CONCRETE FUTURES

AUTUMN 2023

mpa The Concrete Centre

Hit refresh

A new chapter for the UK Concrete Industry Sustainable Construction Strategy

BLUE SEA THINKING
GEARING UP TO DELIVER FLOATING OFFSHORE WIND

MIX MARKERS
THE NEW RATING TOOLS FOR LOW-CARBON CONCRETE

JUMP IN THE E-MIXER ...
... AND JOIN US ON A JOURNEY TOWARDS NET ZERO

5 commitments

Fifteen years after it was first launched, the UK Concrete Sustainable Construction Strategy is being updated. The new 2023 strategy will guide the industry on its journey to beyond net zero, and is underpinned by five key pledges:

1

To advance carbon reduction plans and policies in line with our UK Concrete and Cement Roadmap to beyond net zero, and develop the prerequisites by 2030 to fully decarbonise by 2050

2

To enable greater circularity across the built environment using concrete and encourage the retention of concrete value throughout all stages of its life cycle

3

To develop solutions for a regenerative built environment, incorporate natural capital in decision making, and deliver wider ecosystem benefits

4

To build positive outcomes to improve lives through all our activities, and use concrete to create a safe, comfortable and prosperous built environment

5

To continue improvement of the annual Concrete Industry performance reporting with relelvant performance indicators

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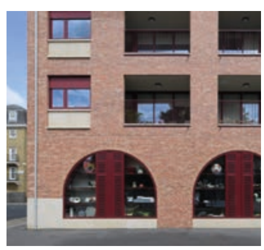

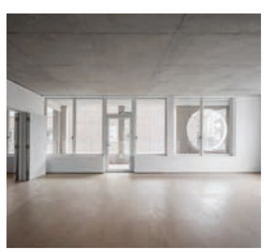

WELCOME

An enormous amount has happened since the UK concrete industry launched its first sustainable construction strategy in 2008. Our industry-wide effort to report and improve against a rigorous set of performance indicators yielded much progress, not least a 30% reduction in the embodied carbon of a tonne of concrete against a 1990 baseline, and a 53% reduction in absolute emissions.

In 2020, we published our UK Roadmap to Beyond Net Zero, outlining the levers that will enable us to become carbon-neutral and even negative by 2050, without the use of offsets. As co-chair of the UK Concrete Sustainable Construction Group, with Emma Hines at Tarmac, I am proud to announce our latest strategy, which formalises the aspirations set out in the Roadmap. Once again, this represents both the culmination of a major industry-wide collaboration to set ambitious but realistic targets, and the beginning of the next stage of our journey to net zero as we strive to meet them.

The refreshed strategy retains its focus on carbon reduction, but expands our commitment to take a more holistic view of sustainability, responding to the wider economic, social and environmental change across the UK over the last 15 years. Its greater emphasis on the circular economy reflects a growing awareness of the importance of using materials as responsibly as possible, to create the greatest long-term value. This not only means extracting and manufacturing them responsibly, and maximising concrete's ability to repurpose waste products from other industries, but supporting designers and specifiers to use the lowest carbon solution for their particular brief – the right amount of the right material in the right place, for the whole life of a building or piece of infrastructure.

We are also pulling back the lens to take a wider view of the enormous social value that our industry generates for society – whether that's through improving air quality or encouraging nature and biodiversity to flourish, speeding up the delivery of critical infrastructure or providing employment and training opportunities. We know that it's about more than just outputs – it's about positive, long-term outcomes. By working together to measure and promote these diverse, often hidden but vital impacts, we hope to unlock even greater opportunities to improve peoples' lives across the UK for the future.

Donna Hunt, head of sustainability, Breedon Group, and co-chair, UK Concrete Sustainable Construction Group

"THE GREATER EMPHASIS ON THE CIRCULAR ECONOMY REFLECTS A GROWING AWARENESS OF THE IMPORTANCE OF USING MATERIALS AS RESPONSIBLY AS POSSIBLE"

mpa
The Concrete Centre

The Concrete Centre provides design guidance, seminars, courses, online resources and industry research to the design community. Our aim is to enable all those involved in the design, use and performance of concrete to realise the potential of the material.

The Concrete Centre is part of the Mineral Products Association, the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and industrial sand industries.
concretecentre.com @concretecentre

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Cover: One Pool Street, designed by Lifschutz Davidson Sandilands, is one of two new buildings on the University College London East campus in east London. It is made up of two towers and a publicly accessible three-storey podium, containing teaching facilities, research labs and more than 500 student rooms. The academic spaces achieved BREEAM Outstanding at design stage; the residential element BREEAM Excellent. The building is part of UCL's strategy to be net zero in operation by 2030. Read more about the project in the forthcoming issue of Concrete Quarterly, Autumn 2023. Photo: Paul Riddle for Lifschutz Davidson Sandilands

LOCAL HERO

Floating offshore wind offers an enormous opportunity, both for the UK's energy security and for local supply chains – but we need to act fast. Tony Whitehead reports

It is the year 2035 and, off the coasts of Scotland, Wales and Cornwall, hundreds of huge new turbines are turning in the wind. They form a major part of the UK's transition to green energy and, unlike those nearer land, are situated in deeper offshore waters where wind speeds are often higher and more consistent. Because of this, they are not fixed to the seabed, but instead rise from vast floating substructures. Each is the size of a football pitch and the depth of a ten-storey building – the enormous mass necessary to provide stability for turbines themselves as tall as the Gherkin in London. Together these turbines will produce up to 24GW of power – more than eight times the output of the new Hinckley Point C nuclear plant.

This is no speculative vision, but part of a settled plan. The Crown Estate has already let some of the development leases for these extraordinary deep-water wind farms. By 2029, designs will have been finalised and the first of hundreds of floating substructures will be under construction.

Although Britain is a world leader in the deployment of offshore wind, this will be of a different order to anything seen before, according to Matt Hodson, chief operations officer of Celtic Sea Power. "The Crown Estate is about to let 4GW-worth of leases in the Celtic Sea, the deep waters to the south and west of Cornwall. This alone will probably involve deploying 270 substructures over a period of about six years, or nearly one a week. Depending on the design and materials used, the substructures can weigh up to 20,000 tonnes – so that is quite a call on local resources and supply chains."

A challenge but also, says Hodson, a once-in-a-lifetime economic opportunity: "Celtic Sea Power is owned by Cornwall Council and we want to ensure the benefits of offshore wind come back to our region. If we don't prepare now, there are any number of overseas interests who will jump at the chance to get involved."

The case for concrete

As to what kind of preparations are required, Celtic Sea Power recently presented a paper detailing how the region can supply the needs of floating offshore wind (FLOW) developers. There are different designs, but essentially substructures can be made from either steel or concrete. Several studies have suggested that concrete offers the lower-carbon procurement method, with reduced transport

Below The 88MW Hywind Tampen wind farm, developed by Equinor, consists of 11 turbines in 260-300m deep waters 140km off the coast of Norway. The turbines are mounted on floating concrete structures with a common anchoring system

Photo: Ole Jørgen Bratland / Equinor

emissions being a major factor. A lifecycle analysis produced for the government's Offshore Renewable Energy Catapult research programme found that a concrete semi-submersible substructure produced 36% of the emissions associated with an equivalent steel structure, and that concrete remained the lower carbon option even when a recycled steel option was used in place of virgin materials, and transport was excluded. This aligns with the findings of a Norwegian study by consultant DNV, which concluded that concrete substructures were between 2.5 and 5 times less carbon-intensive than steel, depending on the design and the end-of-life strategy.

"We believe the concrete option also has the potential to deliver vastly better returns for our local economy," says Hodson. "Current steel fabrication facilities in the UK may struggle with the capacity to produce these things at the rate required – so if you choose steel, that work will probably end up being done elsewhere in the world, with the floating structures being shipped or towed to the Celtic Sea Region. That increases their carbon footprint, and the risks– both as a result of the hazards of the journey, and because of the volatility of the global steel market." The UK is not the only country to be replacing its fossil fuel infrastructure, he adds, which will place added pressure on supply chains for critical materials.

A local solution

On the other hand, the UK does have an aggregate and concrete industry that could supply what is needed. "When we workshopped the concrete substructure scenario with our local concrete supply chain, they didn't even blink," says Hodson. "After all, they are currently turning over these kinds of quantities with Hinckley Point which, when complete, will contain 1.8 million m^3 of concrete. We also have sufficient steel reinforcement capacity in South Wales, and a number of major ports that can handle this kind of work."

"WHEN WE WORKSHOPPED THE CONCRETE SUBSTRUCTURE SCENARIO WITH OUR LOCAL CONCRETE SUPPLY CHAIN, THEY DIDN'T EVEN BLINK"

The arguments in favour of concrete substructures are, if anything, even more persuasive when applied to FLOW in the North Sea. With 24GW of generating capacity to be constructed here by 2035, the opportunities are proportionately bigger, and with economies of scale thrown in.

