Just a few miles east of Denver, an innovative six-span bridge crosses Box Elder Creek on U.S. Highway 36 in Watkins, Colo. The new bridge, which replaces a previous one, is 470 ft long and 44 ft wide, and carries two lanes of traffic. The project’s total cost of $2.1 million includes removal of the old bridge, construction detour, and landscaping.

The superstructure is composed of 77-ft-long W33x152 rolled steel girders. The bridge has six girder lines of grade 50 weathering steel spaced at 7 ft 4 in. The bridge deck is 8-in.-thick cast-in-place concrete. The girders are simple span for non-composite dead load and were made continuous at the piers for composite dead load and live load.

A Competitive Alternative

Highway 36 highway makes a low crossing at Box Elder Creek, demanding a shallow superstructure. During the design stage the Colorado Department of Transportation considered precast prestressed concrete side-by-side box girders and structural steel girders; precast side-by-side box girders are the most common CDOT solution to the low-depth issue, due to the very competitive local precast industry. However, Colorado’s standard precast concrete bulb-T shapes were too deep for the site, and steel was eventually chosen. The designers applied solutions generally reserved for precast concrete to this material alternative. These included:

- Simple-span girder sections made continuous at the piers for composite dead loads and live loads.
- Simple, easily constructed details to obtain continuity at the piers.
- Using the deck to carry the tension component of the negative moment at the pier.
- Low-cost standard girder sections.
- Minimizing the number of diaphragms.
- Simple fabrication details.
- Simple construction details.

Although the Box Elder Bridge is not necessarily the first use of these innovative solutions for steel girders, by using them creatively and in concert the designers provided an alternative that was competitive with the normal precast concrete solution; project estimates showed the rolled W33×152 solution to be less costly than the precast concrete box girder solution. In addition, the W33×152 solution, as designed, was easy to build quickly.

To optimize the use of standard rolled steel sections, the “simple-span-made-continuous” technique (simple span for non-composite dead load and continuous for composite dead load and live load) was used to minimize both steel and fabrication costs. Making the girder continuous shared the live loads between spans, allowing a shallower girder section.

Rapidly Constructable Steel Details

To optimize the use of standard rolled steel sections, a simple yet unique compression plate detail was used at the piers. To carry the negative moment at the piers, the designers used a compression plate welded to the bottom flanges. This plate carried the compression component of the negative moment, and the composite bridge deck, with its rebar, carried the tension component.
To save steel costs and construction time, intermediate diaphragms were not used between all the girders. Instead, they were placed in only three of the five girder bays between the six girder lines. All girder compression flanges were supported by a diaphragm, and all exterior girders were supported by a diaphragm—especially important during deck placement.

Single W27×84 rolled shapes were used for the diaphragms as opposed to multiple cross-bracing pieces. The diaphragms are spaced at 12 ft 8 in. in the two external bays and at about 19 ft in the internal bay. Similar diaphragms in all bays connect the girders at the piers and abutments.

The advantages of employing these details and using rolled beams were numerous:

→ Fabrication costs were low, and therefore total steel costs were much lower than for welded plate girders.

→ All pier cap compression plates and all diaphragm details were similar.

→ After developing shop drawing for one rolled beam, all other drawings were the same or similar.

→ With this bridge, continuity was obtained without any bolted girder splices.

→ The girders were designed so that additional transverse stiffeners were not needed, other than those used for bearing stiffeners and to connect the diaphragms.

→ Concrete diaphragms between the girders were not used at the piers or the abutments. This provided cost and construction time savings over the concrete diaphragms typically used for precast concrete girders.

→ Using weathering steel eliminated the need for maintenance painting.

→ Lifting the rolled beams was handled by relatively small cranes; the prime contractor was able to perform the steel erection.

→ The total amount of structural steel needed for this bridge was only 20.7 lb per square foot of deck area!

**Pier Details**

The piers are founded on five steel pipe piles—which are ideally suited for the rather loose alluvial material making up the foundation soils—as opposed to the much longer pile lengths that would have been required for end-bearing piles or drilled shafts. The steel pipe piles were also less costly and quicker to construct.

The designers accomplished the most significant cost savings by using the pipe piles to create the five aesthetically pleasing round columns supporting the pier cap. The pipe piles were left extending out of the ground—with no pile caps or fussy transition details—and filled with concrete. Then, projecting reinforcing steel was inserted and the pier cap was constructed on top. Not only was this cost-effective, but it also removed several weeks from the construction schedule that would have been required had reinforced concrete columns been used.

**Good Competition**

The innovative six span steel bridge crossing Box Elder Creek in Colorado showcases the viability of standard rolled steel sections as a competitive alternative to precast concrete. The simple-span-made-continuous technique, although not new, was used with an innovative continuity detail and in concert with several other thoughtful design considerations, providing an especially economical, low-maintenance, and visually appealing bridge that was easy to fabricate and construct.

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