INSIGHT#1 : CARBON

The embodied carbon of concrete has reduced by 28% since 1990

Carbon emissions is a simplified popular term for greenhouse gas emissions, a contributor to climate change. The concrete industry has made sector carbon-reduction commitments as part of the Climate Change Act, which legally commits the UK to meeting challenging reductions to emissions: a 34% fall by 2020 and 80% by 2050, based on 1990 levels. The inherent performance of concrete means that it can contribute to reducing the carbon emissions of the built environment.

The built environment is a significant contributor to carbon emissions, predominantly through energy use for heating, lighting and electrical goods. The construction industry therefore has an important role to play in upgrading existing buildings and ensuring that future ▶

The recent refurbishment of Centre Point in London demonstrates the longevity of concrete structures – a key factor in assessing whole-life performance. While the glazing had to be upgraded, the precast cladding panels only needed to be cleaned

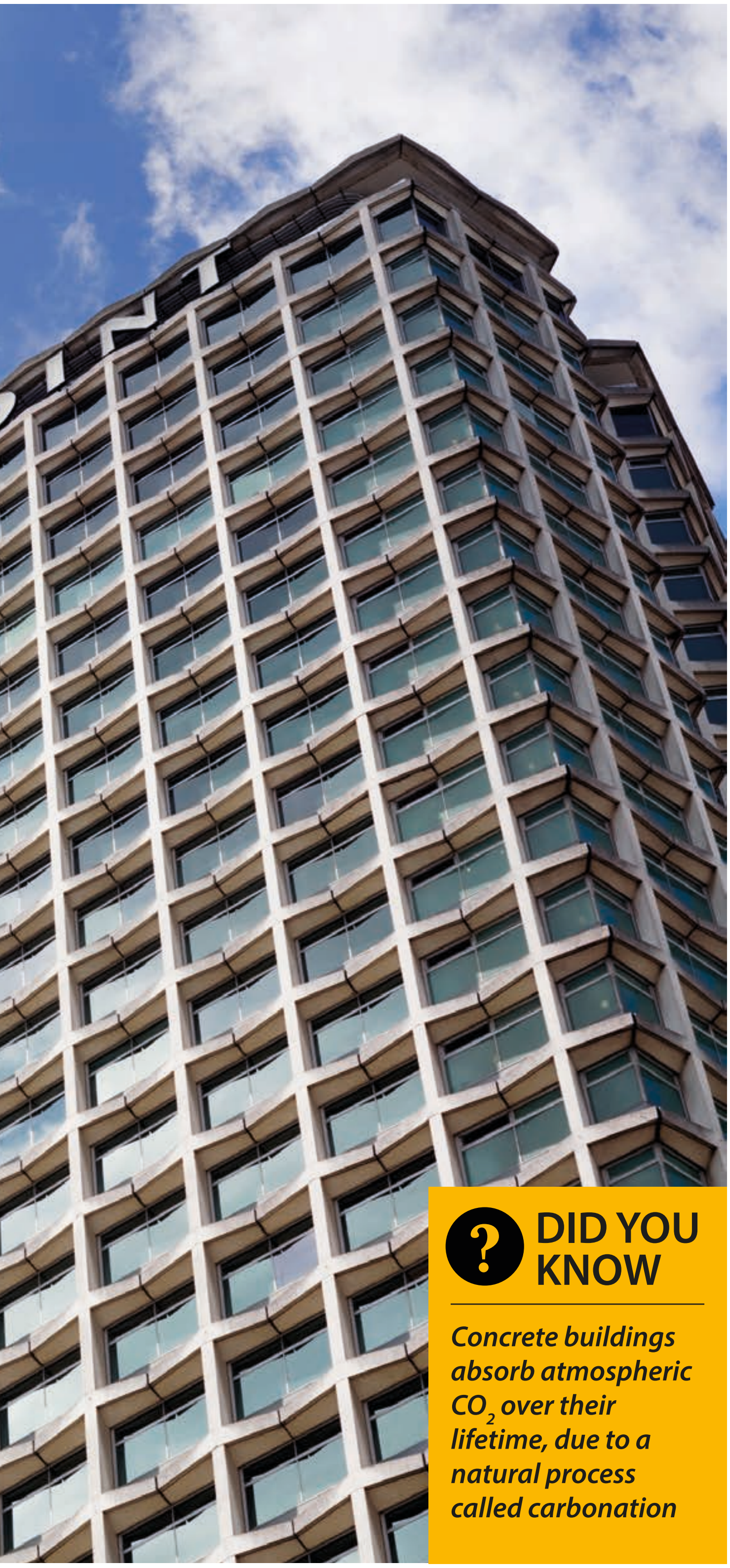


Photo: Paul Grundy

DID YOU KNOW

Concrete buildings absorb atmospheric CO_2 over their lifetime, due to a natural process called carbonation

EMBODIED AND WHOLE-LIFE CARBON

Over the past 10 years, the construction sector's approach to carbon assessment has begun to evolve from focusing almost exclusively on the embodied emissions associated with material production to a more complex evaluation of whole-life performance. This is the final piece of the carbon jigsaw, giving a more complete indication of what can be delivered by buildings and materials.

