Florida Department of Transportation Research

Durability of Concrete Using Low Slag Cement Contents

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Project Number
BEC98
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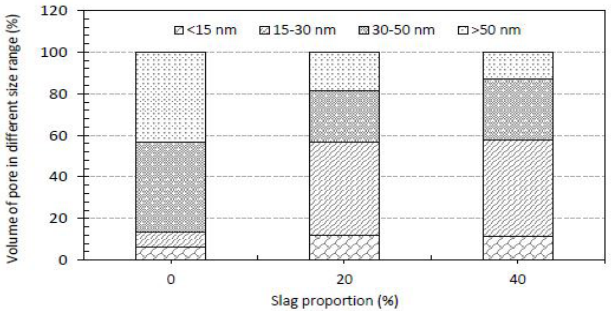
Current Situation

Fly ash is commonly used to enhance concrete durability. Due to a declining availability of fly ash, precast concrete producers are increasingly interested in using slag cement and other supplementary cementitious materials (SCMs) as an alternative. However, slag cement at high levels can reduce early-age strength, which is a concern for meeting certain construction timelines. This research project addressed the use of SCMs in Florida concrete, specifically focusing on slag cement.



This figure shows the pore size distribution of cementitious systems containing slag, illustrating how slag decreases capillary porosity and increases the gel porosity as a percent of the total porosity.

Research Objectives

The objective of this project was to determine the optimal amount of slag cement to use while maintaining both durability and sufficient early-age compressive strength for precast concrete. Specifically, the study aimed to identify (1) the minimum slag content needed to provide equivalent durability to a concrete mix containing 20 percent fly ash, and (2) the maximum slag content that could achieve early-age strength requirements for prestressed concrete products within 18 hours.

Project Activities

The University of Florida and the University of South Florida research team conducted a series of laboratory experiments to examine the strength and durability of various concrete mixtures containing different levels of slag cement. They used both binary and ternary blends, which incorporated fly ash, slag, and silica fume in different combinations. The team characterized the physical and chemical properties of these materials and performed several tests, including compressive strength tests, resistivity tests, and sulfate durability assessments.

The study included accelerated curing methods to determine whether these approaches could provide accurate and faster insights into long-term durability. Mortar bars and concrete samples were tested under different curing conditions, including elevated and standard lab temperatures, to understand the effects of slag content on both strength development and resistance to environmental damage such as chloride ingress and sulfate attack.

Project Conclusions and Benefits

Findings indicated that reduced slag cement proportions can achieve early-age strengths sufficient for precast concrete production but, in some cases, additional heat or accelerators may be required to meet those requirements. The study also found that mixtures with slag cement exhibit good durability properties, qualifying as high sulfate resistant when used with Type IL (also known as Portland-Limestone Cement) cement. The team recommended a minimum slag replacement level of 35 percent for chloride durability in certain concrete classes. This provides an option for precast producers to use lower slag contents without compromising durability, ultimately contributing to more sustainable and efficient concrete production practices in aggressive environments.

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