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The Concrete Centre

CONCRETE QUARTERLY

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HERZOG HITS THE BEACH
How the Swiss starchitects made a deco-inspired tower rise from the Miami sand

THE NEGOTIATOR
Stanton Williams strikes a deal with radical postmodernism at Cambridge's Judge Business School

ROUGH RENAISSANCE
Feilden Fowles' earthy Yorkshire Sculpture Park visitor centre joins the textured-concrete revival

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AGENDA

Guy Thompson
Head of architecture, housing and sustainability, The Concrete Centre

Not a binary issue

Data seems to be the inescapable theme of the moment, for better or worse.

At the University of Oxford's new Big Data Institute by Make Architects (page 10), large, complex datasets will be analysed in the hope of discovering new treatments for disease. At a more sinister level, we have the continuing revelations about the use of social media data to manipulate public opinion and swing elections. Something that until very recently was overlooked or dismissed as trivial, ephemeral or quite frankly dull has suddenly become our most powerful asset and one to be taken very seriously – as the relentless slew of emails about new data protection regulations serves to remind us.

The power of data is something we've been thinking about a lot at The Concrete Centre, as we approach the 10th anniversary of the concrete industry's sustainability strategy. Our latest performance report will be published in July, containing detailed information compiled from companies supplying an estimated 80% of all concrete used in the UK.

Back in 2008, we were determined to improve our environmental performance, but it quickly became clear that we first needed to understand exactly what that performance currently looked like. What followed was a continuous process of gathering data, setting performance targets, and then collecting more data to monitor progress and refine the targets. In many ways, the collection of relevant, coherent data has been the most difficult aspect, across no fewer than 10 different sub-sectors, and from mineral extraction to eventual recycling.

It is only now, as we look back at a decade of hard work that we are fully realising the significance of all that data gathering and the unique position that concrete as a material is now in. It may not compare to the 600 trillion computations per second taking place within the Big Data Institute, but it is an invaluable resource to have at our fingertips as we look to the future and to what might be realistically, but ambitiously, achieved by 2030.

Of course, Big Data itself has begun its own sustainability journey, as the penny drops that "the cloud" is more of an energy-guzzling smog – by the end of the year, bitcoin mining alone is forecast to consume as much electricity as Austria. We will need to use all of our ingenuity to manage the environmental impact of our growing data habit – Make's concrete labyrinth under the University of Oxford is a very welcome example.

THE PENNY HAS DROPPED THAT 'THE CLOUD' IS MORE OF AN ENERGY-GUZZLING SMOG

this is concrete

THE LONG SHADOW OF RONAN POINT

The Ronan Point tower collapse in May 1968 was a watershed moment for construction, says This is Concrete blogger Jenny Burridge on the 50th anniversary of the tragedy. The subsequent inquiry found that the main fault lay in the design and in the standards governing it, and led to significant changes in the Building Regulations for structural design which still stand today. "The disaster shocked the public and changed the way that designers thought about and specified buildings," Burridge writes, "in the same way that the Grenfell Tower disaster is currently changing the way that we consider the fire risks associated with high-rise apartment blocks."
www.thisisconcrete.co.uk

CONCRETE QUARTERLY

On the cover: Jade Signature Tower in Miami by Herzog & de Meuron. Photo: Field Condition
Produced by: Wordmule
Designed by: Nick Watts Design

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www.mineralproducts.org

Blocks in bloom

Concrete blocks took centre stage at Chelsea Flower Show, where they formed the basis of Robert Barker's Skin Deep garden. Different tones of concrete are used to represent various skin types.

Shape of things to come?

Zaha Hadid Architects has designed a school in Jiangxi province, China, with a vaulted structure that will be built by an industrial robot. Lushan Primary School will use advanced on-site robotic techniques to prepare hot-wire cut foam formwork for the in-situ concrete parabolic vaults.

Twisted and listed

CZWG's CDT Building at Bryanston School in Dorset is among 17 postmodern buildings granted listed status by Historic England. The building is notable for its giant precast-concrete columns in the form of G-clamps.

Buried treasure

ColladoCollins' revamp of brutalist Croydon icon Leon House has uncovered a sculpture by renowned concrete artist William Mitchell. The work had been hidden away by partition walls but will now take pride of place in the converted apartment building's lobby.

