Coatings on Dam Intact 4 Years after Rehab, Salt Removal, Repainting

by Jim Johnson, *Chlor*Rid*

To rehabilitate deteriorated concrete components of Arizona's Coolidge Dam and the roadway running across the top of the structure, the U.S. Bureau of Reclamation (BoR) initiated a project in 1995 that combined concrete repair, pressure washing with a solution of liquid soluble salt remover, and coating application. The areas targeted for repair were the spillway walls and sidewalls of the dam, the curbs of the roadway across the top of the dam, the pylon structures on each side of the roadway at each end of the dam, and the roof of the powerhouse. The BoR performed the project as part of the Coolidge Dam, Completion Contract, Safety of Dams

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Deteriorated concrete curbs have been chiseled and cut out before repair, cleaning, and coating.

Concrete curbs four years after repairs, cleaning with soluble salt remover, preparing, and coating. Wet areas have puddled repeatedly from weather but the coating remains intact.

*Photos courtesy of Chlor*Rid International*

Modification, Bureau of Indian Affairs, San Carlos Irrigation Project, Contract 1425-5-CC-32-02570.

The Coolidge Dam was built to supply electrical power and irrigate water for thousands of acres of farmland. Construction began in 1927 and ended late in 1928. Located in a mountain canyon, the area is often subject to high winds, which carry large amounts of chloride-laden, and therefore, corrosive soil. By the mid-1990s corrosion rates in parts of the structure had been accelerated by high chloride levels in the aggregate, the concrete, the soil in the surrounding countryside, and the water the dam was meant to control.

The scope of the 1995 work was to repair damaged concrete in the spillway walls of the dam and the sidewalls of the raceway, where the water exits in its normal pathway through the dam. In addition, the curbs of the roadway across the top of the dam, the pylon structures on each side of the roadway at each end of the dam, and the concrete roof of the dam's powerhouse were to be repaired and coated. This article will focus on the repair of the roof.

Repairing the Spillways and Raceway

Deteriorated areas of the vertical concrete in the spillways and raceway were repaired in accordance with the BOR's specification. The procedures are to saw cut around the damaged areas, remove the damaged concrete and rebar, replace the rebar, and replace the concrete with new epoxy-bonded concrete. All placed concrete had to be vibrated. However, this portion of the project was complicated by needing to perform the work while the raceway was still in use. For irrigation reasons, the water could not be shut off. The work over the raceway had to be performed on scaffolding cantilevered over the top edge and down the face of the raceway wall.

For repairs to the vertical surfaces of the spillways and raceway, the BoR specification required that the concrete be placed in lifts of no more than 2 ft (0.6 m) at a time. In addition, the bonding agent had to be applied and concrete placed within one hour of mixing. No more than one hour between lifts was permitted.

Repairing and Coating the Pylons and Curbing

The scope of work for the pylons and curbing on top of the dam was of structural and aesthetic concern.

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For repair of the curbs, each saw cut was to meet at the corner, but no overlap of cuts was allowed. The concrete within the sawcut area was to be chiseled out, the area formed, and new epoxy-bonded concrete placed. The decision was made to use handmade wooden forms of plywood and dimension lumber.

The work was further complicated because the roadway was to be kept open to traffic, except when it was absolutely necessary to close it. Closures were to be limited to a few hours.

The most complicated portion of the work was on the four pylons. They required not only functional repair and reconstruction, but also major improvements to their appearance. The contractor recognized that the cracking resulted from the rebar corrosion, which was due to chloride contamination. The BoR had no established specifications to deal with chloride contamination. Unchecked chloride contamination would lead to more corrosion and the reappearance of cracks. Although no data were available on how the liquid soluble salt remover would perform in removing the chlorides from a crack when thoroughly washed with a pressure washer, the BoR approved the treatment method for the pylons. The contractor mixed the liquid soluble salt remover in a 1:100 dilution and used a 3,000-psi (20 MPa, gasoline-powered pressure washer. Workers washed the cracks, spending approximately 10 to 15 minutes on each linear foot of crack. They held the nozzles directly to the crack and as close to the surface as possible. The specification called for the pylons to be painted after the repairs, so the entire surface of the pylon was washed during the operation to remove soluble salts. Soluble salt testing using patch tests or swab tests could not be performed for two reasons: the extremely rough texture of the concrete would not facilitate the adhesion of test patches, and vertical surfaces were not suitable for effective swabbing.

