Optimisation of hydraulic properties of a C_4AF, C_3A-rich metallurgical residue

Ahmet Dok, Lubica Kriskova*, Remus I. Iacobescu, Yiannis Pontikes

KU Leuven Department of Materials Engineering, 3001 Leuven, Belgium

KU LEUVEN

SREMat Sustainable Resources for Engineered Materials

ABSTRACT

The possibility to improve the hydraulic behaviour, workability and mechanical strength of a heat-treated metallurgical residue from sponge iron production has been explored in the current work. The as-received metallurgical residue (MR) was mixed with $CaCO_3$ and subjected to heat-treatment in a sinter pan with the aim to adapt its chemical and mineralogical composition towards Ordinary Portland Cement (OPC). The major phases of the treated metallurgical residue were C_2S, C_3A, C_4AF and C_3A. Although all these phases are commonly present in OPC, the high content of C_4AF and C_3A (> 27 wt%) resulted in flash setting, insufficient workability and lower strength results, compared to OPC. To address this, the hydraulic properties of the treated MR were adjusted by additions of various amounts of gypsum, plasticizer (Viscocrete®, Sika®) and triisopropanolamine, TIPA. The results indicated that optimal gypsum addition lies close to 10 wt%; further increase resulted in mechanical strength decline. Additions of TIPA and Viscocrete® enhanced the workability and mechanical strength, but had also a significant effect on the formed hydration products.

INTRODUCTION

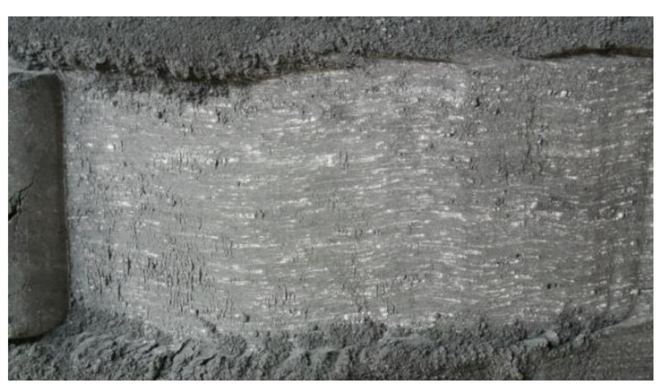
Minimizing waste production, consumption of natural resources, and CO_2 emissions are frequent topics addressed globaly.[1] Production of Ordinary Portland Cements (OPC) is strongly connected to the last two mentioned issues, whilst production of metals in pyro metallurgical processes is connected to a large amount of slag production, which is often landfilled, and therefore contributes to the waste accumulation. It is indeed the reduction in the consumption of the natural resources and the minimisation of the waste production that are the main driving forces behind the development of alternative binders from metallurgical residues.

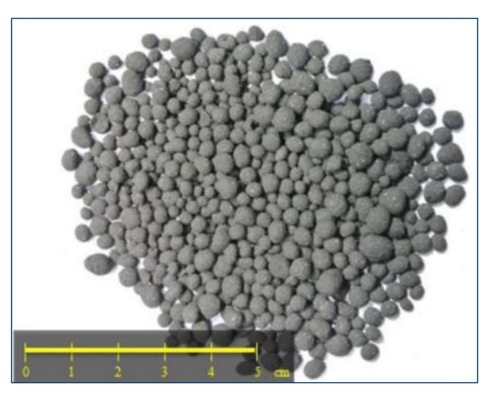
Several industrial residues have been reported as being successfully converted into binders with similar or better properties than OPC.[2-6] The aim of this work was to further extend the family of alternative binders by adapting the chemical and mineralogical composition of a Ca-Si-rich metallurgical residue (MR) from sponge iron production, and creating a hydraulic binder similar to OPC.

