THE MAGAZINE OF THE CONCRETE SOCIETY

CONCRETE

Volume 58, Issue 8 October 2024

HOW LOW CAN YOU GO?

The latest technologies, projects and opinions in the drive towards low-carbon construction.

CELEBRATING 200 YEARS

The invention of Portland cement and Joseph Aspdin's 1824 patent

SPRAYED CONCRETE

Lowering the carbon impact of tunnel linings

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The October 2024 cover

Concrete brings together some of the latest technologies, projects and opinions in the drive towards low-carbon concrete construction.

The feature starts on page 8.

(Photo: iStock.com/treety.)

CONCRETE magazine is produced in-house by The Concrete Society, a not-for-profit, independent membership organisation dedicated to supporting the use of concrete, the most widely used building material in the world.

Established in 1966, and with members from around the world, The Society has built on its technical base to become a leading provider of information, serving the needs of clients, architects, engineers, specifiers, suppliers, contractors and users of concrete.

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The Concrete Society

The Concrete Society

Your concrete community. Est.1966

THE CONCRETE SOCIETY is an independent membership organisation dedicated to supporting the use of concrete – the most widely used building material in the world.

Established in 1966, The Society encourages innovation and the exchange of knowledge and experience across all disciplines. The Society works through the co-operation of our members, who come from all sectors of the industry to exchange information and experience, and to enhance the performance, productivity and quality of concrete as a construction medium. Supported by the technical and administrative staff of The Society, our members collaborate to produce and disseminate state-of-the-art reports, recommendations and practical guidance.

The Society receives special support from the following:

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FROM THE EDITOR

HUMILITY

Humility is one of the hardest qualities to learn and even harder to keep consistent. The world demands much from business and to keep pace with constant change and stay competitive requires an occasional ruthless streak and steely countenance. There are moments, however, when things go badly wrong and there has to be recognition that industry is not infallible – when it has to hold up its hands and, in humility, admit fault. Grenfell is such an occasion.

There has been much comment, quite rightly, in the aftermath of Sir Martin Moore-Bick's 1700-page report into the awful fire at Grenfell Tower on 14 June 2017. Enough comment indeed to match the lengthy report.

Given that blame for the event was placed at the door of every group responsible for fire safety – the Government, tenant management, council, regulatory system, construction industry, manufacturers, contractors, fire and rescue *et al* – it is not surprising that all parties responded with statements following publication of Moore-Bick's report. Most were humble, though some had a whiff of truculence.

Tucked away in the thick of the report were three statements that should make everyone in construction sit up and pay serious attention. The first is the over-riding question for the inquiry, "How was it possible in 21st-Century London for a reinforced concrete building, itself structurally impervious to fire, to be turned into a death trap that would enable fire to sweep through it in an uncontrollable way in a matter of a few hours despite what were thought to be effective regulations designed to prevent just such an event?"

Grenfell happened, not because of failure in a single isolated incident but because of complacency across the whole range of systems and services, of which construction is part. This is shown up in a second damning statement of the report, "Safety of people in the built environment depends principally on a combination of three primary elements: good design, the choice of suitable materials and sound methods of construction, each of which depends in turn in a large measure on a fourth, the skill, knowledge and experience of those engaged in the construction industry… there were serious deficiencies in all four of those areas."

Does this mean that all involved with construction are to blame for what happened at Grenfell Tower in June 2017? It is tempting to say 'no'; to abdicate responsibility. It happened at another time, to another project. Herein lies the danger of complacency, for Moore-Bick's report includes perhaps the most damning statement on the sector's culture, "We are not the first to conclude that the construction industry as a whole needs to become technically more competent and less willing to sacrifice quality to speed and cost."

The response should be humility from all. Not hiding behind efforts since Grenfell, such as the Building Safety Act, as proof that things have changed. And not hiding behind platitudes. But humility. The humility to accept deficiencies in culture and resolve to put things right. Working towards that is beholden on everyone and it'll likely mean humility in working under the jurisdiction of a construction regulator.

Enjoy the issue.

James Luckey, Editor
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NEWS IN BRIEF

UK • Concrete Society
The Society is delighted to welcome BAM UK & Ireland, a major construction and civil engineering company, as a Special Category Member. The Society is supported by its membership subscriptions. Special Category Members provide extra support to the organisation.

UK • Repair
Concrete Repairs Limited (CRL) has entered into a partnership with Tunley Environmental for carbon reporting, following the measurement principles BS EN ISO 14064-1 and the GHG Protocol for SERC reporting.

UK • Appointment
After 42 years at engineering consultancy Waterman, including 17 years as CEO, Nick Taylor is to step down from the group's board on 31 March 2025. He will be succeeded on 1 April 2025 by Neil Humphrey, currently the COO in the UK.

Morocco • Acquisition
Heidelberg Materials has acquired Votorantim Cimentos' assets in Morocco, expanding an existing minority stake in cement and concrete producer Asment de Témara. Morocco is seen as one of the company's core growth markets in Africa.

Turkey • Admixtures
Admixture firm Master Builders Solutions has acquired 51% of MBT Tech, a supplier of construction chemicals such as mortars and grouts to the Turkish market. Master Builders Solutions will enhance MBT Tech's product portfolio by supplying a range of construction chemicals to the Turkish market.

USA • Appointment
Ecocem, a provider of low-carbon cement technologies, has appointed Mike Donovan as technical director for its US business operations. Donovan will drive the firm's business development initiatives as the Dublin-based company brings its scalable low-carbon cement technologies to North American markets.

The Netherlands • Crane
Mammoet, the Dutch heavy lifting and transport company, has launched the world's strongest land-based crane, the SK6000. It allows large energy and infrastructure projects to build from bigger pieces, in parallel. The SK6000 has a maximum capacity of 6000 tonnes.

New BSI guidance launches to help industry cut carbon

BSI has published new guidance to help the construction industry make a sustainable choice of concrete and accelerate progress towards net-zero targets.

Lower Carbon Concrete – Alternative Binder Systems – Code of Practice (BSI Flex 350 Version 2) recommends and demonstrates the potential of lower-carbon technology. It offers advice on assessing appropriate alternative binder systems (ABS) that can be used as lower-carbon concrete alternatives.

This BSI Flex recommends a framework for assessing ABS concretes to facilitate their acceptance as suitable alternatives to the commonly used Portland cement-based concrete when designing and building structures. While this BSI Flex is focused on the application of ABS concrete within the UK, it provides a helpful guide for other countries when considering the use of ABS concrete.

The guide has been devised to help engineers and designers specify and construct using low-carbon technologies, by providing relevant background, recommendations, explanations, guidance and suggestions. Low-carbon technologies are designed to produce less pollution than traditional ones and to help reduce greenhouse gas emissions. These technologies include, but are not limited to, the lower-carbon concrete binder alternatives, which includes geopolymer or alkali-activated materials.

Clare Price, sector lead for the built environment at BSI, said, "This guidance is designed to empower engineers to make more sustainable choices in order to reduce carbon emissions in construction projects, while giving all involved the confidence in the suitability of chosen materials. Steps like this can help us create a sustainable built environment."

Visit: ***https://tinyurl.com/2trpkhec***.

NEW STRATEGY TO BECOME 'NATURE POSITIVE' BY 2030

AGGREGATE Industries UK has published its first company-wide nature strategy, with an aim to be 'nature positive' by 2030. It includes investing £24 million in restoration activity over the next five years.

Other drivers for the framework include adopting the Science Based Target Network's Framework for Nature and the Global Goal for Nature.

The company intends to measure the biodiversity value of all its active aggregates sites by surveying habitats and species, and then set out on a journey to reduce future negative impacts, restore nature and habitats, and advocate nature positivity.

GROWTH IN CONCRETE DEMAND SET TO SOAR

IN THE absence of any abatement action at all, global growth in demand for concrete is forecast to result in 3.8 gigatons of annual CO_2 emissions by 2050. That is one of the findings of new research from the global management consultant Boston Consulting Group (BCG). In the near term, to 2030, research says that the industry will focus primarily on a variety of well-known decarbonisation levers.

BCG says for the cement and concrete industry to reach net zero in 2050, sufficient carbon capture and storage capacity (CCS) must be available to abate more than 35% of its carbon emissions.

Visit: ***https://tinyurl.com/3a8wbxn6***.

BALFOUR Beatty has been awarded a £27 million contract to deliver the Comrie flood protection scheme in Scotland, on behalf of Perth and Kinross Council. The scheme will see construction of 2.8km of river walls and embankments in Comrie along the River Ruchill, River Earn and River Lednock. On completion, the flood defences will protect nearly 200 local homes and businesses, having been designed to meet a '1-in-200-year flood' standard of protection.

COURSES ELIGIBLE FOR SUBSTANTIAL FUNDING FROM CITB

FORMWORK and scaffolding provider PERI has become part of CITB's Employer Networks initiative, which will fund 70% of any course offered by the temporary works specialist per attendee. From September, PERI's training courses have been heavily subsidised for levy-registered employers in the construction sector across London, with many other areas across the UK already eligible for funding. The initiative was introduced by CITB to encourage employers to provide their workforces with more training opportunities through trusted delivery partners, aiming to close the skills gap and address shortages across the industry.

LAUNCH OF INDUSTRY TRANSPORT ASSOCIATION

THE British Concrete Transport Association (BCTA), a not-for-profit organisation, has been launched. The BCTA says it will be dedicated to advancing and supporting the concrete transport industry across the UK.

The association has assembled a team of industry figures, each with specific expertise. Their collective goal is to elevate industry standards through their advice, guidance and integrity, and to shape the sector's future through collaborative effort.

Lindsey Rudd, the acting BCTA chair, who previously served as the group sales director of TVS Interfleet and director of McPhee Mixers, believes the new organisation can continue and amplify the work initiated during his time as chair of the concrete division of the British Aggregates Association (BAA).

"Having seen first-hand some of the issues that affect the industry, especially around concrete delivery, transport and the daily challenges that drivers and operators face, we bring together a group of outstanding people willing to influence change for the right reasons." Visit: ***www.britishconcrete.org***.

France • Appointment
Patrick Sulliot has been appointed as chair of VINCI Construction, joining the group's executive committee. Sulliot holds an engineering degree from the École Nationale Supérieure des Arts et Métiers. In 2021, he became VINCI Construction's CEO Americas and Oceania, and in January this year was appointed COO of VINCI Construction in charge of international proximity networks (Europe, Africa, UK, Americas, Oceania) and of digital transformation.

Germany • Recycling
CEMEX has acquired a majority stake in RC-Baustoffe Berlin & Co. The company processes mineral construction, demolition and excavation materials. The acquired recycling facility can process up to 400,000 tonnes of material per year, which Regenera (a CEMEX subsidiary) will turn into repurposed aggregates for concrete production. In addition to its recycling capabilities, RC-Baustoffe Berlin operates the first plant to permanently store biogenic CO_2 in recycled mineral waste in Germany.

UK • Shoring
Altrad RMD Kwikform (RMDK) has launched a new solution to reduce the effects of thermal loading – the Tubeshor Active Thermal Compensator (ATC). The Tubeshor hybrid hydraulic shoring system is used for propping waler beams or capping beams of large excavations. It comes in a range of diameters to cater for all duties of shoring requirement. RMDK says it can reduce thermal loading by up to 90% compared with a mechanically locked-off prop.

UK • Geotechnical
Bachy Soletanche has restructured its business into three divisions. The geotechnical firm will operate a regional business, formed of Northern and Southern Divisions, along with a nationwide Projects Division. The regional sectors will focus on smaller projects and geotechnical engineering, while the national division will direct substantial geotechnical and civil engineering schemes across the UK and Ireland.

HS2 celebrates first completed viaduct

A VIADUCT in Northamptonshire has officially become the first on the HS2 project to be completed as engineers installed the last stretch of parapet along the sides.

The 163m-long Highfurlong Brook Viaduct, near the village of Aston le Walls, is one of more than 50 being built, while freeing up space on the most crowded part of the existing West Coast Mainline for more freight and local services.

Consisting of seven spans, the viaduct crosses Highfurlong Brook's floodplain at a height of approximately 9m. Each span is made up of four beams weighing up to 56 tonnes and these were lifted into position last year to form the backbone of the structure.

Each of the beams – which are up to 25m long – were manufactured off-site before being delivered overnight to reduce disruption for local road users. The deck – which will support the track and electrical systems – was poured in-situ earlier this year, with the parapets along each side manufactured off-site and installed over the last four months.

Highfurlong Brook was delivered over two years by HS2's main works contractor EKFB – a group made up of Eiffage, Kier, Ferrovial Construction and BAM Nuttall.

CIMSA, a Turkish global building materials company, is to acquire Irish firm Mannok. Under the agreement, the Mannok brand will be retained in Ireland and the UK, and the business will continue to be led by local management. Employing approximately 800 staff, Mannok comprises two divisions, Building Products and Packaging. Its key activities are the manufacture of cement, concrete, quarry and aggregate products, and insulation materials.

FUTURE MATERIALS SUPPLY APPROACHING CLIFF EDGE

THE Government needs to take urgent action to address diminishing reserves of the UK-sourced minerals that are essential for construction.

That's according to the results of a new survey published by the Mineral Products Association, which reveals declining levels of permitted reserves. In its latest Annual Mineral Planning Survey report, the MPA says Britain has an abundance of essential mineral resources and is almost entirely self-sufficient in meeting the 250-million-tonne-a-year demand for materials, 30% of which comes from recycled or secondary sources.

But for more than a decade, MPA says the rate of consumption, mainly for construction, has not been matched by the rate of approval for new planning consents for quarrying, due to a 'broken' system that often allows local interests to be prioritised above national need.

EPIDEMIOLOGISTS and engineers at Stanford University in California are working together to develop a concrete flooring mix that would provide potential health benefits to those living with dirt floors and the same structural support as traditional concrete, but with a lower-carbon footprint. More than 1 billion people around the world live in homes with dirt floors. Unlike dirt floors common in some rural parts of the world, concrete floors are easily cleaned of disease-carrying pathogens – but they come at an environmental cost. A lower-carbon flooring mix could provide a solution. Professors Benjamin-Chung and Sarah Billington are bringing other Stanford experts into the fold to understand why concrete is effective for reducing pathogen transmission and to design low-emission concrete alternatives that retain those helpful properties.

FUNDING FOR GRAPHENE CONCRETE RESEARCH

GRAPHENE@Manchester, in collaboration with four industry partners, has received £400,000 from Innovate UK's decarbonising concrete fund to accelerate the commercialisation of more sustainable concrete. The consortium is led by CEMEX and partnered with Galliford Try, Sika, Northumbrian Water and Graphene@Manchester.

Working with supply chain partners, application experts from Graphene Engineering Innovation Centre (GEIC), part of Graphene@Manchester, will share their expertise and access to equipment.

CALCINED CLAY CONCRETE UNDERGOES TESTING

AUSTRALIAN construction materials firm Boral, in partnership with industry players and researchers, is developing a lower-carbon concrete product using Australian calcined clay as an alternative supplementary cementitious material.

The two-year project is supported by SmartCrete CRC, an independent co-operative research centre.

The partners – comprising suppliers, university researchers, asset owners and providers – will work on accelerated laboratory testing and field trials as part of the validation stage.

A LETTER TO THE EDITOR

Dear Sir,

Trade association urges swift action by Labour to restore the fortunes of specialist mobile concrete plants.

As a construction trade association, the Batched on-Site Association (BSA) strongly supports innovation, carbon savings, minimising disruption in local communities and curbing the soaring costs builders face.

That is why we are urging Louise Haigh (Transport Secretary) and our new Government to honour their pledge to ensure the greener HGVs our members run are not removed from our roads by 2028. The BSA was founded to promote the highest standards in the sector, including daily checks, six-weekly 'MOT'-type inspections and other safety measures.

INVENTED

In 1976, volumetric concrete mobile (VCM) plants were invented as a result of frustrations with the limitations of old-fashioned drum mixers, which are great for big building projects. But if you want less than a full load of concrete, drums are a pain. As well as charging a premium for a part load, drums charge for any unused concrete and for taking it to landfill. By contrast, only VCMs can 'pour' the concrete needed – from 1 cube up.

As Fabian Hamilton MP revealed at a hearing of the Transport Select Committee in February, whether it's a basement you need to line or a hole that needs to be filled in, the customer rarely gets the order volume right. That's why VCMs provide much-needed flexibility, by producing the exact amount of concrete needed on each site.

Equally, they are a boon for emergency services: who knows how long a concrete lorry has to wait for the water company or rail operator to effect a repair? The concrete on a drum mixer is limited to around two hours before it goes off, so drums can't hang around. By contrast, our VCMs can wait at the roadside for hours while the engineers wrestle to solve the problem. And VCMs can pour several different concretes and strength classes from the one delivery vehicle, avoiding calling up three or four separate drum mixers. The two-hour time constraint is even more restrictive on builders in rural areas for obvious reasons – and this pushes up their costs.

VCMs also do a 'milk run', which saves fuel and cuts carbon. After leaving the depot, a VCM on average services four SME customers and within a 12-mile radius. Drum mixers have to shuttle back and forth with each separate order. This causes local citizens grief, uses far more fuel and has a far heavier carbon footprint.

ESSENTIAL SERVICE

For the MOD, we provide an essential service, with the ability to repair a bombed runway and get it serviceable within half an hour – an incredible achievement. That's why we've got our VCMs on RAF bases from Kenya to the Falkland Islands.

And the environmental benefits extend well beyond making concrete with zero waste and the diesel and lorry miles we save. Every drum mixer needs around 1000 litres of water at the end of every day to flush out the drum – around 240,000 litres a year. With c6000 drum mixers in operation, that's a staggering 1.4 billion litres a year. The best companies can recover 80% of this, but that still means over a quarter of a billion litres are wasted, producing 400 tonnes of CO_2.

In 2017, Highways England reported that VCMs were perfectly safe for our roads and bridges, running at 38.4 tonnes on four axles and 44 tonnes on five axles. 44T VCMs can carry on-board concrete pumps, which eliminates the need for a separate HGV.

But instead of the then Government accepting this, it caved in to those who want to eliminate competition from VCMs in the SME market. In 2018, the Transport Minister brought in a bizarre regulation that said it was fine for VCMs to run at these weights but only for the next ten years. The result was an immediate fall in sales from c£55 million in 2017 to £9m in 2020.

