# ENGAGED IN ARIZONA

Arizona's longest steel span is part of a bridge replacement project using a collaborative delivery model. **Jason Nauman** and **Greg Lingor** quantify the benefits of the approach and its influence on final design

Interstate 15 travels along the scenic Virgin River in the north-west corner of Arizona, linking California and Nevada with the Rocky Mountain region. Since 2014, the Arizona Department of Transportation (ADOT) has been repairing, rehabilitating or replacing the seven bridges on I-15 in the state, and Virgin River Bridge No. 1 is the latest to be addressed. The US$57-million replacement project is being completed through a Construction Manager at Risk (CMAR) approach, which has managed risks and improved constructability on what will be the longest steel girder span in Arizona.

Built in 1964, the existing Virgin River Bridge No. 1 is a five-span haunched steel girder bridge which has been classified as structurally deficient and scour critical. The 259.4m-long bridge has a long history of repairs including deck, joint and barrier replacement in 1986; girder fatigue crack repair in 1999; and joint replacement and deck repair in 2012.

After the last repair project in 2012, ADOT initiated a scoping phase to determine the long-term approach for the crossing. Two major findings came out of this process, which lasted from 2012 to 2018: replace the bridge on the same alignment and use the CMAR delivery method.

In early 2018, HDR was retained to provide final design services and, in early 2019, after the 30% design package was complete, Kiewit was retained as the CMAR contractor. The design phase concluded at the end of 2020 and construction began in February 2021. The new bridge is scheduled to be completed in 2023.

The CMAR delivery method is similar to the Construction Manager/General Contractor route and was primarily selected due to challenging access, the need for staged construction, and environmental considerations. With the CMAR method, the contractor and designer work collaboratively, while each has a direct contractual responsibility to the owner. The designer and constructor are contractually required to work together during the design phase to complete the design and to establish a price for construction that is guaranteed by the contractor. As this price is developed, an independent cost estimator reviews the project and provides their own estimate to the owner. In the event the owner and contractor are unable to agree on a guaranteed maximum price, the owner has an option to put construction plans out to bid.

The approach helps reduce the owner's risk through agreement of the guaranteed maximum price and the contractor's participation in reviewing contract documents during design. Contractor-designer disputes are reduced by allowing contractor input and constructability reviews to occur as the design progresses. Quality, cost and construction duration also have the potential to be improved for projects using this alternative delivery method.

Collaborating with the contractor during design provided the opportunity to improve constructability and accommodate the contractor's preferred means and methods for replacing the bridge. On the Virgin River Bridge No. 1 project, several major elements of the bridge layout and design were influenced by the CMAR delivery method: span configuration, horizontal alignment and staged construction, abutment location, girder splice locations, pier drilled shaft construction, and optional construction joints.

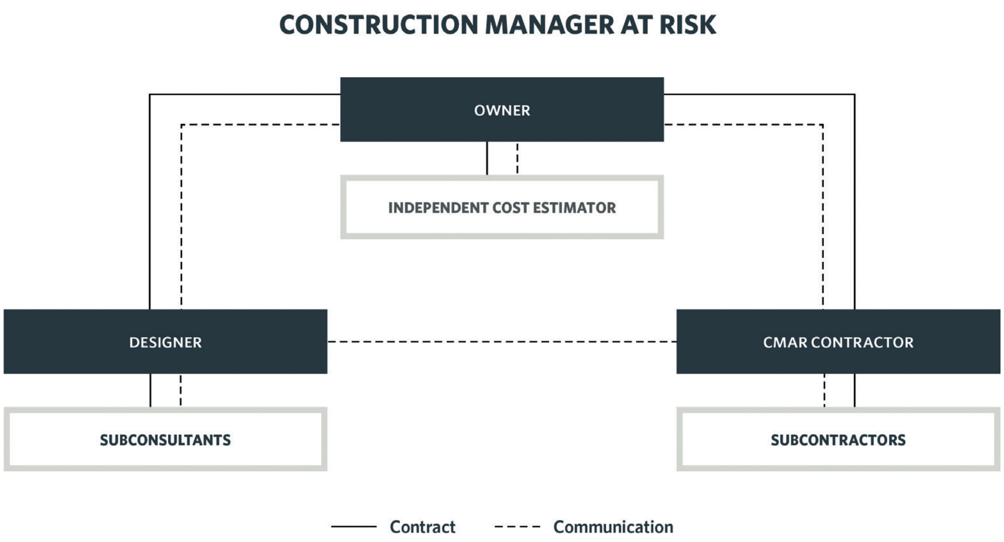
Through the initial design process and ensuing CMAR process, the proposed structure evolved from a five-span haunched weathering steel plate girder bridge to one with three spans.

The five-span bridge had been recommended during the preliminary scoping phase, but replacing a five-span bridge with another in the same location meant avoiding the existing pile foundations and creating unbalanced spans. Consequently, HDR developed a four-span bridge for the 30% design package. Once the contractor joined the team, they proposed a three-span option. Kiewit recognised that much of the project's risk and cost was associated with work in the river, especially considering that deep foundations were required to be designed for nearly 23.3m of scour for a 500-year extreme flood event.

The design of the replacement bridge has evolved from a five-span haunched weathering-steel girder bridge to one with three spans *(HDR)*

Despite a slight increase in cost due to additional steel for the superstructure, it was ultimately decided that a three-span bridge (79.2m, 103.6m, 79.2m) is the best span arrangement for this site to minimise risk associated with pier foundation work in the river. With a main span of 103.6m, the new bridge will have the longest steel girder span in Arizona.