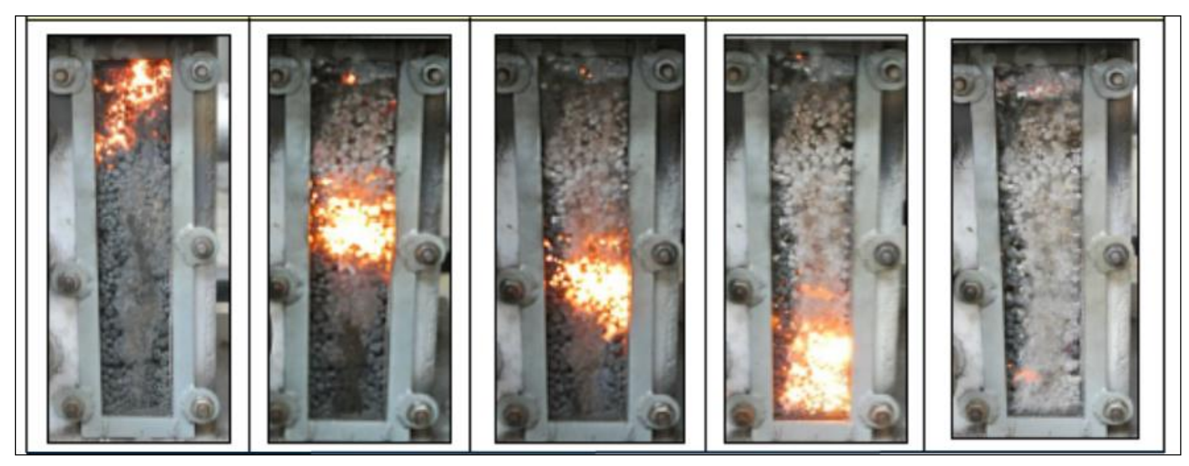
RESULTS

As received MR

$CaCO_3$







Chemical composition	CaO	SiO_2	Fe_2O_3	Al_2O_3	SO_3	TiO_2	MgO	C
As received MR	55	14	7	6	2	1	1	14
Treated MR	64	16	9	7	2	1	1	-

Mineralogical composition	$\beta-C_2S$	C_3S	C_4AF	C_3A	$\gamma-C_2S$	$Ca(OH)_2$	CaO
Treated MR	37	26	19	8	7	2	<1

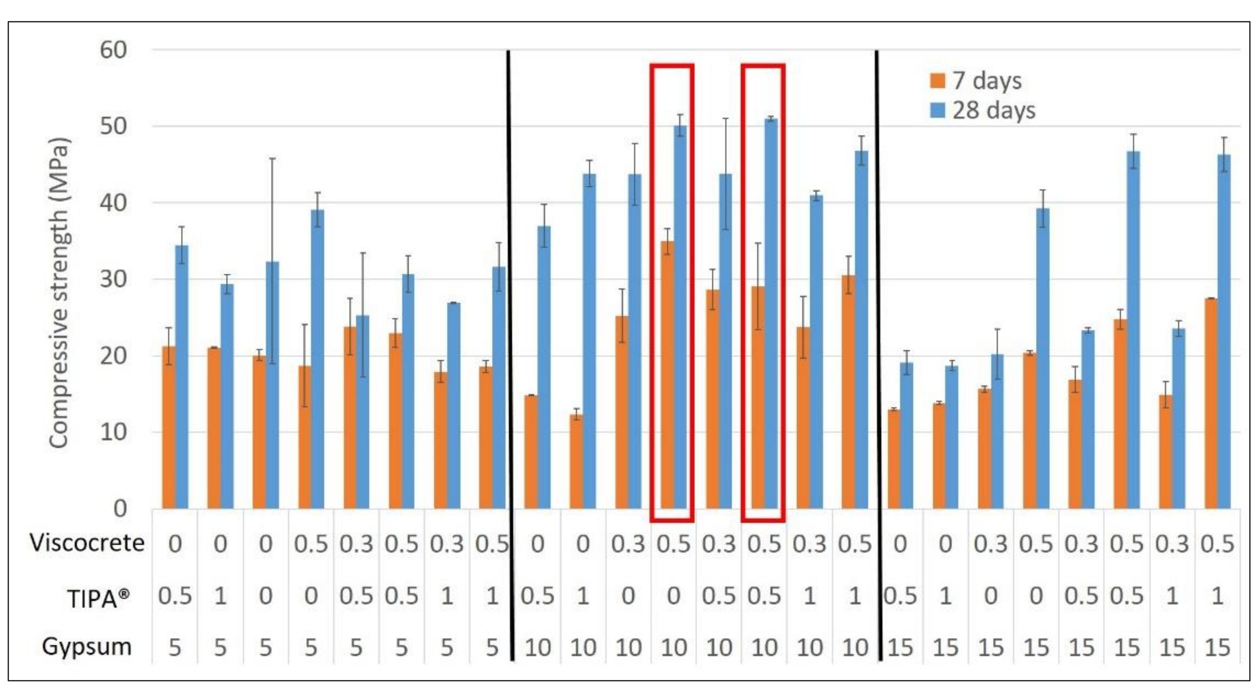


Fig.1: Compressive strength of samples with various gypsum (5-15 wt%), TIPA (0-0.5 wt%) and Viscocrete® (0-0.5 wt%) additions

