Creative Patches Save McCullough Bridge

The Conde McCullough Bridge at Coos Bay, Ore, is arguably the most exquisite showpiece in a series of historic coastal bridges along U.S. 101, the Pacific Coast Scenic Byway. Preserving this signature structure of concrete arches required a variety of innovative approaches. These included a customized, self-consolidating micro-concrete; the addition of salt to the repair mortar; and the use of a cathodic-protection system.

Designed by famed engineer Conde B. McCullough and built in 1936, the 5305-ft-long structure was the longest bridge in Oregon's highway system when constructed. It features extensive Art Deco ornate detailing throughout the bridge.

The Conde B. McCullough Bridge on Highway 101 at Coos Bay, Ore. Photo: International Concrete Repair Institute and BASF Corp.

Many sections needed to be repaired to restore the bridge. Some 20- to 30-ft-long sections received dozens of form-and-pump repairs, typically 2 to 4 in. in depth, plus numerous small hand-applied patches. These repairs required a versatile material that could adhere to the substrate, was compatible with the resistivity of the original concrete, and could be placed both in shallow and deep applications, in a confined area.

Salt Added to Mixture

Normally, it is not recommended that any salt be added to concrete, due to the risk of propagating corrosion; however, in the case of cathodic protection, electrical resistance compatibility is important to ensure uniform current distribution to the embedded reinforcing steel. Electrical resistance compatibility with a concrete exposed to 80 years of marine salt was obtained by adding table salt to the repair mortar. The volume of salt added to each bag was determined by calculating the amount of chlorides found in the host concrete.

The bridge's multilevel enclosure that housed the repair called for a lightweight, mobile concrete pump that could be used on each level and on narrow scaffold planks. Diaphragm-type, hand-operated grout pumps were placed on tight scaffold areas so the material could be pumped full depth both vertically and overhead. In these areas, complex forms were assembled to recreate the original Art Deco designs.

The portable pumps necessitated the use of a self-consolidating, micro-concrete, to ensure that the top-size aggregate was small enough to be pumped while still allowing placement up to full depth without adding any pea gravel.

Once the concrete cured, the repaired surface was sandblasted and a zinc coating was applied to serve as the sacrificial component of the cathodic-protection system. This system redirects corrosion activity that normally would occur in the steel reinforcing bars. It requires the concrete to be uniformly and electrochemically conductive, which was enhanced by the salt in the repair mortar. A low-voltage electrical current drives the corrosion into the zinc coating rather than the reinforcing bars, protecting the bridge.

It took four years to restore the south end of the bridge, and it is anticipated that the longer north end could take five or more years to complete. Meanwhile, work continues on several other Oregon bridges using this form-and-pump repair method. Through the Oregon Department of Transportations efforts to identify and prioritize needed bridge work, many historic bridges are being saved for future generations.

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Cedar Lane Bridge over Rockville Pike

by Dennis F. Campbell,
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Cedar Lane Bridge over Rockville Pike in Kensington, Md., is located in the midst of an important transportation corridor. The bridge is surrounded by interstate arteries, centered in a very populated community, situated on a major school bus route, and handles an average daily traffic flow of 12,650 vehicles. Because of the bridge's deteriorated condition, a forensic investigation was conducted to determine the compressive strength and chloride ion content of the existing concrete. Analysis of the results indicated the bridge had an estimated remaining service life of five years, making the decision to replace the structure easy. The selected replacement solution needed to maintain the architectural appearance of the original bridge, accommodate pedestrian traffic, limit the disruption to the community, and be constructed on a compressed schedule.

Contract specifications for the replacement included incentives and disincentives, and allowed for 70 days for the road closure. Major steps in the design and construction of the replacement bridge included:

- establishing closure requirements and benchmarks,
- submitting and approving shop drawings, demolition plans, and erection plans,
- installing a temporary bridge and opening it to pedestrian traffic,
- fabricating and storing precast concrete elements,
- posting a detour route, and
- assembling demolition and erection equipment and readying them for use.

Geotechnical and foundation analysis showed the existing subgrade and footings were adequate to support a new bridge and did not need to be removed. The precast, prestressed concrete system included prestressed concrete adjacent box beams; reinforced concrete pier caps; reinforced concrete abutment caps; and precast concrete architectural parapets that were created as a second cast on the fascia beams. The architectural parapets and sidewalk were initially shown as cast-in-place concrete. In order to meet the limited time requirements for the project, a precast concrete solution was developed to provide the architectural parapet and sidewalk cast on the prestressed concrete beams before leaving the precast manufacturing plant.