BOAT HAS SAILED

To those who believe a 32-tonne limit for HGVs is sacrosanct, we say that the boat has sailed, with the last Government approving an increase of 2 tonnes just to accommodate the batteries on all-electric lorries.

Here at IHS, we're in the ludicrous position of having export orders for our 44T VCMs from Denmark, Brazil and Canada where they are perfectly legal, while back here all such sales are banned. Without a domestic market to sustain them, my manufacturing plant in Yorkshire will close by 2028.

Thank goodness Labour ministers have seen the folly of this situation. Northern Ireland Secretary Hilary Benn MP spoke powerfully on our behalf in a Westminster Hall debate in the last Parliament. Home Office Minister Angela Eagle and Deputy Chief Whip Mark Tami are long-standing supporters. Labour's Shadow Transport team right up to the election gave us 100% support. Louise Haigh MP, the new Transport Secretary, knows that she doesn't need time on the floor of the House of Commons to reverse this: all that is needed is a Statutory Instrument that changes the 'temporary' time limit permitting our use of VCMs to a 'permanent' one. We make a £380m contribution to our economy and employ 15,000 skilled workers, so her colleague the Chancellor will surely be delighted to see our sector thrive and prosper after 2028.

Chris J Smith
Chair, the Batched on-Site Association, MD of IHS and Mixamate

Mark Reeve
Deputy chair, the Batched on-Site Association and sales manager for BayLynx

Acknowledgement:

Note: In the interests of balance, *Concrete* welcomes comment from all sides in this debate.

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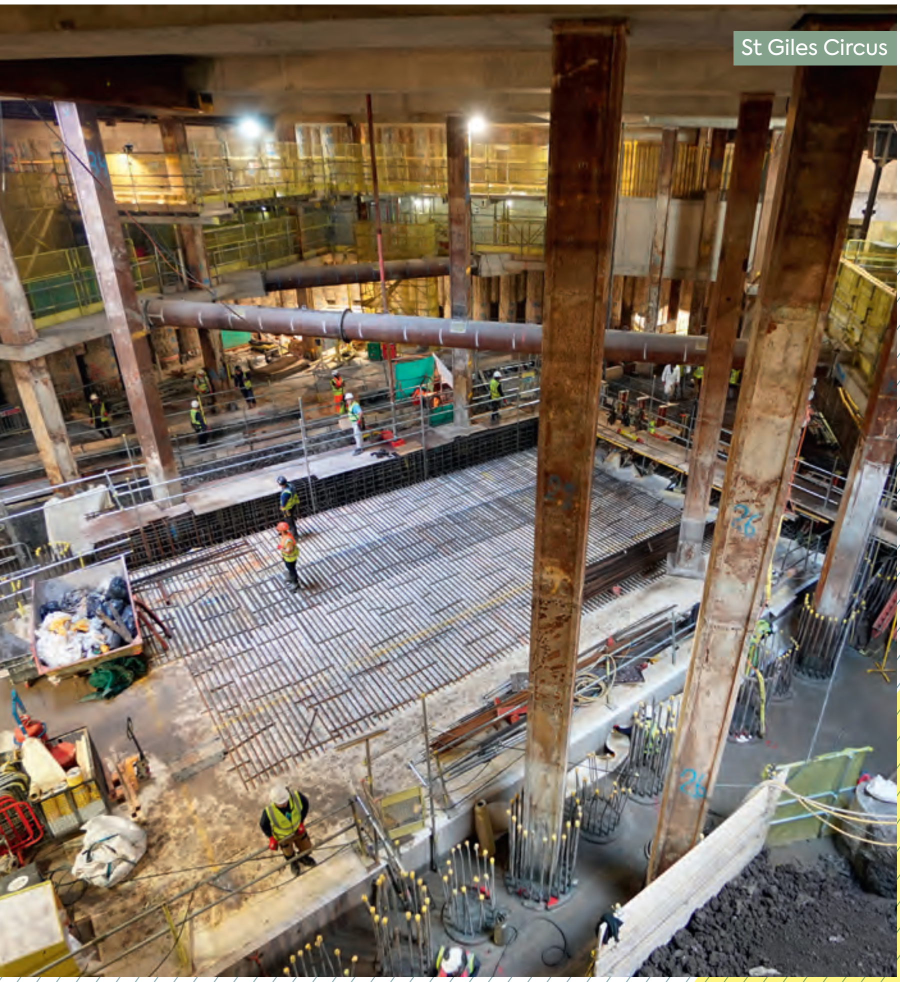


St Giles Circus

Battersea Power Station

Marble Arch Place

RECLAIMED CALCINED CLAY CEMENTS (RE-C3)

The Mineral Products Association (MPA) led an innovative project on 'Reclaimed Calcined Clay for Low Carbon Cements (Re-C3)', which tested the potential of using lower-value reclaimed clays and brick powders, which are typically discarded in UK quarry and brick production sites, as supplementary cementitious materials (SCMs). Roger Griffiths reports.

SCMs contribute to the properties of hardened concrete mainly through their hydraulic or pozzolanic reactivity. Today, these are primarily GGBS, fly ash and ground limestone. The problem with the use of GGBS and fly ash in the UK is one of supply. Production of these materials is declining in the UK and although both are available on the international market, other potentially reactive SCMs (such as calcined clay) need to be investigated to enable an overall increase in the use of SCMs, thereby helping to decarbonise the industry.

The project was a collaborative effort with support from partners: Heidelberg Materials UK, Tarmac Cement, Imerys Minerals, Forterra, University College London and the University of Dundee. It was partially funded by Innovate UK through the Industrial Strategy Challenge Fund (ISCF).

RECLAIMED CLAYS

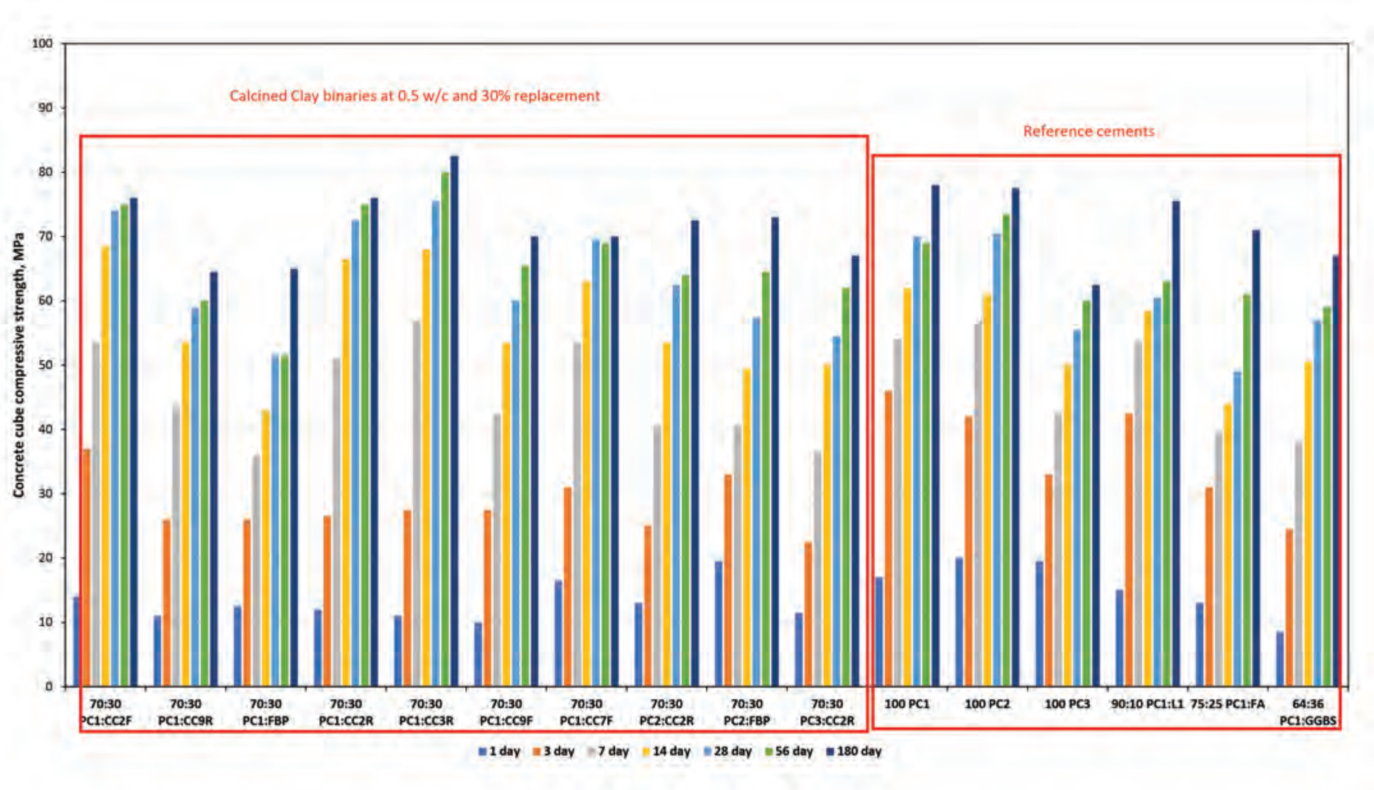
In the project, reclaimed clays from several different UK sources were characterised, calcined and evaluated for the properties useful for cement and concrete production. The clays chosen were from a number of different sites with differing clay species. This is an alternative approach to other research into calcined clays that have predominately evaluated materials with high kaolinite content. The clays tested (Table 1) were a mixture of quarry over/inter-burden, washings from kaolinite production and clays that are available but not currently used in existing quarries.

A number of these clays were calcined at pilot scale (1 tonne of each material) using two different heating methods to enable comparisons of the resulting properties. The two methods trialled were:

- rotary kiln – a commonly available technology in the UK
- flash calcination – a new and innovative heating technique not yet trialled in the UK. This technology has a lower heat consumption when calcining clays compared with the use of a rotary kiln.

The calcined clays produced at pilot scale, along with a waste-fired clay brick dust, were then tested as

BELOW:
Figure 1 – concrete strength development of binary calcined clay and reference concretes at w/c = 0.5.



Samples	Kaolinite	Illite	Montmorillonite	Chlorite	Quartz	Feldspar	Carbonates (Calcite/ Dolomite)	Fe Compounds (Hematite & Pyrite)	Muscovite	Schorl (Tourmaline)
RC1	4				46	20		2	28	
RC2	54				8	16			17	5
RC3	69				4	13			10	4
RC4	75				1	17		1	3	3
RC5[2]	38	10			1			1		
RC6	6	24[1]			29	7	29	4		
RC7	12	31[1]	9	9	20	10		4		
RC8	16	24[1]	24	1	19	5	1	10		
RC9	49	13		2	19	7		7		
RC10	28	21		13	20	3	7	3		
KDRC	7	29		9	23	8	10	6		

1 *Mixed layer illite/montmorillonite is common in these clay types, so the absolute values stated are likely to be aggregated.*
2 *Low total due to high organic carbon (lignite) content contributing to the LOI.*

LEFT:
Table 1 – normative mineralogy based on modelling the chemistry (XRF) with the mineralogy (XRD).

BELOW:
Figure 2 – L-shaped retaining wall units produced as part of the Re-C3 project using the different calcined clays.

cements for conformity with British Standards. The cements containing calcined clay components met over 95% of the requirements set by BS 8615:2019[1]. The extensive testing conducted for the project has informed a revision of this Standard, which will enable a greater range of clays to be used in Portland cement.

Finally, these cements were tested in concretes as part of a programme designed to inform a future revision of BS 8500:2023[2]. Some of the cements contained as little as 45% Portland cement, which was achieved by using a combination of calcined clay and ground limestone as the SCM component. The results demonstrated that these calcined clays, even those with low kaolinitic content, performed exceptionally well in both standard and self-compacting concretes. Standard concretes achieved a strength class of 42.5N and showed continued strength gain beyond 28 days (Figure 1). Durability testing on these concretes demonstrated excellent resistance to chloride migration and the early results from longer-term chloride diffusion, natural carbonation, freeze–thaw, alkali–silica reaction and sulfate-resistance tests show that all concretes are on track to satisfy BS 8500 requirements. This provides the industry with the necessary confidence that calcined clays perform similarly to mainstream SCMs and in some cases, better

The practical application of this study was showcased at Forterra's Somercotes site, with the production of precast self-compacting concrete L-shaped retaining wall elements, using the materials manufactured in the pilot kilns along with a brick-dust source (Figure 2). The findings underscored the significant potential of reclaimed clays and finely ground bricks as SCMs, offering sustainable solutions for the construction industry while aligning with the circular economy objectives of the UK.

RESULTS

The results from the project present an opportunity to use waste-clay materials effectively as a Portland cement substitute, thereby reducing landfill waste and promoting environmental conservation. The use of such materials aligns with the broader industry goals of decarbonisation and supports the UK's commitment to creating a greener construction sector. The potential economic benefits are equally promising, with the possibility of creating new markets, securing jobs and attracting investment within the UK. Additionally, the technology for processing reclaimed calcined clay is proven.

A detailed report of the two-and-a-half-year project is available on the MPA Cement website: *http://cement.mineralproducts.org.*

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1. BRITISH STANDARDS INSTITUTION, BS 8615. *Specification for pozzolanic materials for use with Portland cement. Part 1 – Natural pozzolana and natural calcined pozzolana. Part 2 – High reactivity natural calcined pozzolana*. BSI, London, 2019.
2. BRITISH STANDARDS INSTITUTION, BS 8500. *Concrete. Complementary British Standard to BS EN 206. Part 1 – Method of specifying and guidance for the specifier. Part 2 – Specification for constituent materials and concrete*. BSI, London, 2023.

Ultra-low-carbon concrete – already a feature of infrastructure

The concrete industry has been making significant strides in developing and implementing ultra-low-carbon solutions, with recent projects demonstrating the viability and effectiveness of these innovations in reducing the carbon footprint of concrete construction. Among the companies at the forefront of this movement, Tarmac has been using ultra-low-carbon concrete in commercial applications. Andy Campling explains more.

A ground-breaking initiative at the Hexham Flood Alleviation Scheme in Northumberland marked a UK first in the use of ultra-low-carbon concretes for permanent works. This project, delivered in collaboration with BAM and the Environment Agency, used two innovative concretes: Portland limestone ternary cement C VI and an alkali-activated cementitious material (AACM). Both mixes were developed to meet the C32/40 compressive strength class, ensuring no compromise on structural integrity while significantly reducing embodied carbon.

The Portland limestone ternary cement C VI, introduced by the new cement Standard BS EN 197-5[1], comprises cement clinker, GGBS and up to 20% limestone filler. The mix achieved a remarkable 64% reduction in embodied carbon compared with standard CEM I concrete, resulting in just 119kg/m^3 CO_2e of concrete delivered to the site. Pushing the boundaries even further, the AACM mix, with over 95% of its cementitious component consisting of GGBS, achieved an impressive 70% reduction in embodied carbon, equating to only 100kg/m^3 CO_2e compared with standard CEM I concrete.

The success of these ultra-low-carbon concretes lies not only in their reduced environmental impact but also in their ability to meet or exceed the performance criteria of traditional concretes. Extensive trials have proven the effectiveness of these mixes in terms of their fresh and hardened properties, ensuring they can be used in a range of structural applications without compromising on load-bearing capacity or durability. This is particularly crucial for infrastructure projects exposed to harsh environmental conditions, where long-term performance is paramount.

LOW-CARBON TRIAL

Another significant project showcasing the potential of low-carbon concrete is the M42 junction 6 improvement scheme. This £282 million project, aimed at alleviating congestion at a notorious bottleneck in the Midlands, involves an industry-first trial of low-carbon reinforced concrete. The trial compares traditional steel-reinforced concrete with a low-carbon concrete reinforced with basalt fibre, providing valuable insights into the performance and viability of these materials in major infrastructure projects.

One of the key advantages of these ultra-low-carbon mixes is that they can be manufactured at conventional concrete plants and installed using standard methods. This eliminates the need for specialist equipment or techniques, making them a practical choice for a range of projects and facilitating their adoption across the industry. The carbon reductions achieved by these mixes are calculated using the BSI PAS 2080[2] specification, a method for assessing the whole-life carbon of buildings, ensuring that the reported reductions are both accurate and comparable across different projects and mix designs.

The successful implementation of such ultra-low-carbon concretes is paving the way for wider adoption across the industry. In 2016, the BSI released the first version of a new performance Standard for AACMs[3], which is expected to accelerate the use of this technology. This standardisation is crucial for building confidence in the market and providing a framework for quality assurance and performance expectations.

WORKING IN PARTNERSHIP

Ongoing trials and collaborations with major infrastructure clients such as National Highways and the Environment Agency are crucial for gathering commercial performance data and driving further innovations in mix design and application techniques. These partnerships are helping to refine and develop AACM systems and other low-carbon solutions, ensuring they meet the stringent requirements of modern infrastructure projects.

The advancements in ultra-low-carbon concrete represent a significant leap forward in

sustainable construction practices. By successfully demonstrating up to 70% reductions in embodied carbon without compromising on strength or durability, these innovations are set to play a crucial role in meeting the industry's carbon reduction targets. As these technologies continue to evolve and gain wider acceptance, we can expect to see a transformation in how the industry approaches concrete construction, balancing the need for robust infrastructure with the responsibility to minimise environmental impact.

The projects at Hexham and on the M42 serve as compelling case studies, illustrating the practical viability of these solutions and setting a new benchmark for low-carbon concrete in UK infrastructure. They demonstrate that sustainable construction is not a future aspiration but a present reality, with ultra-low-carbon concretes ready to be deployed at scale across a wide range of applications.

LOW-CARBON FUTURE

As the concrete industry continues to innovate and collaborate, the focus on sustainability is driving the creation of a new era of construction materials. The success of these ultra-low-carbon concretes is not just a technical achievement but also a testament to the industry's commitment to addressing the challenges of climate change. With ongoing research and development, we can anticipate even greater advancements in the coming years, further reducing the environmental impact of concrete while enhancing its performance and versatility.

The shift towards ultra-low-carbon concrete is a fundamental change in how we approach infrastructure development. As specifiers, contractors and clients become more aware of these innovative solutions, demand is likely to grow, driving further investment in research and production capabilities. This virtuous cycle of innovation and adoption promises to accelerate the transition to a more sustainable construction industry, with concrete playing a central role in building a low-carbon future.