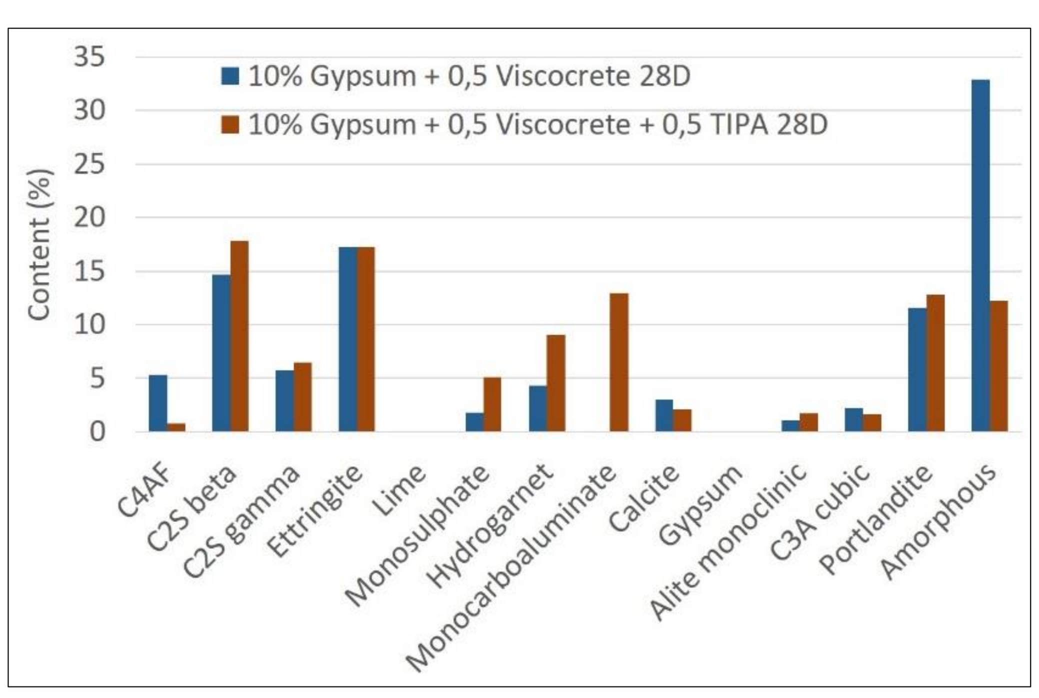


Fig.2: Hydration phases formed after 28 days in system with 10 wt% gypsum, 0.5 wt% Viscocrete® and with (red) / without (blue)TIPA

CONCLUSIONS

MR originating from a sponge iron production was successfully converted into a hydraulic binder after adjusting its chemical and mineralogical composition by means of $CaCO_3$ addition and sintering in a sinter pan. The resulting material (i.e. OPC replica) contained all four main hydraulic phases: C_3S, C_2S, C_3A and C_4AF. The relatively high amount of C_3A and C_4AF led to an increased requirement of gypsum addition. From the additives selected, Viscocrete® showed to have a positive effect on strength results, however its addition should be limited to 0.1 wt% due to increased risk of particle sedimentation/separation. TIPA significantly influenced the hydration products, with no noticeable impact on compressive strength.

REFERENCES

1. R. Kikuchi, Resour Conserv Recycl, 31 (2) 137-147 (2001)
2. Y. Pontikes et al. ,Adv Cem Res, 25 (1) 21-31 (2013)
3. J. B. F. Neto et al., Proceedings of the 10th Int. Conference on Molten Slags, Fluxes and Salts, US, 2016
4. J. B. Ferreira Neto et al., J of Sustainable Metall, 2 (1) 13-27 (2016)
5. W. Banda and H. Lagendijk, Proceedings of the 5th Int. Slag Valorisation Symposium, Belgium, 2017
6. A. Ehrenberg and D. Algermissen, Proceedings of the 5th Int. Slag Valorisation Symposium, Belgium, 2017.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the EIT Raw Material project 15035 for the financial support.

eit RawMaterials

6th International
Slag Valorisation Symposium

Science, Innovation & Entrepreneurship in Pursuit of a Sustainable World

1-5 April 2019 Mechelen, Belgium