PROJECT

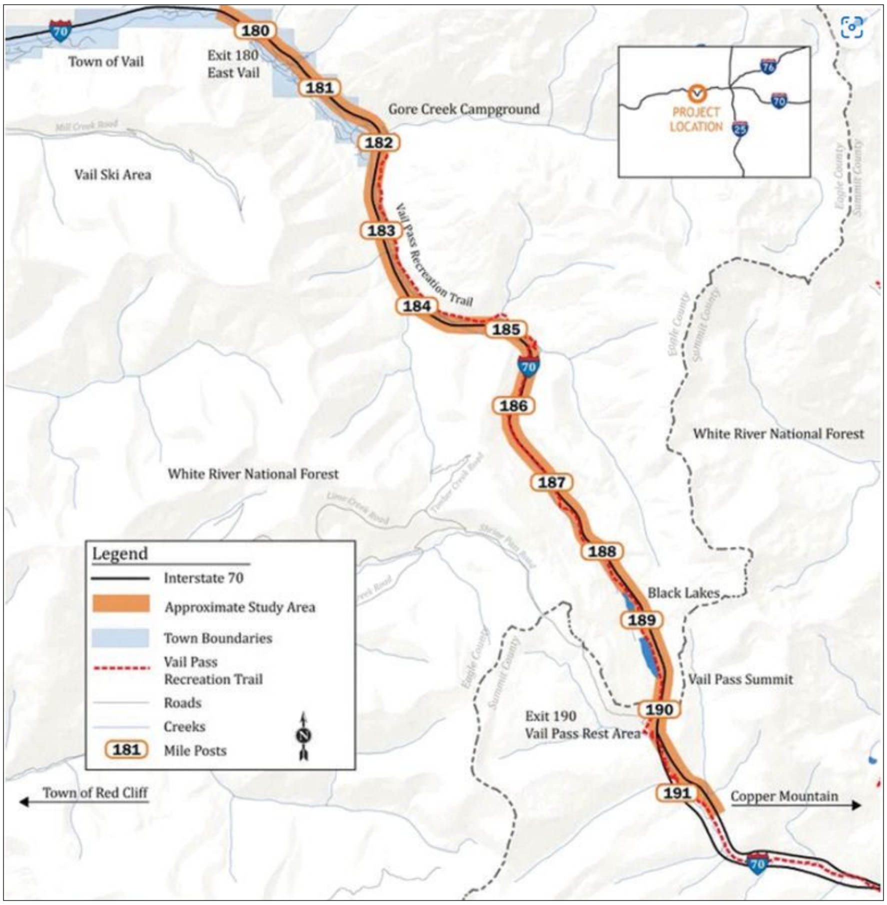
West Vail Pass Auxiliary Lanes

Interstate 70 over Polk Creek bridge replacements using precast, post-tensioned curved concrete U-girders

by Chad Hammond, RS&H, and Angela Tremblay

As part of the Interstate 70 (I-70) West Vail Pass auxiliary lanes project, the Colorado Department of Transportation (CDOT) replaced the bridge structures over Polk Creek in Summit County, Colo., near the town of Vail. The bridge replacements are part of improvements designed to enhance safety and reduce congestion through the steep mountain pass. The existing highway section is only two lanes in each direction, which often leads to unpredictable travel times as slow-moving trucks navigate the steep grades and tight curves. This portion of I-70 has one of the highest crash rates in Colorado, with more than 600 accidents on West Vail Pass between 2017 and 2021, and more than 1800 hours of full and partial closures during the same period.[1]

The West Vail Pass corridor is a vital link for people and freight moving across Colorado's Rocky Mountains. CDOT estimates an economic impact of $1 million per hour when the highway is closed.[2] Safety and capacity improvements for the 12-mile corridor have been studied and planned for more than 20 years. Some of the planned improvements include improving safety and operations on I-70 for the traveling public, maintenance staff, and emergency responders by adding a climbing lane, widening traffic lanes and shoulders, and modifying existing curves to meet current federal design standards. These upgrades also required the replacement of the Polk Creek bridges, which was accomplished under the construction manager/general contractor (CM/GC) project delivery method.



The Interstate 70 bridges over Polk Creek are at milepost 186.5 along the West Vail Pass auxiliary lanes project near Vail, Colo. Figure: Colorado Department of Transportation.

