Enhancing the Carbonation of Reactive Magnesia Cement-Based Porous Blocks

The sustainability credentials of construction materials are increasingly becoming more important as awareness towards the environmental impacts of construction industry is increasing. Portland cement (PC), the most widely used construction material in the world, is currently produced at a rate of 3 Bt/year, and is responsible for 5-7% of anthropogenic CO_2 emissions. This production rate is expected to double by the middle of the century, placing global pressures on the cement industry to reduce its emissions. Reactive magnesia (MgO) cements present technical and sustainability advantages over PC since they (i) are manufactured at lower temperatures, (ii) sequester significant quantities of CO_2 becoming carbon neutral or even carbon negative, leading to high strengths, (iii) offer significant durability advantages in terms of both hydration as well as carbonation products, (iv) are less sensitive to impurities, hence capable of blending with large quantities of cement materials and industrial by-products and (v) are completely recyclable when used alone, as carbonation leads to the formation of carbonates from which the MgO is predominantly obtained.

Previous work on MgO-cement porous blocks has covered both lab-scale and commercial production of blocks, highlighting the differences between the two and the issues faced during production. Out of the 4 different types of aggregates used during commercial trials, mixes with limestone carbonated up to a 100% whereas mixes with natural aggregates achieved between 50-70% carbonation. The work presented here takes the work on porous blocks forward and aims to enhance (i) the sustainability of MgO-cement porous blocks through the carbonation of MgO and (ii) associated mechanical performance by investigating different conditions that influence the carbonation process. Significant advances were achieved by investigating different controlling variables including: (i) composition: cement, aggregate and water components, and particle size distribution, (ii) use of cement and aggregate replacements to induce carbonation, and (iii) curing conditions by varying the relative humidity and incorporating wet/dry cycling conditions.

The innovative nature of MgO-cements offers a unique solution to cement production with a very high potential of resulting in a huge impact through their significant abilities in lowering embodied energies, reducing wastes, and delivering massive sequestration in a wide range of applications. The significant carbonation potential of MgO-cements leading to excellent mechanical performance within porous blocks was clearly demonstrated at each stage of this research work, with an emphasis on the improvements achieved as a result of the work presented.