2013 Outstanding Repair & Rehabilitation Project

The Oregon City Arch Bridge

By Marcus H. von der Hofen

The Oregon City Arch Bridge Rehabilitation project was officially completed on October 31, 2012, by the Wildish Standard Paving Company. Dedication to quality and professionalism, along with a true partnering between owners, contractors, and suppliers, helped find ways to solve problems that could have easily turned the project into overwhelming confrontation and failure.

Originally completed in December 1922, the bridge spans the Willamette River between Oregon City and West Linn, OR, and is a beautiful landmark of the region. It was designed under the direction of State Engineer Herbert Nunn, who adopted and carried out the plans of State Highway Engineer C. B. McCullough. McCullough's signature detailing is evident in the arches, obelisk pylons with sconce light fixtures, ornate railings, and Art Deco piers. It is believed to be the only bridge of its kind in the entire United States—a through-deck steel arch covered with shotcrete that incorporates concrete spandrel columns, corbels, a sidewalk, deck approach spans, and a bridge rail.

The bridge is 900 ft (274 m) long, including the viaduct design approaches. The center section of the bridge measures a horizontal distance of 140 ft (43 m) with the supporting arches above built on a 160 ft (49 m) radius. The remaining 210 ft (64 m) of the center span are supported from below by the continuation of the arches on a 306 ft (93 m) radius. The box beam arches start with a section of 10 ft (3 m) deep at the base, reducing to a 6 ft (1.8 m) depth at the top with the width remaining the same throughout. This all supports a roadway deck 18 ft (5.5 m) across, curb to curb, with a sidewalk on each side and the added bonus of restrooms located at the piers under the sidewalk at each end.

In April 2010, Wildish Contractors was awarded the contract for the rehabilitation of the Oregon City Bridge. The goal was to upgrade the structure to replace structurally deficient components and accurately replicate the details and architectural features to keep the original appearance of this historic icon. A great deal of work was necessary to carry out this upgrade within the short time frame of only 2 years.

During my first visit to inspect the bridge, I must say I was more than a little overwhelmed by the craftsmanship of this structure. It was and still is amazing to me. The quality of the gunite that these crews produced so long ago is impressive. Not that there weren't any problems, but for the most part, the gunite has held up incredibly well over the years. The finish, the consistency, and, again, the overall craftsmanship produced by the crews must have made subcontractor Lanning & Hoggan immensely proud. Most of the deficiencies I saw really didn't have anything to do with the gunite but were inherent to the design. It was amazing to see reinforcing steel mesh exposed in a hydrodemolition test area in the same condition as when it was placed on the bridge 90 years earlier. Even with all the modern shotcreting tools we have today, duplicating the quality of the shotcrete work on this bridge would be a major challenge.

The shotcrete covering had caused many a bridge expert to be deceived into thinking this was a structure made entirely of concrete. Originally placed using the dry-mix method nearly a century before, the protective concrete would need to be removed and replaced to the original lines and grades. One of the first questions to contemplate was: Should it be done wet or dry? Should it be both? Today's shotcrete technology offers efficient site batching of material in small amounts, both wet and dry; state-of-the-art batch plants and testing facilities also allow ready-mix producers to perform various adjustments and quality control that simply was not available 90 years ago. The project has areas that

> A unique feature of the original project was the encasement of the steel structure in what was then called "gunite" to protect it from the emissions of the paper mill located close-by. "The guniting was done under subcontract by Lanning & Hoggan and was directly supervised by A.C. Forrester, Civil Engineer. The outfit used was the N-1 type cement gun of the Cement Gun Co., Inc., and the necessary auxiliary equipment… The work required 40,000 square feet of 2 inch guniting on the steel ribs; 1200 square feet of 6 inch gunite for the web on the underside of the arch; 800 square feet of 4 inches thick; 1200 square feet of 3 inches thick, and 2800 square feet varying from 6 inches down to 2."
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> W.A. Scott, *Engineering World* (December 1922)

Fig. 1: Oregon City Bridge—multiple access methods

Fig. 2 and 3: Shotcrete placement inside the arches

really lend themselves to either method. The bottom line in this case came down to what the personnel felt the most comfortable with. I don't find this reason brought up in the discussion very often, but it really should be part of the process. Many contract specifications are written making the choice, and I personally don't think that is the right answer. The fact is that many jobs can be done efficiently and correctly either way, so the choice should be left up to the qualifications of the contractor.

