1st Street Bridge over Los Angeles River

Preserving a historical monument

by Romeo Firme and Gary Buelow, Atkins

The 1st Street Bridge, inspired by the civic architecture of Paris and Rome, spans over the Los Angeles River near downtown Los Angeles. After more than 80 years of use, the historic bridge needed to be widened and improved to accommodate the ever-increasing transportation demands of a mega-city. In its ultimate configuration, the bridge has capacity for two new tracks of the Metro gold line and 18,000 motorists a day.

A unique set of challenges was posed by the modification of the existing bridge to accommodate a double track light rail transit corridor and meet current design standards; construct the widened portion; and re-use the triumphal arches while maintaining traffic on the bridge, local roads, and 15 sets of live railroad tracks.

Completed bridge with the Los Angeles skyline. All Photos: Atkins North America.

Bridge arch spans across the Los Angeles River.

A Historic-Cultural Monument

In keeping with the neo-classical architecture, the widened north side of the bridge was built with the same aesthetics as the original bridge. The bridge portion over the Los Angeles River consists of two identical deck arch spans on a central pier with pylons at each end. The graceful open spandrel arch has vertically curved concrete arch ribs with equally spaced vertical columns supporting floor beams and a deck slab. The girders have cathedral arches and the exterior girders have ribbed overhangs. The spandrel columns, which are part of the arches above the river, are arched in shape and highly decorative.

At the ends of the arches and at three other locations, massive 200,000-lb masonry blocks in the shape of Roman triumphal arches rise above the river piers. Behind the piers are projecting balconies with benches. The plain frieze is finished with an architrave cornice. The structure is heightened above this entablature with a wide panel bearing plain incised rectangles, finally surmounted by stepped rows of narrow horizontal blocks.

The neo-classical detail extends to the entablature pattern on the fascia girders and to the bracketing for the sidewalk. The railings are simple arcades replicating the historic railing at the south side of the bridge. Bridge lights are replicas of the original lantern electroliers, serving to recreate the look of the bridge when it was first opened in 1929 during the City-Beautiful era in Los Angeles.

Modifications to the Existing Structure

The existing structure was modified to accommodate two lanes of vehicular traffic in each direction, two pedestrian sidewalks, and two new railroad tracks. Of these loads, the biggest challenge was to accommodate two sets of train tracks, as these were much heavier than the truck loads in the original design. To mitigate the additional weight, the

Triumphal arch.

superstructure had to be modified to increase flexural and shear strength. The substructure, including the foundation, had sufficient capacity to resist the additional train loads.

At the west and east approaches, the additional live load was resisted by increasing the sectional properties and resistance of the structural elements underneath the train tracks. Two reinforced concrete tee-beams were strengthened by removing and rebuilding a thicker deck with additional reinforcement. Concrete was also added at the beam stem within the bay. At the arch span, a waffle slab was used with the sole purpose of distributing the train loads directly to the top of the arch beams.

The additional dead loads triggered a seismic review and retrofit to sustain the maximum credible earthquake. Initial diagnosis of the existing bridge showed vulnerabilities in the transverse direction at the central pier of the arch spans. To mitigate this, in-fill walls were placed between the openings to increase the transverse stiffness and resistance and reduce the seismic displacement demand. The greater transverse stiffness increased the overall structural stiffness, resulting in lower seismic displacement demands in both the longitudinal and transverse directions.

Tee-beam strengthening.

For the seismic analysis, a sophisticated 3-D finite element analysis was developed to model the rib arches, spandrel beams, spandrel columns, and cross beams. Non-linear material properties for reinforced concrete members were included to capture the plastic hinging behavior. A similar analysis was performed on the widened portion.

Widening a Portion of the Bridge

The bridge was widened to the north by approximately 26.25 ft to accommodate two westbound traffic lanes and a sidewalk. The widened portion would also house the five re-used triumphal arches and replicate the neo-classical aesthetics at the rails, stairs, and lamp posts similar to the south side of the bridge.

