Supplementary Cementitious Materials for Low-Carbon and Resilient Concrete

Portland cement is the world’s most widely used construction material, with over 4 billion tonnes being produced annually. This goes towards manufacturing up to 25 billion tonnes of concrete, enough for 1 cubic metre per person per year. The use of such huge quantities of material has an environmental impact and the global cement industry is responsible for 6-8% of anthropogenic CO2 emissions. With growing awareness of climate change, there is an urgent need to decarbonise construction, and the industry is looking at multiple decarbonisation strategies. Equally, while we may experience an increasingly throwaway society, infrastructure needs to be built to last. Design lives of 50 to 100 years, or even longer are being expected. Thus, engineers are expected to deliver low-carbon concrete, while also ensuring durability.

One means of achieving this is by replacing some of the Portland cement with supplementary cementitious materials (SCMs) such as ground granulated blastfurnace slag (GGBS) and pulverised fuel ash (PFA or fly ash), producing “composite cements”. These SCMs are often industrial by-products, and so by convention lower concrete’s carbon footprint. They can also improve concrete’s durability – when used appropriately. However, these SCMs can alter the microstructure and phase assemblages within the hardened cement paste. So, if we are to understand the performance of composite cements in aggressive environments, it helps if we can also understand how SCMs alter the microstructure of cement, both in the fresh hardened state and when exposed to aggressive conditions.

This presentation will present an overview of the use of advanced analytical techniques for the characterisation of composite cements. It will show how microstructural characterisation has helped us to understand the performance of composite cements when exposed to sulphates, non-marine chlorides, seawater, freeze-thaw, and carbonation. The focus is primarily on slag cements, but with a trend towards using ternary composite cements, the presentation will also look at the microstructure and durability of limestone-slag cements.

The presentation will finish by considering the situation moving forward, as the palette of cements available to the engineer widens. It will also pose a couple of questions about the suitability of standard accelerated ageing tests for assessing the long-term performance of composite cements.