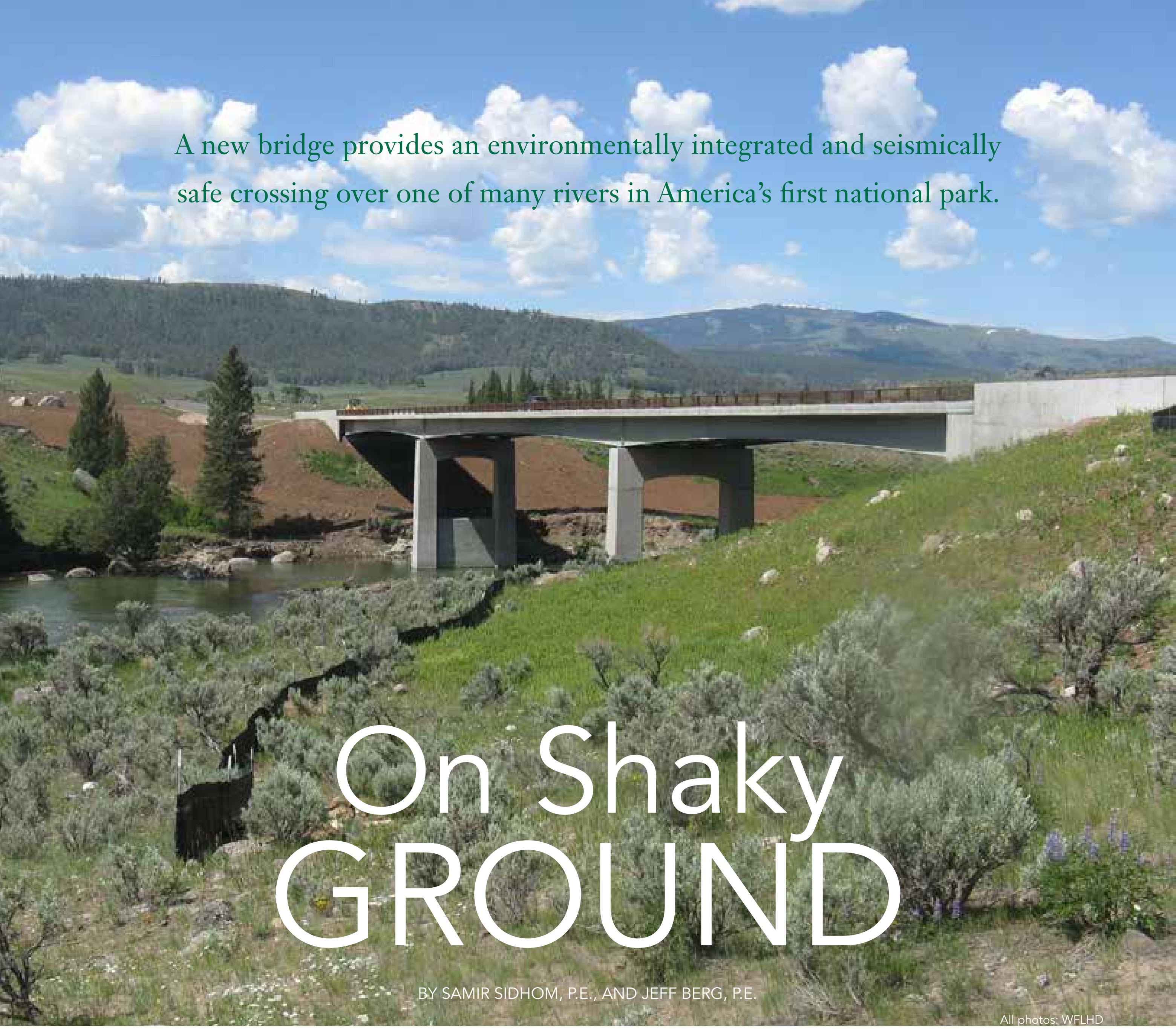


A new bridge provides an environmentally integrated and seismically safe crossing over one of many rivers in America's first national park.

On Shaky GROUND

BY SAMIR SIDHOM, P.E., AND JEFF BERG, P.E.

All photos: WFLHD


Samir Sidhom (samir.sidhom@dot.gov)) is a functional team lead with the Central Federal Lands structure group and was the bridge design team leader for the project. **Jeff Berg** (jeff.berg@dot.gov) is a structural engineer with the Western Federal Lands structure group and was a bridge team member on the cross-functional design team for the project.

