CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-6966: Assessment of Test Methods for Supplementary Cementitious Materials

Background

Supplementary cementitious materials (SCMs) are commonly used to partially replace cement in concrete. In Texas, and most of the U.S., Class F fly ash is the most used SCM due to the many benefits it provides to concrete regarding cost, long-term performance, and durability. In recent years, the availability of Class F fly ash has decreased due to changes in the energy sector causing many coal-fired power plants to shut down. Plants that have not shut down are required to install various emission control systems that can significantly alter the type of fly ash produced. As the face of fly ash production continues to change and supplies of traditional fly ash diminish, the Texas Department of Transportation (TxDOT) and other DOTs must determine if non-traditional fly ashes and other SCMs are usable in concrete.

The supply of Class F fly ash, even including non-traditional sources, may not be enough to meet the demand for SCMs in concrete as concrete production continues to grow, which is spurring an interest in alternative SCMs. Currently, alternative materials are subjected to extensive and long-term testing to qualify their use in concrete. These tests are necessary to fully assess new materials, but as new sources of SCMs are rapidly entering the market, it is inefficient and expensive to perform extensive testing on every potential material source. Rapid tests are necessary to quickly screen out poor-performing materials to reduce the cost and time of long-term testing.

What the Researchers Did

The experimental protocols developed in project he experimental protocols developed in TxDOT project 0-6717: Investigation of Alternative Supplementary Cementing Materials (SCMs), completed in August 2014, and TxDOT project 5-6717: Implementation: Investigation of Alternative Supplementary Cementing Materials (SCMs), completed in August 2017, were performed on a variety of non-traditional fly ashes to determine their suitability for use in concrete. Materials tested include fly ashes from blended coal sources, Class C and Class F fly ash blends, blends of Class F fly ash and milled bottom ash, and remediated off-spec fly ashes. The chemical and physical properties of the materials were examined as well as the performance of these materials in paste, mortar, and concrete. The performance and characteristics of the fly ashes were compared to a traditional Class F fly ash.

In conjunction with long-term testing, rapid SCM screening tests were conducted on materials of different types of reactivity to determine the effectiveness of the tests to screen out poor-performing materials and distinguish between different types of reactivity. Rapid screening tests included standardized methods as well as innovative approaches.

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What They Found

In most cases, non-traditional fly ashes and fly ash blends that meet the physical and chemical requirements of Class F fly ash, but not the definition, perform very similarly to Class F fly ash. This is very promising for the use of these materials in concrete mixtures. There were only a few cases where the fly ashes had performance concerns.

It was determined that remediated fly ash with a high sulfate content can cause the concrete mixture to become oversulfated. This can cause issues in construction, such as delayed setting time, and the use of these fly ashes should be avoided until a solution is found.

Many of the fly ashes tested were blended or remediated in some manner. These processes alter the particle shape of the fly ash from spherical to angular, which can impact concrete workability. Water-reducing admixtures can be used to improve the fresh state concrete properties when using angular materials. While some of the fly ashes required more air entrainment agent (AEA) to achieve a target entrained air content, adequate spacing factors were achieved. This indicates that concrete with these fly ashes can have sufficient protection against freeze-thaw if the air content is adequate.

Class F fly ashes generally improve sulfate resistance of mortars, but it was found that some of the materials performed poorly in sulfate attack testing. The poor performers were either low reactive SCMs or contained sulfate-vulnerable crystalline phases, generally originating from blending with a Class C fly ash. While it is possible to screen for these factors using reactivity tests and x-ray diffraction analysis, additional testing is necessary to determine how to improve the sulfate resistance of these materials.

Two rapid test methods were found to be effective at quickly screening out poor-performing, inert materials: the rapid, relevant, and reliable (R3) test (through calorimetry or bound water) and the University of New Brunswick Pozzolanic Reactivity Test (UNBPRT). By adding an additional test that extends the bound water testing of the R3 method to a higher temperature, called the R3P test, pozzolanic and hydraulic SCMs can be distinguished.

What This Means

The research confirmed the usability of non-traditional fly ash in concrete on a performance basis. By validating these materials, the research provided an avenue for new materials to be included in TxDOT supplier lists. A testing protocol was also developed to screen out poor-performing materials and distinguish between different material reactivity types. By using these protocols, TxDOT can reduce the amount of time spent on testing new materials and quickly determine if changes have been made to existing sources

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