Very Early Strength Latex-Modified Concrete Bridge Overlays

Virginia's Quick Cure for Roadway Maintenance Delays

MICHAEL M. SPRINKEL

The author is Associate Director, Virginia Transportation Research Council, Charlottesville.

Overlays of hydraulic cement concrete usually are placed on bridge decks to extend the service life by reducing the infiltration of water and chloride ions. The overlays also improve the deck's skid resistance, ride quality, and surface appearance. Many conventional latex-modified concrete (LMC) overlays have performed well in Virginia for more than 30 years and clearly presented a cost-effective way to extend the life of bridge decks.

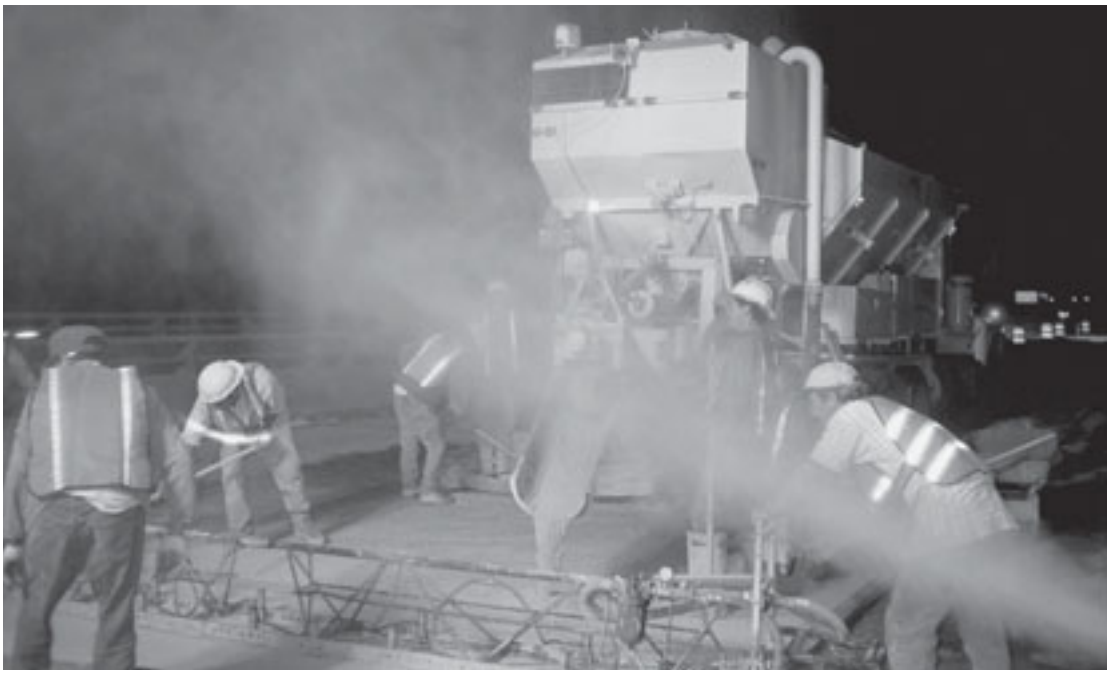
Problem

The construction of overlays has become increasingly difficult because of increases in traffic. Lanes cannot be closed for extended periods because of the resulting traffic congestion, particularly on the Interstate Highway System. To minimize traffic delays, contractors often must work at night, when the ambient air temperatures are generally lower, which increases the curing time of the concrete. The Virginia Department of Transportation (DOT) therefore was interested in a concrete that would require a short time to cure yet would last longer.

Solution

Virginia DOT has used very-early-strength latex-modified concrete (LMC-VE) for patching overlays since 1992. Many decks on Interstate 81 in Virginia were patched at night with LMC-VE. As the number and the size of the patches have increased, however, and as the patches have continued to perform well, it has become obvious that LMC-VE could be used to overlay an entire bridge deck.

In a government–industry cooperative effort, Virginia DOT decided to evaluate the LMC-VE overlay on two entire bridge decks: the first was on the Lord Delaware Bridge on Route 33 in King and Queen County in 1997; and the second was on the westbound lane of Route 620 over I-495 in Fairfax County in 1998 (*1*).



