White Concrete Reflects Highway Safety

A low-maintenance option to make barriers and parapets more visible at night

BY M. K. HURD

Median barriers for Texas, curb and gutter in Chicago, bridge parapets on the Pennsylvania Turnpike—why are departments of transportation turning to white concrete for these and other applications? Enhanced driving safety due to the high visibility of the white structures is a primary reason, but aesthetic considerations are also a factor.

Contractors build white concrete median barriers in much the same way as gray ones, some with the classic New Jersey barrier shape and others following the single-slope Texas barrier design (Fig. 1). Steel reinforcement guards against pieces of concrete being dislodged by a crash, as well as adding to the barrier's flexural strength. Tie-down bars, dowels, or keyways recessed into the base prevent lateral displacement or overturning during impact. Precasting and casting in fixed forms are practical for some jobs, but costs can frequently be reduced by using power-curbing machines and slipform pavers that extrude the white concrete into its final position.

Bridge parapets on the Pennsylvania Turnpike

The Pennsylvania Turnpike Commission is engaged in a $3 billion, multi-year expansion of its routes in western Pennsylvania. The Mon/Fayette Expressway will extend about 70 mi (110 km) south, from Pittsburgh through the Monongahela River Valley and western Fayette County to Interstate 68 near Morgantown, W.V. The Southern Beltway will form a much-needed arc around Pittsburgh between the Mon/Fayette and Beaver Valley expressways. The two routes will improve access to Pittsburgh International Airport and to river towns where steel and coal industries once flourished. Seeking cost-effective ways to enhance the quality and safety of its new route, the Turnpike Commission has specified white concrete for all the mainline bridge parapets on both the Mon/Fayette and the Southern Beltway.

Recognizing that more accidents per mile driven occur at night than during daylight hours, Bernie Zielinski, the commission's bridge engineer, says that

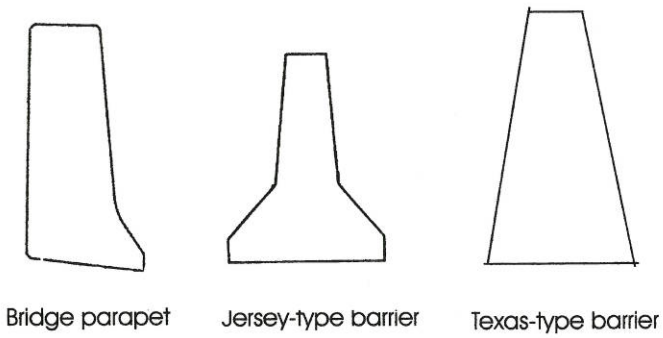

Fig. 1: Single-slope Texas-type and Jersey-type barrier shapes, and bridge parapet shape used on the Pennsylvania Turnpike

they were looking for a way to make bridge parapets more visible during dark, rainy nights. Although they had tried white precast concrete median barriers in northeast Pennsylvania as early as 20 years ago, they had since been using white coatings on conventional gray concrete. Wanting to eliminate the periodic recoating required on these barriers, Zielinski says that they decided to use white concrete. To develop their specifications, they looked at what other states had been doing to get the necessary whiteness.

One of the original developers of the concrete median safety barrier, the New Jersey Department of Transportation, had used white concrete in its barriers for more than 20 years, so it was only natural that the Turnpike staff studied some of the New Jersey specifications for preliminary guidance. Ultimately, they adapted PennDOT specifications, changing from gray to white cement. But when they found a lack of fine white aggregate sources in the construction area, they decided to specify the reflectivity of concrete test sections based on measurement with a portable reflectometer (whiteness meter). Testing concretes both wet and dry, they were able to get reflectance readings double what they could achieve with gray concrete.

How to place the concrete for the bridge parapets is essentially the contractor's option, and many of the Mon/Fayette contractors have called in a specialty subcontractor to slipform them. The 1-in.-slump (25 mm) concrete is placed by a slipformer with a mold that extrudes the F-shaped parapet (Fig. 1). A finishing crew (Fig. 2) follows the slipformer, filling minor imperfections, spraying on curing compound, and cutting contraction joints. The biggest problem is that it's harder to verify coverage of the white membrane curing compound on the white concrete.

