Evidence summary for policymakers

UNIVERSITY OF PLYMOUTH

Professor Steve Goodhew, University of Plymouth

TRADITIONAL BUILDING TECHNIQUES SHAPING THE FUTURE OF CONSTRUCTION AND CARBON REDUCTION

Summary

Efforts to reduce the construction industry's carbon footprint should focus not only on emissions from energy use during building occupancy, but also on emissions caused by the energy used or 'embodied' in the building's construction. This includes accounting for the energy needed to create, transport, dispose of and re-use building materials. Cob, a mixture of subsoil and fibre, was once a common building material where suitable subsoil was available. It has gradually been supplanted by a variety of more energy-intensive materials such as masonry and concrete. A cross-border research project led by the University of Plymouth explored whether traditional cob building techniques can be adapted so they comply with the thermal aspects of modern-day building regulations. Early indications from monitoring two full-sized prototype buildings are that cob has the potential to transform society and resolve many pressing public policy challenges. If adopted more widely, building with the adapted cob material will help the construction industry lower its carbon footprint. Energy use would also be reduced through the life of the product and, as cob uses locally-sourced materials, the risk of supply chain disruption is lower.

"There are very few institutions doing this work; the future of our people and our planet may well depend on research of this kind."

John Fordice, President, US Cob Research Institute

Artist impression of finished CobBauge building

Key points

- Buildings currently account for approximately 40% of all greenhouse emissions. A considerable amount of these are coded into the occupation of buildings. This element of energy use is currently falling. To 'buy' that reduction, considerable amounts of energy used in the construction process and in the generation of materials, such as insulation, is actually increasing.
- The CobBauge project demonstrates that this traditional building technique has an important role to play in the construction industry's future.
- The project team created a durable cob material with an innovative dual-layer composition that improved the thermal efficiency of buildings and met contemporary building regulations.
- A durable cob material that offered improved thermal efficiency was developed in Phase 1. Phase 2 saw the construction of two full-sized prototype buildings using the new material. These are now being tested and evaluated in a single-storey 'living laboratory'.
- Indications are that the newly created cob mixes help reduce CO_2 emissions by around 40% compared to masonry materials. Building with cob also drastically reduces waste and disposal.
- This could become a viable option for the construction of domestic scale ultra-low carbon buildings. It could also become the material of choice for upgrading and maintaining earthen-built dwellings already in existence.
- Cob can genuinely be classified as an ultra-low carbon material; it has clear advantages over other materials in terms of the energy needed to construct it and transport it and is sympathetic to local planning requirements.

Context

The Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report published in August 2021 argues that emissions of greenhouse gases from human activities, averaged over the next 20 years, will probably see global temperatures expected to reach or exceed 1.5°C of warming. One of the least environmentally friendly sectors in the world, which is contributing to this temperature rise, is the construction and building industry. In 2019, it was reported that the sector moved away and not towards the Paris Agreement on climate change of keeping the global mean temperature rise to well below 2°C. This highlights the urgent need to rethink how buildings less carbon can be embodied in building construction and use.

The issue

For centuries people have built homes with a mixture of subsoil and fibre. This housebuilding technique was popular in Southern England (where it was called 'cob') and in Normandy, France (where it was known as 'bauge'). Cob buildings are part of both countries' heritage; constructed using a range of techniques from the locally available subsoils, they reflect their immediate surroundings and environment.

In the middle of the last century, new building regulations meant cob as a construction material became less desirable. It did not comply with the thermal aspects of many building regulations across the world that require a minimum U value or thermal transmission value. Cob has gradually been supplanted by materials such as masonry and concrete and current estimates are that 8% of the world's carbon emissions are caused by the manufacture and application of concrete (Olivier et al., 2016). The challenge facing the construction industry now is to build in a way that also helps reduce CO_2 emissions from the construction process, reduces waste, improves energy efficiency and indoor air quality and ensures buildings are cheap to run.

