Smart, Repetitive Design Accelerates Construction of Dual Cashie River Bridges

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A core slab bridge design facilitated top-down construction for the Cashie River bridges.

Wanted: twin bridges to span the Cashie River and adjacent wetlands. The design must be economical and accommodate an accelerated construction schedule as well as a DOT-imposed moratorium on in-stream work due to the environmental sensitivity of the site.

Solution: prestressed concrete cored-slab design that allows top-down construction. This approach avoids installation of a temporary work structure and facilitates construction of both structures in just 13 months.

Project Scope

The Cashie River bridges are part of the 9.5-mile U.S. 17 Windsor Bypass Project in Bertie County, N.C. This section of four-lane freeway features six bridges, including dual 1,700'-long bridges crossing the Cashie. The North Carolina Department of Transportation (NCDOT) selected the design-build team of Barnhill Contracting Company, HDR and Sanford Contractors, Inc. to complete the project. HDR was the engineer of record and Sanford performed all bridge construction as a subcontractor to Barnhill. The design-build process allowed HDR and Sanford to work side-by-side during the pursuit, design and construction.

The twin bridges span the Cashie River, and also cross associated oxbow islands and lakes, and high-quality wetlands. The request for proposals restricted in-stream construction to a period between October 1 and February 15. Since the contractor's start date was January 2006, there was just a month before the first moratorium went into affect. The project delivery date was set for June 2008, which left just two more full periods for in-stream work.

The "in-stream" area was defined as any wetlands that when inundated with water are connected to the main river. This distinction made it possible for the contractor to complete construction of about 1,300' of the bridges before the first moratorium was lifted in October 2006. The team set a goal to build the Cashie River bridges over in-stream areas during the first full construction season and was already well on its way to achieving that by the time the first full in-stream season began.

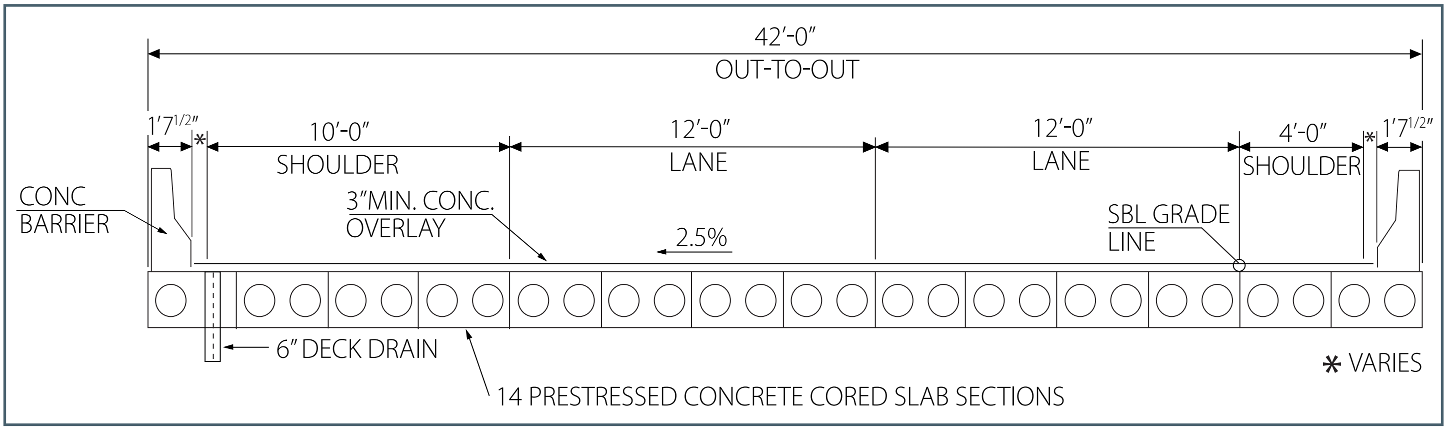

Figure 1. This drawing shows a typical section view through one of the dual structures.

Designing for Top-Down Construction

Several structure types were considered for these bridges. Longer-span precast concrete box beam, I-girder and steel plate girder alternatives required a temporary work bridge for construction, adding substantial cost. Also, the construction of the work bridge itself would be subject to the moratorium on in-stream work. These options were quickly eliminated.

