CONCRETE FUTURES

mpa The Concrete Centre

Futurebuild 2025

Exhibition Catalogue

Circularity in Concrete

Recycled material used to make concrete today

Most concrete contains some recycled and secondary content. The type and amount permissible depend on the application of the concrete. Portland cement typically contains around 10% recycled content and the most commonly used SCMs are by-products from other industries.

Key to samples:

1. Portland cement (CEM I) Forms the basis of most cements used for concrete and typically contains approximately 10% recycled content. It is commonly used in combination with other supplementary cementitious materials (SCMs).

2. Ground granulated blast-furnace slag (GGBS) A by-product of the steel and iron industry, used as a lower carbon SCM. *Sample courtesy of Heidelberg Materials*

3. Fly ash (FA) A by-product of coal-fired power stations, used as a lower carbon SCM. *Sample courtesy of UK QAA*

4 Silica fume Also known as micro silica, this well-established SCM adds durability and strength to concrete. *Sample courtesy of Ferroglobe*

Circularity in Concrete

Recycled material used to make concrete today

Most steel reinforcement used in concrete in the UK is recycled scrap steel, using the lower carbon electric arc furnace (EAF) manufacturing process. Concrete standards permit various types of recycled aggregate in concrete manufacture.

Key to samples:

5. Crushed concrete aggregate (CCA) A category of recycled aggregate principally comprising crushed concrete. Sourced from crushed and graded concrete demolition waste or repurposed returned concrete. *Sample courtesy of Day Aggregates*

6. Recycled aggregate (RA) Coarse aggregate resulting from the reprocessing of inorganic material previously used in construction. Due to its wide potential composition, use in concrete tends to be contract specific, with assessment on a case-by-case basis to ensure it meets specific concrete requirements. *Sample courtesy of Day Aggregates*

7. Recycled granite aggregate A by-product of the china-clay industry sourced from South-West England, otherwise known as stent. *Sample courtesy of Aggregate Industries*

8. Recycled carbon steel reinforcement Made using scrap steel. *Sample courtesy of Celsa Steel and BRC*

Circularity in Cement

Use of waste-derived fuels for cement manufacture

54% of the thermal energy used in the UK to manufacture cement is supplied from waste-derived fuels which have undergone treatment to remove recyclable elements. Co-processing describes the simultaneous recovery of energy and recycling of the mineral content of the waste derived fuels. This reduces CO2 emissions and raw material use, diverting 1.2 million tonnes of waste from landfill.

Key
Examples of waste derived fuels used in cement manufacture include:

A. Glycerin A by-product of the bio-diesel industry, this 100% carbon neutral, alternative fuel was used alongside meat and bonemeal and hydrogen in a world-first demonstration of a cement kiln main burner operating using 100% net zero fuel.

B. Refuse derived fuels (RDF) This non-recyclable household and business waste is diverted from landfill and processed to produce a clean, non-hazardous alternative fuel that is used at every UK cement plant. *Sample courtesy of ClimaFuel, Cemex*

C. Polyurethane (PUR) Waste rigid polyurethane foam containing impurities is recycled through co-processing into cement. *Sample courtesy of Breedon*

D. Recycled tyres Otherwise hard to recycle, tyres, tyre chips and tyre fluff are all used as alternative fuels. The waste steel within the tyres is upcycled, contributing useful iron content for cement manufacture. *Sample courtesy of Tarmac*

E. Pelletized sewage This renewable energy source is a biofuel, produced from sewage sludge. It is already used at several UK cement plants as a fossil fuel replacement. *Sample courtesy of Tarmac*

F. Meat and bonemeal (MBM) This 100% carbon neutral fuel has a significant calorific value. It was recently used alongside glycerin and hydrogen in a world-first demonstration of a cement kiln main burner successfully using 100% net zero fuel mix. *Sample courtesy of Heidelberg Materials UK*

Circularity in Cement

Using recycled material to make cement

Secondary and waste material is commonly used to manufacture Portland cement reducing in-process carbon emissions and resource use. The UK cement industry has avoided sending waste to landfill since 2012. Cement kiln dust can be collected and recycled back into the manufacture of new cement.

