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CLIENT REPORT

BRE Client Report

Demand-led innovation scoping study: D3.1: Final report

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Executive Summary

BRE Group have been commissioned by Innovate UK to carry out a scoping study on the potential for demand led innovation (DLI) in the foundation and construction industries. BRE were also commissioned to hold an industry workshop to help drive forward the low carbon agenda and validate findings.

This final project report summarises a validated shortlist of recommended foundation industry and downstream construction products, (with outline specifications) for Innovate UK to support to stimulate demand led innovation. It also gives a commentary on important considerations arising from the workshop and describes the main demand-side bodies who could play a role in creating demand.

The report was compiled by Dr Andrew Dunster and Gemma Forbes-Pepitone (BRE), with input from Alison Nicholl, Head of Constructing Excellence.

The main products identified with potential for DLI, which are listed in Appendix A, are:

1) For cement and concrete product sectors- (various alternative materials to established fly ash and GGBS), alternative cements (to Portland cement), additives to optimise performance and embodied CO2 of concrete mixes, enabling waste CO2 sources for use in curing of concrete, training packages to widen adoption of best practice with existing solutions)
2) For glass- (business models and technologies for reclamation of flat glass into glass manufacturing)

Following further discussions between BRE and Innovate UK, the following specific examples of potential products and four main interventions in the cement and concrete sector have been identified, Table ES1 (also see Appendix C).

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Table ES1: Four interventions for the cement and concrete product sector

Interventions	Materials and supply chain actors	Time-scale[1]
Demonstration of precast reinforced concrete floor slab unit with lower embodied CO_2 than competitors	Cement/SCM producers E.g: AACM Calcined clay Reclaimed FA Reclaimed cement paste (RCP) Aggregate producer Alternative rebar E.g macro fibres or basalt fibre rebar Admixtures/ additives[2] Pre-cast concrete producer(s) Main contractor (concrete building) Client	A
Demonstration and awareness raising of precast concrete products made from ternary blended cements.	Cement/SCM producer E.g: Limestone fines GGBS Primary FA Reclaimed FA Reclaimed cement paste (RCP) Aggregate producer Existing cement and concrete industry supply chain partners Pre-cast concrete producer(s) Users of precast concrete	A
Demonstration and awareness raising of readymix concrete products made from ternary blended cements	Cement/SCM producer E.g: Limestone fines GGBS Primary FA Reclaimed FA Reclaimed cement paste (RCP) Aggregate producer Existing cement and concrete industry supply chain partners Readymix concrete producer(s) Users of readymix concrete	A
Support for supply chain development & CO_2 infrastructure for precast unreinforced concrete products sequestering CO_2 in curing	In the manufacture of precast concrete products, it is possible to introduce waste or by-product CO_2 sources into the curing process as the concrete sets and hardens	B

[1] A = 1-5 years: B=6-15 years; C = 6-30 years

[2] E.g. Graphene admixture such as Concretene, CarbonCure, Concrete4Change

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Many of the issues identified from within the foundation industries that could benefit from intervention are either supply chain-related or relate to a need to de-risk investment of time and other resources in supply chains or capital equipment. For example.

- There is the greatest potential for intervention in concrete products (as opposed to glass or steel for example) due to the nature of the supply chain, in particular the number of potential intervention points (including with SMEs), plus the size of CO_2 impacts in cement and concrete production and use due to the volumes of cement and concrete used in construction projects.
- There could be a role for a "matchmaking" function between the innovators in concrete products and producers/end users of concrete and concrete products to help both parties appreciate the constraints on scaling up of innovations.
- With the cement and concrete industry, investment in adopting existing best practices more widely and optimally could lead to significant improvements in saving embodied CO_2. This was a key issue mentioned by concrete industry consultees as "low hanging fruit".
- Potential interventions in the steel and glass industry supply chains related to the circular economy and involving new supply chain actors have also been identified.

Report Glossary

DLI	Demand led innovation.
EAF	Electric arc furnace (steel making) process.
ESG	Environmental, Social and Governance
FA	Fly ash (from coal fired power generation)
FI	Foundation industries
GGBS	Ground granulated blastfurnace slag (from primary iron and steel production)
LC3	Limestone calcined clay cement
PC	Portland cement (CEM I)
RCP	Reclaimed cement paste.
SCM	Supplementary cementitious materials (to Portland cement)- GGBS and FA are examples.

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1. Introduction

BRE Group have been commissioned by Innovate UK to carry out a scoping study on the potential for demand led innovation in the foundation and construction industries. BRE was also commissioned to hold an industry workshop to help drive forward the low carbon agenda and validate findings.

Innovate UK and the UK Government wants to offer support to help accelerate innovation in lower carbon products in the UK's Foundation Industries- FI (such as cement, glass, metals, ceramics etc).

Some industry sectors (outside construction) have benefitted from working very closely with their major customers, sharing risk and knowledge to mutual advantage to develop new products. But for too many customers, they miss the benefits of material and product advances because they are individually too insignificant for FIs to address. Similarly, FIs might be reluctant to commercialise products under development where there is insufficient certainty of there being a market for the products. This is particularly the case for "greener" products in cost competitive sectors, like construction, that might be reluctant to accept an initial price premium.

Innovate UK are seeking to assemble an ecosystem of customers, designers, insurers and investors to kick start meaningful change. The project considers a range of products including concrete, glass, metals and masonry products and exploring what is needed to unlock future demand and investment.

This report is the final deliverable D3.1 from the project "Demand-led innovation scoping study-construction products". The contract number is PS22365. The work is supported by Innovate UK with funding from BEIS under the Transforming Foundation Industries Challenge Fund.

The report summarises a validated shortlist of recommended foundation industry and downstream construction products, (with outline specifications) for Innovate UK to support to stimulate demand led innovation. It also gives a commentary on important considerations arising from the workshop.

1.1 Demand-led innovation

This scoping project aims to create a market demand, or "pull", to encourage innovation by giving FI suppliers the confidence to make investments in the production and/or R&D of improved products. This is demand led innovation, (DLI).

In the context of the study, DLI is created by cohorts of customers with an interest in procuring a new and environmentally superior construction product (in terms of embodied CO_2), that is not yet commercially available.

The term "products" includes not just finished products, but can also include new materials, materials with lower embedded carbon, business models, recycling schemes etc. The project has focused on cement and concrete products as this is where it is considered that the greatest impact on embodied carbon is to be made in the short to medium term.

1.2 Introduction to the products

1) Reductions in embodied CO_2 in concrete can be achieved through use of reactive pozzolanas such as calcined clay or reclaimed fly ash to supplement the Portland cement content. Calcined clay is made by calcining (heat treating) the right types of natural clay, rich in the mineral kaolinite.
2) Reductions in embodied CO_2 of concrete can also be achieved through use of alternative cements to PC. Alkali activated cementitious materials (AACMs) are an example.
3) Reductions in the amount of cement in concrete can be achieved by use of additives to the fresh concrete. Examples include introduction of CO_2 or new materials such as graphene.

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4) CO_2 enrichment can be introduced into curing chambers during the setting and hardening of concrete products, to potentially lock up or sequester further CO_2.
5) Tools and training could be developed to help achieve best practice with what codes and standards already allow to lower embodied CO_2.
6) Reclaimed/reused steel derived from construction or other industries (Brown, Pimentel and Sansom, 2019) (BCSA, 2022) (Girao Coelho *et al,* 2020)
7) Flat glass manufactured with lower embodied CO_2 (partly achieved through using recycled glass as feedstock)[3]. (British Glass, 2023) (Environment Agency, 2008) (Saint-Gobain, 2023)

[3] Primary glass manufacture involves decarbonisation of sodium carbonate. Use of cullet as a partial ingredient lowers the melting temperature of the new glass and the amount of ingredients that need to be decarbonated.

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2. Description of the Project

2.1 Scoping study

The project activities have included preparatory desk research by BRE and a period of stakeholder consultation by Constructing Excellence.

- The project has drawn up a shortlist of candidate DLI products.
- The team also identified and assembled a cohort of customers to validate the project findings and who could also in principle be willing to make a commitment to procure a new product that meets their requirements. This core group is supplemented with other relevant stakeholders, in particular FI material suppliers (cement, concrete, steel).

The findings are summarised in Section 3 and presented in more detail in Appendices A and B.

2.2 Industry workshop

The project industry workshop, held on 1st March 2023, brought together a group of built environment stakeholders to explore the actions and innovation needed to decarbonise foundation industry products and materials used in the built environment. Workshop attendees, materials and findings are summarised in Appendix C.

