Cork-containing alkali activated composites: a multifunctional ultra-light building material

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The increasing public perception regarding climate change and its serious consequences for future generations has put pressure on world leaders to change the paradigm towards a circular economy. Industrial sectors, in particular, must rethink their approach (Geng et al., 2019) in order to decrease the consumption of virgin raw materials, mitigate wastes production and enhance the use of natural and sustainable raw materials. The building sector is one of the most energy- and raw materials-intensive industrial activities and may, therefore, play a vital role in climate change mitigation, provided that new building materials with enhanced energy performance and low carbon footprint are developed. One approach to decreasing the carbon footprint of buildings is by reducing their energy consumption, the main source of greenhouse gas emissions, and for that reason the development of ultra-light, environmentally friendly, sustainable, low cost and low thermal conductivity materials is imperative.

Alkali activated materials, also known as geopolymers, are an emerging class of materials which may replace ordinary Portland cement, not only due to their lower environmental footprint (Bai and Colombo, 2018), but also to their superior performance (e.g. thermal durability).

Cork is a perfect example of natures' ingenious and highly versatile materials (Novais et al., 2018a; Pullar and Novais, 2017), which is fully renewable and can be harvested from the cork oak tree without harming it. Cork has unique properties, such as its highly porous microstructure, low density, high thermal and acoustic insulation, and excellent durability. These properties suggest its suitability as a light weight aggregate in the production of lightweight alkali activated composites, as recently demonstrated by the authors (Novais et al., 2018b).

In this work, cork was used as a light weight aggregate to produce extremely low weight composites with enhanced thermal and acoustic performance in comparison with the matrix. The binder was produced using mainly an industrial residue (biomass fly ash) as the reactive solid precursor, which was alkali activated using commercial activators.

Material and methods

Black expanded cork granules were used as light weight aggregates in the production of alkali activated composites.

Biomass fly ash produced by a Portuguese pulp and paper plant was used as the main solid precursor (70 wt.%), while commercial metakaolin (Argical™ M1200S, Univar) was used in minor amounts (30 wt%) as an additional source of reactive alumina.

Chemical activation was performed using a mixture of 10 M sodium hydroxide solution (ACS reagent, 97%; Sigma Aldrich) and sodium silicate solutions (SiO2/Na2O = 3.1; H2O = 62.1 wt.%; Quimialmel; Portugal).

The geopolymer synthesis was divided in four steps: i) mixture of the alkaline activators (sodium silicate and sodium hydroxide); ii) mixing the fly ash and the metakaolin in a plastic bag for 60 s; iii) mixture of the solid precursors and the activator for 10 min; and iv) addition of a predetermined amount of cork to the slurry and its mixture for 1 min.

Mechanical, thermal and acoustic tests were performed on the produced composites following European standards.

Results and discussion

Figure 1 presents a typical photograph of the cork-containing alkali activated composites.

Figure 1. Digital photograph of the cork-containing alkali activated composites (4 cm x 4cm x 16 cm).

The incorporation of cork had a major impact on the apparent density, a steady decrease being observed as the amount of cork in the composites rises. The lowest density achieved (170 kg/m^3) is amongst the lowest values ever reported for geopolymer composites.
As expected, the mechanical performance of the composites drops, while their thermal and acoustic insulation is strongly enhanced.

Conclusions

In this study, the possibility of using a natural, highly renewable and durable material (cork) as a light weight aggregate in the production of ultra-light, low thermal conductivity and high acoustic insulation composite material was evaluated. Results show the remarkable potential of cork as a light weight aggregate in the production of multifunctional building materials that may mitigate the energy losses inside buildings, besides reducing the sound propagation (pollution) crucial to enhance human comfort.

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