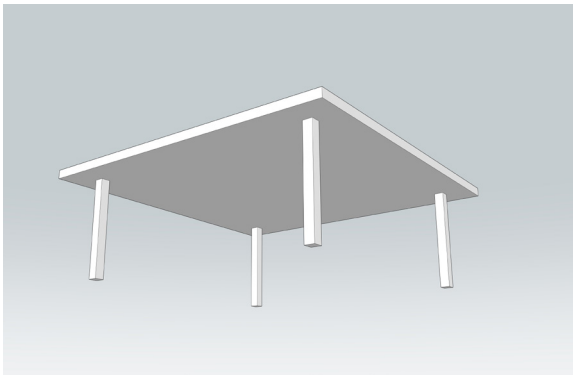
Key
Examples of alternative raw materials (ARM) used in cement manufacture include:

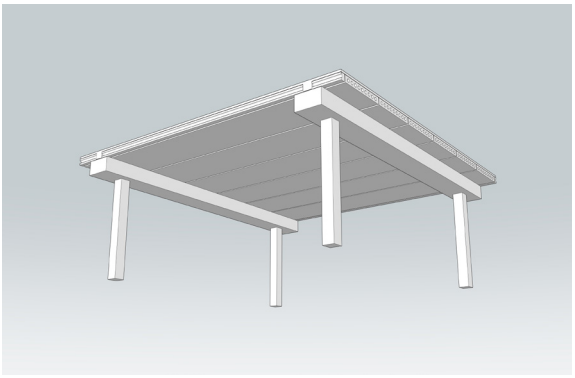
G. Quarry washing. *Sample courtesy of Tarmac*
H. Recycled concrete fines. *Sample courtesy of Day Aggregates*
I. Cement kiln dust. *Sample courtesy of Cemcor*
J. Waste porcelain tiles. *Sample courtesy of Aggregate Industries*
K. Waste plasterboard - *A useful source of recycled gypsum*

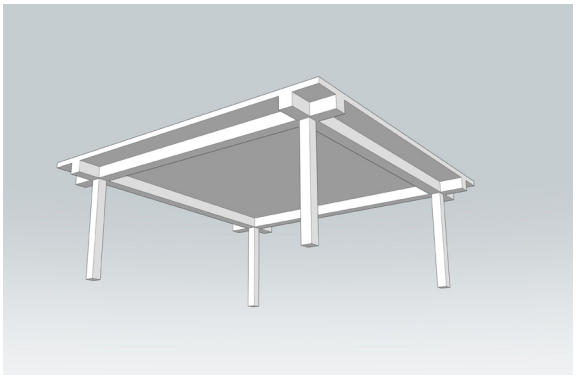
Lean Design and Construction

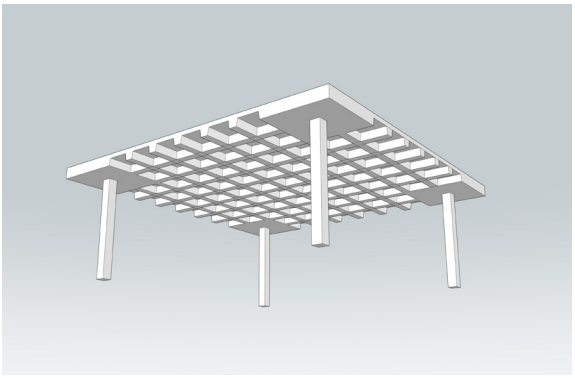
Efficient structural design

There are many opportunities to achieve significant carbon reduction and efficient use of resources through choice of concrete construction system and structural design. Structural frame options include waffle slabs, two-way slab on beams, precast hollowcore slab on beams and flat slabs









Concrete structural frames
1:50 scale models demonstrating a range of structural frame options using concrete. All provide the opportunity to be exposed, reducing resource use and waste associated with ceilings and linings at installation and over the life of a building. Exposing the frame also enables its thermal mass to be utilised in the heating and cooling strategy.