The workshop and scoping study will input into Innovate UK's £250 million foundation industries challenge programme and help Innovate UK to shape future interventions.

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3. Methodology

3.1 Scoping Study

The scoping study has been conducted by BRE and Constructing Excellence. The approach adopted included fact finding from industry websites and one-to-one or group discussions with consultees identified in an earlier project for Innovate UK[4] and others as given in Appendix C. The findings of the scoping study were validated through a face-to-face industry workshop held at BRE and a focus group (on Teams), particularly considering cement and concrete.

For cement and concrete, we are not considering GGBS as the demand for concrete use exceeds supply of GGBS in the UK and greater UK use (in tonnage terms) would rely on imports. Its use is covered by existing standards. Efforts to maximise kg/m^3 of GGBS per unit volume of concrete to minimise embodied carbon in concrete is distorting markets. Volumes of available GGBS can be expected to decrease further still as production shifts away from primary iron and steel production to EAF furnaces (BEIS, 2017).

3.2 Industry Workshop

Based on those who engaged in the consultation during the scoping study and other stakeholders, we invited several key stakeholders to participate in a face-to-face workshop at BRE Watford on 1st March 2023. A structured set of question frameworks were developed by Constructing Excellence to ensure participants were focussed on products and solutions across the three core areas of glass/ceramics, metals, and concrete. Participants had the opportunities to view the research and testing laboratories at BRE to get a feel for how research and testing can help move the industry away from the status quo and implement innovation. Full details of the outputs from the workshop are provided in Appendix C.

[4] The material requirements of the 2050 Construction Sector, PS21180. Commissioned by Innovate UK, December 2021

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4. Findings

4.1 Products- Demand Side

Tables 1 and 2 summarise the results of an assessment of demand-side issues, drivers and organisations that can create demand for low carbon construction products and services. The main findings are described below.

4.1.1 Demand Side Innovation

4.1.1.1 Demand Side Organisations and Their Drivers

This sub-section gives a listing of the demand side organisations that can play a key role in unlocking future markets for net zero innovative solutions from the foundation industries. It is not a listing of all the players in the demand side; just those that can play a significant role in stimulating and growing the market. These organisation groups are shown in Box 1 below:

Box 1: Demand-side organisation groups

- Major Project Clients
- Framework Providers
- Government & Regulated Clients
- Developers
- Investors
- Commercial client advisors
- Engineering consultancies
- Architects
- Main contractors
- Specialist sub-contractors
- Offsite construction companies (MMC)

Table 1 gives a matrix of the main challenges and the client groups to which they apply.

Major Project Clients - Major construction projects have the scale and longevity to explore innovation and stimulate market demand. The challenge is to translate that for the wider construction market.

Examples include- HS2, Lower Thames Crossing, Sizewell C, Heathrow, Geological Disposal Facility

Drivers- The need to demonstrate net zero credentials to secure funding (public and private) and meet planning requirements.

Framework Providers - A framework is an agreement with suppliers to establish terms governing contracts that may be awarded during the life of the agreement. In other words, it is a general term for agreements that set out terms and conditions for making specific purchases. Billions of pounds of UK local and central government construction are procured through frameworks. 'Frameworks enable the net zero carbon commitments of individual organisations to be integrated into coherent strategic plans. They provide systems for net zero carbon proposals and other sustainability initiatives to be carefully evaluated at a strategic level and then to be adopted consistently on successive projects.'(Mosey, 2021)

Examples include- Scape, LHC, YorHub, Southern Construction Framework, Crown Commercial Services.

Drivers- Concern that Environmental, Social and Governance (ESG) and central government funding will soon mean that current solutions will not be acceptable or deliverable and clients want to drive better performance in their supply chains. As clients can often chose which framework to use, the need to deliver value and leadership in net zero represents competitive advantage.

Government & Regulated Clients – These public sector clients (or regulated clients) have ability to drive a consistent market through their regular programmes of work.

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Examples include- Highways UK, Network Rail, NHS New Build Hospital Programme, Ministry of Justice, Ministry of Defence, water companies.

Drivers- These organisations have a strong commitment to net zero and are also concerned that ESG and central government funding will soon mean that current solutions will not be deliverable. They want to drive better performance in their supply chains.

Developers – These commercial clients can drive a consistent market and they will act when they see competitive advantage. The nature of their portfolios means they can take a long-term, strategic view.

Examples include - Crown Estate, Great Portland Estates, Legal & General, Landsec.

Drivers – ESG drivers from funders meaning they cannot attract funding or gain planning consent without a robust approach to decarbonisation. Many of their tenants and buyers are demanding increasingly higher environmental standards, therefore increasing return on investment and long-term asset value. Maintaining shareholder value is increasingly linked to a strong ESG focus.

Investors – The commercial investors provide funding for projects.

Examples include – Legal & General, Blackrock, MacQuarrie

Drivers – ESG to attract investors and maintain fund values. Focussed on shareholder value and return on investment, either through asset value or rental returns.

Commercial client advisors – These organisations work alongside clients to set the commercial arrangements for projects and deliver commercial project management.

Examples include- RLB, Turner & Townsend, Arcadis.

Drivers – The need to make innovative solutions commercially attractive for clients and ensure commercial is dealt with effectively. They are keen to demonstrate competitive advantage on innovation and sustainability to support work winning.

Engineering consultancies – These organisations provide engineering design services and will act as specifiers for products and solutions.

Examples include – Atkins, Aecom, Arup, Mott MacDonald, WSP, Expedition Engineering

Drivers – The need to deliver sustainable, robust, and deliverable solutions that meet the net zero challenge. They are keen to demonstrate competitive advantage on innovation and sustainability to support work winning.

Architects - Design organisations acting as specifiers for products and solutions.

Examples include – Foster & Partners, Ryder Architecture, Fielden Clegg Bradley

Drivers – Need to deliver sustainable, robust, and deliverable solutions that meet the net zero challenge. They are keen to demonstrate competitive advantage on innovation and sustainability to support work winning.

Main contractors - They will manage the project and procure and manage the sub-contracts and materials. Depending on the form of contract they will have greater or lesser influence and incentive to bring on board innovation.

Examples include – Kier, Willmott Dixon, Sir Robert McAlpine, Wates, Ferrovial, BAM, Skanska

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Drivers – The need to deliver sustainable, robust, and deliverable solutions. Need to manage commercial and technical risk. Competitive advantage in sustainability aids work winning and shareholder value.

Specialist sub-contractors - They deliver and install the products and services on site. They may also have manufacturing capability or act as system integrators across their specialist packages.

Examples include – Keltbray, Careys, NG Bailey

Drivers - Need to deliver sustainable, robust, and deliverable solutions. Need to manage commercial and technical risk. Competitive advantage in sustainability aids work winning and shareholder value.

Offsite construction companies (MMC) - These organisations carry out work in factory environments that has traditionally been carried out on site (MMC – Modern Methods of Construction). This ranges from panelised systems through to plug and play modular buildings. Given the repeatable nature of the solutions they can drive a consistent market for low carbon materials.

Examples include – Laing O'Rourke, McAvoy, Algecco, ESS, Premier, Ilke Homes, TopHat

Drivers – The need to deliver sustainable, robust, and deliverable solutions. Need to manage commercial and technical risk. Competitive advantage in sustainability aids work winning and investment potential.

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Table 1: Supply chain and technical challenges to new construction products and the stakeholders to which they apply.

Challenge	Stakeholder										
	Investors	Major Project Clients	Frameworks	Government Clients	Developers	Commercial advisors	Engineering consultants	Architects	Main contractors	Specialists	MMC Providers
Proof of performance in particular applications and asset classes		√	√	√	√		√	√	√	√	√
Proof of long-term performance		√	√	√	√		√	√			
Scalability and reliability of supply chain		√	√	√	√	√					
Competence of supply chain		√	√	√	√	√	√	√	√	√	√
Affordability		√	√	√	√	√	√	√	√	√	√
Ability to fit in with construction programmes		√	√	√	√	√			√	√	√
Professional indemnity						√	√	√	√	√	√
Risk transfer							√	√	√	√	√
Deliverability of solutions		√	√	√	√	√			√	√	√
Interfaces with other systems and products							√	√	√	√	√
Latent defects		√	√	√	√	√					
Insurability of the finished asset	√	√	√	√	√	√					
Return on investment	√	√		√	√	√	√				

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Table 2: Supply chain and technical challenges to new construction products and potential solutions to these challenges.

