ALKALI ACTIVATED CEMENTITIOUS MATERIAL FROM IRON-RICH SLAGS

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Introduction

The environmental impact of the production of Ordinary Portland Cement (OPC) [1] has led to the use of more environmentally friendly binders. This work presents the ability of iron-rich slags to be alkali-activated and used as a cementitious material, hereby improving the carbon footprint and cost efficiency of the binder. Thus, a more sustainable construction industry may arise with the valorisation of iron-rich slag which remain majorly stockpiled as industrial wastes [2].

A 'two part' geopolymer system [3] with potassium hydroxide and potassium silicate as activators (silicate modulus of 2.25 and 57.8 % water content) was mixed with an iron-rich slag at a constant liquid to solid ratio of 0.46. The slag was milled to obtain two different Blaine values of 3000 cm^2/g and 4100 cm^2/g and the influence of the fines on the mechanical development and the microstructure of the inorganic polymer was studied. The mechanical properties were tested for paste samples cured at 80 °C for 24 hours and at different curing ages of 2, 7 and 28 days. Thus, this work is providing a solid basis for further research on understanding the potential of using iron rich slags as binders and the mechanisms in the geoploymerisation process.

Experimental Methods and Results

Isothermal calorimetry

The rate of heat evolution versus reaction was recorded with an isothermal calorimeter for a period of 7 days.

Scanning Electron Microscopy

This electron microscopy technique was applied to the raw material slag as well as to the cured alkali activated materials .

Compressive strength

The compressive strength analysis was carried out at 2, 7, and 28 days of ageing periods

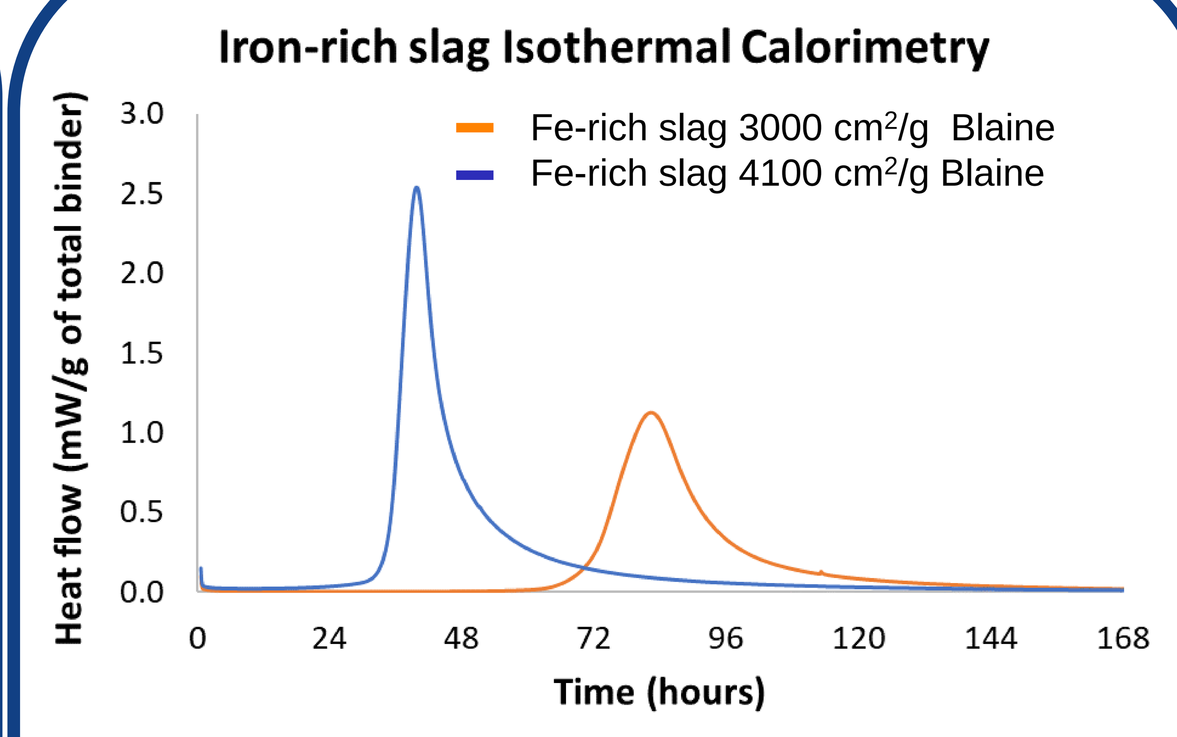

Figure 1: Alkali-activated iron-rich slag Isothermal Calorimetry for: 20 °C (L/S = 0.46).