A Waffle slab
B Two-way slab on beams
C Precast hollowcore slab on beams
D Flat slab

Concept V5

A free online tool to facilitate early design decisions through comparison of carbon, cost and construction time of different concrete frame solutions. Visit here for further guidance on reducing carbon with Concept and to download the tool.

www.concretecentre.com/concept

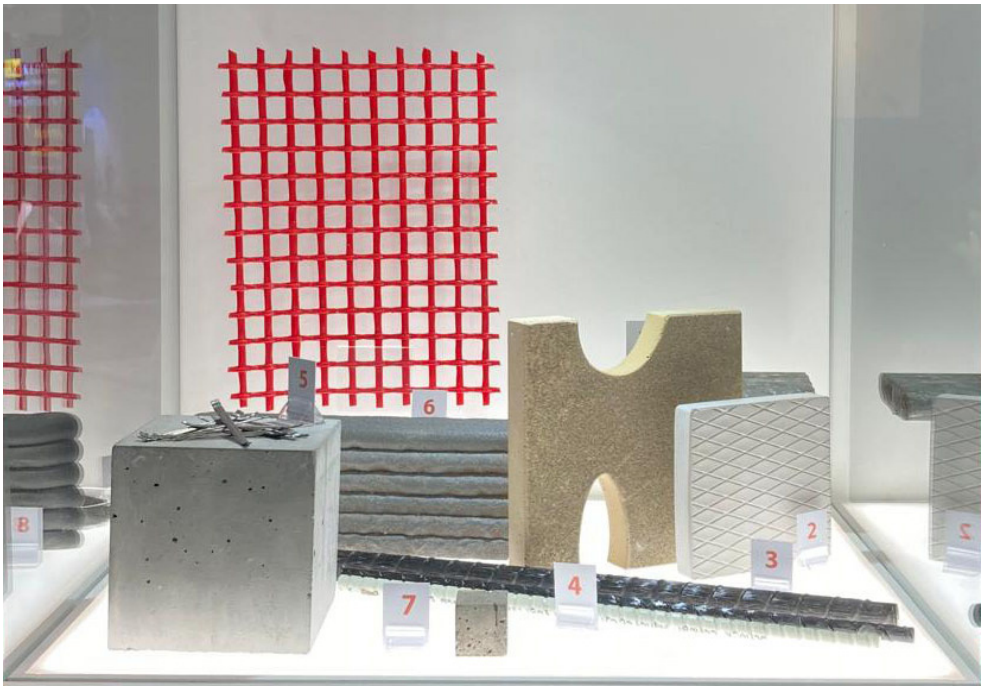
Lean Design and Construction

Efficient structural design

Prestressed concrete - Prestressing concrete elements ensures more of the concrete remains in compression under load, leading to more efficient designs. The stress may be applied before concrete is cast (such as prestressed hollowcore planks) or after the concrete is cast (known as post-tensioning). These methods allow for slimmer sections, reducing material use and extending economic span ranges compared to more conventional reinforced concrete.

Alternative reinforcement - Innovative reinforcement solutions offer the potential to prolong service life as well as reduce cover, creating more slender structural solutions and reducing whole life carbon.

Innovative manufacture and technology - New manufacturing techniques, such as 3D-printed concrete and formwork can reduce material usage through utilising bespoke complex geometries. Advances in concrete technology e.g. admixtures, have the potential to enhance durability and reduce cover.



