PROJECT

Designers of the Bijou Street Bridge in Colorado Springs, Colo., created a spliced, post-tensioned, precast concrete superstructure that features innovative prestressing layouts and variable cross-sections to accommodate the unique geometric requirements and erection scheme.

Unique precast concrete superstructure features variable cross sections to help finish complex structure in 8 months

Innovation Speeds Construction

BIJOU STREET BRIDGE OVER MONUMENT CREEK

by Gregg A. Reese, Summit Engineering Group Inc.

Officials in the City of Colorado Springs, Colo., wanted to create a bridge that would relieve congestion and provide the major access to the downtown area, as well as project an image that allowed the structure to serve as a welcoming image for the city. To achieve these goals, designers created a bridge with a spliced, post-tensioned, precast concrete superstructure that features innovative prestressing layouts and variable cross-sections to accommodate a unique erection scheme. The approach allowed the project to be completed in only 10 months, including the demolition of the existing bridge that was necessary before construction could begin.

The bridge's seven girder lines form four continuous spans that cross Monument Creek and a rail yard with a 148-ft main span. The flared alignment was used to accommodate the variable deck widths.

The bridge's seven girder lines form four continuous spans that cross Monument Creek and a rail yard. The girders vary in spacing from 13.2 ft to 22.8 ft to fit the deck width, requiring the girders to be kinked at closure joints.

The bridge's design matches the lanes from a new I-25 overpass and provides three continuous lanes of traffic into downtown, plus two lanes that cross I-25 into west Colorado Springs, two left-turn lanes to give freeway access, and sidewalks and bicycle lanes in both directions. The bridge deck's profile transitions from the at-grade roadway in the downtown area to a combined crossing over the rail lines and Monument Creek. It then blends into the I-25 ramps and overpass.

City officials wanted to improve user safety by providing a more gradual vertical curve to increase the sight distance on the bridge. This severely limited the vertical depth of the structure to ensure adequate clearance over the rail yard. In addition, the railroad wanted to limit foundations and construction access in the rail yard. A main span of 148 ft 3 in. was agreed upon to provide enough clearance for all current and future active tracks. Only one pier was placed in the yard, isolating an obsolete storage track. Access was limited to construction equipment, and no temporary supports for the girders were allowed in the yard.

profile

BIJOU STREET BRIDGE / COLORADO SPRINGS, COLORADO

ENGINEER: Summit Engineering Group Inc., Littleton, Colo.

PRIME CONTRACTOR: Rockrimmon Constructors Inc., Englewood, Colo.

PRECASTER: Encon Bridge Co. LLC, Denver, Colo., a PCI-certified producer

AWARDS: *Best Bridge With Spans Between 75 and 150 Feet, 2008 Precast/Prestressed Concrete Institute Design Awards*

Contractor Favored Precast Concrete

Preliminary design plans used to bid the project called for a steel-plate girder superstructure with a cast-in-place concrete deck to accommodate the structure's required depth limitations. The contractor requested a precast concrete girder alternate design to take advantage of his own capabilities. Even shortening the span over the rail yard slightly to accommodate pier-to-pier framing using 60-in.-deep precast concrete U-girders resulted in excessive deflections and stresses in the longer spans. So, the spliced, post-tensioned solution was ultimately selected.[1]

The precast concrete girders cantilever 15 ft beyond intermediate piers to support the free end of the adjacent girder during erection, eliminating the need for temporary supports in the rail yard. To allow this construction, designers used an innovative combination of debonded pretensioning, top flange post-tensioning, and internally thickened sections of the webs and bottom slab. Strongbacks were used at girder splices to eliminate the need for temporary shoring in the creek or the rail yard during construction. The bridge was fully post-tensioned between abutments after splices were cast and prior to placing the deck slab.

Substructure

The substructure design used the flexibility of the piers and foundation to minimize manufactured bearings. The foundations consisted of drilled shafts at the intermediate piers and the west abutment wall pier, while pilings provided a flexible abutment at the east end. Intermediate bents had four and five columns, depending on the width of the bridge. Each 4-ft by 8-ft column was founded on a single 42-in.-diameter drilled shaft.

For the crossing of Monument Creek, it was necessary to place a pier in the river basin. This pier was placed on the east bank of the normal creek channel to accommodate hydraulic design conditions for a severe flooding event.

Abutment Poses Challenges

The most challenging aspect of the substructure design involved the west abutment, which consists of a 40-ft-tall wall pier that is 180 ft wide. Along with the adjoining walls, it forms a channel liner for the creek at flood stage and provides support for the bridge. The wall pier was cast against the retaining wall of the existing bridge, and holes were cut through the existing wall to connect tie beams to the new wall pier. The top of the wall is then supported laterally by 19 reinforced concrete tie beams that connect to dead-man anchors 35 ft behind the back face of the pier in the backfill.

