Ouachita River Bridge

Louisiana's Test Bed for Link Slabs

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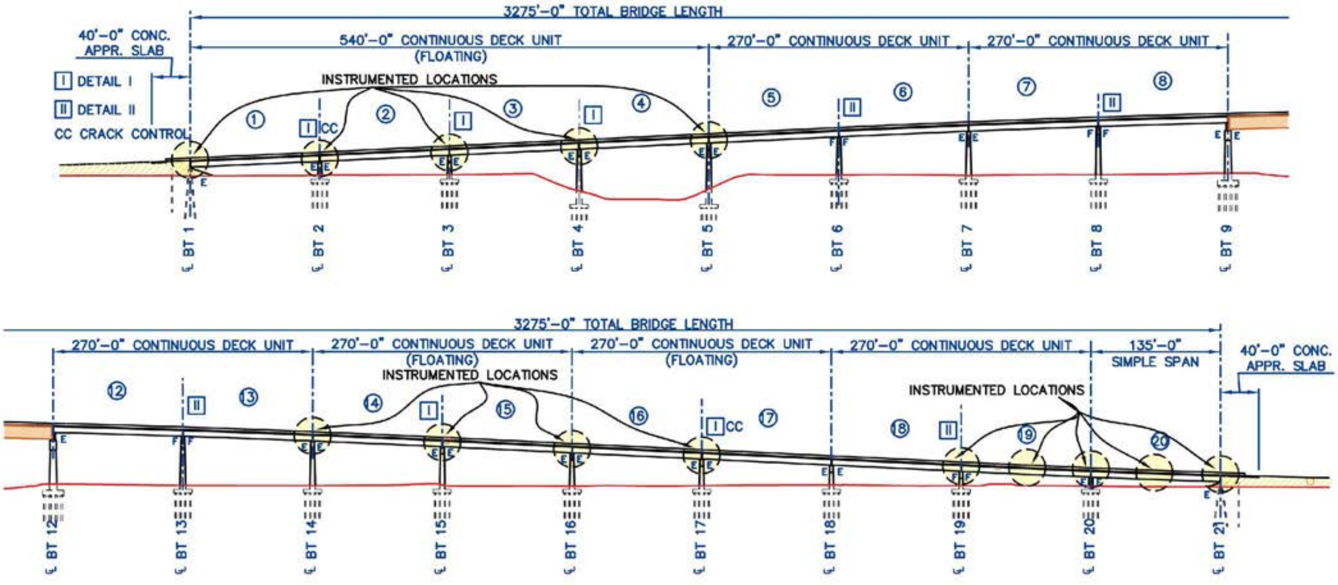
This article describes a research project to evaluate a simplified continuity detail that is now adopted in the recently released revision 8 of the Louisiana Department of Transportation's *LaDOTD Bridge Design and Evaluation Manual* (BDEM).[1] The new detail calls for a continuous deck slab over the joint between the ends of simply supported prestressed concrete girders,[2] which is different from the previous standard detail in which girder ends from adjacent spans were embedded in a continuity diaphragm after a bond breaker was applied to allow for relative movement. The simplified detail discussed here is also different from the detail recommended in National Cooperative Highway Research Program Report 519,[3] in which full continuity is achieved by extending positive moment reinforcement into continuity diaphragms. The latter detail was employed on another LaDOTD project.[4]

Several states have adopted similar simplified details, which may be referred to as "link slabs"; however, there is no consensus on a rational design for this type of detail, and its behavior in service is not yet fully understood. LaDOTD used the Ouachita River Bridge as a test project to evaluate the performance of several variations of the link-slab detail and the older continuity-diaphragm detail.