At the start of the carbon journey, architects and designers tended to focus exclusively on a material's cradle-to-gate impact, as this could be easily measured and assessed. But when used as the sole metric for carbon performance, design decisions could often be skewed. The advent of Environmental Product Declarations (EPDs), particularly those verified in compliance with BS EN 15804, is helping address this, as these often provide cradle-to-grave data at the material level, which includes emissions from the maintenance, replacement, disposal etc. of a material over its lifecycle.

EPDs are an important stepping stone to whole-life carbon assessment at the building level, which is made possible by the data EPDs provide. BS EN 15978 sets out a methodology, which is now used in tools such as IMPACT, ensuring that a building's embodied, operational and end-of-life carbon emissions are collectively measured and reported.

This is good news for concrete, which is expected to outperform other materials in whole-life carbon terms – a fact that wasn't necessarily reflected in a basic assessment concentrating on embodied carbon.

But with more sophisticated lifecycle tools now becoming available, concrete's contribution to minimising a building's overall carbon footprint can be validated in a more quantitative way. The specific qualities that can now be interrogated include those resulting from:

- durability, and minimal maintenance needs
- the ability to fulfil multiple roles (structural, aesthetic, thermal) often enabling other materials, finishes and services to be designed out or minimised
- inherent thermal mass, which can significantly cut building energy use
- longevity and adaptability, which can enable concrete buildings to be reused, reducing the embodied impacts of new-build.

Finally, in respect of embodied carbon it is worth mentioning that forthcoming updates to BS EN 15804, the standard that governs EPDs, is likely to disallow carbon storage in the figures calculated for construction materials – a change that will reward whole-life thinking.

Tom De Saulles is a building physicist at The Concrete Centre

buildings are more carbon efficient.

The concrete industry, via The Concrete Centre, provides designers with robust, detailed information on how carbon emissions from buildings can be reduced. It also provides guidance on reducing the embodied carbon of concrete through specification.

Concrete is a material made up of many parts to a variety of specifications, giving the designer the ability to control the carbon footprint. The main ingredients are fine and coarse aggregates, but essential to the mix is a 10-15% cementitious content that acts as the binder. This will normally be based on a mix of Portland cement and varying levels of low-carbon industrial by-products such as fly ash or ground granulated blast-furnace slag (GGBS). Overall, the embodied carbon of a normalised mix of concrete (see page 27 for definition) is now 73.7kg per tonne, a reduction of 28% from a 1990 baseline, achieved through the reduction of emissions generated during production.

However, it is crucial to consider carbon emissions not just in terms of the production of materials but on a whole-life basis, from design and specification through to construction, in-use performance and end of life. Concrete construction can contribute to buildings with lower whole-life carbon emissions in five key ways:

- By using concrete with a lower embodied carbon
- Through resource efficient design to minimise the amount of materials required
- Through energy efficient design to lower operational emissions
- By reusing concrete structures or elements of buildings
- By absorbing CO_2 through carbonation.

SPECIFYING FLY ASH OR GGBS CAN REDUCE THE EMBODIED CO_2 OF A REINFORCED CONCRETE FLAT SLAB BY

35%

(RESEARCH CARRIED OUT BY ARUP FOR THE CONCRETE CENTRE, 2010)

DECARBONISING CEMENT

The UK cement industry is a world leader in its drive to reduce carbon emissions. Since 1990, it has reduced absolute emissions by 49% – an achievement that is all the greater when you consider that 67% of the total arose when carbon dioxide (CO_2) was liberated from limestone, a critical and unavoidable part of the cement-making process. This huge reduction has been achieved through innovation and investment in efficient plant. But we know that there is much further to go if the UK is to meet its legally binding commitment to reduce carbon emissions by at least 80% by 2050. In 2013, MPA Cement launched its own ambitious strategy that sets out how an 81% reduction in carbon emissions can be achieved by 2050 with the right action taken by the cement industry, the UK government and others.

This is achievable by greater use of alternative waste-derived fuels and carbon-neutral biomass fuels, and cementitious additions to create lower-carbon cements, and lower indirect CO_2 emissions by improving electrical efficiency and decarbonising the electricity sector.

In the long-term, the development and effective deployment of carbon capture and storage/use technology will be crucial to achieving the target. This is one of the biggest opportunities to make further large-scale emission reductions. Early exploration work shows there are two types of technology that could work, but additional research is needed, and the heavy investment will not be justified until government resolves the practical issues of transport and storage – and the political issue of unequal carbon prices.

Richard Leese is director of industrial policy, energy and climate change at the Mineral Products Association

IN PRACTICE

Twiga Lodge, Surrey

Doctoral researcher Eirini Mantesi at Loughborough University carried out a major evaluation of the energy consumption of Twiga Lodge in Surrey, a newly built house using insulated concrete formwork (ICF), constructed to high levels of thermal efficiency and airtightness. As the UK's first research project on ICF, it provides invaluable data to allow comparisons to be evaluated between software-predicted and "as-built" performance.