After both the cracks and the surface of the pylons were sufficiently decontaminated, the cracks were injected with epoxy. A port was affixed every 6 in. (15 cm) with a 100% solids epoxy adhesive. The crack between each port was covered with an epoxy paste made from the same adhesive but blended to a mortar consistency with 60-grit aggregate. Workers also injected the 100% solids epoxy into the ports, starting from the bottom. Pressure was applied on the epoxy injection until the epoxy came out of the port above. Then, the port being injected was plugged, and the injection gun was raised to the next port. In that manner, each crack was filled to the top. The next day, workers removed

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the ports and mortar covering the cracks with a few light taps of a hammer and chisel.

To fill the surface defects, the contractor used the 100% solids epoxy resin, expanded with a very fine aggregate and silica flour. Fill work was performed on the vertical flats in the center of the pylon, on the flutes at the edges, and on the scroll work around the top. All four sides of each pylon were repaired and filled. The fill work was performed partly by putty knife but mostly by hand. The workers wore protective gloves, and much of the work was done by filling an area with a putty knife, then smoothing it with a gloved fingertip. The next day, workers used small, hand-held power tools equipped with grinder bits to remove high material; then they hand sanded the filled areas. After the grinding and sanding was completed, low areas were refilled. This procedure was repeated for three fills on each pylon. The work was extremely labor intensive, but because of the various levels and configurations, other power tool methods could not be used.

The reconstruction of the scroll work side pieces was subcontracted. The subcontractor sent one of its mold makers to the job site to make molds of the damaged pieces of scroll and the crest pieces. Once the molds were made, the contractor mixed the concrete to the same specification as the rest of the repairs and filled the molds. The next day, the molds were removed from the cast concrete and refilled. The cast concrete pieces were laid out to cure and dry while other repairs were completed on the pylons.

Installation of the cast scrolls and crest pieces was next. The crest pieces were not heavy so they were installed by hand from a ladder. The height was approximately 14 ft (4.2 m), and the crest pieces were attached with the same epoxy resin used to fill surface defects. The scrolls, weighing approximately 1,100 lbs (495 kg) each, had to be placed with a crane. The epoxy resin was brushed on the mating surfaces on both pieces, and the crane lifted and fitted them into place. They were blocked and left overnight. The next day the crane was removed and the joint was filled and smoothed with the epoxy resin.

The BoR decided to paint not only the pylons, but also the concrete handrails, the sidewalks, and the curbs to the surface of the roadway. After consulting with the Bureau's engineer about the chloride contamination on the concrete surface, the BoR decided to pressure wash all

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surfaces before painting them. Pressure washing was performed with the same 3,000-psi (20-MPa) pressure washer with the liquid soluble salt remover added in a 1:100 dilution. The paint chosen for the application was a water-based textured elastomeric with a fine aggregate added to give it the appearance of concrete. This material met the specification of the BoR. It was applied with a compressed air-powered high volume low pressure spray unit.

Repairing the Powerhouse Roof

The repairs and coating of the powerhouse roof involved several steps. At many locations, the rebar had corroded, causing the concrete to spall in patches several feet in diameter and several inches deep. By tapping the surface of the concrete, workers could audibly detect the start of the delamination below the surface. The workers started 5 to 6 ft (1.5 to 1.8 m) back from the visible delamination, tapped the surface, and worked their way to the delamination. When they detected the change in sound, a chalk mark was made on the surface. By repeating this procedure every 2 ft (0.6 m), all the way around a delaminated area, the outer perimeter of delamination within the concrete was established.

