CERIS Civil Engineering Research and Innovation for Sustainability

Production of geopolymers using alkaline wastes and carbon dioxide for carbon-negative concrete

Summary

The concrete sector is known for its significant contribution to the global anthropogenic CO_2 emissions. There are two main contributing factors for this condition: the large amount of concrete consumed per year on the planet (which is expected to keep on raising up to 2050, from recent forecasts) and the high CO_2 released from Portland cement manufacture, the key binding agent in concrete. In fact, most of the concrete produced incorporates Portland cement as the key binder, whose manufacture is responsible for 80% to 95% of the carbon emissions from concrete. As a consequence of the large amount of concrete consumed, Portland cement alone is responsible for between 5% to 10% of the total anthropogenic greenhouse gases emissions per year.

In this context, recent research works have explored the viability of mixtures where cement is fully replaced by alkali-activated materials such as fly ash and blast furnace slag. This PhD work fits within this scope, focusing on two objectives: using aluminosilicate nature industrial wastes taking advantage also of potential environmental benefits; and promoting curing with carbonation to improve even more the ecological sustainability from the carbon capture.

The research methodology is composed of the following steps: i) optimization of the carbonation curing of cement concrete mixtures; ii) developing fully alkali-activated concretes industrially applicable and; iii) life cycle assessment of the concrete products.

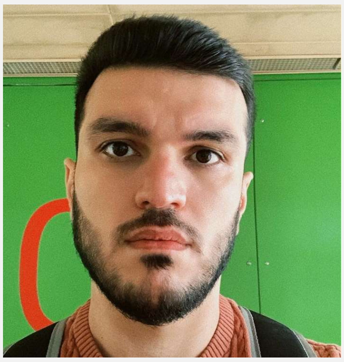
To accomplish the first step, cement concrete mixtures with industrial application will be studied. Thus, a cooperation with producers of masonry blocks, pavement blocks and curbs is planned. These products were selected based on their favourable characteristics to carbonation curing, namely the coarse porosity and shape and size of the elements. These mixtures will be adapted in order to optimize the in-depth CO_2 diffusion, without neglecting the performance properties established by the company. The composition parameters that affect the porosity of the mixture (and, therefore the carbonation rate) will be studied, namely: aggregate grading, type of aggregates (namely RCA), paste: aggregate ratio. Also, different carbonation conditions (HR cycles, CO2 concentration, pressure, temperature, curing time) will be explored.

After achieving the cement concrete mixtures with a suitable pore structure, experiments will focus on an alkali activated material concrete, using industrial wastes. Different industrial wastes will be tested, based on their availability in the Portuguese market and potential for activation. Also different alkali activators and corresponding activator solutions will be studied to maximize the performance of each precursor and concrete product.

Finally, a life cycle assessment of the products will be developed.

Keywords

Eco-friendly concrete, alkali-activated materials, industrial wastes, carbonation curing, masonry blocks.



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