Paul O'Brien is senior development manager for the energy transition and net-zero team at Highlands and Islands

Photo: EDF Energy Renewables

Above Turbine substructures under construction. Each can weigh up to 20,000 tonnes

Enterprise, and also cluster manager for DeepWind – a supply chain organisation for offshore wind with over 850 members from industry, academia and the public sector. He says: "Steel does not have the opportunities for local content that concrete offers – so I'm glad to say most developers have been willing to consider concrete options. It's a local solution with a short supply chain – which makes it attractive in the light of the recent collapse of some global supply chains as a result of Covid and Ukraine. We have a very good civils industry here in the UK , and we know we can do it."

"TO JUSTIFY THE CREATION OF NEW FACILITIES, YOU NEED A CERTAIN THROUGHPUT – IDEALLY 25 TO 50 SUBSTRUCTURES A YEAR OVER MANY YEARS"

O'Brien believes the case for concrete as a low-carbon solution could be strengthened if fabricators are able to deploy the latest concrete technology. "We already know that the embodied carbon of a concrete structure can be lowered by using cement substitutes like fly ash or blast-furnace slag, so we need to ensure supplies of those materials. Other newer forms of even lower carbon concrete are being developed – so they need testing and to be approved for use as soon as possible. Carbon content might be lowered further by replacing some rebar with composite or basalt alternatives."

FLOW developers are becoming more aware of concrete's advantages, he adds. "Nearly all have looked at concrete, and most have at least one concrete substructure in their shortlist."

With the size of turbines increasing, the number of substructures needed per GW is falling. "So the structures themselves are getting bigger, and the fabrication facilities are also going to have to be bigger. To justify their creation you need a certain throughput of business over time – ideally 25 to 50 substructures a year over many years. The Scottish market is easily big enough to justify that kind of capacity."

O'Brien does admit, however, that the sheer scale of such an operation could cause localised supply chain issues. "We do not, for example, want aggregate and cement for the concrete being trucked by road from multiple quarries and plants all over Scotland and beyond. Nor do we want substructure construction to be competing for resources with other major infrastructure projects elsewhere in the UK, such as new rail or nuclear projects. That's why it's important that we identify and secure the right resources now – particularly coastal quarries which can ship material direct to substructure fabrication facilities."

In practice, this means that well-located quarries must be ready to provide considerable amounts of aggregate, as well as limestone for cement, from around 2029, with the capacity to continue for many years. This will not happen automatically, says Mark Russell, executive director at the Mineral Products Association.

"To begin with, there is an issue with replenishment. Every year, we carry out our mineral planning survey where we track aggregate sales versus new permissions to extend existing quarries or open new ones. That is showing, on a 10-year average, that crushed rock is being used nearly twice as quickly as it is being replaced. Sand and gravel is running at a 63% replenishment rate." In other words, they are being used faster than new permissions are being granted. "We also forecast that consumption will rise in the coming years – and that's without factoring in mega-projects like offshore wind. So you either have to replace the reserve or find other ways to meet the demand."

Social value

The alternatives are not attractive, and especially so in the context of FLOW: either material travels further through the UK to supply the fabrication facilities (raising the carbon footprint of the material and putting pressure on road and rail systems) or material has to be imported from overseas – far from an optimal solution in terms of carbon, cost or social value. "Some of the regions concerned – Cornwall, South Wales, parts of Scotland – are places that could really benefit from this," says Russell. "It would be a huge opportunity missed if the business went abroad."

So how much social value could substructure fabrication deliver? Celtic Sea Power estimates that to produce 50 of the larger substructures per year would require 900 round-the-clock shift workers, creating more than 2,000 direct jobs on site. Many more would be created or supported throughout the aggregate industry supply chain. Hodson points out that Hinkley Point C has a "6,000-strong battle-hardened workforce with a proven capability of 27,000m^3 of concrete per month".

It seems fortuitous that Hinkley Point will be winding down just as FLOW is gearing up. Similarly, the offshore oil and gas industry has a large workforce skilled in both large-scale fabrication and offshore installations. As oil and gas extraction declines, those skills could support a Scotland-based substructure sector.

New extraction planning permissions can take between five and 10 years to secure – so planners and local authorities should already be considering what might be required if their areas are to fully benefit from the FLOW opportunity. Russell acknowledges, however, that quarrying is seldom popular, and of course planners have to listen to objections. "That's local

“IF WE GET THIS RIGHT, FLOATING OFFSHORE WIND WILL BE ECONOMICALLY GAME-CHANGING FOR THE REGIONS INVOLVED”

democracy. So we have to help planners and local populations see why this material is needed and the very considerable benefits that could result. If we get this right, then FLOW will be economically game-changing for the regions involved.”

He suggests two regulatory changes that might help to strike a balance between local concerns, regional prosperity and broader national interest. National and regional forecasts of demand used to be produced by government and were reflected in published guidelines for aggregates provision. These were an integral part of the Managed Aggregates Supply System that set out the amount to be provided in each region of England over a 15-year period. Unfortunately these have not been kept up-to-date, and each planning authority now relies on its own forecasts, which may underestimate the need and lead to under-provision.

“Localism does not really suit the needs of major national infrastructure,” says Russell. “A return to something like the former system would help. It’s local democratic accountability through the planning system that determines whether extraction can take place or not, so there has to be clear visibility about the national need, or it’s very easy to say no.” The government has listened to feedback from industry and is now working on new guidelines, he adds.

Secondly, says Russell, planning applications for major projects do not require developers to provide information on where their materials are coming from. “It seems odd that they have to be quite detailed about how they will dispose of waste, but it is simply assumed that the necessary materials will be supplied. And yet where they come from and how they are transported can have big impacts locally.”

Nature restored

Something else that should help bring planners and local communities on side is the aggregate industry’s admirable track record when it comes to restoring former quarries. “It is not always appreciated that our industry has been in the restoration business for a long time and we have a lot to be proud of,” says Russell. “It is only from this year, for example, that housing and other developments must show a 10% net gain in biodiversity. Quarry operators have been achieving far more than that for many decades.”

MPA members have so far delivered over 80km² of “priority” habitat through the restoration and stewardship of former extraction sites, deemed to be of principal importance conserving biodiversity, and the industry has a further 110km² of priority habitat planned as part of the restoration of existing sites.

Besides the close working relationships that MPA member companies have nurtured on the ground, the MPA has formalised partnerships with key conservation bodies including the Bumblebee Conservation Trust and the Freshwater Habitats Trust. Numerous other organisations also collaborate with MPA and its members, including most of the 46 local Wildlife Trusts, the Bat Conservation Trust and the Mammal Society. MPA also has a special relationship with the Royal Society for the Protection of Birds, which has taken the lead on the impressive Nature After Minerals project.

Russell points out that former extraction sites are also providing high-quality leisure facilities, such as the Cotswold Water Park, or space for housing, as at Chipping Sodbury, Gloucestershire, where the site of the former Barnhill Quarry has been transformed into a new neighbourhood.

These examples are good evidence that extracting essential materials seldom results in long-term loss for the areas concerned. Quarries can be restored. Economic opportunities like floating offshore wind, however, do not come along very often – and once lost, they are gone forever.

Below The Floodplain Forest Nature Reserve near Milton Keynes. The site was created in partnership with Hanson, which undertook gravel extraction and landform restoration between 2007 and 2016. The restored habitat was carefully designed to resemble the prehistoric condition of the floodplain

Photo: Nature After Minerals

HIT THE ROAD

The UK is a hotbed of innovation when it comes to concrete manufacture. Join us on a whistlestop tour of just a few of many notable sites on the route to net zero …

When UK Concrete published its Roadmap to Beyond Net Zero in 2020, it gave a clear direction of travel for the industry. It also highlighted the need for speed: after all, it is the innovations and initiatives taking place today that will determine whether or not we reach net zero by 2050.

The roadmap presented seven areas where improved efficiency, new technology and processes can eliminate the industry's remaining CO_2 emissions, so that by 2050 all cement and concrete will be carbon-neutral, or even carbon-negative. Although these "levers for change" consider the whole concrete lifecycle (see right), many of the crucial contributions will occur during the manufacturing process. For example, using carbon-neutral fuels and capturing the CO_2 generated in the production of cement could add up to savings of nearly 500kgCO_2 per tonne of cementitious material. Low-carbon cements and concretes will also make a significant contribution, and together this represents more than two-thirds of the reductions identified in the roadmap.

Technologies are evolving fast. With this in mind, we thought it was a good opportunity to survey the work that manufacturers and innovators are doing across the UK to steer a course for our net zero destination.