The lodge is a two-storey, three-bedroom home, with a floor area of approximately 250m^2. It was designed with an insulated raft foundation in conjunction with ICF walls and an insulated panel roof system, achieving an overall U-value of 0.11W/m^{2}K.

The monitoring period lasted for 18 months and investigated the thermal performance of ICF under all climatic conditions representative of a UK year.

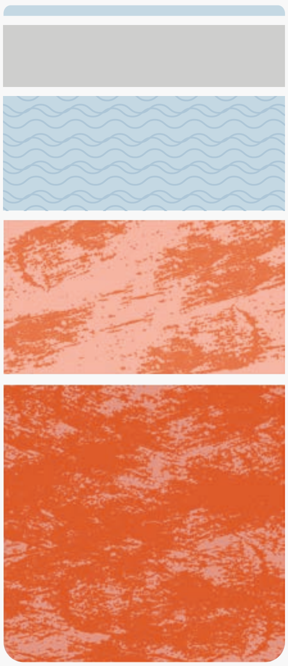
The results showed that ICF was able to significantly moderate the internal air temperature swings, providing a stable internal environment, and that the average internal air temperature was calculated between 22°C and 25°C during summer and around 21°C during winter.

The total annual electricity and gas consumption of the house was calculated to around 2,015kWh and 8,425kWh, which translates to a total annual utility cost of £691. In addition, the PV panels generated 4,609kWh of electricity. Overall, the net utility cost is zero.

The project is supported by Aggregate Industries.

What's in a typical concrete mix?

Approximate proportions by volume



IN PRACTICE

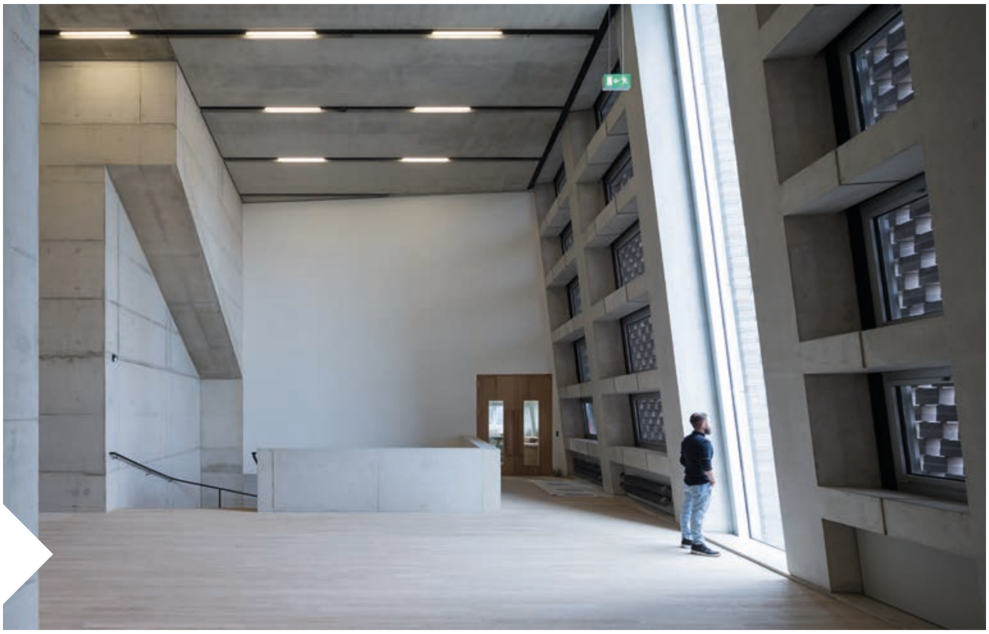
Tarmac Masonry Homes, Nottingham

These two test homes aimed to demonstrate how zero-carbon housing could be delivered at a low cost using proven and readily available masonry products and techniques, providing a template for UK housing.

Designed by architect Bill Dunster's Zed Factory as part of the University of Nottingham's Creative Energy Homes project, in partnership with Tarmac Buiding Products, both homes have three bedrooms, and are intended to be affordable and easy to maintain. Specifying concrete and masonry had a number of sustainability advantages over other methods of construction, including the use of locally sourced materials, high levels of airtightness, high thermal mass to counteract summer overheating, and the sheer longevity of the buildings. They are also fire-resistant, highly secure and built using traditional low-risk techniques.

Both properties also incorporate sustainable technologies including flat plate solar water heating panels, high-efficiency appliances, rainwater harvesting and sun pipes. Completed in 2010, one home was built to meet Level 4 of the Code for Sustainable Homes, the other to meet Level 6 (the highest). Nottingham University is continuing to monitor the homes in occupation.

Photo: Iwan Baan



At Tate Modern's Switch House extension in London, a pale-coloured concrete mix containing 50% GGBS cement replacement was used for the precast concrete frame