Enabling a resilient and sustainable future

2021-22

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UKCRIC™

UK COLLABORATORIUM FOR RESEARCH ON INFRASTRUCTURE & CITIES

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ABOUT UKCRIC

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UKCRIC is transforming infrastructure and cities research and development. Its vision is to connect policy and practice with internationally leading, systems-based transdisciplinary research for the transformation of infrastructure and urban systems to enable safe, resilient and sustainable living, and to generate wellbeing and prosperity for all.

Its mission is to use its integrated research facilities to underpin the renewal, sustainment and improvement of infrastructure and cities in the UK and elsewhere. By engaging academia, government, industry and end users, UKCRIC de-risks, helps to prioritise, and provides evidence, analysis and innovation for infrastructure and urban investments for a safer, more resilient and more sustainable future.

"UKCRIC' is guided by four Scientific Missions that reflect societal needs and aim to facilitate the delivery of interconnected, integrated and transdisciplinary research programmes and projects.

Professor. William Powrie

FOREWORD
from the Chair of the International Advisory Board

I was delighted to be invited by UKCRIC to take up the role of Chair of UKCRIC's International Advisory Board and to follow in the footsteps of my esteemed predecessor, Professor Cynthia Mitchell, Emeritus Distinguished Professor at the Institute for Sustainable Futures, University of Technology Sydney, Australia.

I feel privileged to be part of a diverse group of international academic and industry representatives with an important remit: to provide strategic guidance to a truly unique network of infrastructure and urban systems researchers. For me, diversity of disciplines is crucial to tackling complex infrastructure and urban challenges and I see this diversity across the UKCRIC Network. UKCRIC's strength is its ability to address national infrastructure challenges that draw from multiple institutions and disciplines.

Of course, I must acknowledge that despite progress, the past two years have been extraordinarily challenging, and yet these are the times when we take stock, re-evaluate and start to think outside of the box in order to accelerate our recovery and grow the UK economy.

UKCRIC continues to reach important milestones, with the opening of two more world-class facilities, the launch of the doctoral skills network and joint research programmes underway. These are just a few of the highlights demonstrating how this amazing network of facilities and expertise is unlocking its potential to address global challenges. UKCRIC represents a fantastic opportunity to connect researchers, industry and policy that will develop cities and infrastructure in ways that are sustainable and puts people at the heart of progress.

UKCRIC is a powerful asset and ideally placed to support the UK in its progress towards an economically vibrant, sustainable, resilient, net zero future.

I encourage you to read more about the exciting and innovative projects happening within UKCRIC and perhaps find out for yourselves where you may have a role in this journey.

Robert Mair

Emeritus Professor of Civil Engineering, University of Cambridge, and Chair, UKCRIC International Advisory Board.

Credit: Lewis Roberts / Unsplash

Credit: Christian Lue / Unsplash

LETTER
from the Convenor

The period covered by this review (April 2021-March 2022) continued to be a turbulent time for most of the world. In the UK the rollout of the Government's Covid vaccine programme saw a cautious lifting of lockdown restrictions and settling into a 'new normal', if hampered by the spread of Covid variants.

Following the unprecedented challenges brought about by the pandemic was a palpable sense of returning optimism and business confidence. Innovation was (and continues to be) seen as the path to recovery. For UKRCIC, this meant focussing our efforts on a growth strategy underpinned by sustainability, resilience and collaboration, whilst stepping up our visibility with policy and practice stakeholders.

2021 saw two new UKCRIC facilities come online and another receive substantial funding. In February 2022, the University of Bristol launched the new UKCRIC Soil-Foundation-Structure Interaction (SoFSI) facility, which is capable of full-scale testing of how buildings and infrastructure interact with the ground when subjected to dynamic loads. In May 2021, construction completed on UKCRIC's Person Environment Activity Research Laboratory (PEARL), housing full scale facilities that test the impact of environmental conditions such as space, colour, lighting and sound, on people's behaviour and perception. In July, UKCRIC's Data and Analytics Facility for National Infrastructure (DAFNI) received a further £1.2 million of EPSRC investment, which provides researchers and practitioners with an unparalleled collaborative computational facility and quality data services to design and test future infrastructure innovations.

