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Briefing: Concrete – innovations and practical applications

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Concrete is a highly adaptable material and capable of considerable variation, development and innovation, as can be seen from the pages of journals such as the *Proceedings of the Institution of Civil Engineers – Construction Materials*. This briefing paper describes the 43rd Convention of the Institute of Concrete Technology, which took place on 26 March 2015. The event provided an opportunity for practitioners and researchers to meet and communicate, and to showcase the variety and diversity of current innovations, developments and applications in concrete and cement technology, including carbon-negative aggregate, polycarboxylate ether superplasticisers, waste wood in concrete, steel fibres, calcium aluminate cements, superabsorbent polymers and sprayed concrete tunnel linings.

1. Introduction and background

Founded in 1972, The Institute of Concrete Technology (ICT)'s mission is to preserve and promote concrete technology as a recognised engineering discipline and consolidate the professional status of practising concrete technologists. It is the concrete sector's professional development body, operating internationally, with nearly 500 members in more than 30 countries worldwide. It is an awarding body for qualifications in concrete technology and a facilitator of continuing professional development (CPD), networking opportunities and events, such as the recent biennial Young Researchers Forum on Construction Materials, reported previously in *Construction Materials* (Goodier *et al.*, 2014; Mangabhai *et al.*, 2014). It is a professional institute for suitably qualified individuals. Further details are available at the institute's website (ICT, 2015).

As part of these duties, the ICT holds an annual convention for members and non-members, with a symposium on the key developments in concrete technology. The 43rd ICT Convention, 'Concrete: Innovations and Practical Innovations', was held on 26 March 2015 at Loughborough University, UK and was sponsored by Sika Ltd (Figure 1). Nearly 100 delegates attended, including academics, cement makers, admixture producers, consultants, contractors, students and researchers. It was accompanied by an industry exhibition including Elkem, Bonar, LKAB, Sika, Talent, The Concrete Society, UKQAA and the World Concrete Forum.

The symposium programme was introduced by the outgoing President, Professor Peter Hewlett, and consisted of nine speakers on a variety of recent and ongoing innovations in concrete technology. Full versions of the papers will be available in the ICT Yearbook (2015–2016, unpublished).

2. Presentations

Dr Paula J. Carey, Quality Assurance and Research Director of Carbon8 Systems, presented on the world's first commercially available carbon-negative aggregate and its applications. Paula discussed how greener concrete can be achieved in several ways: using alternatives to Portland cement, reducing the transport of the raw materials, or by using alternative aggregates that either reduce the use of natural resources or impart other energy-saving properties to the concrete in its use. She described the production of aggregates produced from air pollution control residue, which is generated from waste incineration plants by using an accelerated carbonation technique. This, together with the properties of the aggregates (light-weight, carbon negative, grading and complying with EN 1055, certified to ISO 9001, 14001 and OSHAS 18001) and their application in concrete masonry blocks, ready-mixed concrete and no-fines floor screed were outlined. Commercial production of the aggregates is underway in the UK and each plant could produce 800 000 t/year (Figure 2). She concluded that this provides a sustainable solution, diverts waste from going into landfill and reduces the need for natural



Figure 1. Delegates at the 43rd ICT Annual Convention



Figure 2. Example of carbon-negative aggregate

aggregates. The Carbon8 system has received awards such as the Shell Springboard National Prize, the Chartered Institution of Wastes Management (CIWM) innovative practice award, the National Recycling Awards Best Recycled Product award and a Mineral Products Association (MPA) innovation award.

Jürg Schlumpf, Senior Vice President and Head of Corporate Target Market Concrete, Sika AG in Switzerland, discussed the developments in polycarboxylate ether (PCE) superplasticisers and their applications. He described how, by varying the polymer structure, the properties of the superplasticiser can influence the properties of the concrete. He compared the properties of PCE with traditional plasticisers and superplasticisers and identified the major differences: (a) much higher water reduction potential; (b) slump retention without retardation; (c) better cost performance; (d) specific polymer design according to customer requirement; and (e) challenges: robustness, softness and interaction with clay and fines. He then discussed the application in dry mortar, development of bio-based PCE superplasticiser, concrete sustainability, and durability and life-cycle analysis. He concluded that PCEs have played an

important role and that durability, application, speed and sustainability of concrete will be improved significantly.

Andrew Bourne, Senior Sales Manager, Sika UK, presented some case studies of PCE in the UK, including high-rise concrete, which requires a combination of high strength, pumpability and excellent rheological properties, all achieved by the incorporation of PCE. Other cases involved slip forming, Crossrail and nuclear power stations. He concluded that 'admixtures have continued to be developed and the modern PCE-based products give much greater flexibility to the construction process and enable the successful use of modern concretes in a range of environmental and engineering situations that would previously not have been available to us'.