Challenge	Solutions										
	Testing	Standards	Scaled up supply chains	New approaches to risk	Insurance	Assurance	Knowledge	Case Studies	Demonstrators		
Proof of performance in particular applications and asset classes	√	√				√	√	√	√		
Proof of Long-term performance	√					√	√	√	√		
Scalability and reliability of supply chain			√								
Competence of supply chain			√				√				
Affordability			√			√	√	√	√		
Ability to fit in with construction programmes	√	√									
Professional indemnity	√	√	√	√	√	√					
Risk transfer				√	√	√					
Deliverability of solutions	√						√	√	√		
Interfaces with other systems and products	√			√		√	√	√	√		
Latent defects	√	√									
Insurability of the finished asset				√	√	√					
Return on investment			√				√	√	√		

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Table 2 above considers each of the challenges and the kinds of interventions that could unlock those challenges.

Testing – There is a greater need to present test evidence for new unfamiliar products to prove performance and collect data against set criteria. Where there is no clear standard is in place, they may need to be developed through research or an existing standard could be adapted. This could include fire testing, structural loads, durability, VOCs etc.

Standards – These are published documents that define common approaches. There are rigorous processes that sit behind the creation of standards from bodies such as BSI (BS) and the European Union (CEN). Compliance with a standard is a common tool for specifiers and procurers to understand product performance.

Scaled up supply chains – Strong capacity and capability in the supply chain is crucial to provide certainty. Given the volume of construction products and the scale of infrastructure projects, innovations need to move from small start-ups to organisations with the ability to deliver consistent volume. This requires robust manufacturing capability requiring capital investment and investment in skills and technology. Low embodied CO_2 construction products require different upstream supply chains to be established, with availability at scale; (e.g. calcined clays, gaseous CO_2 or new chemical activators for cements and concretes, or hydrogen fuel sources for a range of foundation industries).

New approaches to risk – Traditional contracts and approaches to risk hold back innovation and attempt to pass risk through the supply chain. This effectively compounds risk, making it very difficult to understand. This approach to risk makes it difficult to bring new concepts into adoption. Collaborative forms of contract are available to enable collaboration and innovation, but uptake is not widespread across the construction industry. Policies such as the Construction Playbook and the Value Toolkit advocate for collaborative procurement.

Insurance – Insurance deals in the known and tends to set a premium on the unknown. Current issues in the insurance market are leading to a highly risk adverse approach with premiums, particularly for professional indemnity, prohibitively high. This does not encourage the uptake of new products and solutions.

Assurance – Assurance provides confidence that a particular product or approach will perform in a particular way. Assurance schemes test products to a standard and provide accredited third-party verification that products perform in a particular way or have specific characteristics. For example, Environmental Product Declarations (EPDs) are essential to support claims for embodied CO_2 and other environmental impacts of construction products. Adopting a consistent approach can be challenging. Assessments need to be carried out in accordance BS EN 15804, (BSI, 2019) and other standards with but there is still room for some inconsistency/flexibility in approach and quality of data sources which can make comparisons challenging.

Knowledge – Knowledge at all levels of the supply chain is critical to increase awareness of solutions and understanding of how to apply the solutions. Knowledge transfer can be achieved through everything from high level articles and media campaigns, through conferences and events, reports, training through to engaged technology “matchmakers”.

Case studies – Robust case studies of how solutions have been applied and the impact they have had are critical to get those up and down the supply chain to specify new solutions. Verified evidence can help de-risk decision making, particularly for commercial teams in the client body.

Demonstrators – demonstrators where stakeholders can view practical examples of solutions and prototypes can be instrumental in increasing understanding and inspiring widespread uptake.

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4.1.1.2 Other Market Influencers on the Demand Side

There are a range of industry groups, authorities and assessment frameworks influencing the market. It can be difficult to keep abreast of all the parties and some alignment could be beneficial to ensure that the market does not become confused. The main industry groups, authorities and tools/assessment frameworks include the following. Links to websites are also provided below:

1) Infrastructure & Projects Authority

The Infrastructure & Projects Authority (IPA) is the Government's centre for infrastructure and major projects. The purpose of the IPA is to support the successful delivery of a variety of major projects. These projects range from schools, railways, hospitals, housing, to defence, Information Technology and major transformation programmes. The IPA reports to the Cabinet Office and HM Treasury and sits at the centre of the government. The IPA provides expert project delivery advice, support, and assurance to different Government departments. The IPA also works with industry to ensure projects are delivered efficiently and effectively while improving performance over time.

About_the_IPA_2020_12.03.21.pdf (publishing.service.gov.uk)

2) BREEAM

Building Research Environmental Assessment Method (BREEAM) provides a holistic framework to assess, rate and certify buildings, homes and infrastructure across a range of sustainability measures. The various BREEAM schemes are used extensively by clients, planners, and funders to drive sustainable outcomes for their assets. The framework is owned by a charitable foundation committed to improving the built environment for the benefit of all. BREEAM is based on a drive for continuous improvement underpinned by science. BRE Group is continually seeking ways to enhance the BREEAM criteria, so the BREAAM acts as a vehicle to push innovation and best practice.

BREEAM - BRE Group

3) Construction Leadership Council

The Construction Leadership Council (CLC) is a joint government industry body providing leadership to the construction industry it has two workstreams focused on net zero.

The Construction Leadership Council » Construction Leadership Council

4) The Green Construction Board

The GCB's focus is to advice on the regulatory, policy and technical framework required to deliver a zero carbon, zero waste built environment (both buildings and infrastructure) and to identify the commercial, jobs and export opportunities that such a clean growth, zero carbon, zero waste economy requires. It is currently focussed on:

a) Infrastructure: Re-assessment of the Infrastructure Carbon Review (ICR) 7 Years On – a review of the progress and lesson learning from seven years of the Infrastructure Carbon Review Commitment and the adoption of PAS 2080 (BSI, 2023) Carbon management in buildings and infrastructure on managing carbon in infrastructure projects
b) Development of a low carbon concrete route map, published and kept under review, (Green Construction Board/ICE, 2022)
c) Retrofitting of existing housing stock, making recommendations for a National Retrofit Strategy
d) Buildings – report with case studies of existing high energy performance buildings
e) Zero Avoidable Waste – development of a route map

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f) Collaborating on the Low Carbon Skills report

4) “Construct2Zero”

Construct2Zero is the construction sector’s response to the November 2020 plan for a Green Industrial Revolution. It looks at how the industry can collectively meet net zero based on the CCC 6th Carbon budget. Three of its nine focus areas (as follows), relate to decarbonisation of construction materials:

a) Implementing carbon measurement, to support our construction projects in making quantifiable decisions to remove carbon.
b) Become world leaders in designing out carbon, developing the capability of our designers and construction professionals to design in line with circular economy shifting commercial models to reward measurable carbon reductions.
c) Support development of innovative low carbon materials as well as advancing low carbon solutions for manufacturing production processes and distribution.

CO2nstructZero » Construction Leadership Council

5) CIRIA

The Construction Industry Research and Information Association is a member-based organisation that carries out research and produces guidance for the construction industry.

About (ciria.org)

6) Infrastructure Client Group

The infrastructure client group is managed through the ICE (Institution of Civil Engineers) and brings together the UK’s leading economic infrastructure clients. They have a working group on Low Carbon Concrete that is focused on implementing the low carbon concrete route map (section above).

Infrastructure client group - GOV.UK (www.gov.uk)

7) British Standards Institute

The BSI produces standards that are used widely throughout the industry. These are often aligned with or strongly influence ISO and CEN standards.

Standards, Training, Testing, Assessment and Certification | BSI (bsigroup.com)

8) Insurers

Insurers need to have confidence that new products and materials will perform as expected and they will not have an insurance liability.

9) Legal advisors

Law firms can advise on how risk is dealt with and how liabilities and incentives are written into contracts.