APPROACH

CEVO is the name given to Tarmac's approach to supplying low-carbon concretes. It is based on working with supply chain partners to understand the performance requirements of the project and then advising on mix designs that meet these requirements but also deliver major reductions in embodied carbon emissions. These carbon savings are measured and compared using easy-to-understand performance grading aligned to ratings published by the ICE, endorsed by the Green Construction Board in the *Low Carbon Concrete Routemap*[4]. This system uses A to G gradings similar to the efficiency bars commonly found on electrical items. It means that carbon savings achieved using different materials technology can be evaluated in a simple, transparent and intuitive way. C

ABOVE LEFT: Tarmac on-site at the Hexham Flood Alleviation Scheme in Northumberland.

ABOVE: Hexham is the UK's first time in using ultra-low-carbon concretes for permanent works.

Further information:

For those who want to learn more, Tarmac is now offering an 'Understanding Low-Carbon Concrete' CPD training module. This explores the technical and operational challenges of removing carbon emissions from cement and concrete, considers the current alternative technologies and helps users to understand the decisions and trade-offs when specifying concrete and measuring and comparing low-carbon materials. Contact: kiren.sidhu@tarmac.com.

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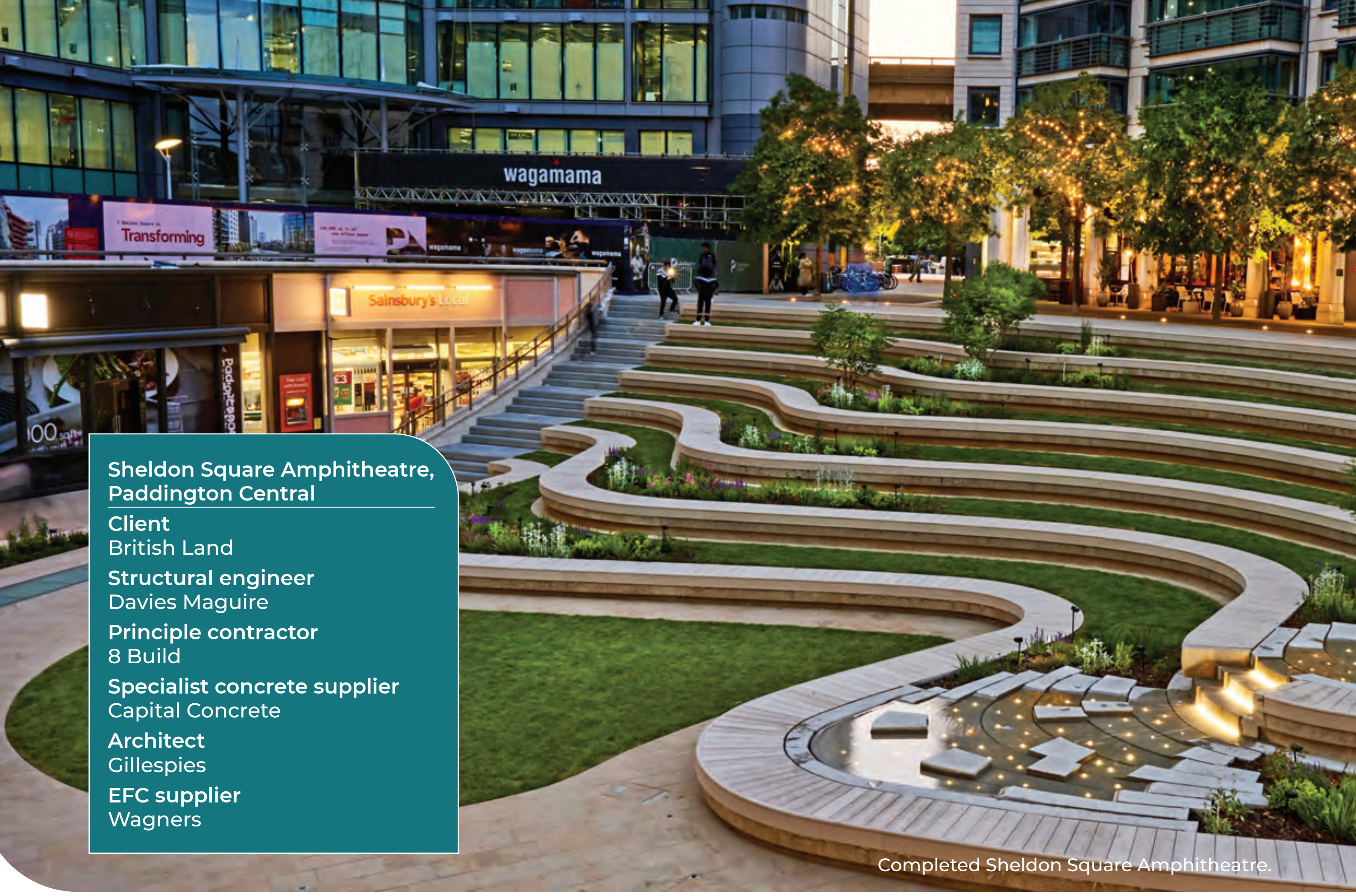


Completed Sheldon Square Amphitheatre.

Sheldon Square Amphitheatre, Paddington Central

Client
British Land

Structural engineer
Davies Maguire

Principle contractor
8 Build

Specialist concrete supplier
Capital Concrete

Architect
Gillespies

EFC supplier
Wagners

SHELDON SQUARE AMPHITHEATRE, PADDINGTON CENTRAL

The amphitheatre, nestled within the vibrant landscape of Sheldon Square, stands as a testament to innovation, sustainability and collaborative excellence in urban architecture. **Adam Green** of **Byrne Bros (Formwork)** highlights the largest use of Wagners' Earth Friendly Concrete (EFC) in an architectural finish within the Northern Hemisphere and the project's commitment to reducing embodied carbon. The cornerstone of the project's success lay in stakeholder collaboration, early design stage engagement and preconstruction concrete trials.

Paddington Amphitheatre's innovative approach to concrete application in an architectural finish sets a new benchmark for future urban projects. By leveraging advanced preconstruction trials and rigorous planning, the project successfully realised a unique design vision that harmonises with the surrounding urban landscape.

COLLABORATIVE EXCELLENCE

While much is already known of EFC, as a geopolymer alkali-activated cementitious material (AACM) and about its reduced embodied carbon compared with traditional concretes, this article focuses on the spirit of collaboration across all stages of the development, from inception to construction. From the initial conceptualisation to the final execution, stakeholders across disciplines had a shared vision of sustainability and excellence. Client, architects, developers, engineers and contractors worked hand in hand, leveraging their collective expertise to overcome challenges and push the boundaries of innovation.

EARLY DESIGN STAGE

One of the most significant factors contributing to the project's success was the early design stage engagement. By involving all relevant parties from the outset, we were able to identify and agree sustainability goals, explore innovative solutions and optimise design strategies to maximise carbon reduction. This proactive approach not only facilitated informed decision-making but also ensured that sustainability considerations were seamlessly integrated into the project's DNA. Recognising the critical role that early collaboration plays in shaping sustainable outcomes, stakeholders came together early into the project's design stage to explore solutions to reduce the carbon footprint.

Gillespies' initial architectural concept to form the sweeping curves of the amphitheatre seating was based on large format monolithic precast units in a 'white' concrete finish. Davies Maguire identified logistical and loading challenges with installing large units weighing up to 2.9 tonnes within a constrained, publicly accessible environment and looked to streamline the installation by stripping out 50% of the concrete volume, minimising weight, necessary plant and equipment for lifting and placement, as well as associated embodied carbon.

In 2020, the use of low-carbon concretes was in its infancy in the precast industry and coupled with the requirement for expensive, irregular and complex curved formwork, delivering the scheme in precast concrete was proving challenging. A different approach was needed if the project was ever to be realised.

Byrne Bros' had previous experience with using EFC and had introduced the product as a viable low-carbon technology to Davies Maguire. Durability (XF4) and robustness, rather than strength, were governing the use of concrete within the amphitheatre environment and the non-safety critical structural design provided the perfect scenario to explore the use of an in-situ low-carbon novel concrete within an architectural setting.

Byrne Bros' and Davies Maguire tabled a proposal to British Land to collaboratively test and evaluate the feasibility of delivering the amphitheatre in in-situ concrete, including the viable option to incorporate EFC for reducing the embodied carbon of the development.

CARBON REDUCTION AND GGBS

As one of the key components of EFC, GGBS served, in line with industry-wide understanding at the time, as a creditable low-carbon supplementary cementitious material (SCM). We recognise GGBS as a finite resource and co-product of the steel industry from an emission-intensive process. As such, it remains a transitional material, offering near-term project-specific carbon savings while other novel materials or solutions are developed medium- to long-term. However, we also believe that at the time, and given industry perception, the use of EFC and GGBS provided an opportunity to signal to the market that we as a collective group of businesses wanted to use novel low-carbon cement replacements in permanent works/features.

ABOVE:
Construction, including formwork and concrete step finish.

The accumulative saving of designing leaner and smarter through the design process resulted in an 85% reduction in embodied carbon associated with the concrete from the initial precast design concept to delivered in-situ.

PRECONSTRUCTION TRIALS

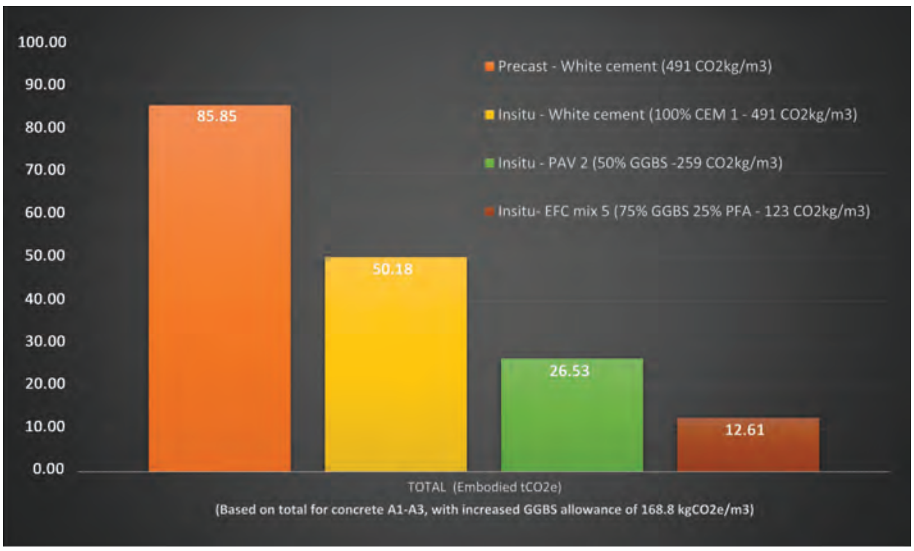
Five sets of full-scale curved seating mock-up segments were produced off-site to trial the parameters of in-situ casting for this application, which played a pivotal role in ensuring the success of the project.

Byrne Bros' preconstruction panel trials aimed to test and benchmark different combinations of concrete, formwork material, release agent, finishing (trowelling off) and the worked finish method required to achieve a desirable final product.

These trialled parameters included:

- concretes: PAV2; white Portland cement; white pigment; EFC – both with and without fibre reinforcement
- form face materials: 9mm film-face plywood; resin and peel ply-skin-faced expanded polystyrene mould; polyurethane face coated expanded polystyrene mould; controlled permeability formliner (CPF)

BELOW:
Total embodied carbon from precast concept to delivered in-situ EFC.



- release agents
- surface retarders
- anti-slip sealer and dry-shake
- unformed finish to top surface of seat: steel hand trowel; high-pressure wash; stiff wire brush.

The results of each mock-up were compared and ranked in terms of the aesthetics and embodied carbon per mix.

These trials served as a crucial process in achieving the required architectural aspirations and gaining the buy-in and confidence of the design team and client. By scrutinising each mix's performance, incorporating feedback from the formwork carpenters and concrete finishers during the mock-up process, the project team gained valuable insights into the practical elements of pouring and finishing the panels. This proactive approach not only ensured that the final concrete compositions met the project's stringent requirements but also instilled confidence in the viability of EFC as a sustainable alternative to traditional concretes in permanent works with an architectural application.

FINISH

One of the key project challenges was achieving a uniform and consistent in-situ concrete finish under site conditions across the formed and unformed surface, replicating a 'light acid-etched' effect more suited to the controlled environments of precast manufacturing plants. The trials were key to overcoming these challenges and the collaborative nature of the exercise allowed all stakeholders to develop the final solution jointly in an open trial-and-error, iterative process. As a result, Sheldon Square Amphitheatre stands out for its characteristic warm honey-coloured tone, blending in with the surrounding York stone while retaining its own distinctive exposed aggregate finish.

To achieve the architectural sweeping curves, bespoke formwork moulds were produced for the formed face of the seating. The formwork design had to consider unit weights, assembly and disassembly of the shuttering system. Logistical restrictions prohibited the use of cranage around the amphitheatre. Lightweight formwork moulds from rigid foamed polystyrene with a hard-wearing surface film were used.

Following the concrete placement and curing of approximately ten days, a high-pressure jet washing was carried out to expose the coarse and fine aggregate, and achieve the desired finish. This approach was taken instead of jet washing the following day due to uncontrollable factors such as ambient temperature affecting the curing time and preventing a uniform exposed-aggregate finish. Allowing the concrete to cure for approximately ten days removed the uncontrollable factor of ambient temperature.

STRIKING FEATURE

Paddington Amphitheatre stands as a testament to the power of innovation, collaboration and early design stage engagement. The project successfully navigated the complexities of urban construction, delivering a striking architectural feature that enhances the vibrancy of Sheldon Square. This achievement underscores the importance of meticulous planning, rigorous preconstruction trials and the skilled execution of innovative concrete techniques.

Rob Stickland, estate director for British Land, says, "We are delighted with the environmental performance of EFC but just as importantly the product has helped to transform Sheldon Square to unanimous approval from all the users of the amphitheatre." C

TOP:
Full-scale trials.

INSET:
Completed project with Byrne Bros' operatives on-site.


WE ARE
Bespoke and more.
Ibstock
At the heart of building

THIS IMAGE AND OPPOSITE: Samples of C4C's low-carbon concrete.

ABOVE OPPOSITE: Research at Concrete4Change's laboratory.

CONCRETE'S CARBON CHALLENGE – THE PATH TO NET ZERO

Dalraj Nijjar of **Concrete4Change** looks at how the UK and Europe are experiencing a shortage of SCMs, the need for innovation and recognition that fly ash and GBBS are not long-term solutions, plus the path forward to achieving net-zero emissions in the industry.

To mitigate rising emissions, the concrete industry has historically relied on substituting cement with supplementary cementitious materials (SCMs) such as fly ash and GBBS. However, the UK's plan to phase out coal power stations by 2025 and the EU's commitment to an 83% reduction in electricity from coal power stations by 2030[1], on top of the steel industry's transition to electric arc furnace technology, are creating a major shortage.

SUPPLY SHORTAGES

According to a recent Government report, fly ash in the UK has been declining since 2016[2], resulting in a sharp increase in prices. Many blast-furnaces in the EU and the UK are also reaching the end of their lifespans and being replaced by greener alternatives, contributing to the shortages.

The scarcity of these materials in the UK and Europe has been exacerbated by increasing demand from major players in the global concrete market in China and India. Companies in these countries have easier access to these materials due to the higher volume of steel and coal production in the regions, therefore they receive priority access to the SCMs due to their high concrete production volumes, pushing the UK further down the list. The UK is also reliant on imports of these materials from China, Spain and Japan, introducing additional environmental costs through transportation and processing.

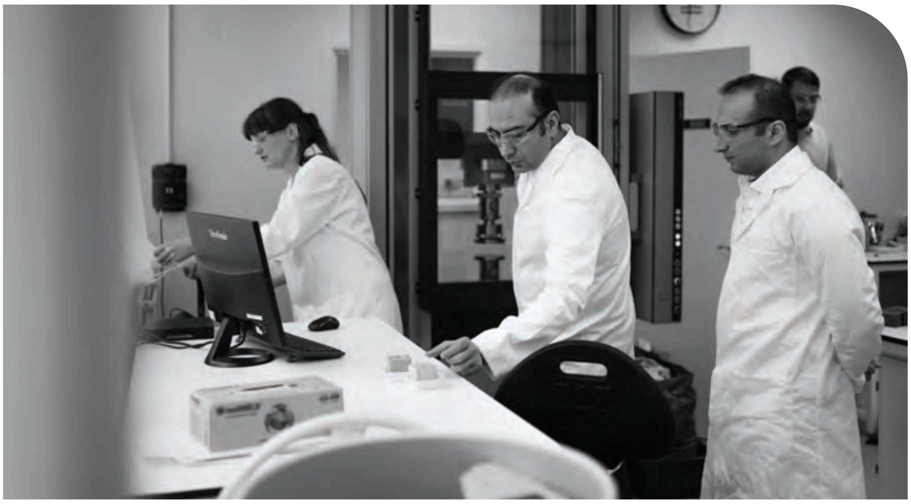
Zooming out though, even at peak availability, supplementary materials could only satisfy approximately 5% of the global demand for cement. This fundamental limitation highlights the urgent need for more comprehensive and scalable solutions to decarbonise the concrete industry.

INNOVATIVE APPROACHES

As the industry grapples with these challenges, several innovative approaches are emerging. The global cement manufacturing industry has a big, carbon-shaped problem. The industry produces 3 billion tonnes of CO_2 per annum, which, in short, it does not know what to do with. One promising solution that addresses this is the mineralisation of CO_2 in concrete. This process sequesters CO_2 into cement in concrete through a carrier material, improving the mechanical properties and the strength of concrete when done correctly. This means less cement is needed in the first instance, leading to reduced emissions.

Additionally, taking CO_2 produced from cement production and mineralising it into fresh concrete fits seamlessly with existing infrastructure, which makes it easier to implement and scale in a shorter time frame. However, the key to success lies in the method and delivery of CO_2 into the cementitious material. Controlled mineralisation can enhance strength and performance while reducing the need for cement by up to 30% – but excessive uncontrolled carbonation during the first day of freshly made concrete can compromise durability. It's an exact science.

