mpa The Concrete Centre

CONCRETE QUARTERLY

AUTUMN / WINTER 2020 | ISSUE NUMBER 273

BLESSED UNION
Patel Taylor marries an exposed concrete extension to the Bath stone of St George's Bristol

CAST AND FURIOUS
Concrete takes pole position at Pirelli's new office building and Coventry's car research centre

HOT DESKS
How thermal mass and low-energy ventilation can keep schools cool in a warming climate

CASTING OFF

Concrete Quarterly is published by The Concrete Centre, part of the Mineral Products Association, the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and silica sand industries. mineralproducts.org

CONCRETE QUARTERLY

Editing and production: Wordmule
Design: Nick Watts Design

On the cover:
St George's Bristol by Patel Taylor. Photo by Peter Cook

DON'T MISS AN ISSUE

Read the online version of Concrete Quarterly at **concretecentre.com/cq**. You can also sign up for email updates about new case studies and technical content at **concretecentre.com**

Elaine Toogood
Head of architecture, The Concrete Centre

Playing to our strengths

Like many of you, I've been thinking a lot about how we can build back better after COVID. We've had a chance to stop and reflect, to reconnect with what's important to us, and to our communities and to nature. We have seen that when something major happens, we can do things differently. So what should we be doing differently?

Something that stood out to me in this issue of CQ was Cullinan Studio's hybrid design for the National Automotive Innovation Centre at Warwick University (see page 12). Here, in the words of practice leader Roddy Langmuir, each material is doing what it's best at.

It struck me that this is the kind of thinking that we need on every project if our solutions are to be appropriate and fit for purpose. What is often missed in the immediate response to a crisis is that we still need to take a long-term view. This is especially true in the case of the built environment, which will be around for many decades to come. To address the urgent issue of climate change, we need to save as much carbon as we can now, but we also need to think about what the future holds – how well will a building perform under future climate conditions and how easily will it adapt? The danger of rushing to knee-jerk solutions is that they don't last, that we just postpone tackling the real issues, or worse, that we will be managing unintended consequences further down the line. Overheating in schools is a key example – turn to page 14 for a detailed exploration of how thermal mass can be used for low-energy cooling.

WHAT IS OFTEN MISSED IN THE IMMEDIATE RESPONSE TO A CRISIS IS THAT WE STILL NEED TO TAKE A LONG-TERM VIEW

The other side of the coin is the embodied carbon of a material itself, something the industry continues to work hard to reduce. The European Commission will this week call for a new emissions reduction target of "at least 55%" by 2030 compared to 1990 levels, according to a leaked draft seen by The Guardian. The concrete industry is already close to meeting this, having delivered a 53% reduction in carbon emissions since 1990, and reporting annually on performance since 2008 as part of the industry's sustainability strategy.

There is no silver bullet for climate change. Mitigating it will take hard work, collaboration and diligent application, as will adapting to the change that is already occurring. As designers, our role is to carefully consider every decision we make on every project, to fully utilise each material's properties and strengths, and to look beyond the headlines to understand both the bigger picture and the details.

ABOVE Agar Grove in Camden by Hawkins\Brown will be one of the schemes featured in a free lunchtime webinar on Passivhaus projects in concrete, hosted by The Concrete Centre on Monday 12 October from 12.30-13.30. Register at **concretecentre.com/events**

Photos: James Newton; maudanros / Alamy Stock Photo; Ally O'Rourke-Barrett; Helge Høifødt

ROUND-UP: PIANO, PICASSO AND PLAY LABS

Even in this year of lockdowns and furloughs, projects continue, and some even get finished. Notable completions over the summer include Allies and Morrison's Sir Michael Uren Building 1, a concrete-finned laboratory in west London named after the pioneer of ground-granulated blast furnace slag, and Renzo Piano's replacement for the Morandi Bridge 2 in Genoa, just two years after its tragic collapse. The 1km-long Genoa San Giorgio Bridge rests on 18 slender reinforced-concrete piers, designed to touch as lightly as possible on the neighbourhoods below. Meanwhile, the shift to learning outdoors in the COVID era has inspired Matter Design and Cemex to team up on an experimental play lab 3 at a school for gifted children near Philadelphia. The Grayson School's "megalithic playscape" features huge, otherworldly concrete elements with anchor points for ropes and junctions for wooden extensions that serve as "scaffolds to fuel the imagination". Finally, demolition has begun on a building that served as a scaffold for one of the 20th century's greatest imaginations. Built in 1969, Oslo's Y-Block office building 4 has a Picasso mural sandblasted directly onto one facade and another in the lobby – the artist's first use of concrete as a canvas. Officials have promised to remount the murals on the replacement building when it is completed in 2029.

INNOVATION: BIO BLOCKS

"Add complexity, and you give life a much better chance of thriving"

Photos: University of Plymouth

Looking a little like giant dice, the five concrete cubes on Teats Hill Beach, Plymouth, are an ongoing experiment in how to encourage marine life to inhabit man-made coastal environments. Each facet of these "Bio Blocks" contains different features – holes, overhangs and recesses of various depths. Everything from kelp to crabs and sea snails can try out a surface to see how they like it.

Plymouth University's Dr Louise Firth has been involved with the project since its inception in 2018. "Expanding populations mean that human development is inevitable, and much of the world's population lives on or near the coast," she explains. "So new development often means replacing physically complex natural habitats, anything from a mangrove to a rocky shore, with hard, engineered structures. Unfortunately these are usually smooth, uncomplex, and leave little room for marine life."

Using concrete's unique ability to be moulded, Firth and her team have been attempting to recreate the complex shapes and surfaces that nature prefers. "Each Bio Block contains multiple habitats," she says. "Overhangs provide shade, different-sized species occupy different-sized holes, and rockpool-like recesses offer shelter for creatures that need to keep wet when the tide is out."

Firth terms this approach "making space for nature" and says it can considerably soften the environmental impact of coastal development. "The principles we use here can make a big difference. Think about sea walls, rock armour defences and concrete groyns – these are all normally constructed from smooth, solid concrete or stone. Add complexity though, and you give life a much better chance of getting a foothold and even thriving."

The $1m^3$, 2.4 tonne Bio Blocks are made by Brixham-based Arc Marine, which specialises in concrete for marine applications, including its signature product: Reef Cubes. These are hollow cubes made from recycled aggregate and low-carbon concrete. They range in size from $150mm^2$ up to $2m^2$ 12-tonne giants, and can be deployed as protection for underwater installations like cables, or to create offshore breakwaters. Advanced casting techniques create a rough surface that invites marine life to attach itself, while the interlocking hollow shapes provide reef-like structures where fish and crustacea can breed.

"This whole area was quite niche only a few years ago, but recently it has exploded," says Firth. "There is now a lot of research going on, and companies all over the world have started producing concrete products that enable the built environment to work with nature, rather than against it."

■ **Interview by Tony Whitehead**

LASTING IMPRESSION

CHLOË PHELPS

MID-CENTURY CROYDON – A TOWN THAT JUST WENT WITH IT

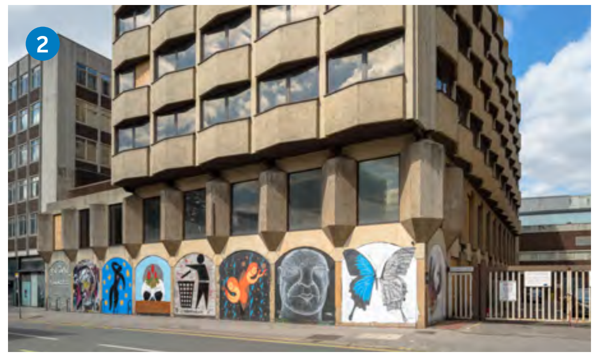
Croydon, where Common Ground is based, is famous for its mid-century commercial architecture. It's such a part of the area's character – that era of architects trying to do something new and not necessarily following the norms. At their best, the buildings have an unabashed confidence. The designers just picked a particular form and ran with it.

Perhaps the most famous example is the "50p building" by Richard Seifert, immediately outside East Croydon station, but Seifert also built a less well-known office building just down the road. In contrast to the 50p, Corinthian House (1) (1964-65) is just a beautifully refined, purpose-built office building, with a really elegant chevron composition in plan. The first thing you notice is this amazing wafer-thin canopy that projects out onto the street, then you see how it floats above these triangulated pilotis. Then you look up, and it has this wonderful undulating soffit. It's not shouty, it's just a very nice setpiece building that has thankfully been kept and restored.

20 Katharine Street (2) (GR Toogood, 1975-81) hasn't been so lucky. It was sadly demolished recently, but was a great example of how you can achieve a lot with not very much – in this case a single faceted spandrel panel that repeats over a tall, square composed facade. There was very little in terms of material variation, but it was highly sculptural, with real depth and character to the facade. The expressed base was quite an amazing thing: an arched colonnade on the ground floor with huge rhomboid column heads that spanned the whole of the floor above. As a practice, we really loved the way it presided over part of Queen's Gardens, one of the main squares in Croydon, and it became the main inspiration for our own Fairfield Homes residential scheme – we've transposed the faceted base to become balconies.

