

## ABSTRACT

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Title: The Effects of Air-Cooled Blast Furnace Slag (ACBFS) Aggregate on the Chemistry of Pore Solution and the Interfacial Transition Zone

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Numerous laboratory and field studies have demonstrated that concrete incorporating air cooled blast furnace slag (ACBFS) aggregate showed a higher degree of infilling of voids with ettringite as opposed to concrete prepared using naturally mined carbonate aggregates when exposed to similar environmental conditions. This observation prompted some to link the deterioration observed in the ACBFS aggregate concrete structures to the compromised freeze-thaw resistance due to infilling of air voids. Concerns about the release of sulfur from ACBFS aggregate into the pore solution of concrete had been presented as the reason for the observed ettringite deposits in the air voids. However, literature quantifying the influence of ACBFS aggregate on the chemistry of the pore solution of concrete is absent. Therefore, the main purpose of this research was to quantify the effects of ACBFS aggregate on the chemistry of the pore solution of mortars incorporating them.

Coarse and crushed ACBFS aggregates were submerged in artificial pore solutions (APSs) representing pore solutions of 3-day, 7-day, and 28-day hydrated plain, binary, and ternary paste systems. The change in the chemistry of the artificial pore solution was recorded to quantify the chemical contribution of ACBFS aggregate to the pore solution of concrete. It was observed that the sulfate concentration of all APSs increased once they were in contact with either coarse or crushed ACBFS aggregate. After 28 days of contact, the increase in sulfate concentration of the APSs ranged from 4.85 – 12.23 mmol/L and 14.21 – 16.87 mmol/L for contact with coarse and crushed ACBFS aggregate, respectively. More than 40% of the total sulfate that was released by the ACBFS aggregate occurred during the first 72 hours (3 days) of its contact with the APSs. There was little or no difference in the amount of sulfate released from ACBFS aggregate in the different types of APSs. In other words, the type of binder solution from which pore solution was

extracted had no effect on the amount of sulfate that was released when it was in contact with ACBFS aggregate.

The relatively quick release of sulfur from ACBFS aggregate into the APSs prompted investigation of the chemical composition of the pore solution of mortar (at early stages of hydration) incorporating ACBFS aggregate. The chemical composition of the pore solutions obtained from mortars prepared using ACBFS aggregate and plain and binary paste matrices was compared those of mortars prepared using Ottawa sand and plain and binary paste matrices. After 7 days of hydration, the sulfur (S) concentration of the pore solution extracted from mortars prepared using ACBFS aggregate was 3.4 – 5.6 times greater than that obtained from corresponding mortars (i.e. mortars with the same paste matrix) prepared using Ottawa sand. Binary mortars containing fly ash (FA) showed the lowest S content after 7 days of hydration amongst all mortars prepared using ACBFS aggregate. On the other hand, binary mortars prepared using slag cement (SC) and ACBFS aggregate had the highest S concentration after 7 days of hydration. These effects on the S concentration in the pore solutions can be explained by the difference in the chemical makeup of the binders, and not because of different rate of release of S from ACBFS into the pore solution. In addition, XRD analysis of 1-day and 7-day hydrated mortars revealed that the monosulfate content was significantly higher in mortars prepared using ACBFS aggregate as opposed to those prepared using Ottawa sand.

The properties of the interfacial transition zone (ITZ), i.e. the zone in the vicinity of the aggregate surface, depends on the property of the aggregate such as its porosity and texture. Therefore, it is expected that the properties of ITZ around the ACBFS particle, which is porous and proven to contribute sulfate, be different from the ITZ around the naturally mined siliceous aggregate. Image analysis conducted on backscattered images obtained using scanning electron microscope revealed that the ITZ of naturally mined siliceous aggregate was more porous compared to the ITZ of ACBFS aggregate. In addition, deposits of sulfate bearing hydration products such as ettringite were more frequently encountered in the ITZ around the ACBFS aggregate than in the ITZ around that of siliceous sand. On the other hand, calcium hydroxide deposits were more frequent and larger in size in the ITZ around siliceous sand than in the case of the ITZ around the ACBFS aggregate.