# Modified Prestressed Concrete Slabs with a UHPC Connection for West Fork Dairy Creek Bridge

by Clayton Davey and Dr. Tanarat Potisuk, Oregon Department of Transportation

Precast, prestressed concrete slabs are a common concrete superstructure type for short- to medium-span bridges in Oregon. Traditionally, side-by-side precast, prestressed concrete slabs are connected with transverse tie rods, topped with waterproofing membrane, and paved with an asphalt concrete wearing surface to complete the bridge deck system. Bridges with these connection details have historically required frequent wearing-surface maintenance due to differential deflection between slabs activated by broken tie rods and eventual keyway failure (**Fig. 1**).

To mitigate this issue, the Oregon Department of Transportation (ODOT) revised the slab connection details to use a series of tie rods installed sequentially between each adjacent slab, instead of one tie rod for a full bridge width, and to add nut-tightening requirements. The new tie-rod system has performed better; however, the construction requires additional steps and time. A reinforced concrete deck has also been used to create a composite section that eliminates the need for tie rods. This method results in a deeper superstructure. Given tight site constraints, the deeper slab section can result in inadequate hydraulic freeboard or lead to costly roadway approach work.

Ultra-high-performance concrete (UHPC) is an excellent material for joint connection and is promoted through the Federal Highway Administration's Every Day Counts initiative. ODOT's first project using UHPC was in 2011, when UHPC was used for the connections between full-depth precast concrete deck panels and between precast concrete deck panels and bulb-tee girders. In 2017, ODOT expanded use of UHPC for connecting adjacent deck bulb-tee girders. Since then, ODOT has published standard details for use by bridge designers and added design guidelines in the ODOT *Bridge Design Manual*[1] for this girder system. The system reduces construction steps and time, allowing a bridge to be built faster.

The West Fork Dairy Creek Bridge project team seized the opportunity to try new details for connecting side-by-side prestressed concrete voided slabs using UHPC, the first such application in Oregon. This method eliminates the need for transverse tie rods without the additional depth of a cast-in-place deck. The bridge deck system includes a minimum ¾-in.-thick polymer concrete overlay.

The bridge carries a section of Oregon Route 47, a two-lane highway with one lane in each direction, just north of the city of Banks, Ore. It has been projected that the average daily traffic for this stretch of the highway in 2040 will be 5600 vehicles, with trucks accounting for 28% of these vehicles.

This project replaced the 85-year-old timber bridge that had deteriorated beyond repair. The new single-span bridge is 44 ft wide and 63 ft long, supported by 16-in.-diameter steel pipe piles at the abutments. The bridge design employed the new UHPC connection system using eleven 27-in.-deep and 4-ft-wide precast, prestressed concrete voided slabs.

**Figure 1. Examples of side-by-side precast, prestressed concrete slab bridges with keyway failures. On the left is a broken, full-width tie rod hanging from the side of a prestressed concrete slab. The photo on the right shows reflective cracks at the joints between prestressed concrete slabs. All Photos and Figures: Oregon Department of Transportation.**

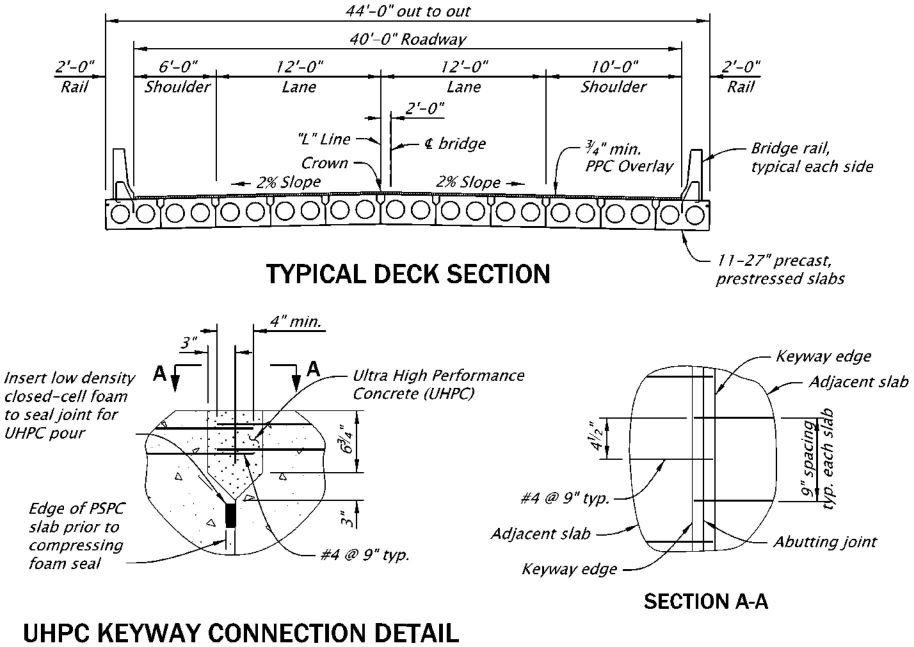


**Figure 2. Cross section and details for the West Fork Dairy Creek Bridge with precast, prestressed concrete voided slabs connected with a larger shear key, noncontact lap splices of transverse dowels, and an ultra-high-performance concrete closure pour.**