Another emerging trend is the recycling and upcycling of end-of-life concrete. Separating cement from aggregates in old concrete structures can create new types of binders that can be reused in construction. While this approach shows great potential, it is costly and faces significant challenges in scaling and establishing efficient



supply chains for upcycling the end-of-life material. However, as landfill space becomes scarcer and circular economy principles gain traction, this method could become a key component of sustainable concrete production.

Researchers are also exploring entirely novel cementitious and binder materials derived from different feedstocks. While these alternatives offer exciting possibilities, their widespread adoption faces significant hurdles due to the risk-averse nature of the construction industry and the rigorous safety standards required for building materials. New materials will require lengthy regulatory approval and could struggle to gain trust from the industry.

INCREMENTAL IMPROVEMENTS

Advancements in kiln technology and alternative fuels are also helping reduce emissions from the cement production process. These incremental improvements represent an important part of the industry's overall sustainability strategy, although they require significant investment to graduate from the laboratory to commercial scale.

Many cement producers are also investing in carbon-capture-and-storage (CCS) technologies as a step toward managing their emissions. While CCS doesn't address the root cause of emissions, it provides a crucial stopgap measure as more comprehensive solutions are developed and implemented. However, CCS requires significant capital investment and ongoing operational expenses, with these costs ultimately passed on to the price of cement.

Each of these solutions represents different aspects of the concrete life cycle and together they offer a hopeful outlook for the industry. However, a realistic timeline for significant progress is likely 15–20 years away, given the relatively slow speed of the concrete sector in adopting new approaches and the rigorous testing required for new materials and methods, especially in critical infrastructure applications.

In the near-term, CO_2 mineralisation and the increased use of recycled materials in non-structural applications could be effective solutions due to their ability to fit seamlessly into existing supply chains. This would mean no change to current production lines and no huge costs for the industry. This initial stage would road-test the technologies and lay the foundations for more ambitious efforts in future, such as the application of these technologies in critical infrastructure projects.

The concrete industry's path to net-zero emissions is achievable but it requires a joint and concerted effort from all stakeholders over a sustained period of time – investors, manufacturers, researchers, policymakers and end users. Regulatory support will be crucial in incentivising the adoption of new technologies and materials, while continued investment in research and development is essential to refine and scale promising solutions.

Concrete is still the most used building material in the world and that is not going to change anytime soon. The solutions are available and savvy companies in the industry will have their eyes firmly set on adoption.

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'BOOK AND CLAIM' FOR THE STEEL AND CONCRETE SECTORS

A new report, co-authored with Microsoft, provides analysis of how a 'book and claim' system can be used effectively to turn corporate demand into real-world investment in low-emission concrete and steel. Chandler Randol and Ben Skinner of RMI report.

Recognising the critical urgency to reduce carbon emissions to limit the impacts of global warming, companies are increasingly broadening their climate commitments to include significant decarbonisation of their supply chains.

For many companies, this means reducing emissions from steel and concrete. The rising demand for lower-carbon steel and concrete highlights the need for innovative approaches to overcome procurement challenges and accelerate scalable decarbonisation pathways in these sectors.

RMI and Microsoft recently published a White Paper[1], which provides a comprehensive analysis of how a 'book and claim' system can be effectively used to turn corporate demand into real-world investment in low-emissions concrete and steel. While highlighting the potential of book and claim, this White Paper also brings a practical focus to the many barriers and lingering questions related to applying book and claim to the materials sector.

Book and claim is an alternative chain of custody model that allows environmental attributes to be decoupled from physical lower-carbon products or services that would ordinarily directly carry those attributes. This creates a separate environmental attribute certificate (EAC) that allows buyers without physical access to lower-carbon products or services to financially enable the decarbonisation of a sector and claim its benefits.

GEOGRAPHIC MISMATCH

Book and claim can effectively address the geographic mismatch often present with low-carbon concrete. It helps producers scale low-carbon concrete by selling EACs to consumers willing to pay the green premium – wherever they may be – and off-take the physical product to their local consumer base.

Additionally, it allows companies to reduce Scope 3 emissions, indirect greenhouse gas emissions not produced by the company itself, but in the case of concrete resulting from upstream activities such as construction. By allowing companies to procure the environmental attributes of low-carbon concrete when a low-carbon alternative may not be available for physical procurement, they can reduce supply chain emissions in their sustainability reporting, while driving investment directly into the concrete value chain.

THE CONCRETE CONTEXT

While book and claim has been effective in other sectors and may be a solution that can scale low-carbon concrete, this White Paper also recognises the nuances of the concrete industry that are not present in other applications.

This includes the fact that: concrete is not a uniform product – it is many different products in which the carbon intensity may vary from batch to batch; the supply chain is long, complex and home to many producers – over 90 cement plants and 8000 ready-mixed concrete plants in the United States alone; and the sector lacks widely agreed-on standards for emissions accounting and reporting, which are necessary to support transparency, credibility and comparability of product level emissions claims. While some methods and norms for emissions accounting exist – Environmental Product Declarations (EPDs) convey a level of certified emissions information and some carbon credit methodologies targeting specific technology interventions can be used as a placeholder – they are not fully fit for purpose.

WHAT COMES NEXT?

This White Paper raises the many barriers and questions that must be in place to facilitate a high-quality book and claim system. In many cases, the paper intentionally falls short of providing answers because these solutions should be derived from stakeholder input. Recognising this need, RMI and the Center for Green Market Activation (GMA) are partnering to convene expert stakeholders across the concrete value chain to tackle these challenges and develop a book and claim framework. C

Further information:

To download a copy of the report, visit: *https://tinyurl.com/5uj36bdy*.

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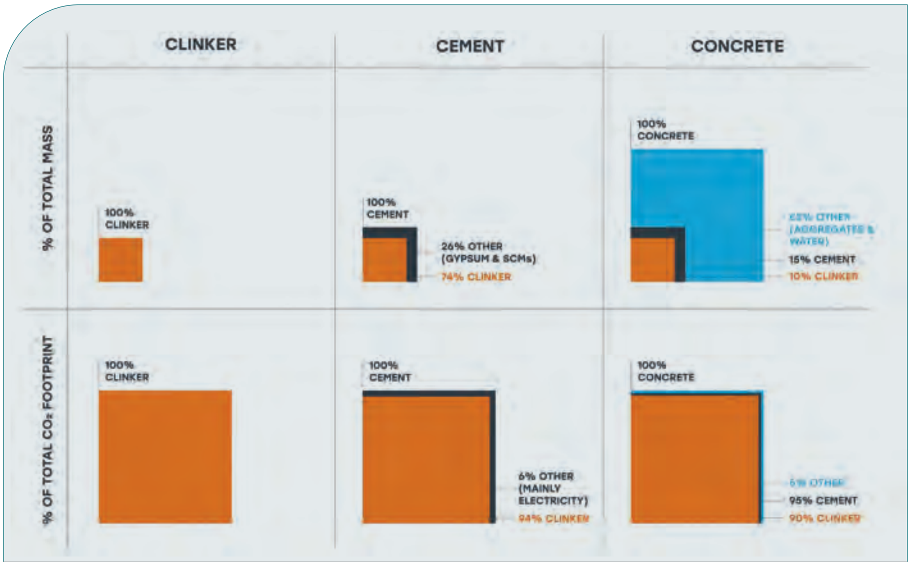
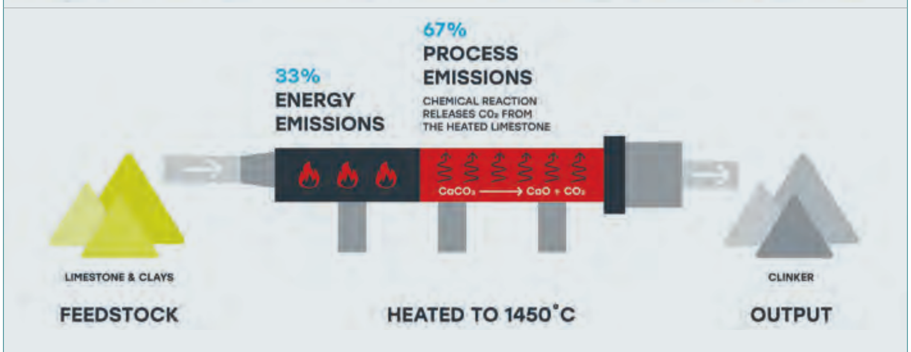
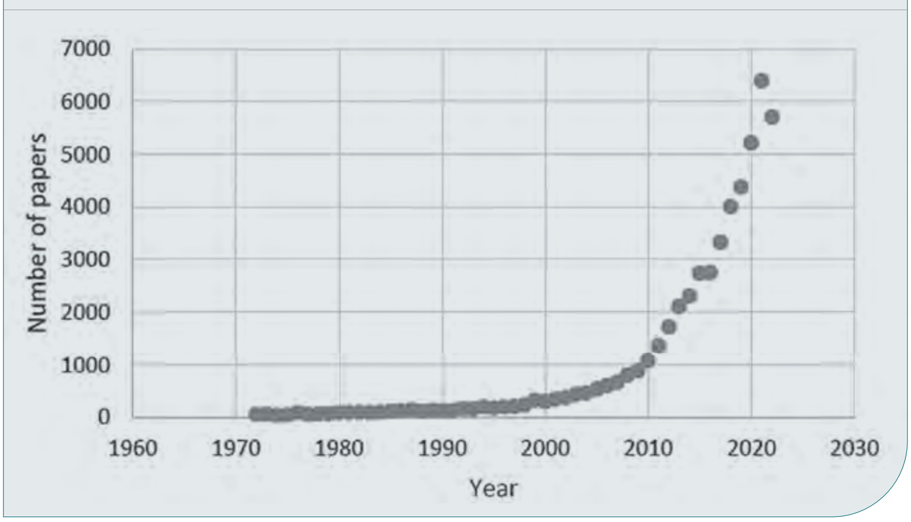
PIONEERING LOW-CARBON CEMENT TECHNOLOGIES WITH SCALABLE GLOBAL IMPACT

The cement and concrete industries have made real progress in decarbonising, yet further emission reductions are imperative to meet increasingly demanding net-zero targets and national policies. Many technologies are emerging, from process improvements and using new materials to carbon capture. John Reddy of Ecocem reports.







To date, the most efficient and immediately available way to decarbonise cement and deliver low-carbon concretes has been to reduce its clinker content using supplementary cementitious materials (SCMs). Extending the use of existing SCMs and developing new ones need to be prioritised if we are to reduce emissions from the concrete industry, rapidly, effectively and affordably.

TACKLING THE CLINKER ISSUE

As the primary source of CO_2 emissions from cement manufacturing, clinker production alone is responsible for 90% of concrete emissions (see Figure 1).

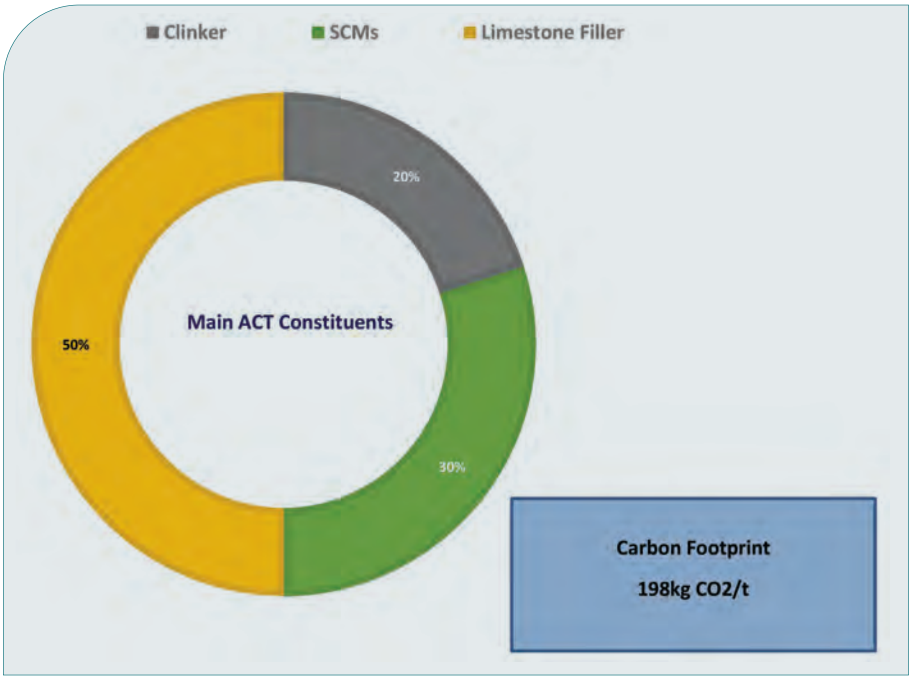
In clinker production, two-thirds of emissions arise from the calcination chemical reaction. To achieve net-zero targets, it's crucial to advance concrete technology and find low-CO_2 alternatives to reduce or substitute clinker (see Figure 2).

The industry faces challenges due to the limited availability of scalable SCMs. While new technologies are promising, none are yet globally scalable. The most abundant SCMs, by-products of the steel and coal industries, also face long-term availability challenges.

TOP LEFT:
Figure 1 – CO_2 footprint from clinker production for concrete.

MIDDLE LEFT:
Figure 2 – transforming limestone and clays to clinker.

BOTTOM LEFT:
Figure 3 – number of papers per year returned by Google Scholar for the search terms 'supplementary cementitious materials', 'pozzolan' or 'cement constituent'[1].



LEFT:
Figure 4 – EPD for the ACT showing the carbon footprint.

BELOW LEFT:
Figure 5 – slump test.

Addressing the clinker challenge involves three key approaches: first, using existing SCMs much more efficiently to enhance the low-carbon constituents of cement and diminish reliance on high-carbon elements. This requires the adoption of industry best practices. As momentum for change builds, it opens avenues to investigate and use new and non-traditional SCMs. Second, material science advancements enable the design of concretes that work with a range of globally available materials that significantly reduce clinker content and CO_2 emissions. Finally, it is imperative that Standards, assessment methods and public policies are updated to support the adoption of these innovative low-carbon SCMs, instilling confidence in a traditionally cautious industry. This includes both specific material Standards, such as those in the EU for concrete additions, and broader performance-based concrete Standards. The transition to net zero requires a significant shift in established practices, underpinned by extensive research and collaboration.

ADVANCES IN MATERIALS SCIENCE

Research activity focused on SCMs has surged, with an 18% increase in scientific papers since 2010 (Figure 3), stimulated by the increased need to decarbonise cement production. As the industry confronts the challenge of limited SCM availability, the adoption of innovative technologies and the diversification of SCMs are crucial for meeting emission reduction targets.

Ecocem's ACT (Advanced Cement Technology) is one such innovation enabling the use of a variety of SCMs, including those not yet fully valorised, with unprecedented efficiency.

ACT has the potential to extend the supply life of current SCMs and facilitate the use of a range of other materials. It lowers the average clinker rate in cement from 75 to below 25%, while maintaining concrete's consistence, strength and durability, without excessive cost, and addressing the challenge of raw material availability.

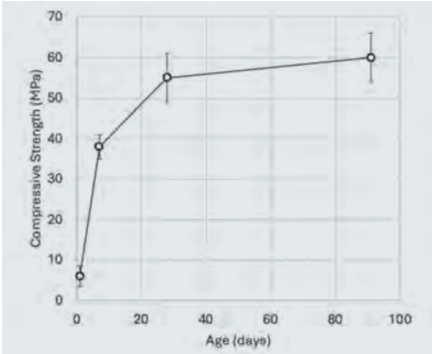
ACT's binder primarily consists of high limestone filler content and a significant proportion of an SCM, which can be adapted to local materials. The rest is ground clinker. This globally scalable composition, using ground – rather than burnt – limestone mixed with an SCM, yields a low-carbon concrete. In fact, its Environmental Product Declaration (EPD) shows a global warming potential (A1–A3) of 198kg CO_2/tonne (Figure 4).

ACT uses low water:binder (w/b) ratios (<=0.35) to ensure strength development and durability performance across a range of exposure classes, suitable for modern construction practices. Maintaining suitable rheology, so that concrete made with ACT technology presents like normal concrete, is essential to adoption; mix designs from flowing S3/S4 concretes to self-compacting concrete and stiffer mix designs have all been cast.

Not only does it present like normal concrete, but it also develops strength similar to normal concrete. The results (Figure 6) are a C40/50 strength-class concrete based on cylinder strengths. Higher and lower grade strengths can be designed by the usual practice of manipulating the binder and w/b ratios.

The technology's development has been bolstered by aggregated data from partner trials, with Ecocem's six patented innovations setting new standards for low-carbon cement, demonstrating that ACT brings market availability closer, without requiring a substantial green premium. Ecocem is positioned to scale low-carbon cements in ways previously thought impossible, with the potential to deliver up to 50% CO_2 reductions by 2040 – essential for achieving the

RIGHT:
Figure 6 – aggregated data from ACT partner site trials conducted over six months. Concrete cast with 350kg/m³ binder, w/b ratio 0.35.



Paris Agreement's 1.5°C target.

ACT technology has achieved an ETA (European Technical Assessment), a significant step for the industry's decarbonisation and commitment to sustainable production methods. Yet, to hasten adoption, national regulations and guidance must evolve, informed by local test cases and pilot projects.

MARKET IMPLICATIONS

As the construction industry faces the growing economic implications of carbon emissions, the impetus to decarbonise cement and concrete production is not only environmental but also financial, with carbon-pricing systems set to potentially impose costs of up to €180 billion globally by 2050. Companies are incentivised to adopt low-carbon practices. Carbon capture, utilisation and storage implementation costs remain uncertain but may exceed current prices by a multiple two to three times higher than current pricing.

> "It is imperative that Standards, assessment methods and public policies are updated to support the adoption of these innovative low-carbon SCMs, instilling confidence in a traditionally cautious industry."

The adoption of sustainable technologies can provide a competitive advantage, meeting environmentally conscious consumer demand and stringent sustainability standards.

Green building certifications such as BREEAM and LEED, validate these sustainable practices, influencing both public- and private-sector construction projects. As governments establish ambitious carbon neutrality targets and regulations, the role of these certifications is pivotal. Government mandates for low-carbon materials further expedite this shift.

