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Editorial

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Welcome to this themed issue on sustainable concrete construction. *Construction Materials* prides itself on being a conduit for research into the full range of materials available for use in construction, particularly those for which there are fewer outlets for academic publication. Within the ICE Publishing family, it can generally be considered that the two sister journals *Advances in Cement Research* and *Magazine of Concrete Research* cater appropriately for academic research in cement and concrete, respectively, and should be the primary route to publication.

Therefore, it may be questioned why *Construction Materials* is providing this themed issue into concrete. Of course, concrete cannot be ignored and it is – and is likely to remain – the most widely used of all our construction materials. Its use governs building and infrastructure worldwide. Even where alternative building materials are utilised, concrete and other cement-based materials are still often found acting as the foundation or providing fire protection. Consequently, *Construction Materials* will continue to permit concrete research within its remit. However, where we do, the Editors look to publish research in concrete that primarily uses the material in a less conventional manner and in a way that could be considered novel and a little out of the ordinary. That is true of the papers in this issue.

This themed issue specifically looks at sustainable uses of concrete in construction. Sustainability remains a misunderstood topic despite the *Brundtland Report* (WCED, 1987) now being over 30 years old. Within the field of concrete construction, many researchers consider it to be synonymous with 'low carbon'. This is partly because the wider concerns with carbon dioxide (CO_2) concentrations in the atmosphere and its role in climate change post-date the *Brundtland Report*.

Nevertheless, low carbon is just one aspect, albeit an important one, of what is a much more complex topic. Sustainability encompasses economic development, social development and environmental protection. Within the environmental aspect, which is the most-often considered in concrete research, there can be significant disagreement. For example, many countries experience significant shortages in natural aggregates for use in concrete. A solution is the utilisation of recycled aggregates. However, recycled aggregates often require washing, sorting and other manipulation to make them suitable as a constituent of concrete. Consequently, recycled aggregates can have higher embodied carbon dioxide than the increasingly scarce natural material they are designed to replace. But which of these two materials is the most sustainable? If low carbon is your base for sustainability then recycled materials cannot be used until all natural resources have been consumed. This, in my opinion, is incorrect but the uncertainty and predominance of low carbon prevails in the field.

This themed issue of sustainable concrete construction includes five papers that consider the sustainability of concrete in different ways, including the development of low-carbon cements, use of waste materials and alternative design methods.

Pozzolanic cements are widely used in concrete construction to provide better quality construction in terms of longer-term strength and resistance to chloride ingress, sulfate attack and alkali–aggregate reactions. As pozzolanic materials are usually an industrially by-product or a natural resource, they have lower embodied carbon dioxide than Portland cement. Consequently, they are widely used in low-carbon concrete. Indeed, they are so good at reducing the embodied carbon dioxide of concrete that many users do seem to have forgotten that the original purpose of using pozzolanic materials was to improve performance. In the paper by Ashiq *et al*. (2019), a locally available glacial deposit, Gini moraines, has been investigated as a pozzolanic material for a dam project. Whilst it is shown that the material has less pozzolanicity than fly ash, the sustainability credentials arise from the fact that supplying an alternative industrial by-product to such a remote mountainous area would have social and economic implications.

Low-lime calcium silicate (Ca_2SiO_4) cements (CSC) provide a further alternative to Portland cement. These cements contain less calcium oxide (CaO) than Portland cements and therefore less carbon dioxide is released from the decomposition of limestone during manufacturing. However, these cements are not hydraulic and do not hydrate when exposed to water. In the paper by Jain *et al*. (201), this property deficiency is compensated for by curing in carbon dioxide captured from waste flue gas streams. This reduces carbon dioxide emissions by permanently sequestering carbon dioxide in cured concrete structures. The resulting concrete showed that CSC concretes have better resistance to sulfate and freeze–thaw attack than Portland cement concretes.

Geopolymer concretes, based on alkali-activated technology, continue to be studied as a potential low-carbon dioxide alternative to cement-based concrete. Geopolymers have many advantages over cement-based concretes but the conservativeness of the construction industry is such that further verification to provide confidence in the properties is still being carried out. The resistance of geopolymer to acid attack has long been promoted as an advantage of geopolymers, although experimental results have shown some variable performance. The paper by Venkateswara Rao *et al*. (2019) provides further data on the acid resistance of these materials.

Coloured concrete is widely used in aesthetic concrete construction. However, the cost of pigments is high and can make concrete expensive. The paper by Newlands *et al*. (2019) looks at a more economically feasible way of making coloured concrete by using recovered toner powders from printer and photocopier cartridges. The results are extremely promising and show that a wide range of colours can be easily obtained with minimal impact on the engineering or permeability properties of the concrete. Here it should be noted that concrete should not routinely be used as a depository for waste materials. Only in cases, like the above, where the waste material is being used to improve the performance of concrete should they ever be considered. Indeed, even where they are used, the waste material should be treated and quality checked, as a product, before use.

The final paper considers whether sustainability can be achieved by altering some of the assumptions that we make in reinforced-concrete design. Assumptions are always required in design to prevent onerous and complex calculations. However, Kar (2019) suggests that the levels of effective bond between reinforcement bars and surrounding concrete needs to be reconsidered. Kar suggests that the use of plain surface wave-type configuration bars generates advantages that will lead to increased load-carrying capability and energy absorption. Consequently, concrete structures can be designed with long life spans at no added cost; clearly, a more sustainable form of concrete construction.

I hope that you enjoy this themed issue and that it gives inspiration in the search for even more sustainable ways of using concrete in construction.

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