My final choice is the building that I call home – the Hallfield estate (3) (Berthold Lubetkin with Tecton, 1951-58) in Bayswater, west London. It's one of those buildings that gives a little bit more every time you walk around it. It's incredibly well-resolved in that it manages to clothe the homes in very intricate geometric cladding without compromising the internal arrangement at all. The estate is surrounded by these grand stucco-fronted terraces, but it works surprisingly well as a backdrop. It's a really interesting balance of something that's incredibly bold and really contextual at the same time.

Chloë Phelps is head of design at Common Ground Architecture



Photos: 1 Iain McLean Photography; 2 James Evans, archoptical.uk; Chloë Phelps

FROM THE ARCHIVE: AUTUMN 1968

ROGERS AND FOSTER – NEW KIDS ON THE BLOCK

The retirement of Richard Rogers, announced in September, marks the beginning of the end of an era in British architecture, one that perhaps started with a house of concrete blocks on the south Cornish coast. Creek Vean was one of the earliest projects completed by Rogers and his then-partners, his wife Su and Norman and Wendy Foster – and prompted the first mention of any of their names in Concrete Quarterly. It did so with little fanfare, tucking them in behind an item on a Crawley housing estate at the end of a longer feature on the architectural use of concrete blocks. However, the fact that the inside front cover was dedicated to a full-page photograph of the house's geometric exterior (right) suggests that the CQ editors liked what they saw.

CQ admired the way that the "plain, natural" walls were dramatised by the ingenious planning, "which makes space flow into space", as well as the complementary palette of blue Welsh slate floors and frameless sliding windows. "The choice of materials seems absolutely right both for the Cornish setting and as a natural background for the display of works of art," the article concluded, giving an early stamp of approval to two architects who would soon become among the most sought-after in the world. (It was pretty impressed by the Crawley housing estate too …)

Access the full CQ archive at concretecentre.com/cqarchive. A book, *The World Recast: 70 Buildings from 70 Years of Concrete Quarterly*, is available from concretecentre.com/publications

ORIGIN STORY

SOBORO

CHRIS TWADDLE ON A HOUSE THAT FINDS SPACE FOR THE RUSTICATED AND REFINED SIDES OF CONCRETE

Soboro came about when the owner of an end-of-terrace Victorian property saw the possibility of building a house in the garden, on the plot of a former garage. He called the local council to ask for advice and they recommended he contact our studio. We knew the council was generally supportive of buildings that didn't just follow the standard narrative on these types of plots and hoped this was why we were put forward.

The idea of a concrete building emerged early on. The plot was between stucco / painted brick and late 20th-century brick and we were looking for a material that would work in this situation. The small footprint meant that a basement was always going to be part of the scheme, which also pointed towards concrete.

There was an urge to exploit the variety found within a single material. Rustication came into the equation as a way of differentiating the basement and ground from the upper floors – the difference here being the heaviest rustication would be seen internally rather than from the outside. When we first discussed the project, our structural engineer Tim McFarlane described it as "an essay in concrete" – Tim is an inspiration and development meetings with his soft pencil in hand were always great.

This way of thinking conjured up ideas of something hewn from the ground and formed with a pattern of solids and voids. A cuboid was cut into the front elevation to form a terrace and a box protrudes at the rear as part of the bedroom. Lightwells were positioned at the front and rear to allow natural light into the basement. We also realised that, with the use of concrete, the basement could extend under the garden of the main house, doubling the size. This further reinforced this idea of digging out and casting spaces in the ground.

I studied at Duncan of Jordanstone College of Art (Dundee School of Art) in the brutalist nautical Matthew Building, designed by James Paul. I can still recall questioning why we could see woodgrain markings on the concrete – we didn't know how or why this occurred but liked it a lot. Twenty-five years later, I would show our client for this project a photograph of the effects of light on the Matthew Building's board-marked concrete to illustrate the effect we were trying to achieve.

Photos: Henry Woide

In Soboro, there is a certain depth and at the same time simplicity that would be hard to achieve in any other material. The timber shuttering was made into panels off site, carefully set out both in width and variation of depth and rubbed down to make the grain more pronounced. After sampling various concrete mixes we decided the batch delivered to site was going to work well although the precision of the factory-made samples isn't there and natural variations occur. This was seen as a feature of the material, the variation adding interest, not unlike the qualities found in timber.

On the upper floors, precast panels allowed concrete to be exposed inside and out, with the insulation sandwiched in between. From the exterior, grit-blasted panels on the lower floor and acid etching on the upper level continue the rustication. Internally, a glass-smooth "as struck" finish made a distinct contrast to the textured underground space.

Excavating a basement in a tight urban site can be tricky, and this was no exception. Watching it progress gradually – due to the sequential nature of the in-situ elements – added to the sense of slight apprehension. It wasn't until much later, when the slab and lid were on, that the qualities of the operation could be appreciated. Deliveries of panels and demi-decks for the upper floors took place in an incredible two days – watching the panel installers crane an 11-tonne panel into place was remarkable.

Chris Twaddle is co-founder of kennedytwaddle

SONGS IN THE STONES

Concrete provides the perfect accompaniment to the Bath stone of Robert Smirke's St George's Bristol, finds Tony Whitehead

In 1976, St George's Church in Bristol was repurposed as a concert venue. It became particularly favoured by classical and folk musicians who valued the superb acoustics, and in 2000 an upgrade installed a small bar in the crypt. More success followed, but with it came problems. There was a lack of facilities for high-profile artists and congestion problems for the audience who experienced long queues to get an interval drink.

An extension was clearly needed if St George's was to realise its ambition to become one of the country's foremost performance venues. But how to add to such a building? It was built in 1823 with columns and portico in the Greek Revival style and this, together with stony spaces in the crypt, gives it a rather ancient, almost mystical atmosphere.

"This is one reason we chose in-situ concrete," says the extension's designer, George Ferrari of architect Patel Taylor. "The church almost seems to grow out of the hillside where it is situated and concrete has this primary, of-the-earth feel to it – like the stone walls of the original crypt."

Ferrari also noted the way in which the material mix of the original building changes – with rough-hewn stone at ground level, but smoother finishes above. "Like a lot of buildings in Bristol and Bath, the original church has a combination of rough pennant stone with paler, smooth-finished Bath stone. We liked the contrast so we did something similar in going for an exposed in-situ concrete frame with some Bath stone walls and details."

The new building comprises two floors. The lower is on the same level as the crypt and provides a much-needed cafe-bar able to accommodate a full house of 560 patrons. The upper storey is level with the performance hall and contains multipurpose rehearsal and event spaces, as well as back-of-house areas for management and performers.

"We don't touch the existing church structurally," explains Ferrari. "The connections are very light – such as the glazed roof which slants down from the church to the new building. It was also important to us that the new spaces, in the bar area especially, were open and welcoming, so we have very few shear walls and just two columns."

This relative lack of support, and the fact that the building connects with but is not braced by the older building, created a challenge for the structural engineer (see box, overleaf). Essentially the extension is supported on the side away from the church by a long reinforced external concrete wall which is stiffened at 2m intervals by regular fins or piers that project out into the bar space. As well as their structural function, these piers have been put to work on the lower level, where the alcoves they create have been fitted with shelves for the bar.

Budget constraints meant that there was little scope for fancy mixes or hi-tech formwork. The mix

CONCRETE HAS THIS PRIMARY, OF-THE-EARTH FEEL TO IT – LIKE THE STONE WALLS OF THE ORIGINAL CRYPT

Smirke's concrete legacy

If Robert Smirke is remembered at all these days, it is for designing the huge classical facade of the British Museum. But the architect of St George's has an arguably more significant claim to fame: he is credited with reintroducing into the UK the use of concrete for foundations.

It was in 1816 that Smirke was called in to save the newly built Millbank Prison in London from collapse following severe structural problems. Together with the engineer John Rennie the Elder, Smirke recommended underpinning the entire building with concrete – thought to be its first use as a foundation material since the days of the Roman Empire.

It proved so successful that Smirke went on to deploy concrete for the foundations of the British Museum – but before that, it seems, he honed his technique at St George's. Completed in 1823, the church predates his Bloomsbury masterpiece by several years.

This was only revealed when Buro Happold dug an investigative pit at the side of the building to establish how the structure was founded. "Much of the church is built directly onto rock, but because the rock-head has a dip in it, this is filled with concrete," says Buro Happold director Claire Smith. "We were not surprised to find it – it's what you expect foundations to be made of – but it would seem to be a very early example of its use."

is standard structural concrete and there is nothing special about the plywood board shuttering. Despite this, Ferrari wanted the finish to be as good as it reasonably could be. "The bar area, for example, is a very visible part of the building and we wanted the finish here to be quite fine," he says. "Being among the earlier pours the contractor had not quite refined the technique, so some piers were a little too rough and had to be remade. What we have now is pretty good. I like the idea that, with the piers, the wall is thick enough to contain things – a bit like the inhabited walls you find in castle architecture."