Images: Malcolm Park / Alamy Live News; ZHA render by VA; Historic England Archive; ColladoCollins

Image: Feilden Fowles

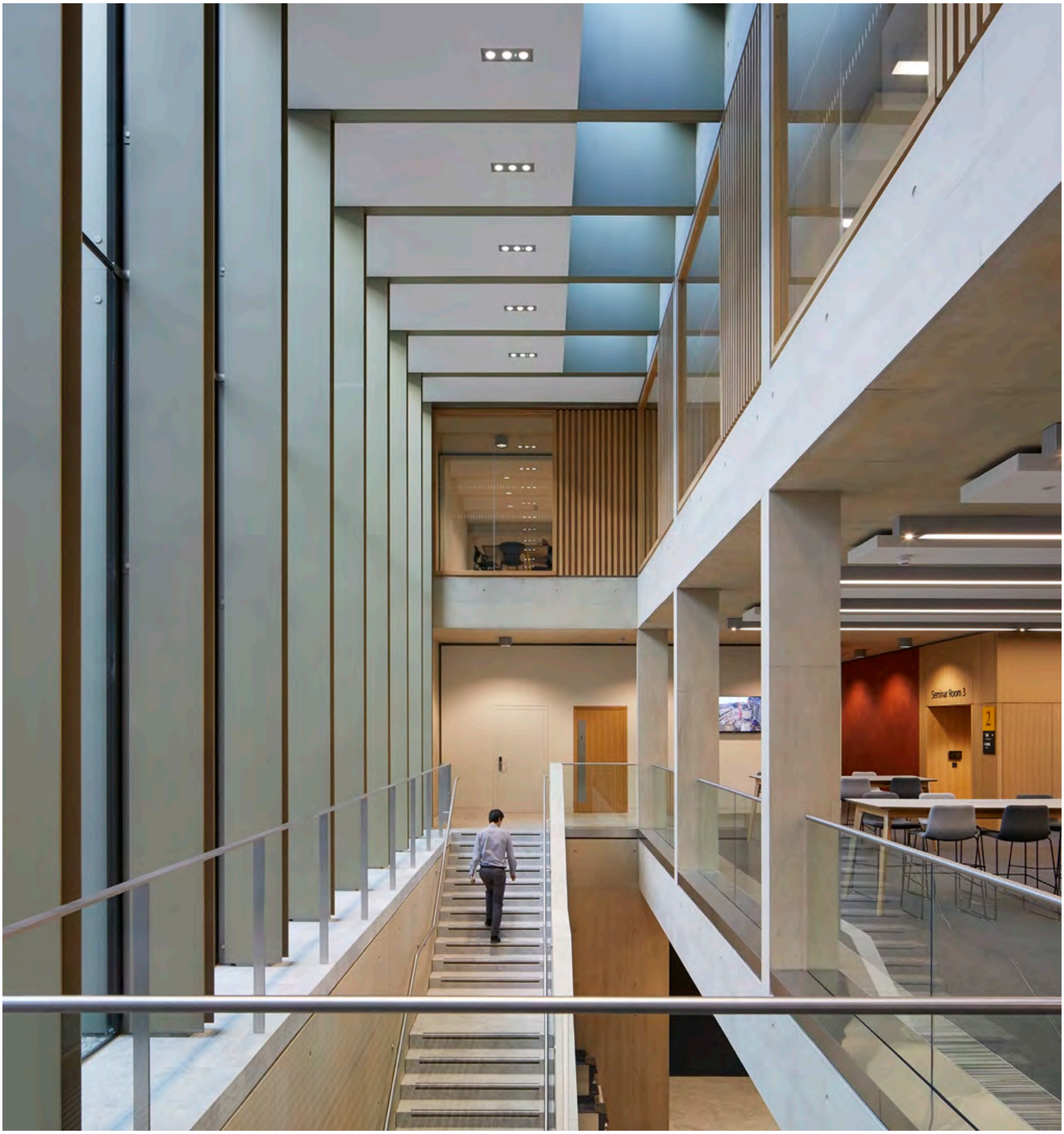
DOWN TO EARTH

Our summer Concrete Elegance lecture features two buildings where the design and use of concrete is strongly influenced by their location.

The University of Kent's Templeman Library (see page 8) will be presented by Penoyre & Prasad Architects and structural engineer Price & Myers. The project is the refurbishment and extension of a brutalist 1960s building, designed by Lord William Holford. It draws on many of the architectural ideas of that era through the use of exposed in-situ concrete and external architectural precast concrete fins.