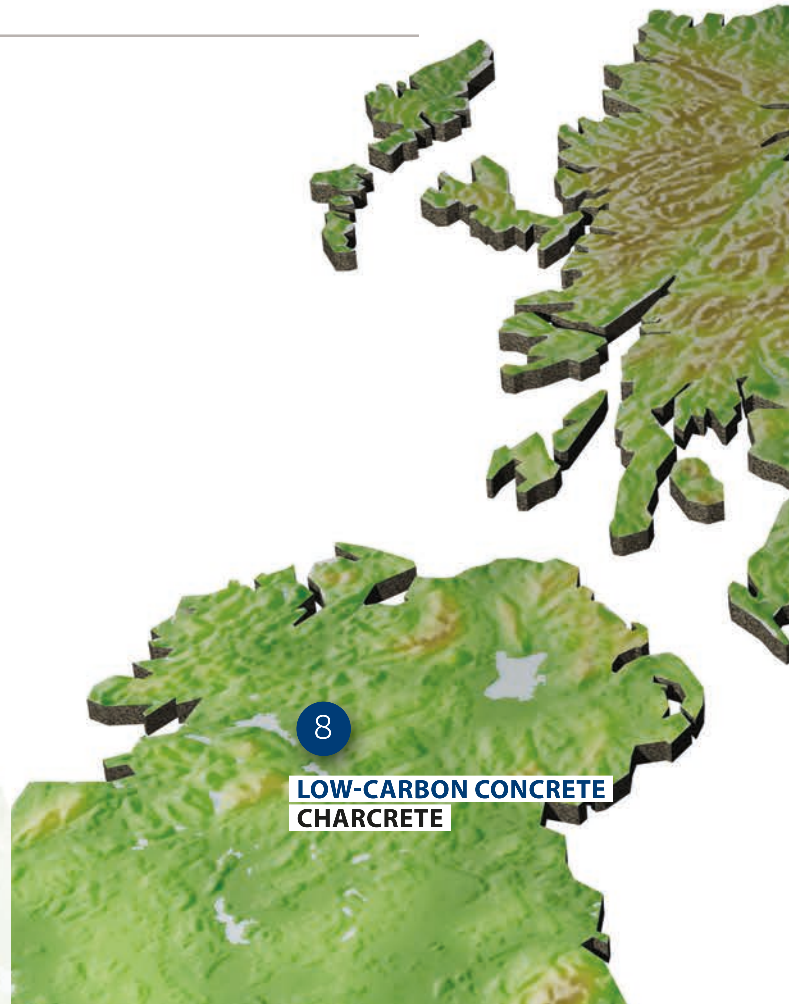
LEVERS FOR CHANGE

Contribution to net zero by 2050

Indirect emissions from decarbonised electricity	–4%
Transport	–7%
Low-carbon cements and concretes	–12%
Fuel switching	–16%
Carbon capture, use and storage (CCUS)	–61%

Contribution to beyond net zero

Carbonation	–12%
Thermal mass	–44%



MEET OUR VEHICLE
TARMAC ELECTRIC MIXER

For this roadtrip, we'll be taking the UK's first all-electric ready-mix concrete mixer, which is now fully operational after completing a three-month trial of commercial deliveries across Birmingham for Tarmac earlier this year. The 'e-mixer', created in partnership with Renault Trucks and TVS Interfleet, is the first to operate anywhere in the UK with zero tailpipe emissions. With the same average capacity as a conventional diesel vehicle, it is expected to save 42 tonnes of CO_2 annually, with zero emissions per mile compared to 1.55kg of CO_2 for its fossil fuel equivalent.

1 ART, SCIENCE AND 70% LESS EMISSIONS

This dramatic 23m-tall sculpture in Glasgow, built to tie in with the COP26 climate conference, was a collaboration between artist Stuart Padwick, Aggregate Industries, Ramboll, Urban Union and Keltbray. To meet the sustainability credentials for the project, the columns and pile caps were made from Aggregate Industries' ECOPact Max+, which has 70% lower carbon emissions than a standard CEM I mix. This bespoke mix included 20% recycled glass as well as a light-coloured aggregate from Skye, which were exposed through power washing to create a rustic finish.

2 ELECTRIFYING CEMENT ON TEESSIDE

The two-year Cement2Zero trial is investigating the technical and commercial aspects of upscaling Cambridge Electric Cement – a process that can produce new, potentially zero-carbon cement from recycled concrete. The first phase of the trial has been undertaken by the Middlesbrough-based Materials Processing Institute using a 250kg induction furnace on its Teesside campus. Recovered cement paste (RCP) is used in place of lime flux to remove impurities during steel recycling. The heat in the furnace reactivates the cement, producing a slag very similar to the clinker for Portland cement. Once trialled, developed and de-risked, industrial-scale melts will take place in Celsa's electric arc furnace in Cardiff. Cement2Zero is a collaboration between the Materials Processing Institute, the University of Cambridge, Atkins, Balfour Beatty, Celsa, Day Group and Tarmac, and is supported by Innovate UK funding.

3 PIONEERS IN THE PEAKS

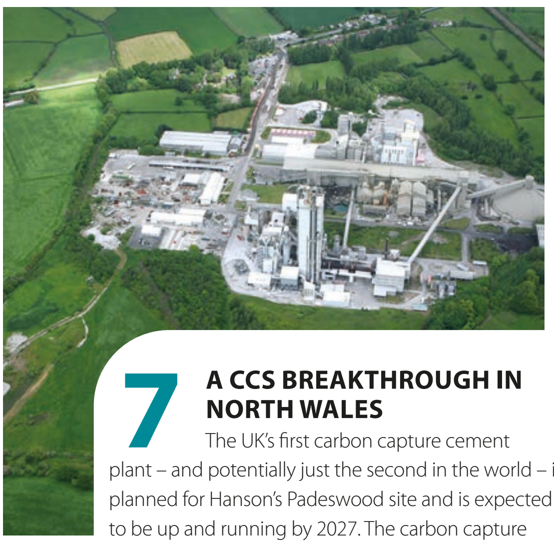
The Peak District and surrounding area is responsible for 40% of all cement and lime manufactured in the UK. Earlier this year, five of the region's leading producers formed a carbon capture and storage (CCS) cluster – the Peak Cluster – with the aim of reducing the sector's emissions by 40%. The cluster involves five cement and lime plants owned by Tarmac, Breedon, Lhoist and Aggregate Industries, plus the Lostock Sustainable Energy Plant in Cheshire. The plants will be linked via a network of pipelines so that they can transport compressed CO_2 to permanent stores beneath the Irish Sea. The project, which is being led by engineering consultant Progressive Energy, aims to capture 3 million tonnes of CO_2 per year and store it offshore by 2030.

4 DECARBONISING PRECAST WITH BASALT FIBRE IN NOTTINGHAMSHIRE

Laing O'Rourke has trialled the use of basalt fibre reinforced polymer (BFRP) as an alternative reinforcement material in two structural systems as part of its Decarbonising Precast Concrete Manufacturing project at its plant in Steetley, Nottinghamshire. Basalt fibre offers improved resistance to corrosion, potentially prolonging service life, reducing maintenance, and saving carbon over the whole life of a structure. The two systems – a one-way spanning precast concrete slab and a lightweight compression shell-based reinforced concrete floor system – saved an estimated 67% and 72% of the reinforcement's embodied carbon respectively.

5 SUPER-STRENGTH CONCRETE WITH GRAPHENE IN DERBYSHIRE

Australia-based First Graphene has begun trials of graphene-enhanced cement and concrete at Breedon's Hope cement plant in Derbyshire. In one of the largest global trials of its kind, about 2,000 tonnes of graphene-enhanced cement will be produced using First Graphene's PureGRAPH – an additive of atom-sized graphene platelets that enhance the hydration phase of concrete, supercharging the strength of the cement as it begins to set. The trials are using existing grinding aid dosage lines, with minimal adjustment needed. Tests have found compressive, flexural and tensile strength gains of around 30%, which could enable significantly less material to be used in concrete structures. Breedon will supply concrete produced under the trial to Morgan Sindall Construction for use in its building projects.



7 A CCS BREAKTHROUGH IN NORTH WALES

The UK's first carbon capture cement plant – and potentially just the second in the world – is planned for Hanson's Padeswood site and is expected to be up and running by 2027. The carbon capture unit will be built next to the existing Padeswood plant, which currently represents about 10% of UK cement production. It will use a proven technology, which involves circulating the flue gases through an 80m-high absorber column, where the CO_2 bonds with amine – an organic solvent derived from ammonia. This prevents 95% of the CO_2 in the exhaust gases from escaping into the atmosphere. CO_2-rich amines are then pumped to a regenerator column and boiled to release near pure CO_2. The energy for this process will be supplied by a dedicated combined heat and power unit, which will be powered by natural gas, with its exhausts fed through the carbon capture stack too. The captured CO_2 is compressed and purified before being piped via the Hynet CCS pipeline for permanent storage beneath the Irish Sea. The Padeswood CCS plant is set to cost around £400m to construct, and will capture some 800,000 tonnes of CO_2 annually.

