Replacement of the M-50/I-96 Bridge

MAKING EVERY DAY COUNT

by Bruce L. Campbell, Parsons

The Federal Highway Administration's (FHWA's) current research concludes that 25% of our nation's 600,000+ bridges need repair or replacement on highways that are already heavily congested without the added strain of road closures. In 2009, the FHWA launched the Every Day Counts initiative in cooperation with the American Association of State Highway and Transportation Officials (AASHTO). Goals of this initiative included reducing highway project delivery schedules and providing workable innovations to combat budget challenges, which commonly prevent jurisdictions from tackling much-needed infrastructure projects.

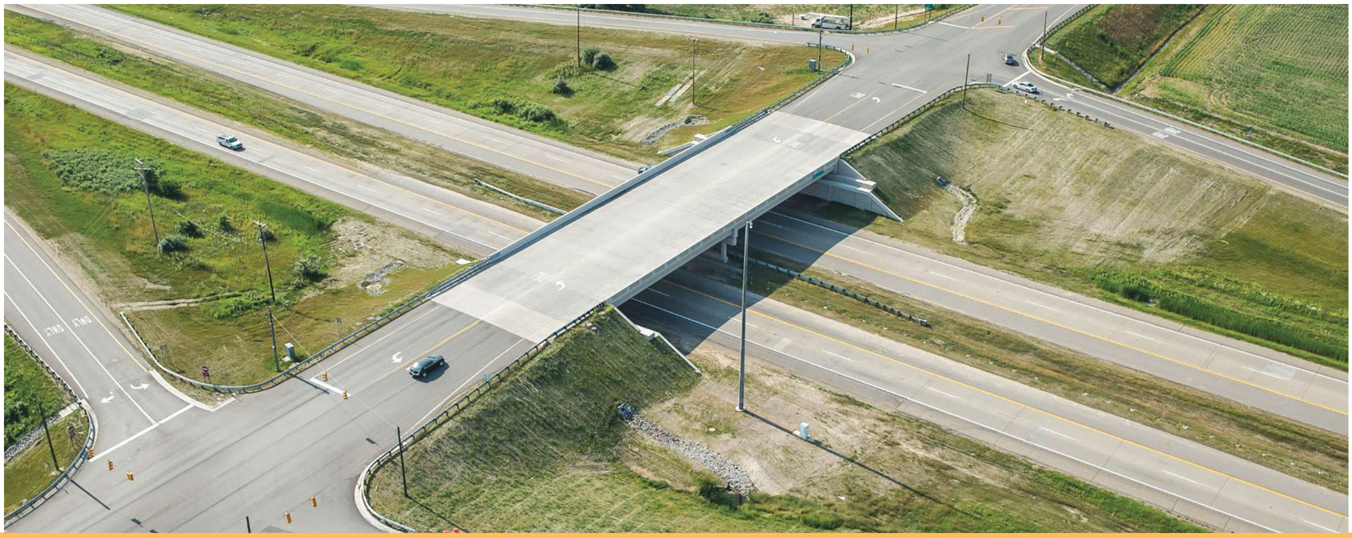
One of the ways that the Every Day Counts initiative is being implemented is through accelerated bridge construction (ABC) methods. ABC technologies are changing the ways departments of transportation (DOTs) across the country do business. Slide-in bridge technology is an ABC method that significantly decreases traffic delays and road closures, improves motorist and worker safety, and reduces project costs.

By advancing twenty-first century solutions, the highway community is ensuring that the nation's roads and bridges are being built better, faster, and smarter. The M-50/I-96 Bridge slide in Lowell Township, Mich., is part of the FHWA's Every Day Counts initiative and is a prime example of the use of innovative ABC technology. According to Roger Safford, an engineer with the Michigan Department of Transportation (MDOT), "This is the type of quality project every engineer wants to be a part of. . .unique, innovative, and extremely effective. Working with such a diverse group of people and watching it unfold the way we intended was very fulfilling. I'm proud that Michigan has raised the bar and set a new standard for bridge replacement."

Project Overview

The $8.1 million replacement of the 1959 concrete-haunched T-beam bridge carrying M-50 over I-96 in Kent County,

Completed replacement of the M-50/I-96 Bridge. Photo: Michigan Department of Transportation.



