A drymix shotcrete process was used to repair the badly deteriorated piers on the Noblestown Road Bridge near Pittsburgh, Pa. The repair method allowed the bridge to remain open during construction and return to full operation quickly.

Noblestown Road Bridge: REHABILITATED WITH SHOTCRETE

by Ted W. Sofis

The Noblestown Road Bridge had provided long service to citizens in Allegheny County, near Pittsburgh, Pa., but its piers had become badly deteriorated. In many places, the concrete appeared to have eroded away like a mud embankment. To repair the damage and restore the bridge, the contractors used shotcrete and a sequenced construction schedule to maintain traffic and return the bridge to full service in a short time.

Sofis Company Inc. performed the work in conjunction with general contractor Thornbury Inc. of West Sunbury, Pa. As contractors could work on only one half of the bridge at a time, to allow traffic to be maintained, Thornbury set up a pattern diverting traffic to the two westbound lanes, with one lane in each direction. Towers were erected at Piers 1, 3, and 5, and the bridge was jacked up to support the structure during removal of concrete on the bridge piers.

Due to structural concerns, removal of concrete from both sides of the piers' hammerheads at the same time was not permitted. The concrete on one side had to be removed, surfaces prepared, and shotcrete applied and allowed to cure, before working on the other side. After work was completed on the piers supporting the two eastbound lanes, traffic was diverted to those lanes so work could take place on the other piers supporting the westbound lanes.

Drymix Shotcrete Process Used

A drymix shotcrete process was chosen for several reasons. With the drymix process, both the overhead and vertical areas could be shot to the full depth of the repair without using accelerators. This approach eliminated the possibility of laminations that can occur when shooting in layers, which can create points of failure. The scattered repair areas also allowed work to stop and start more easily without concern about wet material in the hoses, as is the case with the wetmix shotcrete process.

Utilizing the drymix process permits the nozzleman to make adjustments in water content at the nozzle and allows the material to be placed with less water content. The material being installed was essentially a zero-slump pneumatically placed concrete. The contractor saw-cut the perimeter of the repair areas, chipped out the deteriorated concrete, sandblasted the reinforcing bars, and added new reinforcing bars where needed. Welded wire reinforcement was installed, holes were drilled for epoxied anchor bars, and shotcrete gunned in place to restore the concrete piers to their original contours.

Quikrete Shotcrete MS with an added Cortec migrating corrosion inhibitor was selected. This premixed material eliminated the need for on-site mixing, providing better quality control for the mixture. The prepackaged material was dampened with an auger-type predamper, and the Shotcrete MS was gunned in place with a rotary gunite machine.

Both the auger-type predamper and the rotary gunite machine are continuous feed devices, so as the premixed material was predampened, it was immediately conveyed into the gun and through the hose. The moist material was not allowed to sit and was dampened only moments before being fed into the gunite machine and discharged. That eliminated concerns with truck time as with ready mixed concrete or with the moist sand reacting with the cement in large holding hoppers in some of the older batch-type mixing rigs.

Shotcrete has been used for a century and has proven to offer an excellent cost-effective method for the repair of concrete structures. There is no doubt that advances will continue to be made to improve the process further and take full advantage of its engineered properties.

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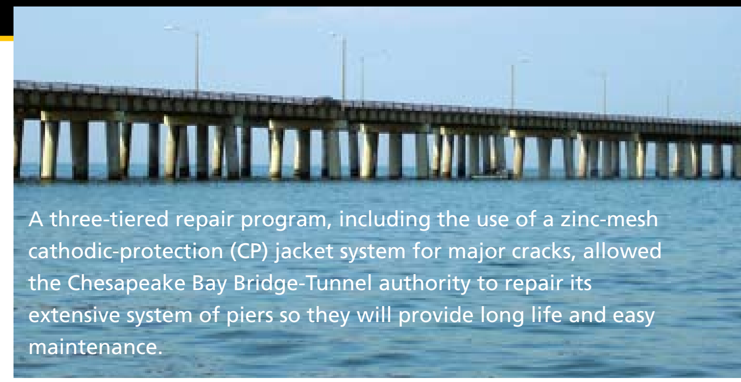

A three-tiered repair program, including the use of a zinc-mesh cathodic-protection (CP) jacket system for major cracks, allowed the Chesapeake Bay Bridge-Tunnel authority to repair its extensive system of piers so they will provide long life and easy maintenance.

Chesapeake Bay: REPAIRING THE WORLD'S LARGEST BRIDGE-TUNNEL COMPLEX

The Chesapeake Bay Bridge-Tunnel, carrying U.S. Highway 13 across the Chesapeake Bay at Cape Charles, Va., stands out for the superlatives it adds to engineering history. The 23-mile-long bridge-tunnel crossing has a shore-to-shore bridge length of 17 miles, making it the world's longest bridge-tunnel. But the complex's concrete piles recently required repairs that likewise stood out, such that the repair work won an Award of Excellence from the International Concrete Repair Institute.

The bridge includes 2523 piles to support the northbound side, which was built in 1964. An additional 2951 piles were added to support the southbound section, which was completed in 1999. An inspection of the structure revealed that corrosion of the reinforcing steel encased within the structure's support piles had caused the concrete piles to crack and spall.

Because of the variety of damage, several repair methods were integrated into the repair strategy. Pile conditions were rated on a severity scale and categorized according to the types of repairs needed. The Chesapeake Bay Bridge & Tunnel District in Cape Charles, Va., worked with Jacobs Engineering Group in St. Louis, Mo., to evaluate conditions. Their survey revealed that 623 bridge piles required repair. Precon Marine Inc. in Chesapeake, Va., performed the work.