6 A NET-ZERO FUEL MIX MILESTONE IN LANCASHIRE

In 2021, a world first took place at Hanson's Ribblesdale plant in Lancashire when hydrogen was used for the first time to make cement. The gas was used to supplement other carbon-neutral fuels including ground meat and bone meal (MBM), and glycerine, with the plant running for three hours on the innovative mix. The MBM contributed 13% to the kiln energy requirements, and the glycerine 48%. A specially designed burner nozzle was then used to supply the hydrogen, which provided the remaining 39% of the heat, ensuring the flame would be hot enough to produce a high-quality clinker. Since around 30% of cement's carbon footprint results from the fuel needed to heat cement kilns, a net-zero fuel mix has enormous potential to cut emissions. Hanson has calculated that, if fully implemented for the whole kiln system, it could save nearly 180,000 tonnes of CO_2 a year at Ribblesdale alone.

8 CHARCOAL TO CONCRETE IN NORTHERN IRELAND

A research project in Northern Ireland is looking at how wood waste – everything from old window frames to chipboard and MDF – could be used in concrete. The team, based at Enniskillen's South West College, initially found that turning the waste into charcoal via pyrolysis made it a purer, more consistent product – although not pure enough for biochar's common secondary use as a soil improver. But they also discovered that it had considerable potential as an aggregate, storing carbon for the long term. Early research also suggests it could have useful properties as a 1-2% cement replacement and as a hydration controller. The charcoal acts as a micro-sponge, initially absorbing moisture and tending to speed up the curing process. Counterintuitively, charcoal's sponge-like properties could also reduce concrete shrinkage, releasing water in the later stages of curing.

9 CARBONCURE BRICKS IN SOUTH WALES

Marshalls Group is using a US-developed carbon capture technology to make concrete bricks with waste CO_2 from the fertilizer industry. CarbonCure injects captured CO_2 directly into concrete while it is being mixed. Applicable to both precast and ready mix, the company says this permanently stores 15kg of CO_2 per m^3, and has been deployed in projects across the US, including the new Amazon headquarters in Washington DC. Marshalls trialled CarbonCure last year and is now rolling it out on all facing bricks manufactured at its plant in Grove, South Wales, which produces 50 million bricks each year. It estimates that the project could permanently remove about 30 tonnes of CO_2 annually.

10 PHASING OUT FOSSIL FUELS IN RUGBY

Cemex has invested £18m in a system to replace fossil fuels at its Rugby cement plant. The new production process has the capability to operate at 100% with alternative fuels. The company was the first in the UK to use hydrogen enhancement and also plans to upgrade the Rugby site to allow greater use of alternative raw materials derived from waste, such as fly ash and gypsum plasterboard. This will involve installing a new grinding mill and extending storage and delivery facilities.

11 CAMBRIDGE ROBOTS PUSH BOUNDARIES OF MATERIAL EFFICIENCY

The ACORN project, based at the universities of Cambridge, Bath and Dundee, is using robotic formwork and advanced structural design software to change the way we build structural elements. The goal is to optimise the production of columns, slabs and beams – ensuring they use just enough material and space to perform their structural function and no more. A full-scale demonstration of a thin-shell vaulted floor, built at Cambridge University's Civil Engineering Department with partner Laing O'Rourke, cut concrete by up to 75% compared with a solid slab floor, and required no reinforcement. Rather than being laid flat, the concrete is used only where it is needed to work in compression. The shape cannot be made using traditional temporary formwork, so the ACORN team developed an adaptable mould and a robotic concrete spraying system that can be used in an offsite factory.

12 FIBRE-REINFORCED CONCRETE CROSSES THE THAMES

On the road south, we'll take a detour to check out progress on the 1.4km Silvertown Tunnel, one of the largest ongoing infrastructure projects in the UK. In order to reduce embodied carbon on this critical transport connection, manufacturer Banagher Precast Concrete has introduced a number of innovations. The tunnel segments use a mix combining limestone aggregates from Banagher's own quarry and 40% GGBS in conjunction with polypropylene micro-fibres, creating a concrete that meets the requirements of fire protection, chemical resistance, a short stripping time and low carbon, while eliminating the need for steel cages. This fibre-reinforced concrete is being used in 6,750 out of 10,100 units, greatly reducing the cost and CO_2 content of the tunnels.

13 CARBON-CAPTURING CHEMISTRY AT IMPERIAL

Researchers at Imperial College London have developed a process that creates a secondary cementitious material (SCM) from olivine – an abundant and naturally occurring mineral formed mainly from magnesium silicate. Unlike commonly used SCMs such as GGBS or fly ash, the Seratech process is strongly carbon-negative as it uses waste CO_2 from flue gases, which is permanently sequestered within a by-product – magnesium carbonate. The company says its product is visually similar to conventional mixes, as well as having similar curing and strength properties. It adds that it can replace 40% of the Portland cement content in concrete, potentially reducing emissions by 3 billion tonnes of CO_2 a year.

14 CUTTING CARBON BY 20-40% WITH CORNISH CLAY

Clay is a naturally abundant material in the UK, and when calcined can be used as a secondary cementitious material. A groundbreaking two-year MPA project – supported by Innovate UK and industry partners Tarmac, Hanson, Imerys and Forterra – is testing two secondary sources of clay, one arising from rock deposits at mineral extraction sites, the other from brick manufacturing. Using calcined clays from these sources could divert 1.4 million tonnes of material from waste streams every year and lead to carbon savings of 20-40% compared to the market leading CEM I cement. The option being explored by Imerys is metakaolin, a type of clay produced in Cornwall and used in high-end applications in many markets, including ceramics, coatings and paper.

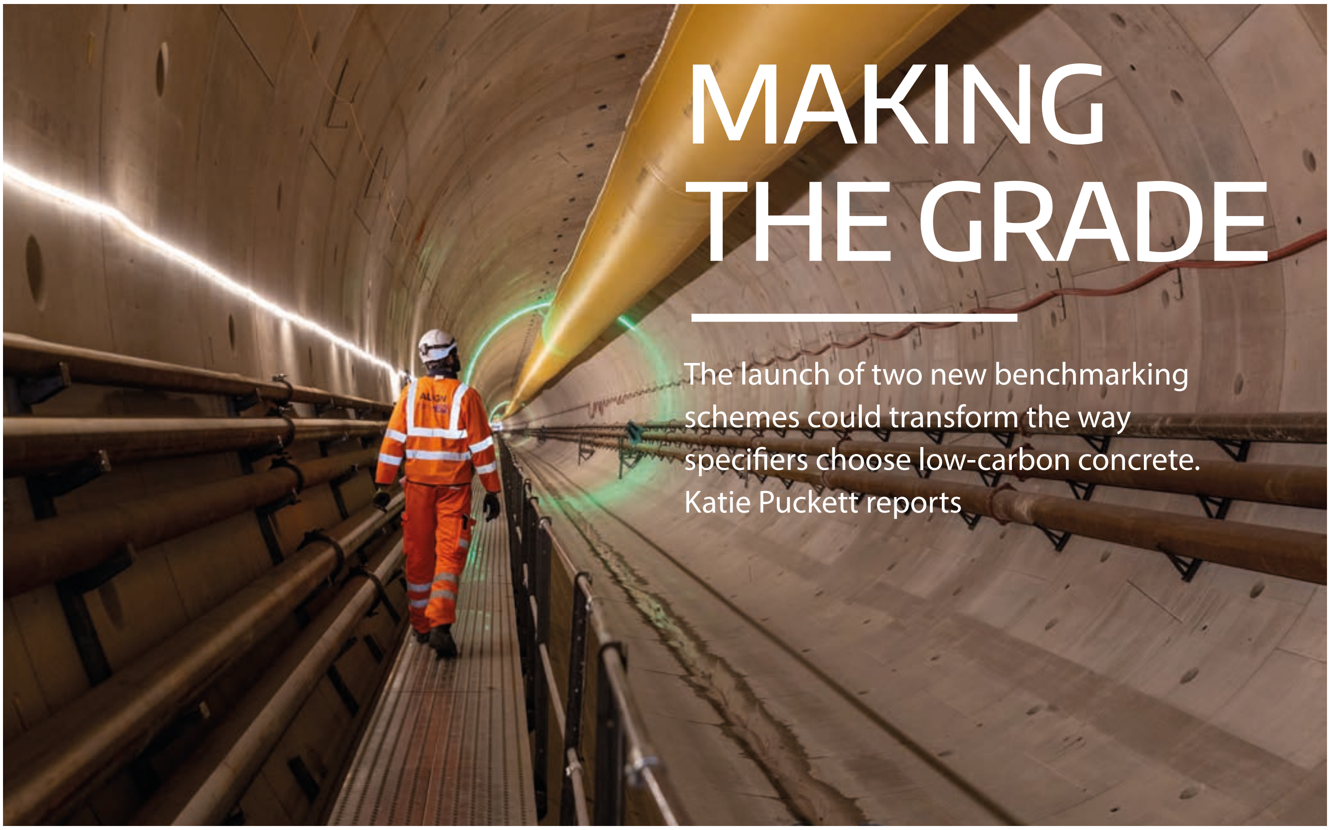


Photo: HS2

MAKING THE GRADE

The launch of two new benchmarking schemes could transform the way specifiers choose low-carbon concrete. Katie Puckett reports

