PROJECT

Cutler Road Bridge over the Looking Glass River

Record-setting beams provide the solution for spanning the Looking Glass River in Ionia County, Michigan

by Jordan Pelphrey, Neha Yadav, and Haley Newhouse, Williams & Works Inc.

Located approximately 2 miles east of the city of Portland, Mich., the new Cutler Road Bridge crosses the Looking Glass River and connects the townships of Danby and Portland in Ionia County. The road serves as a main access route for many residents within the community, with school buses and emergency vehicles crossing the bridge daily.

The previous bridge, which was built in 1980, was 167 ft long and 31.5 ft wide. It was considered non-historic, consisting of six timber spans with a nail-laminated timber deck structure and a bituminous asphalt wearing surface as well as timber piles, piers, and abutments. When the structure was posted for a load restriction due to deterioration of multiple components, the Ionia County Road Commission (now the Ionia County Road Department) tasked the bridge design consultant with design and construction engineering services for the replacement bridge.

The truck backs up the first 126-ton beam to the crane on the west end of the bridge. The unique erection process uses two 550-ton hydraulic cranes—one on each end of the bridge— and a custom beam launcher or "carriage" unit. All Photos: Williams & Works Inc.

Project Description

The structure type was to be either a two-span prestressed concrete spread box-beam structure or a two-span steel I-beam structure, with equal span lengths of 85 ft, a single pier located in the Looking Glass River, and five beam lines. During the permitting process, the Michigan Department of Environment, Great Lakes, and Energy (EGLE) required that no piers be located in the water because the river contains a species of mussels listed as threatened by the state. EGLE recommended using a bridge with shorter tail spans and a longer center span to avoid the water. Other measures to protect the species included a native freshwater mussel survey, relocation of 405 mussels, and continued mussel monitoring.

Rather than designing a bridge with multiple spans, the design team

profile

CUTLER ROAD BRIDGE OVER LOOKING GLASS RIVER / IONIA COUNTY, MICHIGAN

BRIDGE DESIGN AND CONSTRUCTION ENGINEER: Williams & Works Inc., Grand Rapids, Mich.

OTHER CONSULTANTS: Ionia County's engineering representative: Prein & Newhof, Grand Rapids, Mich.; geotechnical engineer, materials testing subcontractor, and prestressed concrete beam third-party inspector: Soils & Structures Inc., Grand Haven, Mich.; steel fabrication third-party inspector: Integrated Inspection LLC, Grand Haven, Mich.; asbestos testing and native mussel survey, relocation, and monitoring: ASTI Environmental, Brighton, Mich.

PRIME CONTRACTOR: Davis Construction Inc., Lansing, Mich.

CONCRETE SUPPLIER: Consumers Concrete Corporation, Kalamazoo, Mich.

PRECASTER: Prestress Services Industries LLC, Decatur, Ind.—a PCI-certified producer

The first beam travels on the beam launcher. Once the beam is within reach of the crane on the opposite (east) side, both cranes set

selected a single-span option. They chose prestressed concrete because it was found to be the lowest-cost option for materials, and they proceeded with a design solution that eliminated six beams and a pier in the water.

The new bridge is 175 ft 0 in. long and 35 ft 4 in. wide, and has a 25-degree skew. The superstructure consists of four 84-in.-deep bulb-tee beams spaced at 9 ft 4 in. with a 9-in.-thick cast-in-place (CIP) concrete deck using epoxy-coated reinforcing steel. The span and beam lengths are 171 ft 0 in. and 173 ft 0 in., respectively. Other bridge components include steel H-piles, CIP concrete footings and abutments, lightweight expanded polystyrene fill blocks (to reduce pile loading), steel sheet piling, and four-tube steel railing. To accommodate the depth of the superstructure, which was greater than that of the existing six-span timber bridge, the grade was raised approximately 6 ft.

The design of the structure was based on 1.2 times the HL-93 loading specified in the ninth edition of the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*,[1] except that the design tandem portion of the HL-93 load definition was replaced by a single 60-kip axle load before application of the 1.2 factor. This resulted in a load designation of HL-93 MOD, which is typical of Michigan Department of Transportation (MDOT) bridge designs. All work on the project is according to the project special provisions and MDOT's *2020 Standard Specifications for Construction*.[2]

According to MDOT, the Cutler Road Bridge is the longest single-span prestressed concrete bridge over water

The 7-ft-deep prestressed concrete beams are among the largest in use in Michigan.