To maintain the aesthetics at the arch span, the sizes and spacing of the rib arches, spandrel beams, and spandrel columns were retained. The center pier and nose were extended north with the same width to maintain channel hydraulics. Similar extensions were made at the west and east pylons at the ends of the arch spans.

A different bridge type was selected for both the west and east approaches. Due to the limited vertical clearance over Santa Fe Avenue and Myers Street, precast concrete girders were selected in lieu of cast-in-place construction as the latter required a falsework system that would further impede the vertical clearance. Even with the precast concrete girders, both Santa Fe Avenue and Myers Street still needed to be lowered to provide 15-ft standard vertical clearance. This involved re-profiling of the roads, utility relocation, and new drainage.

Reuse of Arches, Replication of Aesthetics

Five massive, 200,000-lb masonry triumphal arches were wire cut from their bases and carefully relocated to the widened portion by crane. The contractor used a special lifting apparatus for this purpose. The triumphal arches were then bolted to their new pedestal bases using 18 vertical and four horizontal high-strength rods.

The intricate aesthetics at the exterior girder were included in the forms of the precast concrete girders. At the barrier, the simple balustrade features were shaped into the barrier forms. Finally, the fluted concrete lamp posts were precast to match the existing lamp posts at the south side.

Romeo Firme is the California structures group manager and Gary Buelow was the project manager during the construction phase of the project for Atkins in Orange, Calif.

Murray Morgan Bridge

by Matthew Lengyel, David Evans and Associates Inc.

On February 1, 2013, the Murray Morgan Bridge spanning the Foss Waterway in Tacoma, Wash., reopened to traffic after being closed for more than 5 years because of its load rating. The current, all-concrete, port-approach structure of the Murray Morgan Bridge, which replaced the original timber structure, is more than 55 years old. It is also historically significant to the city of Tacoma because it is one of the first all-precast concrete bridges built in the United States. A funding package totaling $57 million allowed a design-build rehabilitation project to begin in 2011, which ultimately allowed this historic bridge to be reopened in time for its 100th year anniversary celebration that was held on February 15, 2013.

After more than 55 years of service in a marine environment, the current bridge was still fully functional with no load posting restrictions and showed much less deterioration than the steel truss portions of the bridge. Although this was a testament to the durability of concrete, areas of cracking and spalling in high-stress areas, as well as corrosion of prestressing strands and other deficiencies, dictated that the port approach be rehabilitated along with the rest of the bridge to meet the project's 75-year service life extension.

The design-builder developed a unique solution within the boundaries of the project's performance specifications to repair the hollow precast, prestressed concrete columns of the substructure. The solution utilized a two-component, rigid polyurethane system of poured structural foam to support the interior faces of the hollow concrete columns, while the exterior faces were repaired and encapsulated. The 2-lb density foam had a compressive strength of about 0.3 ksi when fully cured and sufficiently supported the interior faces of the

Murray Morgan Bridge port approach with repairs to the tops of the columns in place. All photos: David Evans and Associates Inc.

Murray Morgan Bridge port approach looking east – final deck and lane configuration.

Murray Morgan Bridge port approach looking southwest.

hollow columns during construction. The structural foam also increased confinement capacity of the columns in the plastic hinge zones, which improved the seismic response of the structure.

The design-builder was also able to reduce initial project costs within the performance specifications of the project, when it came to rehabilitation of the precast, prestressed concrete deck girders. The performance specifications dictated that all load-rated structural elements needed to meet a rating factor of 1.25. Originally 25 broken strand locations were identified, primarily in the outer girder lines, and would need to be spliced. However, because the lane configuration on the bridge was changing, as part of the rehabilitation project, the design-builder was able to eliminate the need to repair 13 broken strand locations. This was because the remaining strands in the deteriorated girder locations were sufficient to meet the rating factor requirement, with the new lane and loading configuration.

The reopening of the Murray Morgan Bridge has not only improved the daily lives of Tacoma commuters, it also re-invigorated their love for their cultural history. Additional information on this project can be found in Paper 27 "Rehabilitating Precast Concrete History Using Design-Build Delivery" that was presented at the 2013 PCI Convention and National Bridge Conference.

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