THE CONCEPT

Why we need rating tools and how they work

Calculating the embodied carbon of concrete is complex because a mix may contain many potential ingredients in different proportions, depending on the job it is intended to do and where in the country it is sourced from. In the absence of an objective scale, the term "low-carbon concrete" has been applied to products with widely varying carbon footprints. This leaves specifiers in the dark, and makes it hard for manufacturers of genuinely lower-embodied carbon mixes to compete against cheaper products with a higher carbon footprint.

This is the problem that two new ratings schemes have been designed to solve, by grading products alphabetically, from A and B all the way down to F and G. The hope is that a standardised labelling system will support the market to make lower-carbon choices, and encourage suppliers to develop progressively better products. The two systems take different approaches to communicating the embodied carbon of concrete, and are useful for different things, but most valuable when combined. What unites them is an attempt to reflect a complex reality in a way that can be easily applied.

"There are lots of different opinions and everyone was saying different things," says Bruce Martin, associate director at Expedition Engineering and a member of the Green Construction Board's Low Carbon Concrete Group (LCCG). "So we were trying to find out what was available, and create a market benchmark to identify which were the lower and higher embodied carbon concretes."

The LCCG's benchmark, launched in April 2022, provides a dynamic snapshot of the current market, segmenting products into rating bands that will evolve over time. Bands A to E each represent 20% of concrete produced in the UK, while those in band F have higher embodied carbon than any of the concretes submitted to the LCCG. At the other end of the scale, concretes with a lower embodied carbon than any of the submitted concretes are labelled "market beating".

The first iteration was based on a relatively small dataset, but quickly demonstrated the value of the concept. An updated version, just released, is much more comprehensive, generated using data for around 50% of all the ready-mixed concrete produced in the UK during 2022, thanks to support from MPA and its members. To create the rating bands, this data was plotted on a graph, with the Eurocode strength classes along the x-axis, and embodied carbon along the y-axis.

Although there are many variables that influence the embodied carbon of concrete, strength is a useful metric as both a functional requirement and one that tends to correlate with the proportion of cement, which accounts for by far the greatest share of emissions. As the embodied carbon of available products comes down over time, the boundaries of the rating bands will shift and the curves should become gradually shallower. The latest version further breaks down each of the rating bands into four – ie, A1, A2, A3, A4 – each representing 5% of the market, and providing an additional incentive to improve, even if it's not feasible to jump a whole band.

This dynamic approach is very useful for showing the relative carbon content of different products, and for setting deliverable targets on current projects. But for setting longer-term targets and illustrating progress towards net-zero, it's necessary to have a static benchmark. This is where the scheme developed by Arup with funding from Innovate UK comes in.

This combines real-world data on mixes with higher embodied carbon and statistical analysis to set a conservative baseline, and rating bands at 20% intervals, scaling down to zero and beyond. A G-rated concrete has higher embodied carbon than the current market, a B-rated concrete has embodied carbon 80-100% lower than the baseline, and an A-rated concrete is carbon-negative.

"What's happening in the industry is not necessarily where we need to be heading, as the evolution may not be as fast as we anticipated in terms of technology development," says Dr Fragkoulis Kanavaris, a materials specialist at Arup. "So if we plot the dynamic LCCG data within a static scheme that's the same over time, we'll be able to see how we are progressing."

The scheme is deliberately technology agnostic, and doesn't distinguish between different types of concrete or their intended function – as with the LCCG benchmark, products are characterised only by their compressive strength. "It would be easy to get lost in the details, but if we want to have a standardised scheme it needs to be as user-friendly as possible," explains

"IF WE WANT TO HAVE A STANDARDISED SCHEME, IT NEEDS TO BE AS USER-FRIENDLY AS POSSIBLE"

Kanavaris. "That's very important because we have to satisfy a big spectrum of potential users across the value chain, from clients, policymakers and government bodies, to structural engineers, materials engineers, infrastructure owners and concrete producers."

If the LCCG's greatest challenge was to collect sufficient data to create a true reflection of reality, one of the biggest concerns for the Arup team was designing the system so that it didn't skew the market in unhelpful ways. He highlights several areas where further data would be valuable for avoiding unintended consequences.

For example, both benchmarks focus only on project lifecycle stages A1 to A3, covering the supply and transport of raw materials and the manufacturing process – so cradle-to-factory gate for ready-mixed concrete, or cradle-to-mould for precast. Within this scope, precast concrete typically has a higher embodied carbon than in-situ because mixes are designed for earlier strength gain. "But there are other benefits of precast that can't be encapsulated in a classification scheme that is limited to the A1 to A3 stages," says Kanavaris. Neither can it take account of resource efficiency: "If an A-grade concrete is selected over a C-grade, but twice the volume used for a particular element, that's a potential misuse of the scheme."

For the future, both teams hope to incorporate more granular information about how, where and which concretes are specified. The latest version of the LCCG benchmark includes supplementary data on the total production of volume of different mixes, for example, and the embodied carbon of concrete used in different elements, and in different locations. This is still at an early stage, but Martin hopes that greater collection, particularly from contractors on how concretes are used, will create an increasingly comprehensive picture of the market with each update.

The two teams are now focusing on how the two systems can complement each other best. When the latest LCCG data is plotted on top of the Arup graph, the average rating broadly follows the boundary between the Arup ratings D and E, representing a 40% reduction in embodied carbon against the baseline. Accelerating change to bring this down to

Opposite HS2 is among the major infrastructure clients working to develop a coordinated approach to applying the two rating tools

Right The Environment Agency is also playing a leading role in establishing the rating tools. At the Hexham Flood Alleviation Scheme, it has successfully trialled the use of two ultra low carbon C32/40 mixes, developed by Tarmac

Photo: Environment Agency

zero or below is the ultimate goal for both.

"Our dynamic benchmark is useful to see how the concrete you're procuring or producing compares against the market and to push your supply chain," says Martin. "Then you can use the static scheme to tell them where you want to get to in five or ten years' time. They do very different things, but work very powerfully together."

> "THE TWO SCHEMES DO VERY DIFFERENT THINGS, BUT WORK VERY POWERFULLY TOGETHER"

