Architecture

The tyranny of concrete and its costly carbon footprint

Billions of people live and work in buildings made of the material — but it exacts a heavy toll on the environment

Layli Foroudi MAY 21 2021

Since the first Pritzker Prize announcement in 1979, the feats recognised by architecture's most prestigious award — known as the Nobel of the profession — have tended to be cast in concrete. This is as much a reflection of our built environment as it is of the prize.

But this year, judges took a different direction and honoured a French duo whose projects have involved keeping old concrete structures intact, saving the client money and the world carbon. Potentially a lot of carbon: according to a UN Environment Programme report published in 2020, concrete accounts for 9 per cent of global emissions.

This year's Pritzker Laureates Anne Lacaton and Jean-Philippe Vassal opt for preserving and upgrading existing structures rather than demolishing them to build something new. Some of their most innovative projects are big concrete public housing blocks, such as the Grand Parc estate in Bordeaux in 2017. Instead of demolishing this Modernist estate built in the 1960s, they improved the quality of 530 flats.

Having this type of architecture recognised as the "highest standard to aspire to is a positive thing", says Oliver Wilton, a professor in environmental design at University College London. "It feels like what was happening when concrete was getting trendy in the first place, but now there is cultural prestige that is starting to attach itself to reuse."

Concrete has been used in construction since Roman times and reinforced concrete — the type most buildings are made of today — was patented in 1867. But it was around the mid-20th century when concrete usage took off.

This coincided with the growth of cheap fossil fuel-generated heat that made building with these substances cost and time efficient, says Barnabas Calder, an architectural historian whose book *Architecture: From Prehistory to Climate Emergency* charts how architectural forms have been driven by energy availability at the time. “Reinforced concrete is the most insanely wonderful building material . . . it is a superpower for architects.”

Swiss-French architect Le Corbusier used concrete after the first world war to achieve large-scale housing projects in straight lines. Brazilian architect Oscar Niemeyer — famed for his pioneering curved concrete designs, and who won the Pritzker in 1988 — once said in an interview that “the artistic capability of reinforced concrete is so fantastic — that is the way to go”.

He used the material so much that the Brazilian press called him the “Picasso of concrete”. And worldwide, reinforced concrete really did become “the way to go”: 70 per cent of the world’s population now live in a building made of reinforced concrete.

Museu Nacional da Republica, by ‘the Picasso of concrete’ Oscar Niemeyer, Brasília, Brazil © Alamy

But the concrete-fits-all approach is coming under scrutiny for reasons that weren’t considered by its lauded champions. In particular, concrete’s extremely heavy toll on the environment. “By and large, these changes [in architecture] have been economically rational for each actor involved,” says Calder. “But we need to recognise that carbon-equivalent emissions are much more important than numerical figures related to money.”

The bulk of concrete's carbon footprint is from Portland cement, named for its resemblance to Portland stone, a white-grey limestone quarried on the Isle of Portland on the southern English coast. Its footprint is due to the chemical reaction that produces clinker, the component that gives cement its binding properties, which emits a lot of CO2 itself and requires heating to 1,500C.

Add to that the impact of steel — which as an industry accounts for 9 per cent of global emissions, according to a recent paper in the scientific journal Nature — that is used to reinforce concrete.

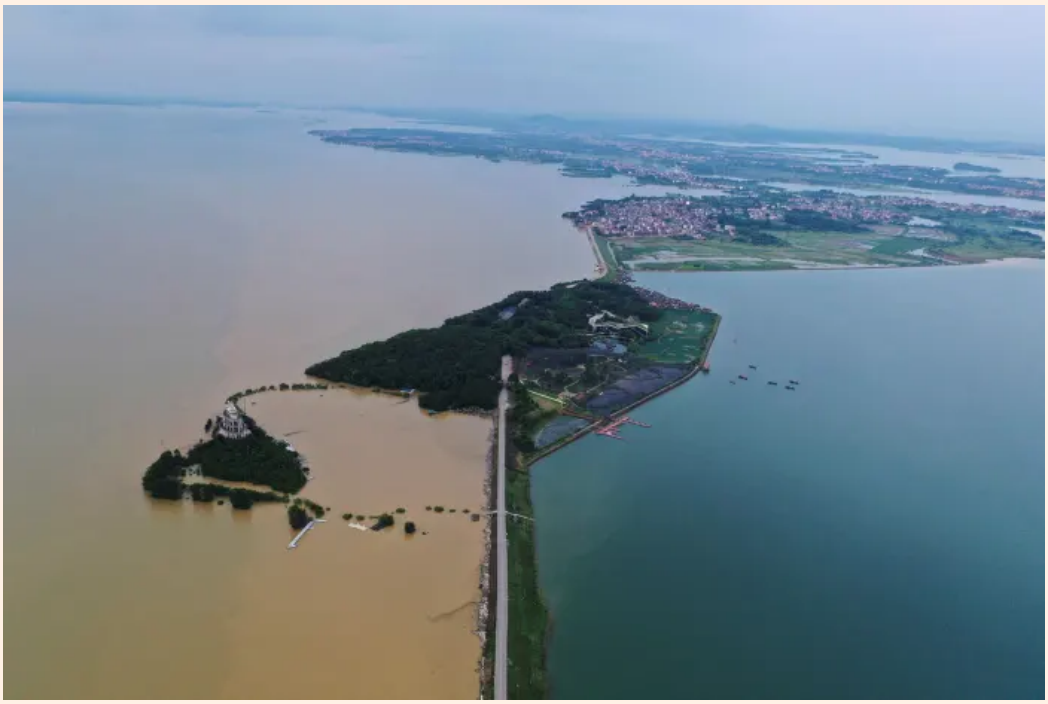
This aspect of construction pollution can go unnoticed where sustainability definitions and regulations are based on how much energy a building takes to run. Yet, embodied carbon — the CO2 emitted to produce a building — on average "makes up between 30 and 70 per cent of a building's lifetime carbon, which is a significant chunk that is just not being addressed," says Paloma Gormley, partner at Practice Architecture in London.