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M-50/I-96 BRIDGE / LOWELL TOWNSHIP, MICHIGAN

BRIDGE DESIGN ENGINEER: Michigan Department of Transportation, Lansing, Mich.

TEMPORARY WORKS/SLIDE ENGINEER: Parsons, Pasadena, Calif.

PRIME CONTRACTOR: Anlaan Corporation, Grand Haven, Mich.

TRAFFIC ENGINEER: HH Engineering Ltd., Detroit, Mich.

SLIDING SUBCONTRACTOR: Mammoet USA South Inc., Rosharon, Tex.

PRECASTER: Stresscon Industries Inc., Shelby Township, Mich.—a PCI-certified producer

M-50 over I-96 traffic on new superstructure in temporary alignment. Photo: Michigan Department of Transportation.

Mich., is part of a complete interchange reconstruction project and represents the state's longest, heaviest, and most rapid bridge lateral slide to date. The project, which is the third lateral slide-in bridge for MDOT, was delivered using a construction manager/general contractor (CM/GC) method. MDOT's own design team produced the final structure design.

An Innovative Solution

The M-50/I-96 interchange serves the community of Lowell, Mich., which has heavy commuter traffic to and from the nearby city of Grand Rapids, Mich. It was evident that the closure of M-50 for bridge replacement would lead to a lengthy detour over rural roads that could not handle the traffic volume. So MDOT, in consultation with the local community, investigated options to reduce mobility impacts of the bridge replacement. This led MDOT to explore ABC options and to eventually select the ABC solution of slide-in bridge technology.

Slide-in bridge technology would substantially mitigate impacts on weekday commuter traffic as well as high traffic volumes on I-96, limiting closure of M-50 to less than five off-peak days over the life of the contract, with no more than two consecutive days of closure at any one time. I-96 closures, other than intermittent closures for beam placement, were not permitted. This is significantly less than the 6 months of traffic detours required for typical bridge construction involving the demolition of an old bridge and construction of a new bridge in its place.

This project is an example of how innovation can be applied to a traditional bridge design. MDOT designed the bridge with spread, 39-in. precast, pretensioned concrete box beams, a cast-in-place concrete deck, cast-in-place concrete barrier railings, on a steel H-pile supported abutment and spread footing pier. This structural system was selected due to its economy, site parameters, and long-term durability. The existing concrete arch bridge had a variable depth of 3 to 6 ft, so the 39-in.-deep box beams were only an incremental difference in the overall structure depth. Cost and fabrication lead-time for structural steel beams were a major consideration. The mass of the concrete box beams was not an issue for the slide-in.

While the ABC technique of slide-in bridge technology resulted in the biggest reduction in lane closure time, a temporary traffic runaround that routed M-50 traffic onto a temporary structure in order to limit traffic impacts was also used. Other innovations, such as partial-width substructure construction and temporary concrete pier caps in lieu of traditional steel caps, further reduced the construction schedule and cost.

Construction

The existing four-span, two-lane bridge was replaced with a wider two-span, five-lane structure. The profile of the new structure was raised to provide adequate under-clearance, which led to reconstruction of the ramps to accommodate the new vertical profile. The new abutments were pile-supported infill, with mechanically stabilized earth (MSE) retaining walls supporting the fill.

With the goal of reducing mobility impacts, the new superstructure was constructed immediately west of the existing bridge from May through July 2014. It was supported on temporary piers and a portion of the new abutments. Temporary roadway approaches and signals were also constructed during this time. Below, I-96 had intermittent 15-minute nighttime closures to set the new beams. The M-50 traffic was then

New superstructure on temporary supports (left) with existing bridge (right). Photo: Parsons.

MICHIGAN DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: The existing four-span structure was replaced with a new bridge that was 33 ft wider to accommodate two additional lanes, including left-hand turn lanes and two full 10-ft shoulders to bring the bridge up to standard.

STRUCTURAL COMPONENTS: Twenty-two (11 each span) 99-ft-long precast prestressed box beams; cast-in-place concrete deck; cast-in-place concrete pier cap, columns, and footing; cast-in-place concrete abutment; and mechanically stabilized earth retaining walls

BRIDGE CONSTRUCTION COST: $8.1 million

AWARDS: Engineering Honorable Conceptor Award from American Council of Engineering Companies (ACEC) diverted to the new structure in its temporary position while the old bridge was demolished.

