PROJECT

New Long X Bridge Merges History with Modern Design

by David Finley and members of the Bridge Division, North Dakota Department of Transportation

The historic Long X Bridge was originally built in 1959 as a two-lane Warren through-truss bridge along U.S. Highway 85 (U.S. 85) over the Little Missouri River. Located in the scenic Badlands of North Dakota, the bridge is named to pay tribute to the Long X Ranch, the largest cattle ranch in McKenzie County in the 1880s era of cattle drives and open range in Dakota Territory, and the Long X Trail, a route used to move cattle from southern parts of the country to eastern Montana and western North Dakota. Both the ranch and the trail are staples of the state's Western heritage and ranching culture.

The bridge serves as a gateway to the north unit of the Theodore Roosevelt National Park and the Bakken oil formation, one of the largest oil developments in the country. This heavily traveled corridor plays a vital role in the economic development and tourism industry for the state.

In July 2019, the North Dakota Department of Transportation (NDDOT) began a two-year, $37 million project consisting of 1.77 miles of highway reconstruction, including replacement of the Long X Bridge on a new alignment east of the existing bridge, and construction of North Dakota's first wildlife crossing built underneath U.S. 85.

The new Long X Bridge is a five-span prestressed concrete girder bridge, which accommodates two 12-ft driving lanes in each direction, and a concrete median barrier. The four-lane bridge is designed to accommodate the heavier loads of today's truck traffic while also removing the original structure's horizontal and vertical clearance restrictions. The new bridge plays an integral role in the upcoming 62-mile, four-lane expansion project from Watford City to Interstate 94 on U.S. 85.

Traffic on U.S. Highway 85 and half of the new Long X Bridge over the Little Missouri River as the old bridge is deconstructed. All Photos and Figures: North Dakota Department of Transportation.

profile

U.S. HIGHWAY 85 BRIDGE OVER THE LITTLE MISSOURI RIVER AND WILDLIFE CROSSING / NEAR WATFORD CITY, NORTH DAKOTA

DESIGN ENGINEERS: Highway bridge: North Dakota Department of Transportation (NDDOT), Bismarck, N.Dak.; south abutment foundation design: Shannon & Wilson Inc., Denver, Colo. Wildlife crossing: NDDOT, Bismarck, N.Dak.; Contech Engineered Solutions LLC, West Chester, Ohio; Civil Design Professionals, Bloomington, Minn.

CONSTRUCTION ENGINEER: AECOM, Bismarck, N.Dak.

PRIME CONTRACTOR: Ames Construction, Burnsville, Minn.

PRECASTERS: Bridge beams: Forterra Building Products, Menoken, N.Dak., and Elk River, Minn.—a PCI-certified producer Wildlife crossing arch structure: Forterra Building Products, Rapid City, S.Dak.—a PCI-certified producer

SPECIALTY CONTRACTOR: Drilled shafts and post-tensioned ground anchors: Malcolm Drilling Company, Salt Lake City, Utah

Construction of the new Long X Bridge on U.S. Highway 85 over the Little Missouri River in the Badlands of North Dakota. Girders for all five spans have been erected, and epoxy-coated reinforcement is being placed for the cast-in-place concrete deck at the far end.

Girders have been erected for the first span of the new Long X Bridge. Formliners were used on all piers to simulate stonework. Wall-type piers were used to limit debris blockage in the channel.

"The completion of the bridge and wildlife crossing will greatly enhance the efficiency of the transportation system in the state," says NDDOT director Bill Panos. "While our number one priority is always safety, we also want to provide the best experience possible for the traveling public."

The State of North Dakota and the NDDOT are investing in this corridor to ensure it is a safe and accessible passageway through the western part of the state. Two lanes of the bridge were officially opened to traffic in October 2020, and the project was fully opened as of June 2021.

"We recognize that U.S. Highway 85 and the Long X Bridge are essential to the transportation needs in western North Dakota," says Panos. "This bridge will serve as an economic development tool, and was an amazing engineering and community effort from our team, the contractors, and all cities in the area."

End of an Era

It became apparent over a decade ago, during the state's oil boom, that the old Long X Bridge could no longer accommodate the current traffic volume.

In fact, during the peak of the boom, more than 4200 vehicles crossed the structure daily, with the majority being truck traffic from the oil and agriculture industries. Many trucks transporting oversized or overweight loads were unable to cross the structure due to width, height, and weight restrictions.

