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Properties and Microstructure of Scaled-Up MgO Concrete Blocks Incorporating Fly Ash or Ground Granulated Blast-Furnace Slag

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Abstract : MgO cements have the potential to sequester CO2 in construction products, and can be partial or complete replacement of PC in concrete. Construction block is a promising application for reactive MgO cements. Main advantages of blocks are: (i) suitability for sequestering CO2 due to their initially porous structure; (ii) lack of need for in-situ treatment as carbonation can take place during fabrication; and (iii) high potential for commercialization. Both strength gain and carbon sequestration of MgO cements depend on carbonation process. Fly ash and ground granulated blast-furnace slag (GGBS) are pozzolanic material and are proved to improve many of the performance characteristics of the concrete, such as strength, workability, permeability, durability and corrosion resistance. A very limited amount of work has been reported on the production of MgO blocks on a large scale so far. A much more extensive study, wherein blocks with different mix design is needed to verify the feasibility of commercial production. The changes in the performance of the samples were evaluated by compressive strength testing. The properties of the carbonation products were identified by X-ray diffraction (XRD) and scanning electron microscopy (SEM)/ field emission scanning electron microscopy (FESEM), and the degree of carbonation was obtained by thermogravimetric analysis (TGA), XRD and energy dispersive X-ray (EDX). The results of this study enabled the understanding the relationship between lab-scale samples and scale-up blocks based on their mechanical performance and microstructure. Results indicate that for both scaled-up and lab-scale samples, MgO samples always had the highest strength results, followed by MgO-fly ash samples and MgO-GGBS had relatively lowest strength. The lower strength of MgO with fly ash/GGBS samples at early stage is related to the relatively slow hydration process of pozzolanic materials. Lab-scale cubic samples were observed to have higher strength results than scaled-up samples. The large size of the scaled-up samples made it more difficult to let CO2 to reach inner part of the samples and less carbonation products formed. XRD, TGA and FESEM/EDX results indicate the existence of brucite and HMCs in MgO samples, M-S-H, hydrotalcite in the MgO-fly ash samples and C-S-H, hydrotalctie in the MgO-GGBS samples. Formation of hydration products (M-S-H, C-S-H, hydrotalcite) and carbonation products (hydromagnecite, dypingite) increased with curing duration, which is the reason of increasing strength. This study verifies the advantage of large-scale MgO blocks over common PC blocks and the feasibility of commercial production of MgO blocks.

Keywords : reactive MgO, fly ash, ground granulated blast-furnace slag, carbonation, CO_2
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