During the weekend demolition of the existing bridge, M-50 was closed and I-96 traffic was reduced to one lane in each direction and routed up and over the diamond interchange ramps. Then the new bridge permanent location substructure was built along with the remainder of the interchange improvements.

On Friday night, October 17, 2014, M-50 was closed for a second time and I-96 traffic was again reduced to one lane in each direction and routed up and over the diamond interchange ramps. Crews then slid the new M-50 bridge superstructure into place. Three hydraulic jacks were used to laterally move the 4.5 million-pound concrete superstructure 75 ft to its permanent location over I-96. The next morning at 7 a.m., crews began placing the concrete approach slabs, and after curing, completed the temporary railings and pavement markings. By Monday morning at 5 a.m., M-50 was reopened for the morning rush hour.

Design Complexity

A number of design challenges were encountered on this project. It is unusual for a bridge that will eventually be slid into an adjacent permanent location to carry traffic in the temporary alignment because the addition of live traffic loads creates additional design complexity for the temporary support structures and temporary approaches.

The addition of traffic to the temporary substructure, which consisted of a steel pile bent pier with a steel cap, required adding AASHTO design vehicular live loads to the structure. This resulted in a substantial increase in the size of the temporary members; for example, the temporary pier cap beam was a W14 x 426 section. The addition of live loads also requires that all welding for the temporary steel bent be done to AWS D1.5 versus D1.1 and that all welds be fully tested. This adds time and cost to the welding. To avoid some of these impacts, the connections were designed to be bolted.

Prior to start of construction, the CM/GC suggested using a concrete cap in lieu of the steel beam, which reduced costs and shortened the schedule due to the long lead time for the fabrication of a steel beam of this size. Two steel tee shapes were cast into the top of the concrete cap to provide a level and weldable surface for the sliding system channel.

The replacement of the four-span structure with a shorter two-span structure, as well as differences in the vertical grade, led to the design of a complex part-width construction of the approach fill. The design utilized a temporary sheet pile wall, combined with a temporary longitudinal MSE wall, to construct the part-width fill.

The temporary runaround of traffic onto the bridge also required the development of a 25-ft temporary approach span. It was created using 12-in.-deep, non-voided, post-tensioned concrete box beams that sat on the temporary pile bent with concrete caps, and an all-steel bent at the roadway approach. This design facilitated the rapid removal of the slabs prior to the bridge slide.

Construction Challenges

In order to avoid the need to vertically jack the structure to set bearings, the bridge was constructed on the sliding system channel, temporary bearings, and permanent bearings. The temporary and permanent bearings were elastomeric with a polytetrafluoroethylene (PTFE) surface. The sliding shoes, which were a part of the permanent superstructure, had a stainless steel sliding surface. Having the structure rest on the sliding bearings for a long period of time did not cause any issues with breakout forces. However, construction debris and dirt did foul the bearing surfaces and there was not sufficient space between the sliding channel and superstructure to adequately clean the surfaces.

The fouling of the sliding bearings led to some damage and movement of the bearings during the slide. At one point the slide had to be reversed to remove a bearing that became lodged on top of an adjacent bearing after it broke the restraining pintle and slide on top of the adjacent bearing pad. Also during the sliding operation, the middle jack began to experience problems. Since breakout

Temporary pier and span 1 beams in sliding track. Photo: Michigan Department of Transportation.

had already occurred, the contractor was able to complete the move using the jacks positioned on each abutment.

'All bridge replacements should be like this!'

Project Success

Upon project completion, the traveling public in Michigan experienced less traffic congestion and a much safer road. The new structure was now 33 ft wider, accommodating two additional lanes, including left-hand turn lanes and full 10-ft shoulders. Through the use of slide-in bridge technology that prevented prolonged lane closures and long detours, MDOT estimates that motorists saved approximately $3 million in time and travel-related costs. In addition, commercial and industrial activities in the area remained viable with limited disruption of highway access to their locations. One local resident put it, "As a business owner and resident of Lowell, I was worried about this project and the delays it would cause. I attended the public meetings and checked the project website regularly. The animation video spoke volumes about the intent and complexity of this new method. My reservations were unnecessary. All bridge replacements should be like this! What a cool project!"

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