Virginia takes its continuously reinforced concrete pavement (CRCP) seriously, so much so that the Virginia Department of Transportation (VDOT) undertook a rigorous analysis of the performance of its CRCP to identify best practices for extending the pavement service life with minimal maintenance.

**Long History of Concrete**

Virginia has the third largest state-maintained highway system in the country, just behind North Carolina and Texas (another CRCP state). VDOT built its first concrete pavement in 1913 and its first CRCP in 1966 on Interstate 64 through Richmond, Virginia’s state capital. VDOT currently has approximately 561 lane-miles of CRCP in service, about three-quarters of it on interstate highways and the remainder on state roads.

CRCP is, simply, concrete pavement that is reinforced with longitudinal steel bars. No transverse control joints are needed. The reinforcing bars control the width of the transverse cracks that form and hold them closed. The transverse cracks do not impair the structural integrity of the pavement.

Because of its greater durability, longer life expectancy, and minimal maintenance requirements, CRCP can provide the best long-term value of any pavement type.

**CRCP circa 1970 (photo below):**

At 52 miles, I-64 west of Charlottesville was the longest stretch of road opened to the state at one time. The entire segment was built with CRCP.

"The key to attaining a long-lasting, safe, and economical CRCP is in learning from its performance. When we apply the lessons learned from our in-place pavement, we can build a better product in the future."

— Andy Mergenmeier, P.E., VDOT Materials Engineer
Larger Aggregate Improves Durability

Engineer. "Based on the life-cycle cost analysis, the cost of CRCP would be within 10 percent of that of other pavements. We chose CRCP to be compatible with the existing pavement."

Several important findings from VDOT's pavement analysis have been incorporated into the CRCP design for SR 288. For example, AASHTO #357 aggregate is being used in the concrete mix instead of #57. #357 is a larger aggregate with a higher percentage in the one- to two-inch range. "Having more rock means that the amount of cement paste is reduced, which will lead to reduced shrinkage and cracking," says Clark. "It's a more durable mix."

Slab Thickness and Steel Content

VDOT recommends using a slab of adequate thickness to reduce the shear stress at the level of the reinforcing steel caused by bending moments in the slab. Depending on the site conditions, slab thickness may need to be increased by up to 2 inches.

VDOT recommends increasing the total amount of longitudinal reinforcing steel from 0.65 percent to 0.70 percent to improve the crack spacing, with the goal of having transverse cracks spaced 4 to 6 feet apart. VDOT also recommends using transverse reinforcing bars spaced every 4 feet to support the longitudinal steel and to keep any longitudinal cracks tight (should they occur).
Poor Subgrade Calls for Thicker CRCP

Traffic on US Route 29, the “Lynchburg Expressway,” is anything but express. When built, US 29 was the preferred route around the “City of Seven Hills,” but is now heavily congested with numerous stoplights and strip malls. VDOT’s new US 29 Lynchburg/Madison Heights Bypass project, 20 miles in total length including connection projects, ramp, and loops, will provide an alternate route.

VDOT performed a life-cycle cost analysis of several pavement options. Although costs were close, VDOT chose CRCP for the mainline pavement. “We believe that CRCP will provide the best structure, given the high traffic counts we expect this pavement to experience,” says Don French, P.E., District Materials Engineer for VDOT’s Lynchburg District.

The project is underlain with “horrible” residual micaceous silt, according to French. To compensate, VDOT is treating the top 8 inches of subgrade with cement (12 percent by volume), installing a 3-inch asphalt drainage layer under the pavement, and constructing a 12-inch-thick CRCP section (the thickest so far in Virginia).

Again, recommendations made from VDOT’s extensive CRCP analyses were incorporated into the design. For instance, the outermost lane will be 14 feet wide to accommodate wheel loads at the pavement/shoulder interface.

Wider Outside Lanes

For the outside lanes, VDOT recommends using a 14-foot-wide lane while still delineating (with white-line striping) a 12-foot-wide lane. The extra two feet width becomes part of the shoulder and provides edge support equal to a full-width tied shoulder without the joint.

The pavement on the truck lane itself experiences interior loading as opposed to edge loading. This extra edge support reduces the potential for edge failures and punchouts.

Concrete Properties

VDOT is altering the concrete mix design for CRCP with the objective of minimizing crack width and increasing crack spacing. VDOT has determined that with larger-sized aggregate, concrete shrinkage and cracking is reduced. Larger aggregate is also expected to provide better aggregate interlock, which will reduce the amount of cracking and improve load transfer across the crack.

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Great Pavement

**Interstate 64** begins in Norfolk, runs in a tunnel under the Chesapeake Bay into Hampton and Newport News, and then travels all the way west to St. Louis, Missouri. I-64 in the Tidewater area of Virginia was built in the late 1950s to mid-1960s as a 4-lane freeway.

Several portions were constructed with CRCP, including one 8-inch-thick, 7-mile-long segment in Hampton that is still in service, not having been overlaid. "The CRCP has provided excellent performance and has needed virtually no maintenance," notes George Boykin, VDOT District Materials Engineer for the Hampton Roads District.

Today, traffic volumes have far outpaced capacity, and segments of I-64 through the Tidewater area are being widened. Currently under construction is a 3-mile-long segment of 6-lane pavement that is being demolished and replaced with 8 lanes of CRCP.

"The location of the reinforcing bars within the section has a big impact on the success of the pavement," says Boykin. To this end, the reinforcing bars are being installed manually on chair supports, rather than mechanically through tube feeders that have given VDOT trouble in the past.

Boykin also believes that construction quality and rigor in construction inspection is critical with CRCP. "If the contractor pays care and attention during construction, CRCP is a great pavement. I don't see any reason not to use it."

**Construction Quality...continued from inside**

"CRCP is a complex structural system," says Andy Mergenmeier, P.E., State Materials Engineer with VDOT. "We've found that the long-term performance of the pavement depends on the quality of construction."

VDOT's main conclusion is that mechanical placement (tube-fed) of reinforcement—in which reinforcing bars are fed through tubes directly into the wet concrete—can result in less dependable reinforcing bar placement. VDOT has found that the reinforcing bars placed this way were sometimes too high or too low within the concrete slab, leading to premature failures.

VDOT is now recommending that the longitudinal reinforcing steel be placed on continuous runner chairs, with clips attached at planned widths, rather than with the tube-fed system. The chairs allow the slab to be poured monolithically, which reduces the probability for cold joints at the reinforcing steel that have resulted from pouring two layers of concrete with the feed-tube system.