Long-Span Precast U-Girders in

Colorado

by Michael L. McMullen, Jamal I. Elkaissi, and Mark A. Leonard, Colorado Department of Transportation

I-270 Ramp over I-76: 2282 ft long, 230-ft-long maximum span, 764-ft-minimum radius.

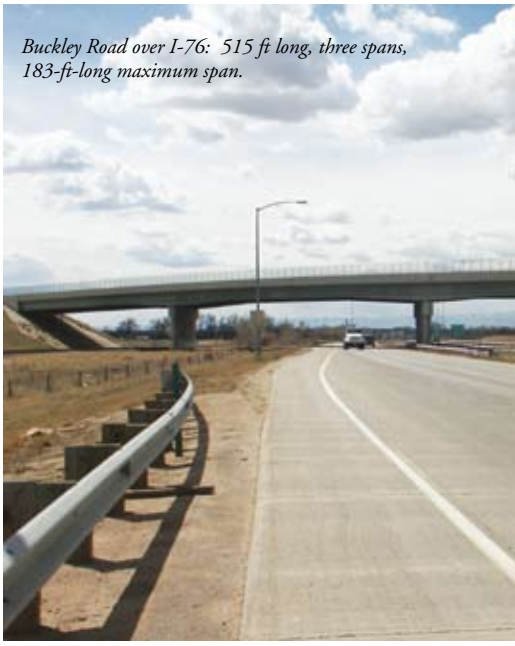
Colorado has benefited from a practice of utilizing a broad range of structure types for its bridges. The Colorado Department of Transportation (CDOT) designers and its consultants have generally been given wide latitude to use the structure type that is optimal for the conditions at a particular bridge site. Consequently, CDOT has a relative large inventory of structural steel, precast concrete, and cast-in-place concrete bridges, with a wide variety of different sections used for these three different materials.

Since the 1960s, precast, prestressed concrete beams have become the structure type used most often because of the typical economy and general construction advantages of these beams. Making the beams more efficient and easier to construct has been pursued aggressively. However, precast concrete beams tended to be used in the past for simpler bridges; the exceptions being the seven segmental box girder bridges used for I-70 over Vail Pass and the nine segmental bridges through Glenwood Canyon. These were especially large and topographically unique projects. Precast girders were generally regulated to spans less than 140 ft and to bridges with little or no curvature.

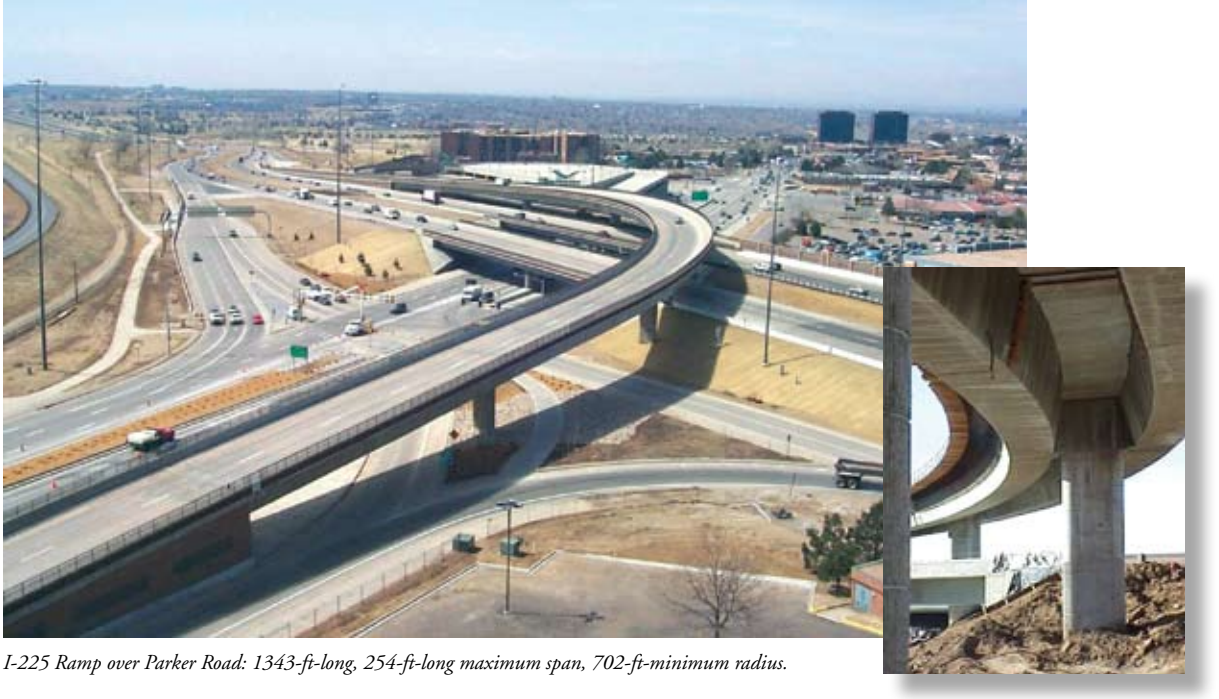
This began to change in 1992 and has increased more in recent years. This year alone, CDOT will construct four precast concrete bridges with span lengths over 140 ft using horizontally curved girders. These will be in addition to the four existing bridges built since 1995 that meet this description. The recently completed I-270 bridge over I-76 is one of these. Although not the first constructed, it was the first bridge designed using yard fabricated, long-segment trapezoidal U-girders for a bridge with significant horizontal curvature. "Long-segment" is used here to differentiate these girders from those conventionally referred to as "segmental concrete box girders" which are typically built with shorter segment lengths.