The Yorkshire Sculpture Park Visitor Centre (left, and page 14), meanwhile, employs heavily textured and layered concrete walls reminiscent of geological strata to reflect its emergence from the earth in a rural setting. This project will be presented by architect Feilden Fowles and engineersHRW.

The lecture takes place from 6-8pm on Tuesday 12 June at the Building Centre in London. To book a place, visit www.concretecentre.com

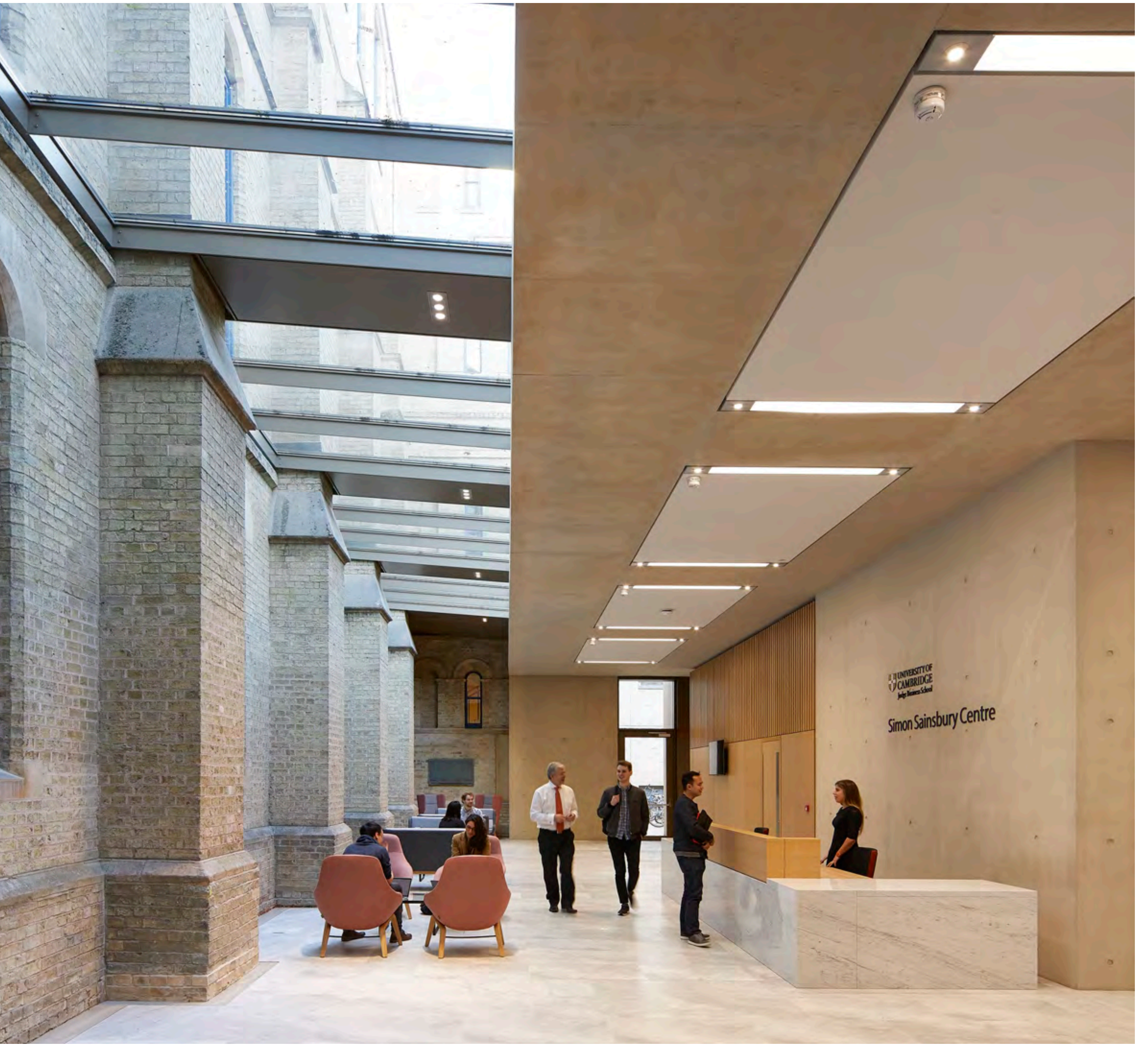


STRICTLY BUSINESS

Stanton Williams has created a calm, controlled extension to John Outram's extrovert Judge Business School. But its cool appearance disguises some mighty structural gymnastics, finds Tony Whitehead