"The focus on energy efficiency over the past decade has seen projects with extraordinarily high embodied carbon receiving awards for sustainability."

Cement plant, 1964 © Bridgeman Images

For example, the Bloomberg building in the City received a rating of 99.1 per cent from the UK's sustainability assessment scheme BREEAM in 2018 despite its heavy use of concrete and steel. Gormley says "embodied carbon is not given enough weighting in the BREEAM certification process". BREEAM, however, says that materials are taken into account and that the "rating achieved by Bloomberg therefore reflects their holistic approach to sustainability".

Another concern is that the mining of sand, which is mixed with cement to make concrete, is having devastating effects on landscapes. The ideal sand for concrete is found in riverbeds. "Nature does the work for you — the size, the shape, there is no salt," says Louise Gallagher, environmental governance lead for the Global Sand Observatory, a UN initiative in Geneva. Desert sand is too smooth, and beach sand needs washing.



Mining sand, which is mixed with cement to create concrete, is ruining landscapes and disrupting wildlife in places including Poyang Lake, Jiangxi Province, China © China News Service via Getty Images

In places such as India, China and Jamaica, excessive sand mining has led to collapsed riverbanks and disruption to fish-reproduction cycles, Gallagher adds. While she says there are no comprehensive statistics on the sand economy, the Observatory estimates that 50bn tonnes of sand are mined each year, mostly for concrete.

Global concrete production has not shown any signs of slowing down: more than 4bn tonnes of cement are produced every year; more than half in China, according to the International Energy Agency (IEA). CO_2 emissions from cement are expected to rise as much as 25 per cent over the next decade due to an increase in production. Yet there are signs of change.

As well as an increase in retrofitting, such as the work of Lacaton & Vassal — and developments in technology such as diamond-wire saws that make it possible to cut and reuse elements of concrete buildings — more architects are looking to lower-carbon materials.

The 35m-tall Dalston Works in east London by Waugh Thistleton was the world's largest cross-laminated timber (CLT) building upon its completion in 2017. With timber buildings, the embodied carbon is negative because trees store carbon until they decompose.

The French government has bought into the idea, declaring last year that all public buildings should be made with at least 50 per cent wood from 2022. British decision makers, however, went in the opposite direction, imposing a ban on combustible materials, including wood, for exterior walls on residential buildings over 18m tall, after the Grenfell Tower fire in 2017.

The repurposed Grand Parc 1960s estate, in Bordeaux, was upgraded rather than demolished © Philippe Ruault

"It is a simplistic blanket ban and a knee-jerk reaction to Grenfell," says Andrew Waugh, the founding architect of Waugh Thistleton, adding that CLT is encapsulated both sides with fire protection.

"[CLT] is necessary as a replacement [for concrete]," says Waugh. "As a species, we need to stop scraping our resources off the surface, we need to use resources that we can regrow."

However, Wilton of UCL — who worked on the award-winning carbon-negative and fully recyclable Cork House in Berkshire, completed in 2019 — doesn't see plant-based materials as a silver bullet. "You can't just stop using concrete and build everything out of cork, without there being serious implications" such as habitat loss, he says.

Award-winning carbon-negative and fully recyclable Cork House, in Berkshire © Tom Jamieson for the FT

Sparing the forests, other architects are thinking about stone and steel-reinforced stone, such as French architect Gilles Perraudin, who proposes making high-rise buildings out of the material.

Meanwhile, scientists are working on how to produce cement without the carbon-heavy clinker. One option is to use coal fly ash or blast furnace slag, which is closer to the type of concrete the Romans made, using volcanic ash to build the Pantheon in Rome.

"These are byproducts of declining industries and are not enough to meet demand so clinker needs to be replaced by multiple substitutes," says Rupert Myers, lecturer in sustainable materials engineering at Imperial College London. His Australian research group Zeobond created an alternative binder using geopolymers.

But the uptake is slow, he says. "Concrete producers want to decarbonise but they are struggling to. A key reason is because everyone knows how to use Portland cement."

Concrete's sticking factor could have as much to do with the material as the industry's way of functioning. Anupama Kundoo, an Indian architect renowned for her ecological and site-specific designs, traces construction's sustainability issues to the industry's tendency to standardise and mass produce.

Ecologically designed houses by Indian architect Anupama Kundoo © Javier Callejas

"We think it is liberating us — this automated thing, the A4 paper size, the ready-made pizza. It is a convenience but it is a tyranny," she says, adding that she resists repeated requests to "scale up" her site-specific innovations.

In her work, Kundoo doesn't completely shun cement. She has mixed small quantities with rammed earth to make her houses monsoon-proof and uses ferrocement, a cement-based material that is reinforced with a light metal mesh. This can end up four times lighter and much cheaper than normal reinforced concrete.

"If you are seriously concerned about sustainability, it is not just materials — it is our human way of using things that will allow us to sustain our practice," she says.

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