The first-floor slab is supported by 8m-long reinforced concrete downstand beams which extend from each pier across to a massive 525mm x 375mm in-situ concrete beam that runs parallel to the bar and is supported by two columns and the lift core. The slab reaches beyond this beam towards the church, but does not touch it – first-floor access to the performance area being via two glass "bridges".

This arrangement of beams has a structural logic that is satisfyingly easy to read, the plain concrete has a textured yet consistent surface, and the whole effect is amplified by subtle architectural detail. The beam on top of the columns, for example, has a cast-in groove along its underside – a "go-faster stripe", as Ferrari calls it. In fact, this detail both celebrates the beam's length while breaking up the visuals of its hefty underside.

"It was also important for the beams to clearly look like they are sitting on top of the columns," he adds, "so the two columns are a little wider than the beam they support. It helps to differentiate them as separate, monolithic elements."

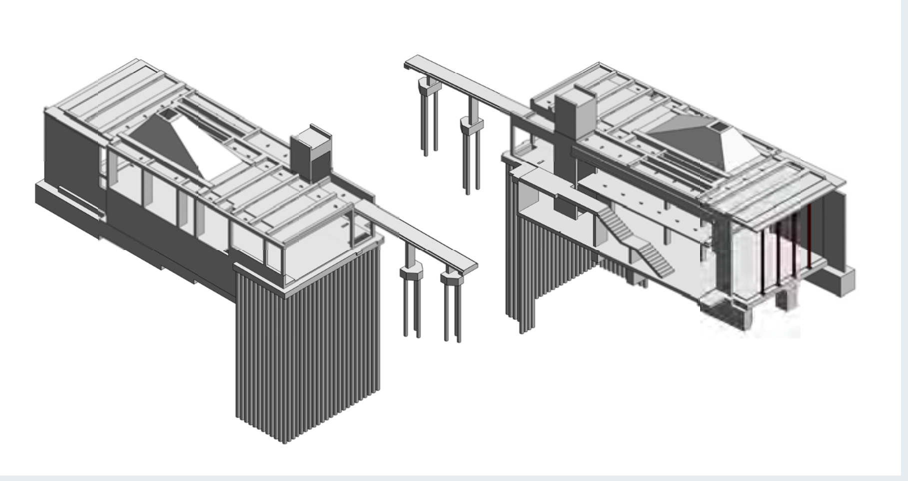
The upper floor is reached via two staircases. One is constructed from a combination of precast concrete treads set within a painted steel structure while the other, with similar treads, has a concrete structure. Mirroring the changes in the original building, the upstairs aesthetic is less structural and more finished. For example, in the bar area the downstands project beyond the ash baton acoustic timber panelling. Above, the panelling is flush with much shallower downstands. Where there are no beams, much of the flat concrete soffit is exposed and the board marks of the formwork clearly visible. At the slab edge, concrete and bath stone abut each other, creating a two-tone textural effect.

A four-sided pyramidal oculus is the stand-out feature of the upper floor. It is constructed from 200mm-thick in-situ concrete slabs set at angles. This rises some 3m from the ceiling soffit and, being asymmetrical, its sides vary in both length and gradient. "We conceived the roof design as a series of sculptural objects," says Ferrari. "The lift core overrun forms one, the pyramid is another. It was a challenge – the formwork was difficult, the gradient made the pours tricky and it was important to vibrate the concrete well to avoid honeycombing."

The end result is worth the effort. The plywood shuttering has been well arranged and the board marks and tie holes add interest to draw the eye up towards the light. The oculus also contributes to the building's heating and ventilation strategy since it naturally collects rising warm air which can be vented from the top if necessary.

"One oculus soffit has the ash batons on it for acoustic reasons," says Ferrari, "and in fact the acoustics created by the shape work well. The area is used by musicians for rehearsals and the feedback has been very positive."

The client too is happy with the design. Trish Brown, St George's operations manager, admits that there was initial nervousness about using concrete so extensively: "But Patel Taylor showed us some examples of how it could work really well. The great thing is that this doesn't feel like a new space added on. The old and the new have been married together. It feels like one building."



The structural puzzle

The structure of the St George's extension presented a challenge for engineer Claire Smith, director of Buro Happold's Bath office.

"This extension is built below ground at the back and to one side so needs to resist large unbalanced soil pressures," she explains. "The building, however, has open, flowing space towards the front – so it was difficult to incorporate solid shear walls to resist these lateral forces. The structure is also separate from the original church so the lateral loads couldn't go into the old building."

Buro Happold's approach was first to design a contiguous piled concrete wall to hold back the earth of the hill and to act as the foundation for the shorter rear wall of the extension. Smith then specified a very strong and stiff reinforced in-situ concrete wall along the longer, far side of the extension away from the church. This wall is 350mm thick and features six 250mm-thick piers or fins which project out 920mm from the wall at 2m centres. These act as "mini" shear walls. "We did need quite a lot of 'beef'," says Smith.

Near to the church, two 400mm x 250mm columns support a large 525mm x 375mm beam running parallel to the piered wall. Downstand beams run some 8m from each pier across to and beyond this beam. These drop 300mm from the first floor in-situ slab, which is 150mm thick.

Smith admits that there were some lengthy discussions with the architect over the lack of shear walls – and also the restriction that only two columns were permitted. "It's certainly not the way a structural engineer would have designed it," she says. "But the free and open space was important to the design and – fair play to the architect – it really works. Not only that, but the structure looks great too."

She adds: "A QS looking at the cost of this frame might raise an eyebrow – it seems a high proportion of the total. But the frame is not just structural. It is beautiful in itself and has become part of the architecture. And because much of the concrete is exposed you save money because you don't have stuck-on bits or expensive finishes."

Finally, adds Smith, the exposed concrete columns and soffits also work in the context of the building's thermal efficiency and user experience. The air in the building is in direct contact with the concrete, so its thermal mass helps to even out temperature variations. "This is particularly important for a concert venue which has a very peaky thermal load – busy one minute and virtually empty the next."

Despite this, says Smith, the concrete's thermal mass enables the building to be almost entirely naturally ventilated: "I have been at St George's in both hot and cold weather and can confirm it is a very comfortable space."

PROJECT TEAM
Architect Patel Taylor
Structural engineer Buro Happold
Contractor Midas
Precast supplier Vobster

OPPOSITE TOP LEFT Completed in 1823, St George's was designed by Robert Smirke in the Greek Revival style

OPPOSITE TOP RIGHT The extension is supported on the side away from the church by a long reinforced concrete wall

OPPOSITE BOTTOM First-floor access to the performance area is via two glass bridges

LEFT The oculus is constructed from 200mm-thick in-situ concrete slabs set at angles

ABOVE The structure is designed to accommodate open, flowing spaces towards the front of the building

Photos: Peter Cook

PIRELLI'S PALAZZO

CLOCKWISE FROM ABOVE
The Bicocca degli Arcimboldi overlooks the rear facade; two views of the in-situ concrete staircases; the streetfront, with its opaque precast panels; detail of the patterned columns

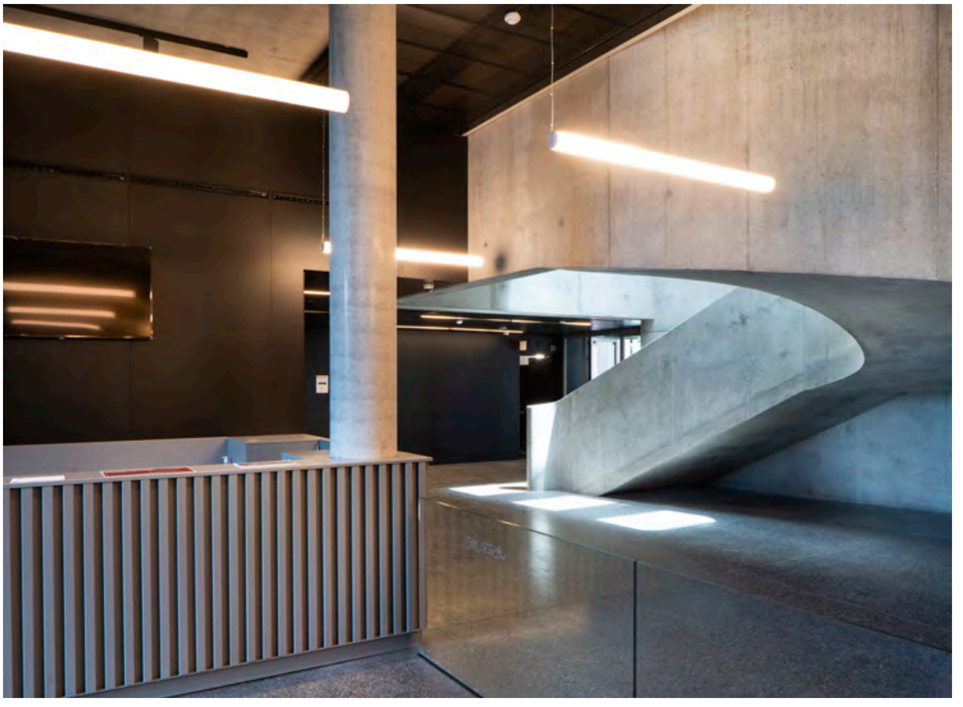
Onsite Studio's patterned-concrete facades follow in the tyre marks of a long and noble graphic tradition, writes Nick Jones