Another option considered was cast-in-place concrete deck slabs with 30' spans. This provided substructure units close enough to build the bridge utilizing top-down construction, eliminating the need for a temporary work bridge. However, it required separate concrete pours for the superstructure and substructure of each span. The additional curing time and number of spans made this alternative less desirable in terms of cost and schedule.

The final alternative considered was prestressed concrete cored slabs. Span lengths were set at 50' to maximize the useful span of the cored slabs and minimize the number of bents required. A cored slab bridge facilitated top-down construction, eliminating the need for a temporary work bridge and allowing construction equipment to advance once each span was erected. There was no waiting for the concrete deck and barriers to be in place or costly cure-time delays. The final design called for 34 spans per bridge, with the last eight spans set on a slight horizontal curve.

New NCDOT design criteria requires cored slabs to have a reinforced concrete overlay in lieu of traditional asphalt overlay. To take advantage of this requirement, the bridge was divided into four-span continuous units.

With top-down construction, the crane is positioned on the fill slope, then the end bent and first interior bent are built. After curing time, the first span of slabs is set, and the anchor rods are put in place and grouted. When the grout cures, the crane is set up on the span and the next bent is constructed. This procedure is repeated over and over as progress continues toward the other end of the bridge (see photo on Page 9).

In eastern North Carolina, deep clayey, sandy soils require skin friction piles to obtain foundation capacities. Steel piles were chosen to allow quicker splices and smaller cranes, which were conducive to top-down construction.

Repetition Saves Time & Money

What ultimately made this project successful was the number of identical structural elements incorporated into the design—in both the superstructure and the substructure.

Superstructure—The typical section on each of the two bridges is 42' wide out-to-out, consisting of adjacent cored slab units, with slip-formed concrete (New Jersey shape) barriers on each side. (See Figure 1.) The project was designed in accordance with the American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications for Highway Bridges. The design live load for the project was HS20, except for the cored slabs which were designed for HS25.

To provide fixity at the bents, the gap between each cored slab end was filled with grout. Negative moment reinforcement was provided in the overlay over the bents. Also, inverted U-bars were used to tie the ends of the cored

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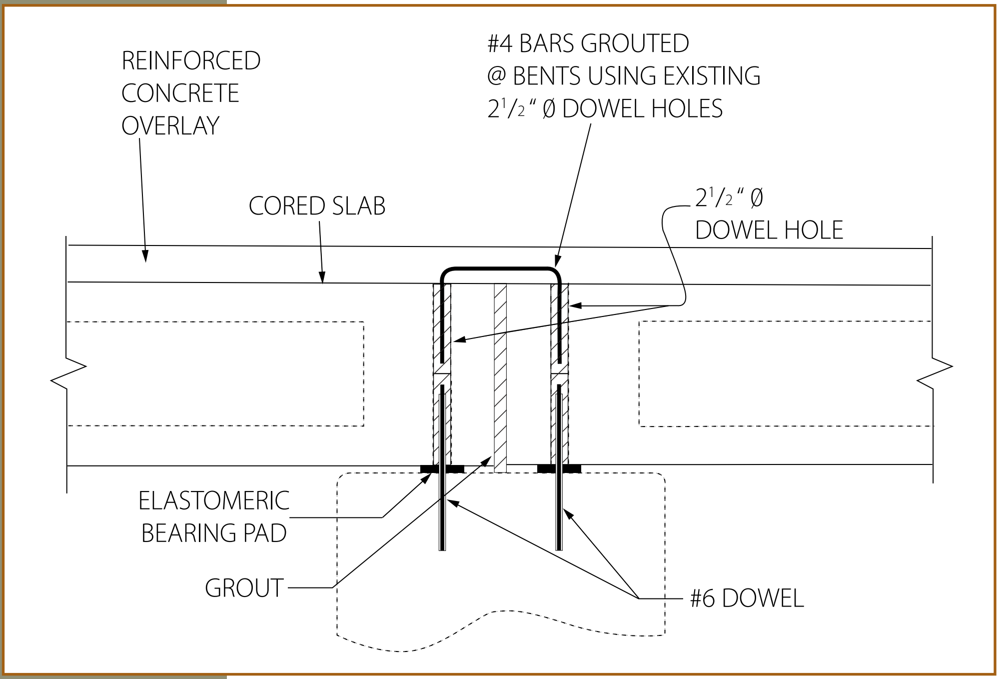

Figure 2. Section view at bent with continuous deck.

slabs together. Armored evazote expansion joints were used at the expansion ends of each four-span unit. (See Figure 2.)