Project Delivery

CDOT structured the West Vail Pass project as a CM/GC project so the contractor and design consultant could work together through the design

profile

INTERSTATE 70 OVER POLK CREEK BRIDGES / VAIL, COLORADO

BRIDGE DESIGN ENGINEER: RS&H, Denver, Colo.

PRIME CONTRACTOR: Kiewit, Lone Tree, Colo.

PRECASTER: Plum Creek Structures, Littleton, Colo.—a PCI-certified producer

POST-TENSIONING CONTRACTOR: Structural Technologies LLC, Wheat Ridge, Colo.

OTHER MATERIAL SUPPLIERS: Custom formwork: Doka, Denver, Colo.

The Ten Mile Canyon National Recreation Trail, which crosses beneath the Interstate 70 bridges, remained open to cyclists and pedestrians during construction. The trail can be seen entering under the bridges at the bottom right-hand side of this photo, then it winds through the trees and climbs toward the top of the photo. All Photos: Kiewit.

process. The CM/GC process allowed the contractor, owner, and designer to collaborate on the complex issues that were known when planning this project and adapt quickly as issues arose.

For example, the initial plan was for twin 1200-ft-long twin bridges, constructed simultaneously outside the original highway footprint. However, during the constructability assessment, the contractor determined that such long bridges would be difficult to construct on the limited footprint of the jobsite. The project team revised the plan to reduce the bridge lengths and phase construction to build one bridge at a time on a roadway alignment closer to the existing I-70 alignment and adding embankment to shift the abutment locations. This facilitated the use of two bridges with 575-ft-long main structures over Polk Creek. The contractor quickly provided a cost estimate for the alternate solution to the CDOT team so they could make an informed decision and move forward without schedule delays. This collaborative approach helped the teams solve contract, scope, and risk issues together without stalling the project or deferring problems to be negotiated through change orders. A risk register was maintained for the project to define risks and clearly state who owned each risk before beginning the work.

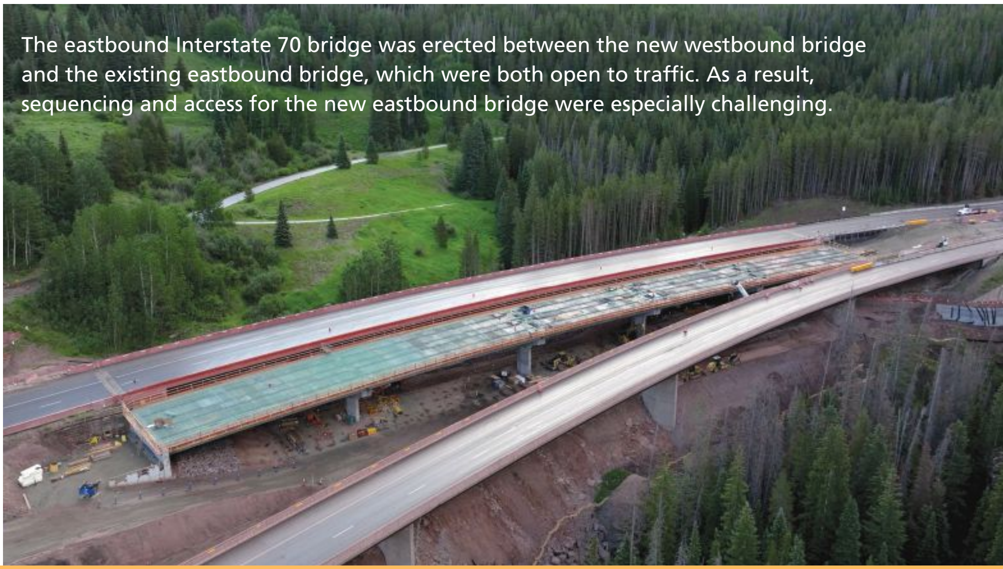
Design Criteria

To enhance safety and bring the bridges and roadway geometry up to current federal standards appropriate for the 65-mph design speed, the radii of the horizontal curves were increased, and the bridges were widened to accommodate three 12-ft lanes and two 8-ft shoulders. Even so, the design still involved a 1680-ft-radius curve, and the curved geometry was a significant consideration for determining the bridge type.