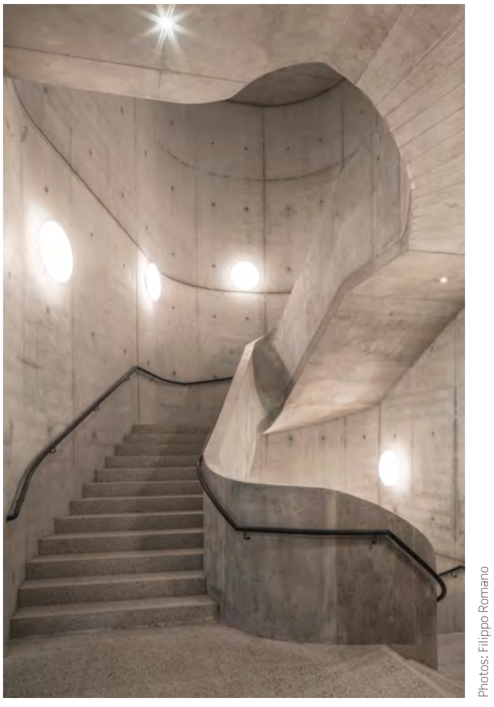
Pirelli looms large over Milan. Literally, in the form of Gio Ponti's Pirelli Tower (CQ051), once the tallest building in Italy. But also culturally: the tyre manufacturer's graphic design – notably Bob Noorda's advertising images from the 1960s – came to epitomise Milan's economic boom, while its former industrial complex in the Bicocca district, north of the city, now houses an art gallery, university campus and opera house. This area, which is also home to Pirelli's corporate offices, was masterplanned and almost single-handedly designed by the eminent Milanese architect Vittorio Gregotti. Which makes its latest addition, a learning centre and communal facility for Pirelli employees designed by local practice Onsite Studio, something of a departure – albeit one that is infused with the site's rich history.

Building Cinturato – named after one of Pirelli's most iconic tyres – is a three-storey building with a regular facade based on a 3m grid of slender columns and cornices. But where you might normally expect to see glazing, the grid is largely filled with slightly mysterious precast-concrete panels. The choice of concrete as a structural and aesthetic material was both a nuanced response to location and history, and a reaction to Milan's current commercial market. "We were thinking about what is happening in contemporary office buildings where everything is very light and very temporary, and felt it would be much better to have something that is a stable presence," explains Angelo Lunati, partner at Onsite. "Good buildings are those that have a very strong physical presence." Concrete had the added benefit of fitting in with the formal language of Gregotti's corporate complex: "We wanted to be in tune with this sobriety, but to do something different in terms of construction." This business-like note is struck through the use of black ebano marble pigment and aggregate to darken the concrete.

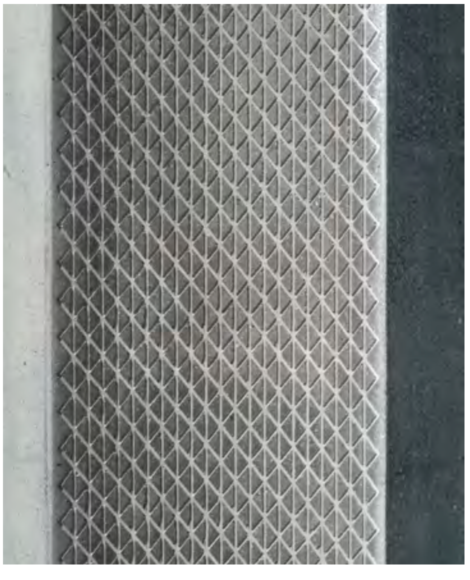
The concrete facades are embedded in their context in more intriguing ways too. All of the panels are imprinted with delicate graphic patterns, partly in a nod to Pirelli's design heritage – "recovering this treasure of graphic sophistication", in Lunati's words. But it also harks back to a far longer tradition. The motifs are full of references to the terracotta arches and porticos of the neighbouring Bicocca degli Arcimboldi, a 15th-

IN CONTEMPORARY OFFICES, EVERYTHING IS VERY LIGHT AND TEMPORARY ... GOOD BUILDINGS ARE THOSE THAT HAVE A VERY STRONG PHYSICAL PRESENCE





Photos: Filippo Romano



century villa now used as a reception building by Pirelli. The facade panels and columns were cast by local company Styl-Comp using metal formwork, with flexible formliners for the decorative elements created by concrete design company RECKLI. These were first carved in wood before the formliner liquid was poured on top to make a negative mould. Self-compacting concrete was used, due to the intricacy of the detailing and the slenderness of the 250mm x 500mm columns. The panels are loadbearing at ground level, but hung from the structure on the storeys above.

The reason for the mysteriously opaque facade becomes clear on stepping inside. A conventional office layout has essentially been flipped around so that the service core, stairs and lifts are at the front of the building. "We located the core along the boundary to help with the acoustics because it's a very busy road," says Michele Miserotti, associate at Onsite. The communal areas and workspaces, as well as the ground-floor restaurant, are therefore shielded from traffic noise and instead oriented towards the fully glazed rear of the building, which looks out over a landscaped piazza.

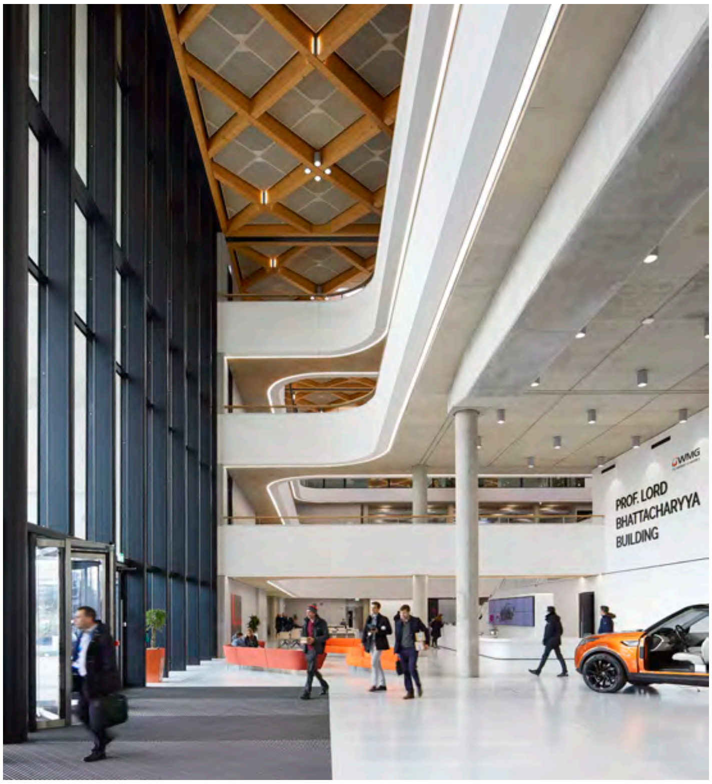
The gridded exterior might suggest a rigid programme within, but it actually enables a fairly flexible space. "Because of the perimeter grid, internal columns are very rare," says Miserotti, adding that the 200mm-deep flat slabs extend to 12m in places. One of the most dramatic open spaces is what Lunati calls the "learning street", a big linear void that cuts through the heart of the building, flanked by meeting rooms and teaching spaces on either side. The various levels of the "street" are connected by two feature staircases in curving concrete – these were cast in situ using polystyrene moulds created by CNC machine.

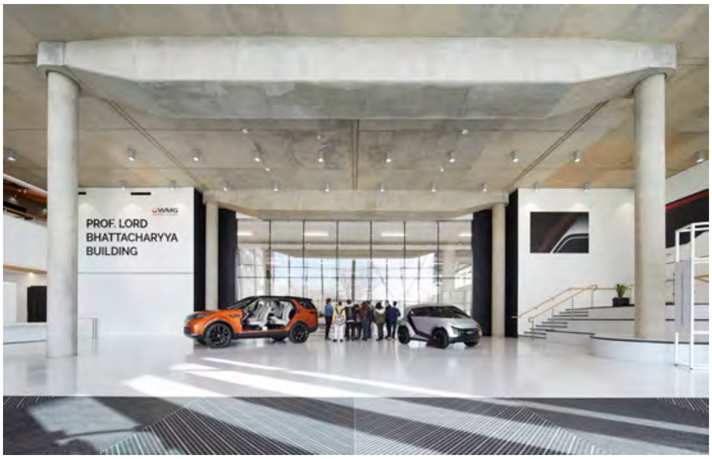
The in-situ concrete structure is in evidence throughout the interiors, and paler in colour than the precast facades. "The idea was for it to be the colour of the stone that it came from – all the colour comes from the cement and the aggregate without any pigments," says Miserotti. "We did some mock-ups in the basement in order to control the finishing, the joints, how to fill the boltholes." The soffits, which have been left with a smooth finish from their phenolic ply formwork, are exposed – an aesthetic that's rare in the Milanese office market, says Lunati – with their joints carefully laid out to conform to the 3m grid. The suspended lighting, acoustic baffles and other services are also based on the same grid. The floors in the restaurant and communal areas, meanwhile, are highly polished and enlivened by terrazzo-like coloured marble aggregate.

