The Need for Speed

Special cements allow for quicker, long-lasting concrete bridge and deck repairs

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Selecting the cement to be used in a concrete can have a lasting impact on the life span of new concrete bridge decks. One option that is underspecified but has a host of proven results is special cement. There are many situations in which these cements can help extend the useful life cycle of concrete bridge decks.

Indeed, most of the almost 350,000 concrete bridges in the country have concrete decks that develop avoidable premature cracking due to initial shrinkage soon after the pour. While the useful life of structural concrete can exceed 50 years, premature cracking on these outdoor installations frequently warrant early repair.

Preventing and reducing cracking

The maintenance costs associated with concrete deck surfaces is a large portion of the nearly $8 billion spent annually repairing, rehabilitating, strengthening, and waterproofing bridges and bridge decks. If the specifiers would use mix designs that help make the hardened concrete more durable in the first place (e.g. shrinkage-compensated concrete for new construction) much of the need for deck repair could be reduced.

Research conducted recently at the University of Kansas supports the conclusion that cracks in concrete are the major source of entry of chlorides. Test results show that where cracks occur, the average chloride concentration at a depth of 3 inches can exceed the corrosion threshold (1 lb/cy) of uncoated reinforcing steel within one year.

After two years, the threshold will be exceeded in most decks. Yet away from cracks, at a depth of 3 inches, the chloride concentration is less than the corrosion threshold even after a dozen years. The research also showed that chloride concentration increases as the bridge deck ages.

There is a solution to this problem—a shrinkage-compensating cement that can offset the tensile stresses caused by shrinkage. Properly performed repairs can extend the useful service life of concrete. The most effective way to help ensure durable concrete bridge decks is to eliminate cracking of the concrete from drying shrinkage. This results in tensile stresses when the concrete still has little or no tensile strength.

One method for this effective repair is to incorporate a specialty cement which has been available since 1963. The product has an initial cost somewhat higher than portland cements predominately used for concrete bridges and bridge decks. But the lower life cycle cost due to reduced maintenance and repair over the long-run would more than compensate for any increased construction costs.

The specialty cement combines an expansive chemical component with traditional portland cement. When it cures, the concrete expands slightly initially but then, as the concrete is bonded to the reinforcing steel, it stresses the steel to a degree. This tension (as per Newton's 3rd law that every action has an equal and opposite reaction) places the concrete
in compression.

Type K cement

In compression, the hardened concrete can resist the tensile stresses from shrinkage. When the concrete later shrinks, the compression is relieved. However, at the same time, the concrete has developed enough tensile strength to resist the tensile stresses put upon it from shrinkage. This product is referred to as a shrinkage-compensating cement, which is recognized in ASTM C 845 as Type K cement. Concrete containing Type K cement is called shrinkage-compensated concrete.

Though shrinkage-compensated concrete requires slightly more water than portland cement concrete (PCC) to hydrate the expansive material, it does not bleed. This eliminates water channels to the surface. The combination of no cracks and no bleed water channels results in low chloride permeability and, therefore, longer life.

Over the past 40 years, shrinkage-compen-

sated concrete has been used in millions of cubic yards of concrete with excellent results in a very broad range of installations. Although it cannot guarantee total freedom from cracking, any cracking will be less frequent and less severe.

Since 1985, the Ohio Turnpike Commission has used Type K concrete decks for all of its new bridges and replacements. Since then, several other states have used Type K cement for bridge decks, including Michigan, Indiana, and Pennsylvania. And in 1995, it was used in a new bridge that was built in Barstow, Calif.

Reducing delays

Repairing a damaged concrete deck with a concrete that includes a special rapid-setting cement is an effective tool for concrete contractors. In many cases, its use can allow traffic back on the deck within hours after the pour.

For example, when the deck of a viaduct in New York City had structural damage, the emergency repair contractor was notified at 11 a.m. The contractor removed the damaged concrete and debris, set a form, replaced rebar, poured rapid-setting concrete at 5:20 p.m., and opened the lanes to traffic at 7:10 p.m.

One such product, Rapid Set Cement, overcomes the set time limitations of latex-modified concrete (LMC) overlays. LMC overlays are relatively impermeable to chlorides but require several days to gain sufficient strength to be able to sustain traffic. Type III cement with the latex (LMC-HE, for high early) reduces the delay but still requires one to two days before the road is ready for use.

Rapid Set Cement (or LMC-VE, for very early latex-modified concrete), is a very rapid-setting and rapid-strength-gain cement that was developed specifically to capitalize on a chemistry that allows it to set extremely quickly.

When the Rapid Set combines with water (hydrates), it forms crystalline compounds much faster than compounds in portland cement form when combined with water. In addition to
shrinking less than portland cement, it gains strength much faster, allowing traffic back on the road quicker.

Rapid Set Cement has been used widely for bridge deck overlays. For example, it enabled a contractor to speed through refurbishing much of the surface of the Lewis and Clark Bridge, which dates back to 1929 and connects Rainier, Ore., and Longview, Wash.

Reducing delays

Though some sections of the deck had to be completely replaced and required partial closures for 18 months, the Washington State Department of Transportation (WSDOT) was keen on keeping closures to a minimum. By using 450 cubic yards of Rapid Set Cement concrete for a 1575-foot overlay during one weekend, WSDOT was able to save at least nine days of closures, compared to using traditional slower setting concrete.

A few years ago, the product was also used for resurfacing the main interstate bridge connecting Interstates 70, 64, and 55 across the Mississippi River in downtown St. Louis. The Missouri DOT was concerned that the surface repairs not disrupt major league baseball at the new Cardinals' baseball park nearby.

The fast set time of the cement enabled start and completion of the entire resurfacing job between Friday evening and noon Sunday, when there were no home games.

When a bridge which used LMC-VE for overlays in 1996 (under the auspices of the Virginia Transportation Research Council and the Virginia DOT) was decommissioned last year and replaced with a bridge offering higher traffic capacity, bond pullout tests conducted on core samples that included both the original deck concrete and the overlay failed in the existing deck concrete.

The LMC-VE bonded to the base concrete was superior to the concrete that was overlaid. Chloride permeability tests on the overlay passed less than 100 coulombs. Earlier in 2006, an inspection of overlays on the two bridges had shown both were in excellent condition.

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