CONCLUDING REMARKS

For the cement and concrete industries, these low-carbon solutions can accelerate their ability to reduce cement and concrete supply chain emissions and meet EU climate targets, cost-effectively. The industry's shift to sustainable production, driven by the tangible financial impact of carbon emissions, is environmentally and economically strategic. It enables companies to capitalise on green construction demand, carbon pricing and mandated carbon reduction policies. C

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Concrete as a medium for carbon dioxide sequestration

Finding effective measures to address hard-to-abate emissions is a critical challenge for many industries, including construction. One way to address this challenge is to develop innovative products that remove and store CO_2 in concrete. Mario Schmitt of ecoLocked reports.

For thousands of years, the construction sector has provided the foundation of human societies. However, buildings have also been contributing close to 40% of all greenhouse gas emissions, of which about 15% arise before the building is ever used: during the production of building materials. Even though several low-carbon technologies designed to replace cement are being developed, many are still in the nascent phase. In this scenario, using instruments such as carbon capture and utilisation can provide a great chance for the industry to achieve its climate targets.

Biochar carbon removal (BCR) is a mature carbon removal technology that captures and stores atmospheric CO_2 in the form of biochar – a stable, carbon-rich material produced through the pyrolysis of biomass residues. The incorporation of biochar into concrete provides an opportunity to lock away captured carbon permanently within a widely used construction material. This approach enables the industry to create 'negative emissions', thereby contributing to climate change mitigation and effectively compensating for hard-to-abate emissions directly within the value chain.

BRINGING THE TECHNOLOGY TO MARKET

ecoLocked, a German climate tech company, is spearheading the introduction of new products that capture carbon. The team has spent three years researching and developing biochar as an additive for concrete, aiming to enhance its capacity for carbon sequestration while maintaining structural integrity. The R&D process involved testing over 600 concretes and more than 50 types of biochar, to identify which biochar is the most effective in different concrete applications. This turns biochar into a dual-purpose material that can replace conventional ingredients such as sand, cement and lightweight aggregates, while also acting as a permanent storage medium for sequestered carbon.

THIS IMAGE: ecoLocked's recent project, 320m² paving stones in Rüsselsheim, Germany.

LEFT:
Testing over 600 concretes and more than 50 types of biochar in less than one and a half years.

The company aimed at optimising factors such as biochar particle size, porosity and surface characteristics to ensure compatibility with various concrete formulations. The prototypes were designed for use in medium-strength concrete, but since then it has been possible to develop products covering various concrete applications with different strength classes and end-use performances.

Recently, the company released its first product specifically developed for precast concrete applications such as paving stones and slabs. The successful completion of the first commercial projects matured into ongoing collaborations with various leading European manufacturers.

ENVIRONMENTAL IMPACT

The use of biochar in concrete enables concrete producers to reduce the global warming potential (GWP, expressed in tonnes of CO_2 equivalent) of their products significantly. Biochar itself is carbon-negative, meaning that biochar products prevent more emissions than are emitted during the manufacturing process. When added to concrete, the sequestered carbon present in biochar is permanently locked within the concrete matrix, balancing out the embodied emissions created during clinker production with negative emissions. In combination with a CO_2 reduction effect from the partial substitution of sand or cement clinker, concrete products' net carbon footprint can be brought to zero or even turned negative.

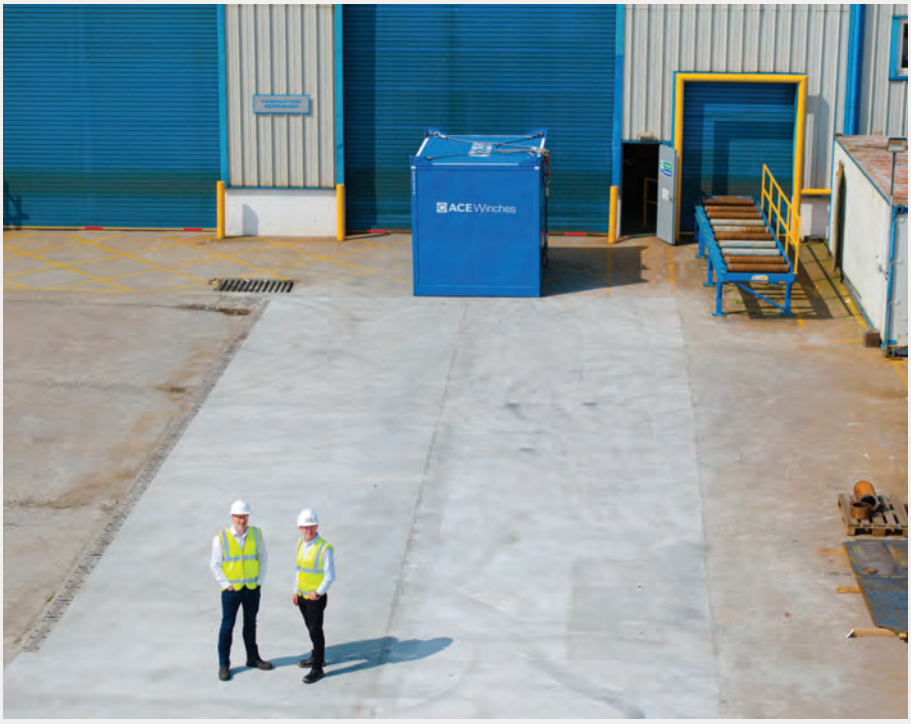
THE ROAD AHEAD

The construction industry has been exploring various options to decarbonise cement and concrete. Quick wins, such as concrete recycling, reducing the clinker content in cement through the use of supplementary cementitious materials and implementing energy-efficiency measures, have already enabled the industry to reduce the carbon footprint of cement by as much as 40–50%. However, novel low-carbon technologies designed to go further are still in development and may not be scalable for years. As a result, even under the most favourable scenarios, studies suggest that an average of 25% of total cement emissions will remain unmitigated by 2050. Moreover, while transitioning to low-carbon materials and technologies is critical, the accumulated historical emissions from decades of production and construction activities must also be addressed.

BCR is a mature technology that can be deployed almost anywhere in the world, enabling producers to make up for both historical and residual emissions. Concrete, meanwhile, offers a durable carbon sink and a 'carbon utilisation' opportunity. Unlike other carbon-storage methods that merely isolate CO_2, incorporating biochar into concrete turns the captured carbon into a functional building material input. In this way, biochar-enhanced concrete supports a circular economy where biomass residues and carbon capture become integral product parts. As this solution advances, it can play a key role in improving the construction industry's carbon footprint and creating a climate-friendly built environment. C

SUSTAINABLE SLAB

ACE Winches, a provider of lifting, pulling and deploying solutions and part of the Ashtead Technology Group, recently appointed Recycl8, a sustainable technology firm, to renew and repair its workshop facilities yard in Turriff, Scotland. This involved a 30m³ pour of a floor slab at the busy modern facilities, which are powered by onshore wind. Mark Gillespie reports.



BELOW LEFT: Keith Anderson, general manager of ACE Winches, and Mark Gillespie, CEO of Recycl8, next to the $30m^2$ floor slab.

The yard, set in the beautiful Aberdeenshire countryside, is where the maintenance and testing of the company's extensive rental fleet of deck machinery equipment takes place. The repairs to the yard surface were to ensure safe and efficient future operations, as ACE Winches sees specialist equipment sent to over 50 countries around the world.

Recycl8 partnered with construction materials supplier Breedon Group to supply its patented solution of sustainable, lower-carbon R8 Mix concrete for the project, which is the latest in a series of successful pours across the housing, industrial, marine and port sectors.

BOTTOM ASH AGGREGATE

Recycl8's R8 Mix technology takes incinerator bottom ash aggregate (IBAA) – often destined for landfill – and transforms it into a sustainable, lower-carbon component for concrete manufacture.

Recycl8 completed the first industry pour of its R8 Mix concrete in September 2023, partnering with Breedon for Barratt and David Wilson Homes. Since then, it has successfully completed pours across a variety of sectors, including ports of Aberdeen and Ardersier, and tackled large-scale commercial projects for Aurora Energy Services, Haventus and, most recently, ACE Winches.

INDUSTRY AND ACADEMIA

Recycl8's team of seven comprises specialists from the waste-to-energy and construction sectors. It works closely with specialists across the wider industry and academia, including the University of Aberdeen and Robert Gordon University. The firm has secured private investment, as well as funding from Scottish Enterprise and Innovate UK during the start-up phase. Its technology has been validated by SEPA in Scotland.

The R8 Mix is well-suited to building contractors requiring large volumes of lower-carbon concrete. Recycl8 has aligned itself with various IBAA providers in Scotland and England, meaning it is well-positioned to scale its business model to meet growing demand. There are 2.5–3 million tonnes of IBAA available annually in the UK and the accessible amount is growing constantly. To date, the volume of IBAA the company has worked with totals tens of tonnes, so the potential to repurpose this resource is vast.

Safety is of paramount importance for the firm. Over the past five years, both the IBAA and the patented R8 Mix have undergone extensive research and development by industry experts, rigorous independent testing and collaboration with Breedon. SEPA in Scotland has approved IBAA for use in concrete.

> "[The] technology takes incinerator bottom ash aggregate (IBAA) – often destined for landfill – and transforms it into a sustainable, lower-carbon component for concrete manufacture."

The theme of collaborating to resolve global challenges and become 'good ancestors' is an important one for the firm. It has been invited to participate in the recently launched Lower Carbon Concrete Collective – a partner ecosystem group spear-headed by Scottish Water and incorporating major utility organisations including Network Rail, Scottish Power, SSE and Transport Scotland, as well as additional supply chain partners and academia.


Project: Manchester Airport, Multi-Storey Car Parks
At Terminal 1, specially designed parapet beams incorporate BSF telescopic connectors to join the precast concrete frame, and TSS telescopic connectors to provide vehicle impact protection. In stair cores at Terminal 1 and 3, TSS and RVK telescopic connectors, in conjunction with REDiBOX recess formers, anchor precast concrete landings to the precast core walls.

PAVING THE WAY FOR DIGITAL PRODUCT PASSPORTS – IT'S ALL ABOUT THE DATA

Georgi Stoyanov of Cobuilder looks at the steps to create Digital Product Passports (DPPs), which aim to go further than Environmental Product Declarations in terms of data collation on a product's environmental impact.

(Image: Thomas Gorny - stock.adobe.com.)

The Ecodesign for Sustainable Products Regulation (ESPR) came into force in July 2024[1], with the aim of making products sold in the EU more repairable, reusable, upgradeable and recyclable. It states that manufacturers will be required to produce a "digital product passport" for every product.

For concrete, this will contain information about not only its composition and characteristics but also its environmental impact, including details such as its carbon footprint and water usage. Precise details are still under discussion, but the requirement means that manufacturers will have to make sure that they can record all this data in one place and make it easily accessible to other parties throughout the supply chain.

ENVIRONMENTAL IMPACT

The concrete industry has already made progress in this direction. Environmental Product Declarations (EPDs) began in Sweden in 1992 and were intended to quantify the environmental impact of manufacturing a product throughout its life cycle. The concept was adopted in Norway and then Germany before spreading across Europe. EPDs are not compulsory but are increasingly common and are also now used in the USA. In the context of concrete, they allow constructors to assess the environmental impact of a concrete product, including cement, ready-mixed and precast concrete, and to select building materials that better meet their sustainability goals.

MILESTONE

Taking the collection and structuring of data one step further, a recent milestone has been the completion of a new data template for ready-mixed concrete, developed by industry experts from Norway, Sweden, Ireland, France, Switzerland and Bulgaria. In layman's terms, this means that agreement has been reached on common standards for storing data about ready-mixed concrete.

Getting to this point is a major achievement for the sector. A consensus had to be reached about precisely which information must be shared and captured, and how terminology and standards are translated so that everyone has the same understanding of what they mean. Based on EN 206[2] as a starting point, this new data template, which we have been proud to be working on, is already available for use and will be updated over time as the industry advances and best practices develop.

Although the data template is only available for use on a European level at present, it is likely to have an impact on how business is done across the EU, including for those organisations based in the UK.

Digital Product Passports are a hot topic. Every industry is talking about how they can use these records to trace products from manufacture to disposal, but most people agree that they are still in their infancy.

> "Digital Product Passports are a hot topic. Every industry is talking about how they can use these records to trace products from manufacture to disposal, but... they are still in their infancy."

The vision for them is that they will initially be populated with static information by the manufacturer and then at each stage of their use, additional data will be added. Achieving this will require a great deal of collaboration across the industry. Perhaps even more importantly, it will require the sector to put the technology in place to make international data shareable and easily accessible. We believe that the combination of new regulations and the practicality of having transparency across borders will quickly drive forward this process. And we'll be a much greener, more sustainable and more efficient industry as a result.

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Ultra-low-carbon cement firm to start production in Wrexham

A Teesside-based operation to mass produce ultra-low-carbon cement says it is close to an industry breakthrough. *Concrete* report.

(Photo: Celsa Steel UK.)

Celsa UK's EAF in Cardiff.

Material Evolution, the company behind the £7.6 million Mevocrete project has worked closely with academic and industrial partners to develop and optimise its ultra-low-carbon geopolymer cement technology for production at scale. The project is funded by Innovate UK through the Transforming Foundation Industries Challenge programme.

The business, based in Middlesbrough, is set to take a step forward this October, rolling out its ultra-low-carbon cement into production at its first manufacturing site in Wrexham.

The company says its solution provides up to 85% less embodied CO_2 than traditional Portland cement (PC), while maintaining concrete quality and consistence, with the business ready to deliver 150,000 tonnes of cement annually.

Through the Mevocrete project, Material Evolution partnered with Teesside University to develop a carbon-negative cement. The business is working on scaling up this technology for future production at the Wrexham factory.

COLLABORATIVE

The firm plans to replicate and scale its production process across the UK and Europe. Professor David Hughes, CSO at Material Evolution and co-lead of the Mevocrete project, says, "This project is a collaborative journey for a more positive carbon-neutral built environment, which, through Mevocrete and new technology, sees an untapped supply of historic by-products from heavy industry diverted away from landfill."

Hughes says that Mevo cement is based on industrial by-products and chemical activators. He adds that what makes the geopolymer cement different to other industry offerings, "is the use of our alkali-fusion technology, which removes the need for calcination and improves strength and durability. It also enables us to use feedstocks that have not been cost-viable in the past. It is an ambient process with minimal energy use."

The Wrexham manufacturing plant, designed through the Mevocrete project, will produce Mevo's first ultra-low-carbon cement at scale, a UK first. Customer trials and results have demonstrated that the product can be scaled up to commercial use, says Hughes. "We have tried the cement in a range of dry, semi-dry and precast applications, in all matching or beating the mechanical performance of control. We have also completed BS EN 196[1] testing on our cement showing it to be a 52.5R."

Across wider industry, other research has seen a number of trials take place at the pilot electric arc furnace (EAF) site at Celsa Steel UK in Cardiff. Material Evolution is undertaking its own testing project at this site to valorise steel by-products, though in a different form to the other research schemes.

BS 8500 REVISION

Material Evolution's journey has been accelerated through revisions to BS 8500[2]. The revision provides greater flexibility for producers to use up to 65% less PC replacement by two or more low-carbon cementitious materials. The new BSI Flex 350 v2[3] also allows for the specification of a greater range of lower-carbon concretes.

The business was founded in 2017 by Dr Liz Gilligan and Sam Clark. Gilligan says, "We are on a mission to rapidly and radically decarbonise the construction industry, by creating a product that emits 85% less carbon than PC, followed by our net-zero-carbon cement, which we are working on scaling into production. Our ultimate goal is to remove one gigaton of carbon by 2040."

The Mevocrete project is set to conclude at the end of 2024. C

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The Concrete Society

Regional Network

The Concrete Society's Regional Network of 11 committees, run by volunteers within the concrete industry, offers members around the UK the opportunity to gain technical experience through an extensive programme of technical seminars. The Regions also hold many social events, such as formal charity dinners and lunches, and also golfing events, where members can widen connections and network with industry colleagues.

View current events calendar

If you are interested in joining, please contact The Society:

Tel: 01276 607140
Email: regional-events@concrete.org.uk

LOWERING THE CARBON IMPACT OF SPRAYED CONCRETE TUNNEL LININGS

Chris Peaston of Peaston Concrete Consultancy highlights the significant observations of the recent ITA report on low-carbon tunnel linings relating to sprayed concrete and discusses their related implementation.

A recently published International Tunnelling and Underground Space Association (ITA) report[1] highlights that once a system-level decision is made to adopt a tunnelling solution, 60–80% of the related embodied CO_2e emissions are in the concrete tunnel linings. The first form of mitigation is reducing the volume of concrete required through efficient design and reduction of construction waste, in which regard the report refers to the previous ITA guidance on single-pass or permanent sprayed concrete linings (PSCL)[2].

Once the lining design is fixed, for a typical concrete the cement will have by far the most significant carbon impact and the reduction of Portland cement (CEM I) provides the greatest mitigation. In both segmental and sprayed linings, the second biggest source of embodied carbon is in the reinforcement. In either solution, there are circumstances in which fibre-reinforced concrete (FRC) may be used to lessen the impact compared with conventional bar reinforcement[2,3].

GENERIC GUIDANCE

The ITA report[1] provides generic guidance on the means of reducing the carbon impact of concrete through the use of supplementary cementitious materials (SCMs) and other alternatives. It also highlights that given the typical dependence on rapid early strength gain, the average sprayed concrete contains approximately 400kg/m^3 and sometimes up to 500kg/m^3 of cement. It records anecdotal evidence of country-specific practice in which SCMs are used to reduce sprayed concrete CEM I content to 300kg/m^3, which has been reported elsewhere[4], and cites evidence that this need not affect early age strength development.

Nonetheless, the CEM I reduction is limited because the contemporary liquid accelerating admixtures necessary to meet typical SCL strength development requirements are formulated to work with CEM I and their efficacy reduces with lower CEM I proportions. Hu[5] and Hu *et al*[6] provide a comprehensive summary of related research while reporting the findings of a High Speed 2 (HS2) Innovation team-funded 'proof of concept' project[7], in which powder accelerators were successfully used to spray a mix including 70% GGBS in a total of 480kg/m^3 cement content using prototype equipment (see Figure 1).

The embodied carbon content of the 70% GGBS mix was calculated using third-party verified Environmental Product Declarations (EPDs) to establish its overall global warming potential value of approximately 220kgCO_2e/m^3. The calculation was repeated for the comparable contemporary mix in use on the HS2 S1/S2 contract, which included 50kg/m^3 of silica fume in addition to the 480kg/m^3 CEM I partially replaced in the 70% GGBS mix.