Building Cinturato stands on the site of the office of Leopoldo Pirelli, the trained engineer and scion of the Pirelli dynasty who commissioned Ponti's tower, and it is another fitting connection through time. Ponti presciently described his building as a "graphic slogan", noting how corporate architecture had in itself become a type of advertising.
Now Onsite Studio has inverted Ponti's maxim and turned Pirelli's graphic identity back into thoughtful, sophisticated office architecture.

PROJECT TEAM

Architect Onsite Studio
Structural engineer SCE Project
Contractor Carron





Photos: Hufton + Crow

GRAND HEFT AUTO

A mighty concrete structure lies at the heart of Cullinan's automotive research centre, writes Pamela Buxton

At some 33,000m², the National Automotive Innovation Centre at Warwick University is the largest single building ever completed by Cullinan Studio. It is a hybrid building in terms of both purpose and materials. Designed to synthesise industry, research and teaching, the four-storey building uses both structural steel and concrete and is topped with a steel and glulam roof that oversails to create a welcoming entrance.

Each material, explains Cullinan Studio practice leader Roddy Langmuir, is doing what it does best: "It's best not to force them to do a job that they're not good at." In the case of concrete, this entails forming the massive in-situ, flat slab frame, with core walls for stability and a 7.5m column grid. Concrete was the only viable choice to deliver sufficient thermal mass and provide the robust and flexible internal environment required for the facility, which includes everything from virtual reality suites and driving simulators to design and engineering halls.

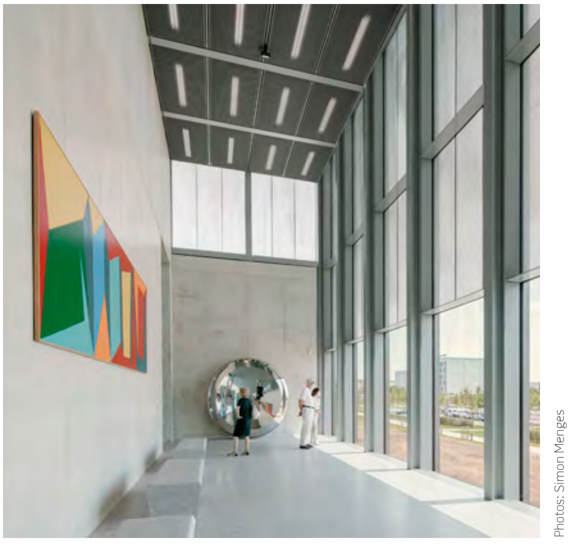
CLOCKWISE FROM TOP LEFT
The tiered atrium includes slab cantilevers of 3m; the structure is exposed wherever possible; the aluminium cladding is offset by natural landscaping

PROJECT TEAM
Architect Cullinan Studio
Structural engineer Arup
Main contractor Balfour Beatty

At the entrance, the structure included slab cantilevers of up to 3m to create a series of tiers surrounding a dramatic atrium. Use of concrete also enabled 15m spans over both the double-height engineering hall and the design studio, which was stacked above it on a suspended slab. Achieving this was particularly challenging, says Langmuir, given the need to limit live-load tolerances to exceedingly small amounts (microns) to suit specialist equipment such as scanning machines. The structure also needed to accommodate heavy (3-tonne) clay vehicle models anywhere on the slab.

After close collaboration with the client stakeholders, structural engineer Arup's solution was a 550mm-deep slab on 1.7m-deep, tapered transfer beams across the engineering hall. Spherical recycled-plastic void formers were used to reduce the self-weight where appropriate. The seven exposed beams were created using a bespoke steel shutter. For the rest of the structure, the contractor used resin-faced standard plywood reusable formwork. The design team created a larger regular grid of joints with the help of chamfered recess battens.

Where the speed of programme permitted, areas such as the reinforced foundations and upper floors include GGBS to lower the embodied carbon. But no pigments were added to the concrete anywhere in the building – the architects preferred the natural concrete patina, which acts as a foil to the areas of white plaster. "We quite enjoy the direct cast quality of the concrete – sometimes concrete can be so carefully done that it looks too homogeneous," says Langmuir.



Photos: Simon Menges

FASTENED IN PLACE

Chipperfield's gallery for a German screw maker uses red concrete to connect it to the landscape. By Nick Jones

CLOCKWISE FROM ABOVE LEFT The 70m-long entrance wall is composed of bush-hammered layers of red and yellow-red concrete; the full-height belvedere looks out over the sculpture garden; the exhibition hall cuts into a natural mound

David Chipperfield Architects has completed the Carmen Würth Forum in Künzelsau, Baden-Württemberg, adding another exhibit to its enviable collection of German museums in concrete. The first phase of the project, which completed in 2017, included two performance venues, which stage both public concerts and events for employees of the Würth Group, the German screw and tool maker whose HQ neighbours the site. To this has now been added a 760m^2 exhibition hall, intended to show pieces from company founder Reinhold Würth's collection of 18,000 modern artworks, as well as a smaller graphic art gallery, a conference area, bookshop and cafe. The interiors are dominated by swaths of as-struck concrete complemented by muted ash timber, while the exteriors are given a more colourful treatment, with in-situ concrete walls that look like strata of red earth.

Project architect Marcus Mathias, an associate at David Chipperfield Architects in Berlin, explains that this was in response to the undulating landscape, into which the low-lying complex is embedded. The exhibition hall, which projects southwards from the earlier building, cuts into a natural mound and is framed by two long retaining walls. "In order to relate to the landscape," says Mathias, "the layers of the retaining walls were given an earthy colour instead of leaving them in ordinary concrete grey." The team tested 10 samples of coloured concrete, with a 1% ratio of red, green and yellow pigments added to a light grey cement, before opting for alternating bands of red and a red-yellow mix. This was combined with an aggregate of local limestone to further merge the building with its surroundings.

The walls were cast in situ in 50cm-deep layers and were bush-hammered to accentuate the geological feel and conceal the joints. "We achieved quite a homogeneous surface. One of the walls is 70m long, and you can't see any joints, only the layers of red and reddish."

For the interiors, the architects specified an unpigmented CEM III mix, which was cast against a PERI panellised formwork system and left as-struck. This continues the material palette of the first building – which was partly inspired by Würth's industrial roots – but with subtle variations. "In the earlier building's foyer, for example, all of the walls were concrete with ash timber, but only parts of the concrete were visible," says Mathias. "In the new foyer, it is the other way around: all of the walls are exposed concrete, and only the two boxes that contain the kitchen for the cafe and the sanitary facilities are wood. We wanted to have the continuity because the foyers are connected. But it was also important to change the emphasis to differentiate the functions." The contrast between the ash and the concrete is particularly effective, he adds, the precision of the timber making the unfinished concrete appear almost crafted.

The gallery spaces all have different atmospheres due to their different lighting strategies, and concrete plays a role here too. The 3.2m-high subterranean graphic art gallery, for example, is lit from between the deep ground-floor concrete beams, casting striking shadows and creating an intimate feel. Upstairs, the 5.8m-high exhibition hall is lit naturally and softly by a light-diffusing ceiling beneath a glass "lichtlanterne", or lantern-like roof structure. This then opens out at the southern end of the building into a full-height "belvedere", with an immense 9m-high window wall spanning the width of the building and illuminating the natural variations in the cast concrete behind. It feels like an outdoor space, with a Tony Cragg sculpture connecting it visually to further examples of the artist's work in the garden just outside, and views of the Waldenburg mountains offering a breathtaking backdrop. "It's like the landscape is now exhibited," says Mathias. "It's become a piece of art."

PROJECT TEAM
Architect David Chipperfield Architects Berlin
Structural engineer Mayer-Vorfelder und Dinkelacker
Project manager Drees & Sommer

Mastering mass: how schools can get the best out of exposed structures

Thermal mass could play a crucial role in combating overheating in classrooms. Nick Jones finds out how to do it right

As the planet grows hotter, keeping classroom temperatures within acceptable limits will become harder and harder. In 2017, the government imposed tougher overheating targets for school buildings, in an update to its Building Bulletin 101 guidelines on ventilation, thermal comfort and indoor air quality. The Schools Design Group at the Chartered Institute of Building Services Engineers (CIBSE) recently modelled the performance of 11 newly designed schools, both in our current climate and under future projections, using weather files to represent scenarios of 2°C and 4°C above pre-industrial levels. While all met the BB101 standard today, a number of classrooms failed under the 2°C scenario, and the majority breached the target at 4°C – a temperature rise that could occur as soon as 2065, according to the UN's Intergovernmental Panel on Climate Change. In seven of the schools, 100% of classrooms failed under the 4°C scenario.

