Copper Mine Gets New Support

By David E. Snider and Heather M. Ramsey, Sauereisen Inc.

A large copper mine and refinery in the western United States had a dilemma. The mine's cell house, which contains over 1,500 cells, each holding more than 20,000 gallons of electrolyte, had exhibited severe corrosion and structural degradation of the concrete support columns for the tanks. Over time, highly acidic leakage from the cells (primarily copper sulfate and 25% sulfuric acid at a pH of 1.0 or less) had caused the support columns to deteriorate and the No. 8 reinforcement bar (rebar) to corrode. Rebar corrosion increased internal pressure because the corrosion products expanded, putting the concrete in high tensile stress to the point where its ability to adequately withstand the imposed load was in doubt. The direct effect of this stress was cracking and spalling of the concrete (Fig. 1).

Fig. 1: Typical column degradation. Photos courtesy of the authors.

Fig. 3: The forms placed around the column

Restoration Project

The original construction of the columns used No. 8 rebar spaced 6 inches on center vertically and 18 inches on center horizontally. The refinery's standard repair procedure was to remove corrosion products, including deteriorated concrete, from the concrete and steel and then to top them with a polymer-modified portland-cement mortar. This standard repair method requires two to three days per column, and although temporarily effective, it did not meet the company's desire for a long-term solution, as the refinery desired to upgrade the facility's ability to withstand seismic activity.

The company decided upon a new approach, using a polymer concrete (PC) designed for maximum flowability, mechanical properties, and chemical resistance. The PC repair system (a bisphenol A epoxy-based material) uses the polymer concrete for encapsulation, chemical protection, mechanical support, and resistance to physical abuse.

The specification for this project was developed by the PC manufacturer's field engineer and the facility's maintenance engineer. The specification development considered cost, ease of installation, downtime, engineering parameters, and corrosion control. The specification also called for a seismic evaluation, which was conducted by the manufacturer of a fiberglass-reinforced plastic (FRP) system also used in the repair. The facility's local preferred contractor performed the work.

Fig. 2: Stainless steel rebar bent and grouted into the channels

Fig. 4: Pouring of the polymer concrete

Fig. 5: Columns after removal of forms

To begin the restoration project, new stainless steel rebar was embedded into the concrete floor using an epoxy mortar. Channels were saw-cut vertically in the concrete column. These channels provided a recess into which the rebar was bent and then secured into place with the epoxy mortar (Fig. 2). Grouting of the rebar with this high-strength epoxy mortar also served to provide tensile stress relief. Lowering stress relief reduced corrosion rates. (The previous repair method did not include installing rebar into the floor to reinforce the material. The original rebar in the columns was mild steel.)

To further ensure structural integrity and to upgrade seismic capabilities, the company chose to use FRP strips and wraps under the PC. The strips were installed vertically on the columns, and a fiberglass fabric was wrapped around the columns horizontally. The columns were formed and the polymer concrete was poured into place, completely encapsulating the columns, the rebar, and the FRP (Figs. 3, 4, and 5). This method required two days per column. To date, 75

Editor's Note: This article is based on a paper presented at PACE 2009, the joint conference of SSPC and PDCA, held February 15–18, 2009, in New Orleans, LA.

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Fig. 6: Completed column repair

columns have been repaired using this method.

The use of protective coatings to give the necessary chemical protection to the repaired concrete was rejected, because, although these coatings typically have a service life of 8 to 15 years in many settings (depending upon the exposure and physical abuse), in this environment, their typical service life is six months. Their service life is also affected and somewhat limited as a result of application thickness, which generally ranges from a few mils to a few hundred mils. Polymer concretes, however, are applied from 1 to 18 in. thick. The thickness of the barrier determines the overall permeability, which is a measure of water vapor's ability to pass through a material and corrode the rebar. Also, a PC requires far less maintenance. The manufacturer reports that the PCs it has used have not failed after 15 years of service. Laboratory evaluations coupled with field observations indicate the service life of PCs to be typically greater than 25 years.

Figure 6 illustrates the completed column, including a protective topcoat for the FRP reinforced concrete. Although not needed for functionality, the topcoat was extended over the PC for aesthetics and coating integrity.

The columns have been inspected twice to date and are in excellent condition.

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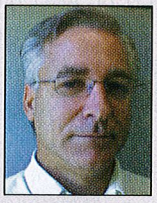

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