State Street Bridge Rehabilitation

Careful planning retains substructures and arches of 83-year-old concrete bridge

by Manjeet Ahluwalia, TranSystems

With a contracted economy, limited budgets, and continued deterioration of the state's structurally deficient bridges, it is challenging to stretch available funding by applying the latest materials and techniques to bridge rehabilitation. One such project is the rehabilitation of the State Street Bridge carrying State Route 4028 over the Schuylkill River in the Borough of Hamburg, Berks County, Pa. Because of its proximity to I-78 over the Schuylkill River, the State Street Bridge is an important local transportation link. The existing six-span structure, built in 1927, consisted of four main spans of open spandrel reinforced concrete arches and two cellular abutment approach spans supporting a 24-ft-wide roadway over a total length of 529 ft.

The main-span arches each span 86 ft between springlines. The arch ribs are longitudinally offset to match the 48-degree skew of the piers that are uniformly spaced at 95-ft centers. Each pair of arch ribs supports spandrel columns, transverse floor beams and opposing cantilevered sidewalk brackets, spandrel beams, and longitudinal beams. The two approach spans were supported by corresponding four-sided cellular abutments, consisting of U-shaped wingwalls. Transverse floor beams spanned the interior between the wingwalls, and sidewalk brackets were cantilevered from the outer faces of the wingwalls.

Based on the results of TranSystems' bridge inspection findings, concrete testing, and structural analysis and ratings, it was concluded that the bridge required major rehabilitation to maintain its structural integrity and load-carrying capability. It was determined that the arch ribs and the substructures were suitable for reuse in the rehabilitated structure. The selected rehabilitation strategy included rehabilitation of the existing main arches, deck and floor beam replacement, concrete re-

South elevation of the recently rehabilitated State Street Bridge over the Schuylkill River in Berks County, Pa. All photos: TranSystems.

View of the underside of the rehabilitated bridge showing the original arches and the new cast-in-place concrete floor beams and deck.

These were the components of the existing structure that were left in place after removal of the deck and floor beams.

pairs to match the existing architectural features of the bridge, and the partial removal and filling of the cellular abutments to support a standard pavement section. Shotcrete and formed concrete repairs were used for the work. Specified concrete compressive strength for the new deck and floor beams was 4000 psi. The general contractor was Allan A. Myers LP. TranSystems, a subconsultant to Whitney, Bailey, Cox and Magnani LLC, was responsible for the bridge repair design.

Because, the State Street Bridge is a contributing element to the Hamburg Historic District, rehabilitation alternatives needed to minimize impact to the historic fabric of the bridge. The project was completed and the bridge opened to traffic on October 29, 2010.

Manjeet Ahluwalia is senior bridge engineer with TranSystems, Langhorne, Pa.

Methods of Corrosion Prevention and Control in Concrete Bridges

by Matthew Pritzl, Michael Baker Jr. Inc., Habib Tabatabai and Al Ghorbanpoor, University of Wisconsin-Milwaukee

This article summarizes a research study sponsored by the Wisconsin Highway Research Program and conducted at the University of Wisconsin-Milwaukee. The research involved accelerated testing and evaluation of new or promising techniques designed to prevent or control chloride-induced corrosion damage in reinforced concrete bridges.

Laboratory Testing

Thirty reinforced concrete laboratory specimens were subjected to 6 months of accelerated corrosion testing that consisted of wet/dry cycles of exposure to saltwater. The specimens also had the application of a constant electrical potential between their top and bottom mats of uncoated reinforcement. The conditions are used typically to significantly accelerate the corrosion process in reinforced concrete.

