PROJECT

SECOND STREET BRIDGE OVER THREE-MILE CREEK

by Michael McDonald, City of Leavenworth, Kans., and Lindsay Madsen, TranSystems

The new single-span adjacent precast, prestressed concrete box-beam bridge with the shared-use trail beneath. All Photos and Figures: TranSystems/City of Leavenworth.

Originally built in 1915, the Second Street Bridge over Three-Mile Creek in Leavenworth, Kans., was the last remaining original concrete arch crossing the creek. It was slated for rehabilitation in 2008, but inspection found extensive damage and so it became eligible for replacement. The project replaces the 50-ft-long concrete arch structure and includes reconstruction of Second Street to the north and south of the bridge.

Leavenworth is a town of about 35,000 people and home to Fort Leavenworth, which was a key supply base in the settlement of the American West and is currently a major military installation. Second Street is a main road in the downtown area, with an average daily traffic of 1100 vehicles. Residents rely on this throughway to connect them between downtown and residential areas. Construction for this project began in May 2017, and the new bridge opened to traffic October 2017. The schedule was aggressive due to the constraints of when and how long the utilities crossing Three-Mile Creek were allowed to be shut down. To meet heating demands, the gas line could not be shut off until May and had to be operational by October. The bridge also crosses over a shared-use trail, and it carries traffic from Leavenworth Landing Park into the heart of downtown, a historic area close to the Missouri River that is being revitalized by private development and city infrastructure projects.

The new railing has a similar aesthetic pattern to that of the former arch bridge.

Advantages of Precast Concrete Box Beams

Initially, the City of Leavenworth intended to replicate the original arch-type structure in the new bridge. However, because of the small footprint of the project, geotechnical limitations, and funding constraints, that plan could not be implemented. Still, the designers kept the aesthetics of the original bridge in mind. Ultimately, a single-span structure with adjacent precast, prestressed concrete box beams was selected. The new structure maintains

profile

SECOND STREET BRIDGE OVER THREE-MILE CREEK / LEAVENWORTH, KANSAS

BRIDGE DESIGN ENGINEER: TranSystems, Kansas City, Mo.

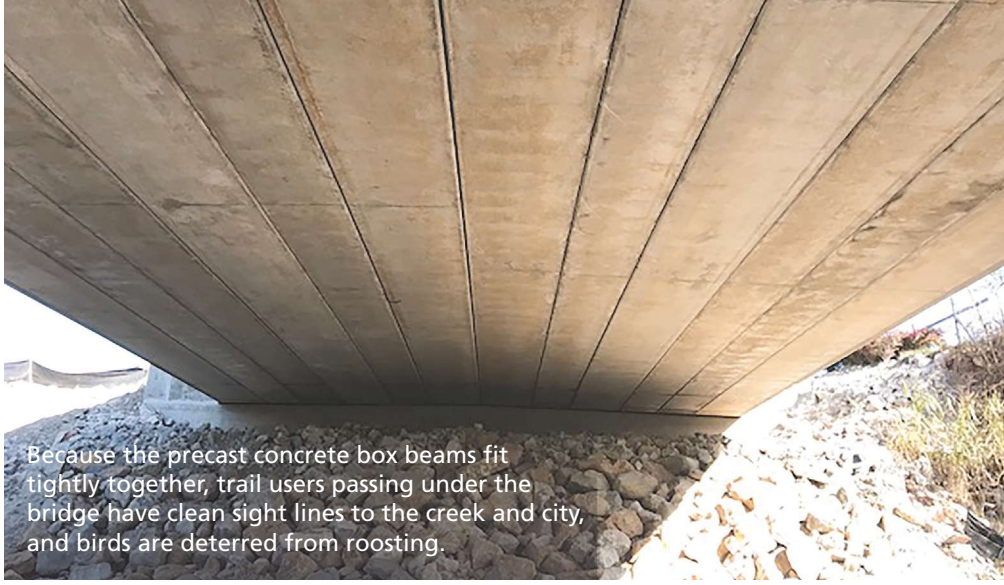
PRIME CONTRACTOR: L.G. Barcus and Sons, Kansas City, Kans.

PRECASTER: Coreslab Structures, Kansas City, Kans.—a PCI-certified producer

the clean profile and alignment of the bridge it replaces. The beams of the bridge fit tightly together so as to not distract from the scenic surroundings, and the concrete box girders placed side by side create a pleasing appearance for the trail users below. Box girders placed tightly also prevent birds from roosting on the bridge, which limits droppings on the trail.