IONIA COUNTY ROAD DEPARTMENT, OWNER

OTHER MATERIAL SUPPLIERS: Crane subcontractor: Erickson's, Grand Rapids, Mich.; steel rail and diaphragm fabricator: Cardinal Fabricating Inc., Williamston, Mich.

BRIDGE DESCRIPTION: Single-span 175-ft-long (171-ft span length), 32-ft-wide clear roadway (35-ft 4-in. out-to-out width) bridge with a two-lane skewed deck, precast, prestressed concrete bulb-tee beams, and 20-ft-long concrete approach slabs

STRUCTURAL COMPONENTS: 173-ft-long, 7-ft-deep, precast concrete bulb-tee beams with a 4-ft 1-in.-wide top flange, 9-in.-thick cast-in-place reinforced concrete deck, cast-in-place reinforced concrete abutments, wing walls, approach slabs, and sleeper slabs

BRIDGE CONSTRUCTION COST: $4.43 million

Placing the deck on the Cutler Road Bridge.

Aerial view of all four beams in place. The single-span solution eliminated six beams and a pier in the water.

in Michigan and the second-longest span overall in the state (the longest span is 171 ft 6 in.). Each beam weighs 126 tons and includes 84 permanent 0.6-in.-diameter pretensioning strands, with six of the strands located in the top flange to improve lateral stability and control stresses during lifting, transportation, and installation. The concrete compressive design strengths are 7200 psi at transfer and 8200 psi at 28 days. The beam manufacturer reported average as-built concrete strengths of approximately 8800 psi at transfer and 13,000 psi at 28 days.

Prestressed concrete spans longer than 160 ft are uncommon in Michigan, so much so that the beam's cross-sectional depth of 84 in. is not listed in MDOT's Bridge Design Guides[3] or Bridge Design Manual,[4] which report a maximum depth of 72 in. The beam manufacturer was consulted early in the design phase to ensure that a beam this deep and long could be fabricated and transported to the bridge location.

Because their history of projects in the state using prestressed concrete beams over 160 ft was limited, the design team added a special provision that required the precaster to perform an independent beam lateral stability and stress analysis conforming to PCI's *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders*,[5] and the AASHTO LRFD specifications to ensure that the beams would be laterally stable during lifting, transportation, and installation. Under this special provision, a licensed professional engineer had to sign the analyis and the precaster was required to monitor and record beam camber and sweep at various time intervals.

Design

In addition to restrictions related to the protection of the threatened mussels species, several other restrictions came from the permitting process. No in-water work was to take place between March 1 and June 30, when warm-water fish species migrate and spawn. The project is in an area that provides habitat for the federally threatened eastern massasauga rattlesnake, so the use of certain types of materials for soil erosion and sediment control was restricted. It is also within the range of the northern long-eared bat, which is federally listed as an endangered species, as well as the Indiana bat; therefore, tree removal was not allowed between April 1 and September 30.

The project's design schedule was slowed by multiple challenges. First, after the COVID-19 pandemic started, collaboration between staff and agencies on design work was impaired for several months as people adapted to working from home. Also, while the team was completing the design, MDOT updated its *2012 Standard Specifications for Construction*. All design work then had to conform to the new 2020 edition of the specifications, so a significant number of revisions were required. The schedule was also affected as staffing changes across the entire team led to schedule postponements.

Construction

These design schedule delays resulted in the project not going out for bid until February 2022, a full year later than originally planned. MDOT awarded the construction contract to the contractor on March 29. As previously mentioned, tree removal had to be completed before April 1 to avoid potential disturbance of bats. More than 60 trees were removed within two-and-a-half days. Once tree removal was completed, the contractor shifted focus to bridge removal. At that point, the team found that a previously undiscovered utility, hidden under the railing, extended across the bridge. Relocating the utility delayed the project an additional six weeks, with construction restarting on May 10.

The four prestressed concrete beams were erected on September 20 and 21, 2022, with two beams set each day. Transportation from the prestressing plant in Indiana to the Michigan–Indiana border required a police escort. The precaster carefully planned the route by selecting navigable intersections and avoiding active construction. After a beam-transporting truck exited the freeway, it was backed down Cutler Road to the bridge site, approximately 1.7 miles from the exit.

