The Kansas Department of Transportation finds a new solution for stream crossings.

KANSAS Crossover

BY TIM LEAF, P.E., AND SCOTT UHL, P.E.

JUST WEST OF TOPEKA, KAN., where Highway K-4 crosses Blacksmith Creek, sat a deteriorating corrugated metal arch culvert that was badly in need of replacement.

One side of the arch was deflecting inward and maintenance crews reinforced it with railroad ties as a temporary measure, but the Kansas Department of Transportation (KDOT) recognized that the span would eventually need to be replaced.

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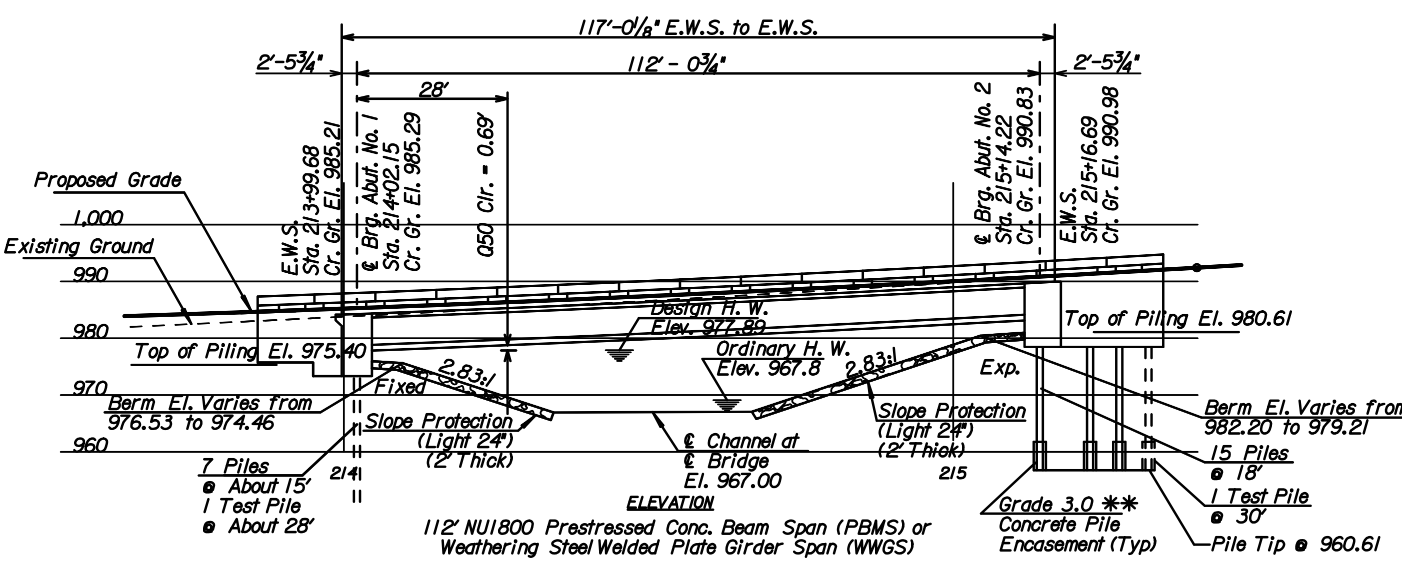
On the surface, this project seemed fairly simple; it's a relatively short bridge over a creek. However, the site was not without its challenges. The old, arched culvert had a maximum height of 12 ft in the center and a maximum width of 30 ft at the bottom. The road above was 19 ft to 20 ft higher than the bottom of the streambed and sloped at roughly a 6% grade. Also, the stream cuts the road at a 45° angle, which meant a replacement structure would require a similar skew.

KDOT routinely relies on three-span reinforced concrete haunched slab (RCHS) bridges for stream crossings and has predetermined span arrangements to simplify design and construction work. Because of this preference, local contractors are accustomed to building these standard structures. However, considering the high skew at this location, the substructure units for the RCHS option would need to be longer than a typical application, thus adding to the overall cost for each intermediate pier. In addition, the smallest standard RCHS span arrangement that could accommodate the required hydraulic capacity and keep all of the piers out of the channel would be longer than necessary.