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4.2 Products- Supply Side

Table 3 and 4 below list the main groups of products identified in the scoping study. The results are given in Appendix A.
The main technical and commercial challenges in generic terms for product producers are (Table 3):

- Development (time and resource commitment) of new standards/evidence on new products vs demand/product acceptability from customers
- Concerns about robustness and capacity of the supply chain (or whether one exists or needs to be built)
- Concerns about supply chain and resource risks against risk of commercial investment (time and capital)

Table 3 summarises challenges, products affected and potential interventions. The following are also worthy of mention:

1) Discussions with members of the concrete industry (Low Carbon Concrete Group) have highlighted a need to help bridge the gap between innovators and potential users of new technologies in the construction industry. Innovators do not always appreciate the barriers and issues associated with scalability of technologies and technology readiness. A scheme called Innovandi (run by the Global Cement and Concrete Association Innovandi - Open Challenge : GCCA (gccassociation.org)) is interesting, but some kind of facilitator or "matchmaking" role in a UK context is worthy of further consideration

–

2) Collaborative commercial ventures (in this case focusing on a graphene admixture for concrete, a product which could enable reduction in cementitious content), are an interesting mechanism with the potential to accelerate adoption of new technologies, Arup takes stake in graphene-enhanced concrete venture | Construction Enquirer News

Further discussion with Innovate UK focused specifically on cement and concrete led to the potential product groups and interventions shown in Table 5 and the Executive Summary of this report.

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Table 3: List of main challenges, product groups and potential interventions: Cement, concrete, glass, steel (Appendix A)

Challenge	Products affected by this challenge	Potential generic interventions/solutions
Standards	LC3, Products made without PC, Products additives/ treatments. Product/remanufactured steel	Support for standards development
Lack of confidence in demand for product and/or commercial viability	Reclaimed fly ash, Alternatives to fly ash and GGBS, LC3, calcined clays. Waste CO_2, Products additives/ treatments Reclaimed glass cullet, Product/remanufactured steel	Support to establish supply chains/ collaboration Assemble customer cohorts
Supply chain related	Reclaimed fly ash, Alternatives to fly ash and GGBS, LC3, calcined clays. Waste CO_2, Products additives/ treatments Reclaimed glass cullet, Product/remanufactured steel	Support to establish supply chains/ collaboration Assemble customer cohorts
Capital investment related	Reclaimed fly ash, Alternatives to fly ash and GGBS, LC3, calcined clays. Waste CO_2, Products additives/ treatments Reclaimed glass cullet, Product/remanufactured steel	Grants/ loans, confidence building
Lack of knowledge about UK resources (characteristics and volumes)	Reclaimed fly ash, Alternatives to fly ash and GGBS, LC3, calcined clays. Waste CO_2,	Resource mapping
Lack of confidence in scale-ability	Reclaimed fly ash, Alternatives to fly ash and GGBS, calcined clays. Waste CO_2, Products additives/ treatments	Resource mapping, support for trials/pilots

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Table 4: Shortlist of potential products/groups suitable for DLI- Cement, concrete, glass, steel- (see Appendix A)

Product/solution	Potential interventions/solutions	Time- frame for impact of intervention
Product: training/awareness raising on concrete	Develop and deliver new concrete training and tools for construction industry at various levels to adopt measures and best practices already allowed in codes and standards- design, concrete selection, specification. Through bodies such as Concrete Centre, BRE, Concrete Society.	A
Product: Reclaimed fly ash for concrete use	To attract and de-risk capital investment for processing infrastructure needed to recover/process/clean for concrete use.	A-B
Products- alternatives to fly ash and GGBS for PC concretes- various (unspecified)	De-risk investment in supply chain capacity to enable imports, UK processing, capacity, R+D (new solutions)	A-C
Products: LC3 cement	Assessment of material availability and suitability /scale up issues (UK clays)	B-C? (UK)
Product: Calcined clays for concrete use	To attract and de-risk capital investment for processing infrastructure,	A-B
Process: Adoption of waste CO2 in curing of pre-cast concrete	Support (e.g. grants/loans) for product development needed and reliable/verifiable sources of waste CO_2.	B-C
Product: Alternative cements made without Portland cement	Support (grants/loans) for Infrastructure, manufacturing capacity and standards. Customer cohorts to create critical mass of demand	A-C
Products: Additives/treatments to allow reduction in cementitious content per m^3 of concrete	Support for standards development, trials, verification of scalability	A-B
Process: Reclamation of glass cullet from construction, demolition and refurbishment for flat glass manufacture	Support for feasibility study	B

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Table 5: DLI List of concrete products and supply chains Alternative/simplified, based on Table C1, Appendix C.

Interventions	Actors	Time-scale
Demonstration of precast reinforced concrete floor slab unit with lower embodied CO_2 than competitors	Cement/SCM producers E.g: AACM Calcined clay Reclaimed FA RCP* Aggregate producer Alternative rebar E.g macro fibres or basalt fibre rebar Admixtures/ additives[5] Pre-cast concrete producer(s) Main contractor (concrete building) Client	A
Demonstration and awareness raising of precast concrete products made from ternary blended cements.	Cement/SCM producer E.g: Limestone fines GGBS Primary FA Reclaimed FA RCP* Aggregate producer Existing cement and concrete industry supply chain partners Pre-cast concrete producer(s) Users of precast concrete	A
Demonstration and awareness raising of readymix concrete products made from ternary blended cements	Cement/SCM producer E.g: Limestone fines GGBS Primary FA Reclaimed FA RCP* Aggregate producer Existing cement and concrete industry supply chain partners Readymix concrete producer(s) Users of readymix concrete	A

[5] E.g. Graphene admixture such as Concretene, CarbonCure, Concrete4Change

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Support for supply chain development & CO_2 infrastructure for precast unreinforced concrete products sequestering CO_2 in curing	In the manufacture of precast concrete products, it is possible to introduce waste or by-product CO_2 sources into the curing process as the concrete sets and hardens (for example, Solidia®). Such concrete products are generally unreinforced. This could potentially be applied to pre-cast concrete products in addition to the other approaches listed in the above table. There could be a risk of reinforcement corrosion with (steel) reinforced products. Capital investment and further R&D are required. The approach is most applicable to concrete manufactured using semi-dry processes.	B

Timeframe
A = 1-5 years
B = 6-15 years
C = 16-30 years

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5. Conclusion and Recommendations

1) Many of the issues within the foundation industries that act as barriers to adoption of innovative products that could benefit from intervention are either supply chain-related or reflect a need to de-risk investment of time and other resources in building supply chains or capital equipment.
2) There is potential for intervention in concrete product and cement sectors due to the nature of the supply chain, the number of potential intervention points (including with SMEs), plus the size of CO_2 impacts in cement and concrete production and use due to the volumes used of concrete in construction projects.
3) Discussion have indicated that there could be a role for a "matchmaking" function between innovators in concrete products and producers/end users of concrete and concrete products.
4) With the cement and concrete industry, investment in adopting existing best practice more widely and optimally could lead to significant improvements (unquantified) in saving embodied CO_2.
5) Some potential interventions in the steel and glass industry supply chains related to the circular economy and involving new supply chain actors have also been identified.

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Appendix A: Project Findings- List of Products Across Foundation Industries

Table A1: Summary table of products

Product: Reclaimed fly ash for concrete use **(from various sources, tips, lagoons)**
Products: Alternatives to fly ash and GGBS for PC concretes **(various- e.g. imported natural pozzolanas or related materials)**
Products: LC3 cement
Product: Calcined clays for concrete use **(Imported and UK sources)**
Process: Adoption of waste CO_2 in curing of pre-cast concrete **(sources of verified waste CO_2)**
Product: Alternative cements made without Portland cement **(e.g. AACM's)**
Products: Additives/treatments to allow reduction in cementitious content per m3 of concrete **(e.g. graphene admixtures, CarbonCure, Concrete4Change)**
Process: Reclamation of glass cullet from construction, demolition, and refurbishment for flat glass manufacture **(flat glass cullet sources meeting an input specification)**
Process: Reclamation of structural and other steel from construction and other industries **(materials meeting an end use specification)**
Product: Training/awareness raising on concrete **(various potential providers)**

Cement and concrete aspects above were informed by discussion with members of the Green Construction Board Low Carbon Concrete Group, Mon 20th March 2023.

