Stretching the Limits of Precast Concrete

by Daniel Baker and Nick Eggen, HDR Engineering Inc.

The Nevada Department of Transportation's $600 million design-build Project Neon includes a connector flyover bridge linking high-occupancy vehicle (HOV) lanes between Interstate 15 (I-15) and U.S. Route 95 (U.S. 95) in the heart of the Las Vegas, Nev., transportation corridor. The connector bridge's geometry involves a greater than 90-degree turn in 18 spans on an 875 ft horizontal radius, all while crossing multiple alignments at severe skews. That geometric complexity might seem to dictate the use of a steel plate girder superstructure. However, the design team refused to accept the status quo and chose precast, prestressed concrete girders for the superstructure.

Chorded, precast, prestressed concrete girders provided an economical solution for Project Neon's high-occupancy vehicle connector bridge in Las Vegas, Nev. The temporary lateral girder bracing visible in in the photo was removed when the structure was completed. All Photos and Figures: Kiewit Corporation.

Three girder shapes were analyzed during the design process: the Utah bulb tee, the Idaho Transportation Department's wide-flange girder, and the California wide-flange girder (CAWF). Each shape has distinctive attributes, but all three are similar in top-flange width (approximately 4 ft 0 in.), web thickness (6 to 6.5 in.), and bottom flange width (3 ft 2 in. to 3 ft 9 in.). All three shapes can also vary in depth by 6- or 8-in. increments. However, the larger bottom flange of the CAWF shape had a distinct advantage for this project because the larger flange lowers the centroid of the section and allows for more prestressing strand to be used for design.

For the connector bridge, large amounts of prestressing were coupled with the use of 10-ksi, high-strength girder concrete to maximize design efficiency. Additional layout efficiencies were captured by making the girders continuous for composite loading through the use of continuity diaphragms at the piers. The superstructure was arranged into six 3-span frames, which balanced the positive moments in the girders to the furthest extent possible while considering span arrangement requirements.

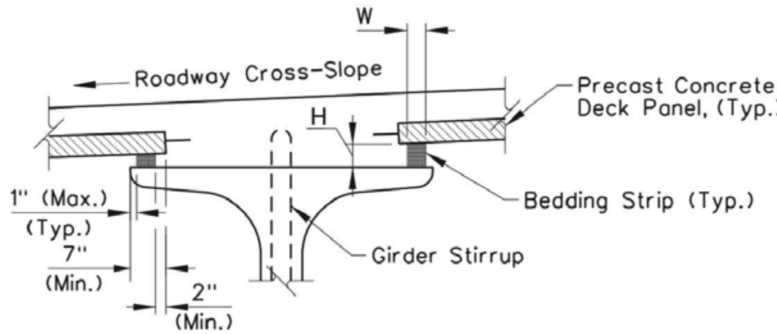
The girders are arranged along chords of the 875-ft-radius horizontal curve between piers. Pushing the span limits of a curved bridge with chorded girders turned out to be a significant limitation in itself. Deck overhangs varied and had to be kept within manageable boundaries, which essentially limited span lengths to approximately 150 ft. Greater span lengths within the curve would create either too small of an overhang or an extremely large overhang that would require extra measures, such as transverse post-tensioning. Precast concrete girders were well-suited for this span range. High-strength, self-consolidating concrete with a design compressive strength of 10 ksi was used for the precast concrete girders. Concrete strength at transfer was designed to be as low as possible to aid in the fabrication schedule.

After the basis for the superstructure's design (girder type, maximum span lengths, frame layout, and concrete strength) was established, it was time to determine the final major design parameter—girder spacing. The 62 ft 0 in. width of the deck lent itself well to a five-girder layout using steel plate girders. This layout would have an approximate girder spacing of 13 ft 9 in. with 3 ft 6 in. overhangs. Girder spacing of this magnitude is relatively routine when steel plate girders are used. However, the design team was using precast concrete girders, and the proposed spacing of 13 ft 9 in. seemed improbable. This girder spacing was beyond that used in any of the design team's previous precast concrete girder projects.

At this point, the design team evaluated all feasible efficiency modifications. In the end, their calculations seemed to support the proposed spacing. Still skeptical, the design team searched for all possible reasons why the spacing would not work. Aside from the standard girder design calculations, engineers investigated other design issues such as deck span, girder top-flange lateral bending, and girder deflection requirements. Surprisingly, every design check came back favorable. After more analysis and optimization, designers landed on a girder spacing of 13 ft 7½ in. The design team took a deep breath and moved forward with design.

To maximize construction efficiency and reduce the amount of traditional deck formwork to be placed and stripped 60 ft in the air, stay-in-place partial-depth precast concrete deck panels were used for the deck design. Panel dimensions were standardized at 11 ft by 8 ft by 4 in. Each standard panel contains twenty-one ⅜-in.-diameter strands. Panels are

Installation of a California wide-flange (CAWF) girder at a straddle-bent location, with the neon lights of Las Vegas shining in the background. Compared with similar girder cross sections, the larger bottom flange of the CAWF shape allowed for more prestressing strands to be used.



A detail of the typical support condition of the 4-in.-thick precast, prestressed concrete deck panels.

normal to the centerline of the girders, and, because of the chorded girders and the curve of the alignment, the panels needed to have a skewed end at most pier locations. This was accommodated through the use of a special skewed-panel (trapezoidal) design.

While the design of the precast concrete deck panels was simple and straightforward, the design and practical accommodation for girder haunches (or buildups) and temporary deck panel support were far from ordinary. Along with typical precast concrete girder haunch considerations, the unique aspects of the bridge, such as the large and drastically varying superelevation and the effect of chorded girder geometry, had to be evaluated. Ultimately, the design heights of camber strips ranged from a minimum of 1 in. to a maximum of 11.5 in.

Deck panel support consisted of polystyrene camber strips placed at the edges of the girder top flanges. These strips are considered temporary—edges of panels become rigidly supported once the deck and haunch have cured. Design of the polystyrene supports was limited to a maximum height-to-width ratio of 2.0; therefore, with a maximum design height of 11.5 in., the maximum actual width was approximately 6 in. To ensure that this extreme haunch height could be accommodated without loss of panel stability, full-scale testing of a sample panel and camber strip assembly was performed before the final design was completed. Furthermore, during construction, panels were connected at intermittent locations along the girder for additional temporary stability. Additional panel stability was achieved by using tie wire to connect the panel-lifting loops (at four locations on each panel) to the projecting shear stirrups in the girders.

The underlying theme for the design of the HOV connector flyover bridge can be summarized in two themes: "push boundaries" and "design smart." The design efficiencies realized on this bridge resulted in enough savings to add an additional bridge replacement to the project. This outcome offers clear benefits to the owner and general public. In times where infrastructure funding is tight and often difficult to secure, finding real and practical design efficiencies should be high on every engineer's to-do list. (For additional information on this project, see the Project article in this issue of *ASPIRE*®.)

Daniel Baker and Nick Eggen are bridge engineers for HDR Engineering Inc., in the Coeur d'Alene, Idaho, and Las Vegas, Nev., offices, respectively.

Partial-depth precast, prestressed concrete deck panels were used in the deck. The 4-in.-thick panels eliminated the need to strip deck formwork 60 ft in the air and accelerated bridge construction.