Martyn Fear, Director of Specialist Precast Products (SPP), presented on using waste to create a new material: woodcrete. Reasons for the development of this Eco Element product included: (a) utilising a waste product in their production process; (b) providing a sustainable product; (c) once fully developed it could have a positive impact on precast production across the UK/world; and (d) its production will give SPP a unique market position. Eco Element is a form of concrete that is made using sand dust and wood shavings as an aggregate that is bound together with cementitious binders. Examples made included a table and bird boxes. He outlined the properties of the product, including strength development, water absorption and freeze/thaw performance.

Dr Wayne Thomas, Managing Director of Co-tropic Ltd, presented on the effect of geometry on reinforcement anchorage performance and integrity, including the development of CoRe reinforcement. Finite-element models were used to analyse the interactions between differently shaped reinforcements and the concrete mix by using pull-out tests, which indicated that the bond strength of CoReBar surpassed the strength of standard rebar by ~40–70%. Performance, behaviour and fracture appearance of punch test specimens indicated that CoReFibre polypropylene reinforcements revealed compound fracture (i.e. not brittle). Three-dimensional steel fibres were also discussed, which indicated that CoReLoops transferred 356% more force to achieve 'pull-out' failure compared with traditional hooked steel fibres, and that the 'three-dimensional' closed loops were 178% tougher and showed a 21% increase in flexural strength compared with traditional steel hooked fibres.

Chris Stanley, Technical Director of Unibeton Ready Mix, UAE, presented the Sir Frederick Lea Memorial Lecture on 'Concrete: Yesterday, today and tomorrow – A visual journey'. The early beginnings of concrete were outlined, which date back to 5600 BC, as well as the development of Portland cement and its manufacturing process. Early applications were

discussed, together with recent developments, and finally the future of concrete.

Dr Francois Saucier, Senior Business Unit Manager of Kerneos, France, presented on the use of 'Calcium aluminate cements (CACs) in H₂S biogenic environment'. The process and increasing problem of biogenic corrosion in sewers was described. The rehabilitation of sewers with polymer linings such as epoxy is common but the failure rates observed, by many operators, is pushing them to search for alternative solutions. He discussed the resistance of CAC and gave a historical reminder of the use of CAC in South Africa, Australia and USA. The difficulty of testing biogenic corrosion resistance of building materials using various test methods was discussed, including: (a) pickle jar test method; (b) Heidelberg test method; (c) Gent University test method; (d) Virginia experimental sewer; and (e) the ongoing work to develop a biogenic corrosion standard test. It was concluded that there are several possibilities to protect or rehabilitate a sewer exposed to biogenic corrosion, and that CAC mortar or concrete is such an alternative, with its main weakness that it is little known in the engineering community.

Dr Agnieszka Klemm, Reader in Construction Materials, Glasgow Caledonian University presented on superabsorbent polymers (SAPs) in cementitious composites. Uses include: (a) internal curing (preventing self-desiccation); (b) offsetting the effect of freezing/thawing; and (c) interrupting capillary pores and influencing transport properties. Properties presented included: (a) mechanical properties; (b) autogeneous shrinkage; and (c) microstructural characteristics (scanning electron microscope (SEM)) of three systems: (i) effect of cement type on the performance of SAP mortars; (ii) effect of SAP type on cement mortars; and (iii) effect of fly ash content on SAP modified mortars. It was concluded that a careful selection of SAP, with desorption characteristics compatible with the hydration process, is the most critical issue.

Richard Foord, Project Manager, BASF Underground Construction, discussed sprayed concrete linings on Crossrail and LUL, [expand] London, UK. Admixtures used were outlined, and also their performance to optimise the mix design. As there was limited site access for ready-mixed concrete and possible delays in getting to site, silos were used for the production of sprayed concrete and batching plant requirements (mixer, admixture dispensing equipment, pump requirement), and so on. This method adopted proved very effective for flexibility in production, ease of use and reducing wastage on site. He then outlined a case study on a tunnel refurbishment. The double-bonded concept for single shell lining was described, which involved detailed design and approval, surface preparation, a regulating layer, dealing with water ingress, ventilation, thickness of application and quality control.

3. Summary

The Convention generated excellent discussion and provided excellent networking opportunities for all the delegates and speakers. Plans for the 44th ICT Annual Convention are already underway, to be held again at Loughborough University, in March 2016 (exact date to be confirmed, please see <http://ict.concrete.org.uk/> for details, including date and provisional programme).

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