LEFT Non-phenolic plywood formwork gives the concrete a matt, stone-like quality

RIGHT A smooth concrete canopy cantilevers towards the older building



Adding an extension is always a delicate business. Do you ape the existing building? Go for contrast? Or attempt a bit of both? For Stanton Williams, architect of the latest extension to the Judge Business School in Cambridge, the situation was even trickier.

For the past 25 years the school has occupied the grade II-listed Old Addenbrooke's Hospital in the historic centre of Cambridge. The main building's defining feature is a long and imposing Victorian facade built in 1860, but in the 1990s it was dramatically extended in a flamboyant multi-coloured style by the radical postmodernist John Outram.

So how to add to architecture that already embraces two highly distinctive identities? Tasked with providing an additional 5,000m² of teaching and office space, Stanton Williams has risen to the challenge in characteristic fashion – by producing a calmly authoritative, almost understated building. With its muted brick and precast concrete facades, and an interior featuring oak, marble and exposed concrete, it is, appropriately enough, rather business-like.

Of course Stanton Williams has good grounds to assert its own style with quiet confidence. Its design for the Sainsbury Laboratory – just half a mile down the road – won the 2012 Stirling prize. The judges praised that building for the way it blended with its historic surroundings, describing it as "beautiful and timeless". No surprise then that the new Simon Sainsbury Centre at the Judge Business School, which reunites

Smooth performance

Despite the smoothness of finish required, and the sometimes complex structures, concrete contractor Whelan & Grant decided not to use self-compacting concrete for the Simon Sainsbury Centre.

"It wasn't necessary," explains contracts manager Steve Wood. "Some of the more complex features, like the ribbed ceilings and the terrace were poured in layered sections – rib then slab – so that made it easier to prevent voids forming. And even for the high, 5m walls, it was sufficient to pour them in short, full-height sections and vibrate them from the top."

The mix included 50% ground granulated blast-furnace slag, which slowed curing times, but W&G was fortunate in that its contract started in the spring. "It was ideal timing," says Wood. "The warmer temperatures meant curing times did not cause programme issues."

The main challenge was in creating formwork and finishes of unusually high standards. "For example, we had to mitre the joints that formed the ribs and hide the joint lines in the slab. The formwork had to be joinery standard throughout."

W&G managed to complete the contract with only one small section of basement needing to be re-poured. The vast majority of concrete was able to be left with little or no making good, and simply rubbed down to create its distinctive smoothness.

The one exception to this was the sloping wall that forms the side and handrail to the atrium staircase. "We poured that in four sections, from top to bottom starting at the highest point," says Wood, "as obviously the concrete has a tendency to slide down to the bottom of the staircase. We used top shutters with designated compaction points. Inevitably there were some air holes at the top so the smooth slope did require a fair bit of finishing and making good."

much of the same project team, employs a similar structure and aesthetic – including a concrete frame and large expanses of beautifully finished visual concrete.

This is not to say that the new design has arisen without regard to the older buildings, as Stanton Williams' project associate Stephen Hadley explains: "The concrete and brick reflects the masonry construction of the old hospital – so the precast concrete on the facades, for example, is a nod to the stone dressing used on the Victorian building. Also, the brief was for a robust, long-lasting building. We wanted to avoid anything that was going to look too new or flimsy. Concrete construction suited that."

In a counterpoint to Outram's more outlandishly decorative style, Stanton Williams liked the idea of the structure being visible, with no obvious separation between structure and architecture. "That's hard to do if you use a steel frame, which you then tend to clad and so disguise the structure," says Hadley. "Here we wanted a more monolithic quality. Concrete was always going to be the way to go, and to be honest we didn't seriously consider other options."

> WE WANTED TO AVOID ANYTHING THAT WAS GOING TO LOOK TOO NEW OR FLIMSY. CONCRETE SUITED THAT

Hadley adds that the original hospital also informed the massing and scale of the new building: "So we have four storeys, and particularly significant was the decision to carry through the 5m floor-to-ceiling height of the ground floor."