2021 marked the end of UKCRIC's capital investment phase. Since 2018, we've built to time and on budget 11 engineering laboratories, six urban observatories and the DAFNI modelling and simulation facility. We've staffed them, installed state-of-the-art equipment, and are now conducting and publishing world-class research. In phase 2 we will be pushing forward our vision to transform from a research community into a sustainable entity – drawing on all our expertise, creativity and resources to realise the multi-dimensional potential of infrastructure and urban systems.

The UKCRIC Transition Roadmap Project began in January 2022 and will provide the framework for UKCRIC's operations for the next five years. The Roadmap will plan how UKCRIC's Vision, Mission, and Scientific Missions can be implemented and realised, ensuring stakeholders across government, academia, business, and the third sector are fully engaged partners.

A substantial part of UKCRIC's ethos is to nurture early career researchers and future infrastructure professionals. In January 2022 we were delighted to launch the UKCRIC Doctoral Skills Network, which combines the collective expertise and capabilities of our university members to deliver skills training and support career development, helping create the engineers of the future. It has proven to be extremely popular, with membership growing rapidly.

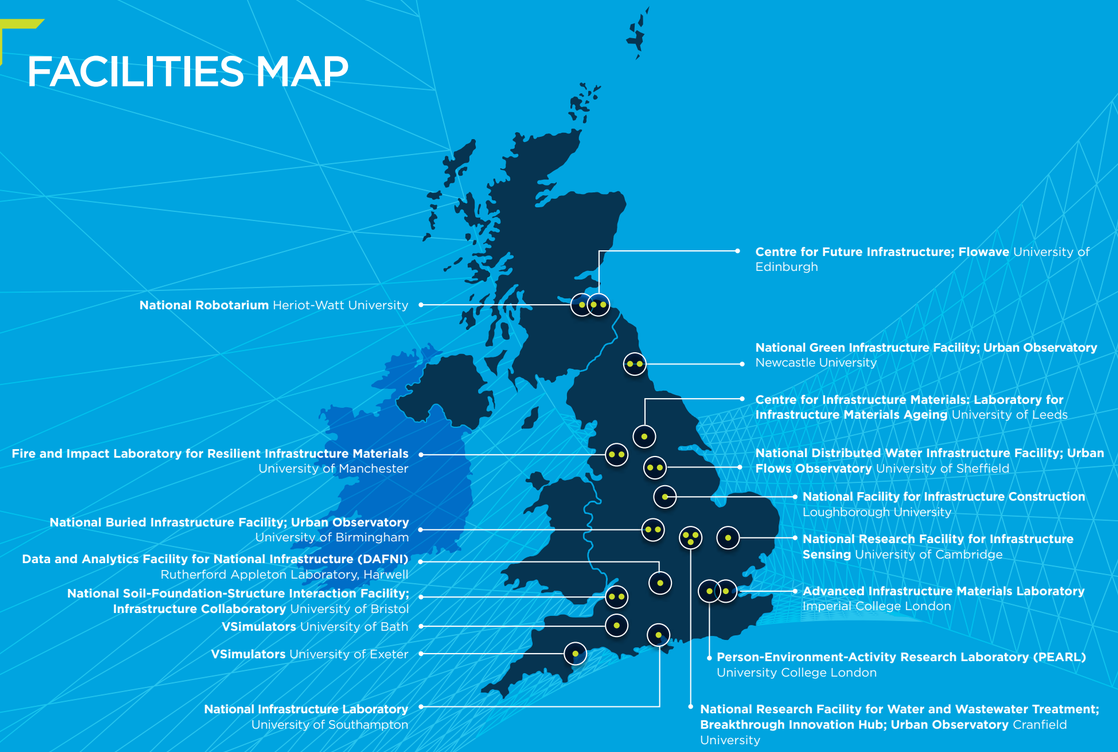
The value of the UKCRIC network is in the enablement of research collaborations from the disparate but complimentary disciplines across the member institutions applied to infrastructure and urban systems. Following an internal call for projects in the first quarter of 2021, UKCRIC members collaborated on five internally-funded projects aligned with UKCRIC's Scientific Missions: Environment and Sustainability, Adaptation and Change, Governance and Resilience, and Social Justice and Healthy Living. Our external partnerships are equally important to us and in August we signed a collaborative agreement on research and innovation with HS2 Ltd.

