Transportation Category

Conde McCullough Bridge Repair—South End

Coos Bay, OR

Submitted by BASF Corporation

South end of the bridge. Enclosure is visible right before the steel midspan. Scope of work was to repair the South end, a 4-year project

The Conde McCullough Bridge is arguably the most exquisite showpiece in a series of historic coastal bridges along U.S. 101, the Pacific Coast Scenic Byway. The series of bridges were built in Oregon between 1919 and 1935 and have all been restored through the Oregon Department of Transportation's (Oregon DOT's) historic bridge preservation program over the past 20 years.

Constructed in 1936 and dedicated posthumously in 1947 to its designer, Conde B. McCullough, this 5305 ft (1617 m) steel cantilever truss bridge was the longest structure in Oregon's highway system when constructed. To ease design conflict between the steel truss and the archway spans, the cantilever was constructed with curved upper and lower chords.

The bridges by Conde B. McCullough are strongly influenced by Art Deco with ornate detail throughout the bridge. The fear of the loss of the structures due to deterioration compelled the Oregon DOT to make fundamental changes to its approach to historic bridge preservation.

THE CHALLENGE

Over time, the elements had significantly deteriorated the bridge. The Oregon DOT discovered that a large number of repairs were required to restore the bridge. Some 20 to 30 ft (6 to 9 m) sections of the bridge received dozens of form-and-pump repairs, typically 2 to 4 in. (51 to 102 mm) in depth, in addition to numerous small hand-applied patches. The bridge required a versatile material that would adhere to the substrate, was compatible with the resistivity of the original concrete, and could be placed both in shallow and deep applications in very confined areas.

Up-close image of the enclosure showing a perspective of the size of the bride and complexity of the project. The enclosure is roughly 100 ft (30.5 m) by 120 ft (36.5 m) long. Once the work inside is complete, the enclosure is dismantled and then moved down the line. At the end of the enclosure, you can see a stepping pattern as you follow from top to bottom. Each step represents a repair level—near the top there are "split levels"—16 total to address the complete structure

Oregon costal winds can exceed 100 miles/h (161 km/h) and are regularly in excess of 85 miles/h (137 km/h). Therefore, working conditions needed to be created to establish a safe environment and ideal conditions for the product application.

In addition to construction issues and the difficulties that come with restoring a large bridge, the Coos Bay is important to salmon runs. The Oregon Department of Fish and Wildlife and the Environmental Protection Agency were concerned about construction debris disrupting the delicate marine environment below. Oregon is famous for its many salmon runs and sport fishing, so there needed to be a means of containment that would protect the fish habitat while still allowing the repairs to proceed relatively unhampered.

THE SOLUTION

Compatibility of the resistivity with a concrete that was laden with 80 years of marine salt was obtained by adding table salt to the repair mortar, under the supervision of the Oregon DOT. Because the chlorides in the salt make the concrete more conductive, the volume of salt addition to each bag of repair mortar was determined by calculating the amount of chlorides found in the host concrete, with the goal of making the chloride content of the repairs match the concrete.

While earlier projects in this series of bridges used a continuous mixer and rotor/stator pump to place the repair mortar, this bridge required a different solution. The multi-level enclosure called for a pump that was lightweight and mobile, allowing access on each level and on narrow scaffold planks. A Kenrich, diaphragm-type, hand-operated grout pump was used. After placing these portable pumps on tight scaffold areas, the material was pumped full depth both vertical and overhead, where complex forms could be assembled to recreate the original Art Deco design of the bridge. The ability to form these repairs and pump the repair mortar inside the forms proved to be one of the main keys to success. Earlier attempts to address the repairs using shotcrete yielded a great deal of waste due to "rebound" of the pneumatically applied mortar, as well as problems with delamination. In contrast, using the form-and-pump method relies on the form to help hold the repair mortar in place while it gains strength and cures. In addition, the impermeable form creates an ideal curing environment in that the moisture is better retained within the repair mortar, such that shrinkage cracking is greatly minimized versus the shotcrete method of repair.

Because of the need to use the portable pumps, a self-consolidating micro-concrete was required, which had top-size aggregate small enough to be pumped through this lightweight pump, and yet still

Inside the enclosure, showing the various levels and work platforms

The repair has been prepared. Rather than cutting out reinforcing bar, the surrounding concrete is prepared and a box form will be built around it

More complex, three-dimensional repairs can also be completed with the solution created by the team. Forming and pumping does not limit the repair to flat surfaces. Note the architectural corbel formed just right of center. Remnants of the white plastic tapit shells are still in the wall, used to hold the form in place

Inside the enclosure you could see the series of platforms that reached out to the center of the enclosure, which was currently erected around one of the main support columns. This photo shows the graceful sweeping nature of the design of this bridge. Note how the arches come together from either side to meet the column. The surface of the repairs has been sandblasted and coated with zinc as a part of the cathodic protection system

allow placement up to full depth without the addition of pea gravel extension. The repair mortar can be placed as shallow as 0.5 in. (13 mm) up to complete full-depth repairs 8 to 10 in. (203 to 254 mm) in depth. While the addition of the table salt helped to increase conductivity, the repair mortar itself still needed to exhibit relatively low resistivity. The project specifications required a resistivity of the patch material to be less than 20,000 ohms-cm (7874 ohms-in.).

To address the severe weather conditions, a resilient, movable enclosure was built to create work platforms with multiple levels. Once the work was completed in the section covered by the enclosure, it was disassembled, moved, and reassembled to address the next section of the bridge to be restored. The unique enclosure, which is approximately 100 ft (30.5 m) tall and over 100 ft (30.5 m) long, operates on hydraulics to adjust for the varying height of the bridge. When the section repair was completed, it took approximately 1 month to move the complete enclosure forward to the next repair section.

The method of repair, using the work platform enclosure, required the team to take into consideration cure time and strength gain. The less time spent waiting for the product to cure, the sooner the team could sandblast the repaired surface and apply the zinc coating used as the sacrificial component of the impressed current, cathodic protection system. Through evaluation of the repair mortar, it was determined by the contractor and Oregon DOT that they could keep the forms in place for 3 days, and upon removal at that time, the concrete and repaired surfaces were ready to be sandblasted in preparation for the coating.

The object of the cathodic protection system is to redirect the corrosion activity, which normally would occur in the structural steel reinforcement (reinforcing bar) out to the surface of the structure. To do so, the concrete must be uniformly and electrochemically conductive. The addition of the salt to the repair mortar enhanced the conductivity of the structure, whereas a low-voltage electrical current is used to help drive the corrosion to the zinc coating—sacrificing the zinc coating before the reinforcing bar—protecting the stability and life of the bridge.

PROJECT SUCCESS

It took 4 years to restore the south end of the Conde McCullough Bridge, and it is anticipated that the longer north end could take 5 or more years to complete. Meanwhile, work is ongoing on several other Oregon bridges using this form-and-pump method of repair. Through Oregon DOT's efforts to develop a system to identify and prioritize needed bridge work, including replacement, widening, and rehabilitation of bridges based on their condition, many coastal and other historic bridges have been saved for future generations to use and appreciate.

Conde McCullough Bridge

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