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Editorial

Editorial for Special Issue "Alkali Activated Cements and Concretes"

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Concrete consisting of sand, stone, water and Portland cement is the most widely used material in the construction of modern infrastructure. During the production of ordinary Portland cement, clinker is formed through a sintering process that releases CO_2 from limestone. This process results in cement factories being significant contributors towards global total annual CO_2 emissions and manufacturers are under pressure to reduce the volume of cement clicker produced. Significant strides have been made in the recent past to reduce the impact of cement and concrete production by allowing for the inclusion of large volumes of cement extenders such as Ground Granulated Blast Furnace Slag (GGBFS) and fly ash. Many of the problems associated with the use of limestone-based clicker as the primary component of cement, however, still need to be addressed.

Alkali Activated Cements (AACs) are one possible solution, as no sintering process is required to manufacture AACs and they can be manufactured from waste materials such as ground granulated slags or pozzolans. These materials are typically activated using sodium hydroxide, sodium carbonate or sodium silicate. The use of these activators can be problematic due to their corrosive nature and relatively high environmental footprint as well as high shrinkage upon setting. Less caustic activators tend to result in slow early-age strength development at room temperature. This Special Issue of *Minerals* contains research papers on alkali activated cement and concrete.

Geopolymers are seen as a special type of AAC, where pozzolans containing alumina and silica are used as raw material for manufacturing cement and a 3D-structured aluminosilicate gel forms as a result of alkali activation. Elmahdoubi et al. [1] studied the use of natural pozzolans that can be found in the Atlas mountains in Morocco for use as binder in geopolymers. To increase the reactivity of the natural volcanic rock, the effect of calcining at 750 °C on the reactivity of the pozzolan was studied. Metakaolin was added to vary the Si/Al ratio, while a combination of NaOH and Na_2SiO_2 was used as the alkali activator. The authors concluded that it would be possible to reduce CO_2 emissions resulting from cement manufacturing by activating a blend of crushed, calcined natural pozzolan and 20% metakaolin with a combination of sodium hydroxide and sodium silicate.

As a result of the thermal stability, mechanical strength, acid resistance and relatively low production cost, Kim et al. [2] used metakaolin-based geopolymers to manufacture lightweight ceramics where the pore structure of the ceramics was enhanced through the inclusion of hydrogen peroxide and Sodium Dodecyl Sulfate (SDS). They used a combination of potassium hydroxide and potassium silicate as the alkali activator to enhance the matrix's strength. Although the hydrogen peroxide released sufficient gas to form a thermally efficient lightweight material, the addition of the surfactant resulted in reduced pore sizes and a refined, more homogenous lightweight ceramic.

Klárová et al. [3] developed a silicate-alumina sol–gel that can be used instead of Calcium Aluminate Cement (CAC) to bind bauxite for use in high-temperature concrete. Although the newly developed binder did not perform well in its gel or powdered form, concrete strengths comparable to that achieved with CAC were obtained when the new binder was used in liquid form.

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Du Toit et al. [4] investigated hybrid cements where 70% of the cement clicker was replaced with coal fly ash. A combination of chemical and mechanical activation was used by adding $NaSO_4$ to the hybrid cement and grinding the fly ash to break open the spherical fly ash particles. Chemical activation as well as mechanical activation increased the rate at which portlandite was consumed, which is further indicative of an increase in the rate of the pozzolanic reaction between portlandite contained in cement and coal fly ash. Their research proved that it is possible to manufacture hybrid cement with a 70% reduction in CO_2 emissions, with properties similar to that of Portland cement.

This Special Issue contains two articles on stabilizing waste materials with Portland cement. Lime or Portland cement are often used as alkaline activators to modify the properties of mine tailings and construction slurries, such as the material used during the construction of bored pile foundations. To improve safety during construction, freezing techniques are increasingly being used and the alkali-stabilized waste slurries thus need to resist these freeze–thaw cycles without a significant deterioration in strength. Fiber-reinforcing can be used to limit deterioration as a result of freeze–thaw cycles. Jiang et al. [5] developed a freeze–thaw model for polypropylene-reinforced cement stabilized waste construction slurry under uniaxial action. Pan et al. [6] investigated the failure mechanism of Cemented Paste Backfill (CPB) consisting of gold tailings, containing silica, quartz, feldspar and plagioclase, about 28% mine water and less than 10% Portland cement. Laboratory testing was conducted using a specially developed test setup in which the combination of shear and tensile stresses resulting in the development of failure mechanisms could be varied. Experimental fracture morphology was matched with numerical simulation through Finite Element Analysis (FEA). The CPB strength was found to be a function of curing duration and binder content.

Although ordinary Portland cement will remain the most widely used binder on the planet for the foreseeable future, research into alternative materials such as alkali activated cements has to continue to not only reduce the high carbon footprint of cement and concrete, but to also address the lack of resistance to both chemical attack and high-temperature exposure. The articles published in this Special Issue contribute towards the ongoing search for solutions to reduce the environmental impact of the cement and concrete industry.

Conflicts of Interest: The author declares no conflict of interest.

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