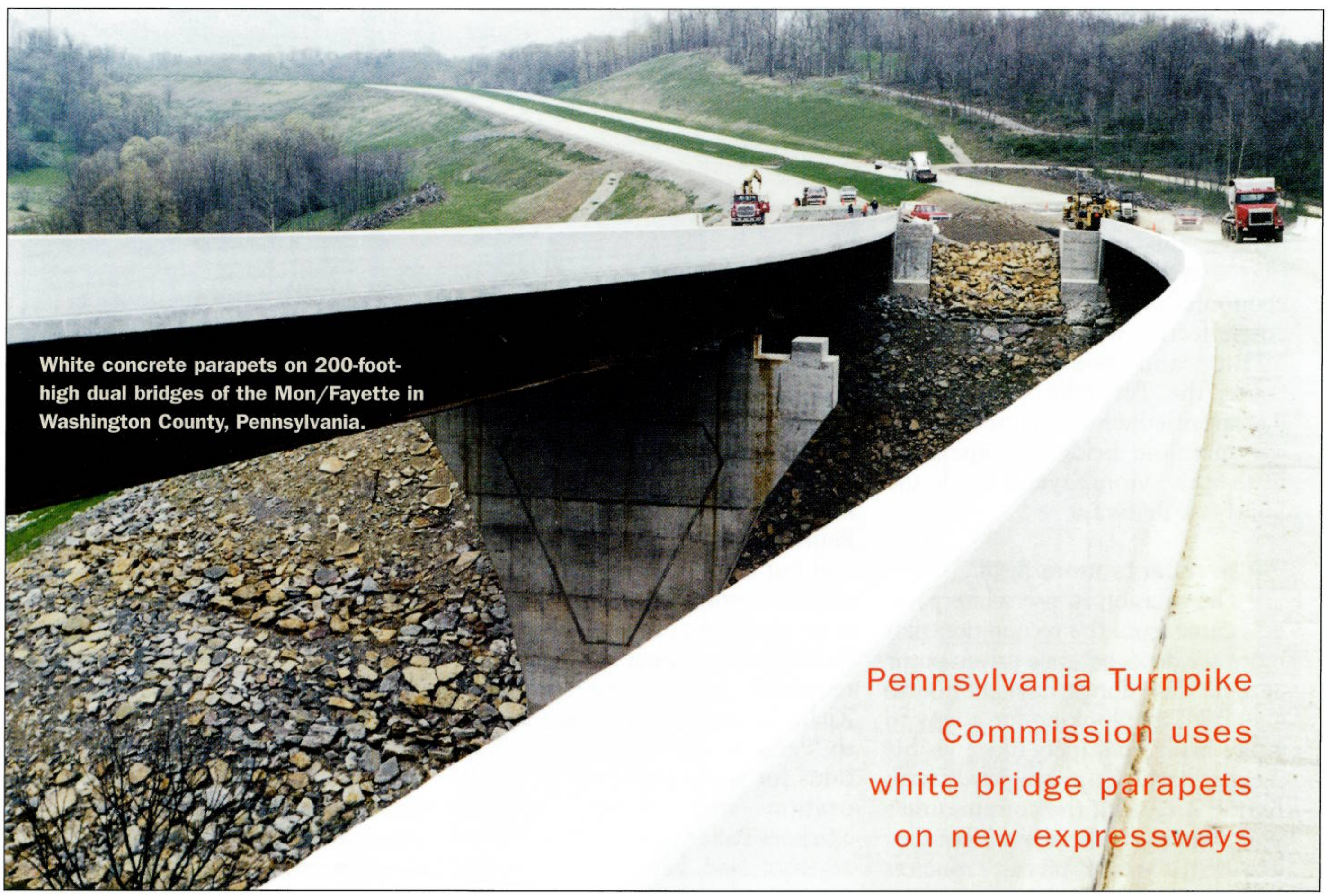
White Concrete

Brightens 'Highways of Hope'



White concrete parapets on 200-foot-high dual bridges of the Mon/Fayette in Washington County, Pennsylvania.

PENNSYLVANIA TURNPIKE COMMISSION

By M.K. Hurd

Two expressways with a total price tag of $3 billion and a construction schedule that could span 15 years have been referred to as “highways of hope” for the region around Pittsburgh in western Pennsylvania. The Mon/Fayette Expressway will extend about 70 miles 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 30-mile arc around Pittsburgh between the Mon/Fayette and Beaver Valley expressways, with a radius of about 15 miles measured from Pittsburgh’s Golden Triangle. The two routes will improve access to Pittsburgh International Airport and to river towns where steel and coal industries once flourished.