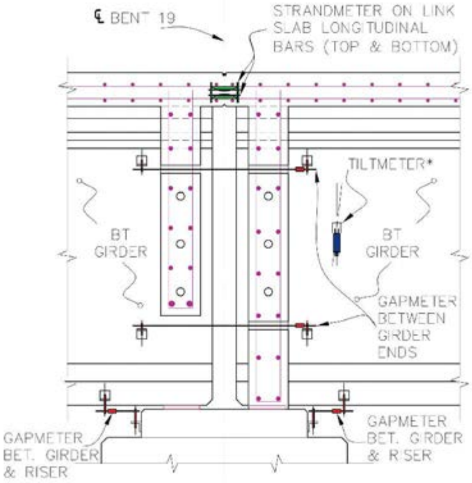
Ouachita River Bridge Project

The new Ouachita River Bridge carries Louisiana Highway 8 over the Ouachita River at Harrisonburg, La. It has a clear roadway width of 44 ft and consists of 20 spans with a total length of 3275 ft. All spans, except for the three-span main unit crossing the river, have a typical cross section consisting of American Association of State Highway and Transportation Officials (AASHTO) bulb-tee (BT-72) prestressed concrete girders supporting an 8.5-in.-thick slab. There are three types of units: the typical unit has two 135 ft continuous spans (270 ft); one unit has four continuous 135 ft spans (540 ft); and there is a single 135 ft simply supported span. Design variations, such as continuity details, numbers of spans per unit, link-slab reinforcement materials (stainless steel versus mild steel bars), and crack control details, were used at different locations. Two diaphragm details were used at interior supports of continuous units: Detail I for "floating" units, which are not fixed to bents, and Detail II for "anchored" units, which, when required, are tied to a bent by reinforcement extending into the full-depth diaphragm.

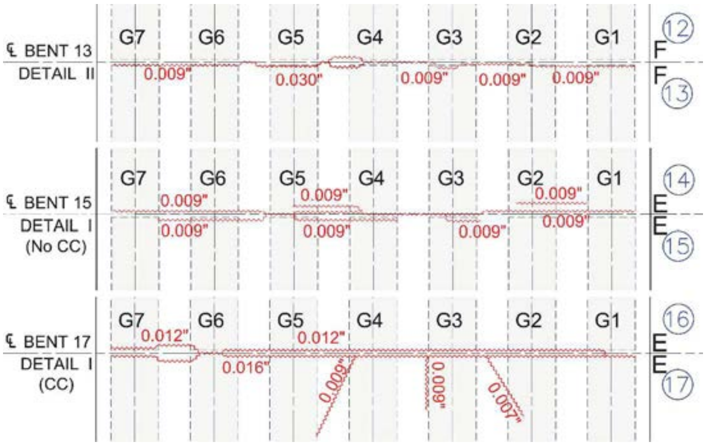
A 136-sensor structural health-monitoring system was installed to assess performance of the different details. Strains, displacement, rotations, and ambient environmental conditions



Configuration of approach spans for the new Ouachita River Bridge. Note: E = expansion bearing, F = fixed bearing. The type of link-slab detail (I or II) used at each interior bent is also indicated. Figure: Dr. Ayman Okeil.



Diaphragm and instrumentation details at an interior bent. Detail II for anchored units is shown with one full-depth diaphragm that is fixed to the bent cap with dowels (not shown). Detail I for floating units is similar with both diaphragms being partial depth. Figure: Dr. Ayman Okeil.



Top-view schematic of typical transverse deck cracking at several link-slab locations where different details are used. Note: CC = crack control (sealed groove), E = expansion bearing; F = fixed bearing; number in a circle = span number. Figure: Dr. Ayman Okeil and M. Canales.

(temperature and humidity) were recorded.

Performance Observations

Deck Cracking

Deck cracking was surveyed for about 15 months before the bridge opened to traffic. As is typical with cast-in-place decks, transverse cracks were observed at all link-slab locations. Mitigation strategies employed in the project did not prevent crack initiation. Where a silicone-filled, ½-in.-wide groove was saw cut in the top surface of the deck (centered over the joint between the ends of the girders), cracks often propagated parallel to the groove. In some instances, the crack formed in the groove but appeared again 3 to 6 in. to either side, a site that roughly coincides with the ends of the prestressed concrete girders. It was therefore concluded that the introduction of a groove at this location did not control deck cracking outside of the groove, and hence it is not required in the new LaDOTD standard details.