Texas median barriers

Although several Texas Department of Transportation districts have installed white concrete median barriers, Richard Skopik, district engineer in Waco, says that Texas does not currently compile information about them on a statewide basis. He has had plenty of experience

Fig. 2: Finishers follow the slipform paver, filling minor imperfections in a white bridge parapet on the Pennsylvania Turnpike *(Photo by Dave Leith, courtesy of Syrstone, Inc.)*

in his own district, though. He thinks the Waco District (central Texas) leads the state in white concrete usage, possibly because there is a leading producer of white cement in the district.

The Waco District constructed 5 mi (8 km) of white concrete median barriers on I-35 in an urban area in south Waco in 1989 and 1990, and then another 2 or 3 mi (3 or 5 km) in the mid-'90s. Some was cast in forms, some was slipformed. In 1999, the district placed white precast concrete median barrier on a 5-mi (8 km) section through the city of Waco. Here, they were replacing an eyesore—old chain-link fence barriers that had been installed in the center of a grassy median in the 1960s. A Waco contractor manufactured the precast median barrier in his own yard and set it in place on footings built adjacent to the inside pavement edge.

The earlier barriers were mostly of the Jersey-style cross section, but more recently, they have been using the single-slope barrier. In 2001, work started on a 6-mi (10 km) stretch of white single-slope median barrier, the first stage of 100 mi (160 km) of white barrier construction extending south on I-35 from Hillsboro all the way to the metropolitan Austin area. In this same area, they also plan to use an adaptation of the single-slope barrier for outside bridge rails made with white-cement concrete.

The primary impetus for use of white concrete in Texas is safety in terms of visibility of the barrier and its reflectance, but Skopik believes white concrete also pays a dividend in eliminating maintenance. Historically, they painted concrete barriers but had a lot of problems with peeling paint, which is particularly objectionable in urban areas. He estimates that paint or coating has to be

Fig. 3: Workers in Chicago place white concrete curbs for a raised, landscaped median on North Avenue between Larabee and LaSalle Streets *(Photo courtesy of Lehigh Portland Cement Co.)*

Fig. 4: White grout cap is slipformed on top of the wet gray concrete mountable curb on the Palisades Parkway in New York. An imprinting wheel, attached behind the curber's mold screed, gives the cap facets designed to enhance reflection of the car headlights *(Photo © Robert Bailey, courtesy of Power Curbers Inc.)*

problems with peeling paint, which is particularly objectionable in urban areas. He estimates that paint or coating has to be redone every 5 to 8 years. Using white concrete eliminates painting and provides a more uniform appearance. This freedom from maintenance is particularly valuable in high-traffic areas because it minimizes danger to workers and traffic delays occasioned by lane closures.

All of I-35 in central Texas is part of the "NAFTA corridor" and is experiencing heavy truck traffic from Laredo due to the North American Free Trade Agreement. "We're getting a lot of hits on these barriers," says Skopik. "A white barrier, if not structurally damaged, is easily cleaned, or in some cases self-cleaning. In case of nonstructural fire damage, water blasting or sandblasting restores the appearance of white concrete. A white coating could be repaired, but it will not match the adjacent weathered coating."

White barriers for PennDOT

The Pennsylvania Department of Transportation has used white concrete, principally in median barriers, on numerous jobs over the past 10 years. Bill Brookhart, district materials manager for the area in and around Harrisburg, reported three jobs under construction there in mid-2001. PennDOT uses white concrete selectively in areas with high traffic density where they believe the increased reflectivity will be beneficial for safety. Improved visibility justifies the extra cost of the white concrete, and aesthetics is not a consideration in the current applications.

The PennDOT specification for white concrete requires white cement and an approved white fine aggregate (sand). Brookhart says "white" may be subject to interpretation, and a very light fine aggregate may be accepted. PennDOT uses visual inspection of concrete cylinder specimens as a basis for approval of whiteness. Even with soiling from traffic, they haven't noticed the white concrete losing its reflectivity. Overall, the results are good; even when it is soiled, it's better than gray concrete, according to Brookhart.

Landscaped median in Chicago

The Chicago Department of Transportation, studying costs and benefits to be achieved with new technology, has focused on the possibility of enhancing visibility through increased reflectivity at night or in wet weather. According to John Sadler, project manager, they chose white concrete in the replacement of an existing raised median because this will give them a better basis for comparison. The project, completed in the summer of 2001, is a landscaped median in the Old Town section of Chicago just outside Lincoln Park.

