by the lack of space between the beams.

Approach

To address these problems, MDOT has accepted the role of lead agency for a Transportation Pooled Fund (TPF) Program study, TPF-5(254), involving four partner states—Iowa, Minnesota, Oregon and Wisconsin. The purpose of the study is to investigate an innovative way to build bridges with alternative materials and a new beam design. Pooling resources allows MDOT and other transportation agencies to undertake large-scale research projects that would be difficult to fund on their own.

Researchers are evaluating the use of prestressed decked bulb T-beams, which have a wider upper flange than I-beams, giving them a T-shaped cross-section. These upper flanges form the deck of the bridge, which allows for faster construction with less traffic disruption, and the T-shaped cross-section provides enough space at the bottom of the bridge for periodic inspection and maintenance.

Researchers are also evaluating the use of ultra-high-performance concrete to fill the longitudinal joints between beams, instead of traditional grouting; and replacing traditional steel prestressing and post-tensioning strands and other reinforcement with corrosion-resistant carbon-fiber-reinforced polymer composite cables, or CFCCs. Post-tensioning will be applied at intermediate internal diaphragms that are integrated into the beams at regular intervals to further compress the cross-section and prevent cracking.

Research

The research plan involves conducting a three-dimensional finite element computer simulation of the proposed bridge system, and a laboratory investigation that consists of designing, constructing, instrumenting and testing one-half scale models of several beams and a bridge superstructure.

Computer modeling will help determine the optimum transverse post-tensioning level and the most effective number of diaphragms. It also will help evaluate load distribution, flexural strength, basic system connections and the appropriate construction sequence.

The laboratory experiment includes constructing seven decked bulb T-beams with CFCC reinforcement and one with steel reinforcement. Of the CFCC beams, five will be used in the construction of the bridge model. Before the model is constructed, one CFCC beam will be tested as a control for flexure and the other for shear strength, while the beam with steel reinforcement will be tested for flexure only. The bridge model will be tested with varying amounts of post-tensioning.

Preliminary Results

In 2012, a literature review on the current state of practice and available techniques for design and construction of decked bulb T bridges was completed. Currently the research is approximately 50 percent complete for both the finite element modeling and the laboratory experiment, and construction of the half-scale beams and bridge model is 100 percent complete. Testing will begin in 2013.

Once completed in 2014, the investigation will offer recommendations for designing and constructing a prefabricated decked bulb T-beam bridge, including beam design guidelines, optimum transverse post-tensioning levels, and the optimum number of post-tensioned diaphragms.

Value

Researchers predict a decked bulb T-beam bridge will last twice as long as current bridges and require far less maintenance, leading to significant cost-savings for Michigan taxpayers. As a prefabricated bridge system, it will also have the potential for accelerated bridge construction and deconstruction, resulting in minimal traffic disruption. Finally, the use of decked bulb T-beams would eliminate problems associated with inspecting and repairing box-beam structures.

Research Administration

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Information about this pooled fund study is available online at www.pooledfund.org/Details/Study/483.

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