The engineers determined that the most severe piles required carbon-fiber strengthening to ensure the piles didn't deteriorate further, particularly at the top region where they exhibited the most localized damage during installation.

Zinc-Mesh Jackets Added

Piles with cracks wider than 1/16 in., were repaired with a zinc-mesh cathodic-protection (CP) jacket system from Electro Tech CP in Tequesta, Fla., and Jarden Zinc Products in Greenville, Tenn. This system was selected to provide long-term protection that would remain maintenance free. CP jackets were installed on 215 piles and will help prevent future corrosion by creating a barrier against chlorides, moisture, and oxygen.

The first step in installing the jackets was to connect each piece of steel in the concrete sections to the pile's CP system. Installers drilled from the face of the pile into the concrete to expose a portion of the reinforcing steel, including the spiral wire and each prestressing strand. Then, they brazed a copper wire onto the steel. The crews then applied epoxy at the connection point and plugged the drill hole with grout material.

Each fiberglass jacket was installed in four sections. Crew members pumped grout comprising portland cement and sand from the bottom of the jacket to the top from alternate pumping ports to create a single monolithic fill approximately 2 in. thick. When the grout fill cured, lead wires from the reinforcing steel in the pile were connected with the zinc anode in the junction box. The existing concrete and the grout fill in the jacket formed a common electrolyte.

Finally, the repair contractor bolted two 48-lb bulk zinc anodes to the bottom of each jacketed pile and connected them to the pile's CP system to add protection to the pile's submerged portion and prevent current dump-off from the jacket's lower region. The repair system, designed to protect the piles for more than 25 years, will self-adjust to meet changes in temperature, humidity, concrete resistivity, and other factors.

For piles with minor damage, including hairline cracks smaller than 1/16 in., repairs were made by routing out the cracks and packing them with cementitious material. Any spalls on the piles were also patched with cementitious material. In addition, a cementitious overlay coating was applied to the rectangular concrete caps, which run horizontal across each set of three piles. The road rests atop these caps.

The three-pronged system and careful analysis allowed repairs to be closely targeted and achieve the twin goals of being long lasting and easy to maintain.

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Sunshine Skyway Bridge: CARBON FIBER REPAIRS GIRDERS

With its signature bright-yellow stay cables, the Sunshine Skyway Bridge in Tampa Bay, Fla., is one of the most recognizable structures in the United States. The bridge comprises the main spans, the high-level approach spans, and the low-level trestle spans. The concrete girders of the low level trestle spans recently underwent repairs to provide significant new service life. The work on the project stood out to the extent that it won an Award of Excellence from the International Concrete Repair Institute.

Repairing the girders represents a monumental project. The bridge is 5.5 miles long with a main span vertical clearance of more than 190 ft. The trestle spans use 1300 precast, prestressed concrete girders. AASHTO Type IV girders are used for a majority of the 100-ft-long spans. The Florida Department of Transportation (FDOT) in Tampa, Fla., worked with SDR Engineering Consultants in Tallahassee, Fla., on the project. Intron Technologies in Jacksonville, Fla., served as repair contractor.

Shear cracks had been observed during routine inspections of the trestle span girders, leading to the repair plan. Inclined shear cracking was much more prevalent in the exterior girders than the interior girders, and numerous pier caps also showed cracks large enough to exhibit signs of water penetration and damage. The damage impacted both the flexural and shear capacity and required several repair procedures.

Shear cracks with a width exceeding 0.012 in. were epoxy-injected. Spalls were patched with a cementitious repair mortar, uneven surfaces were filled with a leveling mortar, and small cavities were repaired with an epoxy paste. A clear protective sealer was applied to protect the concrete after the work was completed.

To restore the shear deficiencies at the end of the AASHTO girders on the 5.5-mile-long Sunshine Skyway Bridge in Tampa Bay, Fla., designers used a bidirectional carbon-fiber fabric wrapped in a specific sequence to limit the number of plies while supplying additional strength.

Carbon-Fiber Fabric Wraps Members

To increase shear strength at the end of the AASHTO girders, a bidirectional carbon-fiber fabric from Sika Corp. in Lyndhurst, N.J. was used to wrap the members. The carbon fiber was applied in a specific way to achieve the strength necessary and meet the design live load requirement.

A 24-in.-wide strip was placed vertically down the girder web, around the bottom flange and up the other face to create a U-wrap similar to a stirrup. Then a strip was wrapped around the bottom flange of the girder to strengthen the flange. Finally, another strip was placed longitudinally along and under the top flange adjacent to the soffit of the bridge deck. The bidirectional fabric allowed the members to achieve supplemental strength in multiple directions without having to install additional plies.

Most of the repairs took place over the water, from where it was difficult to access the bridge's underside to perform the repairs. The contractor worked from a barge using man lifts, because the vertical clearance from the barge to the underside of the girders on the trestle span was about 15 ft. Waves and tides also were major concerns, as was the threat of hurricanes.

Protecting the Environment

Working in a marine environment, the contractor had to ensure no degradation of water quality occurred due to construction, and staging was not permitted in any environmentally sensitive habitats or wetlands. Also, the bridge was located in a Manatee Watch Area, so a lookout was required to watch for the protected mammals when boats were moved.

Despite difficult working conditions, the project proved a success. The repairs were able to be made underneath the bridge without having to restrict even one lane of traffic during the entire process. By close scheduling of the construction sequence, the work was completed one month ahead of schedule, making not only the contractor happy, but FDOT as well.

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