Crack widths were clearly affected by the support conditions. Link slabs over bents with fixed supports where full-depth end diaphragms were anchored to the bent cap (Detail II) experienced wider cracks (up to 0.030 in.), whereas narrower crack widths (<0.016 in.) occurred in link slabs over bents using partial-depth end diaphragms (Detail I). The figure above shows crack patterns at Bent 13 (Detail II), Bent 15 (Detail I with crack control measures), and Bent 17 (Detail I without crack control measures).

Temperature Gradient Effect

Strains were recorded in link-slab reinforcement during the month of January 2018 at Bent 19 over Girder G4. Notably, the strains are out of phase with the recorded ambient temperature. This finding is attributed to upward camber caused by a temperature gradient in the girder, which applies compression at the top of the link slab. During this month, the compressive strains are relatively low and the tensile strains are lower than the cracking strain (~130 $\mu\epsilon$). Summer readings are typically higher, which is the cause of cracking. Displacement sensor readings were used to compute, the relative angle between girder ends, which is important for calculating girder-end forces. The relative movement between the girders joined by a link slab can be translated into forces using an analytical model.

Live-Load Test

A load test was conducted using two concrete mixer trucks filled with coarse aggregate. They weighed 64.35 and 64.67 kip and were positioned in truck-train (one on each span) and truck-tandem (both trucks on the same span) configurations to cause maximum negative—and positive—moment effects, respectively. A total of 23 load cases (12 negative and 11 positive) were executed. The recorded data from the field live-load tests revealed that the live-load effect on link-slab forces is less than that caused by the thermal gradient.

Analysis of Link Slabs

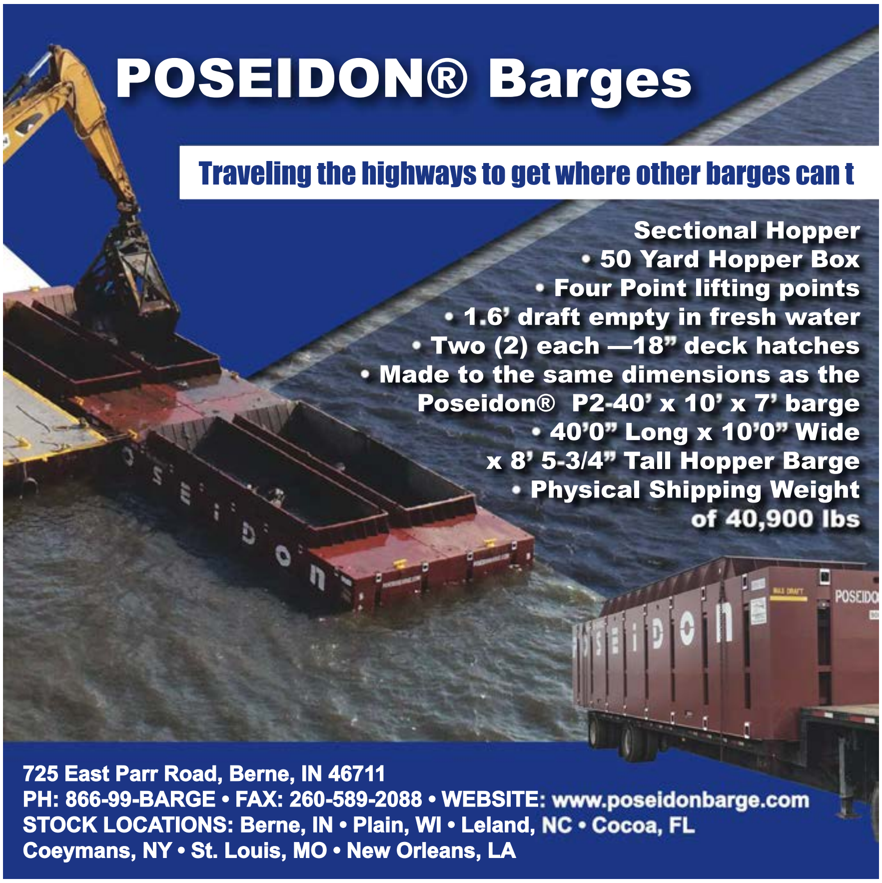
The internal forces in the link slab are calculated using a free-body diagram of the composite girder. It is assumed that the link slab elongates due to girder-end rotation. The extension of the link slab on both ends of the link slab can be calculated using girder-end rotations for live load or thermal gradients.