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Table A2: List of products (developed from content of earlier project deliverable D1.4)

Material		Product/process	Potential market size L, M, H	Timeframe A, B or C in UK	Potential embodied CO_2 saving in product. (H/M/L)	Ranking of suitability for DLI action (1-10, where 1 is high)	Justification for inclusion in DLI shortlist
**	Cement concrete	Product: training/awareness raising	L	A	M-H (due to training)	1	Intervention could accelerate/ unlock quick wins
**	Cement concrete	Product: Reclaimed fly ash for concrete use	M	A-B	M-H due to large volumes of concrete	2	Needs investment in permitting, processing, capacity, resource mapping
	Cement concrete	Products- low clinker/high filler blended cements- with limestone-cement products with higher fine limestone % content	M	A-C	M	5	Cement industry is already doing this, with revision of BS 8500 expected in autumn 2023 (so limited need for intervention) but user adoption/acceptance and wider range of products could be accelerated by intervention
**	Cement concrete	Products- alternatives to fly ash and GGBS for PC concretes- various (unspecified- excluding calcined clay)	H	A-C	M-H due to large volumes of concrete	1	Need investment to enable imports, UK processing, capacity, R+D
**	Cement concrete	Products: LC3 cement	H	?	H?	3	A lot of work globally but there are barriers to production in in UK (materials unknowns for clays) in UK. No standards in the UK.
**	Cement concrete	Product: Calcined clays for concrete use	M-H	A-B	M-H due to large volumes of concrete	2	Need investment in resource mapping, permitting, processing, capacity
**	Cement concrete	Process: Adoption of waste CO_2 in curing of pre-cast concrete	M-H	B-C	M-H	4	Need investment in process source verification. De-risking technical and commercial risks
**	Cement concrete	Product: Alternative cements made without P/cement	M	A-C	M	1	Standards and scaling up barriers
	Cement	Product: Cambridge Electric Cement- resembles PC clinker (see note 4)	M?	B-C	H	3	Standards, scaleup, building supply chains- inputs output materials. Business models- supply/demand matching steel recycling/ cement production all need to be addressed

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**	Concrete	Products: Additives/treatments to allow reduction in cementitious content per m^3 of concrete	L	A-B	M across the global industry	5	Awareness and demand for products, standardisation
	Concrete	Products: Recycled and secondary aggregates for concrete	L-M	A	L	10+	Established and high industry profile for resource efficiency but have similar (and low) embodied CO_2 to natural aggregates
**	Glass	Process: Reclamation of glass cullet from construction, demolition and refurbishment for flat glass manufacture	M	B	M	5	Cost of landfill low compared with alternatives. Limited collection infrastructure
	Glass	Process: Reclamation of flat glass from refurbishment	L	A-B	L-M	8	Uncertainty about infrastructure, demand, business models
	Steel	Product: Green steel	M	A-B	M	6	Lack of volume, choice in market, verified LCA.
**	Steel	Product: Remanufactured/reclaimed steel products	M	A-C	M	9	Uncertainty about demand, collection & process capacity, standards
	Steel	Process: Leasing steel	M	A-C?	M	6	Uncertainty about demand, processing and supply chain capacity and standards
	Bricks	Process: Reclamation of bricks from demolition	M	A (currently niche)	M	9	Uncertainty about cost, demand, collection, and process capacity,

Key:

	Cement and concrete
	Glass
	Steel
	Bricks

Market size- guestimate
L = < 5 Mt product p.a.
M = < 100 Mt product p.a.
H = > 100 Mt product p.a.

Timeframe
A = 1-5 years
B = 6-15 years
C = 16-30 years

Ranking
Based on a combination of potential market size, size of potential for CO_2 savings, level of UK market interest and impact of DLI

Guestimates of market and CO_2 savings are indicative and semi-quantitative.

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Appendix B: Project Findings- Product Specifications

Table B1: Lists of products (from project deliverable D1.4)

a) Outline list/specification/further details- for all products

	Product/process	Need
**	Product: training/awareness raising on concrete	Develop and deliver training and tools for construction industry to adopt the measures and best practices already allowed in standards- design, concrete selection, specification
**	Product: Reclaimed fly ash for concrete use	Capital investment for processing infrastructure needed to recover/process/clean for concrete use. Existing landfilled resources are currently classed as waste
	Products- low clinker/high filler blended cements- with limestone Cement products with higher fine limestone content	Awareness raising- users and specifiers
**	Products- alternatives to fly ash and GGBS for PC concretes- various (unspecified)	Needs investment in supply chain and capacity to enable imports, UK processing, capacity, R+D on new solutions
**	Products: LC3 cement	Assessment of material availability/scale up issues in UK
**	Product: Calcined clays for concrete use	Capital investment for processing infrastructure needed. No commercial calciners in UK as needs critical mass of demand
**	Process: Adoption of waste CO_2 in curing of pre-cast concrete	Significant product development needed and sources of waste CO_2. Investment needs critical mass of demand
**	Product: Alternative cements made without Portland cement	Infrastructure and manufacturing capacity and standards modification needed to scale up. Investment needs critical mass of demand
	Product: Cambridge Electric Cement- resembles PC clinker	To be established depending on outcome of current work based on TRL
**	Products: Additives/treatments to allow reduction in cementitious content per m^3 of concrete	Some products not easily accommodated by existing standards framework. Need for collaborative case studies/confidence building/verification in UK context.
	Products: Recycled and secondary aggregates for concrete	No standards barriers but most recycled and secondary aggregates are best suited to non-concrete uses. Limited embodied CO_2 in concrete is associated with aggregate, whatever the source.
	Process: Reclamation of flat glass from refurbishment	Collection and processing infrastructure and business models would need to be established. Landfill is lowest cost option for flat glass and cladding glass.
**	Process: Reclamation of glass cullet from construction, demolition and refurbishment for flat glass manufacture	Collection and processing infrastructure and business models would need to be established. Landfill is lowest cost option.

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	Product: Green steel	Critical mass of demand needed to drive wider range of product choices in green steel
**	Product: Remanufactured/reclaimed steel products	Need for standardisation/verification schemes, matching reclaimed steel profiles from one industry (e.g oil production/refining), with construction industry needs. Developments would be driven by greater critical mass in demand.
	Process: Reclamation of bricks from demolition	Only cost effective for special bricks due to low value of facing bricks. Critical mass of demand needed to drive wider process changes

Notes to table above

1) We are not considering GGBS for cement and concrete use. The demand for concrete use exceeds supply of GGBS in the UK and greater UK use (in tonnage terms) would rely on imports. Its use is covered by existing standards. Efforts to maximise kg/m^3 of GGBS per unit volume of concrete to minimise embodied carbon in concrete is distorting markets. Volumes will decrease as production shifts away from primary iron and steel production to EAF furnaces.
2) Fly ash: Fresh quality ash from power generation is in limited supply and high demand. Technologies to upgrade historic stockpiles can eke out demand and provide bridging technology before other resources come on stream.
3) Rankings are to a large extent a “straw man”. Ranking of steel may be open to debate.
4) Atkins joins industry experts in world’s first zero-emissions cement trial in the UK – SNC-Lavalin (snclavalin.com)

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b) More detailed specification of need for shortlist products

	Product/process	Need
**	Product: training/awareness raising on concrete	Develop and deliver new training and tools for construction industry at various levels to adopt measures and best practices already allowed in codes and standards- design, concrete selection, specification. Through bodies such as Concrete Centre, BRE, Concrete Society.
**	Product: Reclaimed fly ash for concrete use	To attract and de-risk capital investment for processing infrastructure needed to recover/process/clean for concrete use.
**	Products- alternatives to fly ash and GGBS for PC concretes- various (unspecified)	Needs investment in supply chain and capacity to enable imports, UK processing, capacity, R+D on new solutions
**	Products: LC3 cement	Assessment of material availability and suitability /scale up issues in UK
**	Product: Calcined clays for concrete use	To attract and de-risk capital investment for processing infrastructure. Potential for use of suitable clays in UK produced AACM's LC3, and PC concretes
**	Process: Adoption of waste CO_2 in curing of pre-cast concrete	Significant product development needed and sources of waste CO_2. Investment needs critical mass of demand
**	Product: Alternative cements made without Portland cement	Infrastructure and manufacturing capacity and standards modification needed to scale up. Investment needs critical mass of demand
**	Products: Additives/treatments to allow reduction in cementitious content per m^3 of concrete	Standards. Some products not easily accommodated by existing standards framework and definitions. Collaborative case studies/confidence building/verification in UK context to demonstrate application at scale.
**	Process: Reclamation of glass cullet from construction, demolition and refurbishment for flat glass manufacture	To pump prime/establish collection and processing infrastructure, plus business models would need to be established.
**	Product: Remanufactured/reclaimed steel products	Standardisation/verification schemes, matching reclaimed steel profiles from one industry (e.g. oil production/refining), with construction industry needs. Developments would be driven by greater critical mass in demand.

