Evaluation, Laboratory Testing, Construction Documentation, and Field Testing/Monitoring of the US 52 Overflow Bridge over the Mississippi River

tech transfer summary

This project validated design assumptions and identified potential construction approach issues for a pretensioned, prestressed concrete beam-supported partial-depth precast deck system with cantilever precast overhang panels.

Objectives

The objectives of this project were to validate design assumptions and evaluate the performance of the structural design details for a pretensioned, prestressed concrete beam (PPCB)-supported partial-depth precast deck system with cantilever precast overhang panels.

Background

The bridge that carries US 52 and IA 64 over the Mississippi River overflow was planned to be replaced with a PPCB bridge in 2017. The structural systems planned for the new bridge included integral abutments, a drilled shaft-supported concrete pier cap system, and a PPCB and concrete deck system.

The 376 ft long and 40 ft wide bridge was longer and wider than the bridge it was to replace. The additional width conveniently allowed for the construction of the drilled shaft foundations of the new bridge in the river overflow channel while keeping the existing bridge open to normal traffic.

To further minimize construction time and traffic interruption, multiple innovative accelerated bridge construction (ABC) techniques were proposed for use in this replacement project. The following construction options and their corresponding design plans were provided:

1. **Base design:** For all options, a base design which included partial-depth precast prestressed deck panels and a double-panel precast overhang system to facilitate construction of the bridge deck and cast-in-place (CIP) pier caps were used. Partial-depth precast deck panels have been used in Iowa on low-volume roadways in the past. In those cases, the partial-depth panels span between the precast, prestressed concrete (PPC) beams, and the overhang is formed and cast conventionally with the CIP slab. To accelerate the construction, precast overhang panels have been developed based on a design previously used by the Texas Department of Transportation (TxDOT). The overhang panels are a combination of partial-depth and full-depth components. The full-depth area is under the barrier rail to properly develop the anchorage of the barrier rail reinforcement.

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RESEARCH PROJECT TITLE
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The Bridge Engineering Center (BEC) is part of the Institute for Transportation (InTrans) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.

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2. **Deck options: The contractor was able to choose between the following deck options.**
   a. **AccelBridge deck system:** The patented full-depth precast deck system is used in this design with CIP pier caps. The necessary compression between precast deck panels are provided by "deck jacking," which eliminates the need for conventional post tensioning.
   b. **Partial-depth precast deck**
3. **Pier cap options: The contractor was able to choose between the following pier cap options.**
   a. **CIP pier cap**
   b. **A precast pier cap**

Although the bridge was first designed with a partial-depth precast deck and a propped cantilever precast overhang deck panel, after initiation of the research project, the contactor submitted a value engineering (VE) proposal to change the bridge system to a conventional prestressed concrete beam with a CIP deck.

Problem Statement

The design of the deck system, either the partial-depth panels with the precast overhang or the full-depth precast AccelBridge deck system option, is unique and had not been used in Iowa in the past. The precast/post-tensioned pier cap is also an innovative ABC approach that had not been used in Iowa before.

To further understand and validate the design assumptions and identify potential constructability issues, the original research tasks were proposed to study the behavior of the PPCB-supported deck system and the precast/post-tensioned pier cap system.

Research Description

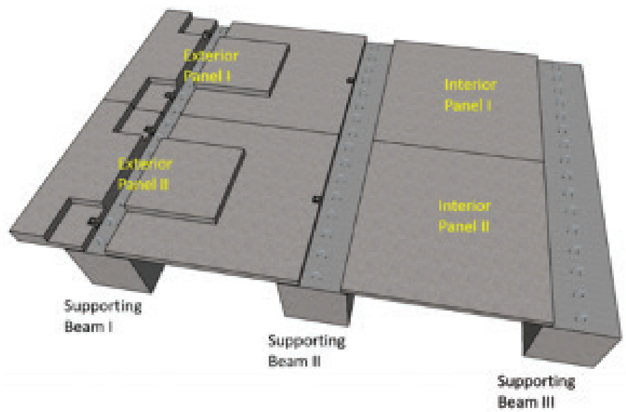
The research plan was intentionally developed with multiple options so the research team could adapt the research based on the specific bridge system selected by the contractor from the options. To meet the objectives of the project, three main work tasks were identified.

Task 1: Literature Review. Given the bridge construction approach was let with various structural design details that the contractor could choose from to accomplish the construction within the critical closure, the literature review was conducted with respect to all possible options including: 1) PPCB-supported partial-depth precast deck system with precast overhang panels, 2) PPCB-supported AccelBridge deck system, and 3) precast/post-tensioned pier cap system.

