Florida Department of Transportation Research

Correlation of Slag Cement Composition with Durability of Portland Cement-Slag Concrete

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Project Managers
Jose Armenteros
FDOT Materials Office

Principal Investigator
Abla Zayed
University of South Florida

Current Situation

As the price of traditional materials for cement and concrete increases and the availability decreases, the search for new materials that can replace some of these base materials continues. Research of this type has found uses for cast-off materials like fly ash from power plants and slag from blast furnaces, and rather than sacrificing quality, the new formulations have resulted in improvements in durability and service life of concrete structures. At the same time, use of cast-off materials improves sustainability and reduces the environmental impact of both the industries that use cement and those that supply the materials. Nevertheless, like all the materials that go into cement, cast-offs like fly ash and slag are very complex. The properties of the raw materials must be thoroughly understood as well as their behavior in cement mixtures in both the short term and long term.

The enormous furnaces that convert iron ore into iron produce tons of slag as a byproduct.

Research Objectives

University of South Florida researchers examined the influence of the properties of slag on temperature rise and durability of cement mixtures.

Project Activities

Field observations of some concrete structures have raised concerns about Florida Department of Transportation (FDOT) specifications for slag in cement mixes. In this project, researchers addressed the effect of slag composition on temperature rise of setting concrete that can lead to cracking and sulfate content that can reduce durability. To investigate the FDOT specifications, cements and slags selected for the project extended beyond those typically used by FDOT, representing a wide range of chemical compositions and fineness of powder samples. Slags varied in alumina content, magnesia-to-alumina ratio, sulfate levels, and fineness. Cements were made with the slags using 60% by mass of slag per FDOT specification.

Sulfate content was optimized for early strength development in cement. Mortar bars – both controls and slag-blended mixtures – were tested for durability, both in terms of sulfate content and external sulfate attack.

To address the temperature issue, two standard cement mixtures were used: Type II(MH) and ASTM C595 Type IL. Ten concrete mixtures based on these standards were prepared, including slag-blended concrete mixtures. The slags varied in their alumina content, aluminate-to-magnesia ratio, and fineness. Temperature rise experiments were conducted at the U.S. Bureau of Reclamation laboratory in Denver, CO.

Based on the findings of the project, the researchers were able to make recommendations for the FDOT standards for slag-blended concrete, with the expectation that the durability will be improved and early temperature rise will be below the threshold that would lead to cracking in massive concrete castings.

Project Benefits

This project enhances the benefits in economy and durability provided by blending slag into cement mixtures, with additional assurances that these blends will be more durable.

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