DRISI

Caltrans Division of Research,
Innovation and System Information

Research Results

Optimizing the Performance of Cement Blends

Ternary blends of cementitious materials can enhance concrete performance, strength, and longevity

Pavement

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Project Title:
Development of Performance Properties of Ternary Mixes, TPF-5(117)

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WHAT IS THE NEED?

Pavement engineers throughout the United States have used waste materials—byproducts of other industrial processes—such as fly ash, silica fume, and blast furnace slag for many years to supplement portland cement in concrete production. These ternary blends of supplementary cementitious materials (SCM) can improve the durability, strength, and cost of pavements and structures, as well as offer environmental benefits. SCMs provide many advantages, but introducing them into a mixture can also cause performance issues if the combination of materials or proportions are not suitable for the particular use. Specifications to produce concrete mixtures that meet specific performance objectives have not been adequately captured. In addition, selecting the SCMs to use has become more complicated with the growing availability of slag cement and silica fume and the limited supply of fly ash in some markets.

WHAT WAS OUR GOAL?

The goal was to document the quantitative information needed to make sound engineering judgments when using ternary mixtures to enhance the performance and life-cycle costs of transportation pavements and structures.

WHAT DID WE DO?

Caltrans, as part of a pooled fund study lead by the Iowa Department of Transportation, evaluated how ternary blends can be used to improve the performance of concrete. This comprehensive project was spread over several stages. During the first phase, the researchers conducted laboratory experiments to study the influence of various proportions of cement, slag, silica fume, and fly ash on specific properties of mortar specimens and to locate ways to optimize the results. Based on the information collected, the second phase involved

selecting a reasonable range of materials and dosages for use in laboratory concrete mixtures.

In the third phase, the participating states had on-site technical support for using ternary mixes in a local project. In California, an 11-mile section on I-80 from Emigrant Gap to Yuba Gap was reconstructed using a ternary mixture.
A mobile concrete laboratory equipped for on-site cement and concrete testing was provided by the Federal Highway Administration to collect data and field observations.

WHAT WAS THE OUTCOME?

Ternary mixtures can be developed for any application and have a high probability of improving performance, lowering life-cycle costs, and reducing environmental impacts than pavements that do not incorporate SCM. However, each mixture—the type of cementitious materials and percentage—should be designed for the performance needs of the intended purpose rather than relying on a fixed prescriptive approach.

The California test section did not experience any difficulties with the materials during construction. After the first winter, some surface loss was observed on one section, which might have been caused by studded tires.

WHAT IS THE BENEFIT?

Using SCMs in concrete production supports environmental and energy conservation as well as provides performance benefits. Cement blends use industrial byproducts otherwise destined for landfills. Incorporating these materials reduces the need to produce more portland cement and uses the energy already expended in the manufacturing process. When properly used, SCMs can dramatically improve the overall performance and lower the long-term cost of transportation pavements and concrete structures.

IMAGES

Figure 1: Concrete batch plant

Figure 2: Mobile research laboratory supporting the on-site project