Key
1. Post-tensioning strands in grouted duct. *Sample courtesy of CCL (GB) Limited*

2. Ultra high performance precast concrete (UHPC) Fibre-reinforced concrete designed to withstand high tensile stress, permitting use of ultra slender elements. *Samples courtesy of Ductal®*

3. Basalt, fibre reinforced polymer (BFRP) rods. Trialled as an alternative reinforcement as part of Laing O'Rourke's Decarbonising Precast Concrete Manufacturing project. *Samples courtesy of Bostech and Laing O'Rourke*

4. Glass-fibre reinforcement Corrosion-resistant glass fibres bonded with resin, offering durability, high tensile strength and less weight. *Sample courtesy of Schock*

Lean Design and Construction

Efficient structural design (cont..)

5. Fibre reinforced precast concrete. Polypropylene micro-fibres and steel fibres, used to reduce the size and embodied carbon of precast concrete segments for the Silvertown Tunnel. *Samples courtesy of Banagher Precast Concrete*

6. Flexible, non-corrosive mesh reinforcement. Used to create a novel, thin-shell vaulted concrete flooring system. *Sample courtesy of Solidian and Bath University*

7. Self-healing concrete. Lower carbon concrete with a bacteria-based admixture that enhances the water tightness and reduces the maintenance of concrete in exposed conditions. *Sample courtesy of University of East London and JP Concrete*

8. 3d-printed concrete. A construction method that uses a robotic arm or gantry system to extrude layers of specially formulated concrete or mortar, eliminating the need for traditional formwork. 3D printing is particularly resource-efficient for creating complex shapes and unique structures, whether by directly printing concrete or producing 3D-printed moulds.
Sample courtesy of Tarmac

9 Graphene-enhanced cement. Graphene was added to the cement process as a grinding aid. Trials have found compressive strength gains in concrete could enable significantly less material to be used in concrete structures. *Samples courtesy of First Graphene, Breedon and Morgan Sindall*

Innovation

Innovative concrete
A wide variety of concrete technologies are being explored, with the aim of creating low, zero and potentially carbon negative concrete. While many are not yet available at scale, they offer the potential for an exciting future for concrete.

Innovation to facilitate use of new concretes
Use of remote digital sensors, artificial intelligence, alternative curing methods and accelerating admixtures are just some examples of new technology evolving to facilitate the use of low and lower carbon concretes.

Enhancing the properties of concrete
Innovative products are being developed to improve concrete's performance, meeting evolving demands for renewable energy supply and climate resilience.

Key
1. Olivine based carbon-negative SCM An innovative low carbon pozzolan based on a naturally-occurring magnesium silicate mineral. MagCarb® is an ultra-low carbon binder co-produced in the manufacture of Seratech's SCM. **1A Concrete made using Seratech's SCM. 1B Concrete made using MagCarb®** *Samples courtesy of Seratech*

2. CO2 utilisation in ready-mixed concrete Ready-mixed concrete using minerals manufactured by combining CO2 and reclaimed residues from wash-out water. *Sample courtesy of CarbonCure*

3. Digital maturity sensor Digital wireless sensor to be embedded in concrete to monitor concrete temperate and strength. Realtime data and AI technology can enable concrete structures to be built faster and smarter. *Sample courtesy of CEVO®, Tarmac*

Innovation (cont..)

4. Powdered accelerator To facilitate the use of lower carbon concretes by speeding up early strength gain. *Sample courtesy of Denka /Imerys*

5. Graphene admixture. Concrete made using a graphene-enhanced admixture, offering leaner concrete solutions through enhanced strength. *Sample courtesy of Concretene*

6. Self-healing concrete with corrosion inhibitor. Lower carbon concrete with a bacteria-based admixture that enhances the water tightness and reduces the maintenance of concrete in exposed conditions. The addition of an innovative corrosion-inhibiting admixture further enhances the durability of reinforced concrete. This sample is part of an Innovate UK funded research project. *Samples courtesy of University of East London and JP Concrete*

7. Concrete Canvas. Flexible sheets that harden when water is applied. Uses have included emergency water conduits, landslide stabilisation and secure emergency shelter. *Sample courtesy of Concrete Canvas®*

8. Magnetite concrete. High density concrete made using magnetite or other iron-rich aggregates. Due to the iron content in magnetite, it can interact with magnetic fields. Common applications include radiation shielding in nuclear power plants, hospitals for X-ray rooms, and ballast weights.