With an embodied carbon content of approximately 510kgCO_2e/m^3 in the CEM I mix, the overall embodied carbon reduction in the 70% GGBS mix was therefore 57%. This shows what might be achieved compared with a 23% reduction claimed for a contemporary silo mix sprayed concrete, with respective embodied carbon contents of 159 and 207kgCO_2e/t[8]. On an assumption of a plastic density of approximately 2400kg/m^3, these figures convert to around 380 and 500kgCO_2e/m^3 respectively and are therefore directly comparable with the 70% GGBS mix.

While recognising that GGBS is a constrained material[9] it should not be used simply to reduce single-project embodied carbon emissions. Nonetheless, the ability to spray higher durability concretes, including CIIIB cement types, potentially facilitates their use in more onerous ground and exposure class conditions. The associated reduced heat of hydration is also of potential benefit with respect to achieving the durability and water ingress requirements necessary in PSCL and is being explored in a continuation project[10].

ALTERNATES

The ITA report[1] does not address mix design efficiencies and the associated carbon reduction that might be gained by adopting alternate FRC test methodologies compatible with the limit state design that is required for PSCL. As previously summarised in *Concrete*[11,12], contemporary limit state design methods characterise fibre performance in a CEN standard notched beam test[13]. *fib* Model Code 2010 (MC2010[14]) allows alternatives to this procedure and more accurate representation of sprayed concrete in service performance is potentially achieved by the notched panel test, which is based on identical crack mouth opening displacement (CMOD) and is now part of the BS EN 14488-3 suite of tests[15].

Work exploring the equivalence of the two test methods in sprayed concrete[16,17] has now been combined with additional data obtained during the 70% GGBS spraying trial[5,6], providing five pairs of grouped notched

LEFT:
Figure 1 – sprayed concrete trial using powder accelerated 70% GGBS (CIIIB) mix.

BELOW:
Figure 2 – notched panel and beam mean (fm) and characteristic (fk log normal) LOP (fL) and residual flexural tensile strengths (fRj, j = 1-4) in 70% GGBS (CIIIB cement) fibre-reinforced sprayed concrete[16].

panel and beam test data[18]. The larger fracture surface explains a consistently lower panel limit of proportionality (LOP) strength and less brittle fracture resulting from the improved load distribution. This leads to at least equivalent EC2[19] crack control performance with nominally identical residual flexural strength performance and MC2010/EC2 ductility related classification (Figure 2). These results suggest that a panel-test-derived result is likely to be conservative, while the classification of crack control and ductility in the larger specimen is likely to better represent in-situ performance.

The notched panel test provides an MC2010 limit state consistent test methodology with typically reduced variability. With the resulting reduced margin between mean and characteristic flexural tensile strengths (Figure 2), this has the potential to facilitate more efficient fibre proportioning and with it reduce the associated embodied carbon. While the preconstruction trial test costs may be greater, this may be cost- and carbon-efficient depending on the volume of sprayed concrete in the SCL works. C

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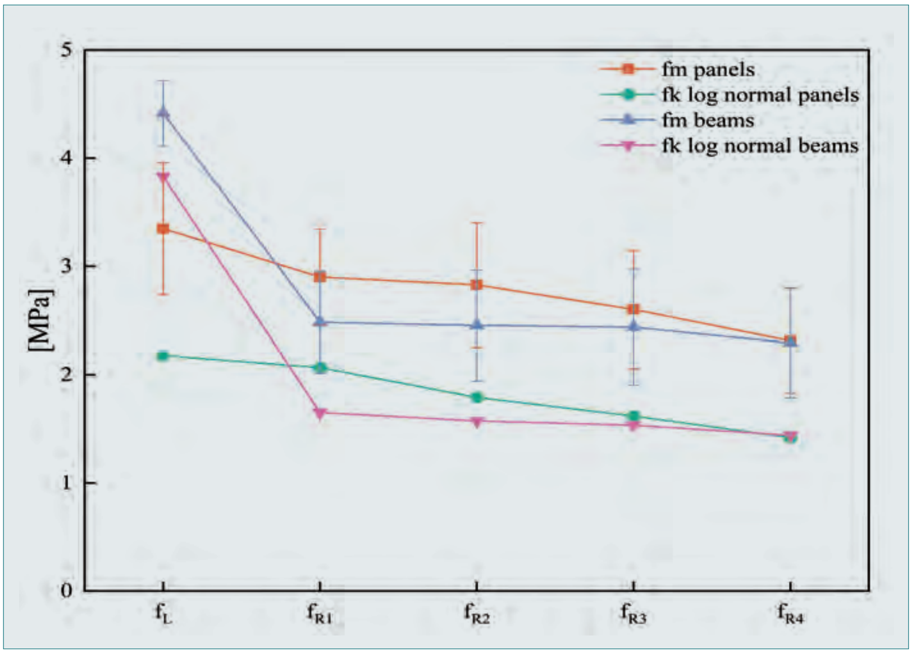


CUTTING OUT THE PARAPET

A major concrete removal project has been completed in Cardiff city centre to support the development of new apartments. Lee Corden for D-Drill & Sawing reports.

D-Drill was called into the city to remove a section of a parapet wall from the development of a new build-to-rent development on the site of the former Brains Brewery. The company was asked to remove the top 600mm of a wall created on the eighth storey of the building, which forms part of a 715-apartment development called Central Quay by Watkins Jones and Legal & General.

Due to a design change, concrete frameworks specialist the Stephenson Group hired D-Drill to carry out the concrete removal on the building, which is at the heart of Cardiff city centre, just a short distance from the Principality Stadium. With approximately 80m to remove, three members of the D-Drill team, Steve Nicic, Richard Robb and Martin Williams – as well as other support staff – were called in to find the best solution.

The added complication was the fact that the building was a live site and on lower floors there was glazing and cladding already being fitted, so there could be no waste or slurry falling below, as it would risk damage.

The team decided to use a combination of stitch drilling and track sawing but had to stop short from drilling completely through the wall to prevent any water or slurry run-off going down the outside of the building, where the new cladding and fascia were being installed. So, they devised a plan


The parapet wall prepared for cutting along the blue line

The track saw is set up ready to carry out the cut.

The stitch drilling is carried out.

where they would set the saw to cut through the concrete parapet wall but stop with 15mm left to go in order to protect the floors below.

The team stitch-drilled every 4m along the wall using a Husqvarna drill rig and then used a Pentruder RS2 track saw to cut out the individual pieces of the wall. They

> "The team decided to use a combination of stitch drilling and track sawing but had to stop short from drilling completely through the wall to prevent any water or slurry run-off going down the outside of the building, where the new cladding and fascia were being installed."

also drilled 75mm-diameter holes in each section to allow for rings to be run through the concrete so that it could be attached to a crane and removed. With just the final 15mm remaining uncut, the pieces naturally broke off and were removed after all of the slurry and waste were removed using a Wetvacuum.

D-Drill provided its own three-phase power supply and arranged for the main contractor to have it hoisted to the upper floor alongside the other tools. Across a seven-day period, 27 sections of concrete were drilled and sawn by the team, each of which weighed approximately 1.5 tonnes.

Lionel Whittemore, D-Drill & Sawing's South Wales and Midlands manager, says the team had worked around testing circumstances successfully to leave a very satisfied client. "Occasionally for buildings of this kind, there can be a design change that means concrete needs to be removed and, in this case, the client wanted a parapet reduced in size.

"They brought us in, we could see that we were going to have to work around a live building site and that it was going to be vital to produce a plan that stopped waste and slurry falling below. We had a very strong team of operatives who came up with a plan to cut through the concrete, which was 300mm thick, and only go through to within 15mm rather than completely cut through, as that would have caused slurry to drop through.

"We were able to operate in this way because we invested in new track saws at the start of the year that make this kind of technique possible. It meant that we did the bulk of the cutting and drilling, and then the final piece of force was the crane simply being able to snap it away, by which time all of the slurry and waste had been removed. It is always testing to work in this way but we pride ourselves on finding solutions."

ABOVE AND INSET, BELOW: The track saw is set up ready to carry out the cut.

SELECTIVE DEMOLITION AND RECONSTRUCTION AT HANOVER SQUARE

As the construction industry responds to the climate crisis, refurbishment and modification of structures are gaining increased importance. While preservation of historically valued features has always been encouraged, a rising number of UK projects aim to preserve much of an existing concrete frame's embodied carbon in their new proposals. John Roberts of McGee reports.

A recent example in London of this approach is 25 Hanover Square, where specialist contractor McGee has executed a series of complex and innovative concrete works involving selective demolition and reconstruction. This project has underscored the growing importance of sustainable construction practices and the essential collaborative role of contractors skilled in devising novel temporary works and construction engineering solutions that create and deliver opportunities for clients.

REFURBISHMENT

The building was a seven-storey concrete-framed office building dating from the early 2000s, occupying a prominent site in London's Mayfair, and it has undergone a comprehensive refurbishment for developer Morgan Capital. Architect Basha-Franklin worked with structural engineer HTS on a 'back-to-frame' reworking and extension, which included relocating the structural lift core and removing several columns to open the ground floor up to views of Hanover Square.

After a preconstruction period and tendering process, McGee was appointed as specialist contractor for the enabling, demolition and structural concrete in January 2023, with Mace later employed to complete the project's cladding and fit-out as general contractor.

Working with an existing concrete structure presents unique challenges when compared with new construction. For example, it is more complex to establish a workable grid that accommodates both old and new works. The tendered scheme's grid naturally had to be based on existing drawings and surveys of finished surfaces, before the soft strip commenced. Once work began, the actual positions of retained structural elements were revealed, generating several pinch points in the design, for instance where escape stairs had to achieve code-compliant widths between existing structural elements and boundary walls. A careful process of collaborative negotiation between the site and design teams was needed to refine the grid to the building's revealed dimensions.

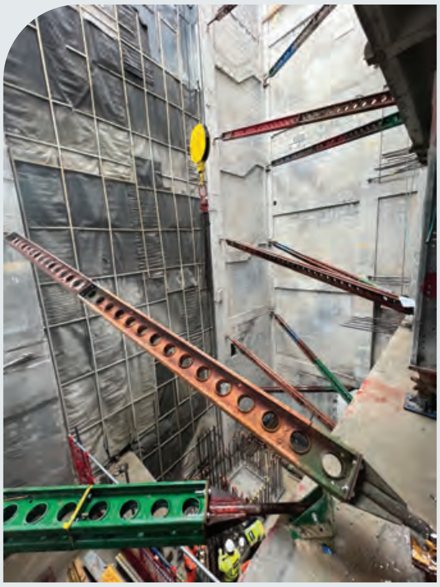
To deliver success on-site, construction logistics always need to be carefully planned and agreed in city-centre locations. At 25 Hanover Square, this was exacerbated by the small plan dimensions of the building at only 12 × 22m. The project was fortunate to be able to support three storeys of cabins on a gantry over the Square's pavements, outside

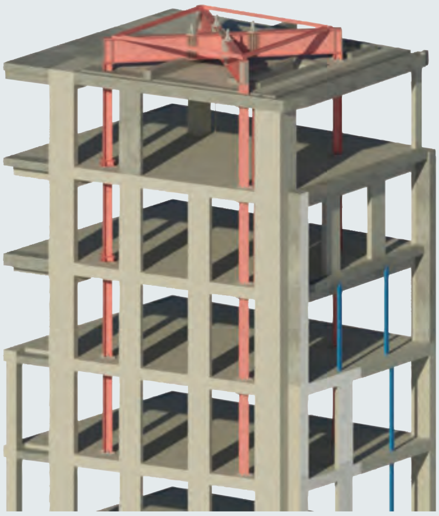
LEFT:
25 Hanover Square, aerial view.

MIDDLE COLUMN, RIGHT AND BOTTOM:
Temporary stability propping at 25 Hanover Square.

FAR RIGHT, TOP:
3D tower crane grillage interface with existing structure.

FAR RIGHT, BOTTOM:
3D temporary walking columns.





the structures being modified.

The site's compact plan dimensions meant that temporary works systems that would normally be distributed around a site were overlapping and competing for space. Several areas became unavoidable 'Swiss watches' of complexity and internal reviews focused on these to ensure all requirements were addressed. Temporary structures providing horizontal stability and retaining party walls competed for space with propping to partially demolished structural elements and then reconstruction.

CRANE

Cranes are always the heartbeat of a site and it was quickly established that the limited space available for lorry deliveries could not also accommodate a tower crane. Careful analysis of the existing reinforced concrete beams and columns identified there was just sufficient capacity to support a Raptor 184 crane above Level 7 if back-propping and ties ensured several levels of spare capacity were mobilised. A bespoke steel grillage was used above the retained area of the existing roof to spread the loads to the concrete frame. Particular care was required to ensure the cut lines and sequence of selective demolition throughout the height of the building didn't erode the safety margins against both the downward and upward flow required at every stage.

The design proposals put out to tender defined the building's element that were to be demolished and reconstructed, but the sequence of this work and the temporary works needed were developed by the specialist contractor. A series of modifications were carried out to the basement, while the most significant superstructure changes included removal and relocation of the main stability lift core, temporarily stabilising neighbouring party walls and removal of alternate perimeter columns at ground-floor level. This later change required temporary steel columns over several levels, 'walking' loads back 1250mm into the floorplate to arrive in the existing foundation while demolition of the ground-floor structure and strengthening works down to the basement were carried out.

JACKING

The retained concrete structures were very stiff, particularly when compared with some of the temporary steel support being used. Jacking subcontractor Hydra-Capsule was a key project partner for McGee and a series of complex jacking sequences were a cornerstone of work on-site, carefully specified and controlled to ensure that final load paths were returned to the intended elements once demolition and reconstruction works were completed.

Reconstruction works included a new reinforced concrete lift core repositioned to the south of the building. This was reconnected to the existing structure by ribbed slabs that replicated the detailing of the retained areas. New concrete transfer structures at the first floor completed the removal of several perimeter columns at the ground floor.

At 25 Hanover Square, McGee's experience as a specialist contractor has been key to the project's success, finding a way to viably achieve the complex structural changes needed. The lack of standard solutions or approaches for this type of cut-and-carve project means that careful collaboration between the design and construction teams is required to develop and deliver a bespoke solution. As construction clients address the climate emergency, the appetite for carbon reduction from both the market and the planners will make these types of complex work increasingly common.

Young's Court Development, Emmanuel College Cambridge

Client
Emmanuel College

Project architect
Stanton Williams

Structural and civil engineer
Smith and Wallwork

Landscape architect
Bradley-Hole Schoenaich

Main contractor
Gilbert Ash

Project manager/planning consultant
Bidwells

Construction cost consultant
Faithful + Gould

Main concrete structure
Oliver Connell & Son

Precast stairs
Cambridge Architectural Precast

Precast façade elements
Amber Valley Stone

Polished concrete floor
Lazenby

(Photo: Jack Hobhouse.)

YOUNG'S COURT DEVELOPMENT, EMMANUEL COLLEGE CAMBRIDGE

The Young's Court Development is the largest single expansion of Emmanuel College Cambridge for over 100 years. The scheme ensures that the college's historic campus continues to nurture communal life, providing spaces that bring the community together and support collaboration, interaction and the exchange of ideas. Gavin Henderson of Stanton Williams reports.

Part new-build, part retrofit, the £21 million scheme introduces new social and informal study areas, as well as residential provision for 48 students. The latter addresses the college's aspiration to accommodate all its undergraduates on the city-centre site for the first time.

The complex 5770m^2 project repurposes existing buildings and underused in-between spaces, stitching them together in a dialogue of new and old. These form a fully accessible network of passageways and courtyards with an intimate, more informal character than traditional, more formal, college courts. The overall aim is to facilitate greater interaction, collaboration and sociability through new spaces, such as the 150m^2 Social Hub that opens onto the newly landscaped South Court, transforming an area previously used for parking and deliveries.

REDEVELOPMENT

The new spaces lead to the major new-build element of Young's Court itself – a redevelopment of a surface car park at the perimeter of the college. The development creates three storeys of student accommodation and forms a courtyard above a new two-level underground car park. Created in durable brick and concrete, it is deliberately modest in scale and character, in harmony with the egalitarian ethos of the college.

Concrete was chosen for the structure after investigating the embodied and operational carbon of other options, including CLT, and a combination of steel and timber. Thermal modelling took account of median projections for the rising temperatures of climate change through to 2080. The results indicated that with a timber structure, the building would overheat by 2050 without the introduction of mechanical cooling, while concrete, aided by its exposed thermal mass, would perform well up to 2080 without any additional cooling. Concrete was therefore selected for the structural frame, supporting the delivery of a low operational energy building.

BALANCED

While important for the client as the long-term custodian of the building, this optimum thermal performance needed to be balanced with efforts to reduce and offset the greater embodied carbon that concrete brings. Together with the rest of the design team, this was achieved through several strategies. First, together with structural engineer Smith and Wallwork, Stanton Williams designed a flexible raft foundation for the two-storey basement instead of more common piled foundations, with sheet piling

LEFT:
View towards Entrance Court on Park Terrace.

ABOVE:
Plan of the scheme, with new and adapted buildings marked in pink.

(Photo: Jack Hobhouse.)

ABOVE: Clad in brick with concrete lintels and cills, Young's Court is the largest element in the expansion and provides 48 student study rooms, together with additional fellows' set.

only required approximately the perimeter. This approach saved 275m^3 of structural concrete from the foundations – a reduction of approximately 25%.

The structural design of the raft foundation was peer-reviewed by a geotechnical expert to confirm that the unusual approach was valid in the clay soil conditions and that the estimated upward heave deflection of 25mm was correct.

PILING

For the piling for the basement retaining wall, steel sheet piles were used in tandem with a Giken 'silent piling' vibrating method. This allowed the piles to be installed just a couple of metres away from the Grade II-listed Furness Lodge, which was refurbished and extended as part of the overall project. Compared with the use of concrete secant piled walls, the sheet piles resulted in savings of 3600 tonnes of structural material, as well as 1600m^3 less soil to landfill and 350 fewer vehicle movements.

Throughout, the concrete was specified with high levels of cement replacement – 50% in the frame and 70% in the basement raft, where it was combined with a water-resistant admixture and crack-control reinforcement.

The basement car park has been designed with future flexibility of use in mind if required. Localised openings can be formed through the intermediate floor to provide vertical access routes. The main car park access is provided via two-vehicle lifts, instead of a long parking ramp that would be hard to remove if the space is repurposed.

