Effects of Ca-rich slag addition on inorganic polymers from fayalite slag

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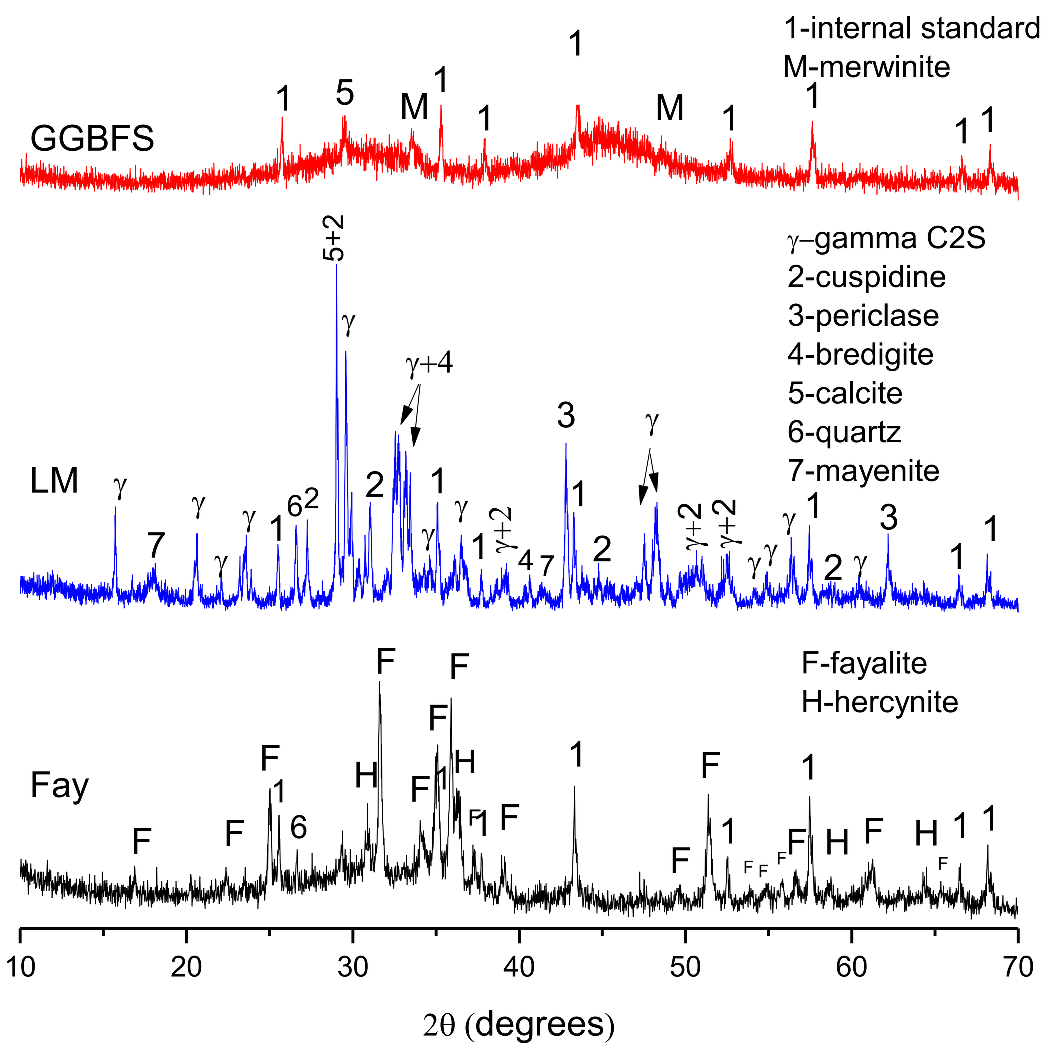
Abstract

Two Ca-rich industrial residues, i.e. ground granulated blast furnace slag (GGBFS) and ladle slag from stainless steel making (LM), were introduced as additives in a fayalite slag (Fay)-based inorganic polymer. The goal was to investigate if the mechanical properties of the final materials could be improved, under the condition that these materials would have been produced only from slags, originating at industries geographically not far from each other. Solutions of NaOH and Na-silicate, mixed in SiO_2/Na_2O and H_2O/Na_2O molar ratios of 1.2 and 22.2, respectively, were used as activators. Different analytical methods were used to investigate the properties of synthesized inorganic polymers. It was found that the compressive strength increases remarkably with the addition of GGBFS, while the addition of LM slag leads to a strength decrease. In all three systems, Fe and Si are the dominant elements in the evolving binder, but as expected, the addition of GGBFS and LM slag does increase the Ca content.