Stanton Williams realised that what the Victorians favoured for a high-ceilinged hospital ward was also ideal for creating airy circulation areas and teaching spaces: "So we have put the two lecture theatres on the ground floor," says Hadley. "And we worked hard with the structural engineer, AKT II, to get spans long enough for those spaces to be column-free."

The solution here was to add deep ribs, or downstand beams, to give strength to the slab. These were typically 475mm deep beneath a 125mm slab and set at 750mm centres. "This not only helped to reduce the amount of concrete we needed to span the 9m across the lecture theatre, it also helped the slab to support loads from above," says Hadley.

"Because the upper floors had different layouts, it meant loads were landing in awkward places above the lecture theatres. Concrete became a key material to transfer those loads."

The ribbed ceiling perfectly illustrates Stanton William's penchant for making structure work

OPPOSITE Precast-concrete window details play a significant role in the exterior aesthetic, and align with the interior ceiling ribs

BELOW RIGHT John Outram's colourful facades have been left exposed in the new extension

architecturally, particularly the way that the recesses between the ribs have been used to house bespoke lighting and colour-matched acoustic panels. "These would normally be hung from an exposed soffit," says Hadley. "But pushing them up into the ribs gives a less cluttered aesthetic. In fact, the ribs themselves also help the acoustics by breaking up the surface and reducing reverberation."

The ribs also contribute to the environmental performance of the building, which is expected to receive a BREEAM rating of Excellent. "Because of the high levels of thermal comfort required by the client, a degree of mechanical cooling was always going to be needed – especially in the highly populated lecture theatres," says Hadley. "But the aim was for active cooling to be kept to a minimum, and so the thermal mass of the exposed concrete is used to passively absorb heat during the day. The fact that the ceiling is ribbed means it acts like the fins of a radiator – increasing the surface area and boosting the ability of the concrete to absorb heat during the day and release it overnight." The result is that active cooling can be kept off for longer.

More structural ingenuity can be found in the reception area, but unlike in the lecture theatres, it is not on display. Above the reception desk a smooth concrete canopy, with a flat soffit, stretches towards the older building. It does not reach it, however, the gap between the two being bridged by a glazed roof. This allows plenty of natural light into the reception area and manages gently to connect the old and new buildings in a way that subtly acknowledges the architectural differences between the two.

"Because it reaches out but does not touch the old building, the concrete has to cantilever," says Hadley. "That meant AKT II coming up with quite a complex, deep structure (see "A long stretch", right). We wanted a smooth [unribbed] soffit here so the slab is strengthened with upstands this time. These have been incorporated into an open terrace above, where tree planters sit between them. The resulting structure is strong enough to take the weight of the soil, paving slabs and the live load of people enjoying the terrace."

Throughout the centre the walls and soffits have been formed from non-phenolic plywood boards, which give a matt, stone-like finish. The formwork was drawn in some detail in order to ensure joints and tie holes aligned and were regularly spaced. Tie bolt holes were filled with site-cast plugs, to a 10mm recess. "We were fortunate that [concrete contractor] Whelan & Grant understood our requirements very well and had a team that could provide the kind of craftsmanship we needed," says Hadley.

A long stretch

Creating the cantilevered canopy that extends over the Simon Sainsbury Centre's reception area (shown on page 5), and stretches towards, but does not actually reach, the brickwork of the Victorian Addenbrookes Hospital, was one of the project's key design challenges.