YELLOWSTONE NATIONAL PARK is home to a variety of wildlife, beautiful landscapes and uncanny geothermal features.

More than 3 million people visit the park every year, and most of them will cross multiple bridges over the park's many water features during their visit. One of these is (or rather was) the Lamar River Bridge, a 335-ft-long, three-span steel structure, built in 1940, that spanned 35 ft to 40 ft above the Lamar River and provided access to the wildlife-rich Lamar Valley and the gateway communities of Silver Gate and Cooke City, Mont.

Due to: severe concrete deck and curb deterioration, which had required the restriction of the permissible loads crossing the structure; the deterioration of the lead-based paint on the steel superstructure; the fracture-critical nature of the girders and floor beam system; and the seismic vulnerability inherent in the 1940 design of the structure, by 2006 it was determined that the bridge was structurally deficient and nearing the end of its service life. In 2007, the Western Federal Lands Highway Division (WFLHD) of the Federal Highway Administration (FHWA), in partnership with Yellowstone National Park, proposed to repair, rehab and/or replace the structure and as such, sought to determine a list of feasible alternatives associated with such work. In February 2008 an engineering study evaluated four courses of action:

1. Rehabilitate the existing bridge and widen the deck.
2. Rehabilitate the existing bridge and replace the entire superstructure.
3. Replace the existing bridge with a new superstructure on the existing alignment.
4. Replace the existing bridge with a new structure on a new alignment immediately adjacent to the existing bridge (a centerline shift).

During the scoping process, Yellowstone solicited public input for any information or suggestions for consideration before developing the environmental assessment plans. In June of 2009, a draft environmental assessment study performed by the Park determined that constructing the new bridge adjacent to the existing bridge would eliminate the need for temporary bridge, offer the most cost-effective, long-term solution to address the deficiencies of the existing bridge and provide for 75+ years of safe, reliable service at this important river crossing.

Updated for Tremors

Due to high seismic activity and active faults within 50 miles of the project area (the park sits atop a massive underground volcano) the study assessed the seismic vulnerability of the existing bridge. It revealed that abutments and piers didn't have the adequate reinforcement to withstand a seismic event and that the shallow foundations were subject to rocking during a potential tremor; they were classified as scour-critical, which could eventually undermine the structural integrity of the bridge. The study also found the bridge railings and approach railings didn't meet current AASHTO standards for crash-tested rails.

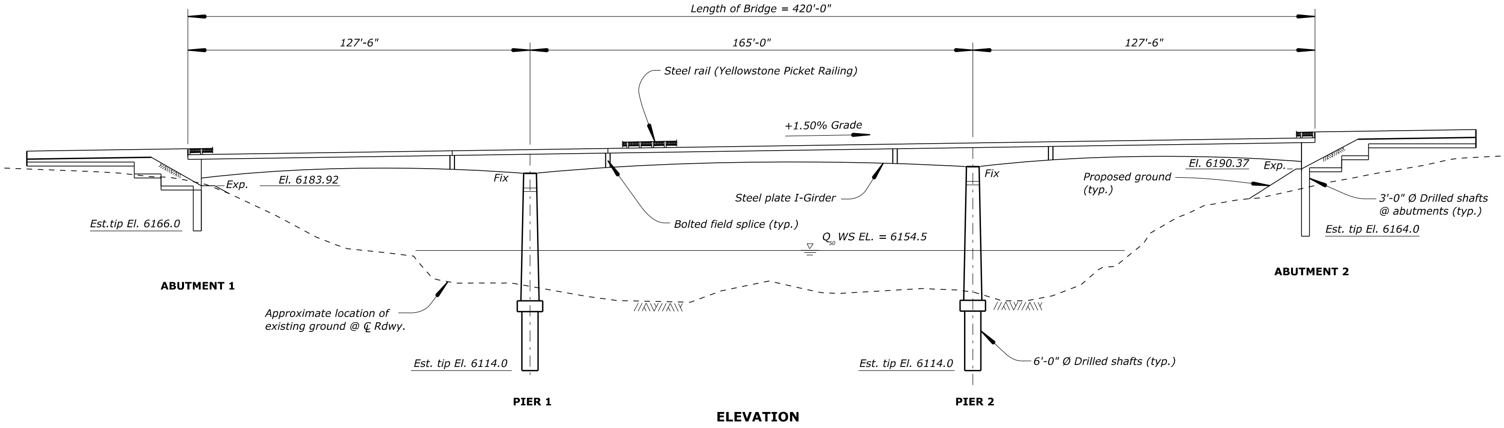
One of the specific goals of this project was to build a structure with architectural features that matched the overall flavor of the existing structures in the park and surrounding vicinity, in order to blend it into the natural environment. Steel girders have historically been used for bridges in Yellowstone due to their cost-effectiveness and aesthetic lightness, and they were chosen for the new bridge for these reasons too—as well as to match the appearance of the existing bridge.