The broadened applicability of precast, prestressed concrete girders has been accomplished by adopting new beam shapes, increasing maximum shipping lengths, utilizing post-tensioning for splicing, and employing curved segments. In 1992, CDOT transitioned from precast I-beams with 5-in.-thick webs to bulb-tee beams with 7-in.-thick webs, permitting the use of post-tensioning ducts. The first precast concrete long-segment girder spliced with post-tensioning built in Colorado was the Buckley Road Bridge over I-76. This bridge was constructed in 1992 using 72-in.-deep bulb-tee beams with 96-in.-deep haunched bulb-tee pier segments.

Before the Buckley Road Bridge was built, CDOT had already begun developing plans for using precast, trapezoidal box girders for long-segment construction. The Park Avenue Ramp over I-25, built in 1995, and the I-225 Ramp over Parker Road, built in 2000, were the first long-segment box girders designed in Colorado



Buckley Road over I-76: 515 ft long, three spans, 183-ft-long maximum span.



I-225 Ramp over Parker Road: 1343-ft-long, 254-ft-long maximum span, 702-ft-minimum radius.

to be precast. Because early fabricator interest in these sections was not certain, these bridges were designed giving the contractor the option of using either precast or conventional cast-in-place concrete, but the contractor had to allow traffic below the main spans during the day. On Park Avenue, the contractor elected to use the precast girder alternative for the main spans. These segments were cast on site and moved to their final position during the night. The largest segment weighed 212 tons. On the Parker Road project, the main span segments were cast-in-place during the night.

The success of these two bridges helped stimulate local fabricators' interest in precast, trapezoidal boxes. From 1995 to 2000, CDOT developed standards for precast trapezoidal U-girder sections. The sections were developed so they could be used for either straight or horizontally curved segments and could also be pretensioned, post-tensioned, or a combination of the two. A web thickness of 5 in. can be used for fully pretensioned segments and 7.5 in. to 10 in. for segments with a combination of pretensioning and post-tensioning. Available girder depths vary from 48 in. to 96 in.

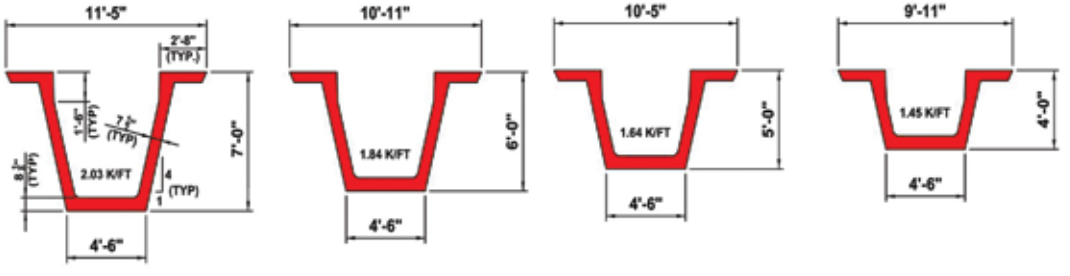
A U-shape was selected over a closed box to eliminate the expense of interior formwork that needs to be removed or sacrificed. The U-shape also facilitates having top flanges with areas that can be readily varied from project to project. It also allows easy inspection of the interior surfaces in the fabricator's yard.

With the new bulb-tee and U-girder sections and the addition of post-tensioning for splicing, shipping weights became the primary limitation on segment lengths. In 2001, CDOT worked with local fabricators and shipping and erection subcontractors to upgrade maximum shipping weights from 85 tons to 120 tons. This was especially significant for the U-girders given their greater weight per unit length.

In addition to economics, aesthetics and constructability have been central aspects of these changes to precast girders. Trapezoidal box girders became especially popular starting in the 1970s. CDOT responded by providing these sections using structural steel, cast-in-place concrete, and short-segment segmental bridges.