Then workers saw cut the concrete approximately 2 in. (5 cm) beyond the chalk-marked perimeter, cut all corners square, and chiseled out the material within the saw cut to the depth of the rebar. Horizontal holes were drilled at the sawed edge to receive the replacement rebar, which was anchored in place with epoxy.

Since the roof was 50 ft (15 m) above ground level, an anchor cable was installed the length of the roof, and each worker wore a full body harness and was tied off to the cable with a 6-foot (1.8-meter) lanyard. As work progressed, a second cable

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Above: The pylon, with coating intact, four years after repairing, removing soluble salts, and coating

Left: Cracks permeate the concrete pylon before rehabilitation work.

was installed to facilitate movement of the workers. After the new concrete was placed and bonded with epoxy, the area was left to cure for 30 days. At the end of the cure time, a mat test was performed. A piece of clear plastic, 18 in. (45 cm) square, was taped down for 24 hours, then visually inspected to assure that no moisture had condensed on the bottom side of it.

The entire roof was swept and pressure washed with a 3,000-psi (20-MPa) pressure washer with tap water and a liquid-soluble salt remover added in a 1% dilution. The roof was then brush blasted with copper slag to

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approximate a 30-grit sandpaper. Workers used a standard abrasive blasting unit with 100 psi (7 MPa) of compressed air at the nozzle. After the abrasive blasting, the contractor washed the entire roof to remove debris and dust.

The BoR specification called for its own coating formula, composed of a vinyl ester resin blended with other ingredients added at the time of use. The coating, including the coloring pigment, was meant to be mixed in five-gallon (19-liter) containers on site as it was used. The contractor knew from past experience that mixing the coating in that manner would be labor intensive and would produce color variation from batch to batch. The contractor supplied a coating manufacturer with a copy of the BoR specification and asked if the manufacturer could premix the ingredients, including the coloring, in large batches and supply it in five-gallon (19-liter) containers along with the activator. The BoR approved of the alternative method. Each container was consistent in mixture and coloring and allowed site work to proceed at a much faster pace.

The specification allowed for several options for the coatings application, but all had restrictions. Another consideration in selecting the method of application was that the concrete had not been troweled very smoothly. The surface of the concrete tended to have swells and valleys.

The specification called for the coating to be approximately 125 mils (3 mm) in thickness. Therefore, the coating had to follow the swells and valleys; otherwise, film build could fall short or exceed the specified thickness.

The contractor considered using a plural component sprayer at ground level with extra hose to reach the roof. However, the contractor decid-

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ed this method was not feasible. The temperature, in excess of 100 F (38 C) was too high for plural component spraying; the material would be under pressure too long for the process.

There was no way to precool the material. In the end, the contractor lifted the five-gallon (19-liter) buckets to the roof by crane and mixed the material as needed. After mixing, the material was dumped on the roof, spread with notched squeegees, and broomed. The squeegee application maintained the correct thickness, and the broom took out the notch marks.

The concrete repair, pressure washing, and coating operation took approximately one month to complete in 1995. In 1999, the contractor inspected the work on the top of the dam. No cracks were evident in the concrete, and the paint was in good condition, with no peeling

Pylon with plaque before any repairs were undertaken

Pylon and plaque four years after repairing, cleaning, including soluble salt removal, and coating

or blistering visible.

The general contract was issued to Inca Construction of Chandler, AZ. The concrete repair, chloride decontamination, and coating was subcontracted to Enviro Coat Systems of Tempe, Arizona. The Larson Company (Tucson, AZ) reconstructed the scroll work on the pylons. Chlor*Rid International, Inc. (Chandler, AZ) manufactures the liquid soluble salt remover. Permite Corporation (Stone Mountain, GA) supplied the 100% solids epoxy bonding agent. Dow supplied the vinyl ester resin. The water-based elastomeric was manufactured by Soberg Industries, Inc. (Phoenix, AZ). ❑

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