Adjacent box beams allow for a thin deck (a minimum depth of 5½ in.), as well as a taller curb and sidewalk, which added additional dead load. The exterior faces of the box beams are flush with the aesthetic barrier rail to mimic the taller, detailed railing on the old arch. Lighting will be added to resemble the same lighting features from the early days of the arch bridge.

The cost savings of using precast, prestressed concrete box beams fabricated less than 30 miles away from the project site were one reason why this material was selected instead of steel beams or traditional concrete I-beams. Also, precast concrete box beams were preferred over traditional concrete I-beams because the geometry of the box beams allowed for more flexibility of the beam shape and size to better meet the needs of the project, which ultimately used two different widths of beams. Another advantage of using precast concrete box beams was the ability to replicate the uniform color of the original structure. Plus, concrete facades require significantly less maintenance than steel ones—painted steel often needs repainting while this concrete will not.



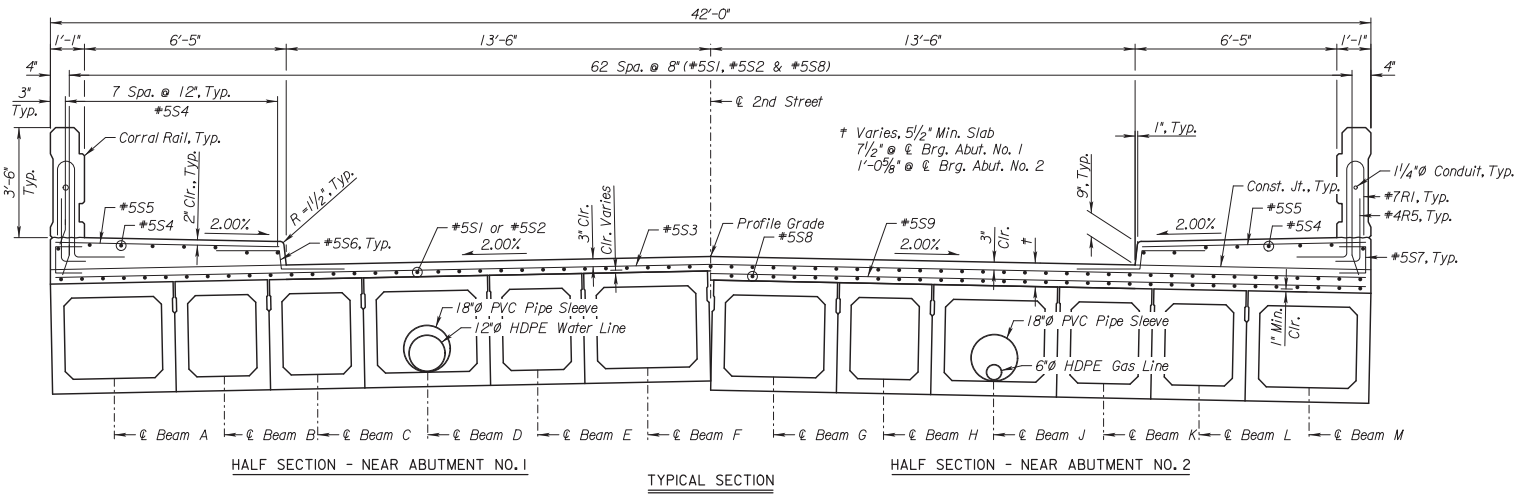
Because the precast concrete box beams fit tightly together, trail users passing under the bridge have clean sight lines to the creek and city, and birds are deterred from roosting.

Physical Project Challenges

Many physical challenges were encountered during the Second Street Bridge project. One was the constrained project site. Because of potential contamination issues, a portion of the adjacent property could not be excavated unless a lengthy, extensive, and expensive investigation was performed. The owner therefore directed the design team to avoid all subsurface use of that property.

Utility relocation was another issue that had to be addressed. Three utilities cross Three-Mile Creek at this location: electricity, water, and natural gas. The high-voltage transmission line could be shut off during construction, but it could not be relocated. The contractor was limited to a 15-ft minimum clearance from the overhead power lines for all work. Also, to meet summer

Typical section of the 42-in.-deep precast, prestressed concrete box-beam bridge.



