U.S. Department of Transportation
Federal Highway Administration

Monitoring Concrete Consistency using Semi-Adiabatic Calorimetry

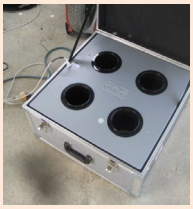
Observations from the FHWA Mobile Concrete Technology Center (MCTC)

The hydration of cementitious materials results in exothermic chemical reactions. These reactions can be monitored by measuring the total heat liberated over time. The amount of heat liberated by cement hydration depends on the chemical and physical properties of the cementitious materials and admixtures used in the concrete mixture. The heat of early hydration reactions can be measured using a Semi-Adiabatic Calorimeter. The hydration curve generated from this process is called the Heat Signature.

Practical uses of Calorimetry/Heat Signature: Calorimeters are effective tools during mix design to determine potential material incompatibility or optimal dosages/sequence of addition of admixtures. They can be used to determine setting times and saw cut times in lieu of physical testing. **Semi-Adiabatic Calorimeters can also be used as a quality control (QC) tool to monitor variations in the sources, quantities, and chemistry of portland cement, supplementary cementitious materials, and chemical admixtures during concrete production.** This test is often underutilized for QC purposes. One of the important aspects of calorimetry is that it provides information in rea l time over 24-36 hours.

How does the test work?

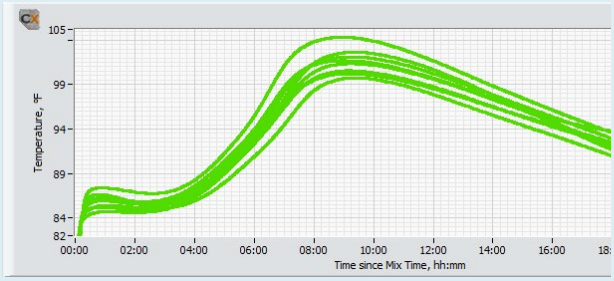
- Cast a standard concrete cylinder during production
- Place it in the Semi-Adiabatic Calorimeter
- Record the time-temperature curve (Heat Signature)
- Compare Heat Signature curves of samples from the same mixture



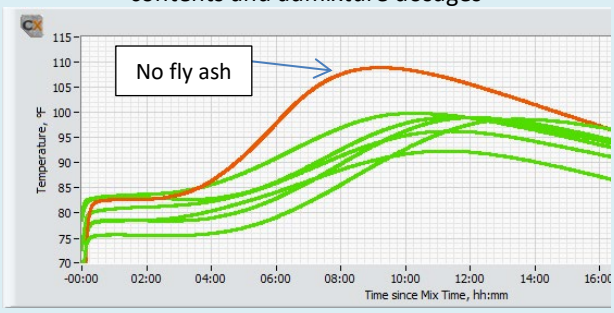
Summary:

- Simple, quick, and inexpensive field test
- Monitors consistency in cementitious materials between batches
- Only for QC applications

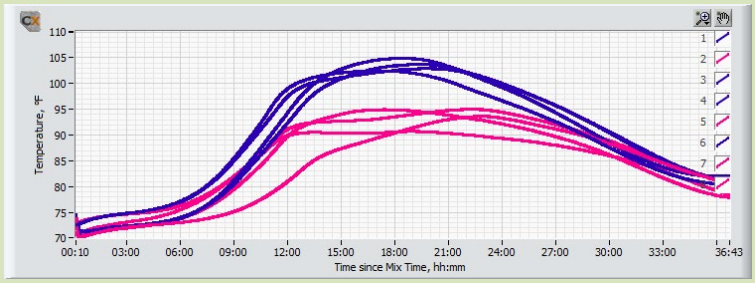
Heat Signature for Quality Control Purposes: During the paving operation, consistent concrete is the key to a quality pavement. Heat Signatures will identify any changes in the chemical reaction of the hydration process. When paired with unit weight testing, calorimetry and unit weight can identify when mixture changes have occurred. Through the use of control charts, the contactor can be alerted to those changes and adjustments can be made to keep the process in control. Heat Signature curves can also be used to identify nonuniformity in real time that will otherwise only become known through later age test results, some of which may be acceptance tests. The following are some Heat Signature data obtained from MCTC field projects. *(FHWA is the source of all images in this document.)*



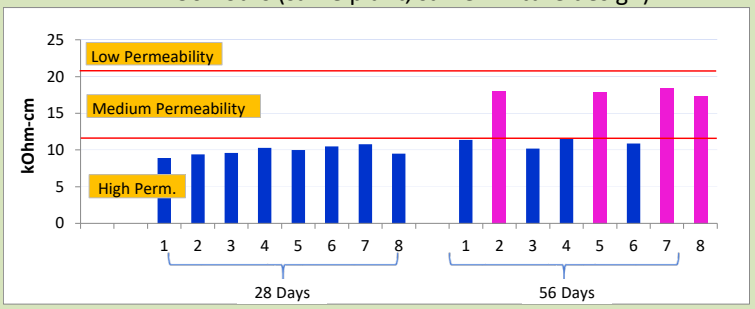
Consistent Heat Signature Curves from a field project with consistent quantities and sources of cementitious contents and admixture dosages



Significant difference in Heat Signature curve (yellow) due to no-fly ash in the sample



Heat Signature curves differentiate performance between samples in 24 - 36 hours (same plant, same mixture design)



Surface Resistivity – 28 Days / 56 Days
It took 56 days to obtain similar information using the Surface Resistivity Test

For more information, refer to "Evaluating Early Hydration of Hydraulic Cementitious Mixtures Using Thermal Measurements," ASTM C1753

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