FHWA

UHPC Link Slabs: A Simple Solution to Retrofit Bridges to Eliminate Joints

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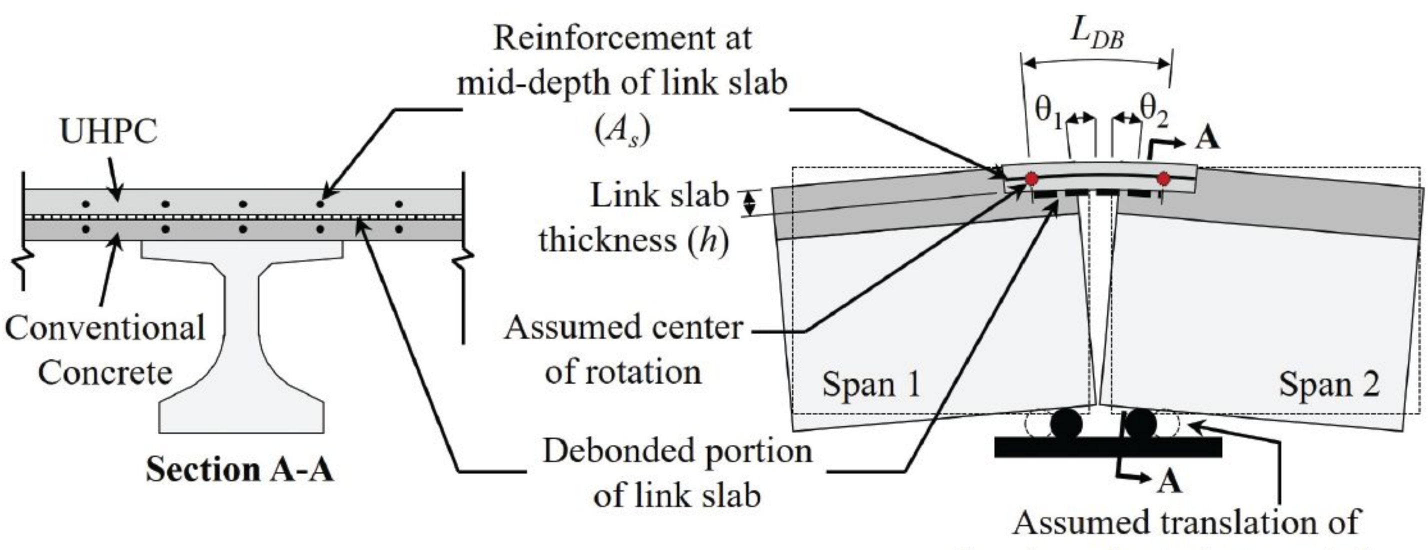
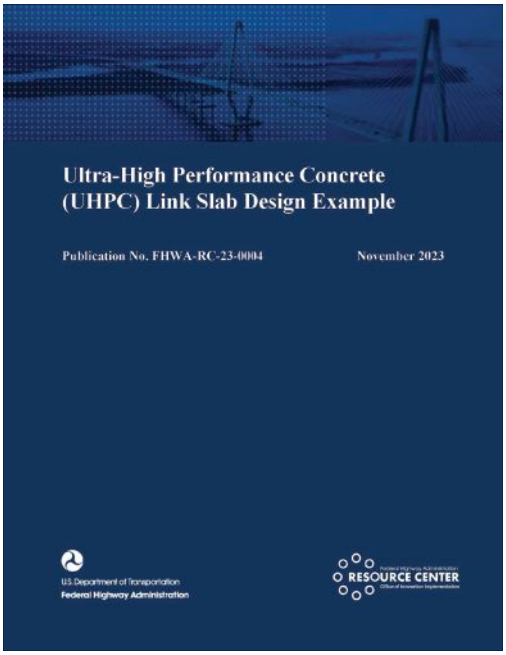
When compared with conventional concrete, ultra-high-performance concrete (UHPC) offers enhanced mechanical and durability properties that make it an ideal material for use in the construction, repair, and preservation of highway bridges. Early widespread adoption of UHPC began with connections between prefabricated concrete bridge elements. UHPC has a high bond strength with conventional concrete substrates and high tensile strength, resulting in shortened development and splice lengths, which makes it an ideal material for connections. The next phase of more widespread adoption of UHPC has involved preservation and repair activities, and has been supported through the Federal Highway Administration (FHWA) Every Day Counts program. UHPC link slabs were identified as one of the most promising applications of UHPC for preservation and repair.[1]

A link slab creates a continuous slab in the longitudinal direction by using a partial- or full-depth slab running between adjacent simple spans that is designed to accommodate the end rotation of the girders without introducing moment continuity between spans. Link slabs can be used to eliminate deck joints between simple spans to help extend the service life of existing bridges. The high tensile strength and post-cracking strain capacity, high bond strength, and decreased splice lengths for embedded reinforcement make UHPC an ideal material for link slabs. UHPC link slabs are typically designed to be only partial depth, often 4 in. deep, and only a few feet long.