The Pennsylvania Turnpike Commission and the Pennsylvania Department of Transportation have completed the first 18 miles of the Mon/Fayette, one of the first toll roads to receive federal funding. By the end of 2002, another 17 miles will be done. Many civic and industrial leaders believe the new highways will play a crucial role in the region’s economic redevelopment. 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.

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SYRSTONE INC., DAVE LEITH

Top: A slipform paver places the white concrete parapet around previously placed epoxy-coated reinforcing steel. Above: Finishers follow the slipformer, filling minor imperfections and applying a light broom finish. They also mark locations for joints to be sawed later.

White reflects more light

The decision to use white parapets came from the recognition that more accidents per mile driven occur at night than during daylight hours.

“We were looking for a way to make bridge parapets more visible during dark, rainy nights,” says Bernie Zielinski, the commission’s bridge engineer. He recalled that they had tested white precast concrete median barriers in northeastern Pennsylvania as long as 20 years ago but since then had been using white coatings on conventional gray concrete. Looking for a way to eliminate the periodic recoating required on these barriers, Zielinski reports that they started to develop appropriate specifications for white concrete. In collaboration with design manager Michael Baker Jr. Inc., they looked at what had been done in other states to give the desired whiteness.

The New Jersey Department of Transportation, which pioneered development of the concrete median barrier, has experience using white concrete for barriers dating from the early 1960s. Thus the Pennsylvania Turnpike Commission modeled initial specifications following New Jersey practices, subsequently making changes in favor of using local aggregates.

The commission modified the PennDOT specification for Class AA concrete to require white cement and water free from iron and other stain-producing impurities. At first the commission called for fine, white aggregate—either crushed marble or crushed calcite—but found that these materials were not readily available in the construction area. Because white concrete was such a small component of the overall project, it was impractical to keep a stockpile of special aggregates.

Instead of specifying the whiteness of the aggregates, as was done in New Jersey, the commission decided to specify relative reflectivity of the concrete, based on measurements made on test sections using a portable spectrophotometer, or whiteness meter. A light meter reflectance of L = 85% was required on dry concrete and 75% on wet concrete, to be tested on a 10-foot-long section of parapet at least 30 days before actual placement of concrete in the structures. According to Terry Dreher, the commission's quality-assurance supervisor, this is double the reflectance readings they would get on gray concrete. Dreher says they tested mixes made with Pennsylvania sands and found one that would give acceptable results.

The specification also required assurance that form-release agents and admixtures would not discolor the concrete, and that equipment for batching and mixing be cleaned to prevent any possible discoloration. Typical mixes had 658 pounds of white cement, with a water-cement ratio of 0.37 to 0.43 and a 28-day compressive strength of 5000 psi.

Slipforming the parapets

The first white parapets on the Mon/Fayette were constructed in September 1998, and the parapet work continues as the route is extended. A few parapets were cast in place in fixed forms, but on the longer bridges, they are being slipformed. How to place concrete in the parapets is essentially the contractor's option. Most of the contractors on the project have called in specialty subcontractor Syrstone Inc. of Syracuse, N.Y., to slipform parapets on their sections of the work.

According to Dave Leith, field superintendent for Syrstone, the PennDOT Class AA concrete modified with the white portland cement has caused no problems in the slipforming operations. He notes, however, that it's important to use a set-retarding admixture to slow the setting process and ice or chilled water to control the concrete temperature. The 1-inch-slump concrete is placed by a Gomaco Commander III slipformer equipped with a mold that produces the F-shape parapet, a modification of the original New Jersey barrier section (see figure).

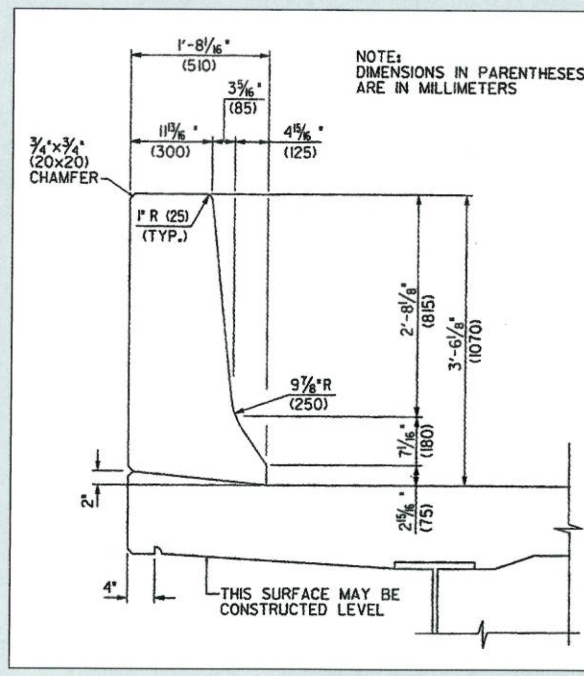
Leith has four finishers following the slipformer to clean up small amounts of concrete that escape the paver where the barrier interfaces with the deck. The crew then fills any minor imperfections, applies a light broom finish, and marks locations for subsequent joint sawing. Turnpike Commission studies show that troweled or broomed finishes are equally effective for light reflectance.