The new bridge needed to be constructed within the limits of the existing bridge, as cultural resources at the western end of the bridge could not be disturbed and maintaining the same profile was desired to limit the amount of approach roadway work. The team was also required to maintain at least one lane of traffic in each direction on I-15 at all times throughout construction. Together, these limitations created one of the major challenges for this project: replacing the bridge in the same location while maintaining traffic. The solution was to use staged construction, but it required dealing with some tight geometric constraints, both horizontal and vertical. The CMAR approach proved useful in verifying constructability while refining the bridge layout and geometrics.




Lines of communication and contractual obligations under the CMAR deliver method *(HDR)*

Ultimately, the horizontal alignment was shifted 2.7m based on input from the contractor. This allowed four of the eight girders to be included in Stage 1 of construction. This slight shift was enough to allow all girders to be erected in pairs without disturbing the cultural resources at the west end of the bridge. Without constructability input from the contractor and no corresponding alignment shift, construction Stage 1 would have included only three out of the eight new girders.

To minimise the length of the new bridge, the new abutments were initially placed behind the existing ones by just enough to avoid conflict with the existing spread footings. Taking advantage of the CMAR process, the design team asked for the contractor's input on the constructability of the new abutments given how close the new drilled shafts would be to the existing footings. Based on this feedback, it was decided to shift the entire bridge 0.3m towards abutment 2. This created a conflict with existing abutment 1 footing, but it provided more clearance to the existing – deeper – abutment 2 footing.

Since the footing at abutment 1 is shallow, the contractor preferred to excavate down to remove the portion of the existing footing that would conflict with the new shafts and then backfill to create a pad for the drill rig. With just 152.4mm between the new and existing abutments, this approach also allowed the contractor to use the existing abutment to form the new abutment cap.

Due to the limited space that the alignment could be shifted by, the majority of the new bridge had to be constructed within the footprint of the existing one. This meant that the new girders had to be designed to clear the existing piers to allow staged construction to occur. The contractor proposed taking advantage of this and recommended using the existing piers as temporary supports during girder erection, in lieu of shoring towers. To make that possible, some of the girder splices needed to be relocated. For the three girders that were not directly above the existing pier cap, the contractor planned to use cantilever brackets attached to the existing piers. Involving the contractor in the design process resulted in a design that provided more options for girder erection methods.

The new piers are 27.4m-tall dual-column hammerhead piers that match the look of the existing single-column hammerhead piers. They are supported by four 1.83m-diameter drilled shafts beneath each column. To minimise disruption to traffic and save costs, the team wanted to install all drilled shafts for the new bridge prior to shifting traffic and removing any portion of the existing superstructure. This would allow all pier shafts to be installed in one mobilisation. Using the CMAR process, the contractor was asked to verify the feasibility, including whether overhead clearance was sufficient for the drill rig.

The CMAR process also influenced the use of an optional construction joint in the pier cap, which allows the contractor to build one column at a time (only what is needed for each stage of construction) or build the entire pier all at once. During design, the contractor indicated that both columns would be constructed simultaneously and the cap would be integral. But, recognising the possibility in the CMAR method that the owner could still advertise the project if unable to agree with the contractor on a price, it was decided to provide the optional construction joint and detail the reinforcing to allow for staged construction of the pier.

In addition to the bridge-related items, other project elements were also influenced by the CMAR delivery method, notably the temporary construction access bridge required for construction. The number of spans, bridge type, span lengths and bridge components were determined by the contractor with consideration of items such as constructability, availability of materials and cost. An important component of their decision was a project requirement to temporarily remove the superstructure for high-flow events to prevent the structure from washing away. With this in mind, the three-span layout designed and constructed by the contractor was detailed in such a manner that a crane could quickly remove the spans.

One of the distinct differences between ADOT's standard specifications aligned with design-bid-build and the additional specifications aligned with CMAR delivery is how risk is incorporated into the bid. In a typical design-bid-build, the contractor needs to assess risk on their own and cover that risk within their bid. For CMAR delivery, ADOT's itemised bidding is specifically designated for allowances to cover risks identified by the designer, contractor and owner. An example of this is the temporary bridge and the requirement to temporarily remove the superstructure during higher flows. In a traditional design-bid-build, bidding contractors would evaluate the probability and associated cost – the risk – and include that cost within the temporary bridge bid item. The winning contractor would be paid regardless of this occurring.

For CMAR, the team collectively decides on the number of occurrences, and the owner and contractor negotiate an allowance for each occurrence. If temporary removal of the temporary bridge superstructure is never required, the owner bears no cost and the contractor receives no payment. If it does occur, the contractor is paid per occurrence based on the negotiated cost. The contractor is a key member in evaluating the probability of occurrence (along with the designer and owner) and in determining the cost of the allowance.

The success of the CMAR delivery method is highly contingent on having an engaged contractor. For this project, the contractor was continuously engaged and therefore the CMAR delivery method was very effective. Also driving success was the fact that all of the team members understood their roles, contributed valuable ideas, and worked together with a focus on achieving a successful project ■

Greg Lingor is a senior bridge project manager at HDR and Jason Nauman leads HDR's bridges and structures practice in Arizona and New Mexico