During the design development phase, input from the local precast concrete producer was considered for the development of the slab details. The modified prestressed concrete voided slabs included an enlarged keyway to accommodate the noncontact lap splice of the steel reinforcement extending from the precast concrete components. The keyway depth was set to have similar performance as a conventional 8-in.-thick reinforced concrete deck—the minimum required by the ODOT *Bridge Design Manual* for a spread-girder system. A clear cover of 3 in. for the top surface was specified to allow for grinding overfilled UHPC keyways and surface preparation for the polymer concrete overlay. This design will achieve the required 2.5-in.-thick minimum clear cover for the top surface of the bridge deck. **Figure 2** shows the cross section and details of the new West Fork Dairy Creek Bridge, and **Fig. 3** shows the prestressed concrete voided slabs in place before placement of the UHPC in the longitudinal joints. With only a thin (¾-in.-thick) overlay specified, the project special provision required that the contractor adjust the camber of adjacent slabs such that adjacent slabs would have a differential camber of ¼ in. or less at midspan before the UHPC for the connections was placed.

The ODOT BDM requires adjacent girders that function as the roadway surface and are connected with UHPC to have at least 15% more capacity than the capacity needed when the roadway is in service, to make up for potential additional loads from the camber-adjustment process. The design must also account for the ½-in. sacrificial thickness of the clear cover.

The unit cost of the precast, prestressed concrete voided slabs was higher than usual because the slab forms required modification. The reinforcing bars for the joint connection extended into the joint space for noncontact lap splices (**Fig. 4**). The option of form-saver bar couplers was made available but was not used. A commercial UHPC product was specified for the connections. The contractor wanted to use traditional concrete mixers instead of the high-shear mixers normally used for mixing UHPC. As a precaution, several concrete mixers were provided on site to provide continuous mixing. The traditional mixers took longer to blend the material, and one of the motors burned out during the mixing of the first batch.

At one point during the UHPC placement, the ambient temperature at the bridge site dropped below 30°F. The UHPC manufacturer requires cold-temperature mitigation measures when the ambient temperature on the concrete surfaces falls below 40°F during the mixing. Unfortunately, the special provision did not include specific requirements for such

**Figure 3. Precast, prestressed concrete slabs for the West Fork Dairy Creek Bridge after erection. The joints were soaked with water to create a saturated surface-dry condition, and concrete ecology blocks were used for adjusting differential camber.**

**Figure 4. The contract specifications required an exposed-aggregate surface finish in the keyway pocket of the closure pour. The bottom of the keyway pocket is sealed to prevent the fluid ultra-high-performance concrete from seeping.**

**Figure 5. Heating with containment is used for cold-temperature mitigation during the ultra-high-performance concrete closure pours.**

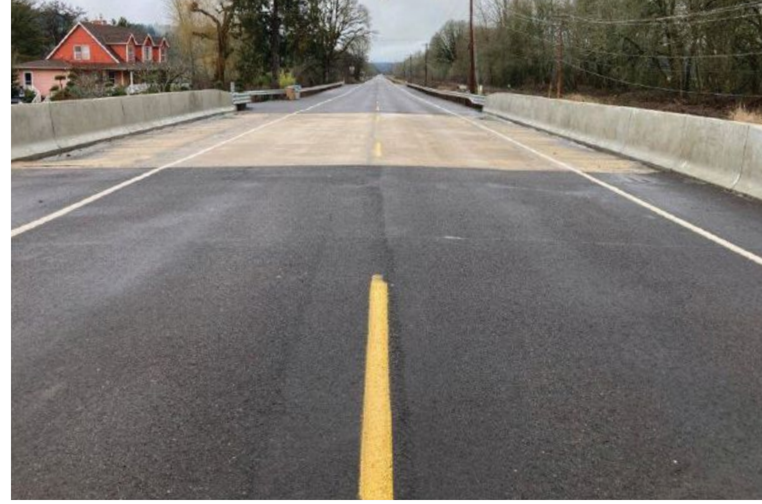

**Figure 6. The West Fork Dairy Creek Bridge after installation of a ¾-in.-thick polymer concrete overlay.**

unanticipated cold temperatures during the UHPC placement. In accordance with the manufacturer's recommendations, thermocouple sensors were placed within the UHPC material to monitor and record the curing temperatures. Forced-air heating with containment was provided under the deck in tandem with insulated curing blankets on top to raise the surface temperature to above 40°F. **Figure 5** shows the cold-temperature mitigation measures.

**Figure 6** shows the new West Fork Dairy Creek Bridge. Its successful completion in November 2022 encourages the use of these new connection details for precast, prestressed concrete slabs on other future bridge replacements. With minor refinements to the specifications and details, these modified prestressed concrete slabs with UHPC connections can enable quick construction and provide another alternative for the precast, prestressed concrete slab system.

## Reference


1. Oregon Department of Transportation (ODOT). 2023. *Bridge Design Manual*. Salem, OR: ODOT. https://www.oregon.gov/odot/Bridge/Guidance/BDM-2023-10.pdf.


---


*Clayton Davey is a bridge maintenance and operations engineer and Dr. Tanarat Potisuk is a concrete bridge standards engineer with the Oregon Department of Transportation bridge engineering section in Salem, Ore.*