Immediately after finishing, the crew applies a white spray-on membrane-forming curing compound. The only problem, Leith says, is that it's harder to verify coverage of the white membrane on white concrete. After joint sawing, workers cover the parapet with white plastic sheeting to help reduce the drying effects of the sun. This is a departure from the usual PennDOT and Turnpike Commission curing practices, which typically require water curing with wet burlap covered with plastic. However, they were concerned that this method could stain the white concrete.

Contraction joints in the parapet are sawcut at random spacings ranging from 10 to 20 feet, as shown on the designer's drawings. Joints about 3/4 inch deep and 1/8 to 3/16 inch wide are sawed 4 to

Parapet design

Typical cross section of the mainline bridge parapet for the Mon/Fayette.



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12 hours after concrete placement, depending on the weather. In midsummer, Leith says, it's likely to be after 4 to 5 hours.

Better visibility at a lower cost

The cost for gray concrete barriers in the United States ranges from $15 to $22 per lineal foot, depending on the barrier's cross section and height and the construction method (precast, cast in place, or slipformed). Some reports indicate that white concrete barriers cost $4 to $8 more per lineal foot than gray barriers. However, Interstate Safety Systems, Clarks Summit, Pa., reports that costs to paint a gray barrier white range from $4 to $7 per lineal foot, depending on the coating or paint used. This does not factor in additional costs due to traffic delays and motorist inconvenience. Effective life of the paint before repainting is required varies widely, from as little as 1 year to as long as 10 years. ■

M.K. Hurd, a civil engineer and writer specializing in concrete construction, is former editor of CONCRETE CONSTRUCTION. She is also the author of *Formwork for Concrete*, the American Concrete Institute's SP-4 manual, now in its sixth edition.

Acknowledgment
Thanks to the following Pennsylvania Turnpike Commission staff who contributed information for this article: Joe Agnello, public information officer; Terry Dreher, quality-assurance supervisor; and Bernie Zielinski, bridge engineer. Others who provided information include Dave Leith of Syrstone, Jerry Jones of Michael Baker Jr. Inc., and Ray Pisaneschi of Lehigh Portland Cement Co.

More about white concrete

What makes it white

■ White cement is manufactured to meet the same ASTM C 150 specification used for gray portland cement but with the added limitation that it cannot contain more than 0.50% by weight of iron oxide.

■ Mixing water for white concrete must be free of iron and other impurities that could cause staining.

■ Fine aggregate has an important influence on concrete color because the fine particles of the sand act as a coloring pigment. Thus manufactured sands such as crushed white limestone or quartzite are frequently specified for white concrete. A limit on iron oxide in the fine aggregate also is necessary.

■ Coarse aggregate has less influence on concrete color, but a light color is preferred to help prevent color variation due to aggregate transparency—a surface mottling that can be caused by show-through of coarse aggregate.

■ Air-entraining agents are not a concern in white concrete because they don't cause discoloration. Other admixtures perform in white concrete just as they do in gray concrete but may cause discoloration, particularly those containing lignosulfonate. It's advisable to get assurance from the admixture manufacturer that its product will not discolor white concrete.

Properties

Construction Technology Laboratories, Skokie, Ill., studied properties of concretes containing the same amounts of cement—either white or gray—and either white silica sand or natural sand. They drew the following conclusions:

■ White cement concretes are significantly more reflective than gray cement concretes.

■ White concretes are lower in chloride permeability.

■ Both white and gray concretes showed no scaling through 100 deicer test cycles.

■ Concrete made with white silica sand showed better abrasion resistance than concrete made with natural sand.

■ Compressive strengths of white and gray concretes are essentially equal.

LEHIGH PORTLAND CEMENT CO.

The New Jersey DOT has been building median barriers made with both white and conventional gray cement concrete for many years. Here, white and gray median barriers are side by side on I-87 in New Jersey. Reflectivity tests on selected gray and white concrete median barriers in New Jersey show that white concrete reflects more than twice as much light as gray concrete.