As well as bringing together UKCRIC's expertise and capability to deliver breakthrough research and new innovations, the dissemination of new knowledge is vital to ensure a systemic approach to de-risking the UK's investment in infrastructure and urban systems engineering. Collectively, UKCRIC's expertise continues to contribute to nationally-significant guidance and reports, and during this period we responded to the Carbon Reduction Code for the Built Environment (part of the Construction Leadership Council's Construct Zero initiative) and the BEIS Inquiry into Net Zero Governance.

UKCRIC is a community of researchers and professionals that share a vision for the transformation of infrastructure and urban systems that enables safe, resilient and sustainable living. I invite you to read about examples of our work and we welcome opportunities for partnership.

Professor William Powrie,
UKCRIC Convenor

FACILITIES MAP



IMPACT 2021 - 2022

>£15.5M
RESEARCH FUNDS LEVERAGED

of which
>£2.7M
is from
COMMERCIAL SOURCES

84
RESEARCH PROJECTS using **UKCRIC FACILITIES**

RESEARCH PROJECTS to the value of
>£63M
using **UKCRIC FACILITIES**

60
NON-ACADEMIC INSITUTIONS using **UKCRIC FACILITIES**

and of which **26**
are **SMALL-** and **MEDIUM-SIZED ENTERPRISES**

of which **26**
are **SMALL** and **MEDIUM-SIZED ENTERPRISES**

>£7.3M
of **COLLABORATIVE RESEARCH & DEVELOPMENT** leveraged for business

22
RESEARCH PROJECTS are with **INTERNATIONAL PARTNERS**

137
PUBLICATIONS

of which
128
are **ACADEMIC PUBLICATIONS**

FACILITATING STRATEGIC PARTNERSHIPS

Credit: Adobe Stock / Olya Oh

A strategic framework with HS2

In 2021, HS2 Ltd signed a ground-breaking agreement with UKCRIC that will enable HS2 to draw upon key centres of British academic excellence to help to drive new insight and technologies across the broad range of disciplines involved in building affordable, low carbon and modern infrastructure.

Co-ordinated by the Universities of Loughborough and Southampton, the agreement enables HS2 Ltd to commission research from across the whole of UKCRIC for Britain's new high-speed rail network. It also provides a channel for UKCRIC's 15 academic institutions to develop research projects the findings from which could be employed by HS2.

The first projects arising from the agreement focus upon key areas for collaboration on low carbon concrete, such as alternative reinforcement methods, reducing embedded carbon in production and the re-use of materials.

Andrew Pestana, Innovation Strategy Manager at HS2, said: "HS2 is a major opportunity for Britain's university and business sectors to collaborate at the leading edge of innovation to meet the challenge of delivering Britain's new high-speed rail network. The project's size and 20-year delivery programme provides the perfect environment in which to develop solutions for High Speed 2 and the wider rail industry – both of which are crucial in helping Britain's transport network to decarbonise."

UKCRIC's Convenor, William Powrie, of the University of Southampton, said: "This landmark agreement will enable HS2 to harness the power of UK universities in civil engineering innovation to meet the challenge of providing a robust, long-lasting railway at an affordable carbon and financial cost. In addition to bringing high TRL research to bear to address known and immediate challenges, engagement with HS2 will stimulate blue-skies thinking and catalyse new research that will have influence and impact for decades to come. The potential to make a real difference is huge."Sergio Cavalaro, Skills and Training Lead for UKCRIC, said: "With this agreement, we will promote collaborations between HS2 and UKCRIC partners aimed at answering the myriad of challenges that must be addressed in the project. This ambitious and comprehensive endeavour acknowledges the complimentary roles of research and training in providing the know-how to address such challenges, while developing the research-minded experts and embedding the skills that will enable continued progress in and beyond HS2."