In this case, my personnel and I agreed that we could perform the job more effectively using the wet process. At first, I believed that we would do the project using both site-batched bagged material and ready mix. After initial testing, I became convinced that the ready-mix supplier CEMEX, with whom I had a long working relationship, could lend invaluable expertise to the project. As it turned out, it was a good decision (or maybe just lucky) on my part, as their ability to provide extensive resources, quality information, and testing played a large part in the success of the project.

Fig. 4: Repairing mesh prior to shoot

Initial trial batches based on the project specification seem to function reasonably well, but there were definitely some issues. The specification called for specific levels of 8% or less boiled absorption. The initial test came back at 7.6 to 7.9%, leaving little margin for variation. Secondly, there was a great deal of reluctance to allow a hydration stabilizer because it might affect the bond. The bond was specified at 150 psi

Fig. 5: Positioning the equipment for the next shoot

(1 MPa) shotcrete-to-steel, but no data were available showing this was achievable. The specification required hydrodemolition of the existing shotcrete followed by an abrasive blast of the surface. This created some degree of ambiguity. Thus, it was decided that a surface preparation mockup test should be conducted.

The initial surface preparation test section was divided into three areas: one with a walnut shell blast, the second with a light sand blast, and the final area with just an air and water blast. The initial process was the belief that minimizing the removal of the existing material (steel surface and attached mesh) would be a good approach, and to then build the sections back up from there. The surface preparation tests had almost identical results from each of the three methods, with values ranging from 0 to 120 psi (0 to 0.83 MPa) with the majority being 0. After this initial test, it was obvious that more extensive testing would be required. Steel road plates were used to represent the bridge surface during the next test, which included a variety of differing parameters, including more extensive sandblasting, bonding agents, accelerators, hydration stabilizers, and different curing methods. In the end, a complete white blast of the steel surfaces proved to be the most effective with a multi-course sandblast material. But even then, the results were still not very consistent. Some sections would bond well and meet the specification and others would have no bond at all. Other attributes that seemed to be creating variability were the shrinkage and the flexural properties of the shotcrete material. The specification called for minimum levels of silica fume and cement, but we decided we needed to rethink this.

This is typically where I've seen a great number of projects become dysfunctional. The focus changes from getting the job done correctly to minimizing the damage and protecting one's best interest. The parties become more adversarial than trying to work together to solve the problems and move forward. Fortunately, with this project, the Oregon Department of Transportation (ODOT) and its team stepped up not only finan-

Fig. 6 and 7: Ever-changing shooting positions

Fig. 8: Overhead finishing

Fig. 9: The finished product

cially but also (and more importantly) remained focused on finding the best solutions. I believe their role was instrumental in allowing both the contractors and suppliers the means to find the best answers in a timely manner. I think a statement made by a member of Wildish Standard Paving sums it up best:

"Our shotcrete applicator was committed to achieving the very best mix design that could be developed. From the original mixture, we reduced the silica fume content; used other supplemental cementitious material, including fly ash and added fiber; and a W. R. Grace retarder to slow the settime. After developing eight different trial batches for the project, they were able to identify a concrete mix that exceeded the requirements of the specifications, while offering better adhesion and more elasticity than originally specified. Were it not for their perseverance in obtaining the best possible product, the shotcrete applied to the bridge might have met the original project specification but would not have been as durable over the years. From the original mix, which produced a 10 to 30 psi (0.07 to 0.21 MPa) bond pulloff strength, we increased to getting over 300 psi (2.1 MPa) with the final mix."

I would add that it was really the commitment of all the parties to achieve the best quality and durability that allowed this to take place.

As a result of the efforts by many, including Wildish Standard Paving, Johnson Western Gunite, CEMEX, and ODOT, the project team rehabilitated a beautiful historic landmark of the region in a safe and effective manner. Through working together toward a mutually desired end goal, I believe we produced a durable, serviceable, and aesthetically pleasing project that will be enjoyed by many generations to come. For information on the concrete mixture designs and specific test results, please contact ASA.

The Outstanding Repair & Rehabilitation Project

Project Name
The Oregon City Arch Bridge

Project Location
Oregon City, OR

Shotcrete Contractor
Superior Gunite*

General Contractor
Wildish Standard Paving

Architect/Engineer
n/a

Material Supplier/Manufacturer
CEMEX, W. R. Grace & Co.

Project Owner
Oregon Department of Transportation

*Corporate Member of the American Shotcrete Association

***Marcus H. von der Hofen**, Vice President of Coastal Gunite Construction, has nearly 2 decades of experience in the shotcrete industry as both a Project and Area Manager. He is an active member of American Concrete Institute (ACI) Committees 506, Shotcreting, and C660, Shotcrete Nozzleman Certification. He is a charter member of ASA, joining in 1998, and currently serves as Vice President to the ASA Executive Committee.*