A B S T R A C T

Given the significant global concerns about the environmental impacts of the production of Portland cement (PC), such as a high energy demand and a high level of CO_2 emissions, and the specific durability problems of PC-based concrete, there is an urgent need to find more sustainable solutions. Recently invented reactive MgO cements have been developed as a potential solution to deal with such environmental and durability issues. MgO cements are blends of reactive MgO and PC in different proportions depending on the intended application. The effect of the high water demand, fast hydration and large expansion of reactive MgO and the unique properties of brucite, the hydration product of magnesia, such as lower solubility, reactivity and pH than Portlandite, are all expected to lead to improved workability and strength. With a small amount of reactive MgO in PC, greater mechanical properties and an enhanced durability performance are claimed. Therefore, the objective of this research was to develop fundamental understanding of reactive MgO cements and to investigate the mechanical properties and durability performance of reactive magnesia-based paste and concrete. MgOs from different commercial sources were tested as well as MgO burned from magnesite at 650-1050°C in the laboratory and a related MgO produced in a commercial trial production in China. The reactivity and the hydration degree of the various reactive MgOs in water and in blends with PC or ground granulated blastfurnace slag (GGBS) were studied. The focus then turned to the properties of MgO cement pastes and mortars with 0-15% reactive MgO. The physical and mechanical properties (density, workability, porosity and strength) and durability performance (resistance to chemical attacks, permeability and shrinkage/expansion) of PC concrete with 4-10% of six different commercial and laboratory burned MgOs were then investigated. The performance of PC-GGBS-MgO and GGBS-MgO concretes was also studied to a lesser degree and involved a commercial trial production.

The production of MgO in the laboratory demonstrated that the most reactive MgO was burned from magnesite at ~850°C with the smallest particle size. Lower burning temperatures left a large residual magnesite content leading to a reduced reactivity but achieved a 100% hydration degree in both water and PC systems. The citric acid

reactivity testing method using 2g MgO samples rather than 2g MgO content was not suitable to assess the reactivity of the MgO with different MgO contents in the samples. The commercial trial production of MgO in a vertical kiln system in China showed that it was difficult to fully decompose magnesite at ~850°C resulting in reduced reactivity. The hydration degree of MgO in PC or GGBS pastes was significantly lower than in water and there was no direct relationship between the reactivity, hydration degree and specific surface area or particle size for the MgOs burned under different conditions and from different sources. A 4% MgO content resulted in an insignificant impact on the workability, density, strength, permeability and resistance to HCl and sulphate solutions but caused a decreased resistance to accelerated calcium leaching. High MgO content (10%) caused a decrease in strength and resistance to chemicals due to an increased macropore volume. However, the concrete with 4% commercial trial burned MgO produced up to a 22% higher strength than the PC concrete by using a cement with up to 20% PFA and/or slag. Concrete with reactive MgOs showed a higher expansion than that of hard burned MgO. For reactive MgO, the reactivity of MgO had a less profound influence on the expansion of concrete. It was found that generally, in the presence of 15-50% GGBS, the 4% MgO had no impact on concrete slump, density and permeability but caused a decrease in strength and resistance to HCl and chloride. However, accelerated HCl attack showed that 7-day water-cured PC-GGBS 1:1 MgO concrete samples had a markedly superior strength and resistance to acid attack over the corresponding control concrete without MgO. Both the commercial trial and laboratory produced MgO concrete exhibited a similar performance. MgO- activated GGBS cement pastes and concrete indicated a greater strength gain and long term strength development than those control samples without MgO.

The work revealed that concrete with a small proportion of an appropriate reactive MgO could offer enhanced strength as well as no detrimental impact on durability performance. In addition, the inclusion of MgO had the potential to compensate for shrinkage in large volume concrete applications. This work also pinpointed specific areas with similar potential which require further investigations.