> *"This ambitious and comprehensive endeavour acknowledges the complimentary roles of research and training*
>
> **Sergio Cavalaro,**
> Skills and Training Lead for UKCRIC

DEVELOPING TALENT, NURTURING CAREERS

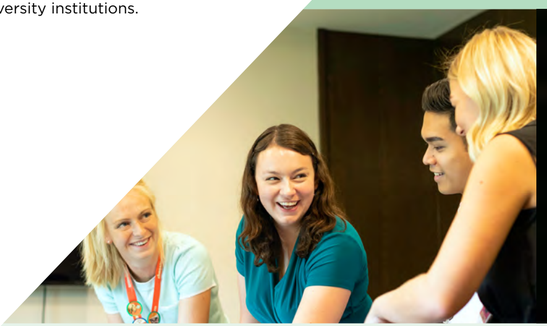
UKCRIC Doctoral Skills Network

The UKCRIC Doctoral Skills Network offers an opportunity for postgraduate researchers from UKCRIC institutions to meet and exchange ideas, support each other and gain skills to develop their careers as engineers of the future. Officially launched in January 2022 as part of UKCRIC's coordinated training activities, the aims of the Doctoral Skills Network are to:

- Offer developmental opportunities to doctoral researchers based in UKCRIC institutions focusing on research in infrastructure and cities
- Create a vibrant doctoral community and promote collaborations and idea exchanges
- Combine the collective expertise and capabilities of the UKCRIC universities and partners in support of the activities of the doctoral network
- Support the development of research-minded leaders that can address national and international priorities

By March 2022 the Network had more than 135 members from across 15 universities. Three webinars were hosted (approximately one a month) and more webinars and conferences are planned in collaboration with UKCRIC Centres for Doctoral Training, the Energy Research Accelerator and C-DICE Network.

A series of exclusive training workshops tailored to postgraduate and early career researchers are also planned in partnership with VOX coaching. A dedicated LinkedIn Group and social media presence ensures members can communicate about events and build professional relationships across university institutions.



DEMONSTRATING PILOT SCALE SYSTEMIC INFRASTRUCTURE SOLUTIONS

Credit: Bim

Exploring the trilemma of integral bridges

All physical infrastructure systems rely upon ground support in some way. Despite this, soil-structure interaction generally, and dynamic and seismic loads particularly, are inadequately understood. Separate codes of practice cover structural and geotechnical sub-systems, with interaction effects crudely represented and often neglectful of subtle, sometimes counterintuitive, systemic responses, especially for extreme loads. Frequently though, holistic soil-structure interaction (SSI) studies are perceived as prohibitively costly.

Advances in infrastructure must also consider their impact on climate change and provide low carbon solutions. Heating and cooling represents approximately 50% of energy consumption in Europe and North America. Thus, for the UK to make a meaningful contribution to reductions in carbon emissions it is essential to deliver renewable and low- or zero-carbon heat.

Ground heat exchange and storage offers such low-carbon opportunities but uptake is low, restricted by high capital costs and adverse electricity and gas price ratios making payback times prohibitive for investors. A novel way to achieve affordable ground heat exchange is to use existing or to-be-constructed infrastructure; and in serving a dual purpose, this reduces capital costs and makes the idea feasible.

Completing the trilemma, despite concrete being one of the most used building materials in the world, how different cement mixes behave over time and in extreme loading and blast conditions isn't well understood. The pervasiveness of concrete also means that its potential to make a positive contribution to reducing the construction industry's carbon footprint is huge, but technical unknowns are preventing the adoption of low-carbon concrete.

The Priming Laboratory Experiments on Infrastructure and Urban Systems project – or PLEXUS – explored the benefits of integral bridges by tackling three important technical challenges: intense physical interdependency of urban infrastructure systems, harvesting energy from buried infrastructure systems and accelerated deterioration of infrastructure materials due to extreme loading.

The diversity of SSI problems, from buried pipes, through soil-retaining structures, deep excavations, piled foundations, highway & railway foundations and offshore structures, to the seismic response of whole urban areas, dictates a generic, systemic and tailorable approach. Many of the crucial epistemic uncertainties are associated with the lack of knowledge of how real infrastructure behaves; uncertainties that conventional laboratory-scale modelling cannot address.

One of the principal motivations of the UKCRIC facilities is to enable investigation of prototype, or near-to-prototype, scale infrastructure behaviour. UKCRIC laboratories of Birmingham, Southampton and Bristol represent a unique, integrated research infrastructure and environment in which these crucial epistemic uncertainties can be explored to devise a new, holistic and systemic SSI framework.