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Appendix C: List of Products and Interventions- Cement and Concrete Products

Table C1 (a): DLI List of concrete products and supply chains- 4th April 2023- PRECAST PRODUCTS

Product	Supply chain members			User or specifier	Timescales
	1	2	3		
Precast unreinforced concrete products with lower embodied CO_2 than competitors Eg kerbs, pavers	Cement/SCM producer E.g: AACM Limestone fines GGBS Primary FA Reclaimed FA RCP* Aggregate producer	Admixtures/ additives[6]	Pre-cast concrete producer(s)	Users of precast concrete Client	A
Precast reinforced concrete floor slab/deck unit with lower embodied CO_2 than competitors[7]	Cement/SCM producer E.g: AACM Calcined clay Reclaimed FA RCP* Aggregate producer Alternative rebar E.g macro fibres or basalt fibre rebar	Admixtures/ additives[2]	Pre-cast concrete producer(s)	Main contractor (concrete building) Client	A
Precast reinforced concrete columns unit with lower embodied CO_2 than competitors	Cement/SCM producer E.g: AACM Calcined clay Reclaimed FA RCP* Aggregate producer Alternative rebar E.g macro fibres or basalt fibre rebar	Admixtures/ additives[6]	Pre-cast concrete producer(s)	Main contractor (concrete building) Client	A B (for AACM)

[6] Admixtures and additives such as graphene admixtures, e.g: Concretene, CarbonCure, Concrete4-Change

[7] GGBS and primary FA are excluded as they are business as usual materials and in limited/declining supply.

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Precast concrete products Reinforced or unreinforced made from ternary blended cements (EN197 Parts 1 and 6 and revised BS 8500: 2023)	Cement/SCM producer E.g: Limestone fines GGBS Primary FA Reclaimed FA RCP* Aggregate producer	Existing cement and concrete industry supply chain partners	Pre-cast concrete producer(s)	Users of precast concrete	A (unreinforced) A-B (steel reinforced) (Adoption likely to be first in ready-mix due to flexibility of production process)

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Table C1 (b): DLI List of concrete products and supply chains- 4th April 2023- READY MIX CONCRETE

Product	Supply chain members			User or specifier	Timescales
	1	2	3		
Readymix concrete Reinforced or unreinforced with lower embodied CO_2 than competitors Non-critical applications: e.g ground bearing slabs, foundations	Cement/SCM producer E.g: AACM Calcined clay Limestone fines GGBS Primary FA Reclaimed FA RCP* Aggregate producer	Admixtures/ additives[6]	Readymix concrete producer(s)	Users of readymix concrete Client	A (unreinforced) A (steel reinforced)
Readymix concrete Reinforced with lower embodied CO_2 than competitors. Cast-in situ slabs	Cement/SCM producer E.g: AACM Calcined clay Limestone fines GGBS Primary FA Reclaimed FA RCP* Aggregate producer	Admixtures/ additives[6]	Readymix concrete producer(s)	Users of readymix concrete Client	B
Readymix concrete Reinforced with lower embodied CO_2 than competitors Structural columns/concrete frames	Cement/SCM producer E.g: AACM Calcined clay Limestone fines GGBS Primary FA Reclaimed FA RCP* Aggregate producer	Admixtures/ additives[6]	Readymix concrete producer(s)	Users of readymix concrete Client	B
Readymix concrete Reinforced or unreinforced made from ternary blended cements (EN197 Parts 1 and 6 and revised BS 8500: 2023)	Cement/SCM producer E.g: Limestone fines GGBS Primary FA Reclaimed FA RCP* Aggregate producer	Existing cement and concrete industry supply chain partners	Readymix concrete producer(s)	Users of readymix concrete	A (unreinforced) A-B (steel reinforced) Adoption likely to be first in readymix due to flexibility of production process

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NOTES TO TABLE C1

a) Interventions could include support for:

- Supply chain building
- Waste CO_2 infrastructure
- R&D
- Demonstrators or demonstration structures/published case studies on carbon savings/cost effectiveness.
- Awareness raising (gains by applying existing best practice as well as innovations)

b) Use of waste CO_2 in the curing of concrete products:

In the manufacture of precast concrete products, it is possible to introduce waste or by-product CO2 sources into the curing process as the concrete sets and hardens (for example, Solidia®). Such products are generally unreinforced. This could potentially be applied to pre-cast concrete products in addition to the other approaches listed in the above table. There could be a risk of reinforcement corrosion with (steel) reinforced products. Capital investment and further R&D are required. The approach is most applicable to concrete manufactured using semi-dry processes. Supply chains could potentially include the following:
Cement/SCM producer, for example of:

- Limestone fines
- GGBS
- Primary FA
- Reclaimed FA
- RCP*

Waste or by-product CO_2 source(s)
Aggregate producer
Specialist supplier of curing and CO2 injection plant
Pre-cast concrete producer
Users of precast concrete

c) More time for design and assess possibilities:

To meet construction programme and minimise design time, there is a tendency to use tried and tested methods. Support/project resource to allow early supply chain collaboration and more time in design could free up time and resource for designers to consider new materials in their specification and allow costs and benefits of new approaches to be assessed.

d) Circular economy

Re-use of concrete elements is less straightforward than for other materials (such as steel) due to (in the former), the large number of concrete mix variants and the difficulty in using reversible connections such as bolts and clips. At present, concrete elements are not generally reclaimed for reuse, (possibly except for more valuable bespoke elements like stairs and loose-laid products such as concrete block pavers laid on bedding sand.

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Websites for innovative products mentioned in tables above:

Concretene - Nationwide Engineering Group (Accessed: 17th April 2023)
CarbonCure's Sustainable Concrete Solution - Concrete Technology Reducing Carbon Impact (Accessed: 17th April 2023)
Concrete4Change | Net-Zero Circular Concrete Technology (Accessed: 17th April 2023)
Basalt Technology (Accessed: 17th April 2023)
Solidia® – Making Sustainability Business as Usual℠ (solidiatech.com) (Accessed: 17th April 2023)
RCP: for example
Breakthrough in new CCU technology with recycled concrete paste | HeidelbergCement Blog (Accessed: 17th April 2023)
Xeroc – Low carbon recycling solutions (Accessed: 17th April 2023)

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Appendix D: Industry Workshop

List of consultees prior to and following workshop in developing product lists and product specifications

Name	Representing
Paul Astle	Ramboll
William Benson	Careys
Chris Clarke	Scape
Richard Kershaw	Cemex
Nick Jowett	Marshalls
Steve Harrison	Scottish Enterprise
Bruce Martin	Expedition Engineering
Andrew Mulholland	Consultant/low carbon concrete routemap chair
Andy Powell	Environment Agency

Cement and concrete sector (grey), contractor/designer (blue), client/procurement (yellow), other (white)

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Agenda for industry workshop, 1st March 2023

Agenda

9.00	Coffee
9.30	Introductions & Welcome
9.40	Foundation Industries Demand Led Innovation - Hugh Falkner
9.45	Low Carbon Concrete Routemap - Bruce Martin
9.50	Visit to innovation demonstrators and laboratories
10.30	Overview of project and current findings - Andrew Dunster
10.45	Glass, Bricks & Ceramics
11.05	Coffee
11.20	Metals
11.50	Cement
12.20	Summary & Next Steps
12.30	Lunch & Networking

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Attendees list for industry workshop

CONSTRUCTING EXCELLENCE
delivered with bre

Demand Led Innovation Scoping Study – Construction Products and Industry workshop
Wednesday 1st March

	First Name	Job Title	Company
1	Ailish Byrne	Environmental & Sustainability Manager	Ferrovial Construction
2	Alison Nicholl	Head of Constructing Excellence	Constructing Excellence c/o BRE
3	Amelia Ku-Neale	Environmental Consultant	DeSimone Consulting Engineers
4	Andrew Dunster	Principal Consultant (Materials)	BRE Group
5	Anna Chaliasou	Senior Materials Engineer	AECOM
6	Antoinette Campbell	Membership Coordinator	Constructing Excellence c/o BRE
7	Bruce Martin	Associate Director	Expedition Engineering
8	David Kerr	PTE Modularisation	Shell
9	Dr Hugh Falkner	Innovation Lead	Innovate UK
10	Efi Tzoura	Innovation manager	Ferrovial Construction
11	Gary Timmins	Head of Construction Testing	BRE Group
12	Gemma Forbes-Pepitone	Fire Consultant	BRE Group
13	James Duncan	Head of Built Environment	BRE Group
14	Keith Quillin	Principle Consultant (Construction)	BRE Group
15	Matthew Teague	Market Engagement Manager	Tata Steel
16	Philip Holden	Principal Structural Engineer	BRE Group
17	Ranjit Bassi	Principle Consultant (Construction)	BRE Group
18	Roger Ridsdill Smith	Senior Partner	Foster + Partners
19	Sophie Bloye	Insight & Engagement Coordinator	Constructing Excellence c/o BRE
20	Stafford Lloyd	Innovation Lead	Innovate UK
21	Su Varma	Academic Director, R&D Incubator	Pilkington (NSG)
22	Tim Yates	Technical Director	BRE Group