Overheight vehicle strikes to the bridge were frequent, and the damage created lengthy closures and costly repairs for the state. The temporary closures resulted in detours up to 75 miles long, adding considerable travel time and costs for motorists.

"The old bridge was a bottleneck for moving oversize freight into the region," says NDDOT state bridge engineer Jon Ketterling. "Not only did it limit loads traveling on this important highway, but the bridge was also often damaged by overheight loads. It was clear to us that the bridge needed to be replaced, and we made it a priority."

These issues, along with the age of the bridge, ultimately led NDDOT to move forward with a redesign with no overhead clearance limitations. According to Ketterling, moving away from the overhead truss system eliminates all of the height restrictions once associated with the Long X Bridge, allowing traffic to flow more easily through U.S. 85 and western North Dakota.

The New Bridge

The new Long X Bridge is 790 ft long and 85 ft wide. It has two 40-ft divided clear roadways and ample room to accommodate the current traffic volume and the wider loads that need to move along this corridor.

The bridge substructure units are supported on steel H piling, except for

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Four-lane, 790-ft-long, 85-ft-wide, five-span prestressed concrete I-beam bridge with cast-in-place deck; nearby wildlife crossing with proprietary twin-leaf precast concrete arch system, 60-ft-wide span, 18 ft rise, 150 ft long

STRUCTURAL COMPONENTS: Bridge: 8-in.-thick cast-in-place concrete deck, sixty 81-in.-deep prestressed concrete I-beams; 7 steel-encased drilled shafts (8 ft diameter × 130 ft) and 145-ft-long ground anchors supporting the cast-in-place concrete south abutment, pile-supported cast-in-place concrete north abutment and piers, cast-in-place concrete diaphragms and approach slabs. Wildlife crossing: fifty 6-ft-wide precast concrete half-span arch segments on pile-supported cast-in-place concrete footings, mechanically stabilized earth headwalls and wingwalls

OTHER MATERIAL SUPPLIERS: Bridge abutment ground anchors: Dywidag-Systems International USA Inc., Bolingbrook, Ill. Wildlife crossing: mechanically stabilized earth wing walls and headwalls keystone retaining wall systems: Kanta Products Inc., Three Forks, Mont.

CONSTRUCTION COSTS: Bridge: $17.34 million ($256/ft^2); wildlife crossing: $3.08 million ($338/ft^2); total project cost: $33.97 million

One span of 81-in.-deep precast concrete beams has been erected as construction of the piers continues on the new Long X Bridge. Delivery trucks were able to use the construction causeway to get girders near their placement span. Two cranes were used to lift the ends of the beams and walk them to their final location.

the south abutment, which is supported on 8-ft-diameter drilled shafts. The pier aesthetics were chosen to reflect the historic nature of the original structure and scenic setting. Pile-driving restrictions were in place due to the proximity of the bridge to Theodore Roosevelt National Park, and a privacy fence was constructed between the worksite and the park to obstruct the view of the construction site from the park. There was also a spawning restriction in place that limited work in the river during certain times of the year. A 50-ft-wide opening in the channel was required at all times.

The superstructure consists of an 85-ft-wide, 8-in.-thick cast-in-place concrete deck supported on sixty 81-in.-deep, 156-ft-long prestressed concrete I-beams. The fabricator made modifications to the original beam design to accommodate stresses during transportation. Some beams were produced in Elk River, Minn., and some were produced in Menoken, N.Dak.

The bridge geometry is straightforward, with a tangent horizontal alignment and a vertical alignment with a constant grade of –1.47% from south to north along the length of the bridge.

The design strengths of the concrete are 3000 psi for the substructure, 4000 psi for the superstructure and drilled shafts, and 8000 psi for the precast concrete beams.

The bridge required nearly 5500 yd^3 of concrete, more than 9300 ft of precast concrete girders, and nearly 940,000 lb of reinforcing steel.

"We are extremely proud of the work our engineers and contractors put into this project," says Panos. "The amount of time and effort that went into making this project possible truly shows the commitment and professionalism of everyone involved."

Construction Challenges in the Badlands

When designing and building the bridge, the variety of soil conditions present in the Badlands required engineers to accommodate constantly shifting terrain. In fact, part of the bridge is located on an active landslide.