PLEXUS's research into the three technical challenges: the design and performance of integral bridges (universities of Birmingham, Southampton, Bristol and Cambridge), energy harvesting from buried infrastructure systems (Universities of Leeds, Sheffield, Newcastle, Cambridge and Cranfield) and the properties of aged (hence carbonated) concrete manufactured using different types of cement and when subjected to blast and fire loading (Universities of Leeds, Imperial and Manchester), can be combined in a proposition for more sustainable and resilient, and more economic, holistic integral bridge systems.

Through its research, PLEXUS demonstrated that the widespread adoption of integral bridges has huge potential for reducing bridge construction and maintenance costs, and for improving their long-term resilience. Following UKCRIC's first call for research projects in 2021 'PLEXUS PLUS' was awarded funding to further understanding of the seasonal bridge-abutment interaction through the combined application of large-scale testing, state-of-the-art modelling and in-soil monitoring.

Credit: Evgeni Tcherkasski

TACKLING CLIMATE CHANGE

Credit: Adobe Stock / alpegor

Permeable concrete pavements

Flooding costs the UK £2.2 billion annually and is projected to cost £27 billion by 2080 without significant flood resilient infrastructure investment. Climate change is predicted to increase the likelihood of major storm events by 59%. It is therefore critical to develop climate change resilient permeable infrastructure, such as permeable pavements, to alleviate the negative impacts of flooding.

Permeable concrete pavements are one of the most promising mitigation strategies used to prevent surface flooding, they rapidly drain stormwater through otherwise impermeable infrastructure. Conventional permeable pavements are, however, prone to clogging by debris that are trapped within the pore network, blocking the pavement and reducing its drainage capacity. Most importantly, the insufficent strength, durability and regular clogging of conventional permeable pavements requires frequent maintenance. This degrades perfomance and ultimately means they are not a suitable solution.

Researchers at Imperial College London have developed a next-generation clogging resistant permeable pavement (also known as Kiacrete) that overcomes the conventional permeable systems' limitations. Kiacrete's engineered uniform pore structure addresses urban flooding and climate change through stormwater management and groundwater recharge. The novelty of Kiacrete, compared with conventional permeable pavements, is its: i) higher permeability (ten times greater); ii) superior clogging resistance, despite extensive exposure to stormwater sediments; iii) improved compressive strength (twice as strong) and iv) enhanced durability performance.

The key innovation that leads to Kiacrete's excellent drainage performance is the channels cast within it, which addresses the clogging associated with conventional permeable pavement's indirect pore network. Furthermore, the cementitious material poured around these direct channels can be tailored depending on the specific application.

After proving the performance of Kiacrete in the laboratory, the team have developed a novel patented interlocking tile system to deliver cast in-situ Kiacrete at a commercial scale. The long-term goal is to develop the first climate change resilient permeable infrastructure that will have the potential to be widely adopted both in the UK and internationally.

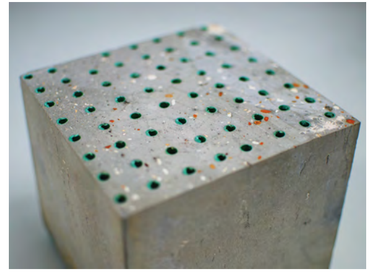
UK FLOODING COSTS

£2.2BN

annually, and is projected to cost

£27BN

by 2080



Permeable concrete created by researchers at Imperial College London. Photo by Hong Wong.

COORDINATING NATIONAL SCALE SOLUTIONS

Credit: Adobe Stock / Serhii Figurnyi

Towards a national digital twin for urban transport

A collaboration between the UKCRIC Urban Observatories of Newcastle, Birmingham and Manchester, the Alan Turing Institute and the Department for Transport (DfT) is demonstrating the potential of a science-led digital twin approach to decarbonising transport, and standardising this approach on a national scale.

In response to the climate emergency, many UK cities and organisations are now investing in Internet of Things sensors and have access to real-time metrics such as traffic flows, air quality, and passenger data to support strategies to reduce their carbon footprints. However, with the pressing need to respond to climate change, the UK's 115 urban centres may well take individual paths to sensor deployment, data management and data access, potentially compounding complex problems through a lack of standardisation and consistency to their approach.

