Florida Department of Transportation Research

Reducing Portland Cement Content and Improving Concrete Durability – Phase II

January 2022

Project Number
BDV31-977-114

Project Manager
Jose Armenteros
FDOT Materials Office

Principal Investigator
Mang Tia
University of Florida

Current Situation

A vast amount of Florida's built environment, including residential, business, and transportation, relies on concrete. The concrete industry in Florida and the U.S. is presently facing two major challenges: the rising cost of cement and a shortage of fly ash. These challenges are the impetus for efforts to develop concrete formulations that require less portland cement and to discover and develop new supplementary cementitious materials.

Bridges, curbs, interstates, driveways, high-rises, and light poles – large and small, concrete is everywhere in the built environment.

Research Objectives

In the current project, University of Florida researchers examined the technical properties of promising new concrete formulations and made recommendations to establish a path for implementation of the new formulations in Florida transportation construction.

Project Activities

In a previous project (BDV31-977-86), the researchers studied approaches to the problem of the cost of concrete and reduced supply of fly ash. They studied concrete mixes with reduced cementitious materials (cement + supplementary materials such as fly ash). They examined optimized aggregate gradation (OAG), which considers the effect of sizes of aggregate materials on concrete strength. They compared the use of portland cement concrete with concrete that uses a cement mix in which a portion of the portland cement has been replaced with limestone (Type IL cement). They also studied concrete made with combinations of these three approaches.

In this project, the researchers studied the technical properties of promising concrete designs from their previous work. Results showed that the partial replacement of portland cement with limestone offered similar properties as portland cement when used in concrete. The new formulation reduced temperature of hydration, which implies lower cracking potential. OAG has potential to improve workability and to reduce temperature of hydration of fresh concrete. A benefit-cost analysis showed a potentially substantial reduction in materials cost and carbon dioxide emission of using reduced cementitious paste content in concrete.

Based on the results of this project, the researchers recommended a mix design method to achieve concrete with a minimum paste volume. This method can help prevent overdesign with excess cementitious content. Minimizing the paste volume and optimizing aggregate gradation in the designed mix can provide better workability, quality and durability of the concrete – an additional long-term benefit of the new mix designs.

The researchers then outlined how current Florida Department of Transportation requirements for specific concrete types and construction applications could be amended to include the new mix designs.

Project Benefits

Results of this project offer significant cost savings, environmental benefits, and improved durability for concrete transportation construction projects in Florida.

For more information, please see www.fdot.gov/research/.