Chief Joseph Dam Bridge

Replacing the old timber truss bridge

By Jason B.K. Pang, KPFF Consulting Engineers

The Chief Joseph Dam Bridge crosses the Foster Creek ravine just upstream of where it meets the Columbia River, below the western crest of the Chief Joseph Dam in Bridgeport, Wash. Since 1959, the bridge has served as an important freight route and primary access to the agricultural and recreational region upstream of the dam. In 2016, the existing bridge was replaced with what was the longest single-span precast concrete spliced-girder bridge in Washington state at the time of construction.

Background

Chief Joseph was a prominent Nez Perce Native American leader. The dam was named in honor of him, and the bridge was subsequently named after the dam.

Before it was replaced, the existing 309-ft-long bridge consisted of a unique 130-ft-long and 20-ft-deep Howe deck-truss main span constructed with glued laminated Douglas fir members and five timber approach spans. Designed by the U.S. Army Corps of Engineers, the bridge was certainly an unusual structure, even for its time. It was constructed during an era when steel replaced wood as the preferred material. It was the only bridge of its kind designed and constructed for highway use in Washington state in the 1950s, and, for many years, it was the only Howe deck-truss bridge remaining in the Washington state bridge inventory. Because of its rare structure type, age, and association with the Chief Joseph Dam, the main span was placed on the National Register of Historic Places.

Despite being retrofitted in 2003, the bridge had major structural deficiencies and needed to be replaced. After evaluating several alternatives, the designers selected a single-span precast concrete, post-tensioned spliced-girder bridge as the preferred solution to address the unique challenges of the project.

Major Project Challenges

The nearly 45-degree side slopes of the ravine, coupled with the presence of large boulders and sharp drop-offs of the bedrock, made site access and foundation construction major challenges. Access was further complicated by strict environmental requirements. No structural or construction activities were allowed in the creek between the existing piers. Despite the creek being dry most of the year, it was highly restricted because of its environmentally fragile nature. Because Chief Joseph Dam is not equipped with fish ladders, Foster Creek is the last creek along the Columbia River that naturally supports the spawning of wild salmon and steelhead. Another issue was the historical significance of the site.

Reinforcing steel and post-tensioning ducts installed in the 100 in.-deep WSDOT "supergirder." For the end segments, the girder web was widened at the end to accommodate the post-tensioning anchorages. All Photos: KPFF Consulting Engineers.

The completed Chief Joseph Dam Bridge in Bridgeport, Douglas County, Wash.

profile

CHIEF JOSEPH DAM BRIDGE / BRIDGEPORT, DOUGLAS COUNTY, WASHINGTON

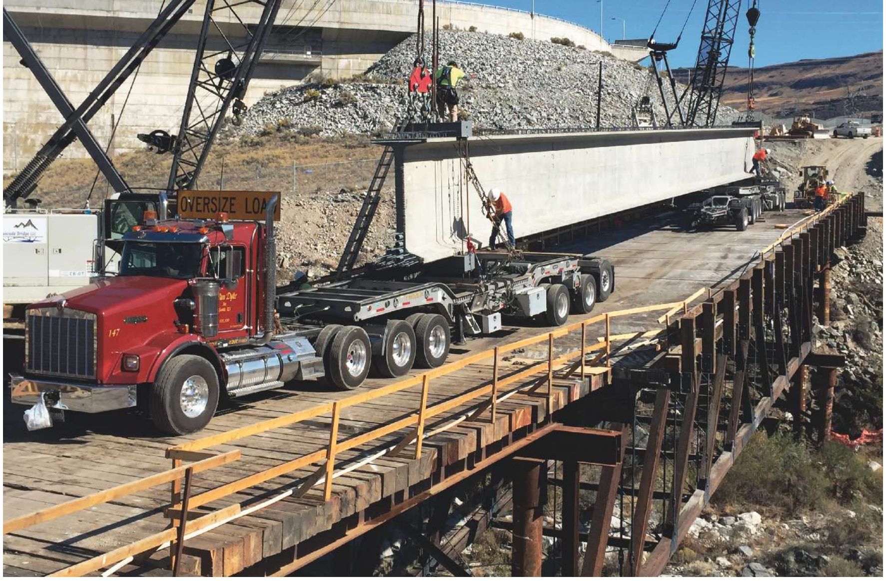
BRIDGE DESIGN ENGINEER: KPFF Consulting Engineers, Seattle, Wash.