Much of the data that is collected by UKCRIC's Urban Observatories relates to mobility and its environmental impact and so the Urban Observatories have developed a common ethos and data sharing access protocols. The challenge addressed in this research is to understand how these can be scaled to regional and national studies to support agile and data driven responses.

To address this challenge, this collaboration lays the foundations for a flexible but homogenous approach by cataloguing existing sensor capabilities, benchmarking current metadata standards, developing mechanisms for data standardisation and data onboarding and exploring applications of real-time data for future urban digital twins.

The project has developed a living sensor catalogue to complement existing DfT portals and has highlighted important issues in capturing key metadata for decision makers.

As a result, a number of use cases have been developed that explore how new sensor assets data can then be exploited with improved models.

> *"This innovative project has the potential to be key in the creation of cleaner, more efficient and more effective cities. Through gathering important transport data on road traffic, as well as walking and cycling uptake in our urban areas, this work will help us develop green, urban environments which are fit for the future."*
>
> **DFT spokesperson**

An onboarding prototype has used the Urban Data Exchange[1] model to demonstrate technology agnostic onboarding and common mapping to smart data models[2] to achieve standardisation.

From these a machine learning based traffic prediction, modelling of Low Traffic Neighbourhoods (LTNs) and monitoring black carbon have been prototyped, demonstrating the potential future use cases of digital twins. Ultimately, the project is developing the foundations for city, regional and national twins for local transport and demonstrating the role that real-time high-resolution metrics can play.

1. www.urbandata.exchange
2. smartdatamodels.org

PUTTING DECARBONISATION AT THE HEART OF NEW INNOVATION

"We have calculated savings of 60% in embodied carbon compared to a traditional flat-slab equivalent.

Dr Paul Shepherd, ACORN Principal Investigator at the University of Bath

Credit: Adobe Stock / Artinun

Reducing carbon impact of use of concrete in buildings

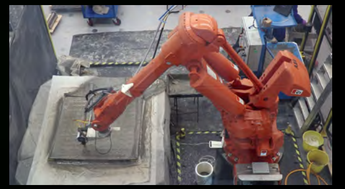
ACORN, which is a collaboration between the Universities of Bath, Cambridge and Dundee, and a growing number of industry partners, is helping to decarbonise construction by rethinking the way that concrete is used in buildings. The project is driving a new industry culture to improve whole-life sustainability and productivity objectives by eliminating waste and reducing carbon emissions associated with traditional use of concrete in construction. ACORN targets the Construction2025 goals by creating digital tools to design complex-shaped concrete beams, columns and slabs for automated off-site manufacture.

The robot-manufactured new vaulted style of floor uses 75% less concrete than a traditional slab floor. This innovation features in the RIBA Journal in an article that describes the engineering behind the project and the possibility that ACORN's approach "could be the secret to unlocking net zero buildings".

In rethinking the way concrete is used in buildings, ACORN combines offsite manufacturing processes, affordable robotics and a highly-automated, quality-controlled environment to help design concrete out of construction – only using concrete where it is needed. The traditional approach to pre-casting prism-shaped concrete slabs has not changed since Roman times and while this method offers highly repeatable results it creates waste and is not carbon efficient. New approaches to concrete use and manufacture are needed and the value of them evidenced to encourage a change of culture in the construction industry and adoption at scale.

Dr Paul Shepherd, ACORN Principal Investigator at the University of Bath, said, "We have carried out some really exciting research, culminating in the manufacture and construction of a full-sized demonstration building in Cambridge's UKCRIC National Research Facility for Infrastructure Sensing (NRFIS) laboratory, for which our Centre for Smart Infrastructure and Constrcution (CSIC)[3] funded researcher has calculated savings of 60% in embodied carbon compared to a traditional flat-slab equivalent. Along with our 27 industry supporters, the team is now eagerly awaiting the results of our application for follow-on funding, so that we can drive these innovations towards large-scale industry adoption."

"The success of the ACORN project makes clear the importance of reconsidering how we use concrete – by developing novel automation techniques for fabrication that inform the design process, we demonstrate the significant low hanging fruit that exist for construction to dramatically cut



carbon emissions by reducing demand for cement consumption. Our collaborations across computing, structural engineering, optimisation, and robotics have been vital to this progress," said Dr John Orr, CSIC Investigator and University Lecturer in Concrete Structures, who leads the ACORN project at the University of Cambridge.

