Florida Department of Transportation Research

# Evaluation of Silica-Based Materials for Use in Portland Cement Concrete

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## Current Situation

When water is added to portland cement, a calcium-silicate-hydrate (C-S-H) binding phase is formed, with calcium hydroxide as a reaction product. The addition to portland cement of fine-grained pozzolanic materials – mostly amorphous materials containing large amounts of silica or silica and alumina – provides a source of silica. In the presence of water, calcium ions from calcium hydroxide and the silicate ions from the pozzolan combine with water to form additional C-S-H. Much work was done in the 20th century to use fly ash from coal-burning power stations as a pozzolan in portland cement mixtures. In the 21st century, the steady move away from coal for power generation has reduced the once plentiful fly ash supply and increased its cost. Research has therefore turned to finding other pozzolans which are both economical and effective as concrete additives.


*An increasing demand for concrete requires new materials and formulas.*

## Research Objectives

University of Florida researchers studied the use of alternative pozzolans, including alternative sources of coal fly ash and locally available materials such as sugarcane bagasse, glass, and volcanic rock.

## Project Activities

The literature review confirmed the value of using pozzolans, or supplementary cementitious materials (SCMs), in cement, but found gaps in testing SCM mixtures, especially regarding long-term durability. A survey of departments of transportation in the southeastern and south-central U.S. states and California and Illinois found many SCMs in use.

The researchers identified five materials as promising for further study as SCMs: alternative sources of coal fly ash, sugar cane bagasse, ground glass, ground sand, and ground volcanic rock. Two types of sugarcane bagasse and two types of fly ash, Class F and Class C fly, were acquired for testing. Ground glass was obtained from a commercial source. Ground volcanic rock was obtained from the Caribbean. Ground sand was produced locally in Gainesville, FL.

To complete the materials for their work, the researchers obtained three types of portland cement: Type I/II, Type IL (higher limestone content), and high alkali Type I/II. Aggregates used included typical coarse and fine aggregate and an alkali-reactive fine aggregate.

The composition and properties of the basic materials and their mixtures were characterized. Fifty mortar mixes were prepared, 25 each with Type I/II portland cement and Type IL. Mortars were tested for flow, time of set, compressive strength, length change, alkali-silica resistance, and sulfate resistance. Concrete made with these mortar mixes was subjected to standard testing for compressive strength, splitting tensile strength, flexural strength, modulus of elasticity, and coefficient of thermal expansion. Long-term durability testing included resistance to alkali-silica reaction, environmental exposure blocks, and surface and bulk electrical resistivity.

Based on this wide range of materials and tests, the researchers were able to make extensive recommendations for specific applications of concrete made with specific SCMs. They provided guidance about the characteristics and proportions that should be used. Because of the promising results in this study, the research also recommended further studies to qualify mixtures for use in Florida and to further characterize the SCMs.

## Project Benefits

This project advanced the understanding of using SCMs in concrete and makes possible several new mixtures that can take advantage of more economical and locally available materials.

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