"The soil conditions were investigated thoroughly beforehand and were planned for through the contract documents," says Ketterling. "The new bridge has a unique design to account for the on-site soil conditions."

Inclinometer readings indicated movement near the south abutment of the existing bridge at a depth of about 50 ft. The NDDOT elected to design the south abutment of the bridge to resist landslide loading using drilled shafts tied-back with ground anchors.

"The south abutment was founded on five 8-ft-diameter drilled shafts that required anchoring to resist the ground instability detected in this area," says Ketterling. "In addition, ground monitoring sensors were installed to detect future soil movement."

The key was to resist landslide loads and not to stabilize the landslide, which would be nearly impossible because of the volume of the landslide mass above the south abutment. By allowing the bridge foundations to resist future movement of the ground as it flows around the foundations, the design was more economical than attempting to stabilize the hillside with a conventional factor of safety.

The design incorporated an outboard, non-load-bearing drilled shaft outside of the bridge footprint. This innovative solution was implemented because three-dimensional analyses showed that

Precast concrete arch segments are erected for the wildlife crossing beneath U.S. Highway 85. The arch provides a 60-ft-wide, 18-ft-tall space to accommodate wildlife passage.

Pier construction on the new Long X Bridge.

The completed new four-lane Long X Bridge on U.S. Highway 85 over the Little Missouri River. The temporary construction causeway has been removed and the river channel has been restored.

The replacement of the Long X Bridge was part of a $37 million North Dakota Department of Transportation project that included 1.77 miles of highway reconstruction as well as construction of North Dakota's first wildlife crossing built underneath U.S. Highway 85.

the inner shafts received less load than the outboard shaft, which attracted higher loading in a flowing ground scenario.

The total post-tensioning force for the 15 ground anchors was 2775 kip with the 185-kip lock-off load at each anchor. All the ground anchors were proof-tested at higher loading.

Wildlife Crossing

When transitioning the roadway from two lanes to four, the NDDOT placed a focus on roadway safety and worked with its partners to help reduce animal-vehicle collisions. A wildlife crossing featuring a precast concrete tunnel under U.S. 85 was built just south of the new Long X Bridge.

The structure consists of a proprietary twin-leaf arch system comprising fifty 6-ft-wide precast concrete half-arch segments supported on a cast-in-place, pile-supported foundation. Because the soils in this region are highly erodible, the foundation is supported by 80 HP14x89 steel piles. The roadway embankment is retained using mechanically stabilized earth headwalls and wingwalls.

The 150-ft-long structure was designed to provide a 60-ft-wide span and an 18-ft-tall space to accommodate wildlife passing under U.S. 85. "It was determined that bighorn sheep need a clear opening of 15 ft high by 40 ft wide for the animals to feel comfortable enough to move through the crossing," says Ketterling. This design is the first of its type in North Dakota and provides a better passageway for area inhabitants such as bighorn sheep, elk, and deer.

"The North Dakota Badlands is a prime habitat for many wildlife species, especially bighorn sheep," says Ketterling. "After conducting a wildlife assessment and consulting with agencies during the environmental process, it was decided the wildlife crossing was necessary to ensure connectivity of the bighorn sheep habitat and to reduce animal-vehicle collisions."

It is estimated that there are 3200 animal-vehicle collisions each year in North Dakota, resulting in $50 million per year in vehicle damage/repairs, insurance claims, hospital bills, towing, cleanup, and value associated with wildlife. The goal of this crossing is to help reduce these numbers and improve safety along the corridor.

Fate of the Old Bridge

The original Long X Bridge was eligible to be listed in the National Register of Historic Places. For this reason, the south span of the through truss was put up for adoption and will be preserved by a North Dakota rancher. This 250-ft-long section of the old Long X Bridge has been relocated to the adoptee's property and will be subsequently reconstructed over the Beaver Creek southeast of Linton.

"The old Long X Bridge served the public well over the last 60 years, and it is nice to see a small portion of its history live on," says Panos.

David Finley is external communications manager for the North Dakota Department of Transportation in Bismarck.

The south abutment of the new bridge has a unique design to account for shifting soil conditions. The south abutment is founded on five 8-ft-diameter drilled shafts that are anchored to resist landslide loading. Ground monitoring sensors were installed to detect future soil movement.