PROJECT

Flying Over Las Vegas

Interstate 15/U.S. Route 95 High-Occupancy Vehicle Connector Bridge

by Daniel Baker and Nick Eggen, HDR Engineering Inc.

Project Neon's signature bridge is the high-occupancy vehicle connector flyover in Las Vegas, Nev. All Photos: Kiewit Corporation.

For nearly 20 years, the Nevada Department of Transportation has been planning and preparing for the largest and most expensive public works project ever constructed in the state. In the fall of 2015, Project Neon was officially awarded under a design-build contract, and its design phase began shortly thereafter. An important component of Project Neon, the widening and reconstruction of 3.7 miles of Interstate 15 (I-15) between Sahara Avenue and the U.S. Route 95 (U.S. 95) interchange, is currently nearing completion. This stretch of interstate is currently the busiest portion of roadway in Nevada, serving over 300,000 vehicles per day.

Installation of the reinforcement cage for a 11-ft 6-in.-diameter drilled shaft, located in the median of U.S. Route 95. Shafts were more than 100 ft deep in several locations.

Geometry for the Project's Signature Bridge

Included in this $600 million project is the "signature" high-occupancy vehicle (HOV) connector bridge, an 18-span, 2600-ft-long flyover structure that directly connects the new HOV lanes between U.S. 95 and I-15 in the heart of Las Vegas. The bridge begins and ends on a tangent alignment and completes a greater than 90-degree left-hand turn on an 875 ft radius. The structure's entrance and exit are in the center medians of each arterial, all while crossing I-15, U.S. 95, Martin Luther King (MLK) Boulevard, and several other ramps. Superelevation varies drastically throughout the length of the structure. On the I-15 side, the bridge has a 3% right-down superelevation and quickly makes a full reversal to an 8% left-down superelevation, which is held constant throughout the main portion of the curve. Near U.S. 95, the superelevation transitions again, finishing in a 2% crown over the last several spans. While the bridge superelevation makes a full reversal and crown break, the profile rises from I-15 at a 5% grade before reaching a plateau at a 0.5% slope. Finally, the flyover drops from the sky at a 6% grade to tie back into U.S. 95.

profile

INTERSTATE 15/U.S. ROUTE 95 HIGH OCCUPANCY VEHICLE CONNECTOR BRIDGE / LAS VEGAS, NEVADA

BRIDGE DESIGN ENGINEER: HDR Engineering Inc., Coeur d'Alene, Idaho

PRIME CONTRACTOR: Kiewit, Omaha, Neb.

PRECASTERS: TPAC, Phoenix, Ariz. (girders) —a PCI-certified producer; Precast Management, Las Vegas, Nev. (precast deck panels)

POST-TENSIONING CONTRACTOR: DYWIDAG-Systems International, Long Beach, Calif.

DRILLED SHAFT SUPPLIER: Hayward Baker, Hanover, Md.

A hammerhead pier configuration was selected for pier locations where possible. Pier caps are 61 ft wide and 11 ft deep over the columns. The cast-in-place concrete caps are conventionally reinforced.

Considering the required bridge geometry, the search to find the most efficient bridge design possible for the structure began during the project pursuit phase. Designers recognized that optimizing individual elements could have a compounding effect that would lead to an overall more efficient system.

Pushing Boundaries to Find Superstructure Efficiencies

Finding the most efficient girder shape, concrete strength, frame layout, and girder spacing (and resulting number of girder lines) was paramount to achieving the most efficient structure possible. The bridge superstructure consists of six 3-span frames composed of California wide-flange (CAWF) precast concrete girders made continuous for live load. The girders are spaced at a remarkable 13 ft 7.5 in. The girders are arranged along chords of the 875-ft-radius horizontal curve between piers. Because of the curved edge of the bridge deck, there are variable deck overhangs. Spans range in length between 124 and 162 ft, for a total bridge length of 2606 ft. Two CAWF girder sizes, 66 in. and 84 in., are used on the bridge structure, and each type of girder uses high-strength (10 ksi), self-consolidating concrete. The overall depth of the superstructure varies with span and according to haunch requirements. In general, the depths are about 8 ft 6 in.