Two 550-ton hydraulic cranes were placed on either side of the bridge. The contractor installed a temporary beam launcher, consisting of two steel wide flange sections and several steel cross members, to assist in erecting the beams. The ends of the launcher were placed on the east and west abutments. The launcher included three temporary supporting H-pile bents located at the quarter points.

The Cutler Road Bridge was opened to traffic in December 2022.

Beam erection began by the truck driver backing the truck up to the crane on the west side of the bridge; then, the crane lifted one end of the beam. The truck driver continued to back up the truck while the crane positioned the beam on the launcher's traveling carriage unit. The beam was unhooked from the crane after it was secured to the carriage unit. The truck driver continued to back up the truck while the beam traveled on the carriage unit along the launcher. Once the beam was backed up far enough, the crane was used to pick it from the truck. Meanwhile, on the east side of the bridge, the contractor connected a steel cable to the carriage unit and began pulling the beam toward the abutment while the crane on the west end guided it. Once the beam was within reach of the east crane, the east crane picked the beam from the carriage unit, and both cranes were used to set the beam in place.

After beam erection, the contractor completed construction on the remaining elements of the bridge, including placing the concrete deck, paving, and installing guiderail. The bridge was opened to traffic on December 22, 2022.

Through collaboration, the design team and the contractor successfully surmounted environmental restrictions, beam delivery and erection challenges, and a pandemic to achieve a successful project.

References

1. American Association of State Highway and Transportation Officials (AASHTO). 2020. *AASHTO LRFD Bridge Design Specifications*, 9th ed. Washington, DC: AASHTO.
2. Michigan Department of Transportation (MDOT). *2020. 2020 Standard Specifications for Construction*. Lansing, MI: MDOT. https://www.michigan.gov/mdot/-/media/Project/Websites/MDOT/Business/Construction/Standard-Specifications-Construction/2020-Standard-Specifications-Construction.pdf.
3. MDOT. n.d. English Bridge Design Guides. Accessed May 9, 2023. https://mdotjboss.state.mi.us/stdplan/englishbridgeguides.htm.
4. MDOT. n.d. English Bridge Design Manual. Accessed May 9, 2023. https://mdotjboss.state.mi.us/stdplan/englishbridgemanual.htm.
5. Precast/Prestressed Concrete Institute (PCI). 2016. *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders*. CB-02-16. Chicago, IL: PCI.

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FHWA *Lightweight Concrete Bridge Design Primer* –

A Tool for Designing and Building Lightweight Concrete Bridges

Photo by: FHWA

In this issue of *ASPIRE*, the *FHWA* article by Holt and Castrodale recalls the over 100 year history of using lightweight concrete in the United States. The material has been used for bridges since shortly after lightweight aggregate was first manufactured here in 1920. Although several major documents have been published since then that described the benefits of designing bridges with lightweight concrete, its use remains limited.

The article then presents benefits for using lightweight concrete, including obvious advantages related to the reduced weight of concrete elements, but also less obvious advantages related to durability since lightweight concrete has been shown to have "equal or improved durability compared to normal-weight concrete with the same compressive strength." Its enhanced durability is surprising to many engineers who wonder how porous lightweight aggregate can make more durable concrete than conventional aggregate. Several reasons are listed, including the increased absorption of lightweight aggregate that provides a unique benefit by releasing absorbed water into the concrete to cure it from within. This feature is especially beneficial for low permeability concrete mixtures typically used in transportation structures. This benefit is called "internal curing"; it is one initiative in FHWA's Every Day Counts (EDC) program – see "Enhancing Performance with Internally Cured Concrete (EPIC^2)" on the EDC-7 webpage: https://www.fhwa.dot.gov/innovation/everydaycounts/edc_7/

The most important feature of the article is its introduction to the FHWA *Lightweight Concrete Bridge Design Primer*, which presents the background and details for design and construction of bridges using lightweight concrete. It also informs "owners, designers, specifiers, and contractors ... [how] to properly evaluate the potential [costs and] benefits of using lightweight concrete."

This important document may be downloaded at:
https://www.fhwa.dot.gov/bridge/concrete/hif19067_Nov2021.pdf

Additional information on lightweight concrete bridges can be found at
www.escsi.org

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate