

# Project: Alkali Silica Reaction (ASR) in Cement Free Alkali Activated Sustainable Concrete

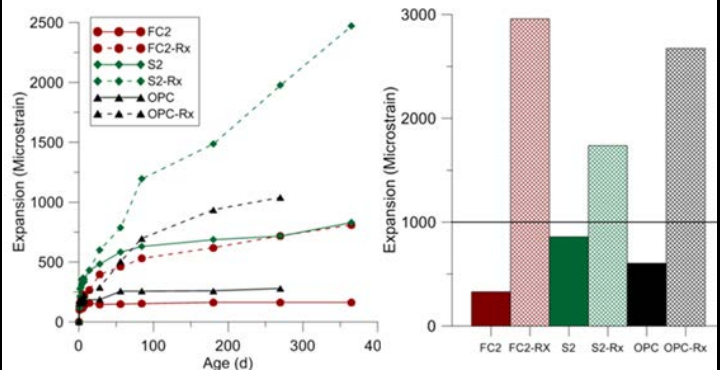
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Alkali-activated concrete (AAC) is an emerging technology in the construction materials sector. Being cement-free, AAC is a promising environmentally-friendly alternative to ordinary portland cement (OPC) concrete. Despite the improved performance and sustainability of AAC that has been established through various studies, some major technical challenges still remain in its realization as a viable construction material. One of them is the uncertainty with respect to the alkali-silica reactivity (ASR) durability performance of AAC. It was suggested that the AAC might be more vulnerable to ASR than OPC since a strong alkaline solution is required for the activation process.

ASR can cause cracking and premature failure of AAC. In this project, a comprehensive study was performed to: (1) assess the validity of using existing ASTM ASR test methods for traditional concrete to measure the ASR reactivity of AAC; (2) quantify the expansion kinetics of slag and fly ash based AAC in the presence of innocuous (non-reactive) and reactive aggregate as a function of the activator type, concentration and solution to binder ratio; (3) assess the microstructural changes due to ASR expansion in AAC; and (4) derive the mechanism of ASR reaction in the slag cement and fly ash based AAC.

No deleterious ASR occurred in AAC concrete unless highly reactive aggregate was used in the mixture. Results from this study also show that both the long-term ASTM test method C1293 and accelerated C1567 can be used for evaluating the potential ASR reactivity of alkali activated systems but care should be taken to interpret the results. Both the test methods had given some false positive test results when there was no ASR occurred in the system. Hence, it is recommended to use petrographic analysis as a supplementary test to verify the findings of ASTM C1293 and C1567 test results. Several alkali activated slag cement concrete samples experienced expansion beyond the stipulated limit of ASTM C1293. Those samples had excessive autogenous shrinkage and very low internal relative humidity before exposing them to the test environment (100% RH, specifically). Samples absorbed moisture immediately after exposing them to the test environment and expanded ~400  $\mu\text{e}$  even during the first week of exposure to ASTM C 1293 test condition.

It is recommended either to precondition the samples (such as heat curing the samples to 40°C for 24 hours and soaking it in water for another day before exposing the samples to ASTM C1293) or increase the expansion limit from 400  $\mu\text{e}$  to 1000 when evaluating slag cement based AAC with excessive autogenous shrinkage and low internal relative humidity is needed. The 400  $\mu\text{e}$  expansion limit was found to be more effective for fly ash based AAC. The expansions were minimal unless reactive aggregates were used in the experiment.



**Fig.1: Expansion of slag (S) and fly ash (FC) based AAC under ASTM C1293 (left) and C1567 (right). Rx-indicates concrete with reactive aggregate.**

In petrography analyses, ASR reaction product or gel was not found in AAC concrete with non-reactive aggregate. Even in samples with reactive aggregate, the cracks in the aggregate did not show much gels inside them in contrast to the massive gel formation found in the cracks of the reactive aggregate in the OPC system. Finding the presence of extensive amount of ASR gels elsewhere in the sample was also challenging in the AAC with reactive aggregate. Occasionally, a rosette-shaped ASR gel was found in slag cement based AAC with reactive aggregate. The observed high resistance of AAC to ASR can be attributed to (1) the lack of sufficient amount of free alkali in the AAC system due to the binding of most of the available alkali by the reaction products (70% by 8 hours) very early on during hydration, and 2) due to the absence of calcium hydroxide in the AAC system.

**Sponsors:**

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