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Performance of Fibre-Reinforced Slag-Based Alkali Activated Mortar in Acidic Environment

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1 Introduction

Interaction of cementitious materials with acidic environment is an important factor to be considered for the durability of structures exposed to aggressive environments. Though there are published studies on the low solubility and high resistance of AAM in aggressive environments (Aiken *et al*., 2018), there are also limitations in understanding their performance in the presence of fibers. In this study, an effort is made to study the effect of sulphuric (H_2SO_4) and acetic (CH_3COOH) acid on alkali activated slag (AAS) mortar with different fibers.

2 Material and Methodology

Alkali activated slag mortar (G1) was made with ground granulated blast furnace slag co-grinded with anhydrous sodium silicate in the ratio of 1:9. Binder to aggregate ratio was 1:2, in which the fibers (Steel, glass, basalt) were introduced. Water-binder ratio (0.35) and fiber content (1% weight of binder) were kept constant. Fresh fiber-reinforced AAS mortar was cast into cubic molds and cured in 20 ˚C with 100% RH for 28 days. Mix were named in such a way: G1S6 represents G1 mix with steel fiber of 6 mm length. Similarly, G and B were used for glass and basalt fibers, respectively. Resistance to acid attack was studied by exposing the cubic specimens in 5% acetic (pH 2.4) and sulphuric (pH 0.8) acids for 30 days.

3 Results and Discussion

Visual examination of the AAS mortar shows very small change in appearance with acetic acid environment, however there is visible disintegration of the specimen when exposed to sulphuric acid. Figure 1 (a) displays the effect of fibers on the compressive strength of AAS mortar before and after exposed to acetic and sulphuric acid. It also indicates the percentage reduction in strength with different mix in acidic medium. The addition of steel fibers increased the compressive strength of AAS mortar significantly whereas it was not the case with glass and basalt fibers. Strength reduction with acetic acid exposure is within 10% for the fiber reinforced AAS mortar except basalt fiber. This could be due to the use of uncoated

basalt fiber which might have been damaged in the high alkaline medium (Wei *et al*., 2010).

Further exploring the chemical/ mineralogical changes on the acid exposed specimens explains that the reaction products formed by interaction of different acids plays an important role. The formation of calcium acetate as an intermediate layer in acetic samples, acted as a protection to the core matrix from further attack (Fig. 1b). Though there is also formation of similar layer with sulphuric acid, the reaction products are mainly gypsum and calcite (Fig. 1b) which were not stable enough to stop the progress of the sulphuric acid in to the core (Khan *et al*., 2018).

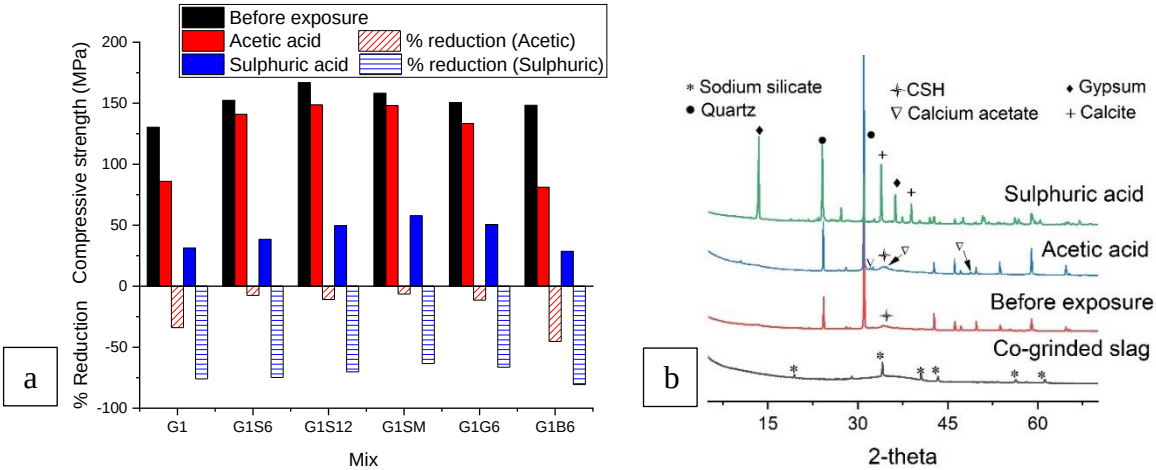

Figure 1. X-ray diffraction curves and compressive strength of alkali activated slag mortar.

4 Conclusions

The effect of sulphuric acid on the AAS mortar was detrimental which is also the case with fiber reinforced AAS mortar. However, with incorporation of fibers, the residual strength improved in the corroded specimens irrespective of the type of acid. Residual strength of AAS mortar specimens are 19% and 7% higher with the reinforcement of mixed steel fibers (6 and 12 mm) in acetic and sulphuric acid exposure, respectively.

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References

Aiken, T. A., Kwasny, J., Sha, W. and Soutsos, M. N. (2018). Effect of slag content and activator dosage on the resistance of fly ash geopolymer binders to sulfuric acid attack. *Cement and Concrete Research*, Elsevier, 111(April), 23–40. doi: 10.1016/j.cemconres.2018.06.011

Khan, H. A., Khan, M. S. H., Castel, A. and Sunarho, J. (2018). "Deterioration of alkali-activated mortars exposed to natural aggressive sewer environment." *Construction and Building Materials*, 186, 577–597. doi: 10.1016/j.conbuildmat.2018.07.137

Wei, B., Cao, H. and Song, S. (2010). "Tensile behavior contrast of basalt and glass fibers after chemical treatment." *Materials and Design*, 31(9), 4244–4250. doi: 10.1016/j.matdes.2010.04.009