CITY OF LEAVENWORTH, KANSAS, OWNER

BRIDGE DESCRIPTION: Simple-span, 119-ft-long bearing to bearing adjacent precast, prestressed concrete box-beam bridge

STRUCTURAL COMPONENTS: Twelve beams: six 42-in.-deep AASHTO Type BIV-36 concrete box beams and six 42-in.-deep AASHTO Type BIV-48 concrete box beams (two of which have 18-in.-diameter PVC pipe sleeves for utilities); 5½-in.-minimum cast-in-place concrete deck; cast-in-place concrete abutment pile caps; and concrete-encased H-piles

BRIDGE CONSTRUCTION COST: $1,547,523

AWARD: 2018 APWA Kansas City Metro Chapter Public Works Project of the Year Award-Small Communities

cooling demands, the power lines could not be de-energized once the air temperature was more than 80°F. This requirement limited the working time in the summer months.

The water and natural gas mains were more of a challenge than the power lines. The construction time frame was constrained by when gas could be turned off. While the natural gas main was to be removed during construction, it had to remain in service until April 1 and be reinstalled and operational by October 1 to meet heating demands. Although the time frame for the water main was not as restrictive, it was to be shut off and resume operations within the same timeline as the gas main.

The design team worked with the precaster and utility companies to design an interior framework to support utilities within the voids of the box beams. By routing the water- and gas-main lines through the voids, the team avoided boring under the creek, which would have been costly and time consuming and would have exposed the utilities to possibly unstable subsurface conditions. Routing the utility lines through the box beams kept the mains on their original alignment while concealing them, providing a cleaner look for the new bridge and eliminating places for animals to hide and cause a nuisance to trail users. This solution also allowed the team to work within the tight time frame to make the utilities operational again. This project is the first time in Kansas that utilities have been routed through the voids of a box-beam structure of this length.

Creative Use of Resources

The foundations of the original arch bridge remain in place as retaining walls along Three-Mile Creek, thereby providing a simple design for the new abutments outside the creek waterway and minimally disrupting the creek banks. This reuse and repurposing of the original foundations and adjacent retaining walls saved money and construction time. By leaving the lower 8 ft of the existing walls in place, a more open crossing of Three-Mile Creek was achieved while offering a reminder of what the previous structure looked like. The soils along one bank were found to likely be contaminated, and those on the other bank were of questionable use as fill material. By repurposing the original arch foundation, environmental challenges were avoided, aesthetics were improved, and a significant amount of money was saved.

Other unique site elements contributed to modifications in the design. Information about the old structure's foundation was scarce, which is not unusual for a century-old bridge. In this case, the lack of information proved to be a challenge in construction. During excavation for the abutments, counterforts for the existing wing walls were discovered. These counterforts interfered with the placement of the new abutment cap and piling. On-site modifications were discussed, and an adjustment was engineered to avoid the conflict.

The south abutment was designed to be supported on driven H-piles set into shale, but a rock shelf was encountered roughly 15 ft higher than expected, even with two borings within 20 feet of the shelf. The H-piles were quickly redesigned as concrete-encased H-piles set into the shale and limestone, with a final elevation 15 ft above the original design. Reuse of the old foundations and new abutments placed outside of the creek reduced the complexity of the permitting required from both the State of Kansas and the Corps of Engineers.

Another unique aspect of the construction process was the setting of the precast concrete box beams. The box beams were 120 ft long, and the transporting trucks had to back through a residential neighborhood. Setting the beams was difficult because of the proximity of adjacent buildings, overhead power lines, and the deep creek channel. The traditional method of using one crane to pick up the beam from the truck and swing it around to place it was not possible. Instead, after the truck backed up to the south bank, the north beam end was picked up by a crane on the south bank. The truck then backed up farther while the north beam end was launched out over the creek by the crane. Midway across the creek, the north beam end was transferred to the crane on the north bank of the creek. Then, the crane on the south bank picked up the south beam end, and the two cranes worked in tandem to carefully move the beam out over the creek and place it on the abutments.

Michael McDonald is the director of public works for the City of Leavenworth, Kans. Lindsay Madsen is a project manager with the Kansas City, Mo., office of TranSystems.

A box beam being readied to be lifted from the truck by the crane on the south bank of the creek after passing the north end to the crane on the north bank.