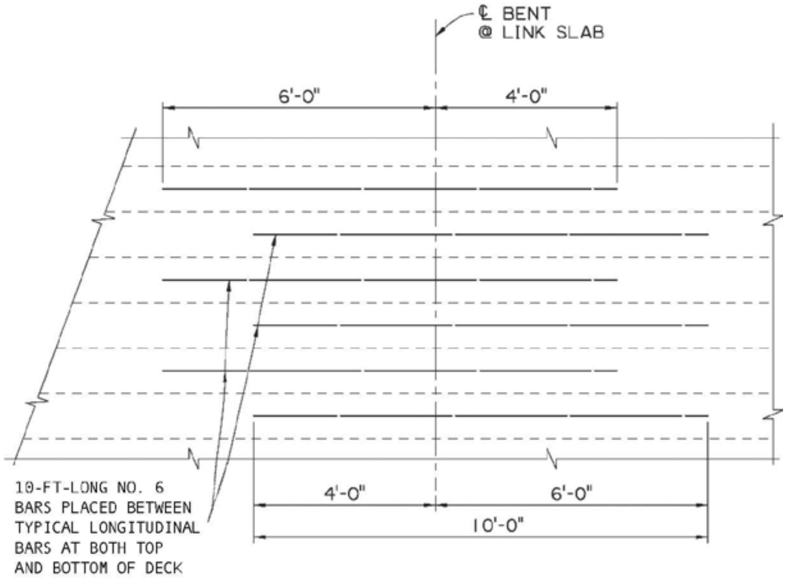
Analyses of typical slab-on-girder configurations revealed that required link-slab reinforcement can be achieved by adding 10-ft-long no. 6 longitudinal bars between typical longitudinal bars in both the top and bottom of the deck. This detail controls crack widths expected in the link slab and resists the axial forces that develop.

Conclusions

This project allowed LaDOTD to fine tune its new continuity deck detail. Based on the project findings, the following were observed:

- The floating link-slab detail (Detail I) performed better than the anchored diaphragm detail (Detail II).
- A groove in the middle of the link slab is not necessary because transverse deck cracking in link slabs is inevitable but not alarming if Detail I is used.
- Temperature effects are at least as significant as the live-load effects and should be considered in the design.
- The use of floating spans is feasible





Additional reinforcement at a link-slab location for nonskewed bents. The detail for a skewed bent is similar. Figure: Louisiana Department of Transportation and Development.

for bridges that are not expected to experience large lateral and uplift forces (for example, structures in low seismic zones or structures unexposed to wave action).

- Cracking caused by forces that develop in the link slab can be controlled by adding 10-ft-long no. 6 bars placed between typical longitudinal bars at both the top and bottom of the deck.

Acknowledgments

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EDITOR'S NOTE

Use of the term "link slab" in this article differs from a more common link-slab concept in which bond is prevented between girders and deck slab in the link-slab region. See the Concrete Bridge Technology article on eliminating expansion joints in the Fall 2016 issue of ASPIRE®.