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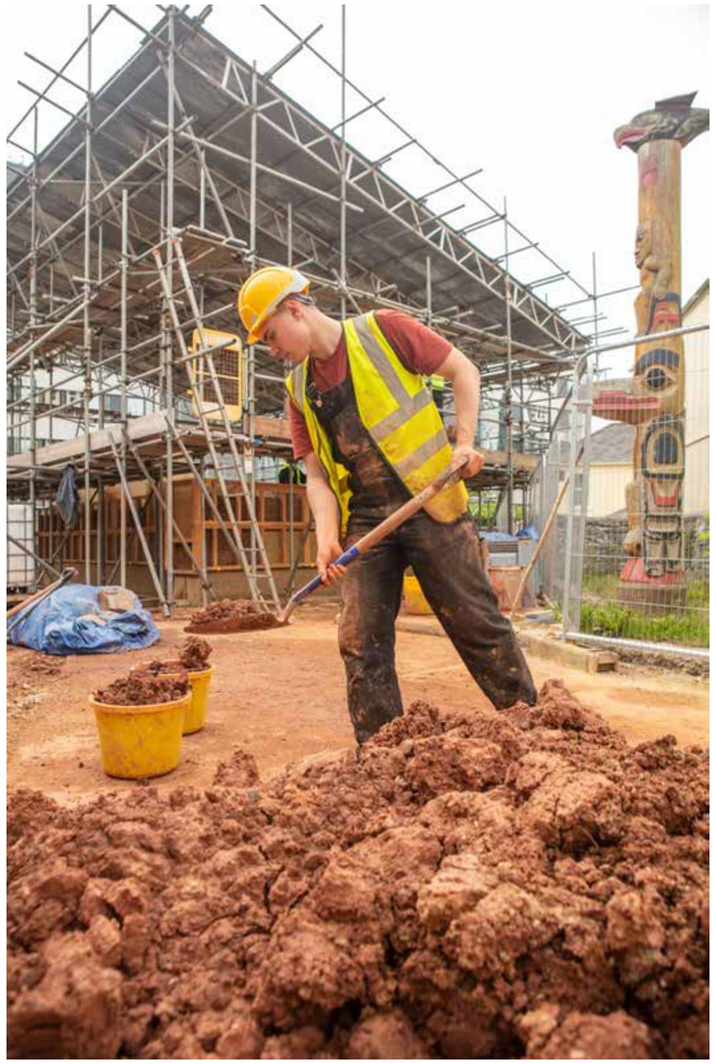


June 2022 Professor Steve Goodhew, University of Plymouth

Prototype CobBauge building at University of Plymouth campus

The project

The CobBauge project is a cross-border research project that aims to demonstrate that this traditional technique could play a role in the future of the construction industry. It is led by the University of Plymouth (UoP) alongside the Ecole Superieure D'ingenieur des Travaux de la Construction de Caen (ESITC), Syndicat Mixte du Parc naturel régional des Marais du Cotentin and Bessin (PnrMCB), Earth Building UK and Ireland (EBUKI) and the Université Caen-Normandie.

The University of Plymouth's Environmental Building Group undertook research to examine whether it was possible to scientifically upgrade cob so that it meets today's regulatory thermal and structural standards. In the first phase of the project, conducted in laboratories on both sides of the Channel, the CobBauge partners focused on creating a durable cob material that improved the thermal efficiency of cob buildings. New cob mixes – with differing ratios of soil and fibre – were created and then subjected to thermal and structural tests in line with building regulations and models of household energy efficiency. Efforts to create a material that would not exceed the 0.3W/m²K maximum U-value for walls led researchers to develop a composite product with two separate layers for structure and insulation. Using only natural fibre for insulation, they found they could increase the volume by up to 50% and significantly decrease the thermal conductivity value. The structural layer could then be optimised to create a density as high as required and could offer a ready-made solution for compliant low-carbon energy-efficient low-rise properties or the extension of existing historic buildings.

The project's second stage saw the construction of two full-sized prototype buildings using the new CobBauge material. Construction of one building, located on the University of Plymouth campus, began in August 2021. It utilised 'formwork' with cob being poured into a frame before being tamped down. This ensured the walls remained 'plumb' straight. The structural mix to form the inner part of the building was poured in first, followed by the thermal layer coating the external part of the building. The CobBauge material required time to dry and set. Both layers, measuring 300mm in thickness, dry at the same rate, offering complementary hygrothermal properties. The walls were then built in stages, or 'lifts', of 500mm in height.

