CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-6717: Investigation of Alternative Supplementary Cementing Materials (SCMs)

Background

In Texas, Class F fly ash is extensively used as a supplementary cementing material (SCM) because of its ability to control thermal cracking in mass concrete and to mitigate deleterious expansions in concrete from alkali-silica reaction (ASR) and sulfate attack. However, uncertainty in the supply of Class F fly ash due to impending environmental restrictions has made it imperative to find and test alternate sources of SCMs that can provide similar strength and durability benefits to concrete. This research characterized and evaluated the performance of eight natural pozzolans, available in Texas, to assess their potential as a Class F fly ash replacement in concrete.

What the Researchers Did

Eight natural pozzolans were characterized extensively in the laboratory and tested in cement paste, mortar, and concrete mixtures. Their performance was compared to mixtures without SCMs and to mixtures containing an equivalent replacement of Class F fly ash in terms of workability, setting time, compressive strength, drying shrinkage, coefficient of thermal expansion, resistance to alkali-silica reaction, resistance to sulfate attack, and resistance to chloride penetration. Pozzolans with poor performance in a given aspect were modified by grinding, calcination, and chemical treatments in an attempt to improve their performance.

What They Found

Six out of the eight pozzolans tested were found to be viable alternatives for Class F fly ash. These included a metakaolin, a perlite, a pumice, a calcined shale, a vitric ash, and a zeolite. Two zeolites tested did not have good performance and also suffered from high water demand; however, calcination did reduce the water demand of these materials. Guidelines are provided on the optimum SCM replacement levels for different applications; Figure 1 illustrates the determination of optimum replacement dosages.

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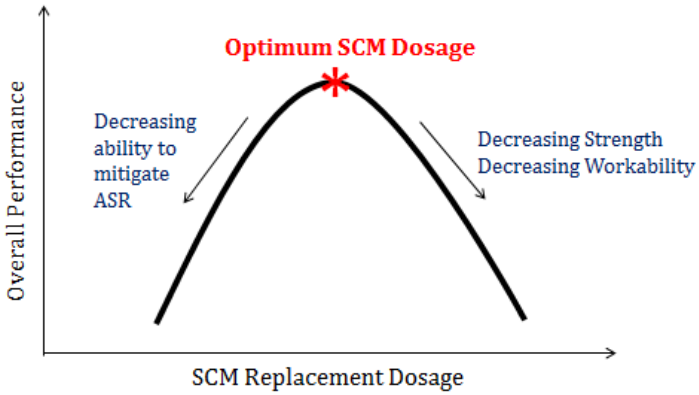

Figure 1. Finding the Optimum Replacement Dosage.

This project also resulted in recommendations on how to improve current testing practices for SCMs. Table 1 summarizes these evaluations and recommendations.

What This Means

Many alternatives to Class F fly ash are available for improving the durability of concrete produced in Texas. Incorporating these materials into concrete mixtures should be straightforward from an engineering perspective. Very few changes, if any, need to be made to Texas Department of Transportation specifications regarding the qualification of these materials. It should be noted, however, that although these materials have positive contributions to concrete strength and durability, many are more expensive than fly ash and cement and so will negatively impact the economics of concrete production.

Table 1. Summary of Evaluations and Modifications Needed in Current Concrete Tests.

Test	Evaluation	Recommendations
ASTM C 618	Good for basic characterization. Tests are able to filter out the bad performers but tend to be biased against SCMs with a high water demand.	The strength activity index should be run with a fixed water-to-cement ratio (w/c). The flow test of ASTM C 1437 can be used to detect workability problems.
ASTM C 1567	A quick test for predicting optimum dosages for ASR mitigation in the field.	This test should be run with ASTM C 618 to understand the ASR mitigation potential of SCMs.
ASTM C 1012	A good test for measuring sulfate resistance but tends to be biased against SCMs with a high water demand.	Researchers recommend running the test with a fixed w/c. They caution against extrapolating ASR results to predict the sulfate resistance of SCMs.
Laser Particle Size	Good for understanding the entire particle size distribution but requires a special machine.	Researchers recommend using this test instead of the fineness test in ASTM C 618.

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