One answer to the problem of overheating would be to install more mechanical cooling – but this is neither sustainable in terms of mitigating climate change or future-proofing schools' running costs. Instead, we need to find low-energy methods of keeping classrooms comfortable – a quest that is set to become a fundamental part of school design.

One potential strategy is to use the thermal mass of a building to even out diurnal temperature variations, by absorbing excess heat during the day. This can be very effective: CIBSE's research found that many of the best-performing schools built in recent years were thermally massive structures. But not all thermally massive schools are created equal, and some performed considerably less well, typically those without adequate ventilation. So it is vitally important that designers understand how to leverage thermal mass to its full potential – and that they pass this on to those operating the building to enable them to benefit from low-energy cooling for many years to come.

IT'S NOT ENOUGH TO DESIGN SOMETHING THAT YOU THINK SHOULD WORK, YOU HAVE TO HAVE CLIENT BUY-IN

Night purging

A low-energy cooling strategy using thermal mass has two essential components. One is a high proportion of exposed heavyweight structure, to absorb heat during the day. The other is a natural or mixed-mode ventilation system that cools the building at night, thereby "resetting" the structure so that it is ready to repeat the cycle the next day.

In order for a night-purging strategy to be successful, the building's users have to have absolute confidence in it, warns Jeremy Climas, head of education at Max Fordham, which has designed a series of high-performing naturally ventilated schools. "There are thousands of buildings where, for example, the design team allowed for natural ventilation at night but the people who operate the building don't use it like that. It's not enough to design something that you think should work, you have to have client buy-in."

Understandably, one of schools' chief concerns is security. "If night ventilation relies on opening windows then you can be pretty sure it's not going to happen," says Climas, "because nobody wants to leave windows open in an unoccupied building overnight." A safer alternative is a grilled or louvred opening, often behind a closable panel. If the school is in a noisy location, these units also need to incorporate acoustic buffers to insulate against external noise. This is particularly important in city locations and for rooms close to play areas.

In order to create a cross-draught in naturally ventilated classrooms, there needs to be both an opening through the facade and a means of exhausting air. As rooms rarely have two external facing sides, air usually has to be vented into a single-sided corridor or atrium via a fire-rated, acoustic-attenuated bulkhead against the corridor-side wall of the classroom, which allows air to escape while preventing noise from entering.

External louvres, meanwhile, should be located as close as possible to the exposed soffit, although the

ABOVE At Levitt Bernstein's recently completed building for Eltham College in south-east London, the precast-concrete structure is exposed internally to exploit the thermal mass and provide a contemporary contrast to the school's historic quad. In classrooms, acoustic baffles are hung vertically to maximise the area of soffit exposed to cross-ventilation


Photo: Ben Tynegate

layout also depends on factors such as window size and shape and the orientation of the classroom. The extra depth of side panels can be an advantage for placing acoustic buffers, says Giovanni Bonfanti, director at Walters & Cohen, which has just completed the naturally ventilated extension to St Paul's School in London (see box, overleaf). They can also provide an architectural feature – such as the vertical timber louvres on the facade of Walters & Cohen's Reigate Grammar School.

The upshot is that, for an essentially simple process, natural ventilation can feel complicated and may need a bespoke solution. "We always say to clients that a naturally ventilated building isn't necessarily a lot cheaper," says Bonfanti. "It's a simple solution, but there's a lot to build."

In the reality of today's public-sector school procurement, compromises often have to be made, particularly where layouts include double-sided corridors with no obvious means of cross-ventilation. At Penoyre & Prasad's BREEAM Excellent Bobby Moore Academy in east London, mechanical ventilation and heat recovery (MVHR) units were used, partly for acoustic reasons – the

Insights: Concrete and masonry school structures

By Jenny Burridge

School buildings need to be robust, resilient and low maintenance, and concrete and masonry provide these benefits. Of particular importance is the inherent fire resistance of these materials – each year more than 2,000 schools in the UK suffer fires large enough to need action by the local fire and rescue service. Concrete and masonry not only provide fire protection for the occupants, but to the structure itself, particularly as this does not usually rely on the ongoing maintenance of additional linings to meet minimum standards. Their non-combustibility limits the extent of damage and minimises repairs and disruption, so that the school, or part of the school, can be reopened quickly.

A concrete structure can be cast in situ, precast or a hybrid of the two. The spans required in school buildings are normally around 8m x 8m, with typical room sizes ranging from 57m² for a junior classroom to 90m² for a drama studio. Concrete flat slabs, either normally reinforced or post-tensioned, are well suited to this flexible grid. They can be supported on walls or columns, depending on the requirements of the project. Using concrete or masonry walls means that the heavily trafficked corridors are enclosed in a robust material, while columns offer greater long-term flexibility. Both have been used to good effect in recently built schools. Concrete can also be left as a low-maintenance finish, a visually pleasing backdrop to school life.

■ **Jenny Burridge is head of structural engineering at The Concrete Centre**

ALL THE ENERGY THAT'S GENERATED FROM KIDS OBVIOUSLY NEEDS TO BE ABSORBED

Photos: Hélène Binet; Tim Crocker

TOP Louvred panels and high-level actuated windows provide cross-ventilation at Tim Ronalds Architects' science centre for Sevenoaks School

ABOVE Integrated acoustic and lighting panels at Penoyre & Prasad's Stratton Upper School, Bedfordshire leave the thermal mass above exposed

building is on the flightpath to City Airport – and partly because of the energy savings that MVHR systems provide. The units, positioned at high level behind fixed louvres, incorporate an ultra-low-energy fan that can either draw air in from outside or push it out. It also enables night-time purging to take place securely without opening windows.

The BREEAM Outstanding-rated Ashmount Primary School in north London, also by Penoyre & Prasad, offers a variation on the same theme. This three-storey building uses a 'e-stack' low energy ventilation system located at the back of the classroom. In winter, the fan draws air down a chimney stack and premixes it with warm air before distributing it into the classrooms. In summer, the fan operates in the opposite direction, exhausting warm air drawn out of the classroom from windows opened in the external wall. "In terms of night purging, both systems work in a very safe way and worked well for an inner-city site," says Rafael Marks, associate partner at Penoyre & Prasad.

Automation can play a key role – at Bobby Moore Academy, the louvres are connected to a building management system (BMS), which opens them at night, as well as to air monitors, which can trigger daytime opening in response to temperature and carbon dioxide levels. Teachers do still have an element of a manual control, over an openable window at the lower level of the louvre panel.

Structure

The other key element of a successful thermal mass strategy is, of course, an exposed heavyweight structure. Concrete is ideal because its high specific heat capacity and density allow it to absorb a lot of heat, and these are combined with a moderate thermal conductivity, so absorption takes place steadily over the course of the day. From a school's point of view, concrete also offers a range of other advantages, from durability and low-maintenance to adaptability. "I would say 90% of the schools I've done have had a concrete frame," says Marks, "for thermal mass reasons but also because they give other benefits such as acoustic and fire properties. A flat slab gives you the flexibility for different services and also longer-term adaptability." In multistorey schools, where high ceilings are often unfeasible, a thermally massive soffit can be vital for moderating the classroom environment, he adds. "All the energy that's generated from kids obviously needs to be absorbed." Marks also points out that precast-concrete planks can be added to other structural systems as a means of incorporating thermal mass – such as at Penoyre & Prasad's recently completed Anna Freud Centre, a multistorey centre for children and young people's mental health, which has a hybrid structure with timber.

But exposed concrete also presents challenges, particularly since the BB93 acoustic standard for schools has become stricter on reverberation times. The government's baseline designs state that acoustic panels should cover about 40% of the classroom ceiling area, which could obstruct much of the thermal mass of a soffit. Solutions include suspending acoustic panels and incorporating them with light fittings to reduce unnecessary clutter – generally suspended systems need about 600mm clearance, so work well in room with a floor-to-ceiling height of 3.2m or more. "It's a fairly standard detail now," says Marks, "and the added benefit is that the space feels lighter and taller."