THE APPLICATION
How clients are using rating tools to reduce their carbon impact

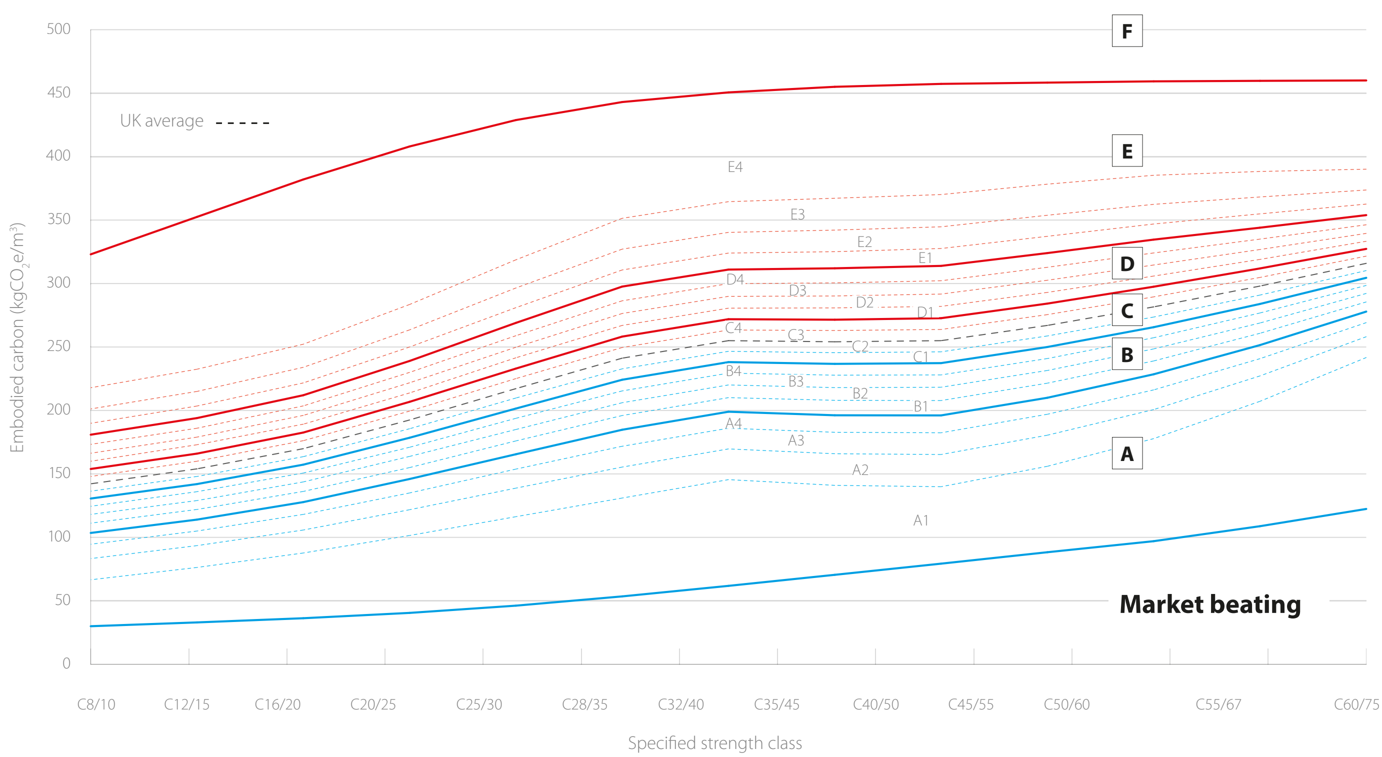
When the Low Carbon Concrete Group's embodied carbon benchmark was released in April 2022, it wasn't a novel concept for Andy Powell at the Environment Agency. The agency had already set its own carbon caps for the concrete used on its projects. The new benchmark did, however, make him reevaluate both its approach and the targets themselves.

"We didn't really have enough data to put together something really accurate, and the benchmark system is much more refined in terms of the different strength classes," says Powell, who leads the EA's national engineering innovation team. "We also realised that our caps were higher than they ought to be, and it gave us the confidence to work with our delivery partners to set tougher limits. It wasn't a difficult conversation about what was possible: we know it's possible because the data shows it's happening."

Since then, the Environment Agency has been working with other major infrastructure clients, including HS2 and Transport for London, to develop a coordinated approach to applying both the LCCG benchmark, and the complementary one released by Arup in June. "Each client will have slightly different drivers. But if we're all striving to decarbonise from where we are, that will send a clear, understandable message to the market and drive it forwards," says Powell. "If enough of us are specifying at the better end, that will drive the boundaries lower."

Taking a collaborative approach not only provides consistency for the supply chain, it also enables individual organisations to pool their influence. Transport for London, for example, is a relative minnow in terms of its concrete consumption. "We realised that working alone, we won't have as big an impact," says Jane Wright, a systems engineer working on its decarbonisation strategy. "If we're all working as a block, we're sending a clear signal to

Fig 1: LCCG market benchmark for embodied carbon, normal weight concrete, LCA stages A1-A3
(Readymix: cradle to batching plant gate. Precast: cradle to mould)



the market about where we want to go."

HS2, meanwhile, already has a target to halve the embodied carbon of its concrete and steel by 2030, says Jon Knights, lead materials engineer on the high-speed rail project. "Of nearly 200 mixes, more than 90% contain SCMs and 50% contain very high levels of replacement, so the bar is quite high already. That means we've got a lot of work to do to reduce it further."

All three organisations propose to set a minimum requirement of a B rating under the LCCG market benchmark, which means that only concrete with embodied carbon in the best 40% of the market should be used on their projects. This is a pragmatic decision, based on what's attainable: as public-sector bodies building essential infrastructure, they have to balance carbon with deliverability and cost, points out Knights. "On HS2, we have contractors trialling very low embodied carbon concretes containing alkali-activated cement. But as it stands, that type of technology is not a volume player."

What's possible will differ for each client, depending on what exactly is being constructed and their priorities at the time. On certain building elements, where strength or curing time is less important, it might be possible to do much better. "If there's a concrete that is A-rated or market-beating and it's suitable for the application and it's

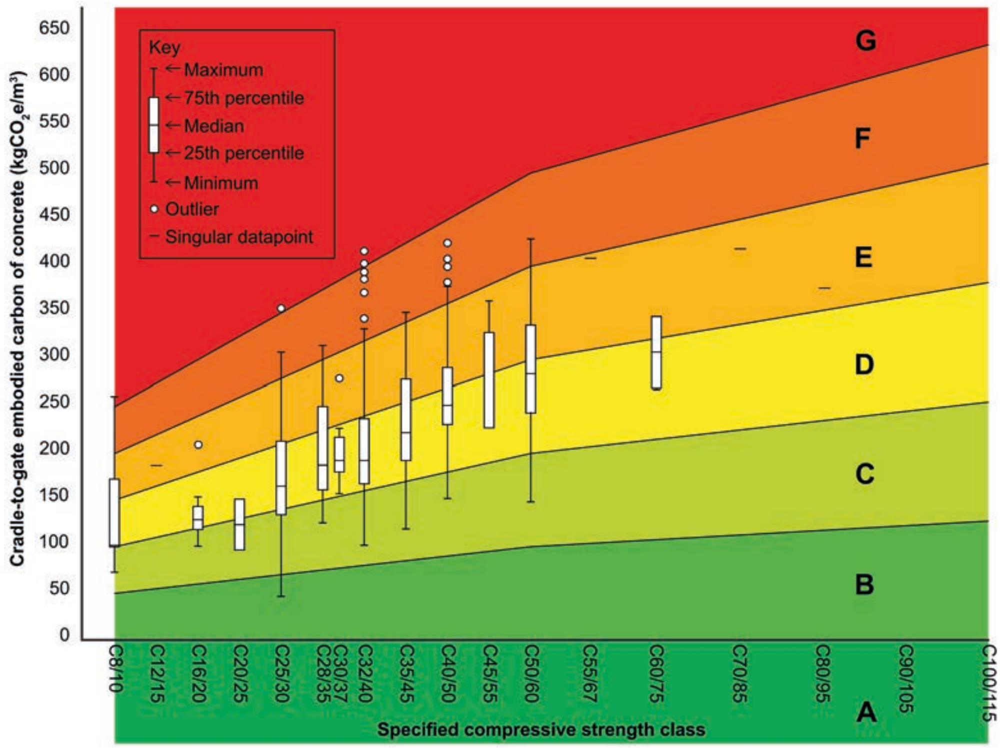


Fig 2: The Arup static rating scheme, with industry data from the LCCG 2023 benchmark mapped onto it to show the embodied carbon of commercially available concrete

the best option, then we absolutely want designers to suggest that," says Wright.

She is also keen to emphasise that designers should focus on a whole-life analysis, before getting into the details of material specification. For example, it might be more resource-efficient to specify a smaller amount of a stronger mix. "It's not just about the concrete, it's about the whole design," agrees Knights. "We want to reduce the CO_2 generated in the production of Portland cement clinker, we want to reduce the amount of clinker in our concretes, and we want to reduce the total amounts of cement and of concrete. One way to do that is performance-based design, and taking a holistic approach."

The more important thing is that the industry adopts a standardised way of measuring and reporting embodied carbon. This is what they are currently focusing on, working with MPA to develop a consistent structure that will feed back into the benchmark to refine future iterations. "We have a project carbon calculator, but the challenge for us is to pull out one material type," says Powell. "And depending on when you decide to report, you might be cutting across a whole load of different projects at different stages, so that's something we need to work through."

Like HS2, the Environment Agency is trialling newer mixes and using the performance-by-testing approach to validate them. "But obviously that's relatively time-consuming and costly," says Powell. "The more novel materials are not scalable at the moment, but we have used A-rated blends of existing supplementary cementitious materials on one project, so we need those sorts of things to come through and land in the standards."

This ongoing innovation is why the benchmark rating system is so powerful, says Wright. "We're not saying that there's a particular material that you should be using. We're focusing on the outcome – lower-carbon concrete – but how we get there is an open playing field. It's really important that as clients we continue to support that work, so that we get to the low-carbon future that we're all striving for."

