Florida Department of Transportation Research

Advanced Analysis, Validation, and Optimization of Virtual Cement and Concrete Testing

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Current Situation

Though cement and concrete (C/C) seem simple, they are remarkably complex. Small changes in proportions, materials, or processing steps can lead to big changes in C/C performance. Extensive study has yielded equations and tables that can predict the behavior of new cement mixes, as long as they fall within certain limits. This approach is called the empirical method, and it is very useful for estimating the macro behavior of C/C.

In many areas, empirical methods are being replaced by computational methods based on the properties of the materials from which C/C are made. This approach can produce more accurate predictions and cover a wider range of mixes and conditions, and computational methods do not require the extensive testing of specific mixtures that empirical methods do. Computational methods have been applied to C/C in the Virtual Cement and Concrete Testing Laboratory (VCCTL) software which can connect the chemical and thermal behaviors of C/C at the microscale with macroscale behavior, providing insights into the behavior of C/C and new mixes.

Cement and concrete are critical to the structures we use every day. New concrete mixes can extend the life of these structures or create new construction possibilities.

Research Objectives

University of Florida researchers investigated the capabilities and limitations of the VCCTL with respect to practical implementation. They also studied the implementation of new computational techniques to improve or expand the capabilities of the VCCTL.

Project Activities

The specific project objectives were diverse, falling into three broad areas: use of the VCCTL in laboratory certification; validation of VCCTL for application to concrete mixes; and adaptations and improvements in the general operation of the VCCTL. In the first area, researchers validated the VCCTL for use in Cement and Concrete Reference Laboratory (CCRL) proficiency testing. CCRL is a project of the American Society for Testing Materials (ASTM), which assists laboratories to achieve a high level of performance in applying the ASTM's standard test methods.

In the second area, the researchers examined how VCCTL handles temperature rise in large concrete pours, which can significantly alter concrete's performance. The researchers integrated finite element modeling of this effect into the VCCTL. The researchers also examined the use of VCCTL with admixtures, which are chemicals or minerals added to C/C to alter its behavior prior to hardening. Based on their findings, they made improvements to this area of the VCCTL. They also investigated the applications of the VCCTL to prediction of durability parameters.

In the third area, the researchers developed a number of enhancements that will increase the speed and scope of the VCCTL. They developed applications that allow the VCCTL to take advantage of the University of Florida supercomputer. They also studied applications that analyze the behavior of the VCCTL and help to optimize its performance. They investigated the use of machine learning in the VCCTL to improve the accuracy of its predictions.

Project Benefits

The ability to predict the behavior of cement and concrete mixes more accurately can lead to new, more durable cement mixes and concrete structures.

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