Editorial

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When I was first introduced to concrete in the early 1960s, it seemed to be a relatively 'simple' material, produced using only Portland cement, aggregate and water. Chemical admixtures were mostly confined to air-entraining admixtures and primitive water reducers, and supplementary cementing materials were not commonly used. Cement and concrete were inexpensive, both selling in North America for about \$20–25 per tonne. There were then no concerns about 'sustainability', or greenhouse gas emissions, and hence little interest in other (non-Portland) cementing systems. Studies on the hydration mechanisms, or the detailed structure of hydrated cement were considered to be the province only of a few eccentric academics, and were not thought to be of much practical importance. So much has changed since then! The seven papers presented in this issue of *Advances in Cement Research* would have been largely incomprehensible to the cement researchers of that time, and are excellent exemplars of how much cement science has advanced in the last 50 years.

One non-Portland cementing system of interest that only emerged in the 1990s, magnesia–phosphate cement (MPC), is described in the first paper by Li *et al.* (2015a). They studied the effects on MPC of the additions of fly ash and a boric acid retarder under different calcination conditions. One problem with this cement is that it sets too quickly to be used in conventional construction. While boric acid can be used effectively as a retarder with MPC, it decreases the strength by reducing the compactness of the hardened material; however, this can be compensated for in part by the addition of fly ash. This might eventually become an interesting niche material in certain applications.

Another new type of cement, belite-barium calcium sulfoaluminate cement, has emerged within the last 10 years. The properties of this material when it is doped with strontium oxide are described in the paper by Zhang *et al.* (2015). This system is of interest because of the low energy consumption and low carbon dioxide emissions compared to Portland cement. This has obvious environmental benefits, particularly now when sustainability is such a major issue. The drawback to the use of this material is its relatively slow rate of strength gain; this study suggests that this can be overcome by the introduction of strontium oxide into the system, which could lead to a wider use of what is still a little-known cement.

Unlike the cements described in the first two papers, calcium aluminate cements have been around for a very long time. They are particularly useful due to their rapid hardening characteristics and their ability to yield high strengths. They are, however,

expensive, and may undergo significant strength loss under certain environmental conditions, which has led to some notable structural failures in the past. The paper by Ukrainczyk (2015) describes how the use of a polycarboxylate superplasticiser, combined with methyl cellulose and lithium carbonate to compensate for the rheological problems induced by the superplasticiser, can improve the properties of this material.

Nanosilica is another material which is only now being introduced into concrete – it too was unavailable 50 years ago. Singh *et al.* (2015) describe how the introduction of small amounts of nanosilica into Portland cement mortar can greatly reduce the penetration of chlorides; this can have major benefits on the durability of reinforced concrete structures, since chloride-induced steel corrosion is currently perhaps the most serious form of deterioration.

Although durability has always been a consideration in concrete mix design, it used to be generally considered that the stronger the concrete, the more durable it would be. Thus durability was then considered to be a secondary issue. Today, of course, it is durability rather than strength that is of greatest concern. Shanahan and Zayed (2015) describe a study on the role of alite (impure tricalcium silicate) on the sulfate resistance of Portland cement-based systems. Their conclusion that high alite content systems are more susceptible to sulfate attack may cause cement producers to reconsider the formulation of sulfate-resistant cements, where the focus hitherto has been on reducing the tricalcium aluminate content of the cement.

While the properties of a calcium sulfoaluminate-based cement were described in the second paper (Zhang *et al.*, 2015), the focus of the work by García-Maté *et al.* (2015) is on how to determine the amount of amorphous material present in the hydrated material. This can lead to a better understanding of the hydration characteristics, and how the hydrates may be modified to improve the performance of these materials. While the production of calcium sulfoaluminate cement is very small compared to that of Portland cement, its low carbon footprint makes it attractive, and studies of this type are essential to its wider use.

The last paper, by Li *et al.* (2015b), deals not with a new cementing system, but with a novel technique for monitoring the hydration of Portland cement. They have developed a piezo-electric composite transducer to permit ultrasonic monitoring of the hydration reactions, leading to a more complete understanding of cement hydration.

While these seven papers may appear to be rather unrelated to each other, collectively they serve to show how much cement research has changed in the last half-century, and how sophisticated it has become. I can only wonder what the next 50 years will bring. . .

REFERENCES

- García-Maté M, Santacruz I, Cuesta A *et al.* (2015) Amorphous determination in calcium sulfoaluminate materials by external and internal methods. *Advances in Cement Research* **27(7)**: 417–423, <http://dx.doi.org/10.1680/adcr.14.00026>.
- Li Y, Sun J, Li J and Shi T (2015a) Effects of fly ash, retarder and calcination of magnesia on properties of magnesia–phosphate cement. *Advances in Cement Research* **27(7)**: 373–380, <http://dx.doi.org/10.1680/adcr.14.00029>.
- Li L, Xu D, Huang S and Cheng X (2015b) Investigation of piezoelectric composite transducer in ultrasonic monitoring of cement hydration. *Advances in Cement Research* **27(7)**: 424–432, <http://dx.doi.org/10.1680/adcr.14.00032>.
- Shanahan N and Zayed A (2015) Role of tricalcium silicate in sulfate resistance. *Advances in Cement Research* **27(7)**: 409–416, <http://dx.doi.org/10.1680/adcr.14.00036>.
- Singh LP, Goel A, Bhattacharyya SK *et al.* (2015) Effect of nanosilica on chloride permeability in cement mortar. *Advances in Cement Research* **27(7)**: 399–408, <http://dx.doi.org/10.1680/adcr.14.00024>.
- Ukrainczyk N (2015) Effect of polycarboxylate superplasticiser on properties of calcium aluminate cement mortar. *Advances in Cement Research* **27(7)**: 388–398, <http://dx.doi.org/10.1680/adcr.14.00022>.
- Zhang J, Gong C, Wang S, Lu L and Cheng X (2015) Effect of strontium oxide on the formation mechanism of dicalcium silicate with barium oxide and sulfur trioxide. *Advances in Cement Research* **27(7)**: 381–387, <http://dx.doi.org/10.1680/adcr.14.00021>.