3. R.D. Eash and H.H. Shafer. In Transportation Research Record 542, TRB, National Research Council, Washington, D.C., 1975.
4. Portland Cement Association. Properties of Latex Modified Shotcrete. Construction Technology Laboratories, Skokie, Ill., 1978.
5. Bonneville Second Powerhouse. Report on Tests on Latex Modified Shotcrete and Conventional Shotcrete Panels. North Pacific Division Materials Laboratory, U.S. Army Corps of Engineers, Troutdale, Oreg., 1980.
6. Grand Rapids City--County Parking Garage. Concrete Repair Method Evaluation. Grand Rapids, Mich., 1980.
7. American Concrete Institute. Specifications for Materials, Proportioning and Application of Shotcrete. Standard ACI 506.2-77. Detroit, Mich., 1977.
8. Styrene-Butadiene Latex Modifiers for Bridge Deck Overlay Concrete. FHWA-RD-78-35. FHWA, U.S. Department of Transportation, 1978.

Applications of Permanent Precast Polymer Concrete Forms for Concrete Rehabilitation

DOUGLAS BARNABY and JAMES T. DIKEOU

ABSTRACT

Two case studies are presented of the use of precast polymer concrete stay-in-place forms for rehabilitation of transportation structures. The first study is on precast median barrier shells used by the Pennsylvania Turnpike Commission. The new barrier replaced an obsolete, deteriorated 4-ft-wide concrete island. The shells are 1-in.-thick and come in 20-ft-long sections. They are placed on the roadway, aligned, anchored with anchor bolts, then filled with conventional concrete through holes at the top of each section. The system is easily and rapidly installed, and provides a more impact-resistant and durable barrier than conventional concrete barriers. The second study is on precast bench panels that replaced deteriorated bench walls in Boston's Sumner Tunnel. Polymer concrete panels were selected because of their high strength and high modulus, good impact resistance, and their outstanding resistance to de-icing salts, chemicals, and freeze-thaw. The work, performed during the night, consisted of placing and anchoring panels, sealing off vent openings to prevent backfill concrete from coming out, then placing concrete behind the panels. In addition to improved performance properties, rapid construction time was a major benefit.

The continual use of salts to remove snow and ice and the adverse effects of freeze-thaw cycles and water penetration have combined to accelerate the deterioration of U.S. highways and bridges at an alarming rate. To overcome the deteriorating effects, use of polymer concretes have increased. The high strength-to-weight ratio of polymer concretes and their resistance to freeze-thaw cycles and road salts enable them to be used for rehabilitating and upgrading highway and transportation structures. Because polymer concrete formulations do not include water, the tiny capillaries that remain in conventional cement concrete after the curing water evaporates are not present. Therefore, the material is nonporous and provides a sealing and protective barrier from the elements.

The two case studies included in this report are descriptions of projects completed in the fall of 1983. In both cases, a special formulation of polymer concrete was chosen over other materials because of its ability to decrease life-cycle costs, prevent shear bond failures, and simplify the construction operation while solving particular engineering design requirements that other methods or materials could not accomplish economically.

POLYMER CONCRETE MEDIAN BARRIER--PENNSYLVANIA TURNPIKE

The Pennsylvania Turnpike Commission installed 4,900 linear ft of polymer concrete median barrier on the Susquehanna Bridge as part of a $2.4-million bridge rehabilitation program. The new nonporous and extremely durable material will be more impact-resistant and reflective than traditional precast or poured-in-place concrete barriers.

Located on the Pennsylvania Turnpike between exits 18 and 19, the continuous-span Susquehanna Bridge was built in 1953. Before the bridge rehabilitation, there was a 4-ft concrete island curb with guard rail on top that proved to be unsatisfactory. Figure 1 shows a schematic of the old concrete island. Turnpike engineers investigated precast and poured-in-place barriers but had problems with the precast type because of difficulties with the anchoring system as a result of the condition of the

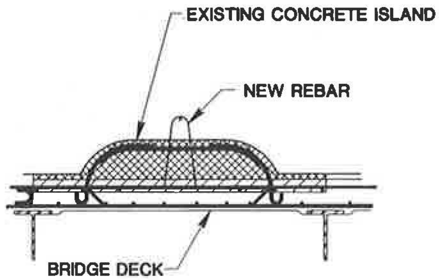

FIGURE 1 Schematic of the old concrete island.

existing concrete median. They were also concerned with environmental factors such as rain, snow, freeze-thaw cycles, and heavy traffic (about 20,000 vehicles per day). Conventional portland cement has a tendency to deteriorate under these conditions, darkening over time and becoming difficult to see on dark rainy nights.

The Commission selected 2-ft-wide x 20-ft-long polymer concrete median barrier shells that are filled on the site with a superplasticized concrete. The shells are placed over new or existing reinforcing steel and anchored to the roadway with 0.375-in.-diameter anchor bolts. Figures 2 and 3 show schematics of the barrier in place and the anchoring system. The barriers are four times stronger than conventional concrete and are impervious to water and freeze-thaw cycles and virtually all acids, salts, corrosive chemicals, and oils. Manufactured in sections for ease of transportation and installation, the barriers were also cast with a smooth white surface to enhance reflectivity. Electrical conduits may also be placed in the shell void, which eliminates the need for excavation or other special details to provide housing for the utilities.