The 1/2-mi-long (0.8 km) section of new median has essentially the same geometry as the one it replaced. All exposed cast-in-place concrete is white, including some median surfaces and the curb, which is 6 to 9 in. (150 to

Fig. 5: A section of the faceted new curb (above) and a piece of the weathered old curb below. Palisades Parkway staff members believe the original concrete was white, and they have found it much whiter when they broke open pieces of the old curb *(Photo © Robert Bailey, courtesy of Power Curbers Inc.)*

Fig. 6: Color contrast between white and gray concrete barriers increases when the concrete is wet (bottom), as this installation on I-35 in Texas shows *(Photo courtesy of Lehigh Portland Cement Co.)*

230 mm) high depending on drainage needs (Fig. 3). The irrigated planter areas are bordered by precast concrete panels, provide an environment for salt-tolerant plants.

Palisades Parkway restoration

White concrete figured prominently in what Manny Amorin, owner of A-Tech Concrete, calls "the biggest curb job in the history of New York State." The curb portion of the Edison, N.J., contractor's work on the Palisades Parkway restoration was so large that he purchased a customized slipform curber to reduce manpower requirements (Fig. 4).

Michael Cullen, senior landscape architect for the Palisades Interstate Park Commission, estimates that there were more than 40 mi (65 km) of the special mountable curb. Specifications called for a white grout cap to be placed on a base curb of conventional gray concrete. The curb is 13-3/8 in. (340 mm) wide and 15 in. (380 mm) tall, including the 1.5-in. (38 mm) cap. Roadway asphalt is laid up to and alongside the curb, leaving only the white cap exposed to view and easy for drivers to spot on the heavily traveled parkway. The new curb was designed to replicate the curb originally installed on the parkway in the '50s (Fig. 5), with facets designed to catch car headlights while also directing storm water runoff to nearby catch basins.

A-Tech, working with the curber manufacturer, came up with a machine that would handle two different mixtures simultaneously. Because the mixtures had to bond chemically, it was necessary to place the white cap while the gray concrete was still wet. A drum attachment behind the curber's mold screed imprinted the faceted pattern as the machine moved forward.

New Jersey median barriers

Although white concrete was the New Jersey Department of Transportation's standard for vertical curbs, median barriers, and traffic islands for 25 years or more, they have begun to phase it out of new construction. A major reason, according to Eileen Connolly, chief of the Bureau of Materials, is that NJDOT believes that current requirements for lane marking and reflectors on median barriers give satisfactory visibility without white concrete.

The phase-out may be reconsidered, depending on the results of a research project now underway. NJDOT installed test sections on Route 31 during the summer of 2001 with typical installations of both white and gray concrete barriers and curbs, with and without reflectors, and with and without roadway striping. This year, an evaluation team that includes both technical and nontechnical drivers will travel the route night and day, rating the effectiveness of different ways of achieving

Making white concrete

It's the cement that makes white concrete white. White cement meets the same ASTM C 150 specification as gray portland cement, but with the added limit of 0.5% by weight of iron oxide. Mixing water must be free of iron and other impurities that could cause staining. Fine aggregate should also have a limit on iron oxide, but its natural color influences the reflectivity of the concrete. Manufactured sands such as those crushed from white limestone are considered ideal, but some specifiers accept light natural sands, using the reflectance of the concrete as a standard for acceptance.

Admixtures work in white concrete just as they do in gray concrete, but the possibility of discoloration is a concern. Air-entraining agents do not cause discoloration at normal dosage rates, but it's advisable to get assurance from the manufacturers of other admixtures that they will not discolor the white concrete.

The producer of white concrete must use clean equipment to prevent contamination by materials that could cause discoloration. Cement bins and weigh hoppers should be free of loose gray portland cement, and truck mixers should have all loose gray concrete cleaned out of the drum.

All of these precautions tend to put a premium on the cost of white concrete. One cement manufacturer finds the gray barrier's cost ranging from $15 to $22/lineal ft ($49 to $72/m) across the United States. Using white concrete barriers can increase that by as much as $4 to $8/ft ($13 to $26/m). Some of this undoubtedly relates to job size. In central Texas, Richard Skopik says, "We're not noticing the cost differential that you would normally expect between white and conventional gray concrete." He thinks that this may be due to the relatively large volumes of white concrete that they are using and the availability of white cement from a local source.

Selected for reader interest by the editors.

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