PROJECT

BURNT RIVER BRIDGE REPLACEMENT PROJECT

Connecting precast concrete deck panels with ultra-high-performance concrete

by George Bornstedt and Craig Shike, Oregon Department of Transportation

As part of an ongoing effort to develop methods and materials that increase concrete bridge deck durability, the Oregon Department of Transportation (ODOT) recently constructed the U.S. 30 Burnt River Bridge replacement project located near Huntington in rural eastern Oregon. This Federal Highway Administration (FHWA) Highways for LIFE (HfL) project demonstrated precast, prestressed high-performance concrete (HPC) deck panels composite with precast, prestressed concrete bulb-tee girders and ultra-high-performance concrete (UHPC) connections in a 160-ft-long, single-span bridge.

The Burnt River Bridge consists of four 90-in.-deep precast, prestressed concrete bulb-tee girders supporting fifteen 8½-in.-deep, precast, prestressed HPC deck panels that are 9.5 ft wide and 30.8 ft long. The bridge is located on a 15-degree skew and has a 28-ft-wide clear roadway. The bridge spans the Burnt River and a Union Pacific railroad mainline.

Burnt River Bridge in October 2012. Photo: Oregon Department of Transportation.

profile

BURNT RIVER BRIDGE / HUNTINGTON, OREGON

BRIDGE DESIGN ENGINEER: Oregon Department of Transportation, La Grande, Ore.

CONSTRUCTION ENGINEER: McGee Engineering, Corvallis, Ore.

PRIME CONTRACTOR: Hamilton Construction Co. (Oregon), Springfield, Ore.

PRECASTER: Knife River, Harrisburg, Ore.—a PCI-certified producer

UHPC SUPPLIER: Lafarge North America Inc., Calgary, Alberta, Canada

ODOT's Goals

ODOT's primary purpose in developing precast, prestressed concrete decks is to provide a deck system with increased durability including abrasion resistance. Precasting and curing deck panels in a controlled plant environment results in a superior product with enhanced attributes. These attributes include high strength, abrasion resistance, and reduced cracking. Cracks provide a path for corrosion and, thereby, compromise long-term durability of the deck. Use of precast concrete decks is expected to eliminate most, if not all, deck cracking leading to significantly improved durability and better long-term performance.

HPC Deck Panels

The Burnt River Bridge project is an extension of ODOT's abrasion-resistant deck research. This demonstration project has allowed ODOT to develop design standards and specifications for HPC precast bridge deck panels and UHPC connections for use on this project and future accelerated bridge construction (ABC) projects. The 8.0 ksi HPC used in the precast, prestressed concrete deck panels was based on ODOT-funded abrasion-resistant concrete research conducted by Oregon State University. The connection design for the Burnt River Bridge project was based on FHWA research.

The long-term vision for ODOT includes increased use of precast concrete deck panels. ODOT anticipates use of both post-tensioned concrete panels and panels with cast-in-place UHPC joints and connections. The method used will depend on the structure type and option that provides the best value.

Precast concrete deck panels provide the following advantages:

- Improved durability with high-strength concrete and high-quality aggregate
- Faster construction by taking advantage of precasting off site and then erection on site
- Improved quality because panels are constructed under factory conditions in a controlled environment

High-performance, precast concrete deck panel erection over an active Union Pacific railroad mainline. Photo: George Bornstedt.

UHPC Connections

The precast concrete deck panels, precast concrete girders, and concrete bridge substructure were designed by traditional methods according to the Fifth Edition of the *AASHTO LRFD Bridge Design Specifications*, the PCI *Bridge Design Manual*, and the ODOT *Bridge Design and Drafting Manual*. The panel-to-girder connections were based on FHWA research where steel-fiber-reinforced UHPC was used successfully to connect precast concrete members.

The deck panels for this project were reinforced with prestressing strands in the deck's transverse direction and non-prestressed steel reinforcement in the longitudinal direction. The longitudinal, epoxy-coated, No. 5 bars in the transverse panel-to-panel connections can be fully developed in less than 6 in. with steel-fiber-reinforced UHPC. For field applications, FHWA recommends a 6-in. bar lap as a practical minimum. To develop the longitudinal deck bars and sufficiently connect the precast concrete panels, a UHPC design strength of 14 ksi at 14 days and 17 ksi at 28 days was specified on this project.