The superstructure was set on bearings at the top of the wall pier. A back wall was added and backfilled after the superstructure's post tensioning was completed. An expansion joint was placed between the superstructure and approach slab. The abutment wall features a full-height mechanically stabilized earth (MSE) wall panel on either side that tapers to the existing retaining walls.

The precast concrete U-girders cantilever beyond intermediate piers to support the ends of the drop-in sections during erection, eliminating the need for temporary supports in the rail yard.

The contractor requested a precast concrete girder alternate design to take advantage of his own capabilities.

SPLICED, POST-TENSIONED, PRECAST CONCRETE BRIDGE OVER MONUMENT CREEK AND UNION PACIFIC RAIL YARD / CITY OF COLORADO SPRINGS, OWNER

POST TENSIONING MATERIALS: DSI, Long Beach, Calif.

BRIDGE DESCRIPTION: Four-span continuous, spliced, precast concrete U-girder bridge, 475 ft long and 96 ft to 181 ft wide, with seven girders per span

BRIDGE CONSTRUCTION COST: $6.0 million

In keeping with CDOT regulations, epoxy-coated reinforcing bar was used for all elements of the bridge that touched the deck slab.

Superstructure

The girders for end spans 1 and 4 were erected from each abutment and cantilevered 15 ft past the first intermediate pier at each end. Girders in Span 2 spanned from a splice that was 15 ft up-station of Pier 2 and cantilevered 15 ft past Pier 3 into the west side of the rail yard. Drop-in girders were supported over the rail lines from the girders cantilevering over Pier 3 from the west and Pier 4 from the east side of the rail yard.

The ends of the drop-in girders at the splice locations were suspended from steel strongbacks that were attached to the cantilevered ends of the adjacent girders. At each splice, two 1$^{3}/_{8}$-in.-diameter post-tensioning bars were used to suspend the girders.

The design for the precast concrete girders incorporated features that were necessary to ensure smooth erection and maximize the use of existing forms. To accommodate the cantilevered erection scheme, post-tensioning tendons were placed in the webs near the top flange. A thicker web and tapered bottom flange were then necessary.

A 30-ft-long section with 10-in.-thick webs was centered over the piers. At the end of the 30-ft section, standard forms were used to transition to a typical 7$^{1}/_{2}$-in.-thick web. The section also featured a tapered bottom slab that varied from a standard 8-in. thickness to a maximum 20-in. thickness over the pier. The nonstressing end of the top flange tendons were placed at the interior end of the transition.

The longitudinal prestressing consisted of a combination of pretensioning and post-tensioning. The pretensioning was designed to optimize the prestress force in the positive moment regions. Prestressing in each section consisted of twenty to thirty-nine 0.6-in.-diameter strands in the bottom flange. Up to two-thirds of the pretensioned strands were debonded in the cantilevered section to minimize top flange tensile stresses. A seven 0.6-in.-diameter strand tendon was anchored in the top of each web in the cantilevered section and deviated to minimum cover over the piers. The top flange tendons were stressed and grouted prior to the girders being shipped and erected.

Parabolic tendons were placed in the webs and ran the full length of the bridge. The web tendons were stressed after the abutment and pier diaphragms and closures were cast and cured. The deck, which was designed to be fully replaceable, was placed after all post-tensioning was completed.

A continuous 6-ft-thick cast-in-place diaphragm section was used over the piers and abutments. Four columns of ducts were placed in the webs of the girders to provide a passage for a continuous reinforcing cage at the pier diaphragms. The girders were notched at the abutment ends to allow a continuous diaphragm and anchorage zone for the longitudinal web tendons. A thickened bottom slab section was included to temporarily support the girders at the abutments.

Deck Width Varies

The large degree of variation of the bridge deck width made it difficult to use continuous girder lines. The ultimate configuration created spans of approximately 105, 135, 148, and 86 ft, with a deck width that varied from 181 ft 1 in. at the west abutment to 95 ft 6 in. at the downtown end. To accommodate this variation, the girder spacings varied from 22.8 ft to 13.20 ft. The typical deck slab overhangs varied from 2.5 ft to 3.5 ft, increasing to a maximum of 17.4 ft on each side of the bridge at the west abutment curved turn lanes.