All cored slabs were designed and detailed to be identical, with the exception of minor variations in lengths and skews in the curved spans. The fabricator assured the team that these variations could be accommodated at a minimal cost. Given these assurances, the design team kept all bents parallel and varied the cored slab details to expedite construction. Minimizing variations in the slabs also allowed the precaster to make more efficient use of the casting beds, which reduced costs.

Details for the standard barrier were modified to accommodate the thickness of the cast-in-place overlay. The designers used a yield line analysis to demonstrate structural adequacy of the barriers.

Substructure—The selected substructure consisted of cast-in-place concrete bent caps on driven steel HP14x73 piles. The typical bent required six piles, with four being vertical and one at each end being battered transverse to the direction of traffic. Developing common bent designs allowed the contractor to prefabricate and reuse bent cap formwork. Dowel holes in the cored slabs were oversized to allow for construction tolerances.

A structural model showed that a single brace bent was adequate to resist the longitudinal forces for a four-span unit, if that bent had two additional interior piles and all of the interior piles were battered longitudinally. The ability to accommodate the longitudinal forces at one bent per unit reduced the number of battered piles, which are more costly and time-consuming to install. The transversely battered piles at each bent resisted all the transverse loads. In addition, a pile driving analyzer was used to verify pile capacities to allow the use of higher design capacities (lower factor of safety)—further enhancing the efficiency of this design.

The bents were shifted transversely to accommodate the horizontal curvature.

Construction

Good planning and favorable weather made it possible for this project to be completed February 15, 2007—avoiding the second moratorium and the second construction season entirely.

As stated previously, about 1,300' of the bridges were completed before the first full in-stream allowance began in October 2006. The contractor was able to start

Top-down construction in action — construction over the wetlands area progressed at an average of one span per week.

construction early by installing turbidity curtains before undertaking any ground-disturbing activities. The curtains were then removed within the timeframe of the in-stream allowance. Without this jump-start, clearing of the bridge sites could not have begun until the in-stream season in October.

Part of the design-build contract called for the team to obtain all necessary permits for the project. The team made good use of the time required for the permitting process by prefabricating bent cap forms and pile-driving templates as well as stockpiling the piles and cored slabs. Once the permits were issued, the contractor had enough materials on hand to immediately begin construction.

Construction started at the west end of the structures with work that could be done outside of the in-stream allowance. Work then shifted to the east side, proceeding rapidly from there into the wetlands at an average of about one span per week. When October 1, 2006, arrived and the first moratorium was lifted, the substructure had already been completed to Bent 19 of the southbound lanes and Bent 17 of the northbound lanes. During this time, any delays due to an inundated condition were used to work on forming and pouring bent caps and installing the cored slabs. The contractor used NCDOT Class AA concrete in the bent caps to achieve strength more quickly, allowing for more expedient erection of the cored slabs.

After October 1, work proceeded without the in-stream restrictions. By the end of 2006, all interior bents were completed and cored slabs on both bridges erected except for a single span. The final drop-in span for each bridge was cast after all the other spans were in place, allowing the contractor to confirm the dimensions. These measurements were given to the precaster in late December, and the drop-in spans were erected in mid-January 2007.

Conclusion

Thoughtful design, well-planned construction and a true partnership between designer and contractor led to the most economical design and allowed construction of the Cashie River bridges to proceed very efficiently. Prior to starting construction in March 2006, the contractor estimated the construction duration to be 15 months, spanning two moratorium periods. But with the final drop-in spans placed four months ahead of schedule, the contractor was able to avoid the second moratorium period entirely.

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