Another important consideration was the historical significance of the I-70 corridor at Vail Pass. This segment of I-70 was originally constructed in the 1970s with the intent to integrate aesthetics into the various highway elements to honor the natural environment. In 2011, Vail Pass was declared historically significant and eligible for listing on the National Register of Historic Places as a linear historic district because of the way it was designed and constructed to "enhance the alpine environment."[3] As such, CDOT was bound to adhere to aesthetic and environmental commitments on the pass and honor the original design. As part of the aesthetic criteria, bridges were to portray a slim, curvilinear, and elegant appearance that would blend into the landscape. The bridges had to use box or tub girders on single-column piers, and curved structures could not use chorded, straight girders to approximate a curve.

Structure Type Study

After the initial roadway layout and constructability reviews, the design



The eastbound Interstate 70 bridge was erected between the new westbound bridge and the existing eastbound bridge, which were both open to traffic. As a result, sequencing and access for the new eastbound bridge were especially challenging.

COLORADO DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Twin five-span post-tensioned, precast concrete simple-made-continuous tub girder bridges.

STRUCTURAL COMPONENTS: Three girder lines per five-span bridge for a total of 30 precast concrete U72 tub girders; an 8½-in.-thick cast-in-place concrete deck with 3½-in.-thick precast concrete deck panels; cast-in-place concrete semi-integral abutments and single-column piers supported on drilled shafts.

The completed westbound bridge (left) and the in-progress eastbound bridge (center) have improved roadway geometry compared with the existing eastbound bridge (right). The horizontal curves and shoulder widths were upgraded to current federal standards appropriate for the design speed of 65 mph.

team determined that the best solution for the bridges was to use a total length of approximately 550 to 575 ft on a constant horizontal curve. The out-to-out width was 55 ft to allow three traffic lanes, shoulders, and 1.5-ft-wide CDOT type 9 bridge railings. The team developed several alternative structure types and span configurations that would meet the aesthetic criteria to use curved tub or box girders, and they ultimately evaluated the following three options in detail:

- Four-span, spliced steel tub girders
- Four-span, spliced post-tensioned concrete tub girders
- Five-span, simple-made-continuous curved precast concrete tub girders

The structure selection process involved an evaluation of all three options for aesthetics, cost, schedule, constructability, and serviceability. The spliced steel option promised a favorable schedule and constructability benefits as girders could be spliced in the air, eliminating falsework towers and closure pours that would be needed for spliced concrete girders. Cost and serviceability were major concerns with this option, as the cost was expected to be $2.2 million more than the lowest-cost option and bearings would be required at all supports, which would increase future maintenance costs for CDOT. There was also concern that compared with the concrete options, the steel design would produce a larger cyclical (temperature-based) movement that would be less favorable to the performance of expansion devices or require the use of larger expansion devices.

The spliced concrete option would cost less than the steel option, even after field work and larger cranes for picking concrete girders were considered. The major concern with this option was the schedule associated with building falsework towers, casting field splices for the girders, and post-tensioning the tendons. The contractor estimated that this option would add 10 weeks to the schedule for each bridge.

Traditionally, most multispan, post-tensioned concrete girders are spliced. However, because access and construction schedule were limited, the design team wanted to include an option that would eliminate the use of falsework towers and post-tensioning on site. Therefore, they developed a design that would use precast, post-tensioned concrete tub girders in a manner similar to that used for pretensioned girders, where girders are tensioned in the casting yard after they are removed from the forms but before they are shipped. For this project, the precast concrete tub girders are assumed to behave as simple spans for noncomposite loads applied before the deck cures, but continuous for loads applied to the composite section (superimposed dead and live loads).

The bridge design includes 3.5-in.-thick precast concrete deck panels that were used as forms for an 8.5-in.-thick cast-in-place concrete deck. In this photo, the precast concrete deck panels have been placed, the continuity diaphragms have been formed, and reinforcement is being placed in preparation for the cast-in-place concrete deck placement.

The cast-in-place concrete deck placement is complete on the eastbound bridge. The deck will be topped with a waterproofing membrane and an asphalt concrete wearing surface to complete the driving surface as seen on the completed westbound structure.

The simple and elegant lines of the new bridges honor the original structures and complement the mountain environment. Design choices along the Vail Pass corridor were chosen to "enhance the alpine environment" consistent with the corridor's eligibility for listing on the National Register of Historic Places as a linear historic district.

