CERIS Civil Engineering Research and Innovation for Sustainability

DecarbonCrete – Decarbonizing the Planet through Concrete: Implementing the Paris Agreement

Summary

This research program aims at providing a new way of producing structural concrete with positive environmental impact throughout its life cycle. To achieve that, synergies between two main vectors will be developed: replacement of concrete`s traditional binder by one of lower environmental impact and with the ability to capture atmospheric CO2; use of recycled aggregates instead of natural ones. In order to provide concrete with innovative CO2 capturing capacity, the performance of concretes in which a part of the Portland cement will be replaced by reactive magnesium oxide (MgO) will be studied (Figure 1). The use of MgO will allow to keep concrete`s functional performance, while increasing its environmental behaviour. Additionally, the use of recycled aggregates will lead to concrete compositions that have lower environmental impact, since it will grant concrete the ability to reuse itself cyclically, improving their life cycle analysis from a 'cradle-to-cradle' point of view.

Figure 1. Reactive MgO powder.

The first experimental campaign studies the performance of concrete with reactive MgO with different levels of reactivity. It started with the production of mortars from three types of MgO and percentages of replacement of cement between 5% and 25%, in which mechanical, durability, physical, chemical, and microscopical analysis were made. The conclusions obtained from mortars were important to define the compositions for concrete in terms of percentage of MgO, which were subsequently tested through mechanical and durability performance, and its performance when subjected to a curing time in a CO_2 chamber.

The second experimental campaign studies the performance of concrete with reactive MgO and supplementing cementitious materials (Figure 2). Starting with the production of mortars, different percentages of MgO and fly ash or slags replaced the cement (0-20%), with the aim to test its mechanical, durability, physical, chemical and microscopical performance. The second stage of this experimental campaign focused on applying the best results on mortars for concrete, by partially replacing cement with MgO and fly ash.

Figure 2. Concrete with partial replacement of Portland cement by reactive MgO.

The third experimental campaign studies the application of recycled concrete as replacement of Portland cement. This study was made exclusively on mortars, by evaluate different percentages of MgO, fly ash and recycled concrete (0–20%) in the replacement of ordinary cement. The experimental tests focused on its mechanical, durability, physical, chemical and microscopical analysis.

The fourth experimental campaign studies the performance of concrete with reactive MgO and recycled aggregates, in which mortars were produced by using recycled aggregates (RA) and two types of MgO, as a replacement of natural aggregates and cement, respectively (Figure 3). The analysis of the viability of both materials was made separately, incorporating MgO alone and RA alone, and collectively, incorporating simultaneously MgO and RA (Figure 4).

The fifth study assesses the technical viability for different strength classes, in which are currently underway two experimental campaigns. The first one aims the analysis of alkali-activated mortars subjected to different curing procedures, to optimize the strength of mortars with MgO. The second one aims to optimize the strength of

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Leading Institution

IST-ID – Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento (Portugal)

Partners

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mortars through the alkali-activation of cement with MgO as the binder and RA.

The sixth study evaluates the performance, cost and life cycle assessment of the previous campaigns by doing a multi-criteria analysis.

The seventh and final task intends to analyse a "Case study", which allows the application at real scale of an optimized solution from among the various cementitious materials produced during this research project, in partnership with Cascais Municipal Council.

Figure 3. Recycled aggregates.

Figure 4. Concrete with partial replacement of natural aggregates by recycled aggregates.