As well as its role as thermal mass in the operational energy strategy, concrete forms a key part of the Young's Court material palette, both inside and out. Soffits are exposed throughout, including in the bedrooms. Staircases – made

(Photo: Smith and Wallwork.)

ABOVE:
For the basement retaining wall, steel sheet piles were used in tandem with a Giken 'silent piling' vibrating method. This allowed the piles to be installed just a couple of metres away from the Grade II-listed Furness Lodge.

RIGHT:
One of the communal staircases in Young's Court. Concrete forms part of the scheme's material palette, with soffits exposed throughout.

(Photo: Jack Hobhouse.)

by Cambridge Architectural Precast – lead off the courtyard in the traditional Cambridge way. These have a robust character with a polished concrete finish and granite nosing on the tread – part of a long-life, low-maintenance strategy for finishes across the project. That's also the case in the basement events space of Furness Court – part of the car park excavation – where there is a polished, poured concrete floor made by Lazenby.

FAÇADES

Externally, Young's Court has a variety of precast concrete detailing within the self-supporting brickwork façades. While the heart of the college is predominantly stone, it was felt that on this perimeter location, the vocabulary should fit in with the brick language of the neighbouring residential area, while echoing the more orange-red brick of much earlier college buildings. Precast concrete was used with this as a more contemporary interpretation of the traditional stone window dressing. These bespoke precast elements were created by Amber Valley Stone, including cills, lintels and copings.

Carbon calculations for Young's Court conducted at Stage 4 indicated upfront carbon (stages A1-5) of 612kgCO_2e/m^2 gross internal area (GIA), with an embodied carbon from inception to end of life (A-C) of 743kgCO_2e/m^2 GIA. However, Young's Court is designed with far greater longevity in mind than the 60-year industry standard.

The project adds another layer to Emmanuel's 400-year-old setting. Already it is proving transformational, enabling the college to respond to changing student needs while enhancing its much-cherished spirit of place and sense of community. C

(Photo: Rizzani de Eccher.)

Mitigating corrosion of post-tensioning tendons before grouting

Ash Hasania, **Ivana Liposcak** and **Julie Holmquist** of **Cortec Corporation** look at the application of migrating corrosion-inhibiting powder as a solution to protecting PT tendons, especially in winter months.

Corrosion in construction is a global problem that impacts the structural integrity, material durability and profitability of a project. Various types of corrosion that may lead to failures include, but are not limited to, steel reinforcement corrosion, structural steel corrosion, corrosion of metallic anchors and supports, and corrosion of post-tensioning (PT) tendons. The last issue may start right after manufacturing if PT tendons are not stored properly. Corrosion may also occur during shipping and transit if tendons are not properly packed and corrosives sealed out. Finally, PT tendons for bonded systems may corrode after installation if water and salts intrude into the ducts. This happens more prominently in winter months when grouting is delayed due to freezing temperatures, creating a window of time in which it is easier for corrosives to get in contact with PT stands and initiate the corrosion process. Since these tendons are under tension, metal loss due to corrosion could make it easier for them to snap and fail.

WHY DOES PT PROTECTION MATTER?

PT tendons are critical components of the structural system in bridges, parking garages, buildings and more. Their concrete compression offers a variety of advantages such as increasing load-bearing capacity, reducing the number of supports and size of spans needed, allowing for thinner slabs, decreasing cracking and increasing durability. A corrosion failure in a PT tendon can lead to a sudden loss of load-bearing capacity with significant or catastrophic consequences if the remaining tendons are not able to compensate for the lost structural capacity. This may result in significant costs and downtime for repairs, if not complete structural failure.

MAIN IMAGE:
Figure 1 – sections of the Roskilde Fjord Bridge were built off-site and assembled on-site. A grouting delay prompted the application of migrating corrosion inhibitors for PT corrosion protection.

INSET ABOVE:
Figure 2 – Skulte overpass under construction.
(Photo: Cortec Case History 758.)

PT PROTECTION STRATEGIES

Traditionally, emulsifiable oils have been applied for corrosion protection of PT tendons until grouting. While they may provide corrosion protection, these oils cause increased tendon slippage, typically requiring them to be flushed out before grouting. Unfortunately, the introduction of water can cause grout voids, water disposal challenges and tendon corrosion (see Lüthi *et al*[1]).

Migrating corrosion-inhibiting

(Photos: Cortec Case History 758.)

ABOVE:
Figure 3 – Skulte overpass.

ABOVE RIGHT:
Figure 4 – preparing to apply MCI-309 to PT ducts after freezing temperatures delayed grouting.

powder, developed by Cortec, is a solution that protects PT tendons after installation and prior to grouting. This powder can be easily fogged into the PT ducts from one end using a low-pressure air tool. Unlike conventional messy oil injections, application of migrating corrosion-inhibiting powder is completely dry, eliminating the need for water flushing prior to grouting. Once the prescribed amount is applied (500g/m^3 for MCI-309), the vents and ends of the duct can be capped or sealed. After the powder is trapped inside the duct, it begins to vaporise and migrate throughout the void, adsorbing onto ferrous and aluminium metals as a protective molecular layer. Removal is not necessary prior to grouting, as the technology does not detrimentally affect the adhesion between the grout and the tendons, making this method easy and cost-effective.

TESTING AND VALIDATION

Long-term corrosion testing was conducted by the Pennsylvania State University Grouting Laboratory on PT strand specimens to confirm the efficacy of migrating corrosion-inhibiting powder. After one year of exposure, they saw a significant reduction in the amount of corrosion occurring in the treated tubes – one an environmental chamber with a constant temperature of 26°C (78°F) and 95% relative humidity, the other containing salt water (see Schokker and Musselman[2]).

GLOBAL USE

Migrating corrosion-inhibiting powder for PT strands and voids has been, and continues to be, used in many projects globally:

- Roskilde Fjord Bridge, Frederikssund, Denmark, was built to provide an additional route over the Roskilde Fjord, where the only other bridge dates from 1935. Post-tension bridge sections for the 8km (5 mile) dual-carriageway bridge were cast in Poland before transporting them to Denmark for installation. Migrating corrosion-inhibiting powder was applied to the tendon casings to protect PT tendons that were installed but not yet grouted. Since grouting was not performed until 30 days after the segments had been delivered to the construction site, this was an important step toward promoting the integrity of a significant structure.
- The Skulte Overpass, Riga, Latvia – OK Building Materials and Tensa provided and installed a post-tensioned reinforcement system totalling 200 tonnes for the Skulte Overpass. With such a large project, contractors did not expect to complete tendon stressing and grouting in a single construction season but almost reached this goal before freezing winter temperatures set in, forcing them to delay grouting for two to three months. What was appealing about using migrating corrosion inhibitors in this project was that they offered protection but did not require flushing. The powder was applied using conventional compressors.

CONCLUDING REMARKS

Many elements can lead to PT tendon corrosion and migrating corrosion-inhibiting powder represents a powerful line of defence to safeguard post-tensioning tendons. Its formulation, ease of use, versatility and proven efficacy make it a preferred choice for users seeking a reliable solution to mitigate the risks associated with PT corrosion. By incorporating migrating corrosion-inhibiting powder into PT protection practices during construction, contractors can promote safer and more durable structures.

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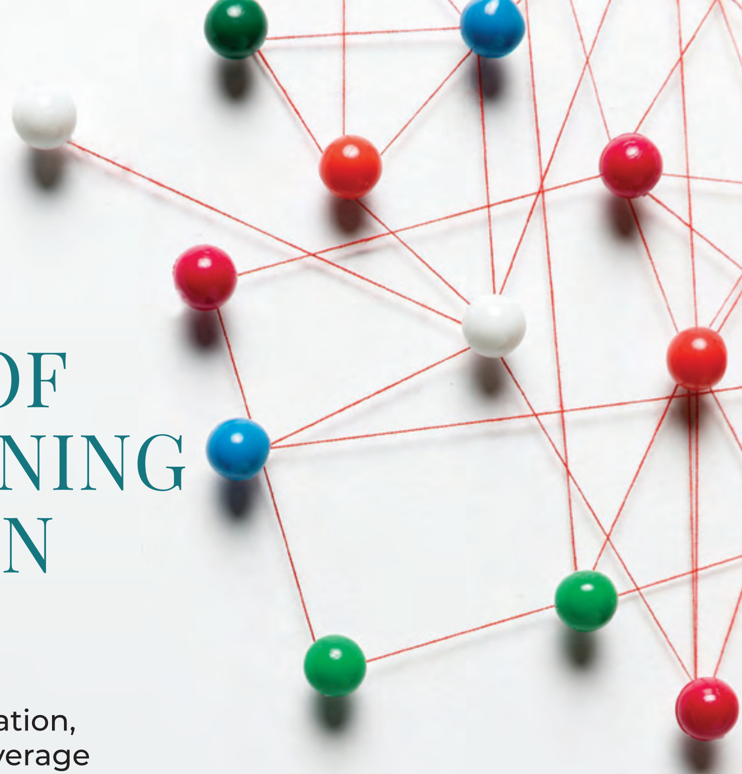


THE IMPORTANCE OF PRODUCTION PLANNING AND MONITORING IN CONSTRUCTION

With the world rapidly advancing towards automation, it is imperative for the construction industry to leverage advanced technology to enhance monitoring and tracking capabilities. Integrating real-time production planning and tracking in construction projects allows companies to manage the dynamic environments of construction sites effectively. Shanthi Rajan of Linarc reports.

Whether dealing with concrete work, carpentry or interiors, meticulous planning and real-time monitoring are crucial for large-scale commercial projects. Reliable production control is essential for ensuring efficient, timely and budget-compliant project completion, regardless of the management approach. Innovative solutions and cutting-edge technology are needed to streamline production management and provide accurate production estimates.

UNDERSTANDING PRODUCTION PLANNING RESPONSIBILITIES

Traditional construction production planning organises tasks around resources and project goals, often using a work breakdown structure (WBS) for cost estimation and scheduling. This method lacks input from trade contractors and vendors, leading to reactive management and delays, focusing on high-level details rather than ensuring safe and efficient task execution.

Conversely, contemporary construction planning integrates concurrent product and process design, incorporating detailed task specifications and constraints to enhance reliability. The last planner system (LPS) exemplifies this approach by identifying task-level workflow issues and enabling decentralised decision-making, thereby improving overall project performance. Effective production planning organises tasks, resources and quantities for efficient project execution within timelines. Aligning daily trade-specific production with the overall schedule ensures precise resource allocation, effective co-ordination, continuous progress monitoring and schedule realignment.

AIRPORT TERMINAL PROJECT

A case study showcases an airport terminal client using Linarc's tools to overcome challenges, achieving superior outcomes through enhanced planning, co-ordination and real-time adjustments, illustrating the transformative impact of comprehensive production planning in construction management.

A major contractor encountered significant challenges in planning, managing and monitoring the production of a new airport terminal project. These challenges included accurately planning, scheduling, setting weekly production quantities, co-ordinating multiple trades and ensuring timely progress tracking.

The project is the construction of a new terminal and the extension of an existing terminal at a major international airport. The project's scale was 102,000m^2 of terminal space and 66,000m^2 of apron over five years.

PROBLEMS FACED

The size and scale of the project inherently had significant challenges in planning and co-ordination. The contract terms stipulated timely completion. Lack of co-ordination and consensus with critical trades threatened the project schedule. Identifying the resources required and verifying weekly production quantities were nearly impossible. Key issues included:

- Resource allocation:
  - ◇ Labour – ensuring timely availability of skilled operatives.
  - ◇ Equipment – managing procurement and allocation of essential machinery.
  - ◇ Materials – co-ordinating material supply to avoid delays.
- Integration and communication:
  - ◇ Stakeholder alignment – keeping all stakeholders, including subcontractors, in sync with production goals.
  - ◇ Project phases – integrating various phases smoothly to prevent miscommunication.
- Risk management:
  - ◇ Demand fluctuations – handling unpredictability in resource demand.
  - ◇ Material delivery – keeping track of materials required and availability on-site.

◇ Productivity losses – mitigating risks of delays and reduced productivity.

- Strategic planning:
  - ◇ Optimisation – using resources efficiently and minimising conflicts.
  - ◇ Productivity – maintaining high productivity levels to meet project milestones.

MAIN OBJECTIVES

The construction manager aimed to optimise weekly production quantities, resource planning and productivity. The key objectives included: calculating weekly production by trade and zone; efficiently allocating labour, equipment and materials to minimise waste; enhancing stakeholder co-ordination; and developing a flexible construction schedule.

Additionally, the construction manager sought to: identify and resolve resource conflicts early; enforce stringent quality control; mitigate risks related to supply chain and labour disruptions; maintain a safe working environment; and leverage technology and data analytics for informed decision-making. Continuously realigning production quantities and trade schedules was essential to keep the goals realistic.

THE SOLUTION

By integrating Linarc's scheduling, planning and monitoring tools, the client achieved superior project outcomes. The platform provided critical insights that streamlined operations and enhanced overall efficiency:

- Break down the project by location and set delivery dates – with Linarc's mark-up and mapping tool, the project was divided into zones and levels for efficient management and monitoring. This enabled breaking down the work or activities by trade for each zone and set dates.
- Build a comprehensive schedule – the planner and scheduler allowed the client to create detailed WBS and activity schedules, organising planned quantities by zones and trade. The ability to adapt the sequence based on the project execution methodology, lean and critical path method (CPM) methodology helped maintain a consistent core process. Once the schedule is set with planned start and end dates, quantity units, work hours and dependencies, Linarc can identify the critical path and adjust dates to ensure alignment with the delivery timeline.
- Schedule with quantities – integrated with the schedule, the production planner generated comprehensive weekly tables outlining planned production. These weekly production quantities could be customised based on task type, difficulty, ideal production curve and concurrent tasks. The

platform's flexibility in adjusting weekly production, considering factors such as material and operative availability and task interdependencies, provided construction managers with precise and adaptable production planning capabilities.

- Weekly production quantities – the client was able to request weekly quantity updates from trade project managers. With alerts and notifications from Linarc, the entire project team stayed on top of quantity updates. This allowed the construction manager to review planned vs actuals and make revisions for the upcoming weeks. Integrated collaboration and role-based permissions helped connect the team and secure access to relevant information in real time.
- Cumulative weekly production and actuals – the platform facilitated tracking cumulative weekly production, comparing planned progress against actuals. This transparency helped identify bottlenecks and make timely interventions.
- Weekly operative distribution – the planner provided insights into the planned weekly operative distribution for the required quantities, ensuring that the right number of operatives was allocated to each task at the right time.
- Cumulative weekly production and operative count – by comparing cumulative planned production with actual operative counts, the client could optimise labour and maintain schedule alignment, improving efficiency and reducing delays.

KEY OUTCOMES

The airport terminal project overcame its previous challenges using production planning and monitoring tools. The client achieved:

- enhanced accuracy in production planning and execution
- improved co-ordination among different trades
- real-time visibility into project progress and resource usage
- reduced delays and risks through proactive adjustments based on real-time data.

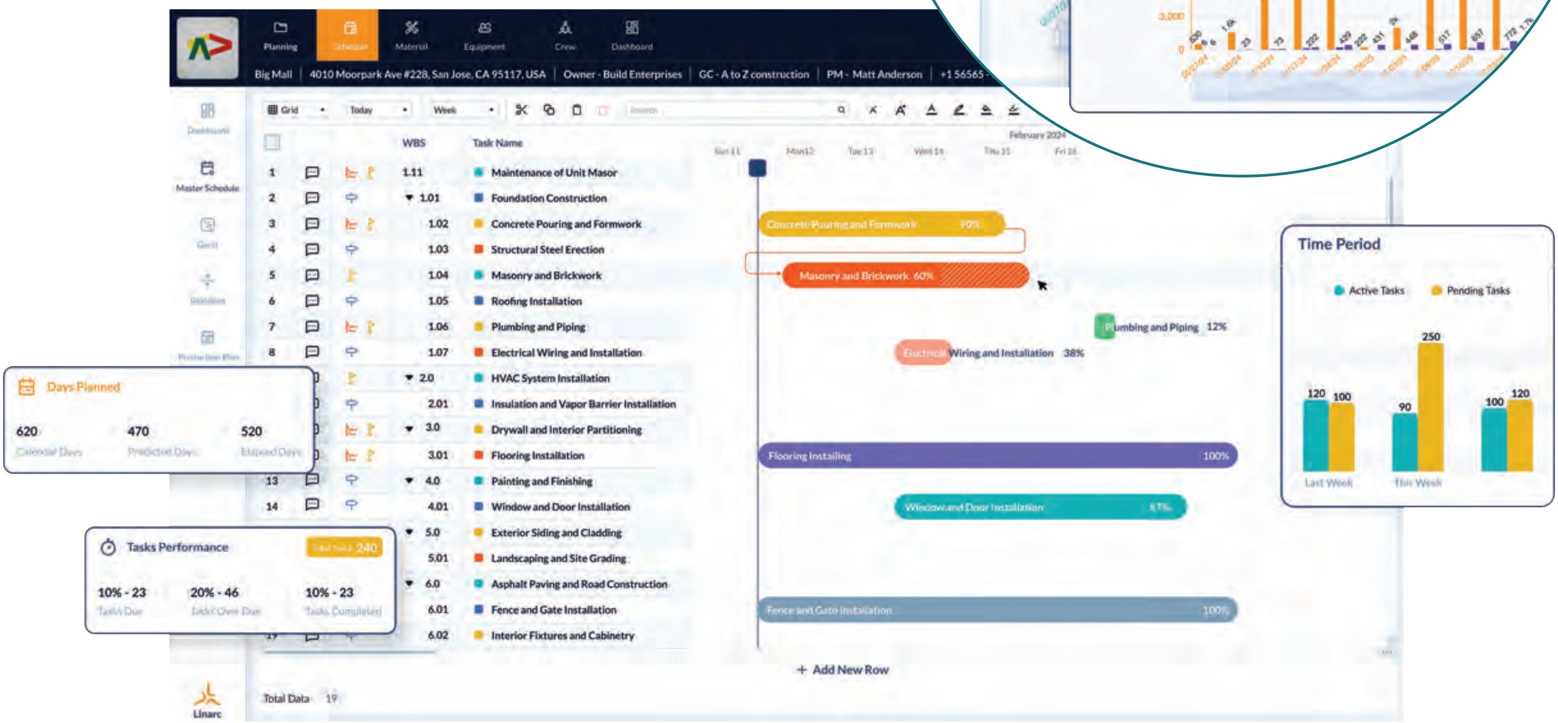
This case study shows how the platform can transform construction project management, driving efficiency and ensuring successful project completion. By focusing on meticulous production planning and continuous monitoring, construction projects can achieve higher efficiency, timely completion and budget adherence, ultimately leading to successful project outcomes. C

OPPOSITE PAGE, BOTTOM: Location mapping by area/zones to plan production.