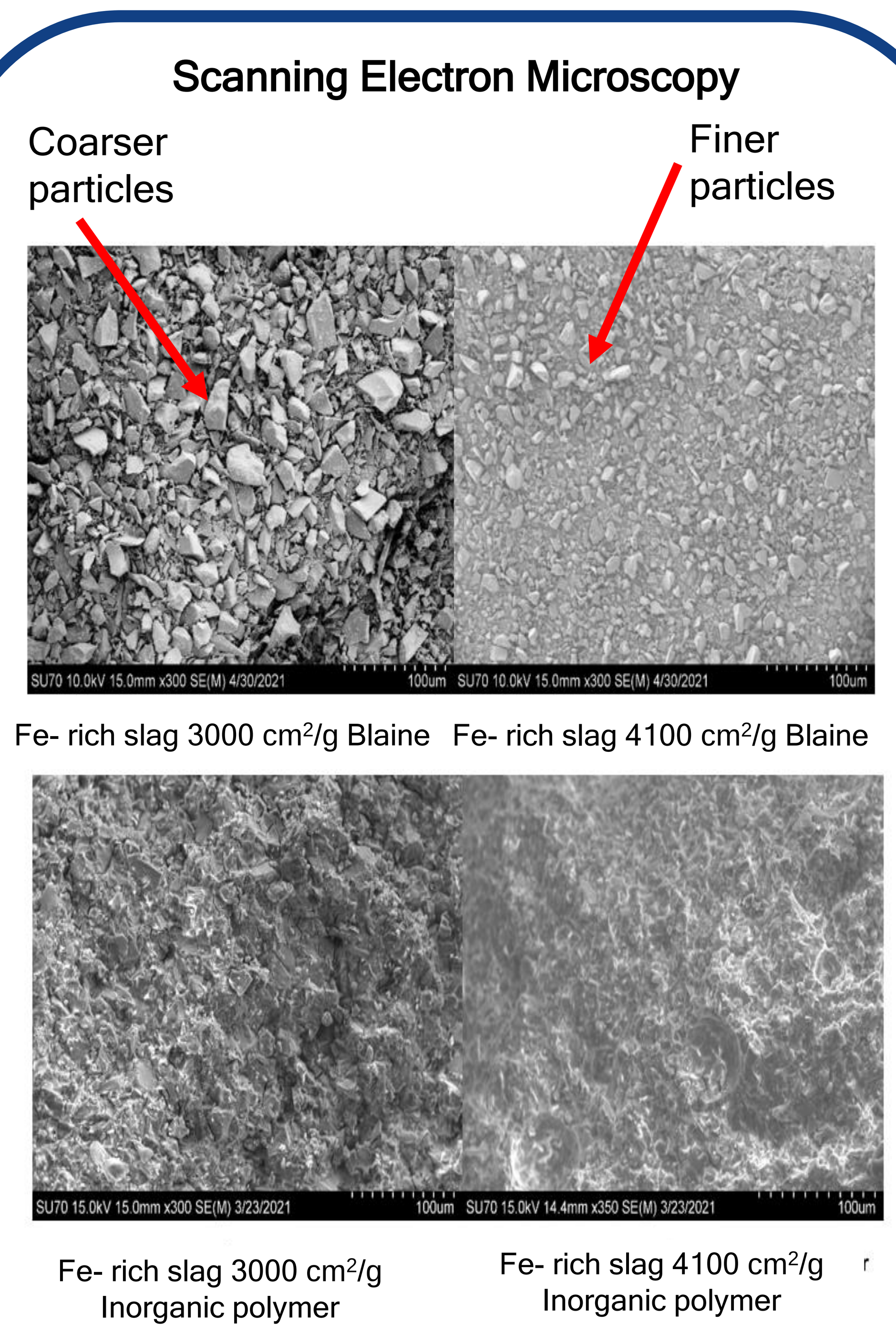

Figure 2 - Scanning Electron Microscopy

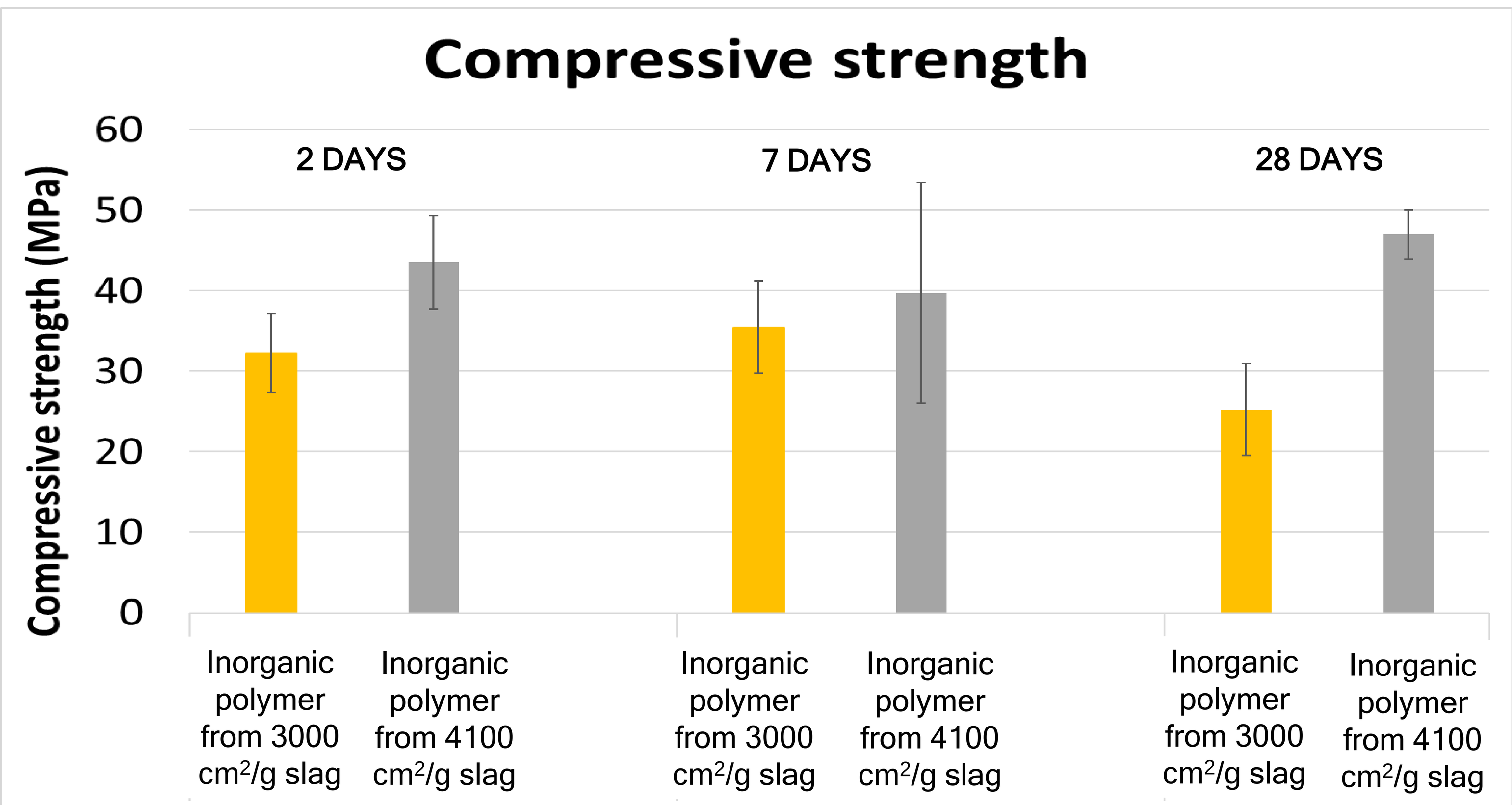

Figure 3 - Compressive strength Analysis

Conclusions

- Fe-rich slag inorganic polymer paste is workable with a liquid to solid ratio of 0.46.
- The smaller the particle size (3000 cm^2/g) of the slag, the slower the reaction start compared to slags of larger particle size (4100 cm^2/g).
- SEM images of the raw materials confirm the difference in particle size, previously measured by the Blaine method
- The inorganic polymer micrograph depicts the presence of pores due to the air trapped.
- The compressive strength of samples cured at 80 °C varies between 20-48 MPa, therefore, a wide range of possible applications in construction works [4].
- Inorganic polymers formed from slag of lower particle size (3000 cm^2/g) have lower compressive strengths compared to those with large particle size (4100 cm^2/g). The strength however does not significantly improve over time, probably after curing at 80 °C and ageing for 7 days, there is no potential for increase.

References

[1] A. Palomoa, P. Monteirob, P. Martauzc, V. Bilekd, A. Fernandez-Jimeneza. Hybrid binders: A journey from the past to a sustainable future (opus caementicium futurum). Cement and Concrete Research 124 (2019) 105829.
[2] Jagmeet Singh, S. P. Singh, Evaluating the alkali-silica reaction in alkali-activated copper slag mortars, Constr. Build. Mater. 253 (2020) 119189.
[3] J. L. Provis and Jannie S. J. Van Deventer. Alkali Activated Materials (2014). Springer State-of-the-Art Report, RILEM TC 224-AAM.
[4] A. M. Neville, J. J. Brooks. Concrete Technology, Second Edition 2010.

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