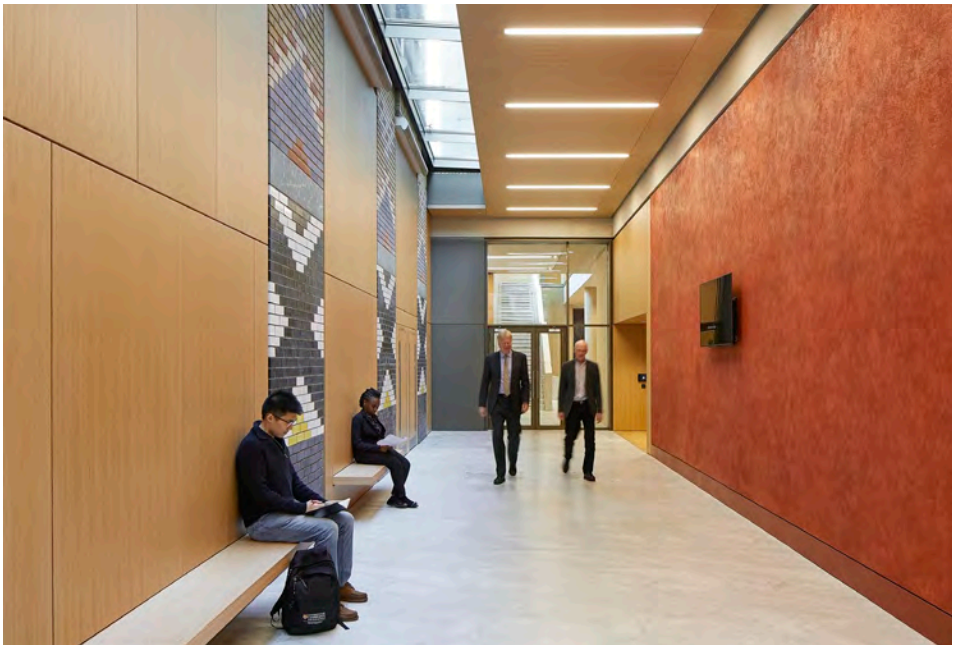
It looks elegant, even simple but, as AKT II structural engineer Steve Toon explains, its construction was anything but. "There's a lot going on beneath the surface," he says. "Essentially the canopy cantilevers from a first-floor, open-air terrace situated above and behind the reception. But whereas in the theatre area we used slabs with downstand ribs for extra strength, these do not work particularly well in a cantilever as you just have the bottom of the 'T' in compression."

The solution was first to invert the ribs – enabling the smooth concrete soffit of the canopy – and then to place a second slab on top. "So in places we have slab, rib, slab – almost like a monocoque construction," says Toon. "In others we are also using the depth of the tree planters on the terrace to accommodate upstand beams."

In some areas this meant constructing the terrace in three phases (slab, rib, slab), which presented special construction challenges. "It took a lot of propping," says Toon. "Because the bottom slab did not have the strength to support itself."

This situation was further complicated by the use of 50% ground granulated blast-furnace slag – a mix that is prone to darkening or bruising if left in formwork too long. "It meant that when the time came to remove the formwork, we had to get it out of the way quickly and immediately prop the slab to prevent it sagging," says Toon. "We had to do this in sections, sequentially, and then keep the slab propped while the ribs and top slab were cast."

In some parts of the reception area AKT II insisted that the props remained in place even when all the concrete in the monocoque construction had reached full strength. "The Young's modulus curve [the indicator of stiffness] comes up slower than the strength gain curve," says Toon. "If you are not careful you can get excessive early non-elastic deflections not accounted for in the non-linear analysis. So, in deflection-critical points, the props remained even after the concrete had hit its 28-day strength."



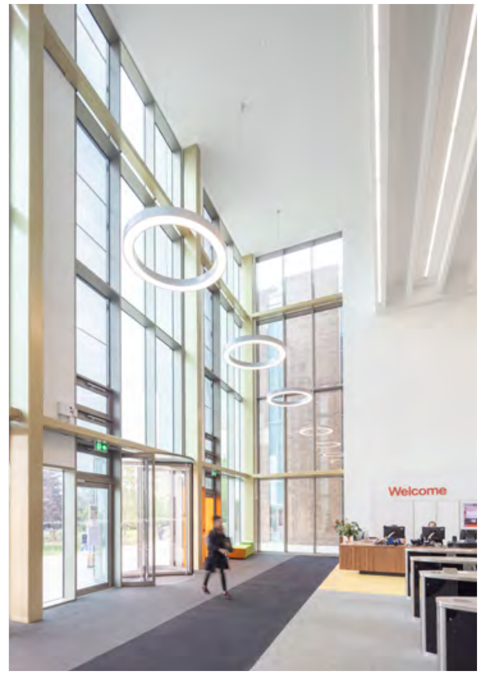
Outside, while brickwork dominates, precast concrete elements play a significant role in the aesthetic. Windows are formed from precast lintels, sills and vertical fins. These elements have a more yellow complexion than the in-situ concrete inside – the better, says Hadley, to blend with the brickwork and the tone of the neighbouring Victorian terraces.

"The other reason we went for precast was because the site was very tight – especially where the building sits right up against the street pavement. Using precast meant those elements could be placed relatively quickly."