For more information, see "Embodied carbon of concrete – Market Benchmark", published by The Concrete Centre on behalf of the LCCG, or visit www.concretecentre.com/marketbenchmark

"WE'RE NOT SAYING THAT THERE'S A PARTICULAR MATERIAL THAT YOU SHOULD BE USING. WE'RE FOCUSING ON THE OUTCOME"

HOW WE WANT TO LIVE

Health and wellbeing will be central to housing design over the coming decades. But our understanding of these broad concepts is evolving all the time, writes Tom De Saulles

Right: Deep balconies, which cantilever up to 3m from the reinforced-concrete frame, play a key role in the overheating strategy at Allies and Morrison's Bayside tower in Worthing, West Sussex, by providing solar control on the south facade without obstructing daylight and views. The balconies and structural frame were made from 40% GGBS concrete

Photo: Tim Crocker

What do we want from our homes? It may sound like a straightforward question but for many people the answer will have changed considerably since the Concrete Industry Sustainable Construction Strategy was first launched in 2008 – and it is likely to change again as we head towards 2050. Even in the past few years, the rise in energy prices, extreme weather, working from home and the changing needs of an ageing population have posed new questions about how we design living spaces.

But new challenges can also obscure the fact that much of what we want from our homes hasn't changed at all – in fact, it has been hardwired in over generations. A dwelling's primary requirement is still to provide a secure and robust living environment where occupants feel safe. Likewise, many of the key elements of the emerging health and wellbeing agenda are based on well-established principles, focusing on thermal comfort, light, air and materials.

The best housing over the coming decades will be built in a way that adapts to our changing lifestyles and changing climate, but without losing sight of the issues that have always shaped the way we want to live. This lies at the heart of the refreshed Sustainable Construction Strategy – one of our key commitments is to continue to provide a safe and comfortable built environment (see page 2).

But it is a complex challenge – here, we explore some of the areas that are likely to force their way up the agenda, and that designers can't afford to ignore.

Health and wellbeing

Issues around health and wellbeing have been gaining prominence in building design over the past decade. Although this has largely focused on the workplace, driven by the WELL Building Standard, it is clearly an important issue in housing too – not least because of the growing overlap between work and living. According to the Office for National Statistics, working from home has increased nearly fivefold since 2015, with a dramatic rise driven by the Covid lockdowns.

This shift in focus to the domestic arena gives an opportunity to consider aspects of health and wellbeing that are often overlooked. Environmental noise, for example, is the second biggest environmental cause of health problems after air pollution, according to the World Health Organisation. Among the effects of constant exposure is sleep disturbance and stress.

"ENVIRONMENTAL NOISE IS THE SECOND BIGGEST ENVIRONMENTAL CAUSE OF HEALTH PROBLEMS AFTER AIR POLLUTION"

In housing, this is likely to become an increasingly urgent issue. The trend is already for development to concentrate in urban areas and this is only likely to intensify. Government data suggests that the population will grow – albeit at a slower than current rate – by 4 million people over the next 20 years. At the same time, we will be grappling with challenges around biodiversity, transport, energy and water and food security, all of which will drive further densification.

The challenge is to ensure that denser development doesn't become noisier development. The minimum Part E (Resistance to the passage of sound) airborne sound resistance for the dividing walls and floors between new-build homes is currently 45dB. This can easily be achieved using heavyweight materials, due to their inherent mass, stiffness and damping properties. Concrete and

Below: Flood-resilient housing by BACA Architects in Shipston, West Midlands. All of the houses use cavity-wall construction, with a concrete block inner leaf. The concrete ground floors are raised on a reinforced-concrete frame, leaving an accessible void under the buildings. Internal walls forming the staircases and halls are also blockwork

Photo: BACA Architects

masonry separating wall and floor solutions are detailed in Part E and also in the Robust Details scheme, which offers a practical alternative to the pre-completion sound testing that is otherwise required by Part E. Specific requirements for finishes and any additional acoustic insulation are also set out in Part E and Robust Details.

Overheating

Overheating is already thought to affect up to 20% of England's housing stock, and is a growing threat to both health and wellbeing – as borne out by the unprecedented heatwave during the summer of 2022 and the equally record-breaking temperatures in June 2023. Sudden spikes in temperature and prolonged periods of excess heat are difficult for occupants to cope with, especially if they have an underlying health condition. The elderly are particularly at risk, with projections showing a three-fold increase in heat-related mortality by the 2050s.

In the housing sector, there is a new section of the Building Regulations – Part O – to address overheating. The best approach is to employ a variety of design measures, prioritising the removal of excess heat through solar control and ventilation. Designers should also consider building form, orientation and the use of thermal mass, all of which can help with Part O compliance.

To take advantage of thermal mass, it is important that heat absorbed during the day is removed overnight, so the building fabric can repeat the cycle the following day. This is achieved with night-time ventilation, using the cool night air to draw heat out of the fabric of the dwelling, as well as enabling the benefit of comparatively cool air to be carried forward to the following day.

It is worth highlighting a potential conflict between acoustic design and night-time purging, with the danger of external noise being transmitted through ventilation openings. However, new requirements set out in Part O help to tackle this problem through the use of sound-attenuating windows and vents. Thermal mass also has the potential to lessen the impact of noise and pollution during the day by reducing the need to open windows.

Good sources of overheating guidance include the Future Homes Hub Part O 2021 technical guide and the Concrete Centre publication, Designing to Avoid Overheating (2022).

Security

Like external noise, security is an often overlooked aspect of wellbeing, despite becoming increasingly significant in an age of high-density city living, often in shared spaces. According to the famous hierarchy of needs proposed by 20th-century psychologist Abraham Maslow, safety ranks second only to our physiological requirements as a behavioural motivation.

The Secured by Design police initiative gives specific recommendations to improve the resilience of walls to withstand criminal attack in certain parts of a dwelling. Guidance is also provided on robust wall construction between individual accommodation for students, key workers and other "single" room accommodation with shared facilities. In such instances, it is identified that "the security of a development can be severely compromised if lightweight framed walls do not offer sufficient resilience to withstand a criminal attack". The walls either side of any security door are also identified as areas requiring

"SUDDEN SPIKES IN TEMPERATURE AND PROLONGED PERIODS OF EXCESS HEAT ARE DIFFICULT FOR OCCUPANTS TO COPE WITH, ESPECIALLY IF THEY HAVE AN UNDERLYING HEALTH CONDITION"

robust performance, and specific requirements are provided on how to meet the necessary standard using framed construction.

Concrete and masonry walls can provide secure and robust enclosures, able to withstand criminal attack with little or no additional measures. Other ways in which the building fabric can be used to enhance home security include specifying concrete floors below and/or robust walls between shared attic spaces in apartment blocks, and masonry or concrete facades in vulnerable locations such as road sides.

Flood resilience

The risk of flooding is also likely to play a greater role in our perception of security. Floods are believed to cause around £740 million of damage each year in the UK, an increase of 1.4% since 1990, according to the New Scientist.

British standard BS 85500 can help identify when flood-resilient and resistant construction is appropriate, and offers guidance on how to achieve it. A key recommendation of BS 85500 is the use of a range of concrete and masonry structures, as they retain their structural integrity in flood conditions. Concrete has the strength to keep water at bay, with few construction joints to let the water through. It is also resistant to rot or fungal growth if water does get in and can be easily washed and disinfected.

Reinforced concrete or concrete blocks can be used, for one or both of the leaves in conventional cavity-wall construction, or as a single structural leaf in a solid masonry solution. Alternatively, an insulated concrete formwork (ICF) system can be specified, which typically employs rigid polystyrene as both insulation and formwork. The insulation properties are unaffected by moisture, making

ICF appropriate for most flood situations.

Concrete floors are also the preferred solution when it is not possible to place the ground floor above the predicted flood level. This should be in the form of a reinforced-concrete slab, at least 150mm thick.

The demands placed on the design of new homes will continue to increase over the coming decades. Alongside carbon and energy targets, health and wellbeing will be central to this. But health and wellbeing is a broad concept, one that cannot be easily delivered without high levels of thermal, acoustic, security and flood performance. These benefits will only become more important as the climate changes, and as we continue to adapt to more urban, more home-based lifestyles. Indeed, the ability of our homes to adapt with us may be the most critical design challenge of all.

