New Nondestructive Test Promises Better Data on Pavement Thickness and Distress

What Was the Need?
Slab thickness is a critical design characteristic of concrete pavements. Thicker concrete slabs support heavier traffic loads than thinner slabs and better resist damage—including fatigue cracking, which has the greatest impact on concrete pavement service life.

MnDOT builds thickness requirements into construction contracts. For quality control, MnDOT directs contractors to pull concrete cores from a finished pavement every 1,000 feet and has its engineers analyze these cores for thickness. If the thickness of a core is less than specified, MnDOT requires additional cores to be pulled from nearby spots. Payment on the contract is adjusted if thin cores are found. To avoid such penalties, contractors routinely construct the pavement slightly thicker than the design requires. The cost of the extra material is typically borne by MnDOT.

MnDOT also aims for uniform thickness across the slab to better meet traffic needs, resist damage and discourage waste from construction. Increasingly sophisticated design procedures have enabled slabs to be made thinner, which in turn has made it more critical for slab thicknesses to be uniform.

To ensure pavement quality, MnDOT is seeking thickness measurement techniques that are less destructive than coring and provide greater coverage across slabs. It also wants to be able to correlate thickness variation with pavement distress in order to evaluate the usefulness of penalizing contractors for insufficient thickness.

What Was Our Goal?
MnDOT aimed to achieve those goals by using nondestructive ultrasonic testing, which can provide data for many more locations on a slab than is possible through coring. Ultrasonic testing can be done once the concrete has cured enough to be walked upon. Data from such testing would be useful in contracting and would have implications for process-oriented quality assurance, product-oriented quality control and performance-based design.

What Did We Do?
MnDOT helped researchers identify several concrete pavement projects that would be closed to traffic before rehabilitation. Researchers reviewed construction records, gathered data on surface distress at those sites, mapped the distress and conducted ultrasonic testing.

The ultrasonic testing produced shear wave propagation readings. The nondestructive technique furnished thousands of readings in longitudinal and transverse directions on a project that would otherwise have yielded 10 to 15 cores in a day. Researchers used the readings to determine shear wave velocity and slab thickness. Then they compared the shear wave data with the surface distress maps.

Researchers demonstrated the significant advantages of a new nondestructive ultrasonic test method for measuring pavement thickness as compared to the traditional coring method. The new method shows promise for correlating thickness measurements and material properties with pavement distress.
The research team next conducted statistical analyses of the thickness and distress relationships to identify correlations between thickness variation and slab distress.

What Did We Learn?
The study showed that nondestructive ultrasonic testing can gather vastly more data than traditional coring, including data on thickness across and along the length of the concrete slab. Researchers were not able to directly correlate distress with thickness variation, but they did find a correlation between shear wave velocity and material properties of the concrete mixtures used: Shear waves moved rapidly through areas of stronger concrete, but more slowly through areas of lower strength and microdamage. However, the available data did not permit researchers to identify the specific material properties of importance in the concrete mixes.

The research team concluded that thicker pavements do not necessarily outperform thinner pavements simply because they are thicker. Instead, undefined material properties related to material strength seem to have more impact on a pavement’s resistance to fatigue cracking and other damage. Controlling for the materials used in design and construction appears to be more critical to long-term load-bearing performance than does controlling for uniform thickness.

What’s Next?
These findings have implications for newer design methods that optimize pavement construction by making slabs thinner. While less critical in conservatively designed (that is, thicker) pavements, thickness variation may become more significant as pavement slabs become thinner. As discovered in this study, controlling designs for the material properties of concrete mixes may also become more important as thicknesses decline. These implications will require further investigation.

To define the unidentified material properties that could impact pavement performance more than thickness variation, MnDOT recently pulled cores from one of the highway projects examined in this study. One property to be examined is the concrete’s coefficient of expansion, a trait controlled predominantly by large aggregate in a mix.

Meanwhile, ultrasonic testing can serve as a valuable tool in controlling the quality of concrete paving. Examinations of thickness variation in cured concrete can be used to inform contractors of the effectiveness of their building methods so the contractors can adjust those methods in current and future projects if necessary.