In order to develop composite action between the deck panels and girders, UHPC was used in the panel to girder connection shear pockets and built-up haunch sections. Due to the strength properties of UHPC and as a cost savings, a haunch width less than the full girder flange width was used. As defined in the AASHTO LRFD Specifications, interface shear design takes into account the roughness of the

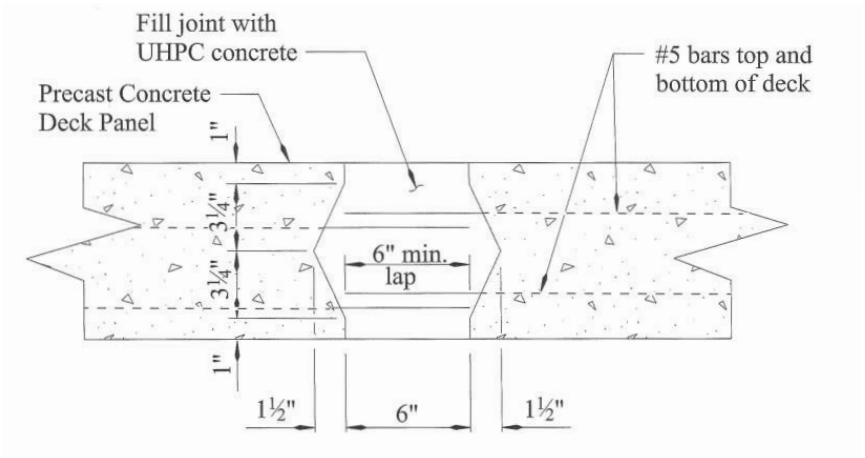
OREGON DEPARTMENT OF TRANSPORTATION, OWNER

PROJECT DESCRIPTION: 160-ft-long, single-span bridge with high-performance precast concrete deck panels over 90-in.-deep, precast, prestressed concrete bulb-tee girders and ultra-high-performance concrete connections

STRUCTURAL COMPONENTS: Four 160-ft-long, 90-in.-deep prestressed concrete bulb-tee girders; fifteen 8½-in.-deep, 9.5 ft-wide by 30.8 ft-long, 8.0 ksi, precast, prestressed high-performance concrete (HPC) deck panels; and 17.0 ksi, ultra-high-performance concrete connections in the transverse deck panel joints, shear pockets, and interface shear haunches

BRIDGE CONSTRUCTION COST: $2.95 million

AWARDS: 2014 Alliant "Build America" Award, Associated General Contractors of America—First Place for Highway & Transportation Projects Under $10 million



Ultra-high-performance concrete, keyed-joint detail used to connect the precast concrete deck panels for the Burnt River Bridge project. Figure: George Bornstedt.

interface shear surfaces. The tops of the precast concrete girders can easily be roughened while the precast concrete deck panels have a smooth underside. Therefore, designs need to assume a smooth concrete interface shear surface for the cohesion and friction coefficients. Even though the AASHTO LRFD Specifications now allows for an interface shear reinforcement spacing of up to 4 ft, ODOT uses a maximum spacing of 2 ft.

To cast the haunches, UHPC was placed in the joints and shear pockets through a sealed wood chimney or chute that provided approximately 1 to 2 ft of static head, as required. With the excellent flowability of UHPC, no mechanical vibration or pumping was required. To maintain the steel fibers in suspension, vibratory equipment was not used. Based on UHPC research test samples cast with these methods, annular spaces such as shear pockets and haunches can be completely filled without air voids normally found with traditional grouts.

The 6-in.-wide precast concrete deck panel joints, shear pockets, and leveling coil bolts. Photo: George Bornstedt.

Precasting and curing deck panels in a controlled plant environment results in a superior product with enhanced attributes.

Compressible foam backer rod was used to form the haunch sections. Seals based on standard mortar-tight specifications are not adequate to contain and maintain the integrity of the UHPC. The foam backer rod must form a tight seal to contain the very fluid UHPC mixture. To contain UHPC in areas of superelevation or cross-slope, exposed joints and shear pockets require a plywood seal or cover. If plastic-coated form grade plywood is used to contain and cover exposed areas of UHPC, no additional measures are required for curing. Curing times vary from 3 to 7 days depending on environmental conditions.

ODOT's Future Intentions

ODOT anticipates that precast concrete deck panels will have a greater initial cost than cast-in-place concrete decks. Therefore, precast concrete deck panels will be more desirable on higher-volume routes where the improved durability will result in significantly lower future maintenance costs. In such cases, the life-cycle cost for precast concrete deck panels may be less than that for a cast-in-place concrete deck.

The projects designed to date have used relatively few precast concrete deck panels per bridge. Although ODOT does not have a threshold for minimum number of panels to make precasting competitive, the agency understands that bridges with more panels should be more economical for precasting. ODOT does not believe that the initial projects have demonstrated the true cost of supplying precast concrete deck panels.

ODOT is pleased to have precast concrete deck panels as an available option. It believes that there will be future projects where durability or ABC will favor precast concrete deck panels over traditional construction. ODOT also sees a future where precast concrete could be the predominate deck type in the state of Oregon.

George Bornstedt is the interim Region 5 bridge manager for the Oregon Department of Transportation in La Grande, Ore. Craig Shike is the Oregon Department of Transportation's bridge operations and standards managing engineer in Salem, Ore.

Casting the 6-in.-wide precast concrete deck panel joints and haunches for the Burnt River Bridge project. Photo: Oregon Department of Transportation.