The new Highway K-4 bridge replaces a deteriorating corrugated metal arch culvert.

The stream cuts the road at a 45° angle, which meant a replacement bridge would require a similar skew.

An elevation view of the new bridge.



The next solution considered was a single-span girder bridge. It would be shorter yet still have a sufficient hydraulic opening, and came with the benefits of lower maintenance costs and ease of construction. Bartlett and West investigated this option in the hopes that by reducing the overall bridge length and eliminating two piers, the single-span bridge would be more cost-effective than the three-span RCHS. In addition, by eliminating two of the piers, drift accumulation and scour concerns would be greatly reduced.

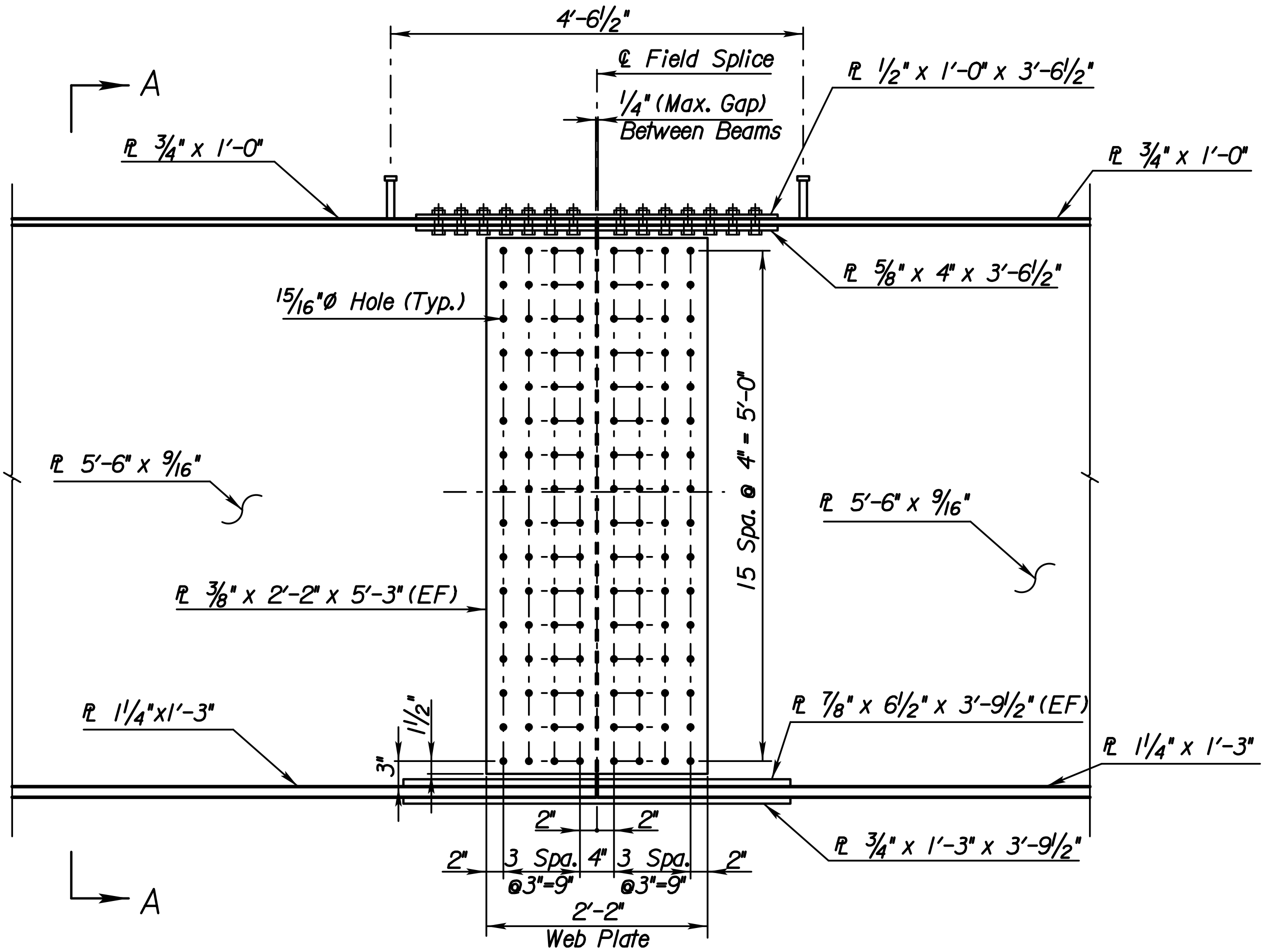
Separate preliminary cost analyses for both steel and concrete superstructures were performed to see which would be the more cost-effective solution. The estimates showed that the difference in cost for a bridge with a steel plate girder superstructure versus pre-stressed concrete girders was marginal. KDOT's assumption was that labor costs more than materials and therefore predicted that placing a long single-span concrete girder in one piece would be more economical than the steel option, which would require additional intermediate diaphragm and field splice work. By bidding both superstructures, this theory was put to the test.