Cast-in-place concrete has been especially versatile for providing a variety of trapezoidal box girder sections for different conditions including long spans and complicated geometry. The new precast U-girder sections provided CDOT with a competitive alternate to structural steel girders in terms of cost, on-site construction time, and appearance. The recently completed I-270 Ramp over I-25 in Denver is an example of the elegance that can be obtained with trapezoidal boxes.

The project was bid using a contracting method where a fully detailed default design was provided in the plans and specified contractor design-build alternatives to the default were allowed. In this case, the default design was a steel box girder bridge and the successful contractor elected to use the precast U-girder design-build alternative.

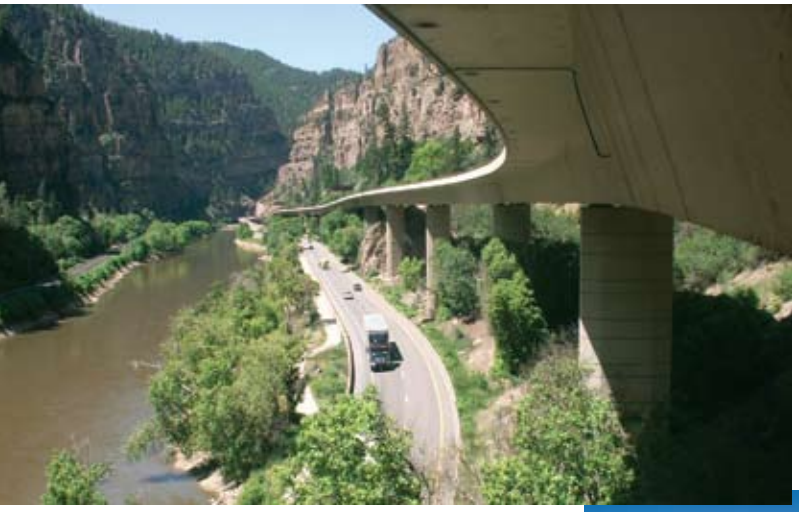


Precast U-girder — group II pretensioned or post-tensioned.

I-270 Ramp over I-25: 1424 ft long, 200-ft-long maximum span, 950-ft-minimum radius.

Conventional short-segment, precast concrete box girder bridges provide a trapezoidal box section and also the means for construction without the heavy influence of falsework in high traffic areas. The Hanging Lake Viaduct in Glenwood Canyon is one of the most popular bridges in Colorado for its appearance. The new precast U-girder standards, however, can provide a competitive alternate to these bridges. The U-girder sections are now commonly used in Colorado for bridges of all sizes. Three precast concrete fabricators in Colorado have the formwork necessary to readily produce these sections—making them competitive for small, as well as very large projects.

The State Highway 52 over I-25 Bridge is an example of a smaller project using the U-girders and built in 1999. This was the first vehicular bridge in Colorado constructed using shop fabricated precast U-girders. This bridge is a striking example of the clean details that can be obtained for a simple grade separation with long-span concrete U-girders, and by simply ordering the girders from a local fabricator.



I-70 Hanging Lake Viaduct: 6396 ft long, 208-ft-long maximum span, 1650-ft-minimum radius.

I-70 Trinidad Viaduct: NB 1985 ft long, SB 2058 ft long, 256-ft-long maximum span, 1000-ft-minimum radius.

State Highway 52 over I-25: 322 ft long, 3 spans, 190-ft-long maximum span.

The I-70 Trinidad Viaduct, currently under construction, is an example of a large project using the U-girders. Here again, CDOT employed a default design with specified contractor design-build alternatives. The default design was for a conventional short-segment concrete box girder bridge. The successful contractor elected the design-build alternative using the precast U-girders provided by a local fabricator.

Looking to the future, there are a number of enhancements CDOT would like to see. Strong-backs were used on the Buckley Road Bridge for splicing the girders without the use of shoring towers. Further developments to allow splicing the girders in the air would improve construction options. On the Trinidad Viaduct, full-width precast deck panels were used to eliminate forming the bridge deck overhangs. Other developments to reduce deck forming would reduce on-site construction time. The Park Avenue Bridge had significant vertical curvature and twisting superelevation, but was formed on-site with plywood. Form innovations that could push the limits of girder geometry would be desirable. The Parker Road Bridge used fiberglass reinforcement and carbon fiber prestressing strands for the precast deck panels. Future use of non-corrosive reinforcement and prestressing strands would enhance durability.

Having a large arsenal of different structure types readily allows for superstructure optimization for the cost, constructability, and appearance needs of a particular bridge site. The relative recent developments with precast concrete, especially the development of precast U-girders, has significantly strengthened CDOT's arsenal of potential solutions.

Michael L. McMullen is supervising bridge design engineer, retired; Jamal I. Elkaissi is supervising bridge design engineer; and Mark A. Leonard is state bridge engineer with the Colorado Department of Transportation.

For more information on Colorado bridges, visit www.dot.state.co.us.