Calcined Clays

Local, reclaimed sources for calcined clay
ReCe3 – a recently completed, two-year Mineral Products Association (MPA) project tested calcined clay from reclaimed UK sources for use as SCMs in concrete. 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 CEM I cement.

1. Reclaimed clay *samples courtesy of Imerys, Heidelburg Materials and Tarmac (CRH Group)*
2. Calcined clay from ground waste brick *Sample courtesy of Forterra*
3. Concrete made using calcined clay as an SCM *Sample courtesy of Forterra*

Calcined London Clay (CLC) for use in lower carbon concrete
Excavated London Clay from the HS2 London Tunnels project is being calcined to be reused as a Supplementary Cementitious Material (SCM) in concrete applications. The project team includes Skanska Costain STRABAG jv, Arup, Tarmac, the University of Leeds, Sika UK, Expedition Engineering and the Mineral Products Association (MPA).

4. Raw, excavated London Clay, before calcination process
5.Calcined London Clay (CLC)
6. Concrete with 50% CLC. This concrete has been previously tested under compression.
Samples courtesy of SCSjv -HS2

Calcined Clays (Cont..)

Calcined clay in precast concrete
To date, more than 3,000 tonnes of calcined clay have been produced by Cemcor in Northern Ireland, using locally available clay in existing kilns and production plant. In partnership with local precast manufactures it is now being trailed in industrial-scale precast concrete applications to make lower carbon paving and larger precast concrete elements.

7. Lower carbon concrete manufactured using 50% calcined clay and less than 45% clinker (CEM IV/B-Q)

8. Lower carbon LC3 concrete using a combination of powdered limestone, calcined clay and 37.5% clinker *Samples courtesy of Calcinx, Cemcor*

Concrete Futures

Enhancing the value of recycled concrete

Expanding the potential of recycled concrete
Innovative technology, combined with improved demolition and sorting processes, is creating new opportunities for the reuse of concrete demolition waste - maximising its value within the supply chain.

Key

A. Recycled concrete fines Created from concrete demolition waste with the potential for use as a supplementary cementitious material (SCM) in the manufacture of new cement.
Sample courtesy of Day

B. Recycled clinker Innovative clinker manufactured using 100% recycled content, including recycled concrete. *Sample courtesy of Aggregate Industries/ Holcim*

C. Innovative low carbon cement. Concrete manufactured using an innovative low carbon cement based on a co-product of steel recycling, using recycled concrete. *Sample courtesy of Cambridge Electric Cement*

D. Crushed concrete aggregate (CCA) Crushed and graded concrete from both demolition waste and repurposed returned concrete for use in concrete manufacture. *Sample courtesy of Day Aggregates*

Concrete Futures

Carbon storage in recycled concrete

The process of crushing concrete accelerates natural carbonation, enabling the permanent capture and storage of CO_2 within the material. This process can be enhanced and accelerated with advanced forced carbonation techniques.

Key

E. Enhanced aggregate for concrete by carbonation. Recycled concrete aggregate using an innovative process to accelerate carbonation using CO2 contained in cement plant flue gases. This process improves the quality of the aggregate for potential use in concrete.
Samples courtesy of FastCarb and Holcim

F. Recycled concrete paste. Created from concrete demolition waste with the potential for carbon capture and as alternative raw material in the manufacture of cement.
Sample courtesy of Heidelberg Materials

G. Carbon capturing granules. Sorted and crushed concrete demolition waste that has been then injected with captured CO2 for permanent storage through mineralisation. Uses include concrete manufacture and road construction.
Sample Courtesy of Neustark®/ Holcim

Upcycling into Concrete

Alternative secondary and waste resources

Concrete technologists are researching and developing ways to utilise alternative waste streams and by-products in the manufacture of cement and concrete.