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Product briefing sheets used in the industry workshop:

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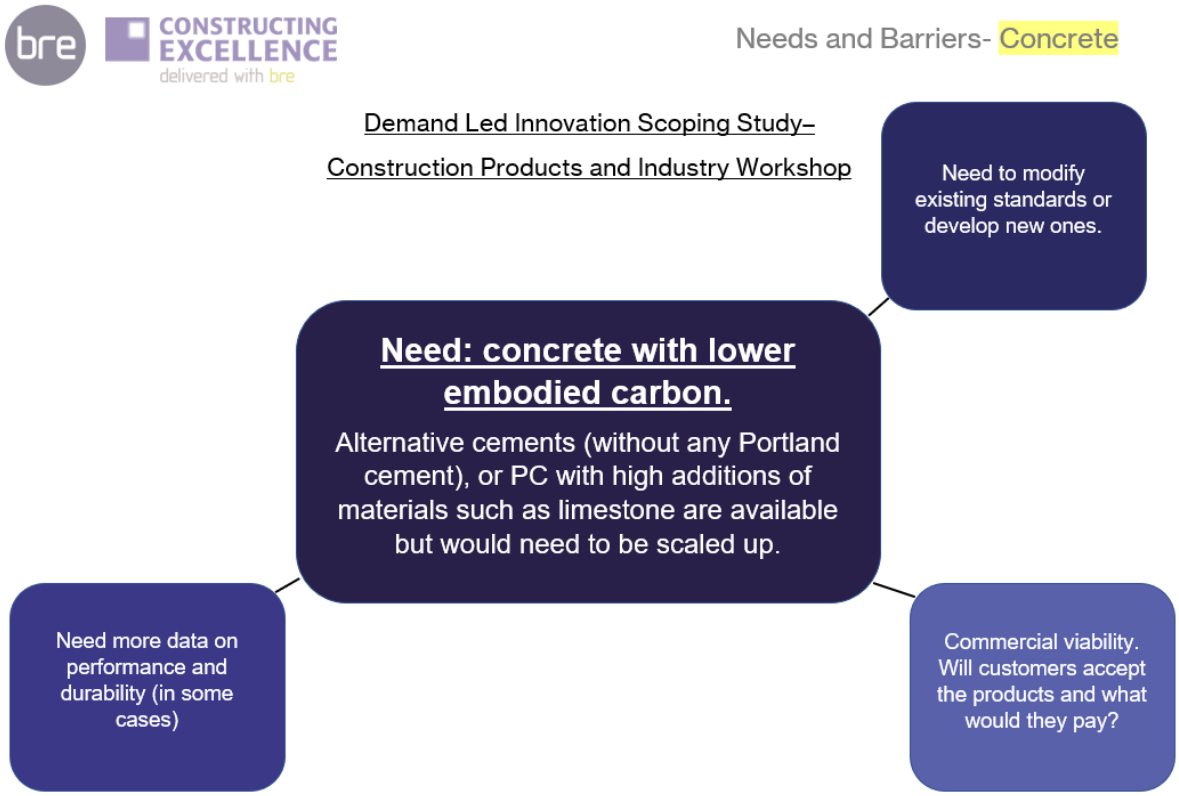

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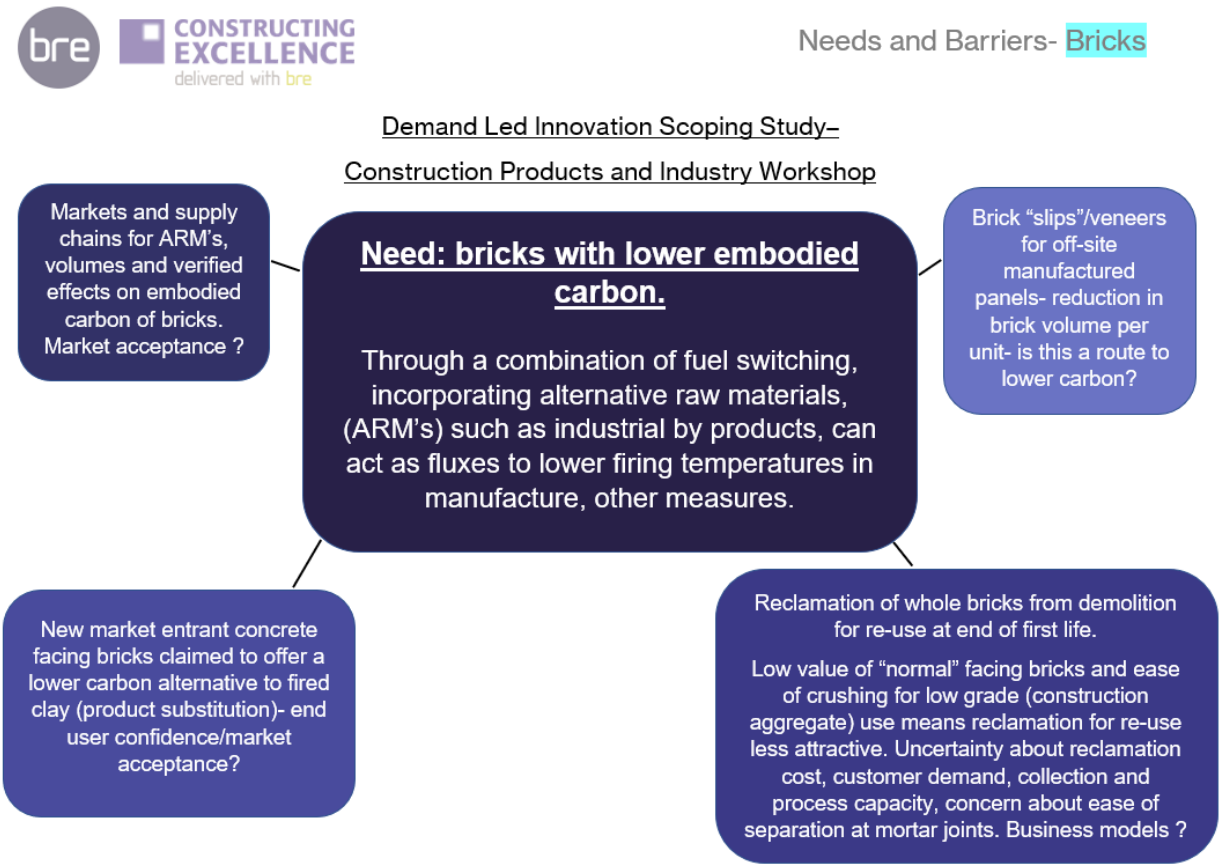

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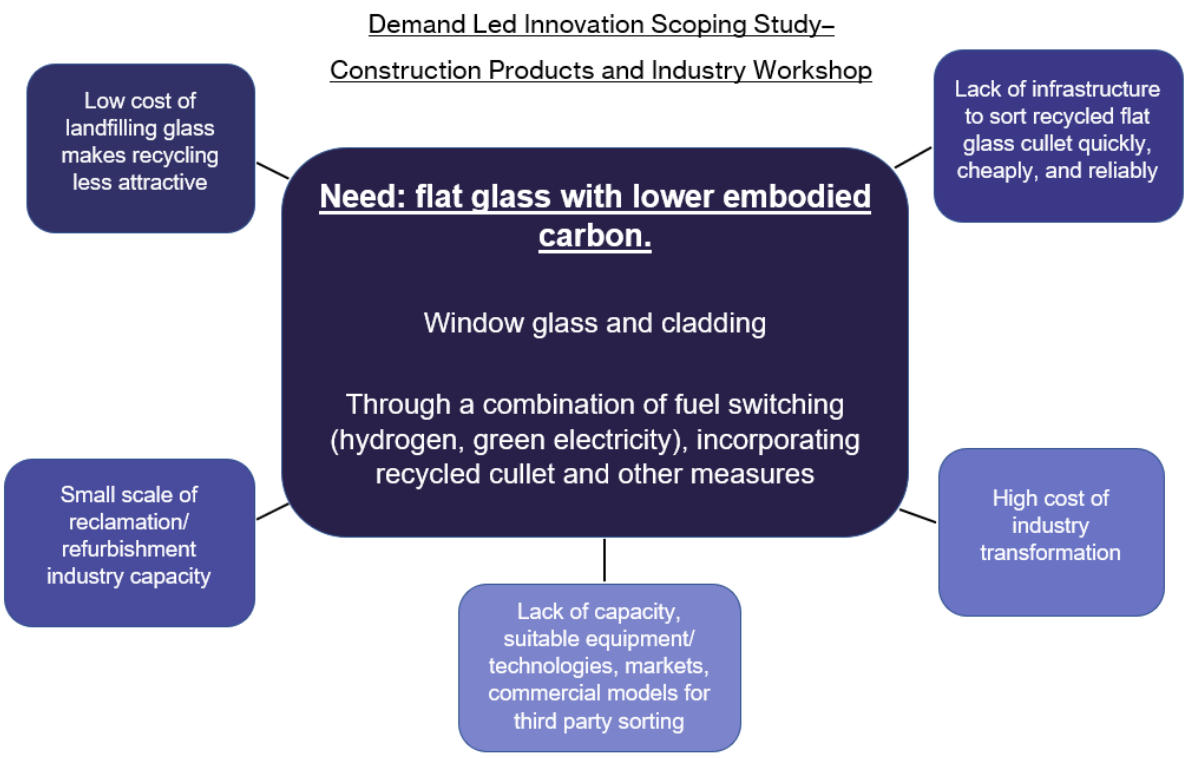

