Design and optimisation of new formulations of Belite-Alite Calcium Sulfoaluminate (BACSA) eco-cements

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Abstract
Belite Calcium SulfoAluminate (BCSA) eco-cements were developed as OPC substitutes since in their production release 22% less CO_2 than OPC. BCSA eco-cements contain belite as main phase (>50 wt%) and ye'elimite as secondary main phase (~30 wt%). However, these materials develop low mechanical strengths at intermediate hydration ages (3, 7 and 28 days). A solution to this problem may involve the design and preparation of clinker/cement with the highest percentage of coexisting alite and ye'elimite. These materials are known as Belite-Alite Calcium SulfoAluminate (BACSA) clinkers/cements. Their manufacture may produce 15% less CO_2 than OPC. Alite is the main component of OPC and is responsible for early mechanical strengths. The reaction of alite and ye´elimite with water will develop cements with high mechanical strengths at early ages, while belite will contribute to later curing times.

This work is focused on the design and optimisation of all the parameters evolved in the preparation of BACSA eco-clinkers that develop mechanical strengths comparable to those of OPC with a reduction in CO_2 emissions of at least 15% when compared to OPC production. These parameters include the selection of the raw materials (lime, gypsum, kaolin and sand), milling conditions of the crude, clinkering temperature (from 1280 to 1300ºC) and holding time at every temperature, and final composition. The clinker with the targeted composition (belite ~ 60 wt%, alite ~ 13 wt% and ye'elimite ~ 10 wt%) was chosen to perform the scaling-up (2 kg).

BACSA eco-clinkers were chemically and mineralogically characterised through X-ray fluorescence and laboratory X-ray powder diffraction (LXRPD), the latter in combination with the Rietveld methodology to obtain the full phase assemblage including Amorphous and Crystalline non-quantified, ACn, contents.

Finally, the hydration of the selected BACSA cement paste (prepared with the scaled-up clinker and anhydrite) was studied mainly through rheological measurements (at very early hydration time) and LXRPD in combination with the Rietveld methodology and G-factor method. The compressive strengths were also measured at different hydration times and were compared with OPC.

Keywords*: BACSA eco-cement, clinkering, rheological behaviour, Rietveld Quantitative Phase Analysis, laboratory X-ray powder diffraction, compressive strengths.*

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