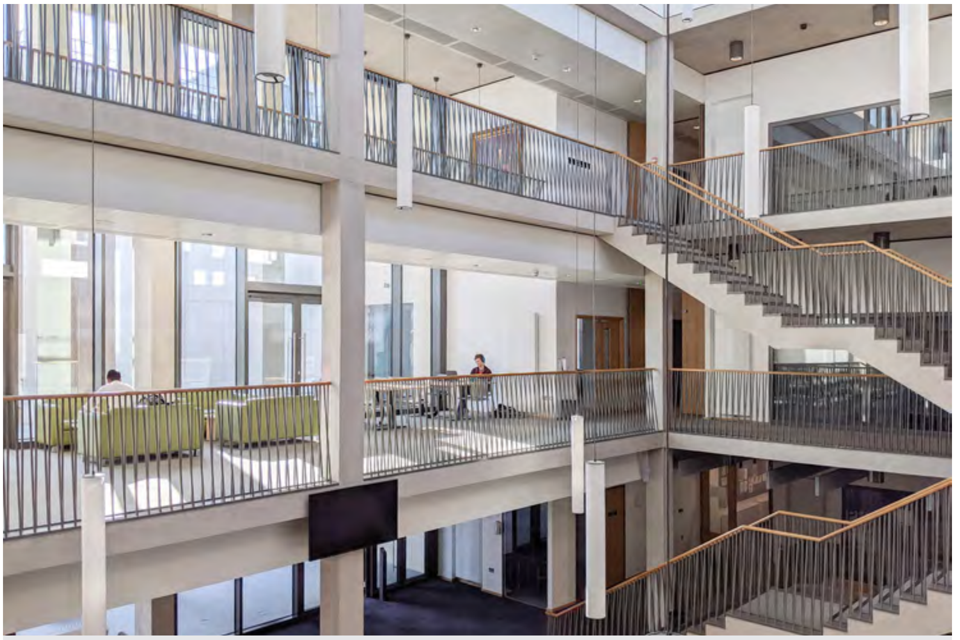
Bonfanti suggests vertical rather than horizontal baffles, which have less impact on the soffit. "In some cases they are even more effective, because both sides of the acoustic material are exposed to the sound reverberation." Carpet is an option for reducing the reverberation between soffit and floor (see St Paul's School box) – but this means forgoing the useful thermal mass of the exposed screed.

There are various techniques to make the concrete structure as materially efficient and low-carbon as possible. At Sevenoaks School Science & Technology Centre in Kent, Tim Ronalds Architects used ribbed precast-concrete soffits in some areas, to minimise the concrete used. "You don't need as much of it and it increases the surface area so the thermal mass works even better," says Climas.

Another innovative approach at Sevenoaks School was the use of groundwater-chilled pipes cast into the concrete to super-charge the slabs' cooling potential in high-occupancy, high-energy areas such as labs. Although this was a private-sector project, with a corresponding budget, Climas suggests that this solution could also be pre-installed in the state sector as a means of future-proofing new buildings. "You can cast it in now, because it's just some plastic piping – it's not a particularly expensive thing to do. The expensive bit is putting in a chiller or heat pump, but once the pipes are in, that can be installed in the future."

It is also important to remember that solutions may need to be classroom-specific – what works in a normal teaching space might not in a workshop or theatre studio. At Bobby Moore Academy, for example, larger classrooms have two MHVR panel units, and excess air can also be drawn out of the back of the classroom into the 4m-wide corridors, from where it extracts via three louvred rooflights.

Thermally massive buildings that are well-designed and well-operated are already providing relief in the more frequent heatwaves the UK is experiencing. Climas recently returned to one of his first Max Fordham projects, The City Academy in Hackney, on a scorching hot summer day. "The school had continued doing the night ventilation the way they were supposed to, and they managed to get all of the heat out of the concrete overnight. It was wonderfully cool, 6 or 7°C lower than outside."



▲ St Paul's School second phase, by Walters & Cohen Completed 2020

Walters & Cohen has just completed the second phase of its energy-efficient, concrete-framed teaching complex at St Paul's School in London. Exploiting the structure's thermal mass was one of the main drivers from early in the design process. "The MEP engineer, Max Fordham, was targeting reductions on energyuse within the building, and we are always keen to embrace natural ventilation wherever possible, so a high thermal mass was a good way of bringing the two together," says Walters & Cohen associate director Tim Rowley.

All of the rooms with natural ventilation have a large, low-level manually operable panel, and a smaller, high-level automated panel. This high-level panel, linked to the BMS, opens when the room is too warm, has too much CO_2, and at night. Air is drawn across the classrooms and into the deep-plan building's circulation area, from where it is exhausted via a series of lightwells.

The acoustic strategy involved the use of fabric hanging-baffles suspended within the classrooms, augmented with some acoustic treatment on the walls. "The use of carpet was crucial as well in order to avoid sound 'bouncing' between the floor and ceiling," Rowley adds.

"We are designing state schools right now which will use exactly the same principle. We might not have the budget for the concrete to be finished quite so finely, but the greater challenge, particularly for schools in an urban context, is dealing with external factors such as noise and air pollution when trying to implement natural ventilation. Using the thermal mass for night-time cooling doesn't have this constraint so we are always keen to utilise it."

Photo: Peter Segasby

ABOVE Gusto Homes' Woodlands Edge development near Lincoln. The majority of glazing is on the south side, maximising solar gain and minimising heat losses from north-facing elevations

The beautiful **south**

The interaction of south-facing windows, shading and thermal mass can reduce a home's energy demand by up to 40%. Tom De Saulles explains how

Passive solar design (PSD) is a simple technique that helps capture the sun's energy, reducing the need for space heating from autumn to spring. It works by combining appropriate building orientation and window size with thermal mass in the building fabric, which collectively enable sunlight to be absorbed and used as a source of heat. Studies have calculated potential energy savings of around 11% in conventional masonry and concrete homes, with greater savings of around 40% (35% in Scotland) where more specific design features are applied, such as the use of sunspaces.

In spite of its recognised benefits, uptake in mainstream UK housing has been few and far between, partly due to building regulations that do little to encourage passive design, partly due to a housing industry that prioritises density and generic design over orientation and spacing, and partly due to the absence of appropriate shading on south-facing windows, which has resulted in the common misconception that a southerly aspect automatically increases overheating risk.

However, this may change over the coming years, as renewed focus is turned to passive performance. Revisions to Part L and the introduction of the Futures Homes Standard are likely to increase emphasis on dwelling orientation in response to greater uptake of photovoltaic panels, which should ideally be south-facing. Meanwhile, the need to reduce overheating risk should lead to a regulatory requirement for proper shading on south-facing windows, ideally in the form of deep roof eves, balconies and overhangs – all capable of keeping out the high summer sun without limiting solar gain during the heating season.

Design considerations

In its simplest form, PSD can be implemented by increasing the level of glazing on the south elevation so it is roughly twice that on the north elevation. North-facing windows have a net heat loss over the year, so should be sized to just provide adequate daylighting. Conversely, south-facing windows experience a net heat gain over the year, so should be sized to take advantage of this.

Designing to take advantage of PSD requires an integrated approach to find the best overall balance of glazing, orientation, and thermal mass. However, the general approach can be summarised as:

- A southerly orientation to allow passive solar gains from autumn to spring
- A sufficiently clear view of the sky from the south
- A high standard of insulation and airtightness
- A medium to high level of thermal mass
- Well-insulated double glazing that combines an inner pane designed to reduce heat loss and an outer pane of extra-clear glass to increase the amount of free heat from the sun
- Windows or an alternative means of passive ventilation that provide cooling on summer nights, while taking account of any security or noise issues
- A compact rectangular plan with the main living area on the south side of the house.

Orientation and shading

Orientation is the most critical factor in determining the amount of sun that a dwelling receives from autumn to spring. Ideally most of the window area should face within around 30° of south, with the south elevation enjoying a relatively clear view of the sky, to allow radiation from the low winter sun to pass directly inside.

In midwinter, the sun reaches a maximum altitude above the horizon of about 17° in southern England. During the height of summer it will reach about 64°, which can be particularly useful when designing a shading strategy, as a simple overhang will block the sun during the hottest part of the day. This very simple form of shading requires no user control or maintenance.

Dwelling location and spacing

The further north you are, the lower the solar gain. However, the heating season is longer, so the benefits of PSD could be more significant. A house in Scotland, in an average year, will require nearly 45% more energy to maintain a given temperature than in south-west England. Greater emphasis could be placed on winter performance in the north and more effective solar shading in the south.

To avoid overshadowing, the spacing of dwellings also varies between northern and southern Britain. Based on average house height, minimum spacing is 20m in Southampton and 25m in Leeds, increasing to 35m in Inverness. Where an obstruction is likely to reduce the amount of direct solar radiation, some heat is still obtained from diffuse and reflected radiation.

Thermal mass

A medium to high level of thermal mass is most easily and cost effectively provided by concrete and masonry floors and walls with a suitable finish that does not impede heat flow. As a rough guide, the surface area of the floor/soffits and walls providing the mass should be at least six times that of the glazing in the room, although this will to some extent be influenced by the particular thermal capacity and conductivity of the material. So, as the area of south-facing glazing increases, more thermal mass is required to maintain a stable temperature during the summer.

The position of the insulation is also very important, as the thermal mass needs to be located inside the insulated building envelope. In practical terms, a masonry cavity wall already satisfies this basic rule, as the insulation is located in the cavity, allowing the inner leaf of blockwork to be room side. For solid masonry walls, the insulation should be located behind the waterproofing layers on the outer surface of the structural wall. The insulation for solid ground floors should be located under the slab, although screed placed on top of insulation will also provide useful thermal mass.