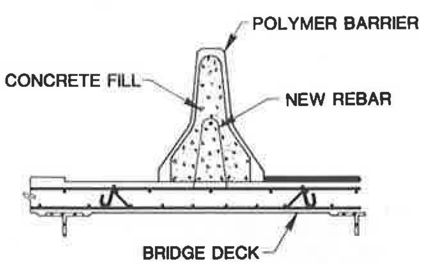

FIGURE 2 Schematic of new barrier in place.

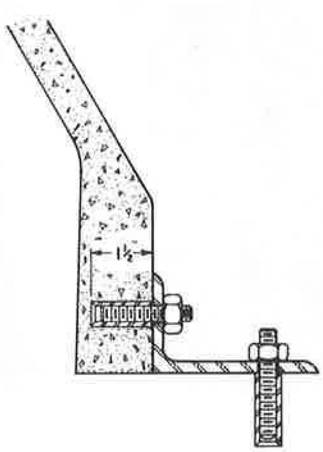

FIGURE 3 Anchoring system for new barrier shell.

Another advantage of the shell concept is its ability to encase existing out-dated medians that are to be upgraded to the new safety shape without the need to demolish the old barrier. The polymer concrete shell can be simply placed over the old barrier or wall and filled with concrete in the usual manner. This feature is especially desirable on those bridges where rehabilitation of the parapet is necessary. A half-shell section is placed alongside the deteriorated parapet wall, anchored in place, and then backed up with concrete (Figure 4). The half-shell prevents further deterioration from splashing salt-laden water and also improves the impact-safety aspect of the parapet. According to the contractor, the median barriers are much easier to install than cast-in-place concrete barriers and they are able to easily set over 500 ft per day with a smaller crew size than would normally be possible with conventional systems.

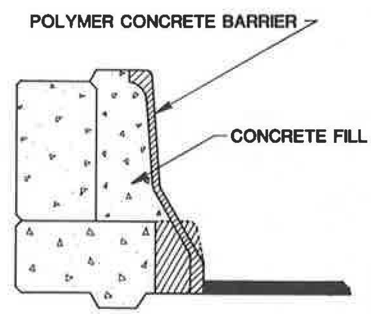

FIGURE 4 Schematic of half-shell used to protect parapet walls.

This was an important feature of the shell concept for the Pennsylvania Turnpike project because work could not begin until after the busy 4th of July weekend and had to be completed before the Labor Day weekend. The tight schedule would have been difficult to meet with conventional methods. Post-finishing operations such as patching were also eliminated.

Erection of the shells began as soon as the trailer load of 12 20-ft sections arrived. (The ability to transport a large number of sections per trailer load minimized the size of the staging area.) The shells were then unloaded by a three-man crew and placed in their approximate location--plus or minus a few inches. After the shells were unloaded, the same crew dropped back to align and anchor them to the roadway with anchor bolts set through clip angles at the base of the sections (Figure 3). After anchoring, they were ready to be filled with 3,000 psi concrete through-holes provided at the top of each section. Figures 5 and 6 show photographs of the erection process.

If unforseen conditions such as the presence of light poles and catch basins had occurred, which would have prevented installation of standard sections, the shells could have been cut with a conventional carborundum saw to suit the required size needed. To complete the operation, polymer concrete plugs were set into the pour-holes.

The $2.4-million contract, including upgrading of the bridge deck surface, began in July 1983. The polymer concrete median-barrier portion and one-half of the deck resurfacing was completed on schedule in early September 1983.

FIGURE 5 Pennsylvania Turnpike: Erection crew unloading polymer concrete shells prior to setting over reinforcing bars.

FIGURE 6 Pennsylvania Turnpike: Polymer concrete shells installed and awaiting placement of infill concrete. (Note the pour holes at the top of the barrier and the splice section to the right).

BOSTON'S SUMNER TUNNEL SIDEWALL PANEL REHABILITATION

Precast bench panels made of a polymer concrete were installed in Boston's Sumner Tunnel (Figure 7). The purpose of the $1.2 million tunnel rehabilitation project was to repair damage caused by years of automobile accidents and concrete deterioration. The engineers in charge of the project evaluated several design alternatives before deciding on polymer concrete panels.

This was the third sidewall rehabilitation project of this 50-year-old tunnel. When first built in 1934, the bench walls of the tunnel were made of concrete and then painted. In the early 1960s, the benches were covered with 4 x 4-in. ceramic tiles. However, the tiles became loose over a period of time because of traffic accidents and concrete and mortar deterioration or both. In 1970 the Authority responsible for the tunnel reconstructed approximately 40 percent of the bench walls with concrete panels and 4 x 4-in. ceramic tiles. The original ceramic tiles continued to deteriorate and fall off the remaining sections of the tunnel. In January 1982, the Authority decided to replace the 2-ft, 6-in. low bench side and the 3 ft, 2-in. high bench side with a more attractive impact-resistant sur-

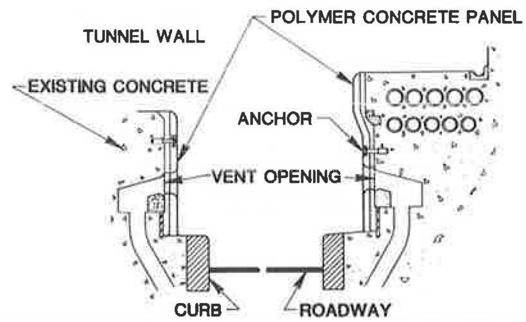

FIGURE 7 Schematic of precast panels in place at Sumner Tunnel.

