The Santa Ursula Connector

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The completed Santa Ursula Connector in Laredo, Tex., curves downward towards the Rio Grande River front. All photos and drawing: Structural Engineering Associates Inc.

As part of a plan to revitalize riverfront commercial development, the city of Laredo, Tex., required a solution to provide easier access to the area. To reach the riverfront, commuters had to negotiate a route of heavily congested, narrow, streets through business and residential areas. The idea was proposed to build an elevated connector from Santa Ursula Avenue, an access road from I-35, to the riverfront and thereby avoid the congestion of the city streets.

The Santa Ursula Connector was proposed to be 31 ft wide and 1155 ft long. The bridge would be required to connect the higher elevation Santa Ursula Avenue to the flood plain. It required spanning over federal property between two international bridges on the Texas-Mexico border. Because the majority of the bridge is below the design high water level by as much as 25 ft, it was necessary to design the bridge to withstand the flood forces of the Rio Grande River.

The engineer's first task consisted of a feasibility study. The study was followed by the layout and design for the bridge, and coordination with the city of Laredo, Webb County, local utility companies, and federal agencies including the General Services Administration, Customs and Border Protection, and the International Boundary and Water Commission (IBWC).

The IBWC regulates construction within the floodplain; in order to gain their project approval, the impact to the river had to be minimized. Therefore, the bridge required a shallow superstructure to reduce the impact on the river during a flood event. Additionally, a sharp horizontal curve was required to allow space for a future "up ramp" connector to be built. Finally, methods were needed to resist forces from a flood.

Design Challenges

The project presented several design challenges. The requirement for a future "up ramp" adjacent to the Santa Ursula Connector down ramp, necessitated a very sharp horizontal curve with a radius equal to 340.5 ft. It was desired to expedite construction within the federal property. Security within federal property (especially areas at border crossings) is extremely stringent. Workers required being on federal property needed to go through a lengthy federal security background check. Completing construction in secure areas as quickly as possible was a critical aspect of the design.

Finally, due to the bridge's location, an aesthetically pleasing structure was necessary.

Design Solutions

The Texas Department of Transportation's (TxDOT's) 15-in.-deep slab beam was selected to provide the minimum superstructure depth. The slab beam has a rectangular cross section and is available in both 4 and 5 ft widths. The typical cross section was framed with four, 5-ft-wide slabs and two, 4-ft-wide slabs. The slab beam provides a superstructure total depth of just 20 in. including a 5-in. deep cast-in-place composite concrete deck. Because the beams are abutted side-by-side, debris could not become lodged under the bridge during high water.

profile

SANTA URSULA CONNECTOR / LAREDO, TEXAS

BRIDGE DESIGN ENGINEER: Structural Engineering Associates Inc., San Antonio, Tex.

PRIME CONTRACTOR: Concho Construction Co. Inc., Garland, Tex.

PRECASTER: Bexar Concrete Works Inc. Ltd., San Antonio, Tex.

AWARDS: 2010 PCI Bridge Design Award, Best Bridge with Main Span up to 75 ft; 2011 Texas CEC Engineering Excellence Awards, Silver Medal Winner, Category C: Structural Systems

From the flood plain, the Santa Ursula Connector reaches upward to Santa Ursula Avenue.

A lateral load analysis of the entire structure was performed including the foundation. Using geotechnical data, the required embedment length of the drilled shafts was determined. The capacity of an extreme event loading was then checked.

The slab beam is seldom used on curved structures. When horizontal and vertical curves are combined, the bearing seats for these very wide, rectangular beams require special details to ensure that torsion is not introduced into the beams. A roadway cross slope adds complexity as well. The engineer determined that it was possible to overcome these hurdles without significant additional cost. The complex geometry was handled with a bridge geometry computer program using a modified and detailed input model.

Aesthetically, the straight-sided, chords of the slab beam were overcome by using a cast-in-place concrete overhang. The slab overhang was formed and cast with the bridge deck. The bottom of the overhang projected below the top of the exterior slab beams. It was connected laterally to the beams with mechanical couplers placed in the exterior edges during fabrication. The cast-in-place concrete overhang provides a very attractive horizontal curvature to the edge and the "drop-down" detail gives the superstructure the appearance of being thinner.

The location of the bridge, between two heavily used international bridges, required a method to ensure that the bridge would remain in place during a flood event. The owner was concerned about the possibility of the new bridge becoming dislodged and damaging or destroying the downstream international bridge. The slab beams are usually restrained from horizontal movement with the use of upturned ear walls on the ends of the bent caps. In addition to the ear walls, a nonstandard strand pattern allowed slotted vertical holes to be formed at the ends of the exterior beams. Hold-down anchors were provided in the tops of the bent caps. The exterior beams were erected with the slotted holes over the hold-down anchors. A steel plate was placed over the beam and clamped in place with a nut. Fiberboard was placed over the plate to allow for the superstructure movement after the deck was cast.