Erection of precast concrete pier caps. All photos: Newcrete Products.

The structure was assembled by first setting, and vertically post-tensioning, the pier caps and abutment caps to the existing pier stubs utilizing 1-in.-diameter, epoxy-coated, high-strength, threaded bars. These bars conformed to ASTM A722, Grade 150, Type II and were tensioned to 54 kips. The adjacent box beams were then placed and transversely post-tensioned using 1¼-in.-diameter, Grade 150, hot-dipped, galvanized, ASTM A722 threaded bars, which were tensioned to 120 kips. A 5-in.-thick, cast-in-place, concrete overlay on the roadway and a 4-in.-thick concrete overlay on the sidewalk completed the structure.

The concrete components consisted of 36 typical box beams, 8 thickened box beams for the sidewalk, 8 fascia beams with decorative parapets, 3 precast concrete pier caps, and 2 precast concrete abutment caps. The abutment caps were the heaviest components weighing over 62 ton each. Span lengths were each 42 ft.

Notice to proceed was given on February 14, 2011. The road was closed on June 16, with bridge erection completed on July 7. The bridge was reopened on August 6, 2011, well in time for a new school year.

Planned and orchestrated for success, the removal and replacement construction was completed in 51 days, 19 days ahead of schedule. The application of accelerated bridge construction techniques, using precast, prestressed concrete structural components provided an economical solution, met the schedule, and produced the desirable end results of this truly unique project.

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Completed bridge.

Route 76 Bridge over Lake Taneycomo

by Thomas P. Lohman, Horner & Shifrin Inc.

Photo of the completed bridge. All photos: Kevin Skibiski, Horner & Shifrin.

The Route 76 Bridge over Lake Taneycomo in Branson, Mo., is the longest and oldest spandrel-arch bridge in Missouri and is generally recognized as one of the state's most notable structures. The Branson area is a popular vacation destination with an estimated 8 million visitors annually and 20,000 vehicles crossing the bridge daily. Consequently, the importance of limiting road closure during construction was paramount. Additionally, the historic significance of the bridge required that bridge preservation, rather than bridge replacement, be employed.

Built in 1931, this structure is 1085 ft long and connects the cities of Branson and Hollister. The bridge consists of five 195-ft-long reinforced concrete open spandrel arch spans with concrete deck girder approach spans. The deck and spandrel beams of the arch spans were severely deteriorated and needed replacement. The existing spandrel columns were to remain in place.

Early in the design phase, it became apparent that accelerated construction was necessary to minimize traffic impacts. Many options were explored including the use of precast concrete spandrel beams, precast concrete deck panels, and combinations of the two. Local precast concrete fabricators were consulted to determine their capabilities and preferences. Based on those discussions, two innovative uses of precast concrete were developed: precast, reinforced concrete spandrel beams and partial-depth, precast, prestressed concrete deck panels.

Existing concrete spandrel beams were spaced at 10.5 ft along the length of the arch spans. The existing beams were cast on concrete spandrel columns that carry the load to the arches. To speed and simplify construction, new precast, reinforced concrete spandrel beams were used. The beams had pockets cast in them to allow the existing column reinforcement to be re-used in the connection detail.

Spandrel beams were set on a bed of epoxy on top of the existing columns. The epoxy acted both as a leveling pad and joint sealant around the exterior of the reinforced connection. The pockets were then filled with grout. Once the process was mastered, the contractor was able to complete the work quickly, saving months of construction time.

Challenges included casting the grout pockets and handling the beams because of the reduced cross section at the grout pockets. Ninety-five beams were required, each approximately 32 ft long with a 2-ft-square cross section. The tops of the beams were sloped 2% transverse to the roadway to provide a better fit-up of the partial depth, precast, prestressed concrete deck panels.

Missouri has used partial-depth, precast, prestressed concrete deck panels as their standard method of deck construction for slab-on-girder bridges for many years. This project required the main reinforcement to be parallel to traffic on the spandrel arch spans, not transverse to traffic as is the case for more traditional slab-on-girder construction methods. This required a special design for over 30,000 ft^2 of 3.5-in.-thick panels, but the shape and materials of the standard panels were maintained, allowing the fabricator to use forms and materials already available. The panels were made composite with a 5.5-in.-thick, cast-in-place concrete deck.

The use of precast concrete allowed for accelerated construction, saving the contractor months of construction time. In addition to these time savings, the elements fit together so smoothly that the bridge was re-opened more than one month ahead of schedule.

The bridge was recognized as the Best Rehabilitated Bridge in the 2012 PCI Design Awards.

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Precast spandrel beams were placed on top of the existing columns.