One of the two straddle bents on the project, which are critical aspects of the bridge layout. To keep span lengths reasonable so precast concrete girders could be used, straddle bents were required to span more than 100 feet over each mainline arterial.

The bridge is 62 ft wide with a 9.5-in.-thick deck. The deck is composed of a 4-in.-thick partial-depth precast concrete deck panel and a 5.5-in.-thick cast-in-place topping slab. Because of the climate in the Las Vegas area, standard plain reinforcing bars are used for the entire project; epoxy-coated reinforcing steel or other methods of corrosion protection are simply not needed.

Substructure Optimization

In addition to seeking an efficient superstructure design, designers were challenged to find the most economical substructure layout feasible given the geotechnical conditions of the site and surrounding geometric constraints. Efficiency came in the form of conventionally reinforced, single-column hammerhead piers. Column heights range between 13 ft 0 in. and 60 ft 5 in. throughout the length of the bridge. Most columns are rectangular in cross section and measure 7 ft by 10 ft, with 1 ft corner chamfers. However, two exceptions to this pier size were made where the bridge alignment crosses I-15 and U.S. 95 at extreme skews. In these locations, post-tensioned (PT) straddle bents were used to achieve reasonable superstructure span lengths given the chosen girder types. The PT straddle caps are 8 ft 6 in. wide by 11 ft 6 in. deep and include 12 PT ducts, each with thirty-one 0.6-in.-diameter strands, for a total initial post-tensioning force of 16,000 kip. These straddle bents, which span 106 ft 0 in. over I-15 and 104 ft 6 in. over U.S. 95, are supported by 8-ft-square columns, with 1 ft corner chamfers. Because of the large amounts of post-tensioning in the caps, tensioning was completed in stages to ensure that temporary concrete stresses remained within the limitations of American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*.

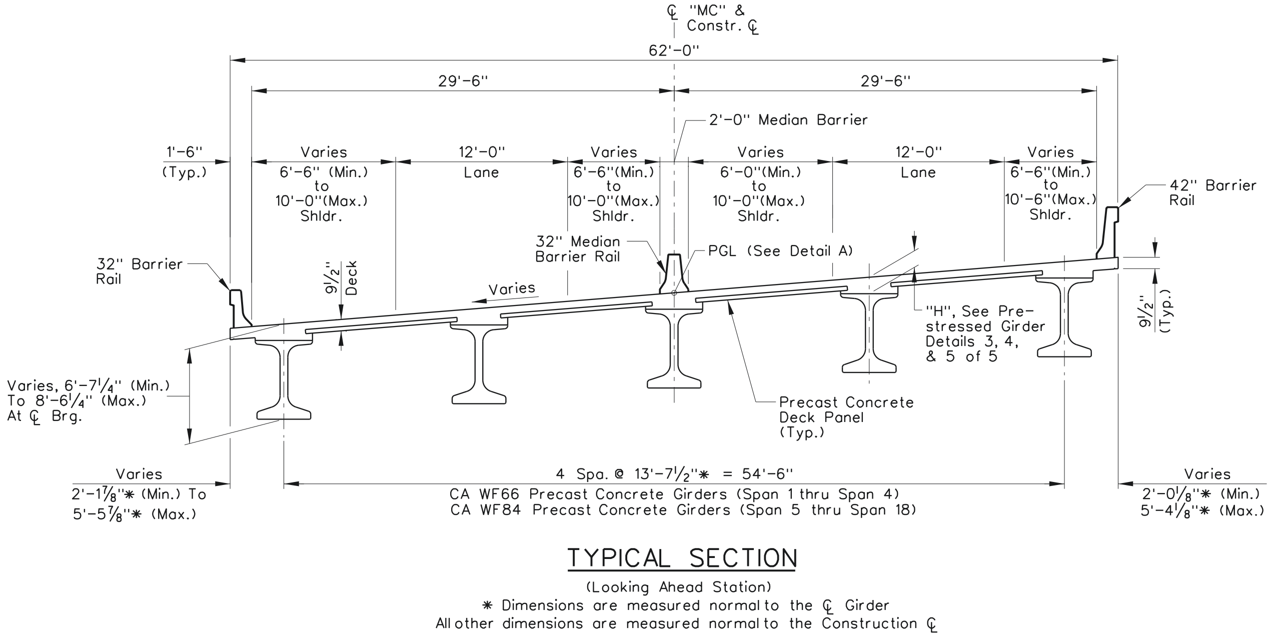
Drilled Shafts—What Lies Beneath

In the original concept, the foundation design included groups of small-diameter shafts with a typical cap