Placing an LMC-VE overlay with conventional equipment. The concrete is batched and mixed in a mobile concrete mixer and struck off with a vibrating screed. A fog spray is applied, as shown, to increase the relative humidity and help prevent plastic shrinkage cracking.

A typical LMC-VE overlay construction sequence starts by closing a lane at 9 p.m. By midnight of the first night, the concrete surface is removed by milling, and the patch area is removed with pneumatic hammers. The patching is completed by 2 a.m., and the lane opens to traffic at 5 a.m.

Between 9 p.m. and midnight of the second night, the surface is prepared by shot blasting, and the deck is prewetted. During the placement of the overlay, a fog spray increases the relative humidity to prevent shrinkage cracking, and the work is completed by 2 a.m. (see photograph, facing page). The lane opens to traffic at 5 a.m. The sequence is repeated until all lanes are overlaid.

The overlays achieve the required compressive strength in as little as 3 hours at ambient temperatures in the range of 17 to 24 degrees centigrade (62 to 76 degrees Fahrenheit). In contrast, conventional LMC overlays require 2 to 3 days or more.

LMC-VE overlays have the same mixture proportions as conventional LMC overlays—7 bags of cement per cubic yard, 3.5 gallons of styrene butadiene latex per bag of cement, and a maximum water-to-cement ratio of 0.40. For LMC-VE, the specified minimum compressive strength of 2,500 psi (ASTM C39) is achieved in 3 hours, permitting Virginia DOT to open the lane more quickly to traffic. Virginia DOT researchers determined that the very-early strength was due to the special cement, which contains approximately 1/3 calcium sulfoaluminate and 2/3 dicalcium silicate (*1*).

Chloride permeability tests (AASHTO T277) show that LMC-VE has significantly lower permeability to chloride ions than LMC and therefore could be more durable. At 28 days, the permeability of conventional LMC overlays is low and that of LMC-VE overlays is low to very low. After 1 year, the permeability of LMC overlays is low and that of LMC-VE is very low (*1, 2*).

LMC-VE overlays are less prone to cracking because they have less shrinkage than LMC and therefore can be more durable. The length change (ASTM C157) of LMC-VE specimens at 170 days is approximately 0.02 percent, compared with 0.06 percent for LMC specimens (*2*).

Like other concrete overlays, LMC-VE overlays achieve high bond strengths with the appropriate selection and use of surface preparation equipment and procedures, mixture proportions, and placement and curing procedures (*3*).

The bond strength and chloride permeability of the first LMC-VE overlay were evaluated after 9 years of service. The bond strength was adequately high. The chloride permeability was still negligible, indicating long-term protection.

Application

In 2006, an LMC-VE overlay was placed on a 5,000-square-yard deck on I-64 over the Rivanna River. Another overlay was placed on the Theodore Roosevelt Bridge, which carries I-66 into the District of Columbia. Work on these projects took place during off-peak traffic periods, often at night, to minimize delays to the traveling public.

Virginia DOT expects to increase the use of the LMC-VE overlay, and the record of success continues to grow. Because of this research, Virginia DOT now has a special provision for LMC-VE in overlay programs.

Benefits

LMC-VE can protect and repair decks with a minimum of inconvenience to the traveling public. The patches and overlays can limit lane closures to 8 hours and can be applied at night. A 3-hour curing period is adequate, depending on the temperature.

Virginia DOT research has shown that LMC-VE overlays are more durable than other concrete overlays. They are less prone to cracking because they have less shrinkage, and they are more resistant to chloride ion penetration than other overlays.

In addition, LMC-VE overlays cost about 75 percent of what conventional LMC overlays cost (*1*). The special cement required for the LMC-VE overlay, however, costs 4 times as much as the Type I and II cements for conventional LMC overlays. Although this adds approximately $90 per cubic yard of concrete, the higher cost is more than offset by the reduced cost of traffic control.

For more information contact Michael M. Sprinkel, Associate Director, Virginia Transportation Research Council, 530 Edgemont Road, Charlottesville, VA 22903, phone 434-293-1941, fax 434-293-1990, e-mail: Michael.Sprinkel@VDOT.Virginia.gov.

References

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Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-2952, e-mail gjayaprakash@nas.edu).