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Effect of Chemical and Mineral Admixtures on Performance of Florida Structural Concrete

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Current Situation

For structural concrete, experience and continued research have shown the advantages of both mineral and chemical additions, "admixtures," to strengthen the final product and to control the setting process. New chemical admixtures are constantly being developed, and new mineral admixtures are constantly being explored. While the effect of any particular admixture may be well understood, admixtures are often used in combination, and interactions among their many possible combinations have not been adequately studied and documented.

Modern concrete structures rely on advanced types of concrete for extra strength and durability.

Research Objectives

University of South Florida researchers studied the effect on concrete performance of several mineral and chemical admixtures that are commonly used in Florida structural concrete.

Project Activities

Mineral admixtures used in the project were Class F fly ash, silica fume, blast furnace slag, and metakaolin. Chemical admixtures were an air entrainer, a water reducer/retarder, and two superplasticizers. Mineral materials, including cement, were thoroughly characterized as to chemical oxide composition, crystalline and amorphous content, density, fineness, specific surface area, and particle size distribution.

The performance of concrete mixes containing two or three admixtures was assessed using several tests, including heat of hydration (HOH) using isothermal calorimetry, strength evolution, rheological properties, setting properties of paste and mortar, sulfate durability, semiadiabatic calorimetry and adiabatic temperature rise, and cracking potential. Microstructural evolution was followed by x-ray diffraction of the hydration phases, nanoindentation, and characterization of the pore structure using nitrogen adsorption for two-admixture systems. The effect of chemical admixture dosages on the evolution of pore size distribution was followed during the setting process using nitrogen adsorption. The cracking potential for binary cementitious concrete mixtures was studied using an imposed temperature profile simulating a 1-m^3 wall.

Generally, mineral admixtures retarded the setting process. Metakaolin mixtures showed the highest early strength gain. HOH measurements indicated that both metakaolin and slag affected the sulfate-to-aluminate balance in the cement mix. Factorial design successfully predicted potential interactions in admixture combinations. Sulfate durability tests indicated that mixes containing slag performed no better than plain cement mixes, and silica fume offered superior protection for cement mixes exposed to sulfate environments. High dosages of water reducer/retarder and superplasticizers increased pore size distribution in the 2- to 30-nm range. Metakaolin and slag mixtures increased large gel pores.

Project Benefits

A more thorough understanding of the effect of admixtures and their interactions can lead to more predictable and improved performance of concrete.

For more information, please see dot.state.fl.us/research-center