PRIME CONTRACTOR: Cascade Bridge LLC, Vancouver, Wash.

PRECASTER: Concrete Technology Corporation, Tacoma, Wash.—a PCI-certified producer

POST-TENSIONING CONTRACTOR: DYWIDAG Systems International, Long Beach, Calif.

OTHER SUPPLIERS: Structural Earth Walls: The Reinforced Earth Company, Englewood, Colo.



The existing timber Howe deck truss was moved to the temporary work trestle and used as the platform to erect the girder segments. Detailed inspection and analysis were performed to ensure that the existing truss could safely support the loads.

The entire reach of Foster Creek has a history of human use dating back to precontact Native Americans. Archeological sites in the ravine near the existing bridge limited the bridge replacement to the same alignment.

The biggest challenge was the owner's requirement to salvage the historically significant truss. The design and construction sequences had to address preserving the truss by removing it whole or dismantling it without entering the creek in the steep ravine.

Alternative Bridge Designs

Designers first considered a three-span continuous girder bridge. A 170-ft-long mainspan and two 70-ft-long back spans were required to clear the existing piers and remain outside the sensitive, restricted areas. Construction of the two intermediate piers would have been difficult and costly, given the geotechnical conditions and lack of access in the ravine. Furthermore, transporting a 170-ft-long girder to the site would have been problematic, if not impossible.

Constructing a single-span bridge on tall fill abutments was the most economical and feasible option. A single-span steel plate girder bridge was considered. However, the owner had concerns about the cost of long-term maintenance of a steel bridge and firmly preferred a precast, prestressed concrete bridge.

A single-span concrete girder bridge using the Washington State Department of Transportation (WSDOT) "supergirder" was the best option. The precast, prestressed concrete, post-tensioned spliced girder allowed designers to extend the span range of conventional precast concrete girders to eliminate costly intermediate piers on the steep-sloped ravine and avoid affecting the environmentally sensitive area, while satisfying the owner's requirement for an all-concrete bridge. Spliced girders also allowed for shorter and manageable precast concrete components to be transported to the remote site, and designers could resourcefully use the existing piers as temporary supports for splicing the girders.

"Supergirder" Bridge

The new two-lane, single-span bridge is 240 ft long and 32 ft wide. The bridge is framed by five girder lines, spaced at 6.25 ft, each consisting of three precast, pretensioned concrete segments (49, 136, and 49 ft in length). The splice locations were strategically located so that the span could be erected on falsework supported on the intermediate piers, avoiding the need for a temporary structure.

Girder segments use the 100-in.-deep WSDOT WF100PTG "supergirder" section and were constructed with high-performance concrete with a 28-day design compressive strength of 10.8 ksi. The segments were pretensioned to support self weight and ensure zero tension during shipping and erection.

Segments were joined together on site with a 2-ft-wide cast-in-place closure pour, where longitudinal mild steel reinforcment was lap spliced and post-tensioning ducts were coupled. Each girder was post-tensioned with four 19-strand tendons using 0.6-in.-diameter, low-relaxation Grade 270 strand.

The completed girders after the post-tensioning tendons were installed and tensioned. Stirrups were prebent to provide clearance during hauling.

DOUGLAS COUNTY, WASHINGTON, OWNER

BRIDGE DESCRIPTION: The two-lane bridge is 32 ft wide and composed of a single post-tensioned 240-ft long span and a 69-ft earth-filled approach. The superstructure is framed by five girder lines, each consisting of three precast, pretensioned concrete segments erected on existing bents and post-tensioned together. The abutments consist of cast-in-place concrete and structural-earth walls.

