Alternative Supplementary Cementitious Materials in Ultra-High Performance Concrete

Project Number:

21CNMSU60

Start Date:

08/01/2021

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Lead Institution:

New Mexico State University

Funding Source(s):

Tran-SET

New Mexico State University

Total Project Cost:

$ 120,000

Implementing alternative SCMs in ultra-high performance concrete

Ultra-high performance concrete (UHPC) is an advanced fiber reinforced composite material with compressive strengths greater than 17,000 psi (120 MPa), flexural strengths greater than 1450 psi (10 MPa), and exceptional durability properties. UHPC is produced with a high cementitious materials content, and silica fume and high-range water reducing admixtures are used to produce a dense microstructure that can result in compressive strengths greater than 29,000 psi (200 MPa). The superior durability and corrosion resistance provided by UHPC provides the potential to increase service life and lower repair costs in concrete structures. The research project includes a comprehensive literature review to identify the most important characteristics of SCMs for use in UHPC and to expose critical concerns for UHPC mixtures produced with these materials. A suite of mixture proportions utilizing the SCMs considered in the project will then be developed. Each of the new UHPC mixtures will be evaluated for fresh and hardened properties including workability, compressive strength, and flexural strength. The most promising UHPC mixtures will then be tested for durability related properties including rapid chloride permeability, surface resistivity, shrinkage, and frost resistance. Results from the testing program will be compared to results from existing mixtures containing silica fume and class F fly ash.

Problem Statement

Geopolymer Previous UHPC research at New Mexico State University (NMSU) has shown that UHPC produced with local materials and supplementary cementitious materials (SCMs), such as silica fume and class F fly ash, can exhibit comparable mechanical and durability properties to proprietary UHPC mixtures. Incorporation of locally available materials can reduce materials cost up to 70% compared to proprietary UHPC. The UHPC mixtures developed at NMSU have recently been specified by the New Mexico Department of Transportation (NMDOT) for use in pre-cast, pre-stressed bridge girders and bridge deck overlays because of their exceptional durability properties and ability to bond with substrate concrete. Unfortunately, class F fly ash production has decreased sharply as the energy industry has moved to renewable energy technologies to produce electricity and coal burning generating stations have been decommissioned. The New Mexico Department of Transportation (NMDOT) expects that by as early as 2022 the supply of class F fly ash will be insufficient to meet their needs for concrete construction, so alternative SCMs are needed for all concrete mixtures including the non-proprietary UHPC mixtures.

Objectives

This research project will assess the potential of three alternative SCMs that might be used in non-proprietary UHPC. The SCMs to be studied are a natural pozzolan mined from a pumicite deposit near Espanola, NM, a manufactured metakaolin product produced by a local cement manufacturer, and a ground-granulated blast furnace slag (GGBFS) from a neighboring state. The important performance characteristics of new UHPC mixtures produced with the SCMs include workability in the fresh state, compressive strength, flexural strength, and durability related properties such as rapid chloride permeability, surface resistivity, shrinkage behavior, and frost resistance.

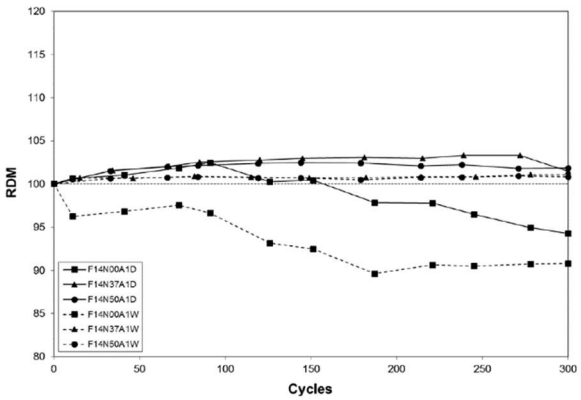

Figure 1. RDM versus cycles of freezing and thawing for mixtures with varying fly ash content

Intended Implementation of Research

In addition to the technical aspects of the research, efforts should be made to address education, outreach, and workforce development. To address these issues, the following tasks will also be performed as part of this project:

- Development of a powerpoint presentation containing educational content that can be used in the education and recruitment of high school and community college students considering transportation engineering careers, interested in construction related careers, or interested in pursuing careers in the concrete industry.
- Presentation of the research at conferences, meetings, and workshops associated with Tran-SET and the transportation engineering community to provide workforce development and continuing education opportunities for people considering transportation related careers and transportation professionals.

Anticipated Impacts/Benefits of Implementation

Developing the ability to use a broader selection of SCMs in non-proprietary UHPC is expected to broaden the use of this material by improving the durability of transportation infrastructure. Additionally, the UHPC mixtures developed in this research can be used in repair applications to extend the life of existing concrete structures

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.