Key

1. Recycled steel fibres derived from waste tyres. Research is underway to extend the use of recycled steel fibres for high strength, precast concrete elements and components with high sheer strength capacity. *Sample courtesy of Birmingham University and SIKA*

2. Powdered sea shell. Innovative low carbon concrete cast using powdered seashell and eggshell as cement replacement. Project partially funded by the Institution of Structural Engineers. *Samples courtesy of University of East London & Sensicon*

3. Recovered Ash. Varying grades of coal derived fly ash (CDFA) sourced from single use stockpile or lagoon reserves in the UK for potential use as a lower carbon cementitious material. *Sample courtesy of UK QAA*

4. Pigmented concrete using reclaimed ink toner. An innovative solution for creating coloured concrete. *Samples courtesy of University of Dundee*

5. Recycled terracotta. Low carbon concrete using activated calcined clay from recycled terracotta tiles. S*ample courtesy of Cemblend*

Upcycling into Concrete

Alternative secondary and waste resources

Performance specific products, and non-structural concrete offer immediate routes to market for recycling under-utilised non-standard materials into concrete.

Key

1. Carbon sequestering aggregate. An innovative lightweight aggregate created from waste material and CO2. *Sample courtesy of O.C.O Technology Limited & Carbon8 Systems*

2. Circular lightweight aggregate. Block pavers made using this innovative aggregate that uses by-product and waste materials. *Sample courtesy of Low Carbon Materials & Aggregate Industries*

3. Pigmented concrete with wooden aggregate. Innovative, lower carbon, interior concrete with 30% GGBS and 100% wooden aggregate. *Sample Courtesy of NCF and HD Studio*

4. Char-crete. Charcoal made from waste wood products, being investigated for use as a cement replacement in concrete manufacture. *Sample courtesy of CREST, South-West College, Enniskillen, NI*

5. Low carbon concrete using alternative slags. Product development is underway for under utilised steel making slags to be treated for use as a feedstock for new cement binders. *Sample courtesy of Cemvision*

Lower Carbon Concrete

An expanding range of available low and lower carbon concretes

The range of low and lower carbon concrete available today is expanding with new products being brought to market to facilitate specification. These include both Portland cement-based concretes and concrete using alternative binder systems including Alkali Activated Cementitious Materials (AACMs).

Key

Low and lower carbon cements available for specification today include:

1. **Vertua®** *sample courtesy of CEMEX*
2. **Earth Friendly Concrete®** *sample courtesy of Capital Concrete part of Brett/Breedon Group*
3. **ECOPACT®** *sample courtesy of London Concrete/Aggregate Industries*
4. **CEVO®** *sample courtesy of Tarmac*
5. **CarbonCap®** *sample courtesy of Capital Concrete part of Brett / Breedon Group.*
6. **Evobuild®** *sample courtesy of Heidelberg Materials UK*

Concrete producers can reduce the embodied carbon of concrete using a variety of available resources and technologies. The most suitable solutions depend on several factors, including the availability of local materials and project-specific requirements for programme, construction, performance, and cost.

Lower Carbon Concrete

Low and lower carbon supplementary cementitious materials (SCMs)

A wider variety of cementitious materials and combinations are now permitted under BS 8500 and available for manufacturers to reduce the CEM I content in concrete. These include ground granulated blast-furnace slag (GGBS), limestone fines, and fly ash, as well as natural pozzolana and calcined natural pozzolana.