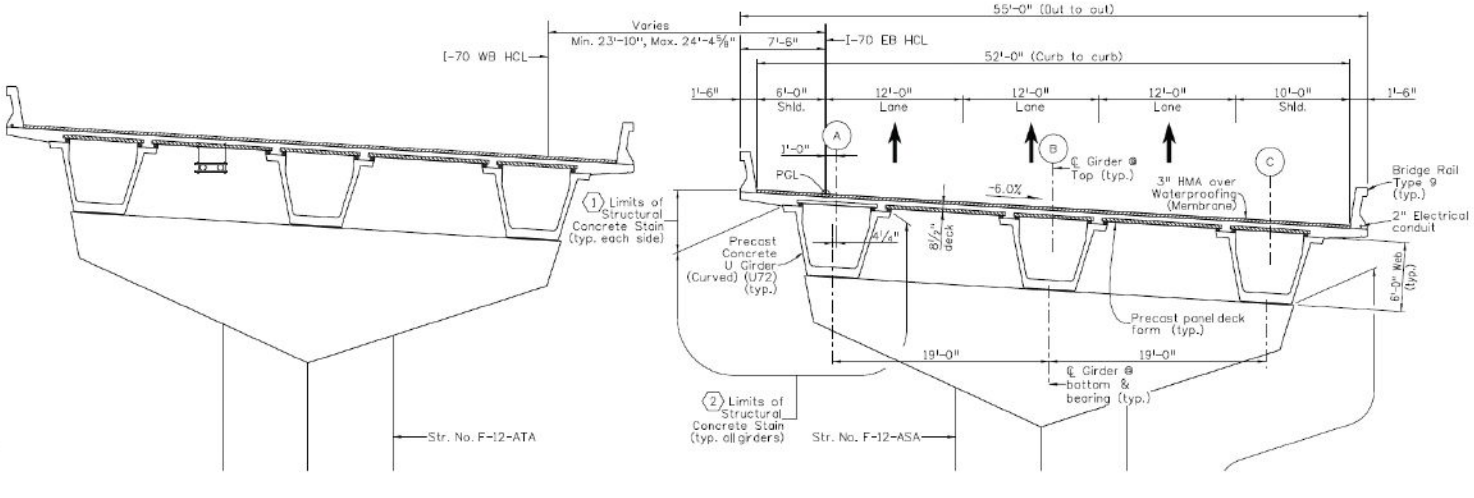
The simple-made-continuous for live load precast concrete girder option offered cost and schedule advantages. Despite adding a pier, this option would cost less than the other options, and the added construction time for the additional pier was minimal. These factors ultimately led the stakeholders to choose this option for the final design.

Design

The westbound I-70 structure over Polk Creek has span lengths of 86.5, 115, 115, 115, and 113.5 ft for a total of 545 ft, whereas spans for the eastbound bridge are 115, 131.58, 105.25, 105.25, and 115-ft long for a total of 572.08 ft. Three girder lines were used for each bridge. While these girder lines each have a different radius when laid out on paper, the design team decided to use the same radius for all the girders so that a single set of forms could be used. This decision saved labor and time in the casting yard. Because the girders have a constant radius, they are not perfectly parallel to each other or to the edge of deck and they do not have a constant offset distance between them and the edge of deck. Calculations showed that the difference in offset between the exterior girder and the edge of deck radius was only ½ in. at its maximum point and would be imperceivable to any observer. The deck consists of 3.5-in.-thick precast concrete deck panels, prestressed with ⅜-in.-diameter strands, that were used as forms for the 8.5-in.-thick cast-in-place concrete deck. Partial-depth precast concrete deck panels are used on many bridges in Colorado, and forming a soffit and placing shoring towers under the bridge was not cost or schedule efficient, so the precast concrete panels were a great fit for the project. All cast-in-place concrete for the superstructure was CDOT class DF concrete, which includes macro or hybrid polyolefin fibers to reduce shrinkage cracking and extend the service life of the structure. The concrete deck was topped with a waterproofing membrane and a 3-in.-thick asphalt wearing surface.

With the CM/GC contract and because the bridges were phased such that the westbound bridge was completed before construction began on the eastbound bridge, the contractor was able to give feedback on construction of the first bridge that could be applied to the design of the second bridge. One example of this was the contractor's request that the girders be designed to allow a large overhang from the support to the girder end during shipping. To facilitate this request, the girder design was modified to add a temporary post-tensioned monostrand to the girder top flanges. The monostrand was

The improved cross section for the bridges over Polk Creek has an out-to-out width of 55 ft to allow three traffic lanes, shoulders, and 1.5-ft-wide CDOT type 9 bridge railings. Figure: RS&H.



Temporary and permanent bracing is in place as the formwork and reinforcement for the continuity diaphragms at the piers are prepared.