The exterior fins align with the interior ceiling ribs, and fit well with the slotted appearance of the interior oak panelling. It is a solid, careful use of materials and forms, and one that exerts a calming influence on the extravagant style of the 1990s extension.

PROJECT TEAM
Architect Stanton Williams
Structural engineer AKT II
Main contractor SDC Builders
Concrete contractor Whelan & Grant
Precast concrete supplier Minsterstone

Photos: Hufton + Crow



Photos: Quintin Lake, Tim Crocker

REVISED EDITION

Penoyre & Prasad has edited and extended a brutalist classic at the University of Kent, writes Debika Ray

When RIBA president Lord William Holford masterplanned the campus for Kent University in the 1960s, the brutalist Templeman Library was one of its centrepieces. Over time, the building was adapted and expanded to meet the university's changing needs, but its narrow circulation and skinny staircases couldn't keep up with a student body that by the 2000s had doubled in size. It was beginning to burst at the seams.

Architect Penoyre & Prasad won the contract to solve this problem: its task was not only to improve the original structure while maintaining its strong presence, but also to add new space and make the whole building suitable for contemporary ways of learning, with more room for group work, an exhibition space and a 250-seat lecture theatre.

The architect's solution was to add a 5,400m^2 extension, using concrete to tie together the old and the new. The ambition was to draw on the ideas inherent in brutalism – honesty of materials and the display of the structure as an architectural element – without falling into pastiche.

"The original building was made of brick, but had some very strong concrete elements – a big concrete frame, with concrete beams that projected out to the facade – which gave it a very strong profile," says lead architect Suzi Winstanley. "We felt that the concrete really defined the original building and the extension should pick up on that."

Reflecting these elements, the new building's facade – as well as the new entrance – is made up of projecting precast-concrete fins, ranging from two to three storeys in size. "It was important for them to be single pieces because that gives the building the right kind of weight – smaller panels wouldn't have had the power to stand up against the original building," Winstanley says.

The facade is also testament to the successful use of BIM, as the shared use of ArchiCAD on the project allowed the precast contractor to develop the fins concurrently with the structural model.

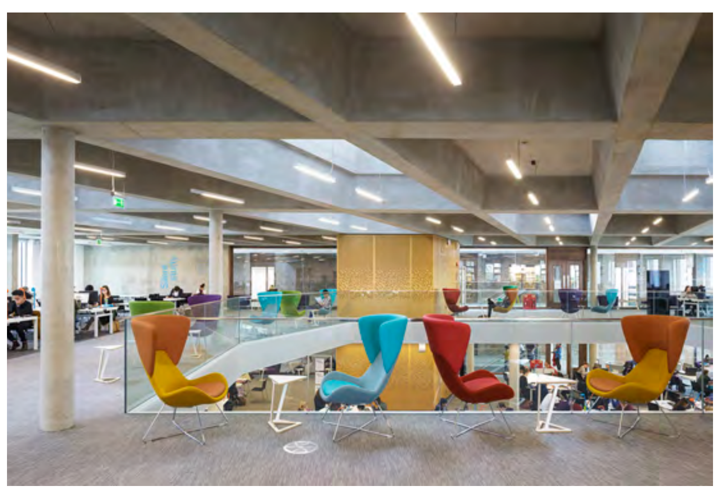
Inside the original library, the floor structure was a hollow system made from prefabricated moulded concrete pots – typical of a 1960s building. This is echoed in the diagonal structural grid on the extension's expansive top floor, where the soffits were formed using in-situ concrete poured into large silicone moulds – a nod towards pot construction but on a far bigger scale.

"We knew the concrete would be exposed and that you'd really feel the concrete in the building, so we wanted the structure to sing," says Winstanley. This structure also allows large floor spans and therefore highly flexible spaces.

Meanwhile, lying quietly beneath everything is an innovative natural ventilation system of underground passive cooling pipes – a reminder that concrete has assumed new, less ostentious roles since the heyday of brutalism.

