UKRI Interdisciplinary Circular Economy Centre for Mineral-based Construction Materials (ICEC-MCM)

Mineral-based construction materials are the largest national and global resource flow, and are of strategic importance for construction, the third largest UK economic sector. In 2016, the UK consumed 177 million tonnes of virgin aggregates, 15 million tonnes of cement and 2 billion bricks to build houses, civic and commercial buildings, roads and railways, etc.. 64 million tonnes of waste arose from construction and demolition in this period. Environmental impacts are associated with each stage of our current linear approach to construction. These impacts include depletion of mineral and energy resources, and water use and emission of greenhouse gases and other pollutants to air, land and water, during extraction, processing, use and demolition. With the government's drive to level-up the UK and £600 billion committed to new infrastructure over the next decade, there is a need to move from a linear to a circular approach to construction.

The goal of the UKRI National Interdisciplinary Circular Economy Research Centre for Mineral-based Construction Materials (ICEC-MCM) is therefore to do more with less mineral-based construction materials, to reduce costs to industry, reduce waste and pollution, and benefit the natural environment that we depend on. The ICEC-MCM will harness changes already taking place in the construction sector for better productivity through innovative technologies and a more highly skilled workforce, to also transform its resource efficiency. There is potential for mineral-based construction materials to be reused and recycled at higher value, for example, by refurbishing rather than demolishing, or by building using reusable modules that can be disassembled rather than demolished. It may also be possible to substitute minerals from natural sources by other types of mineral wastes, such as the 76 million tonnes of waste arising from excavation and quarrying, 14 million tonnes of mineral wastes that come from other industries, or 4 billion tonnes of historical mining wastes. We can also be more frugal in our use of mineral-based construction materials, by designing materials, products, and structures to use less primary raw materials, last longer, and be suitable for repurposing rather than demolition, and using new manufacturing techniques.

The ICEC-MCM research programme is a collaboration between 26 world-class investigators from a wide range of disciplines, including: biology, geology, soil science, environmental engineering, materials science, materials engineering, civil engineering, structural engineering, architecture, construction management, information management, mathematics, accounting, finance, economics, policy, law and archaeology. This multidisciplinary academic team brings together six UK universities, University College London (UCL), Leeds, Loughborough, Lancaster and Sheffield Universities, Imperial College London, and the British Geological Survey (BGS). We are supported by a network of more than 60 national and international partners from all sectors of the construction industry (clients, designers, contractors, suppliers, consultants), local and national government, non-governmental organisations (NGOs) and other academics.

Together, we aim to develop the scientific and socio-economic understanding and technological basis for design and implementation of systems, processes and policy that will support the transition to a sustainable Circular Economy, particularly for built environment infrastructure, using case studies for mineral-based construction materials. These aims will be achieved through advanced training of 15 postdoctoral researchers and more than 20 doctoral students. The postdoctoral researchers will work on 15 interlinked projects that have been structured for 1) development of understanding, principles or a method, of wider applicability to the Circular Economy, and 2) practical demonstration of the understanding, principles or method in one or more case studies. The 15 postdoctoral researchers will gain

experience through research in the universities for 2 years and will then work with an industrial collaborator for one year, to implement the results of their research in a real-world context. The project teams will work in collaboration with external stakeholders from industry and government to yield actionable solutions for implementation in the initial 4y period of the Centre, in relation to **3 key interconnected Challenges** linked to the construction material life cycle (Figure 1):

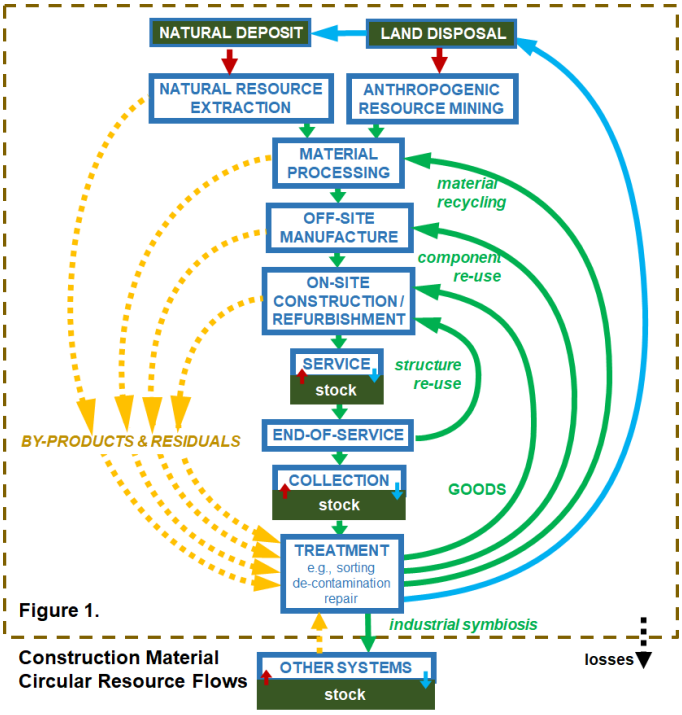

Figure 1.
Construction Material Circular Resource Flows

1. Dynamic Spatial Modelling of Material Stocks, Flows and Impacts;
2. Technological Innovation for Material Demand Reduction, Circularity and Impact Reduction
3. Systemic Enablers for Circularity of Materials.

The objective of **Challenge 1** is to characterise and model the flows and stocks of mineral-based construction materials over their whole life cycles, and the resulting environmental, social and economic impacts. The modelling will be used: a) to prioritise flows and processes for intervention, by identifying sources of supply and demand, failures of linear approaches, and barriers and opportunities for circularity, and b) for scenario analysis, to examine the potential effects, benefits and trade-offs associated with material substitutions and changes in policy and technology (interactively with Challenges 2 and 3) on system circularity and impacts.

The objective of **Challenge 2** is to develop the technical understanding for each life cycle stage of mineral-based construction materials and new technologies to reduce their demand, enable their circularity, and create economic value while improving their environmental and social impacts. Identified opportunities for transformative technological changes will feed back to the scenario modelling in Challenge 1 and circular economy business model for mineral-based construction materials in Challenge 3.

The objective of **Challenge 3** is to create a framework for implementing eco-design for mineral-based construction materials and proposing changes to the practices of businesses throughout the whole value chain and system, including investors, to remove barriers and create market support for adoption of circular materials and technologies, as well as changes in policy and regulation that will support these new business practices.

Many CE challenges are common across resource flows, and interaction between the ICEC-MCM and the other 4 NICER Centres, through and alongside the CE-Hub, will be essential. An Independent Advisory Board will help shape the direction of the Centre and support uptake of 16 Cross-Cutting Themes: Circular Economy Principles, Sustainable Development Goals, Resilience, Metrics, Standards, Education, Behaviour Change, Digital Innovation, Virgin Materials Demand, Industrial Symbiosis, GHG Emissions / Energy, Natural Capital, Social Impacts, Business Impacts, Policy Impacts and Other Impacts (e.g. air pollution, water use, unintended consequences, trade-offs with other systems).