Internal finishes

It is important that the surface of heavyweight walls and floors remain as thermally exposed as practicable. For walls, this is best achieved with a wet plaster finish, which conducts heat relatively freely, as well as providing a robust air barrier that will help minimise air leakage. Dry lining will reduce heat flow, but its impact will depend on the thermal mass potentially available in the wall. For an aircrete block inner leaf (which has relatively low thermal conductivity), plasterboard is less of a thermal bottleneck than for heavier aggregate blocks. These have higher thermal conductivity (and thermal mass), and if their full potential is to be unlocked, the choice of finish will have more impact. With some forms of concrete wall and floor construction, it is possible to achieve a high-quality, visual finish with little more than a coat of paint.

Wherever feasible, the thermal mass of the ground floor (particularly in south-facing rooms) should be optimised, with carpet avoided. Stone, ceramic or porcelain tiles are useful, as is exposed concrete. Shiny or glossy floors will absorb less heat than a dull finish; however, this must be evaluated alongside daylighting requirements and the tendency of such a surface to absorb light. These surfaces also work well with underfloor heating.

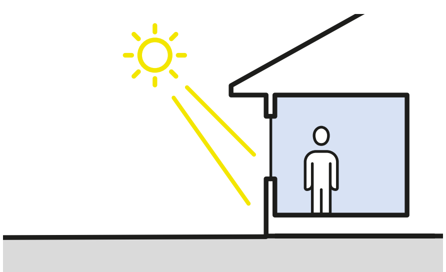
Layout

Where practicable, the most frequently used rooms should be on the south side, with bathrooms, utility rooms and halls to the north. In southern England, bedrooms are usually best located on the north side to help maintain comfortable night-time conditions during summer. Where possible, the layout of bedrooms should also enable cross-ventilation or stack ventilation, particularly effective in lowering the internal temperature during summer and removing heat from the thermal mass.

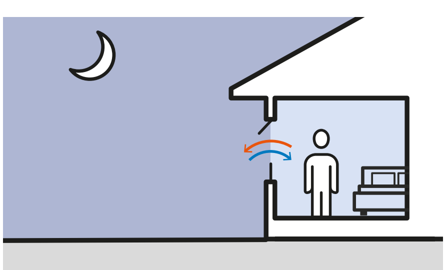
■ **Tom De Saulles is a building physicist at The Concrete Centre**

FIGURE 1: HOW PASSIVE SOLAR DESIGN WORKS

Thermal mass during summer

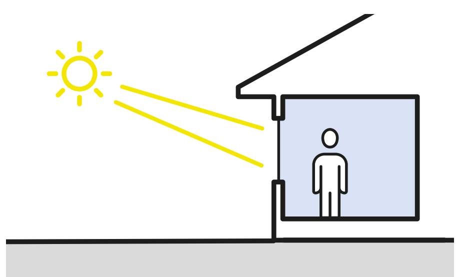


DAYTIME On hot days, windows are kept shut, and shading is adjusted as needed to minimise solar gain. Cooling is provided by the thermal mass. On cooler days, windows may be opened.

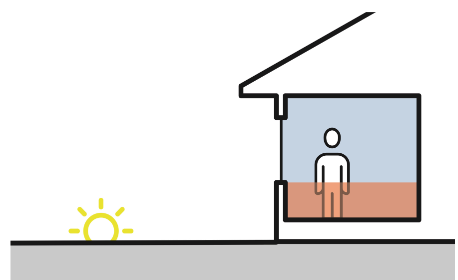


NIGHT-TIME If it has been a hot day, windows are opened to cool the thermal mass.

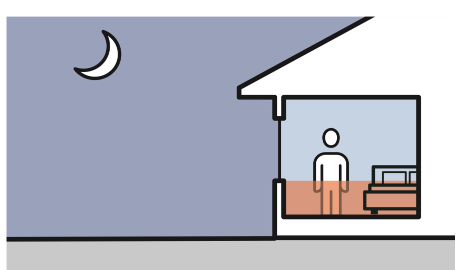
Thermal mass during the heating season



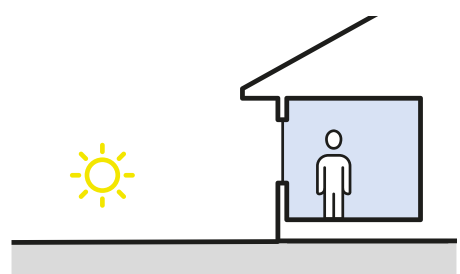
10AM – 5PM Sunlight enters south-facing windows, heating the air and the thermal mass. On most sunny days, solar heat can help maintain comfort from mid-morning to late afternoon.



5PM – 11PM By sunset, a substantial amount of heat has been stored in the thermal mass. This is then slowly released, helping to maintain comfortable conditions in the evening.



11PM – 7AM Only minimal supplementary heating is needed. Good airtightness and insulation minimise heat loss.



7AM – 10AM This is the hardest time for passive solar heating to maintain comfort, so some supplementary heating is needed.

FINAL FRAME: MARSHALL BUILDING, LONDON

Work is nearing completion on Grafton Architects' Marshall Building at the London School of Economics, which is due to open next year. The £140m eight-storey building includes a grand public hall on the ground floor, teaching and research areas, a basement sports hall and a two-storey rooftop pavilion. The large spans of the flexible lower-level spaces are accommodated by a structure of huge tree-like concrete columns.

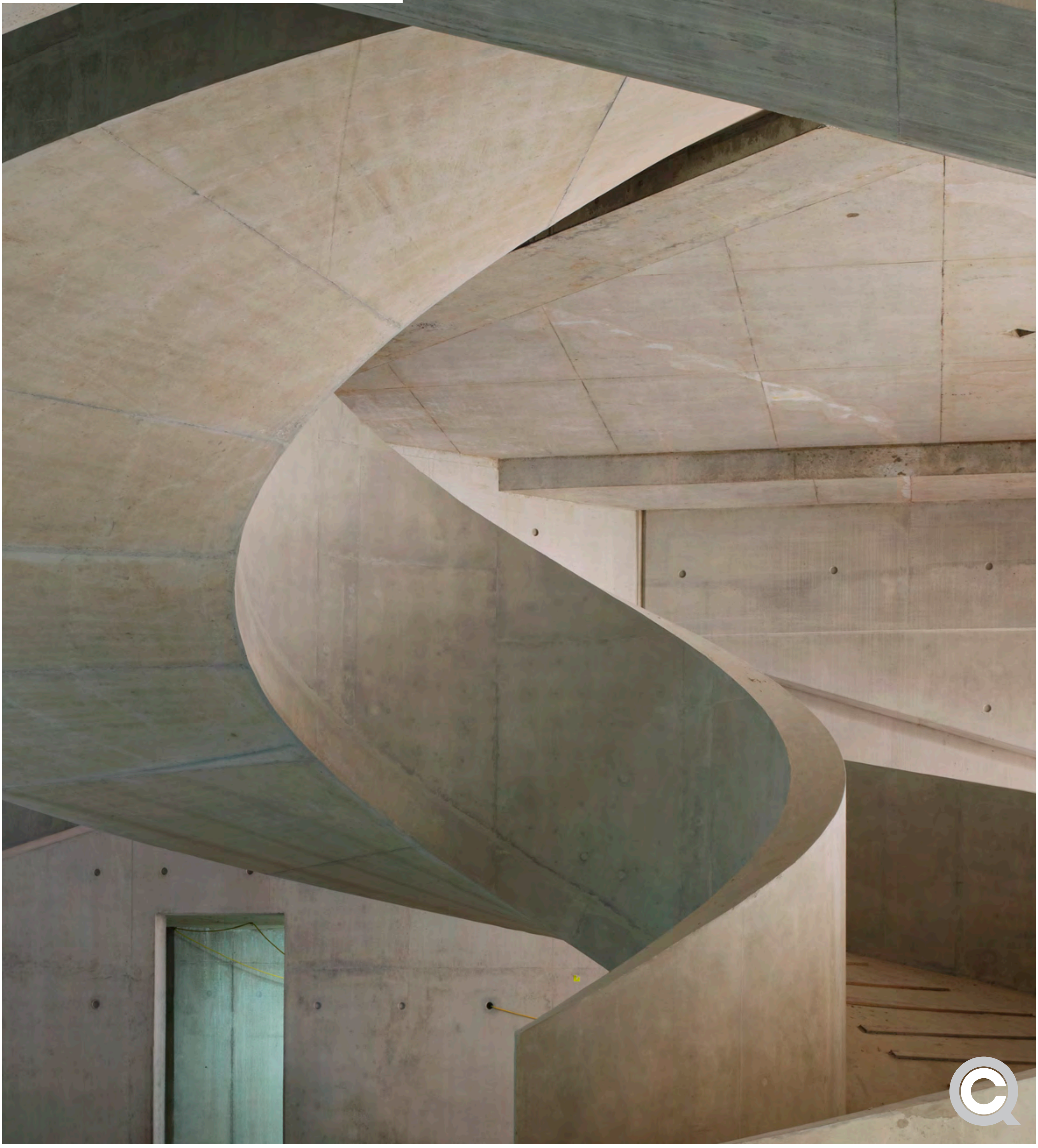


Photo: Dennis Gilbert / VIEW Pictures