OPPOSITE PAGE, INSET: Schedule with quantities.

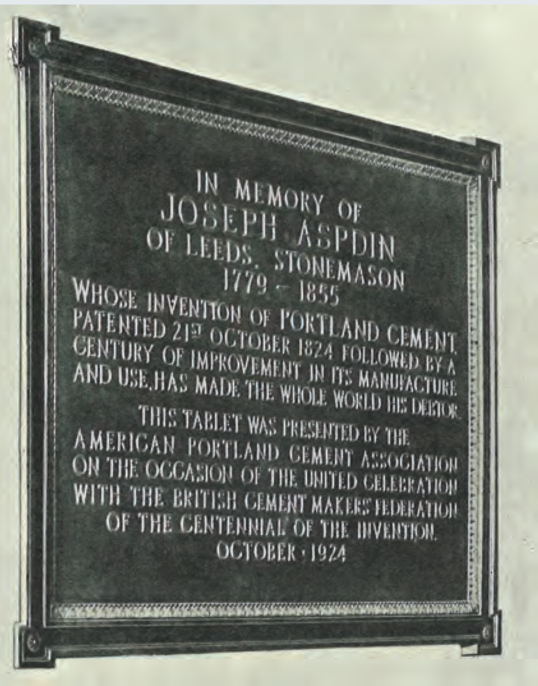
BOTTOM: Building a comprehensive schedule.

INSET BELOW: Cumulative weekly production and crew count.



CELEBRATING CEMENT OVER TWO CENTURIES

Edwin Trout of **The Concrete Society** commemorates Joseph Aspdin's patent of 1824 and the invention of Portland cement.



That Joseph Aspdin of Leeds was the inventor of Portland cement and the 'father' of the modern cement industry, seems not to be in doubt today (despite the claims of others over the years). But that was not always so; the significance of Aspdin's discoveries was often downplayed or simply overlooked. It was, perhaps, not until the centenary of his famous patent, now so widely recognised, that Aspdin's place in the history of cement was assured. Prior to 1924, Joseph's role was perceived principally as a foundation for the self-promoted achievements of his son William, while the family firm led by his other son James finally foundered in the late 19th Century and the Aspdin name disappeared from whatever prominence it had enjoyed.

1824 – JOSEPH ASPDIN'S PATENT GRANTED

The patent for Portland cement was granted on 21 October 1824 and manufacture commenced in Wakefield a year or so later. Distribution was necessarily limited to the distribution network existing in Yorkshire and out to Liverpool; haulage to the principal market in London would have been constrainingly expensive. However, Portland cement was publicised in London during the 1840s by the commercial activities of William Aspdin and the designation 'Portland' adopted by other manufacturers, initially led by JB White & Son, following public trials of the material in 1843. Yet Aspdin's cement remained unknown to such authorities as General Sir Charles Pasley until the Great Exhibition of 1851. After this, Portland cement could reasonably be said to have attracted national notice and its use accelerated rapidly from the late 1850s onward.

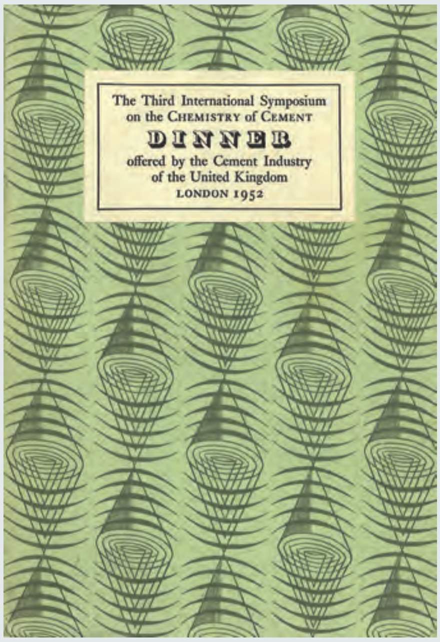
Joseph Aspdin's pioneering role was acknowledged in his son's publicity material – "Patent Portland Cement, solely manufactured by Aspdin, Ord & Co… originally invented by Mr Joseph Aspdin, of Leeds, a builder in that town" (pamphlet c.1852–1855) – and on his own gravestone in Wakefield: "Sacred/To the Memory of the late Joseph Aspdin of this town (Inventor of Portland cement) who departed this life on the 20th day of March 1855 Aged 76 Years". However, William died soon after and James in 1873. Aspdin's firm, having long since surrendered its principal position in the cement industry, ceased production in 1892.

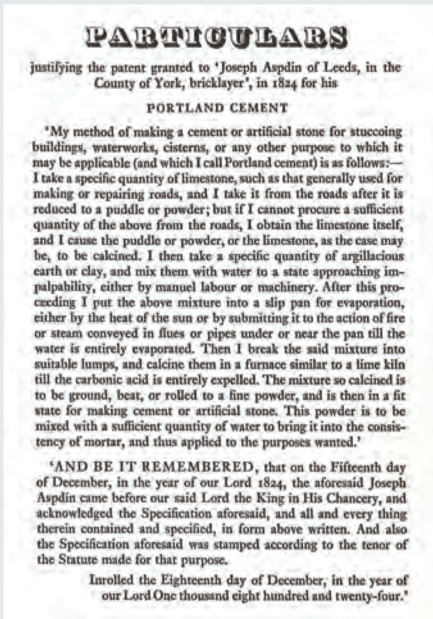
1903 – A MEMORIAL PROPOSED

In 1900, many of the leading British cement firms amalgamated to form an industrial combine, the Associated Portland Cement Manufacturers, facilitating the adoption of the rotary kiln for clinker production and, in 1903, prompting agreement on the first British Standard specification for cement (later designated BS 12). In this climate of sector advancement, the suggestion of a memorial to Joseph Aspdin was promoted in the city of his birth. However, the proposal failed to attract widespread support at the time.

1924 – THE CENTENARY

It was the centenary in 1924 that captured the sector's attention, promoted by the emergence in the meantime of concrete industry champions Concrete Publications Ltd and the Institution of Structural Engineers (which until a year or two before had been known as the Concrete Institute). On taking office at the latter, Major James Petrie OBE, gave his presidential paper in January 1924





PARTICULARS

justifying the patent granted to 'Joseph Aspdin of Leeds, in the County of York, bricklayer', in 1824 for his

PORTLAND CEMENT

'My method of making a cement or artificial stone for stuccoing buildings, waterworks, cisterns, or any other purpose to which it may be applicable (and which I call Portland cement) is as follows:— I take a specific quantity of limestone, such as that generally used for making or repairing roads, and I take it from the roads after it is reduced to a puddle or powder; but if I cannot procure a sufficient quantity of the above from the roads, I obtain the limestone itself, and I cause the puddle or powder, or the limestone, as the case may be, to be calcined. I then take a specific quantity of argillacious earth or clay, and mix them with water to a state approaching impalpability, either by manuel labour or machinery. After this proceeding I put the above mixture into a slip pan for evaporation, either by the heat of the sun or by submitting it to the action of fire or steam conveyed in flues or pipes under or near the pan till the water is entirely evaporated. Then I break the said mixture into suitable lumps, and calcine them in a furnace similar to a lime kiln till the carbonic acid is entirely expelled. The mixture so calcined is to be ground, beat, or rolled to a fine powder, and is then in a fit state for making cement or artificial stone. This powder is to be mixed with a sufficient quantity of water to bring it into the consistency of mortar, and thus applied to the purposes wanted.'

'AND BE IT REMEMBERED, that on the Fifteenth day of December, in the year of our Lord 1824, the aforesaid Joseph Aspdin came before our said Lord the King in His Chancery, and acknowledged the Specification aforesaid, and all and every thing therein contained and specified, in form above written. And also the Specification aforesaid was stamped according to the tenor of the Statute made for that purpose.

Inrolled the Eighteenth day of December, in the year of our Lord One thousand eight hundred and twenty-four.'

OPPOSITE, FAR LEFT:
Figure 1 – tablet to the memory of Joseph Aspdin, unveiled in Leeds Town Hall on 6 September, to mark the centenary of his invention of Portland cement (taken from *C&CE* October 1924).

OPPOSITE, TOP:
Figure 2 – from the cover of the commemorative brochure.

OPPOSITE, MIDDLE AND BOTTOM:
Figure 3a–b – from the 1952 dinner booklet.

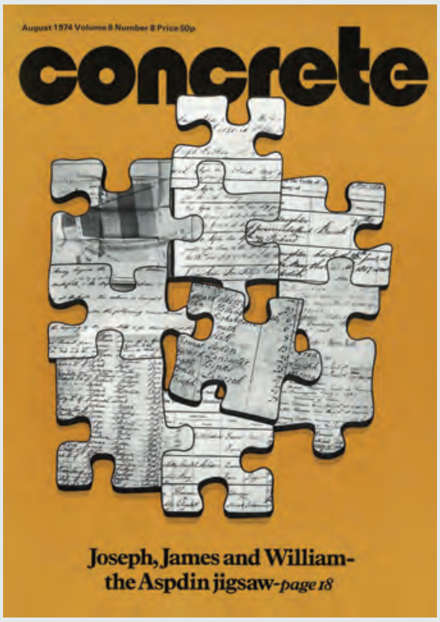
RIGHT:
Figure 4 – a) the cover of *Concrete's* Aspdin issue and b) the University of Leeds plaque.

on the subject, published under the heading 'The Centenary of the Invention of Portland Cement' in the Institution's journal in February 1924. Simultaneously, an article of the same title, by HC Badder MIEI, appeared in the February issue of *Roads and Road Construction*.

It was later in the year, closer to the date of the patent's grant on 21 October, that the commemorations reached a climax in Leeds Town Hall, with the unveiling of a tablet to the memory of Joseph Aspdin on Saturday 6 September (Figure 1). The local newspaper reported, "The memorial, which is in the form of a plaque, is a gift from America... The American Association of Portland Cement Manufacturers and the National Association of Cement Users have co-operated to provide facilities for research work and to develop the use of concrete. A delegation from these bodies is now in this country to present the memorial to Leeds."

Invited by the Lord Mayor of Leeds, Sir Edwin Airey JP, the proceedings opened with the American national anthem. Mr FW Kelly, President of the Portland Cement Association, then presented and unveiled the tablet, which the Lord Mayor accepted on behalf of the city. Mr PM Stewart, chair of the British Cement Maker's Federation, then proposed a vote of thanks and the ceremony ended with the British national anthem. The occasion was recorded for posterity in the journal *Concrete and Constructional Engineering* (*C&CE*).

This journal also noted the publication by its proprietors of a commemorative book, *A Hundred Years of Portland Cement, 1824 to 1924*: "A new book, by Mr AC Davis, which has been specially written and published to commemorate the centenary of the invention of Portland cement and which gives

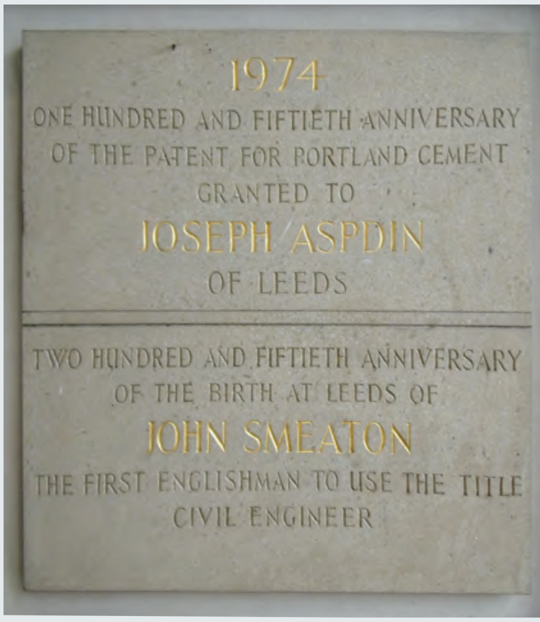


a full account of the remarkable history of the growth both in quality and output of the materials". It was reviewed in the October issues of *C&CE* and *The Structural Engineer*, which noted: "This being the centenary of the discovery of Portland cement, it is a suitable time for the appearance of a book dealing with its history."

1938 – PLAQUE UNVEILED IN WAKEFIELD

In the mid-1930s, the cement lobby found a collective voice in the Cement Makers' Federation and the Cement and Concrete Association (C&CA), and an opportunity was soon found to celebrate the industry's origins in the city where Aspdin had commenced production.

On 24 November 1938, The Rt Hon Viscount Wolmer, representing the Association, presented a plaque and gates to the vicar of St John's Church, Wakefield, "to be a perpetual memory to Joseph Aspdin, the inventor of Portland cement". The event was carried out in some style. Special seats were reserved and luncheon served on a train from King's Cross. Guests were received by the Mayor of Wakefield at the town hall. Moving to the church, the party was received by the Lord Bishop of Wakefield and the vicar of St Johns for a dedication service and the plaque's unveiling. Outside, the gates were formally opened and the key handed over. Finally, guests filed past Aspdin's tombstone, which was marked by a laurel wreath. To accompany the proceedings, a booklet was published with the title, 'Commemorating Joseph Aspdin: the inventor of Portland cement'.



1952 – INTERNATIONAL SYMPOSIUM

After the Second World War, the relocation of the planned Third International Symposium on the Chemistry of Cement to London offered another opportunity for co-host the Cement and Concrete Association to celebrate the national origins of the cement industry. The C&CA's library undertook the purchase of copies of early books on cement, as well as acquiring what were described at the time as 'early relics' of the industry, for an exhibition to accompany the symposium. The proceedings featured a keynote paper, 'The early history of cement in England' by divisional heads, P Gooding and PE Halstead, which was the result of "exhaustive" research into "the origin of Portland cement in this country and the lives of the first manufacturers".

The climax of the event, held on 17 September 1952, was a dinner offered by the 'Cement Industry of the United Kingdom'. The accompanying craft-printed booklet (Figure 3) made reference to Aspdin, featuring a reproduction of the seal of George IV that had been affixed to Aspdin's patent and quoting the particulars set out in 1824. Moreover, in a carefully considered typographical gesture, the sheets of antique paper on which the booklet was printed dated from the 1820s, "as was the shaded type which appears in some headings".

1974 – THE 150TH ANNIVERSARY

In 1974, it was the turn of the relatively young Concrete Society to champion the 150th-anniversary celebrations, a convergence of interest heightened in Aspdin's

INSET:
Figure 5 – the blue plaque in Leeds.
(Photo: Chemical Engineer – Own work, CC BY-SA 4.0.)

home town by the tenure of incoming Society President Adam Neville as Professor at the University of Leeds. The first of several events under the auspices of The Concrete Society was a public lecture entitled 'Cement and building from Roman times to the twentieth century', given at the University of Leeds by the distinguished cement chemist Sir Frederick Lea.

"A public lecture delivered at the University of Leeds on 6 May 1974 by Sir Frederick M Lea... to mark the 150th Anniversary of the granting of a patent in 1824 to Joseph Aspdin of Leeds. The lecture followed the unveiling of a plaque to commemorate the anniversary by the President of the Concrete Society, Mr AH Brown, in the Department of Civil Engineering at the University. Those present at the unveiling of the plaque and the lecture included the Vice Chancellor of the University, Lord Boyle of Hansworth, Mr William Aspdin, great-grandson of Joseph Aspdin, and Professor AM Neville, Head of the Department of Civil Engineering who arranged the lecture and ceremony."

The lecture referred to earlier physical memorials – the bronze tablet in City Hall (1924) and the plaque and gate at St John's Wakefield (1938) – and followed the unveiling of yet another, which still hangs in the Department of Civil Engineering to this day (Figure 4b).

Three months later, the August issue of *Concrete* carried an article entitled 'Joseph, James and William – the Aspdin Jigsaw', by RJ Barfoot (Figure 4a). It was prefaced with the lines: "In a few weeks' time will occur the 150th anniversary of the patenting by Joseph Aspdin of Portland cement. It seems an appropriate time, therefore, to examine critically what little is known of Aspdin and his sons, and to add to that knowledge several new facts, some considered conjecture and an inspired guess or two." Those few weeks soon passed and The Concrete Society marked the moment by holding a 'Sesquicentennial Luncheon' at the Savoy Hotel.

Also commemorating the anniversary that October was a feature in *Concrete's* 'sister' magazine, *Cement Technology*, under the heading '150 anniversary of Portland cement'. It featured illustrations of the new plaque in Leeds and the 'History of Cement' mural at Portland House, London.

1994 – BLUE PLAQUE

Twenty years later, The Concrete Society and the British Cement Association (BCA) supported an initiative of the Leeds Civic Society in placing a 'blue plaque' at the Lands Lane entrance to Packhorse Yard, Leeds, Aspdin's address at the time of the patent. Described by the Civic Society as "the latest plaque on our trail", it was unveiled on 21 October 1994 – at the invitation of Olav Arnold, president of the Leeds Civic Trust – by Sir George Moseley, chair of both the Civic Trust nationally and the BCA. Also present were the Lord Mayor of Leeds, the directors of the BCA (Jim Stevenson), The Concrete Society (Tom Kirkbride) and other sector bodies, the university and Leeds College of Building, several commercial companies and members of the Aspdin family. The plaque is shown in Figure 5.

2024 – THE BICENTENARY

And now, 200 years on from October 1824, 2024 has seen several commemorative gestures. The history of cement has formed the theme of keynote lectures at conferences in London (UCL & ICT), Edinburgh (Heriot-Watt & ICT) and Belfast (IOM3), a symposium at the Neville Centre in Leeds, a webinar hosted by RILEM and the publication of a bicentenary booklet by the Mineral Products Association. C

UPCOMING FEATURES 2024/2025

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THE CONCRETE SOCIETY AWARDS 2024
Deadline – 4 November

Concrete Engineering International January 2025
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Deadline – 1 November

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