The simple-made-continuous design uses precast, post-tensioned concrete tub girders in a manner similar to that used for pretensioned girders. The girders were tensioned in the casting yard after they were removed from the forms, but before they were shipped.

tensioned on the same day as all other prestressing, but it was tensioned last in the sequence. This additional post-tensioning limited the tensile stress induced in the top flanges by the large girder overhangs during shipping. The monostrand was detensioned after the girders were set on site.

The substructure consists of cast-in-place concrete semi-integral abutments and single-column piers with a diamond-shaped cross section. Each pier is supported by a pair of 48-in.-diameter drilled shafts, and the abutments are each supported by four 30-in.-diameter drilled shafts. The abutments are relatively tall, with an exposed height of 6 ft from the ground to the bearing seat and a height of 13 ft from the ground line to the top of abutment; therefore, the earth load behind the abutments was significant. To reduce the total load applied to the drilled shafts, crews built a basket-faced, mechanically stabilized earth wall behind the abutments to prevent the full lateral earth pressure from the backfill being applied to the abutments and foundations.

Construction

The logistics of the Vail Pass project differed significantly from those of projects on Colorado's Front Range. Working on a busy mountain pass, the construction crew faced many unique constraints.

- There were limited local trucking options, so the contractor had to use companies from farther away in Denver or Grand Junction to meet hauling needs.
- The construction season on the pass is very limited due to the harsh winters, and working through the spring is very slow due to muddy conditions from snow melt.
- The Ten Mile Canyon National Recreation Trail crosses the project site and needed to remain open to cyclists and pedestrians during construction.
- In addition to the high volume of vehicular traffic, large events and cycling competitions had to be accommodated.

Public safety was a priority—the team had a duty to protect cyclists, trucks, and cars moving through the project area. To promote safe travel, full-time flaggers were used and lane closures were limited.

In addition to maintaining safety, the team had to work through solutions to address environmental and site-access challenges associated with the project. The terrain and general logistics of the location made it difficult to ship materials to the jobsite. Cast-in-place concrete construction had to be carefully planned because the supplier was limited to 200 yd^3 of concrete per delivery. The plan to ship the girders from Littleton, Colo., to the jobsite near Vail Pass, a distance of roughly 98 miles, was also complex because there were very few alternative routes to I-70. Structurally deficient bridges had to be avoided, or the load had to be distributed so that the structures would not be overloaded.

The team designed custom haul trucks to transport girders on the planned route. This arrangement worked well for the westbound bridge construction because there was space for a staging area on the north side of the bridge that allowed the contractor to pick and place the girders with no interference.

However, the eastbound bridge was nestled between the new westbound bridge and the existing eastbound bridge, both of which were needed to maintain traffic; therefore, sequencing and access were especially challenging. The haul route had to be revisited after the westbound bridge was built and it came time to deliver the girders for the eastbound bridge. The detour used to move westbound girders around a deficient bridge was no longer viable when shipping the eastbound girders because there was another CDOT project underway along I-70. There were many transportation meetings to work through this issue. Eventually, the team determined that the best solution was to use the crane to pick the girders off the newly built westbound bridge with a lane closure in place. Then the girders could be placed directly into their final position, which reduced crane time and avoided double handling of the girders.

The curvature of the girders presented a challenge when it came to girder erection. The girders would tend to rotate without the full bracing of the deck in place and the dead load from above balancing out their weight and shape. To provide the needed stability during construction, temporary bracing was designed and installed. After the concrete deck was completed and cured, the bracing was removed. A similar issue applied to the bearings. When the girders were set, there were


A precast, post-tensioned concrete tub girder passes through the Vail Tunnel on its way to the bridge location over Polk Creek. The terrain and general logistics of the project made it difficult to ship materials to the jobsite.

gaps at the bearings. The application of the weight from the precast concrete deck panels and deck placement closed the gaps at the supports and shifted the girders back into their proper alignment.

Conclusion

Construction of the westbound I-70 bridge over Polk Creek was completed in 2023, and work on the eastbound bridge wrapped up in 2025. Precast concrete construction saved an incredible amount of time on this project. The innovative, simple-made-continuous precast concrete girder concept proved to be cost-effective and saved time in construction. Furthermore, the simple and elegant lines of the new bridges honor the original structures and complement the mountain environment. The bridge replacements are an important milestone in the West Vail Pass auxiliary lanes project, which is improving safety and operational capacity in the region.

References

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