"Achieving the net-zero targets recently ratified at the COP26 conference will require significant change by the construction industry, which is responsible for about half of the UK's total emissions. Since concrete is the world's most widely consumed material after water, and its production contributes more than 7% of global CO2 emissions, the easiest way for construction to begin its journey to net-zero is to use less concrete. That has been the driving force behind this project, which we hope could make a major difference to the impact of construction," said Dr Shepherd.

3. www-smartinfrastructure.eng.cam.ac.uk

COLLABORATING ACROSS ACADEMIA, GOVERNMENT AND INDUSTRY

Credit: Adobe Stock / NicoElNino

Connected data for climate resilient infrastructure and services

The Climate Resilience Demonstrator (CReDo) is a groundbreaking digital twin project funded by BEIS through the Centre for Digital Built Britain. Partners including Anglian Water, BT and UK Power Networks are collaborating with researchers to investigate the effect climate change, and flooding in particular, could have on power networks in the UK, and how they can adapt and become more resilient.

CReDo is a systems-based approach, connecting digital twins across critical infrastructure and services to demonstrate how connected data and greater access to the right information can improve climate adaptation and resilience.

Researchers and decision-makers in government and private bodies were unable to access secure data and sophisticated data models in one place. The Data & Analytics Facility for National Infrastructure (DAFNI) supported CReDO by providing a shared platform which enabled access to the analytics necessary to support resilient infrastructure and services decisions required to adapt to climate change.

DAFNI is a trusted third party and independent operator which holds the CReDo datasets and others in its National Infrastructure Database.

The DAFNI platform allows these datasets to be combined and analysed, and safely destroyed at the end.

Without DAFNI the sensitive shared work on a combined dataset on a non-commercial platform would not have been possible in this project.

The systems-based approach through CReDo using DAFNI is necessary because of cascade effects: flooding can cause loss of power which in turn can impact communications infrastructure.

Energy, water and telecoms digital twins were at the core of this first round of the project, with data mapped and models created to identify the impact of extreme weather for individual infrastructure services and across them.

Flooding, in particular, is under the spotlight and CReDo scenarios provide infrastructure operators with a tool to better understand the immediate and knock-on impact of extreme weather on their services, and better mitigate the impact on network performance and service delivery. The project relies on highly sensitive data from a variety of infrastructure operators, shared safely and securely, in the platform where they can uniquely collaborate and work on that data.

The first phase of CReDo completed in March 2022. The next phase for CReDo begins in October 2022 and will take digital twins in new directions: by modelling other components of infrastructure such as power and roads, to model events other than flooding, and to support climate emergency mitigation and net zero. Connected Places Catapult will lead the next stage of development and DAFNI remains at the core, providing crucial data and cyber security expertise.

> *"DAFNI, the Data & Analytics Platform for National Infrastructure, was selected as the critical platform which allows the likes of BT, Anglian Water, and national power networks to share their sensitive datasets.*
>
> **Dr Jens Jensen,**
> Data Security Architect for DAFNI

PARTNERS

Cranfield University

Heriot Watt University

Imperial College London

Loughborough University

Manchester 1824 The University of Manchester

Newcastle University

UCL Civil, Environmental & Geomatic Engineering

University of Bath

University of Birmingham

University of Bristol

University of Cambridge

The University of Edinburgh

University of Exeter

University of Leeds

University of Oxford

The University Of Sheffield.

University of Southampton

Credit: Adobe Stock / Rob

UKCRIC™

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FOR RESEARCH ON
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WORK WITH US

We are actively seeking collaborative partners from the research community, industry, government, the third sector, finance, commerce and investment communities to work with us to solve the complex problems relating to infrastructure, cities and systems.

There are a number of ways of engaging with UKCRIC; through direct commissioning of a facility or facilities, sponsoring a research stream, and framework agreements. We also offer technical consulting services and welcome collaboration on higher TRL opportunities via the trading company of UKCRIC, UKCRIC Limited.

If our Scientific Missions complement your organisation's research and innovation priorities, we'd like to hear from you.

CONTACT US TO FIND OUT HOW UKCRIC IS ABLE TO HELP.

UKRI Engineering and Physical Sciences Research Council