Evaluation of the Buena Vista IBRD Bridge: A Furthering of Accelerated Bridge Construction in Iowa

tech transfer summary

This application and demonstration project represents an important step in the development and advancement of accelerated construction techniques in Iowa as well as nationwide.

Problem Statement

The importance of accelerated bridge construction (ABC) technologies has been realized by the Federal Highway Administration (FHWA) and the Iowa Department of Transportation (DOT) Office of Bridges and Structures. This project, which involved the construction of a two-lane single-span precast box girder bridge, is another in a series of ABC bridge projects undertaken by the Iowa DOT.

Objectives

Prior funding for the design and construction of this bridge (including materials) was obtained through the FHWA Innovative Bridge Research and Deployment (IBRD) Program. The Iowa Highway Research Board (IHRB) provided additional funding to test and evaluate the bridge.

This project directly addresses the IBRD goal of demonstrating (and documenting) the effectiveness of innovative materials and construction techniques for new bridge structures.

The objectives of this project included the following:

- Assist the Iowa DOT and Iowa county engineers in demonstrating the benefits of precast, post-tensioned bridge components and provide an opportunity for them to design and construct more cost-effective, durable bridges
- Perform testing and evaluation of precast bridge components to assess overall design, construction, and structural performance

Load testing the completed, single-span, 50 ft (center to center of supports), Buena Vista County IBRD bridge

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RESEARCH PROJECT TITLE
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SPONSORS
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CO-PRINCIPAL INVESTIGATORS
Brent Phares, Associate Director
Bridge Engineering Center
Iowa State University
515-294-5879
bphares@iastate.edu

Terry Wipf, Professor
Civil, Construction, and Environmental Engineering
Iowa State University

Jon Ites, Buena Vista County Engineer

Wayne Klaiber, Professor Emeritus
Civil, Construction, and Environmental Engineering
Iowa State University
klaiber@iastate.edu

MORE INFORMATION
www.bec.iastate.edu

Bridge Engineering Center
Iowa State University
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-8103
www.bec.iastate.edu

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.

The sponsors of this research are not responsible for the accuracy of the information presented herein. The conclusions expressed in this publication are not necessarily those of the sponsors.

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Project Description and Results

Buena Vista County, Iowa, with the assistance of the Iowa DOT and the Bridge Engineering Center (BEC) at Iowa State University, constructed this bridge using rapid construction techniques. The design involved the use of precast, pretensioned components for the bridge superstructure, substructure, and backwalls.

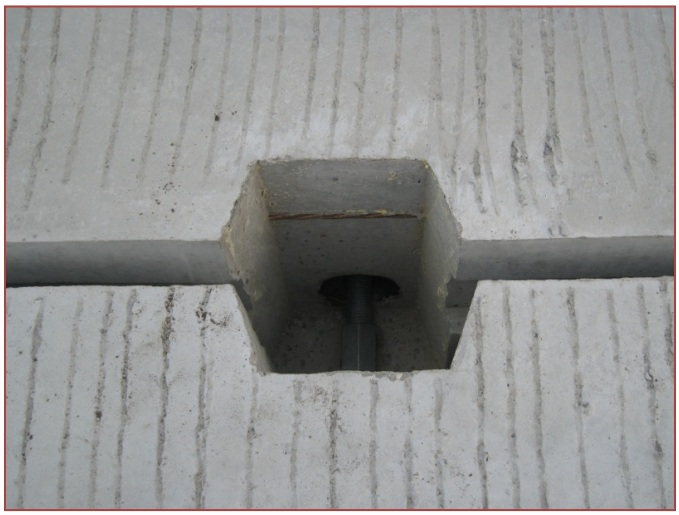
It took only five calendar days to remove the existing bridge and replace it with the new precast bridge; the approaches that were completed by county crews took an additional 14 days. Precast elements in the bridge included precast cap beams, precast backwalls, and precast/prestressed box girders. Construction of the bridge, as well as fabrication of the various precast elements, were closely observed.