The following systems were evaluated:
- tri-silane sealer (alkylalkoxysilane)
- acrylic coating
- epoxy/polyurethane coating
- surface applied galvanic thermal sprayed zinc (with and without epoxy/polyurethane coating)
- embedded galvanic anodes (with or without acrylic coating)
- epoxy repair patch mortar

Sixteen of the specimens received a protective treatment prior to exposure to accelerated corrosion. The remaining 14 specimens were cast with mixed-in chlorides and subjected to patch repair treatments after 3 months of accelerated corrosion. After repairs, the group of 14 specimens was subjected to an additional 3 months of testing. Each treatment was applied to two specimens.

The specimens were evaluated with respect to corrosion currents, chloride ingress, half-cell potential readings, extent of cracking, rust staining, and condition of the reinforcing steel after the conclusion

Thirty laboratory test specimens were subjected to 6 months of accelerated corrosion testing. Photo: University of Wisconsin-Milwaukee.

of testing. The different treatment processes resulted in widely varying performance.

Field Testing

In addition, the effectiveness of some admixtures and sealers was evaluated on nine different bridge decks across Wisconsin through an extensive analysis of chloride ingress. Two of the bridge decks were cast with corrosion inhibiting admixtures, four of the bridge decks were treated with surface applied tri-silane sealers at various times during their service lives, and three of the bridge decks were untreated.

Results

In the laboratory, it was found that the surface applied tri-silane sealer, as well as conjoint use of galvanic thermal sprayed zinc and epoxy/polyurethane coatings, were much more effective in preventing the onset of corrosion than the galvanic anode cathodic protection systems alone or the control.

When used in a patch repair application, the galvanic thermal sprayed zinc, as well as conjoint use of galvanic thermal sprayed zinc and epoxy/polyurethane coatings, were shown to be the most effective in controlling corrosion. In general, corrosion prevention measures taken before chloride contamination were far more effective than the same steps taken after contamination of the concrete.

In the field, it was determined that the application of penetrating sealers at the time of construction, without any reapplication in later years, was not an effective means of reducing chloride ingress. In contrast, periodic reapplication of sealers proved to be an effective means of reducing chloride ingress, even when the initial application was not made at the time of construction. The use of corrosion inhibiting admixtures had varied results based on the type of admixture used.

A complete research report on this study is available online at: http://www.whrp.org/research-areas/structures/downloads/06-06%20Final%20Report.pdf.

Matthew Pritzl is construction engineer at Michael Baker Jr. Inc. in Madison, Wis.; Habib Tabatabai is associate professor; and Al Ghorbanpoor is professor, both in the Department of Civil Engineering & Mechanics at the University of Wisconsin-Milwaukee, Milwaukee, Wis.

Preserving Lincoln's Heritage

Concerns for safety, speed, quality, and money are met in repairs to longest Illinois bridge

The 7122-ft-long Abraham Lincoln Memorial Bridge in LaSalle, Ill., the longest bridge in the state, is supported by 43 pairs of piers. The bridge spans 70 ft above the Illinois River, crossing numerous roads, lakes, wetlands, and railroads. Repairing the piers in areas with limited access required an approach that would maximize safety and quality, while minimizing repair time and costs. To accomplish these goals, shotcrete was applied using platforms hung from above.

The piers range in height from 50 ft to 100 ft and are 6 ft thick at the base and 4 ft thick at the caps. The caps are 4 ft wide and 41 ft long. Bridge spans are between 135 ft and 165 ft. Access on the bridge was limited to a 10-ft-wide area adjacent to live traffic. Ground access was restricted to only a handful of piers, as most were surrounded by the Illinois River, sensitive wetlands, lakes, and the historic Illinois-Michigan canal.