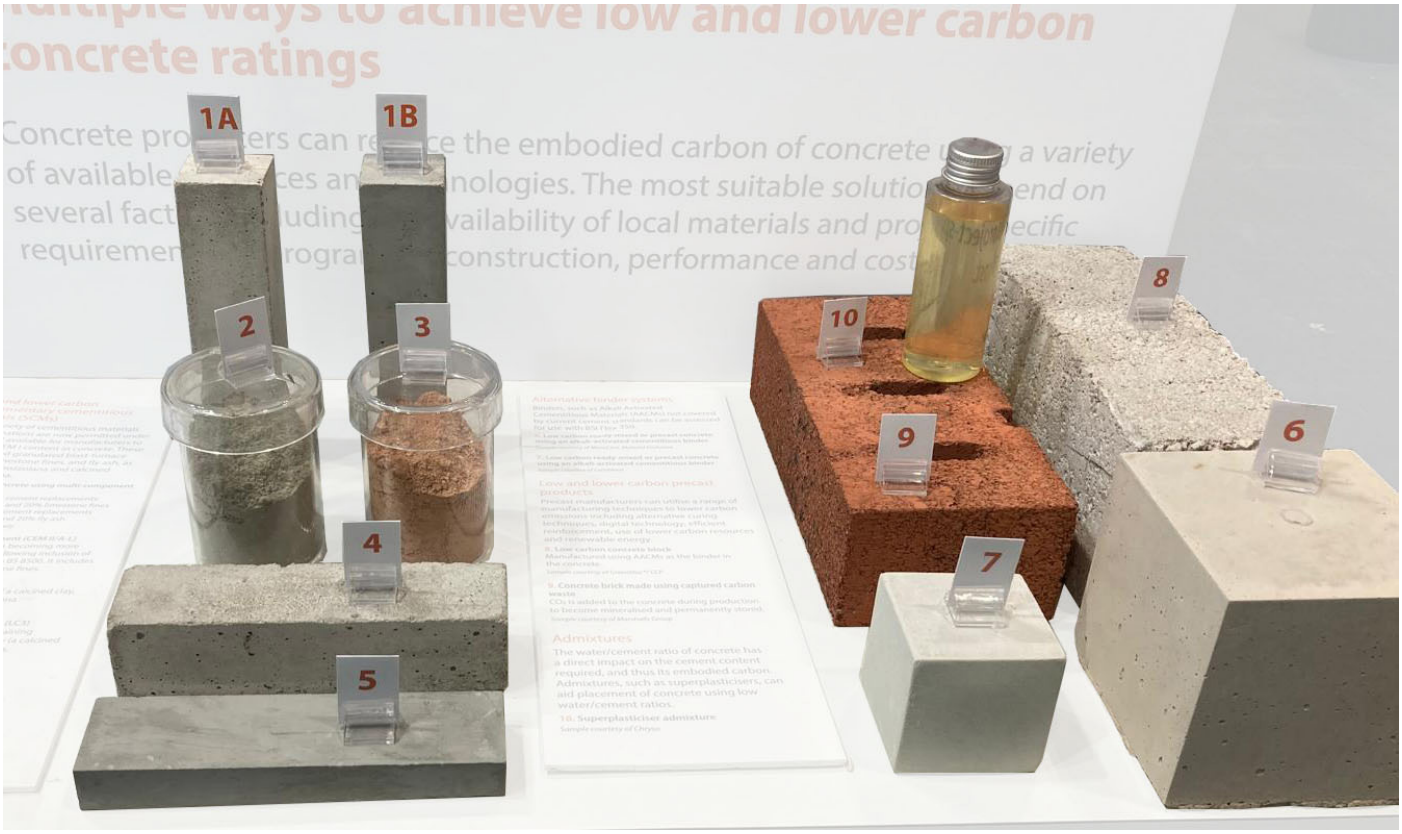
1. Lower carbon concrete using multi-component cements
1A. CEM VI (S-L): 60% cement replacements comprising 40% GGBS and 20% limestone fines
1B. CEM VI (S-V): 60% cement replacements comprising 35% GGBS and 20% fly ash
Samples courtesy of Leeds University

2. Portland limestone cement (CEM II/A-L) This lower carbon cement is becoming more widely available in the UK following inclusion of multi-component cements in BS 8500. It includes between 6% and 20% limestone fines.

