



Monitoring Heat Evolution of Concrete Mixtures

tech transfer summary

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RESEARCH PROJECT TITLE

Developing a Simple and Rapid Test for Monitoring the Heat Evolution of Concrete Mixtures for Both Laboratory and Field Applications

SPONSORS

Federal Highway Administration (Project 17, Phase I)

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The mission of the National Concrete Pavement Technology Center is to unite key transportation stakeholders around the central goal of advancing concrete pavement technology through research, tech transfer, and technology implementation.

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Accurate, inexpensive heat evolution tests for concrete pavements can help predict several important early-age and long-term behaviors.

Objectives

- Identify an inexpensive, standardized, and relatively rapid test for measuring the heat of hydration of concrete using calorimetry and related methods.
- Develop a prototype test procedure for measuring the heat of hydration of field concrete.
- Develop a model and software for converting the raw test data into relevant test metrics as well as acceptance criteria for test results.

Problem Statement

Numerous test methods are routinely used to control concrete quality in the field, such as slump, air content, and strength. However, no standard methods currently exist that can monitor the heat of hydration of field concrete both practically and accurately.

The heat of hydration of field concrete can influence concrete workability, setting behavior, strength gain rates, and pore structure development and affect the early-age behavior and long-term performance of the concrete pavement. Various test methods are available for measuring the heat of cement hydration, but most existing methods require expensive equipment, complex testing procedures, and/or extensive time. These tests are thus not suitable for field application.

Therefore, it is important to identify, develop, and evaluate a practical, standard test procedure for the characterization and quality control of concrete pavement mixtures using a calorimetry technique applicable to both the laboratory and the field.

Research Description

The research in this phase identified user needs for heat of hydration testing and synthesized existing test methods for monitoring the heat of hydration, including device types, configurations, test procedures, measurements, and applications.

Key Findings

- Besides concrete materials and mix proportions, the configuration of the calorimeter device, sample size, mixing procedure, and testing environment (temperature) have significant influences on the concrete heat evolution process.
- Four major types of calorimeters are available: adiabatic, semi-adiabatic, isothermal, and solution calorimeter. Most practical tests used by the concrete and cement industry are semi-adiabatic.
- Simple, inexpensive devices for testing heat of hydration include Dewar, coffee cup, and sprayed-foam basket. Many types of temperature sensors and dataloggers are also available, ranging from \$20 to \$1,000, with varying temperature ranges and accuracies.
- Models and computer programs for analyzing heat evolution data are often developed for specific heat evolution devices and sensors, but are generally complicated and expensive.
- There is currently no consensus about using heat evolution curves, developed from hydration data, to characterize concrete materials and effectively relating the characteristics of heat evolution curves to concrete pavement performance.

Implementation Benefits

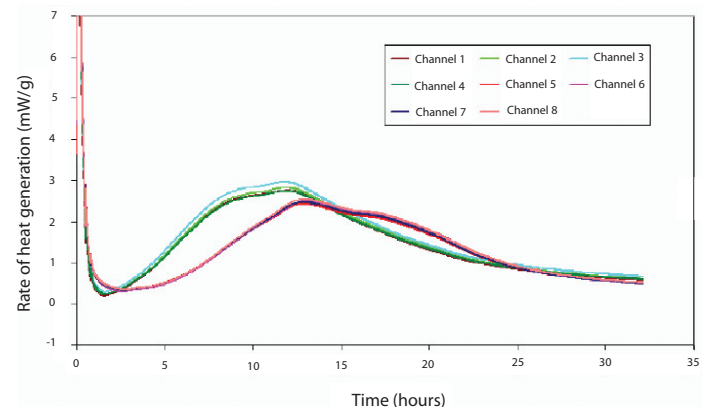
- A more practical standard calorimetry technique will provide higher quality control at a lower cost than existing tests.
- The use of calorimetry devices on concrete paving projects can have a number of applications, including the following:
 - Prescreening mix designs and materials
 - Forecasting set time
 - Predicting strength gain
 - Evaluating risk of thermal cracking
 - Estimating sawing and finishing time
 - Flagging cementitious changes
 - Identifying materials incompatibility
 - Verifying mix proportions
- Better monitoring of the heat evolution of concrete mixtures in both the laboratory and the field will lead to an improved understanding of the characteristics of concrete materials and mix proportions and will help identify necessary features of construction and environmental conditions more rigorously. Knowledge of concrete workability, setting behavior, rate of strength gain, and pore structure development will also be enhanced.

Implementation Readiness

In the next phase of this project (2006-2007), a standardized test device and procedure will be developed, field tested, and demonstrated using the CP Tech Center's Mobile Concrete Research Lab. This focused and systematic study will bring together test equipment specification, procedure development, heat evolution curve characterization, and pavement performance prediction.



Device for measuring heat evolution data, to be developed in the next phase



Cement heat evolution curve