Construction of the 30m2 building, the first to be approved under modern UK regulations, was completed in February 2022. The cob is now being tested and evaluated in a single-storey 'living laboratory': the building's thermal performance and air quality are being monitored through a range of climatic conditions by the project team. Meanwhile, the first commercial CobBauge dwelling is under construction in East Anglia. The planning process for a number of terraced social housing buildings on the border between Brittany and Normandy is also underway.

Monitoring these buildings will give researchers, project partners and other interested parties data and insights into how the material behaves during construction and, importantly, what sort of internal environment the CobBauge buildings offer. These results have been shared with the construction industry. Building guidelines for the new cob mixes have been published. More than 30 training videos will be shared online and via social media during 2022.

Industry engagement

The CobBauge project will be of particular interest to policy makers, planners, architects, designers, engineers and builders, as well as to clients who are interested in environmentally sound building techniques. Whilst it is unlikely that cob will replace concrete in large scale commercial projects, this scientifically upgraded version complies with current thermal building regulations, both in the UK (HM Gov. Part L, 2021), and France (RT2018). In time, it could become a viable option for the construction of domestic scale ultra-low carbon buildings, particularly in rural areas. It could also become the material of choice for upgrading and maintaining earthen-built dwellings already in existence.

Building guidelines for the new cob mixes have been published. More than 30 training videos will be shared online and via social media during 2022.

Project partners

Professor Steve Goodhew, University of Plymouth

Global relevance

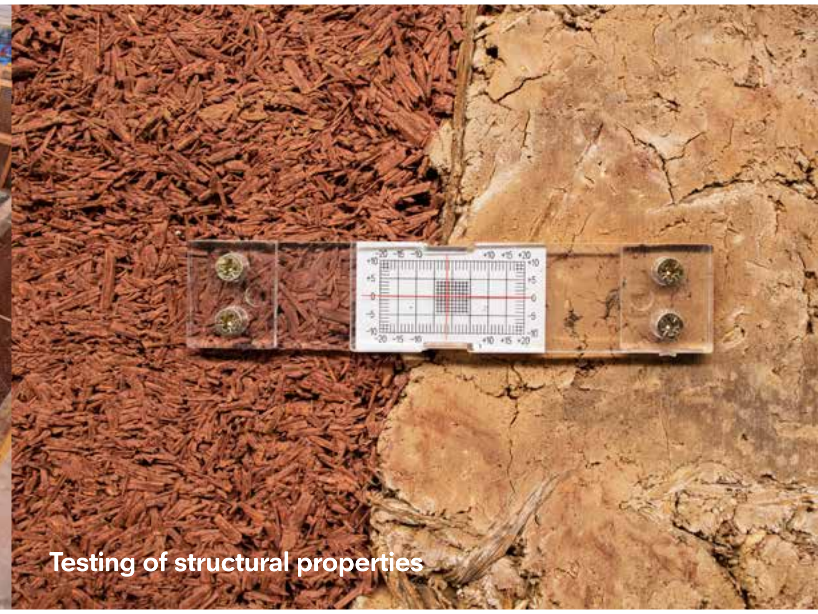
The project has attracted significant interest from the Australian Earth Building Association and the US Cob Research Institute. Both have experienced similar issues preventing the uptake of earth materials in their respective countries. The US Cob Research Institute (CRI) used the CobBauge project's research on the exceptional characteristics of cob and used the University of Plymouth's data regarding the energy efficiency of cob to supplement their work for cob construction to be approved for the first time and included in the 2021 International Residential Code (IRC), the modern, building safety codes that help ensure the engineering of safe and resilient structures in the US. The new earth building code has now been accepted in California and is likely to be replicated elsewhere in the USA as efforts to identify more sustainable and durable building methods, which construction-related waste and CO_2 emissions, intensify.

The newly created cob mixes were produced from local soils, helping to reduce CO_2 emissions by around 40% compared to the production of traditional masonry materials. They also reduced construction waste by a projected 16 tonnes per property (a saving of €2115 in terms of landfill costs).