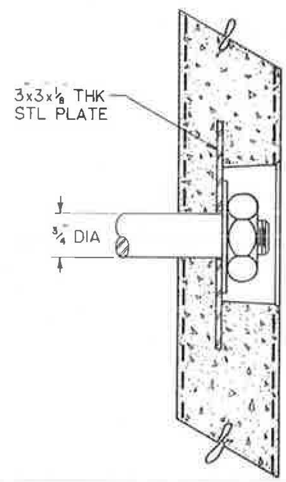

FIGURE 8 Anchoring system for panels.

FIGURE 9 Sumner Tunnel, Boston: Work crew places conventional portland cement concrete with a superplasticizer additive between the polymer panel and the existing sidewall concrete.

face. Because of space constraints, precast concrete was eliminated from consideration. Excessive amounts of existing concrete would have to be removed in order to install new precast barriers. Also, precast sections would have reduced roadway width, would have been too cumbersome to handle in an already tight workside, and would be difficult to modify to unforseen field conditions. Preformed galvanized steel was also rejected because of the concern about deterioration caused by the caustic atmospheric conditions in the tunnel.

Polymer concrete was selected because of a wide range of desirable performance characteristics: a compressive strength of 15,000 psi and a high modulus of elasticity. The panels are unaffected by water, salts, corrosive acids, and chemicals, and are washable. The 3-ft x 15-ft panels were reinforced with fiberglass for greater impact resistance and were manufactured with a precisely located vent opening to conform to existing air vents. The panels were manufactured with a smooth white surface to match the existing tunnel lining and to increase illumination.

Because both lanes of the tunnel must be operational during the day to handle the estimated 80,000 car-per-day volume, construction was begun at midnight and continued through 5:30 a.m. A crew of 12 men placed and anchored approximately 36 15-ft panels per shift. The erection operation on a given shift began by bringing into the tunnel a flatbed trailer with enough panels to be set that evening. The trailer was equipped with a boom device that lifted the panels off the trailer and set them into predrilled holes in the sidewalk to receive anchors that were cast into each panel. Figure 8 shows the anchoring system for the panels. An alignment crew followed up the unloading operation by anchoring the panels to the sidewall. Vent openings were sealed off to prevent backfill concrete from coming out. A modified concrete mix with a superplasticizer was then placed behind the panels (Figure 9). The vertical joints between the panels were sealed and the contractor plugged the anchor holes with a special plastic plug to create a smooth uniform surface. Figure 10 shows the completed bench wall repair. All work had to be completed before the morning rush hour.

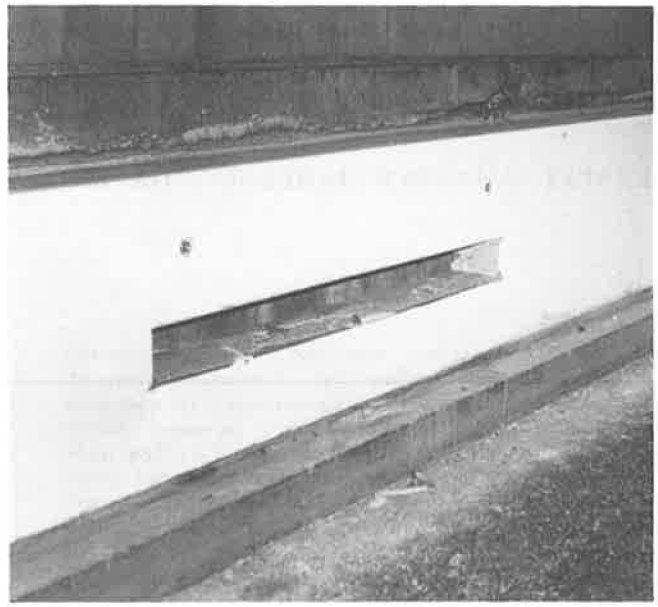

FIGURE 10 Sumner Tunnel, Boston: Completed bench wall repair showing contrast of old and new. Anchor holes were filled with a matching plastic plug to create a uniform smooth surface.

CONCLUSION

Polymer concrete is an advantageous material for use in solving many rehabilitation problems. The design concepts of these two projects combined the advantages of both polymer concrete and conventional portland cement concrete. The polymer concrete was used at the outside surface where deterioration occurs most and portland cement concrete was used as a backup or to give the section mass.

The process of determining how the desirable characteristics of the material can be applied to current engineering needs has made polymer concrete a viable material for solving highway and transportation problems.