Photo: David Grandorge

Above: Adam Khan Architects' Central Somers Town housing and community centre, which has been shortlisted for the 2023 Neave Brown Award for housing. The designers worked to 2050 climate levels, which meant a thorough approach to overheating: external roller blinds and internal side opening windows allow simultaneous ventilation and solar protection. Thermal mass – achieved by using blockwork external and internal walls – enables this passive cooling strategy

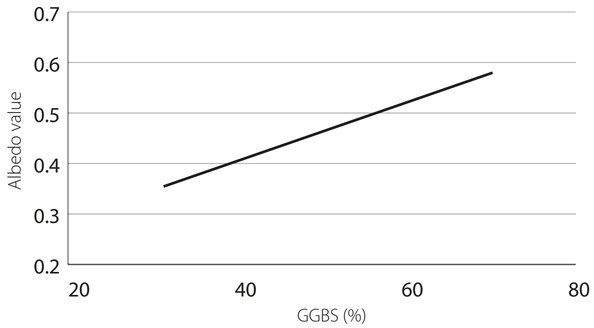
HOW GGBS CAN HELP COOL THE CITY STREETS

Temperatures exceeded 40ºC in July 2022 and saw the UK's first level 4 health heatwave warning. Heatwave preparedness is a growing issue for local and national government and is the basis of a recent policy brief from the Grantham Research Institute on Climate Change and the Environment, which details recommended actions for heat-related policies in the UK. Included in these is a range of urban measures, one of which is the use of cool pavements and streets.

Conventional paving materials can reach peak summertime temperatures of 48-67°C, while light-coloured, high-albedo finishes reflect solar gains back into the sky, giving a surface temperature that is around 20°C lower. Research in the US, where the use of cool pavements and roofs is more established, suggests that every 10% increase in solar reflectance could decrease surface temperatures by 4°C. It is estimated that if pavement reflectance throughout a city were increased from 10% to 35%, the air temperature could be reduced by around 0.6°C, increasing to 0.8°C if used in combination with other mitigation measures such as trees, green roofs and vegetation.

Light-coloured surfaces have an albedo value of around 0.8, meaning 80% of the sun's heat is reflected, while darker surfaces with values closer to zero result in greater heat absorption. Ordinary concrete has an albedo value of around 0.2-0.4. This is higher/better than asphalt, which has a value of 0.1-0.15, but not as high as concrete that has a high GGBS content or is made with white cement, which can give values up to 0.8. Concrete with a high albedo finish can be beneficial for both paving and building exteriors, helping to reduce the build-up of heat in the urban environment.

CONCRETE ALBEDO WITH VARYING GGBS CONTENT



Source: Boriboonsomsin and Reza, 2007

THIS IS **NOT THE END**

Circular economy thinking has enormous potential to reduce the carbon impact of the built environment, by keeping valuable resources in use at their highest value for as long as possible.

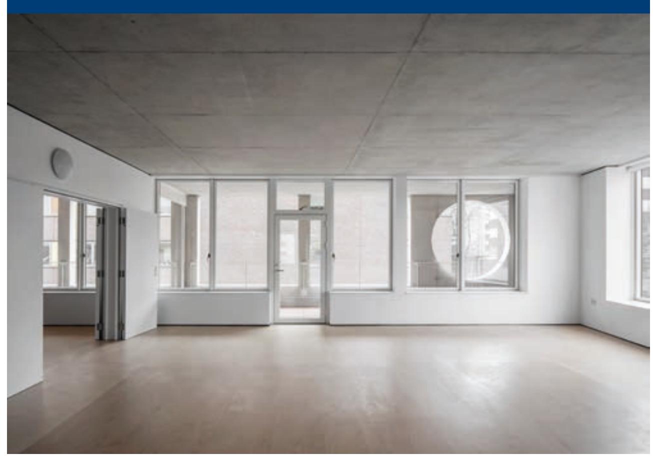
This is at the heart of the transition away from a linear "take-make-dispose" approach, and towards a model where consumption of raw materials is greatly reduced and waste is eliminated. In this world, designing concrete buildings becomes a balance between efficiency and flexibility. It means using the minimum amount of materials to achieve the desired goal, while looking towards the second, third or fourth lives of a structural frame and ensuring that it can be readily repurposed to fulfil new uses and shelter future generations. Through a net-zero lens, obsolete buildings are no longer problems to solve, but low-carbon resources, full of potential.

Elsewhere in this magazine, we've looked at how the concrete industry is lowering the embodied carbon of its products (pages 4-9), and supporting its customers to make the most carbon-efficient choices (10-13). This article is about how we keep those resources in circulation for as long as possible, and how we can derive the greatest value from them when they finally reach the end of their lives.

RETAIN

Designing for longevity

The best way to keep a concrete structure at its highest value is to reuse it. Designers can facilitate this by thinking about the future lives of their buildings when they are designing their first iterations, and making them adaptable for other uses. This might mean considering optimal spans, loads, grids and floor-to-ceiling heights, and making partitions removable so that internal layouts can be reconfigured. Creating an as-built digital twin will also be invaluable for future designers.



Photos: Johan Dehlin (left); Laing O'Rourke (below)

Right At Apparata Architects' A House for Artists, soft spots in party walls and external circulation allow flats to be completely reconfigured
Below right The deep facade of Henley Halebrown's 100 Kingsland Road helps to conceal the residential function, improving future flexibility
Below Lifschutz Davidson Sandilands' Hoxton Southwark features long spans and open spaces, enabling it to switch between hotel, residential and office functions

Photos: Paul Riddle (right); Nick Kane (far right)

Photo: Skanska

Left Derwent's Featherstone Building in London has a demountable glass-reinforced concrete facade fixed to its concrete frame, so that it can be easily removed and replaced in the future

Below left The Hylo Building, where structural engineer AKT II added 15 storeys to a 1960s office block, reusing much of the existing concrete structure

Designing for disassembly

Disassembly offers an alternative route for keeping structural elements in use for as long as possible. For some types of building, precast systems that are designed to be demountable will enable the components to be reused again when they have fulfilled their first function. Another route to circularity is to retain the building structure, but design all the layers attached to it so that they can be disassembled, replaced and potentially used elsewhere.

Renewing and adapting

Reusing existing buildings is not only extremely efficient in terms of embodied carbon, it also preserves their social and cultural value, as well as the fabric of our towns and cities. Existing buildings may have been designed for a lifespan as short as 25 years. But concrete structures can last for well over a century, and they may be able to support much greater loads than originally intended.

Structures may be renewed and reused for the same purpose – with shorter lifespan elements such as facades, building systems and internal finishes upgraded to meet modern performance standards. Or the original structure and foundations can become the base for a larger building – with the benefit of today's digital tools, designers are identifying spare load-bearing capacity that can help to meet higher demand in growing cities, without expending new resources.

Below Laing O'Rourke recently trialled its M Frame system as part of a kit of parts for housing and schools. The floor slabs require no structural topping and connections are made with steel bolts and removable low-strength grout

RECYCLE

End of life

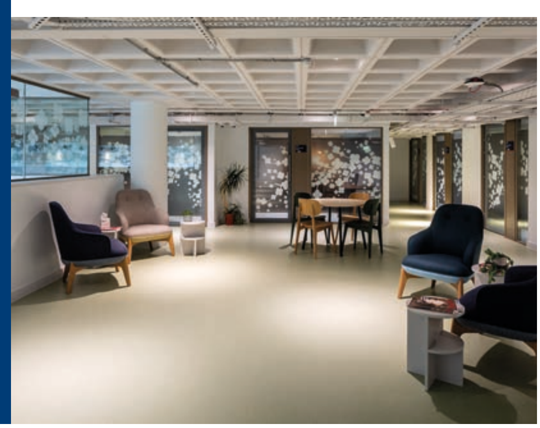
At the end of its serviceable life, concrete can be recycled ad infinitum as a low-carbon resource. In the UK, virtually all concrete from demolished buildings is recycled – whether as aggregate within new concrete or hardcore for load-bearing surfaces, it goes on to have a second useful life often even longer than the first.

Carbonation is another important element of concrete's lifespan. All concrete absorbs CO2 from the air over time, storing it permanently within its chemical structure. Crushing concrete increases the rate of absorption. Research is underway to maximise this carbon-sequestration potential in both new products and in recycled concrete.

New technologies are also in development to more effectively separate old concrete into its component parts of aggregate and cement, and reprocess them into a new source of materials – holding the promise of yet another way of closing the loop.

Round again to pages 4-9

Below Page/Park's Health Centre at the University of Edinburgh. Original 1970s features, such as the coffered slabs, have been exposed and celebrated



Photos: Keith Hunter Photography (left); Jan Friedlein (above left)

UNDERGROUND OVERGROUND

The 2.5km Chipping Warden tunnel in Northamptonshire is one of five pioneering precast-concrete "green tunnels" in phase one of the HS2 high-speed rail project. More than 5,000 giant segments are being made in Stanton Precast's Derbyshire factory, and then delivered to site. Five different segments are slotted together to achieve a double arch – one central pier, two side walls and two roof slabs. The completed tunnel will be covered by earth and landscaped to fit in with the surrounding countryside. The lighter-weight modular approach is expected to more than halve the amount of carbon embedded in the structure.

Photo: HS2