▲ The old, arched culvert had a maximum height of 12 ft in the center and a maximum width of 30 ft at the bottom.

▼ The final girder layout of the new bridge was a single span of 112 ft, using five girders at a 9-ft spacing; the steel plate girders are made from weathering steel.

Out of four contractors that bid on this project, only King Construction, Inc., went with the steel superstructure option—and ultimately secured the contract. King chose the steel option for the following reasons:

1. Due to the small size of the job and the single-span scheme, they were not planning to have a large crane on-site. They could lift the steel girder in place with the crane they had available and would have needed a larger crane just for placement of the concrete girders (each concrete girder was 36 tons heavier than each steel girder).
2. Forming would be easier for the concrete diaphragms at the end bents with the steel girder option. The difficulty in forming the concrete girders was due to the large and thin top flanges, which could potentially be broken during the formwork stage of construction.
3. Steel would be quicker for construction.



▲ A connection drawing of one of the web plates.

▼ A field splice was located 33 ft, 9 in. from the end of the girders, which allowed them to be shipped more easily and without the need for special permits.

The final girder layout was a single span of 112 ft, using five girders at a 9-ft spacing, and the steel plate girders are made from weathering steel. Each girder used a 12-in. × ¾-in. top flange, a 66-in. × 9⁄16-in. web and a 15-in. × 1¼-in. bottom flange. No adjustments were made to the size of the flanges to account for differences in moment envelopes across the span. According to the steel fabricator, DeLong's, Inc., this was due to the fact that the fabrication costs of adding shop splices to adjust the flange dimensions can end up costing more than the cost per weight of steel saved from putting in smaller flange sections near the girder ends.

A field splice was located 33 ft, 9 in. from the end of the girders, which allowed these longer assemblies to be shipped more easily and without the need for special permits. Since this was a single-span bridge, the splice location could not be put at the dead load contra-flexure point and instead was located at 30% of the total span length. This location helped avoid an unnecessary shop splice as well as

The bridge crosses Blacksmith Creek near Topeka, Kan.

kept the field splice away from the maximum moment region.

For KDOT, this project was an opportunity to test a new system that it wasn't yet familiar yet and expand its bridge portfolio, as well as correct some of its cost-related assumptions. And most importantly, it opened the door for another economical solution for future stream crossings. ■

Owner

Kansas Department of Transportation, Topeka, Kansas

Engineer

Bartlett and West, Inc., Topeka, Kansas

General Contractor

King Construction Company, Inc., Hesston, Kansas

Steel Fabricator

DeLong's Inc., Jefferson City, Mo.