Florida Department of Transportation Research

Evaluation of Alternative Pozzolanic Materials for Partial Replacement of Portland Cement in Concrete

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Current Situation

A pozzolan is defined in ACI CT-16 as a finely divided, siliceous or silico-aluminous material that, at ordinary temperatures, reacts with calcium hydroxide (CaOH) and water to form a calcium-silicate-hydrate binding phase. The original pozzolan used in Roman times was a volcanic ash mined near Pozzuoli (therefore, *pozzolan*). The lack of acceptable pozzolanic materials for cement production eventually led to the development of an alternative, Portland cement, in the early 1800s (first patent 1824), and it is now the most common cement in use – over 4 billion tons are produced each year. Pozzolans, originally the main part of the cementitious binding phase, are now used as an additive to Portland cement concrete to increase the amount of cementitious phase produced, allowing a reduction in the amount of Portand cement needed to produce concrete of a given strength.

Concrete is critical to transportation – roads, ports, airports, etc. – but its costs, economic and environmental, are rising.

Demand for Portland cement is steadily increasing in a rapidly developing world, and its price is rising as a result. Portland cement production also has a high environmental cost. For every ton of cement that is produced, about 0.9 ton of greenhouse gas is released, accounting for 4% of all industrial carbon dioxide emissions in the U.S. alone. Therefore, substitutes for Portland cement that produce quality concrete – alternative pozzolanic materials – have been researched and developed for many years.

Research Objectives

In this project, University of Florida researchers identified underutilized materials which could be used for partial replacement of Portland cement in Florida concretes.

Project Activities

The researchers studied several materials as possible partial replacements for Portland cement. Many were recycled: class C coal fly ash (from coal-fired power plants), pulverized glass (from glass recycling), wood ash (from wood-fired electricity production), sugarcane bagasse ash and rice husk ash (from agricultural production). The chemical and physical properties of each material were characterized using a number of methods to determine whether they fell within standard requirements.

Using the alternative pozzolans, the researchers made a total of 55 mortar mixes (cement + sand + water) and 22 concrete mixes (mortar + aggregate). Each mixture was tested for compressive strength, modulus of elasticity, splitting tensile strength, flexural strength, surface and bulk resistance to cracking, bulk resistivity, coefficient of thermal expansion, and heat generation.

From this extensive test matrix, the researchers were able to produce a series of specific recommendations for the use of these alternative pozzolanic materials and the testing of concretes produced from them.

Project Benefits

The use of alternative pozzolanic materials has benefits both by lowering costs while maintaining standards of strength and durability and protecting the environment by reducing greenhouse gas production and utilizing waste materials.

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