1. Materials

Table 1 Chemical composition of slags used in this study (XRF)

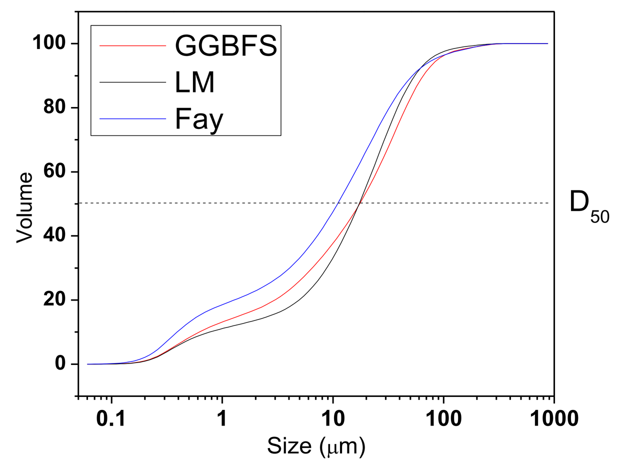
Oxide (wt%)	CaO	FeO	SiO_2	Al_2O_3	others
Fay	1.9	41.8	31.3	7.9	17.1
GGBFS	43.2	0.3	34.2	8.7	13.6
LM	57.8	0.3	28.5	1.2	12.2



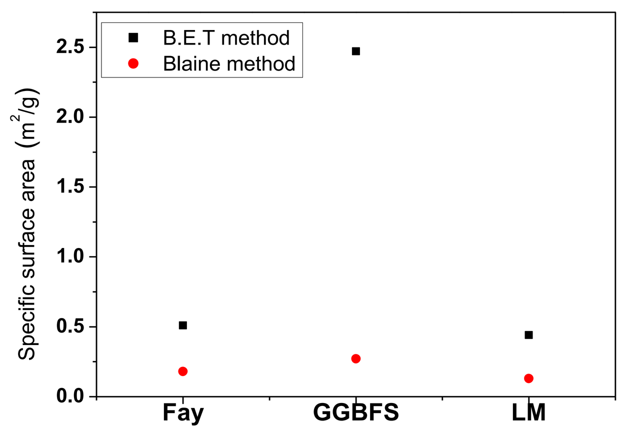
Slags	Amorphous content (from QXRD)
GGBFS	95 wt%
LM	20 wt%
Fay	77 wt%

Figure 1 X-ray diffractograms of slag precursors

2. Grain fineness of slag precursors



Similar particle distribution



Surface area: GGBFS>Fay>LM

3. Formulations design

- Ca-rich slags were introduced at room temperature and added at identical FeO/CaO molar ratio (2.5)
- Distilled water was added to keep the workability of the IP pastes comparable

Table 2: Fay-based IP formulations and percentages of water added with respect to the total amount of liquid

Samples	Solid			Liquid		Solid/Liquid ratio
	Fay (wt%)	GGBFS (wt%)	LM (wt%)	Activators (wt%)	Water (wt%)	
100Fay	100	-	-	100	-	5.5
20GFay	80	20	-	95.5	4.5	5.3
15.75LFay	84.25	-	15.75	90.5	9.5	5.0

4. Properties of synthesized inorganic polymers

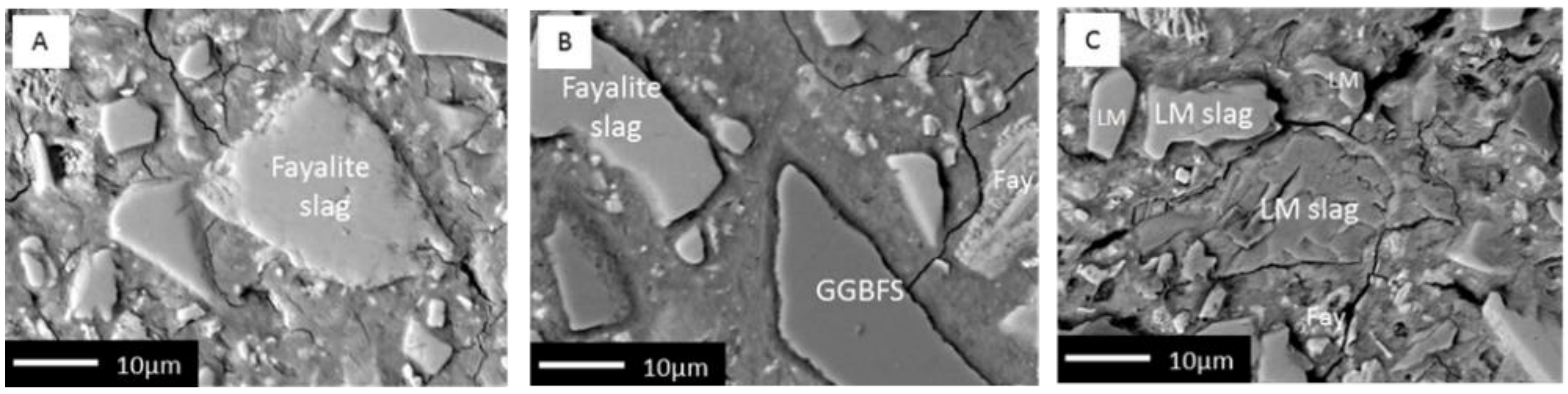


Figure 2: BSE images of 28-day IP samples (×2000) (A) 100Fay (B) 20GFay (C) 15.75LFay

Samples	Compressive Strength (MPa)	
	7-day	28-day
100Fay	66.6±1.1	64.7±1.7
20GFay	93.8±1.6	122.0±6.4
15.75LFay	42.2±1.9	43.7±1.8

Table 3: Compressive strength of synthesized inorganic polymers

5. Conclusions

- The alkaline reactivity of Ca-rich slags strongly influences the mechanical behavior of blended inorganic polymers.
- In the samples with 20 wt% GGBFS, the compressive strength reached 120MPa, which is almost two times of that of 100Fay. In contrast, in the sample with 15.75 wt% LM slag, the compressive strength decreased around 30% with respect to 100Fay.