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Improved Analysis Tool for Concrete Pavement

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Current Situation

Concrete slabs used on roadways are often evaluated or designed through closed-form analytical solutions based on the work of Westergaard. Many finite-element-based programs are also available that model the concrete as two-dimensional rectangular plates supported by a bed of springs. These approaches may not accurately account for design and construction details and are limited in their ability to predict pavement structural responses. Recent advances in three dimensional finite element (3D-FE) models address many of these limitations. 3D-FE models can simulate more realistic pavement behaviors, such as non-uniform load distributions, multi-wheel loads, pavement cracks, and nonlinear dynamic analysis.


Dowel bars, studied in this project, are set in one slab of pavement waiting for the next one to be poured.

Research Objectives

University of Florida researchers developed 3D-FE models to more accurately predict the behavior of concrete slabs. They also followed up on a project to characterize strain gauge performance for a Florida Department of Transportation (FDOT) concrete pavement test road.

Project Activities

The researchers developed a 3D-FE modeling method and applied it to three types of concrete pavement: PPCP – precast prestressed concrete pavement; JPCP – jointed plain concrete pavement; and CRCP – continuously reinforced concrete pavement. Modeling solutions were developed as extensions of the widely used ADINA software. The researchers also created a specialized interface to assist designers in using the software.

For each pavement, a 3D-FE model was developed for typical Florida conditions, especially the state's unique environmental conditions that result in curling, expansion, and contraction in concrete. The PPCP model, tested against measurements taken from an actual PPCP road, was used to determine how variations in pavement parameters affected the pavement's strength behavior under vehicle loading. The JPCP model was based on concrete that uses RAP for part of its aggregate. RAP changes concrete's response to stress. Strength relationships predicted by 3D-FE modeling were more realistic, compared to those derived from the 2D modeling. Further testing of the 3D JPCP model included dowel bars to transfer load between the slabs. Again, the 3D-FE modeling compared better with field results than did 2D modeling. CRCP modeling focused on concrete's strength behavior relative to the network of steel that reinforces it. In this case, 3D modeling helped to explain how concrete characteristics influenced horizontal cracking. Altogether, the modeling provided many insights into the design of concrete pavements.

The researchers also advanced the planning for a new FDOT test road. The researchers examined the performance of a variety of sensors by incorporating them into concrete cylinders which were subjected to compression testing. Sensors were also incorporated into full-size concrete slabs that were field tested using the Heavy Vehicle Simulator at the FDOT State Materials Office. Recommendations were made for sensors and methods of analysis.

Project Benefits

Both components of this project will advance FDOT road design capabilities, resulting in more efficient, more economical, and safer roads.

For more information, please see www.fdot.gov/research/.