The bridge deck is 8-in.-thick cast-in-place concrete for Spans 2 to 4, where the girder spacing varied from 13.2 ft to 20.5 ft. The slab had clear spans of 4.2 ft to 11.5 ft. Girder spacing in Span 1 varied from 20.5 ft to 22.8 ft, with clear slab spans of 11.5 ft to 13.75 ft and a maximum overhang at the west abutment of 17.4 ft at the turnout lanes. The deck thickness in span 1 is 9 in. nominal but increases slightly due to the slope on the underside of the deck. The deck slab was conventionally reinforced for the entire length of the bridge.

City officials allowed the existing bridge to be closed during construction, to accelerate the schedule. Demolition took 2 months, after which constructing the new bridge took only 8 months, finishing 2 months ahead of schedule.

The Bijou Street Bridge used a variety of existing design technologies in innovative ways to meet a multitude of challenges that produced a cost-effective design. Its success resulted from careful consideration of every aspect of the existing conditions, methodologies, and capabilities to create a signature structure that was finished before the deadline.

Reference

1. Reese, Gregg A., 2008, “Design and Construction of the Bijou Avenue Bridge over Monument Creek,” Proceedings of the PCI-FHWA National Bridge Conference, October 5-7, Orlando, Fla., 13 pp.

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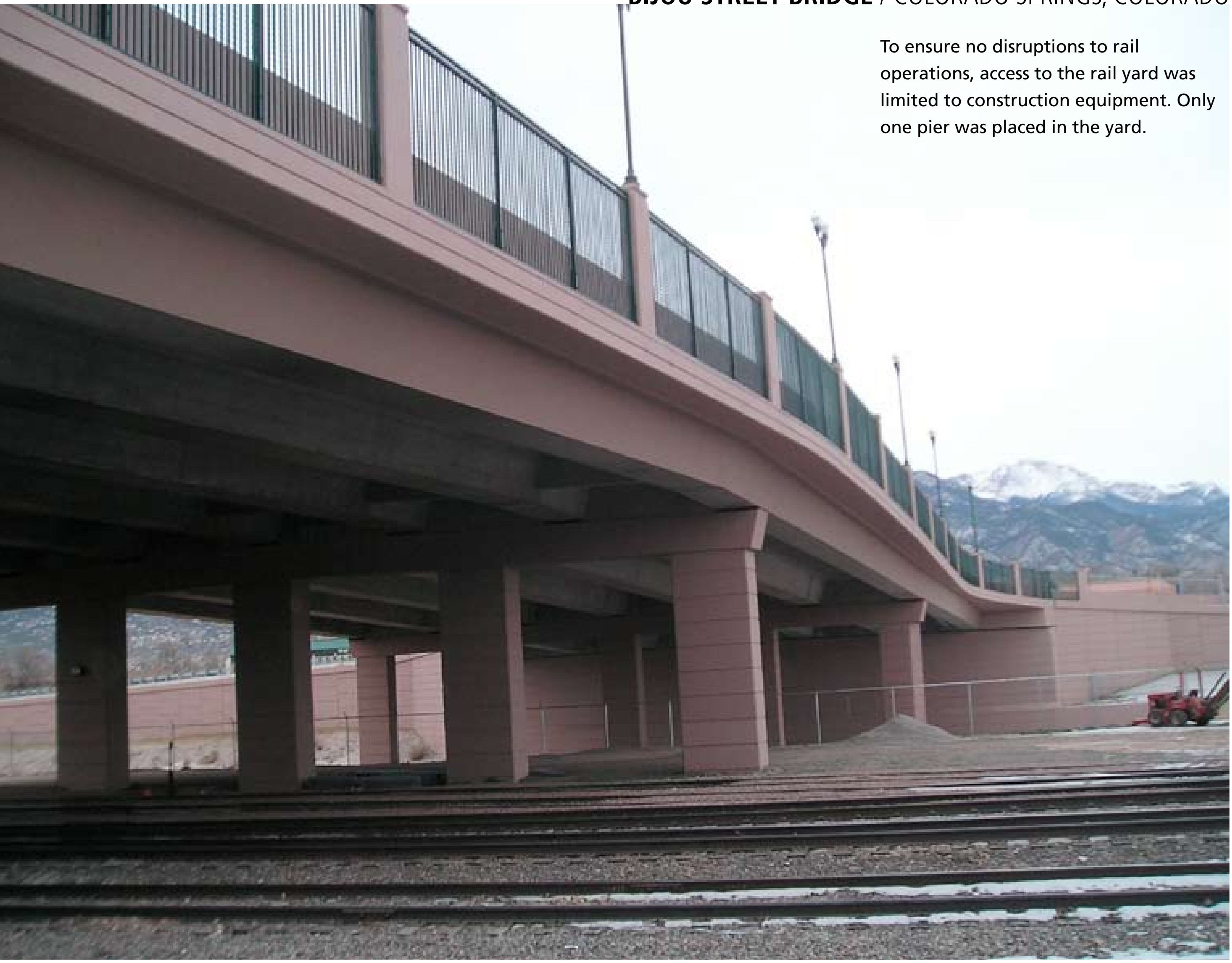
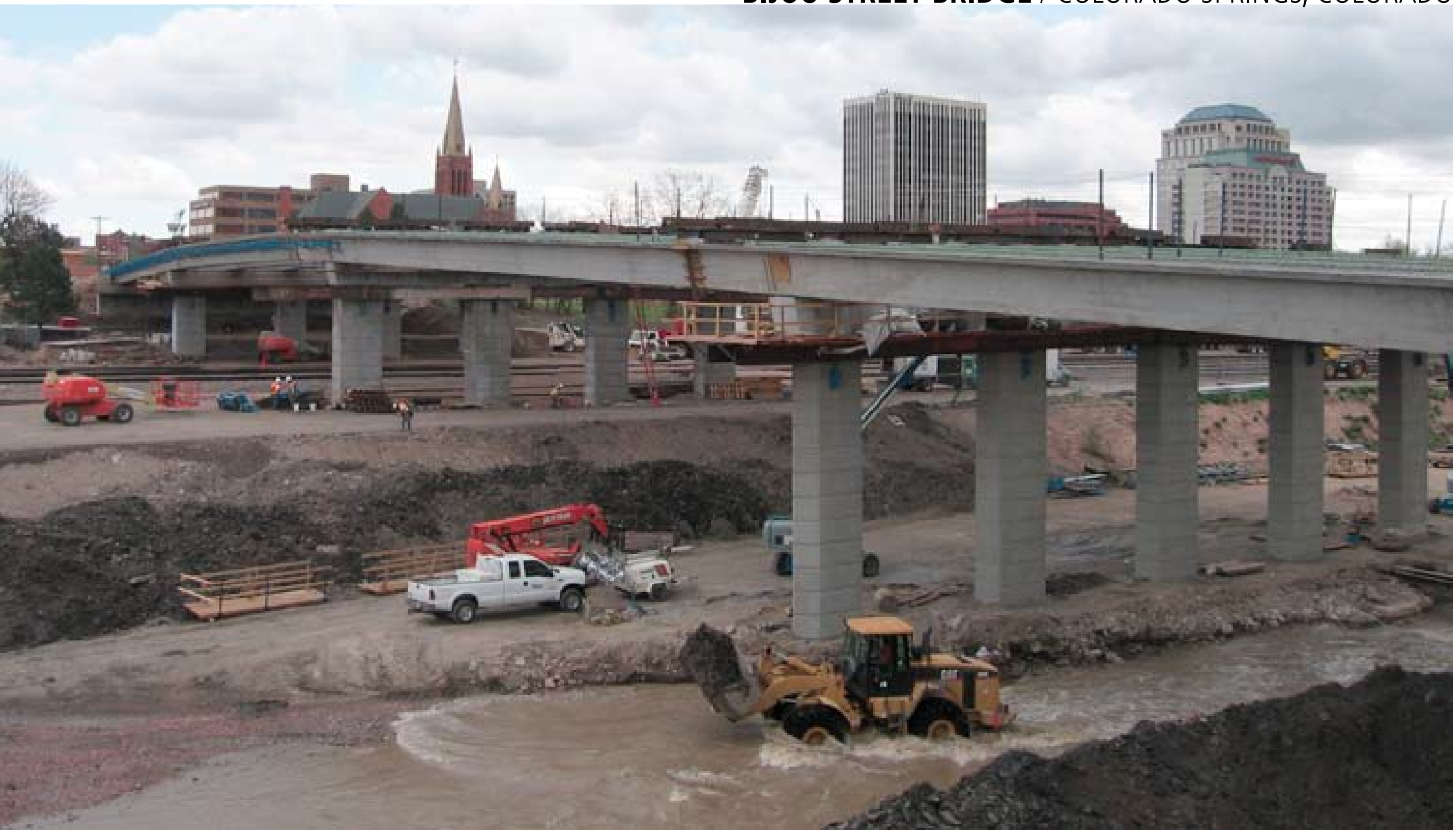


To ensure no disruptions to rail operations, access to the rail yard was limited to construction equipment. Only one pier was placed in the yard.

The substructure design used the flexibility of the piers and foundation to minimize the need for manufactured bearings.

The longitudinal prestressing consisted of a combination of pretensioning and post-tensioning.



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