Project Summary

Texas Department of Transportation

0-4563: Prediction Model for Concrete Behavior

Background

Prediction of heat generated by cement hydration in concrete mixtures is important to mitigate thermal stresses, cracking, and premature concrete deterioration caused by Delayed Ettringite Formation (DEF). Under this project, the Concrete Durability Center (CDC) at The University of Texas at Austin developed an innovative software program called *ConcreteWorks*. The software provides laboratory technicians, engineers, and contractors with a tool that combines concrete design, analysis, and performance prediction to improve and guide TxDOT to better designs. *ConcreteWorks* is a free stand-alone Microsoft Windows® based application that can be downloaded at www.texasconcreteworks.com. C*oncreteWorks* version 2.0 has the ability to assist with the following:

- Mass concrete: temperature prediction, cracking probability classification, chloride diffusion service-life analysis,
- Bridge decks: temperature prediction and chloride diffusion service life analysis for many bridge deck types,
- Pavements: temperature prediction,
- Precast/prestressed concrete members: temperature prediction of common beam shapes, and
- ACI 211 concrete mixture proportioning procedure.

Research Performed by:

Center for Transportation Research (CTR), The University of Texas at Austin

Research Supervisor:
Kevin J. Folliard, CTR

Researchers:
Maria C.G. Juenger, CTR
Jonathan Poole, CTR
Kyle Riding, CTR
Anton K. Schindler, CTR
Sam Slatnick, CTR

Project Completed: 8-31-07

What the Researchers Did

To accurately model heat generation and resultant thermal stresses in concrete members, a sophisticated testing program was undertaken to understand the interlinking relationships between concrete mix constituent components and concrete element size and shape on heat generation. A unique feature of the testing performed is the use of rigid cracking frames. This test was developed in Germany, and measures the cracking sensitivity of a restrained dog-bone-shaped concrete specimen from the time of concrete placement. The test setup is shown in Figure 1. Temperature-controlled formwork is used to cure the specimen to match field conditions of mass concrete members. These frames are designed to allow fresh concrete to be cast into their formwork, which enables the study of very early-age behavior of concrete mixtures. More than 70 tests have been completed to date and these results were used to characterize the very early-age creep behavior and risk of cracking of various concretes.

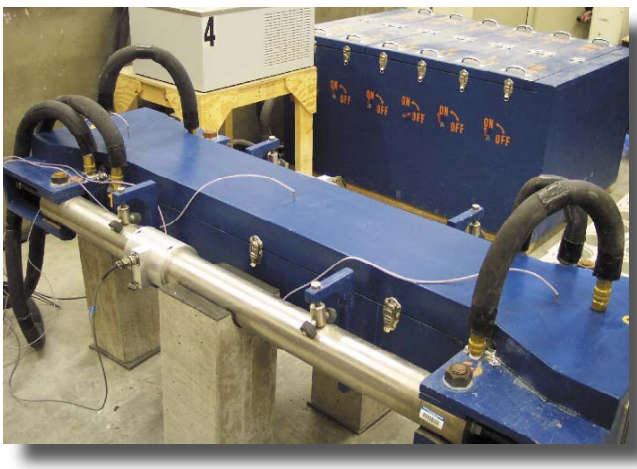

Figure 1: Cracking frame test set-up.

Mixture-specific heat of hydration values are used to accurately model the effect of various cementitious materials on the in-place concrete temperature distribution. These hydration parameters were generated through an extensive laboratory program, utilizing isothermal calorimetry and semi-adiatabic calorimetry. A wide range of cementitious materials, chemical admixtures, and aggregates were evaluated, and predictive equations were developed and integrated into *ConcreteWorks*, allowing end users to tap into this vast hydration database and utilize the model to predict heat generation in a variety of applications and for a variety of boundary conditions and climatic conditions. Figure 2 shows typical output of the model, which includes animated graphical simulations of temperature distributions within hydrating concrete elements.

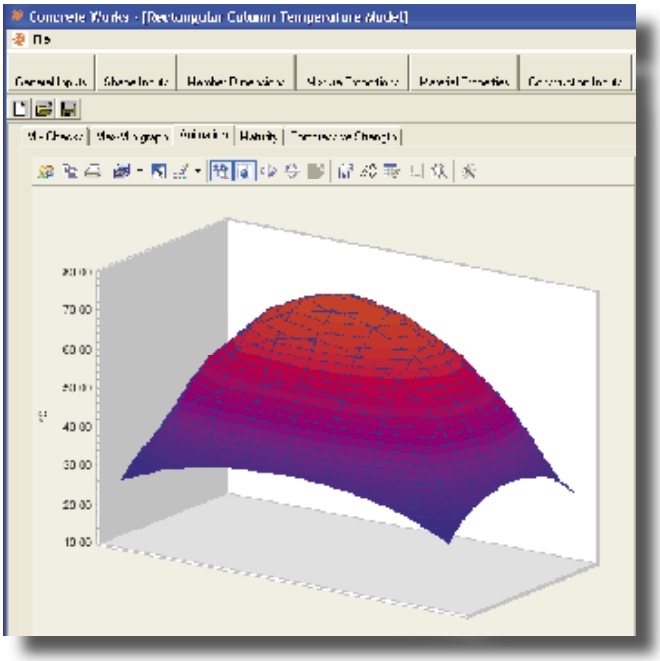

Figure 2: Typical output from ConcreteWorks, which includes animated simulations of temperature distributions within a hydrating rectangular column.

What They Found

ConcreteWorks provides detailed results to check compliance with specifications to control thermal cracking, alkali silica reaction, delayed ettringite formation, and service-life expectancy. The following are just some examples of items that the user can evaluate:

- Use of an array of different combinations of cement, ground-granulated blast-furnace slag, fly ash, silica fume, and chemical admixtures,
- Effects of various concrete mixtures, such as cement content, water-cement ratio, and aggregate type,
- Development of in-place strength through the use of maturity concepts,
- Effects of various formwork types, form removal times, curing methods, and insulating blankets,
- Effects of concrete placement temperature and the use of concrete cooling techniques,
- Effects of various placement times, and climatic conditions during construction through the use of a built-in, hourly climatic database of all 50 states in the U.S, and
- Prediction of service life for reinforced concrete structures exposed to external chlorides.

What This Means

ConcreteWorks has been and is currently being used in various projects throughout the United States and was recognized by TxDOT as a Top Innovation while the project was still on-going.

For More Information:
Research Engineer - Tom Yarbrough, TxDOT, 512-465-7403
Project Director - Ralph Browne, TxDOT, 512-399-4301
Research Supervisor - Kevin Folliard, CTR, 512-232-3591

Technical reports when published are available at:
http://library.ctr.utexas.edu/index.html

www.txdot.gov
keyword: research

Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080
512-465-7403