Geophysical Research Abstracts
Vol. 20, EGU2018-6303, 2018
EGU General Assembly 2018

Alkali-activated cements incorporating marble-cutting powders: towards low GHG emissions, sustainable binders implementing circular economy and by-product valorization

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The production of alkali-activated binders offers a reduced embodied energy and a significantly lower release of greenhouse gases when compared with Portland cement. These materials can develop comparable mechanical strength and performance when properly formulated and cured. Among the many systems proposed, Na_2CO_3 activated slag based cements have the longest track record of application, having been extensively used in central and eastern Europe in the second half of 20^{th} century [1]. The main drawback of these materials is the slow hydration kinetics and low hardening rate [2]. The CO_3^{2-} ions in solution control the reaction rate, and different strategies have been proposed to enhance early age reactivity [3,4].

In the present work we have tested different approaches to enhance the reactivity of Na_2CO_3 activated slag cements, including hydrated lime, Portland cement clinker and the byproduct marble-cutting sludge. We have found that the availability of Ca^{2+} couples with the presence of CO_3^{2-} in controlling the hydration kinetics of the system, both at early and late curing times, through the $CaCO_3$ solubility. The presence of marble powder is sufficient to increase the hydration rate at early times, its efficiency being related to the particle size distribution.

The rheological characteristics of the fresh paste are also influenced by the CO_3^{2-} and Ca^{2+} ions in solution, as well as the dispersing efficiency of anionic polyelectrolytes.

The alkali-activated binder based on blast-furnace slag, activated with Na_2CO_3 and marble cutting powder has the potential of delivering suitable properties for industrial use, while being low-cost and safe for handling and placing. It can thus contribute to improving the environmental footprint of the construction industry.

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