X-ray diffraction, cements and environment, three worlds in one.

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Abstract. This keynote lecture will be focused on the strategies for reducing CO_2 emissions in the cement production. Concretely, the production of ecocements with optimised formulations that yield reductions in CO_2 emissions of up to 25%, when compared to OPC production. Phase assemblage has to be carefully optimised to be competitive and these new ecocements should develop compressive strengths of at least 50 MPa at 28 days of hydration. Optimised compositions of several ecocements will be discussed, but all of them are ye'elimite or calcium sulphoaluminate containing ones: belite-ye'elimite-ferrite (BYF), belite-alite-ye'elimite (BAY) and ye'elimite rich ones (CSA). The clinkering temperature of BYF and BAY has to be established to obtain the targeted phase assemblages. Moreover, the stabilisation of alpha-forms of belite is needed to develop high mechanical strengths at early ages. The benefits of the use of waste materials (such as fly ash or slag) as additions to ecocements are three-fold: lower CO_2 emissions due to clinker replacement; valorisation of "useless" products that need a lot of landscape and the consequent efficient consumption of raw materials; and to enhance mechanical properties of the corresponding mortars. The design of appropriate CSA, BYF and BAY mortars, with the final aim of knowing and controlling the hydration mechanisms, will be presented. Particularly, the role of i) type and amount of set regulator (gypsum, anhydrite, etc.), ii) water/cement ratio (w/c); iii) superplasticiser; and iv) pozzolanic additions will be discussed. The role of these parameters in the microstructure and hydraulic behaviour has been investigated through traditional techniques as well as advanced synchrotron characterisation. The formers include laboratory/synchrotron X-ray powder diffraction combined with Rietveld methodology (to obtain phase assemblage), electron microscopy techniques for paste microstructure determination, rheological studies (to control the effect of the different additives, w/c ratio and setting time retarders) and mechanical tests (setting times, compressive strengths and dimensional stability). The latters comprise a group of techniques available at synchrotrons such as: i) high temperature x-ray diffraction for clinkering studies and ii) total scattering data to be analysed by pair distribution function, PDF.