3. Calcined clay. Powdered brick is an example of a calcined clay, a type of natural calcined pozzolan.
Sample courtesy of Forterra

4. Limestone calcined clay cement (LC3) Concrete made using a cement containing Portland cement clinker, calcined clay (a calcined natural pozzolana) and limestone fines. *Sample courtesy of EPFL, Laboratory of Construction Materials (LMC)*

5. Natural Pozzolana (volcanic material)
The concrete contains 70% SCM based on mechanically activated naturally abundant volcanic material. *Samples courtesy of EMC cement BV*



Lower Carbon Concrete

Low and lower carbon supplementary cementitious materials (SCMs) Cont..

Alternative binder systems

Binders, such as Alkali Activated Cementitious Materials (AACMs) not covered by current cement standards can be assessed for use with BSI Flex 350.

6. Low carbon ready-mixed or precast concrete using an alkali-activated cementitious binder
Sample courtesy of MevoCem, Material Evolution

7. Low carbon ready-mixed or precast concrete using an alkali-activated cementitious binder
Sample courtesy of Cemblend

Low and lower carbon precast products

Precast manufacturers can utilise a range of manufacturing techniques to lower carbon emissions including alternative curing techniques, digital technology, efficient reinforcement, use of lower carbon resources and renewable energy.

8. Low carbon concrete block. Manufactured using AACMs as the binder in the concrete.
Sample courtesy of Greenbloc®/ CCP

9. Concrete brick made using captured carbon. Waste CO2 is added to the concrete during production to become mineralised and permanently stored.
Sample courtesy of Marshalls Group

Admixtures

The water/cement ratio of concrete has a direct impact on the cement content required, and thus its embodied carbon. Admixtures, such as superplasticisers, can aid placement of concrete using low water/cement ratios.

1**0. Superplasticiser admixture.** S*ample courtesy of Chryso*

Sustainable Drainage Systems (SuDS) using concrete

Sustainable Drainage Systems (SuDS) are designed to mitigate surface water flooding while enhancing groundwater recharge. A diverse range of concrete solutions, including both precast and in-situ options, can be integrated into designs to provide durable hard-standing surfaces and support the creation and management of kerbside rainwater gardens, ensuring effective water management and long-term resilience.

Features and benefits include:

Water Drainage: Reduces surface water runoff by allowing rainwater to filter through gaps between the blocks.

Flood Prevention: Helps prevent localized flooding and reduces pressure on drainage systems.

Sustainability: Supports groundwater recharge and minimizes water pollution.

Durability: Provides a strong, load-bearing surface suitable for roads, driveways, and parking areas.

Low Maintenance: Reduces standing water and puddles, minimizing erosion and surface wear.

Sustainable Drainage Systems (SuDS) using concrete (cont..)

Concrete block permeable paving (CBPP)
Proprietary block paving systems designed to allow surface water to pass between blocks. Suitable for domestic use and up to heaviest traffic conditions.
Samples courtesy of Brett (red and yellow) and Aggregate Industries (grey)

Permeable concrete
Pervious concrete, designed to have a network of interconnecting voids which allow water to free-flow through the product. Can be cast in situ to create large areas of continuous paving.
Sample courtesy of Permaflow ®,Cemex

Precast concrete grass paver
Precast concrete paving grid that provides a durable surface for vehicle parking while allowing natural rainwater drainage and promoting grass growth.
Samples courtesy of Pavestone

Precast concrete modular paving system
Designed to be used in a variety of configurations. The gaps can be filled with gravel or soil to support plant growth while ensuring efficient rainwater drainage
Samples courtesy of Pavestone

Rainwater kerb diffuser flag
Designed to moderate surface water flow into rain gardens from kerbsides, facilitating water filtration and absorption.
Sample courtesy of EDENKERB®, Marshalls

Innovative permeable paving
Using innovative permanent formwork made from recycled plastic to facilitate water flow.
Sample courtesy of Kiacrete / Permia