Link-slab design is different than the design of conventional reinforced concrete elements, where an element is designed to resist applied loads. The demand on a link slab is generated from the total girder end rotations from the ad-

Figure 1. Typical ultra-high-performance concrete link-slab configuration for retrofitting a precast concrete beam bridge with a composite cast-in-place deck superstructure to eliminate deck joints. All Figures: Federal Highway Administration.





jacent spans occurring after link slab installation: $\theta_T = \theta_1 + \theta_2$ for a configuration like that shown in **Fig. 1**, where θ_1 is the girder end rotation from span 1, and θ_2 is the girder end rotation from span 2. The primary design assumption for UHPC link slabs is that the center of rotation at the end of the girder moves from the top of the bearing, before installation of the link slab, to the centroid of the UHPC link slab, after installation of the link slab (Fig. 1). This assumption allows for the link slab to be designed for only rotation, not axial demand (other than thermal effects and shrinkage). Link slabs are debonded from the girders or composite deck to allow the demand from end rotations to be evenly distributed over the debonded length of the link slab. This results in an average curvature over the debonded length of the link slab ψ_{avg} that is equal to the total rotation from both spans θ_T divided by the debonded length L_{DB}: $\psi_{avg} = \theta_T/L_{DB}$.

The link-slab thickness h, debonded length L_{DB}, and longitudinal reinforcement A_s are designed to resist this "applied" average curvature ψ_{avg}. Service I, Fatigue I, and Strength I limit states are checked in the design process, including the effects of shrinkage and thermal deformations. The bearings must be designed for the additional translation caused by the shift in the center of end rotation (Fig. 1). The substructure must be designed for additional horizontal forces caused by the connectivity across the superstructure created by the installation of the link slabs at any supports or bearing types that can transfer horizontal forces to the substructure.

A recent FHWA report, *Ultra-High Performance Concrete (UHPC) Link Slab Design Example*, presents a design example for a UHPC link slab.[2] The example illustrates the step-by-step process of designing link slabs to replace the expansion joints on a four-span superstructure. The example is for a steel simple-span composite bridge containing traditional expansion joints, but the same design principles and process would be applicable to a prestressed concrete simple-span composite bridge. Construction details are provided for the existing structure and link-slab design. Calculations are provided to determine the longitudinal horizontal loads for the structure to evaluate the effect of the link slabs on the existing substructure and foundation elements. The redesign of the bearings is also included, and the procedure for accounting for thermal effects and shrinkage in the link-slab design is provided. Additional details on previously constructed link slabs and the approaches used by several states for the design and implementation of link slabs are summarized by Thorkildsen[3] and Ailaney.[4]

The FHWA link-slab design example is a valuable resource to bridge owners and bridge designers looking for a simple and innovative solution to retrofit deteriorated or leaking bridge deck joints and preserve the superstructure and substructure elements below them.

References

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2. Garber, D., M. McDonagh, G. Sakellos, C. Chong, J. Ocel, and B. Graybeal. 2023. *Ultra-High Performance Concrete (UHPC) Link Slab Design Example*. FHWA-RC-23-0004. Washington, DC: FHWA. https://rosap.ntl.bts.gov/view/dot/72955.
3. Thorkildsen, E. 2020. *Case Study: Eliminating Bridge Joints with Link Slabs—An Overview of State Practices*. FHWA-HIF-20-062. Washington, DC: FHWA. https://www.fhwa.dot.gov/bridge/preservation/docs/hif20062.pdf.
4. Ailaney, R. 2021. "Eliminating Bridge Joints with Link Slabs." *ASPIRE* 15 (3): 46–47. https://www.aspirebridge.com/magazine/2021Summer/FHWA-EliminatingBridgeJoints.pdf.