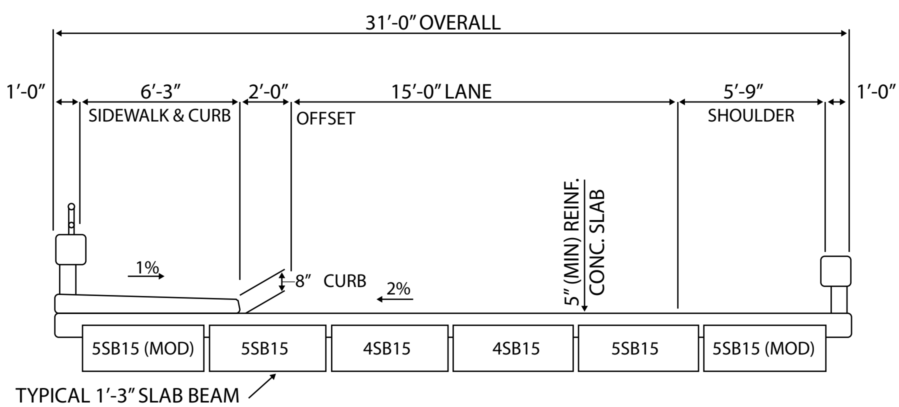
In addition to the shallow depth, the precast slab beams expedited construction over the federal property. Since slab beams are erected and placed side-by-side, they also act as a stay-in-place form for the cast-in-place deck slab. This feature saved valuable time, allowing the contractor to minimize the time of construction.

Design Innovations

The project resulted in innovations and accomplishments that can be considered for future projects with similar constraints. These innovations include:

- Using precast, prestressed TxDOT slab beams for sharp horizontal curves
- Using a nonstandard strand pattern to accommodate slotted holes to be formed in the beam ends for hold-downs to the pier cap
- Anchoring the precast superstructure to the substructure without resorting to cast-in-place concrete connections

The typical section of the single-lane Santa Ursula Connector superstructure.



PRECAST, PRESTRESSED CONCRETE SOLID SLAB BEAM BRIDGE WITH 25 SPANS TOTALING 1155 FT WITH A 5 IN.-THICK CAST-IN-PLACE CONCRETE COMPOSITE DECK SLAB / CITY OF LAREDO, TEXAS, OWNER

BRIDGE DESCRIPTION: A precast, prestressed concrete slab beam bridge 31 ft wide with 25 spans totaling 1155 ft and with cast-in-place composite concrete deck slab supported on a substructure comprising single-column bents and drilled shafts

STRUCTURAL COMPONENTS: Adjacent precast, prestressed concrete slab beams, 4 or 5 ft wide and 15 in. deep with cast-in-place composite deck slab and cast-in-place single column bents with single drilled shafts

BRIDGE CONSTRUCTION COST: Bridge cost $3.16 million ($89/ft²); Total Cost $4.20 million (including approach work)

The upper portion of the bridge spans over federal property. This is the overflow inspection station used at the border during busy holiday periods. One of only two, 2-column bents on the project is visible.

Less than a year after completion, the Rio Grande River submerged the bridge under 23 ft of water during a flood in July 2010.

Construction

The bridge comprises 25 spans, ranging in length from 41.5 to 48.4 ft., for a total length of 1155 ft. The foundations are predominantly 6-ft-diameter, single drilled shafts, 45 to 50 ft deep. Two bents required double drilled shafts to straddle underground utilities. All foundations and bents required a 28-day concrete compressive strength of 3600 psi. All but one of the bents are single column or hammerhead bents. The tallest bent is about 30 ft high. The slab beams required concrete with a minimum compressive strength of 5000 psi. The bridge deck has a minimum thickness of 5 in. at midspan. Continuity is provided in the deck across the transverse construction joints using typical TxDOT details, which are specifically designed to not provide full continuity for live load. The slab overhang depth varies due to the haunch thickness but has an 8.5 in. minimum depth at midspan. The deck concrete required a minimum compressive strength of 4000 psi.

Construction occurred between February 2008 and August 2009. The project construction schedule required adjustments for several local events including an unscheduled flood. Because the connector crossed over a federal inspection station used for overflow border traffic during busy times such as holidays, construction was stopped when use of the station was required.

Conclusion

The Santa Ursula Connector has successfully served the needs of the city of Laredo. It has provided quick and easy access to the riverfront as intended, and has generated interest from developers with concepts for revitalizing the area. Additionally, the connector has shown it can withstand the flood forces of the Rio Grande River when it was tested by the flood of July 2010.

The two edge slab beams have slotted holes through the ends that will receive anchor bolts from the bent caps. Cover plates and nuts will prevent the slabs from being displaced during high water.

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