Portland's Sellwood Bridge

By Eric Rau, P.E., and David Goodyear, P.E., S.E., P.Eng.

T.Y. Lin International was an Outstanding Award winner for the Sellwood Bridge Replacement project in the 2017 Annual Excellence in Structural Engineering Awards Program in the Category – New Bridges or Transportation Structures.

The Sellwood Bridge is the busiest two-lane bridge in the state of Oregon. Located near downtown Portland, the bridge serves as a vital east-west link across the Willamette River. Its predecessor, a four-span, continuous 1,091-foot-long steel Warren Truss was built in 1925 to replace a ferry line that had serviced the community since 1903. Constructed on a restricted budget, the truss bridge was only 32-feet-wide, with two traffic lanes and a single 4-foot sidewalk. It was not designed for seismic loads or relatively large streetcar vehicles, as other Portland bridges of its era had been. The crossing was also located at the narrowest section of the river, later determined to be the result of an active landslide at the western landing.

In 1960, a 3-foot section of approach girder was removed to mitigate for landslide distress. Twenty years later, the entire west approach was reconstructed. Continued movement and cracking required Multnomah County, the owner of the bridge, to post a 10-ton load restriction in 2003. Since the bridge was deemed functionally obsolete and structurally deficient, the County initiated a National Environmental Policy Act (NEPA) planning process in 2006 to evaluate options.

Numerous structure types, vehicular traffic and pedestrian configurations, and roadway and interchange alignments were evaluated. The County also formed a Community Advisory Committee (CAC) to represent public interests throughout the evaluation process. Composed of local residents, Willamette River users, and business owners, the CAC recommendation of a steel deck arch structure on the same alignment as the original bridge was reviewed and approved by the County's Board of Commissioners in 2011.

The 1,275-foot-long, three-span steel deck arch structure is the signature component of the new, 1,976.5-foot-long Sellwood Bridge. The arch is formed by two parabolic arch ribs, which are 6-foot-deep welded box sections. Four Vierendeel braces are provided between the arch ribs in each span, which coincide with the location of spandrel columns and floor beams at the deck level. Longitudinal girders frame between the floor beams, both of which are composite with the concrete deck. Over 5,000 tons of structural weathering steel was used to construct the steel deck arch structure.

The roadway varies from 63 to 90 feet, carrying two 12-foot vehicular lanes, two 6.5-foot bike lanes/emergency shoulders, and two 12-foot shared-use sidewalks, and is designed to accommodate future streetcar service. Twice as wide as the original structure, the new bridge provides the same vehicular lane configuration as recommended by the CAC to serve the Sellwood community. Traffic mobility is substantially improved with a modern intersection connection to Oregon Highway 43, accomplished through additional turn lanes on the arch bridge paired with 3,600 feet of ramp and retaining wall structures.

The design team developed an innovative anchored shear pile slope stabilization system to mitigate chronic landslide movement. Displacement of the 800-foot-long, 500-foot-wide, 50-foot-deep landslide mass is resisted by 40 vertical six-foot-diameter drilled shafts and 70 diagonal prestressed anchors. The arch foundation is also considered in the 3D analysis, which eliminates displacement at service levels with a 4-inch limit at extreme seismic events.

Seismic design for both the bridge and the landslide mitigation considered multiple earthquake events, including a moment magnitude scale (MMS) 9.0 Cascadia Subduction Zone earthquake. The new bridge was designed to be operational with minor repairable damage through a 500-year earthquake and to withstand a 1000-year event without collapse.

The four foundations of the steel deck arch structure consist of 22 ten-foot-diameter drilled shafts, with tips anchored in bedrock up to 155 feet below the riverbed. Large, 2,500-cubic-yard concrete footings with multiple rows of drilled shafts were provided at the landside piers to resist the thrust of the deck arch. Concrete placement occurred over a 30-hour period, with an active cooling system that piped river water through the footings, used to meet mass concrete requirements. At the two in-water piers, shafts extend into the pier walls in a "perched foundation" configuration. This eliminated the need for large conventional footings located at the river bottom and minimized risks and costs associated with cofferdam construction.

Concrete Y-arms extend from the substructure, with the steel arch ribs located above the 100-year flood stage. The springing connection was hinged through construction and fixed after deck construction to control demand levels on the arch ribs. Ten 4-inch-diameter rods are anchored 15 feet into the Y-arms to provide fixity, post-tensioned to service level demands, and grouted for corrosion protection.

A key aspect of the project was to minimize traffic disruption during construction for the 33,000 daily users of the bridge. The project team developed an innovative solution to this challenge, translating the existing 1,091-foot long truss via hydraulic jacks to temporary foundations constructed on a detoured alignment to the north. The bridge move was accomplished over a 12-hour period and eliminated the need for staged construction of the new bridge.

The project utilized the Construction Manager/General Contractor (CM/GC) method for project delivery. Multnomah County selected Slayden/Sundt Joint Venture as the CM/GC and a design team led by T.Y. Lin International (TYLI), with key subconsultants CH2M and Cornforth Consultants. As the Prime Consultant and Project Manager, TYLI oversaw all engineering disciplines during final design and served as Engineer of Record for the steel deck arch structure. The Sellwood Bridge opened to traffic on February 29, 2016.▪

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