Alkali-Silica Reaction Mitigation Using High Volume Class C Fly Ash

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THE PROBLEM

Alkali-silica reaction (ASR) occurs between reactive silica typically found in aggregates (rock and sand), alkalis in cement, and an external source of water. It forms a gel that imbibes water, which exerts internal pressure in the concrete, leading to cracking and premature deterioration of the structure.

Partially replacing cement in concrete mixtures with fly ash can help reduce ASR. Class F fly ash is the industry standard, but it is not available in Arkansas unless shipped from Texas. Arkansas has an abundance of Class C fly ash.

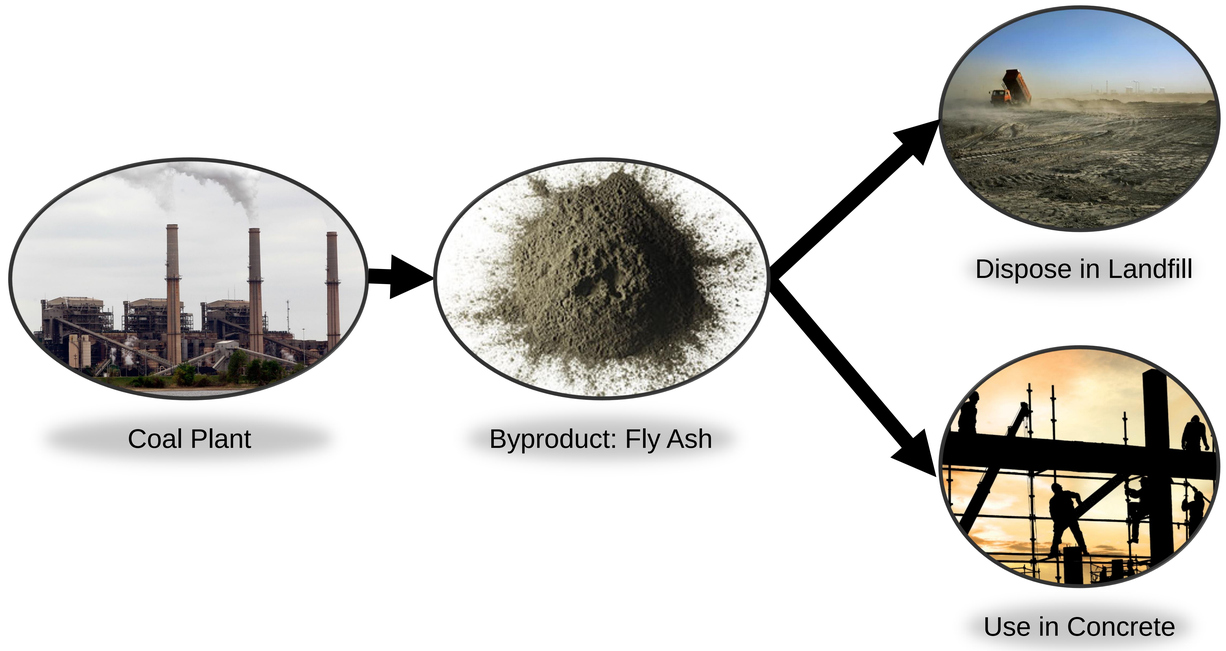
Barrier wall exhibiting ASR deterioration

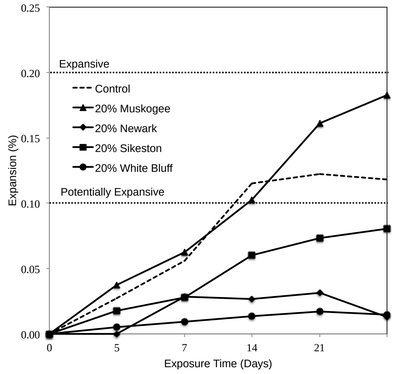
THE PROJECT

Investigate the effectiveness of Class C fly ash as a partial cement replacement in concrete using the accelerated mortar bar test (ASTM C1567).

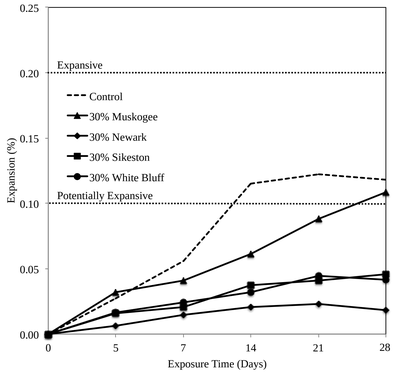
- Soak mortar bars for 28 days in 1 N NaOH at 80° C.
- Measure expansion using a digital micrometer at 1, 5, 7, 14, and 28 days after casting.
- If mixture passes the test (expansion <0.10% at 14 days), the likelihood of ASR occurring is minimal.

All of the Class C fly ash sources tested effectively reduced the expansion of the mortar prisms when used at levels above the pessimum limit.

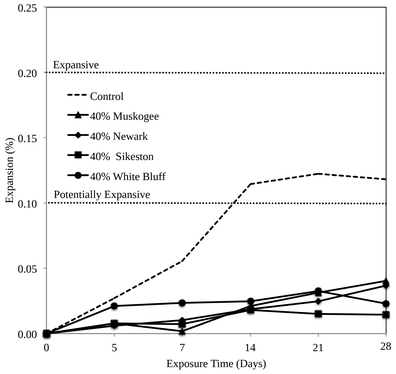




Effect of 20% fly ash replacement on ARS expansion

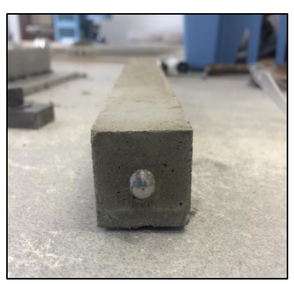


Effect of 30% fly ash replacement on ARS expansion

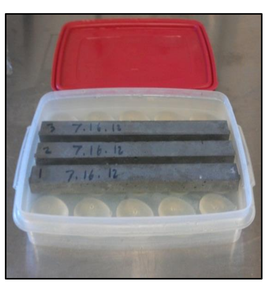


Effect of 40% fly ash replacement on ARS expansion

Specimens



End view of specimen



Alkali Bath

Digital Micrometer

SUSTAINABILITY

Natural System

Cement production accounts for 5% of global carbon dioxide emissions. Replacing a portion of cement with fly ash reduces energy consumption and emissions and diverts coal production byproducts from landfills. Over 80 million tons of residue produced from coal combustion is disposed of in landfills every year in the United States. Fly ash provides greater workability properties, meaning less water is needed in the mixture and pump ability is greatly enhanced, which saves energy.

Built System

ASR can deteriorate a structure quickly. Fly ash increases concrete's durability and extends its service life. With infrastructure costs on the rise, the design life needs to be maximized.

Social System

Shipping fly ash within Arkansas may provide more jobs for its residents.

Managed System

Minimum compressive strength requirements can be achieved quicker with the use of fly ash, which decreases construction time, In addition to the time saving factor, which is essentially money, fly ash costs approximately 50% less than cement, making it a cost effective solution.

Student's Outlook on Sustainability

Engineering problems extend beyond equations and calculations. One small change can greatly affect the natural, built, social, and managed systems. Everything is connected, and an engineering problem cannot be isolated.

This poster was prepared in partial fulfillment of SUST 4103 Sustainability Capstone