Task 2: Field Information Collection. The field information was collected via two means: construction documentation and interviewing the contractor. During construction of the bridge, a webcam was placed at the site to document the entire bridge construction process. This step was designed to provide live updates of the construction activities and store images at regular intervals. In addition to the webcam, the contractor was interviewed to understand the major reasons resulting in their final decision to change the deck system.

Task 3: Laboratory Testing. The experimental tests were performed on the PPCB-supported partial-depth precast deck system and precast overhang panels. Two small-scale superstructures that included all the critical components of interest were designed, constructed, and tested.

After discussion with the technical advisory committee (TAC), the original research plan was adjusted and the scope of the laboratory tests were to include the partial-depth precast deck panel system with a propped cantilever precast overhang deck panel.

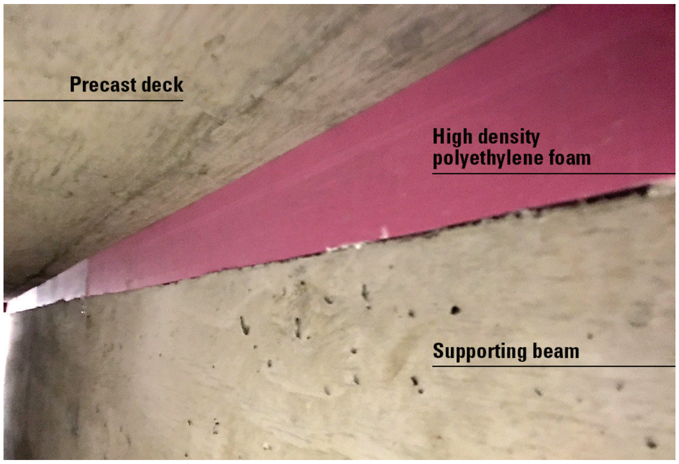


Model of proposed laboratory test specimen without a barrier or the CIP concrete deck

The characteristics of the two specimens are listed in the table.

Specimen components

Specimen	Components	Quantity
Specimen I (with barrier)	Pre-stressed interior panel	2
	Exterior panels with barrier	2
	Supporting beam	3
	CIP deck and barrier	1
	CIP barrier	1
Specimen II (without barrier)	Pre-stressed interior panel	2
	Exterior panels	2
	Supporting beam	3
	CIP deck	1



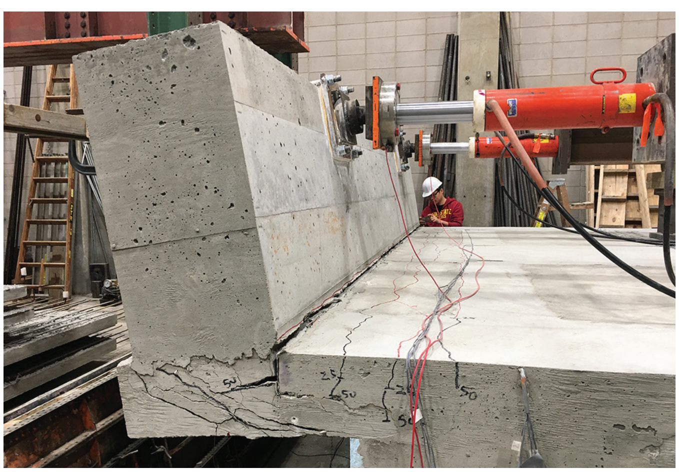
High density polyethylene foam between the precast deck panel and the supporting beam


Vertical load applied to the deck

Ten load cases, which included horizontal and vertical load applications, were conducted. The specific interests of conducting these experiments were identified as follows:

- Verify the sufficiency of the proposed polyethylene bearing between the precast deck panels and the supporting girders
- Verify the sufficiency of using flexible polyethylene foam to create an adjustable haunch form, its strength to resist the lateral pressure from CIP concrete, and the constructability of using the sealing strip in conjunction with leveling bolts
- Validate composite action between the CIP concrete deck and the precast panel by investigating the behavior of the deck panels under vertical and horizontal loads

The laboratory specimen details and construction work were carefully documented.


Horizontal load applied to the barrier

Key Finding and Implementation Readiness

- The high-density polyethylene foam has sufficient stiffness and strength to support the precast deck panels and the construction load during concrete deck placement.
- The leveling bolt with normal polyethylene foam works fine to support the deck panel and resist the lateral concrete load.
- The gluing work of the polyethylene foam needs additional attention to ensure a strong connection between the girder/deck concrete surface and the polyethylene foam.

The load test results indicated that both types of interior panels reached ultimate capacity when a point load of about 240 to 250 kips was applied, leading to punching shear failure, exceeding the demands of the bridge service life. The composite action between the CIP and precast deck concrete is functional through the load application process, and no debonding or sliding was found at the horizontal interface between the CIP and precast concrete.