NEVADA DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: An 18-span, 2600-ft-long curved flyover bridge that uses precast, prestressed concrete girders placed on chords, partial-depth precast concrete deck panels, post-tensioned straddle bents, and drilled-shaft foundations.

STRUCTURAL COMPONENTS: Ninety California wide-flange precast, prestressed concrete girders; 4-in.-thick partial-depth precast concrete deck panels composite with a 5.5-in.-thick cast-in-place concrete deck; conventionally reinforced single-column hammerhead piers; two post-tensioned concrete straddle bents; and 11.5-ft-diameter drilled shafts



A typical section of the HOV connector flyover bridge. Chorded precast concrete girders spaced at 13 ft 7½ in. highlight the efficiencies realized in the project design. Precast, prestressed partial-depth concrete deck panels contribute construction-related efficiency for the bridge superstructure.

footing supporting each column. This design was soon revised during the pursuit phase of the project to use a single, large-diameter drilled shaft for each column. The single, large-diameter drilled shaft was more economical than the shaft groups for this application. Additionally, in pinched areas where the flyover departs or ties in with I-15 and U.S. 95, the single-shaft configuration provided a clear geometric solution that would significantly reduce the structure's impact during construction on the adjacent roadway and the general public.

To support the typical 7 ft by 10 ft column and provide adequate reinforcement clearances between the column and the drilled-shaft reinforcement cages, drilled shafts were oversized by 1 ft 6 in., resulting in a diameter of 11 ft 6 in. Shaft lengths typically range between approximately 70 and 100 ft, with a few shafts in excess of 100 ft deep.

The design of the drilled shafts for the structure is controlled by axial demands. However, the single-shaft configuration provides a significant contribution to overall lateral flexibility of the bridge. The consequences of this flexibility for the design of the overall structure are both adverse (p-delta effects) and beneficial (a higher seismic period leads to lower accelerations). Even after consideration of the detrimental effects, the single-shaft configuration provided clear economic and geometric benefits to the bridge design. As these drilled shafts were constructed, their size and scale made quite an impression on observers.

The Final Puzzle Piece

The largest efficiency realized for the structure was the simplest—making the bridge shorter. This concept required the most "outside of the box" thinking on the project. The original HOV connector concept called for a total structure length of 4668 ft. To reduce the bridge length to 2600 ft would require a drastic change to the point where the flyover landed within U.S. 95. Because of a width restriction between existing bridges over MLK Boulevard, the HOV concept structure remained in a viaduct configuration until the U.S. 95 split was wide enough to land the HOV lanes in the center median. This original conceptual design resulted in a structure length extending for more than 2000 ft past MLK Boulevard.

The resolution of this issue was linked to the existing northwest ramp direct-connect bridge, an adjacent flyover bridge that landed on the west side of MLK Boulevard. This bridge was not originally scoped to be modified or replaced. However, the design team noticed that if the last frame of the existing bridge were realigned and reconstructed, it would create sufficient width to shift the U.S. 95 northbound structure far enough to the north so that the HOV connector flyover could touch down just to the west of MLK Boulevard. This innovation eliminated more than 2000 ft of bridge when compared to the base concept, resulting in roughly $20 million in savings. This concept was made possible by the alternative technical concept process within the design-build delivery model. Without this avenue for change, this type of innovation would not likely be realized or put into action.

Design Smart

Project Neon's HOV connector flyover bridge is a shining example of the benefits of using standard concrete bridge elements while also pushing the boundaries of what is possible for a precast concrete girder bridge. Often, the most economical design can be found by leveraging individual element efficiencies to create a compounding effect that significantly reduces the structure's costs for the client and general public. For more information on this project, see the Concrete Bridge Technology article in this issue of *ASPIRE*®.

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