STRUCTURAL COMPONENTS: WSDOT WF100PTG precast, prestressed spliced, post-tensioned concrete girders (five girder lines, three segments each: 49-ft, 136-ft, and 49-ft); 7.5-in-thick cast-in-place concrete deck; cast-in-place concrete and structural-earth-wall abutments

BRIDGE CONSTRUCTION COST: $3.8 million ($495/ft^2)

BRIDGE CONSTRUCTION COST: 2018 PCI Design Award - Transportation: Best Main Span More than 150 feet; WSDOT Local Programs 2017 Award of Excellence – Best County Project; Washington Aggregates & Concrete Association 2016 Excellence in Concrete Award – Public Works: Bridges

The existing truss bridge was lifted onto the completed superstructure and dismantled.

Instead of a conventional single parabolic curve, the tendon profile consisted of two parabolic curves in the end segments and a tangent straight profile in the middle segment. This was done to reduce the high stresses at the closure pours and allowed for concrete with a lower strength than used in the girder to be placed in the closure pour. Designers opted to use a lower-strength concrete because higher-strength mixtures were of limited availablity and would cost more to deliver to the remote location. The closure pours required a strength of 6 ksi at post-tensioning and a 28-day strength of 7.5 ksi.

Each tendon was tensioned to 835 kips and had a final effective force of 730 kips. Post-tensioning was applied to the girders before the deck was placed for two reasons. First, the extra weight of the concrete deck would have overloaded the existing piers that were used as temporary supports. Second, this sequence allows the deck to be extensively rehabilitated or replaced in the future, if needed, without concerns about overstressing the girders. An even longer span could have been achieved if the composite deck were in place when the girders were post-tensioned.

Precamber

Vertical deflection of the spliced girder from self weight and superimposed dead load was estimated to be 15 in., which is considerable. To ensure a smooth road profile and no sag, and to minimize the girder haunch, the girder profile was precambered. This was achieved by elevating the temporary supports at the closure pours 5 in. above a straight line connecting the ends of the girder. After casting the closure pour and post-tensioning the girder, a final camber of 3 in. was achieved in the girder soffit profile.

Girder Transportation

The distance from the precaster to the project site was more than 230 miles. The longest girder segment weighed more than 190 kips and was 9 ft 9 in. high, including the length of stirrups extending from top of the girder. To clear the lowest bridge along the haul route, the hauler required the girder stirrups to be prebent with only 5-in. extensions, which reduced the total girder height to 105 in. A special stirrup detail using a hat-shaped bar was used to accommodate the variable haunch depth. These bars formed a splice with the prebent stirrups and extended into the 7.5-in.-thick cast-in-place concrete deck slab. Both the top and bottom layers of the deck-slab reinforcement were epoxy-coated. All reinforcement extending from the precast concrete girders was coated with a zinc-rich primer.

Substructure

The abutments were placed on benches cut into the steep-sloped ravine to accommodate the girders' maximum span. This resulted in the abutments being upward of 37 ft in height. The east and west abutments are supported on 21 and 15 HP16 steel piles, respectively, under a 5-ft-thick pier cap. Overexcavation of the footings was required to remove large cobbles and boulders in the ravine that obstructed pile driving. Structural earth walls were used behind the abutment wing walls to retain the roadway approach fill. To access the site, the contractor constructed a pile-supported work trestle next to the existing bridge. The trestle was used to demolish the existing bridge, construct the abutments, and erect the new girders.

Salvaging the Historic Truss

Extensive analysis of the existing truss was performed, and several construction sequences were developed to either dismantle the truss in place (without entering the creek) or lift it out whole.

The innovation in the ultimate construction sequence was moving the entire existing truss to a temporary trestle and using it as the girder-launching truss. To do so, the strength of the truss was checked against the launching demands, which included the weight of the girder and hauling truck. The recent inspection report of the existing bridge was referenced to establish reasonable strength reduction factors for each structural element. After the new bridge superstructure was completed, the existing truss was lifted onto the new bridge to be dismantled.

Conclusion

The precast concrete, post-tensioned spliced girders were a cost-effective and durable solution that addressed the unique challenges and met the goals of this project, which is an innovative example of stretching the practical use of precast concrete girders to longer spans by splicing girder segments with manageable weights and lengths for transportation. In this project, precast concrete was the best solution to minimize disruption to the natural environment, while promoting constructability, providing durability, and facilitating the salvage of a historic structure.

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View of completed bridge from below. Piers from existing bridge remain, which were used to support girder segments at splice locations.