RUTGERS
Center for Advanced Infrastructure and Transportation

Project Overview Report

1. UTC Identifying Number

   DTRT13-G-UTC28

2. Center Identifying Number

   CAIT-UTC-NC37

3. Project Title

   New Methodology for Evaluating Incompatibility of Concrete Mixes in Laboratory: A Feasibility Study

4. Principal Investigator & Contact Information

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7. Project Description

   The current specifications encourage the use of supplementary cementitious materials (SCMs) and as much as possible recycled materials in portland cement concrete. The use of SCMs, especially along with low water-to-cementitious material ratio, low total cementitious material content and cements with a low C3A content and low alkali, can produce some incompatibility in the paste due to the fact that they are not optimized for sulfate content when used with SCMs, or that have anhydrite or hemihydrate as the main sulfate source. This situation can create a concrete mixture that is sensitive to changes in ambient temperature, admixture dosage, cement and SCM properties, creating problems in the curing process, developing some early cracking, and compromising the performance of the structure. The following five factors are considered as the most significant factors contributing to the stability of the mixes: (1) type of cement, (2) type of chemical admixture, (3) dosage of chemical admixture, (4) type of SCMs, and (5) testing temperature. A study is proposed to develop an easy to use, relatively inexpensive laboratory test and equipment to determine potential concrete mixture incompatibilities among the aggregates and the above five parameters.

   The proposed equipment is a miniaturized free-free resonant column (FFRC, ASTM C215) device that has been used by many agencies with success. We have prototyped a fully-automated computer-controlled FFRC device that at user-defined time intervals collects data without the need for a technician. The computer used for this device, can also be readily used to gather temperature measurements from thermocouples. Therefore, the proposed test setup can collect the shear and compression wave velocities as well as the thermal maturity of the material up to an age of 72 hours. We will also utilize a thermal and/or digital imaging processes to estimate the patterns of heat dissipation and shrinkage of the concrete during curing.

   The proposed device will be assembled and tested for accuracy and precession and will be tested with a number of mixed with different levels of SCM and cement content, among other factors, to establish the feasibility of the system.

8. Implementation of Research Outcomes (or why not implemented)

   Concrete producers expect cement to remain versatile, and to maintain a consistent and predictable performance with all types of concrete mixes. Concrete workability problems can be costly and can affect concrete producers and contractors alike. Many cement parameters can play a role in such incompatibility, including grain size (clinker mineralogy) and amount of tricalcium aluminate (C3A); the content, chemical form and fineness of sulfate bearing phases; alkali and free lime contents; and, fineness and prehydration of cement. The incompatibility among various components of the PCC may lead to abnormal set times. Although ASTM C 1074 (Activation Energy Testing) and ASTM C 403 (Time of Setting of Concrete Mixtures by Penetration Resistance) are available for evaluating the curing process at different temperatures, they are not very practical because either they cannot be automated (ASTM C403) or a large number of specimens needs to be tested (ASTM C1074). The objective of this research project is to develop an easy to use, relatively inexpensive laboratory test and equipment to determine potential concrete mixture incompatibilities among the sulfate system, mineral and chemical admixtures. The study will focus on simultaneously measuring several aspects that contribute to the PCC early age behavior in a practical and reasonably inexpensive manner.

9. Impacts/Benefits of Implementation (actual, not anticipated)

   TBD

10. Dates and Budget

    Start Date: 6/1/2016
    End Date: 9/30/2018
    UTC (CAIT) Dollars: $ 100,999
    Cost Sharing: $ 122,598
    Total Dollars: $ 232,597

11. Keywords

    Portland Cement Concrete, Laboratory Equipment Evaluation, Supplementary Cementitious Materials Compatibility Testing

12. Web Links (Reports and Project Website)

    https://cait.rutgers.edu/cait/research/new-methodology-evaluating-incompatibility-concrete-mixes-laboratory-feasibility-study