Environmental benefits

Cob buildings are made from subsoil fibre and water. The newly created cob mixes were produced from local soils, helping to reduce CO_2 emissions by around 40% compared to the production of traditional masonry materials. They also reduced construction waste by a projected 16 tonnes per property (a saving of €2115 in terms of landfill costs). When a building comes to the end of its lifespan, local soils used for the cob mix can be returned to the earth from which they came. With the circular economy in mind, the ability to reuse the material again and again offers a particularly low impact and favourable Life Cycle Assessment and drastically reduces issues with waste and disposal.

By creating new inexpensive cob technologies that meet building standards (Construction and Housing Code, 2017; UK Building Regulations, 2016), local and national building firms and consumers can meet planning, environmental and financial challenges.



Testing of structural properties

Embodied energy

Embodied energy is the sum of all the energy required to produce a building, good or service. Describing the energy incorporated or 'embodied' in the product itself, it can be useful in determining the "real" replacement cost of a building and, because energy-inputs usually entail greenhouse gas emissions, in deciding whether a product contributes to or mitigates global warming.

Buildings currently account for approximately 40% of all greenhouse emissions; a considerable amount of that is coded into the occupation of buildings. As standards of insulation improve, the energy used to run buildings is decreasing whilst the energy used in creating materials used in construction is actually increasing. The quest for operational efficiency has unintentionally increased the embodied energy of the buildings they serve with energy being 'shifted' from the operations to the upfront building cost. This offsets the carbon savings of the whole-life cost.

In order to reduce the carbon footprint of infrastructure it is important to account for the energy embodied in construction materials. If the UK government quantified this energy use it could be included as part of the country's contribution to achieving carbon net zero. It is currently difficult for anyone purchasing a new build from a developer to choose an ultra-low carbon building; this is excluding those purchasing houses from actively contributing to reducing carbon emissions.

A new approach to building affordable and sustainable housing

By creating new inexpensive cob technologies that meet building standards (Construction and Housing Code, 2017; UK Building Regulations, 2016), local and national building firms and consumers can meet planning, environmental and financial challenges. The CobBauge project is helping address the need for affordable, sustainable, energy efficient dwellings. With increasing concern on the rising cost of living, the low energy operating cost of cob buildings could be transformative in social housing projects or in buildings occupied by people on low incomes.

Conclusions

Cob has clear advantages over other materials in terms of the energy needed to construct it and bring it to site. The construction process will also make use of the traditional skills of small businesses and tradesmen in areas where cob has historically been used. By developing new methods and training professionals in how to adapt this traditional technique, and with authorities requiring new construction and renovations that are sympathetic to the historic built environment, there is a clear benefit to having cob re-join the construction landscape.

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Sustainable Earth Institute

Evidence summary for policymakers

Relating to the following Global Sustainability Development Goals

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

15 LIFE ON LAND

A three-time winner of the Queen's Anniversary Prize for Higher and Further Education, the University of Plymouth is renowned for high quality, internationally-leading education, research and innovation.

The **Sustainable Earth Institute (SEI)** connects the University's world leading research expertise with the wider world to collaborate on creating a more sustainable future. We bring together researchers from natural and social sciences, engineering, arts, humanities, health and business, to take an interdisciplinary, systems-thinking approach to help tackle sustainability challenges.

This Policy Brief is part of a series aiming to inform policy-makers of our sustainability research, in particular around Net-Zero Carbon and Healthy Landscapes.

To read more in the series visit: www.plymouth.ac.uk/sei-impact

Voice of a sustainable earth

Researcher biography

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Professor Steve Goodhew is Professor of Environmental Building and the REF UoA 13 coordinator for the School of Art, Design and Architecture at the University of Plymouth. He is a Fellow of the Royal Institution of Chartered Surveyors as well as the Chartered Institute of Building, the Royal Society of Arts, the Higher Education Academy and a chartered environmentalist.

Prof Goodhew's research specialises in the monitoring of buildings and the relationship to perceived building performance with a specific focus on different monitoring techniques including the use of thermography and its use in relation to improving the energy and comfort performance of homes and commercial properties. He also works in the areas of sustainable construction materials, thermal measurements and wider issues in relation to the energy use in buildings.

He is a member of the editorial board of several peer review journals, a reviewer for a number of academic journals and a drafting member of ISO9869 'Thermal insulation-Building Elements, in situ measurement of thermal resistance and transmittance'.