Setting the middle section of the last girder.

Following the decision to replace the existing bridge on a new alignment, the WFLHD bridge team developed the preliminary type, size and location (TSL) plans for the new Lamar River Bridge. From there, they asked the Central Federal Lands Bridge Office design team in Lakewood, Colo., to finalize the TSL plans, design and detailing of the project. The plans called for a two-lane, 420-ft-long, 33-ft, 4-in.-wide, three-span (127.5 ft-165 ft-127.5 ft) steel plate girder bridge. It also required four spliced haunched girders supported by two concrete abutments founded on drilled shafts and two concrete piers located within the Lamar River and founded on drilled shafts.

After a preliminary analysis of the superstructure, the Federal Lands Bridge design team finalized the haunched girder dimensions by using 3.75 ft as the minimum depth at the middle of the spans and 6 ft as the maximum depth at abutments and piers. The parabolic shape of the steel girders, with the shallow depth at the middle of the spans, created an aesthetically pleasing and functional structure.

In April 2010, the final bridge package was delivered to WFLHD for incorporation into contract documents. That August, the $7.46 million contract was awarded to Morgen and Oswood Construction Co., Inc. WFL project engineer and inspectors administered the construction contract with the support of the Western Federal Lands bridge team and the Central Federal Lands Bridge design team.



The new Lamar River Bridge is a two-lane, 420-ft-long, 33-ft, 4-in.-wide, three-span (127.5 ft-165 ft-127.5 ft) steel plate girder bridge.

An independent platform was built to carry all construction equipment and materials across the river.

Digging Deep

The use of deep foundations in a high-seismic area and the proximity of the project to several faults was, again, one of the challenges faced by the design team. To analyze the effects of the seismic forces on the superstructure, substructure and drilled shafts supporting the bridge piers and abutments, a complete 3D finite element model of the structure was developed. The design team used the latest AASHTO LRFD bridge design specifications to design and detail substructure and foundation elements to meet the seismic requirements of the design code.

Another challenge was the variable width of the column at the bottom of the pier and its connection to the drilled shaft. The column width in the final design was 6.75 ft, which required a minimum 8-ft drilled shaft to reduce the possibility of plastic hinge forming below the bottom of column elevation. The cost of the shafts and transporting equipment capable of drilling them in the river was of major concern. To alleviate these concerns, the design team decided to create a larger footing that connects the base of the column to a 6-ft drilled shaft inside a 1-in.-thick, 14-ft-deep permanent steel casing to reduce the possibility of the plastic hinge forming.

To overcome the challenges of constructing the drilled shafts in an active river and the load restrictions on the existing bridge, the contractor decided to build an independent platform across the river that carried all construction cranes as well as other construction equipment and materials.

Additionally, after finalizing the TSL plan the design team was asked by WFLHD to extend the bridge's flared wing walls at both ends to about 65 ft to match the length of the existing wing walls of the old bridge. The design team decided to separate the wing walls from the structure and design separate wing walls founded on spread footings at the four corners of the bridge. The wing walls were then designed as retaining walls that varied in depth from 12 ft to 4 ft with curtain walls to cover the abutment cap and bearing area. Approach slabs were also provided and connected to the cantilevered end walls at both ends of the bridge. The cantilevered end walls were provided and designed to engage the soil behind the abutments in case of an earthquake. Expansion joints were provided between the end of the approach slabs and the sleeper beams, eliminating any joints along the bridge superstructure.

The new Lamar River Bridge, which uses 270 tons of steel in all, opened to traffic in the fall of 2012; the old Lamar River Bridge was demolished the following June. ■

Owner
Yellowstone National Park

General Contractor
Morgen and Oswood Construction Co., Inc., Great Falls, Mont.

Structural Engineer
Federal Lands Structure Group

Steel Team

Fabricator and Detailer
TrueNorth Steel, Billings, Mont., (AISC Member/NSBA Member/AISC Certified Fabricator)

Erector
Danny's Construction Company, Inc., Shakoppe, Minn., (AISC Member/AISC Advanced Certified Steel Erector)