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Answers from the industry workshop breakout sessions

What challenges do you face in the context of deploying zero carbon technologies and construction products?	Where would you like to implement the technologies/ products?	What is needed to deploy the solutions at scale/ replace/ partially replace existing solutions?
➢ Concern about risk ➢ Clients want low carbon but no additional risk ➢ Clients are happy with using more short-term solutions, within existing standards, but not viable long term. ➢ Use alternative SCMs to reduce use of CEM I o Fly ash from stockpiles o Calcined clay o Limestone fines o Volcanic ash ▪ These options require client demand- create demand for new products and give batching plants confidence. ➢ Longer term new alternative SCMs that sequester carbon during manufacture ➢ Use of alternative technologies o Textile reinforced concrete to reduce cement content o Fibre reinforced concrete ➢ Codes ➢ Specs ➢	➢ Start with pavements, low risk precast with a performance based spec ➢ Create the economic case for doing all of it.	➢ Long term durability studies ➢ Means to mitigate risk (e.g., government backed insurance) ➢ Knowledge sharing rather than lots of independent efforts ➢ Organic forms to save. E.g. 3D printing concrete fabric framework- Bath University. ➢ Guidance for engineers on risk-consequence ➢ Investment in infrastructure e.g. silos, etc. + grants/loans ➢ Institutional investors + venture capital. ➢ Knowledge lab ➢ Innovation need study o Material o Process o Specification ➢ Training and information provided for engineers to support and build confidence

Concrete

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What challenges do you face in the context of deploying zero carbon technologies and construction products?	Where would you like to implement the technologies/ products?	What is needed to deploy the solutions at scale/ replace/ partially replace existing solutions?
➢ Standardisation of alternative reinforcement ➢ Cost of electricity, or how electricity is supplied to production ➢ Difficult to understand the quality of steel in a project ➢ Copper- is it reclaimed? ➢ Laser cut reinforcement ➢ Lack of understanding around alternatives ➢ Lack of incentives to reuse/recycle	➢ Labelling steel- better understanding of what grade steel has been used ➢ Potential testing methodology that's accepted across industry ➢ Market place for recycled material- reuse not recycle ➢ Modular products in combination to other materials e.g. glass ➢ Reclaim copper? ➢ International grading allows reuse ➢ Can we replace reinforcement methods with laser cut? ➢ Design optimisation	➢ Regulatory- VAT incentive to reduce cost ➢ Wholistic approach in design account for materials change of use o +modular o +bespoke ➢ BIM- where is it going? ➢ Materials passports- BIM to track existing elements ➢ Identification of grades/alloys ➢ Hybrid design- best use of different structural materials ➢ Reversable connections ➢ Organic shapes/ less martial in elements. E.g., studtgaart airport

Steel

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What challenges do you face in the context of deploying zero carbon technologies and construction products?	Where would you like to implement the technologies/ products?	What is needed to deploy the solutions at scale/ replace/ partially replace existing solutions?
➢ Planning requirement to provide a brick finish ➢ People like to buy brick look houses ➢ We don't have low carbon bricks available (due to firing using fossil fuels) ➢ Mortgages on non-standard construction ➢ Brick slip only available on high carbon backing	➢ Alternative firing fuels for brick ➢ Alternative finishes instead of brick- render, timber (maintenance), glass ➢ Brick slips on low carbon backing ➢ Concrete facing bricks- lower carbon than fired clay (new market entrants) ➢ Brick slips/veneers	➢ Need a market for it ➢ More availability of alternative finishes

Bricks

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Bricks

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A summary of answers and points from the industry workshop sessions (1 March 2023, compiled by BRE)

Product category	Commentary and needs/interventions
Cement and concrete	Clients are happy with using more short-term solutions, within existing standards, but not viable long term. Concern of specifiers and clients about risk and working beyond existing codes and standards For alternatives to fly ash and GGBS to lower embodied carbon, options require client demand to create demand for new products and give concrete batching plants confidence. Unblocking/accelerating new codes and standards Fibre reinforcement or other means to reduce binder (and steel) content in concrete. What is needed: • Long term durability studies/data sharing • Standards for new materials- see above. • Create/demonstrate economic cases. • Means to mitigate risk (e.g., Government backed insurance) • Knowledge sharing rather than lots of independent research/site deployments. • Organic forms to save on material. e.g. 3D printing concrete fabric framework. • Guidance for engineers on risk-consequence • Investment in infrastructure e.g. silos, etc. + grants/loans • Institutional investors + venture capital. • Knowledge lab • Innovation need study on: • Materials • Process • Specification • Training and information for engineers to support and build confidence

Steel and other metals	Difficult to understand the quality/grade of steel in a structure or project. Can we replace/improve reinforcement methods with laser cutting? BIM- where is it going?
	What is needed:
	
	• Standardisation/certification of alternative reinforcement (to steel)
	• Greater awareness/understanding around the alternatives (to steel)
	• Labelling or adoption of NDT methods for steel- better understanding of what grade/alloy steel has been used in a structure.
	• A potential testing methodology/protocol (for reclaimed steel) that is accepted across industry.
	• A marketplace for recycled material (steel)- for reuse not recycling.
	• Modular products in combination to other materials e.g. glass to assist reclamation.
	• International grading allowing re-use of steel elements.
	• Design optimisation- design tools and specifications to encourage/enable- e.g organic shapes/ less material in elements.
	• Regulatory/fiscal- e.g. VAT incentives
	• Holistic approaches in design account for materials change of use:
	  o +modular
	  o +bespoke
	• Materials passports- use of BIM to track existing elements.
	• Wider adoption of hybrid design- best use of different structural materials (e.g concrete, steel)- tools and specifications to enable.

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	• Adoption of reversable connections to assist in reclamation of steel elements
Product category	Commentary and needs/interventions
Bricks	Planning requirement to provide a brick finish and people like to buy brick look houses. Can be issues with mortgages on non-standard construction, which use materials other than traditional brick. Brick slip is only available on high carbon backing. What is needed: • Alternative firing fuels for bricks • Alternative finishes instead of brick- render, timber (maintenance), glass • Brick slip/veneer products on low carbon backing • Concrete facing bricks- lower carbon than fired clay (new market entrants) • Confidence in market demand and mortgage-ability for non-traditional brick
Flat glass (cladding and windows)	Changing/evolving standards mean that reuse/reclaimed glass doesn't meet standards for new windows or cladding. Window leasing business models. What is needed: • Thinner glass (material savings) • Thermally efficient glass- fewer panes needed (e.g double rather than triple) • Reclaiming glass cullet in closed loop to lower CO_2 emitted in flat glass manufacturing. • Recycling of glass (flat glass cullet) is not readily available. • Modular systems to facilitate removal of glass quickly and with minimal contamination (designed for circular economy) • Retrofit technologies/systems to upgrade existing glazing thermal properties without wholesale replacement. • Glass reclamation infrastructure/supply chains • Standards need to allow re-use. • Windows in housing- leasing business model
Products (brought down from above)	Reduced binder (and steel) content (reinforced) concrete. Assessment methodologies/labelling schemes for reclaimed steel Lower embodied carbon brick panel systems Modular window systems Thinner glass Thermally efficient glass Windows in housing- leasing business model

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