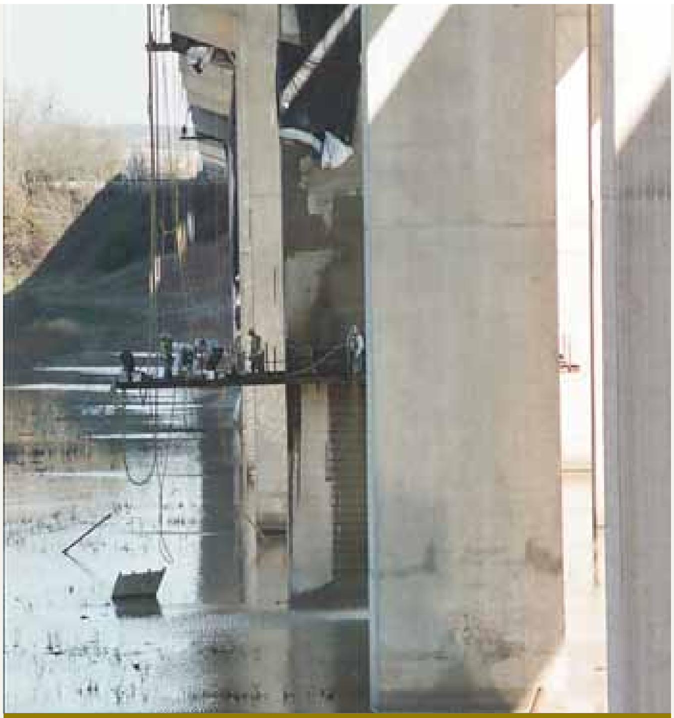
Repairs were completed in two phases, with work on the southbound structure being followed by work on the northbound one. For land-based piers, 70-ft-tall boom-lifts were placed over the bridge's side with cranes. A detailed safety program was created to allow raising and lowering of platforms that were placed just below the deck. They were used at all finger-joint piers over the inaccessible areas. The concrete in the piers was removed past the first mat of reinforcing steel during which saw-cutting the edges and sandblasting with abrasive grit was performed, taking care to blast the saw-cut edges that were polished by the saw. The existing reinforcing bars were supplemented as necessary.

Shotcrete Solution

The shotcrete work was staged from the bridge deck, including delivering prebagged materials. Water was hauled to the site in 250-gal. totes, and the material was monitored to ensure its temperature remained between 70 °F and 78 °F. The shotcrete had a 0.42 water-cement ratio and contained 10% by weight of 3/8-in. river rock.

The project was designed by the Illinois Department of Transportation in Springfield, Ill., with Civil Constructors Inc. in Freeport, Ill., serving as general contractor. American Concrete Restorations Inc. in Lemont, Ill., performed the shotcrete services.

Shotcrete was used to repair the 86 piers on the 7122-ft-long Abraham Lincoln Memorial Bridge in LaSalle, Ill., the longest bridge in the state. Using shotcrete ensured contractors could visually check encapsulation of the reinforcing steel.



All work was completed from overhead, which provided less risk due to the ability to feed air and water hoses over the side rather than handling formwork.

Shotcrete provided a variety of benefits, including the ability to remove and replace concrete in stages. On several severely deteriorated piers, 33% of the pier was repaired and remobilized when the shotcrete reached 70% of the required strength. The procedure was then repeated, eliminating destabilization concerns. The use of prebagged shotcrete also ensured freshly placed, consistent mixtures. Using air and water hoses placed over the side of the bridge also provided a safe procedure.

Construction time was shortened, as the shotcrete placement was completed the next day with sandblasting or high-pressure water blasting of the patch's edge. The shotcreting process also provided a visual encapsulation of the reinforcing steel, eliminating concerns about voids. Shotcrete curing with wet cotton mats also provided a superior finish.

More than 15,000 ft^3 of concrete were replaced. The attention to safety resulted in no accident reports while working 80 ft in the air. The shotcrete solution produced a long-term, affordable repair that proved so remarkable it was named the 2008 Outstanding Shotcrete Project by the American Shotcrete Association.

This article is an abridged version of an article published in the Winter 2010 issue of Shotcrete *and is published with permission of the American Shotcrete Association. For more information, visit www.shotcrete.org.*

Concrete placement was eased with the use of shotcrete, which could be smoothed even in unreachable areas without having to maneuver forms. The work was performed by ACI-certified nozzlemen.