Upon completion of the bridge in 2009, it was instrumented and load tested using two county trucks loaded with gravel. Approximately one year later, instrumentation was re-installed and the bridge was tested a second time to determine any changes in its performance and/or behavior in that time period.

Key Findings

- Concrete strengths in all elements exceeded design targets and the bridge performed well, as expected, with essentially no change in its behavior 13 months after construction.
- Pre-assembly of the various precast elements completed in the casting yard was definitely worth the effort. By pre-assembling, problems can be identified early and resolved before the precast elements are delivered to the bridge site, eliminating costly delays in the field.
- This bridge was completed in 18 days (from closure to reopening). Construction of the bridge (including removal of the existing bridge at the site) took only four working days. The remainder of the time was spent constructing

Fabrication form setup for one of the seven precast/ prestressed box girders/beams with Styrofoam cylinders used to create the voids



Tie rod block outs in final precast beams for tightening the interior tie rods once bridge components are in place on site

Construction of abutment cap formwork showing one of the beam lift loops near one end of the form and two of the corrugated metal pipe (CMP) pile connection openings

One of the two precast abutment caps showing pile connection openings, guardrail post anchor rod extension openings along the edge, and one beam lift loop

the roadway approaches to the bridge. Due to the low volume of traffic on this road, it wasn't necessary to actually accelerate completion of the bridge and thus the approach fill was completed using county personnel. If the bridge had been on a high-volume road and thus desired to be open as soon as possible (obviously a function of the site), it is estimated that the fill could have been completed in three days. Total road/bridge closure would have been only eight days then.

- The maximum bridge deflection measuring during testing was 0.259 in. Normalizing this value for the different between test truck weights and the weight of design trucks, this value becomes 0.479 in., which is significantly less than code requirements.
- Very small differential movement occurred between adjacent box beams. In 2009, the maximum value measured was 0.021 in. while in 2010 it was significantly less (.0027 in.). The hand-tightened transverse tie rods and grout-filled joints provide good lateral load transfer between adjacent units.
- The maximum box beam strains measured at midspan in 2009 and 2010 were 86 με and 81 με, respectively. At 28 days, the box beam concrete strength was 7,710 psi (which means the approximate modulus of elasticity of the concrete was 4.55 x 106 psi). Assuming this value for E_c mean, the maximum stresses measured in 2009 and 2010 are very small: 390 psi and 370 psi.

Construction of formwork to precast four back wingwalls, with this being the first ABC project in Iowa to use them

Recommendations

Based on observations and field testing, the following recommendations can be made:

- Prior to shipment to the field, the overall dimensions of all precast elements should be checked to see that they conform to the plans. If that had been done on this project, the delay caused by a deck beam being too large on one edge could have been eliminated.
- Non-shrink, non-metallic grout was used to fill the joints between adjacent deck beams, pockets required for tightening the transverse tie assembly, and other voids in the bridge assembly. Unfortunately, the contractor used water from the creek for mixing the grout. Depending on the impurities in the water, it could have a deteriorating effect on the grout strength and its long-term performance. In future applications, only potable water should be used in mixing the grout.
- Construction details used in the bridge resulted in minimal end-restraint. Thus, future bridges using these details should be designed as simply-supported, as was done for this bridge.
- The use for the 0.5 load distribution fraction is conservative and thus is recommended for use in the design of other box beam bridges.

Implementation Benefits

The successful implementation of the approach demonstrated with this project may have far-reaching implications in Iowa where proven rapid construction techniques could result in significant cost reductions.

Two of the four back wingwalls, each with three lifting loops and seven anchor rod openings

Driving piles with close attention to locations and tolerances using templates to position the five piles correctly

Installing west abutment cap onto pilings before cutting off the lift loops and filling CMP voids with concrete

Positioning exterior beam after extension of anchor rods along the edge of abutment caps and middle beam placement

Tightening transverse tie rods before filling block outs with epoxy grout

Placement of second back wingwall onto anchor rods and epoxy grout bed on west end of bridge

Installation of guardrail posts on south side of bridge