PROJECT TEAM

Architect Penoyre & Prasad
Structural engineer Price & Myers
Services engineer Max Fordham
Contractor Kier
Concrete contractor AD Bly
Precast concrete Decomo



CLOCKWISE FROM TOP LEFT
The precast-concrete fins echo the beams of the Holford building; A glazed entrance weaves old and new together; The extension's top floor is defined by its moulded soffits – a nod to the original building

Photos: Richard Chivers, Nigel Rigden

GRAND SLAB

PAD Studio's tennis pavilion in Portsmouth aces a fair-faced concrete soffit, writes Pamela Buxton

Not only is Canoe Lake Leisure Tennis Pavilion the first new public building to grace the Southsea seafront in Portsmouth for 30 years, it is the first public building that its architect, Lymington-based PAD Studio, has completed. It is a success story all round – the £1.1m venue has since hosted a major Lawn Tennis Association event and been shortlisted for a RIBA Award.

Not bad at all for a collaboration that began fortuitously when the client picked the architect out of the Yellow Pages. It was a challenging project – the local council initially wanted just a single-storey building and the previous pavilion had suffered a lot of vandalism. But the architect secured planning permission for a two-storey structure that includes rooms for community use as well as tennis facilities. A key element is the in-situ concrete first-floor slab, which provides thermal mass as well as enabling the 9.4m free spans required.

"To keep the building as low as possible and ensure a first floor could be included within restrictions on ridge heights, we looked to minimise the depth of the structure and maximise the space available," says project architect Ben Munro.

The composite structure consists of brick-faced blockwork for ground-floor walls with a concrete slab and lightweight steel upper structure. Large expanses of glazing are protected from vandalism at night by sliding shutters that are perforated to allow the building to "glow" when illuminated.

The designers initially considered a precast solution for the first floor but chose to go with an in-situ slab, which was poured in one go using phenolic-faced ply formwork. The 230m^2 slab is 400mm thick in the centre tapering to 300mm at the edges and incorporates void formers to reduce weight and cope with the long spans. "Since we were going to that effort we decided to leave it exposed," says Perring.

A bespoke but simple specification was developed for the exposed concrete, with reference to the National Structural Concrete Specification for details related to a "special finish". This included a methodology for post-finishing, which meant a process and budget was already in place when some localised post-finishing was required.

The project was delivered using a construction management contract, which allowed PAD the flexibility to explore construction methods and obtain input from different consultants. Collaboration was very much at the core of the process, and is regarded by PAD as essential for achieving good results with exposed concrete.

As well as its structural and thermal benefits, the use of concrete and other deliberately utilitarian materials responded to the context. "Although it's surrounded by green courts it's quite an urban condition, and the materiality of the building reflects that," says Munro. At the same time, the architect took care to avoid a fortress mentality, arguing that the best protection against vandalism is a building that engenders civic pride. "We want it to be a shop window for tennis and for what's going on inside," says Perring.

PROJECT TEAM
Architect PAD Studio
Structural engineer Eckersley O'Callaghan
Building contractor Rice Projects
Concrete slab contractor Mohan Building Services
Concrete consultant GreyMatter Concrete

CLOCKWISE FROM TOP LEFT
The exposed concrete soffit is complemented by plywood walls and ash floors; 9.4m spans create the sense of an open, permable building; The glazed first floor adds to the sense of transparency

MAKE'S MAZE

Processing data takes a lot of energy. Make Architects' Pete Matcham and Mace's Phil Hilton explain how a 1km-long concrete labyrinth lightens the load at Oxford's Big Data Institute

The Big Data Institute (BDI) in Oxford is a cutting-edge research centre dedicated to the analysis of large, complex data sets that could hold the key to the treatment of a variety of diseases. But its users may go about their pioneering work completely unaware of one of the most innovative aspects of the building. With such huge quantities of data to be processed – up to 600 trillion computations per second – the 7,500m^2 facility needed a vast server room, which in turn required an innovative cooling strategy in order to meet the project's target of a BREEAM Excellent rating. Service engineer Long and Partners, together with sustainability consultant RES, proposed a first for a UK research building: a subterranean labyrinth. This eventually helped to surpass expectations, securing BREEAM Outstanding – the first ever such rating for both Make and the University of Oxford.

The building

The design of the BDI, Make's fourth completed project at Oxford's biomedical research campus, was shaped by the need to encourage collaboration between researchers; to be adaptable to future uses; and to keep energy use to a minimum. Four levels of perimeter offices and open-plan spaces are arranged around a timber-lined atrium, with social and breakout areas interspersed throughout. Not only does this layout foster a sense of openness, it is also key to the passive energy design, as it maximises cross-ventilation by drawing air through the building using controlled atrium ventilators.

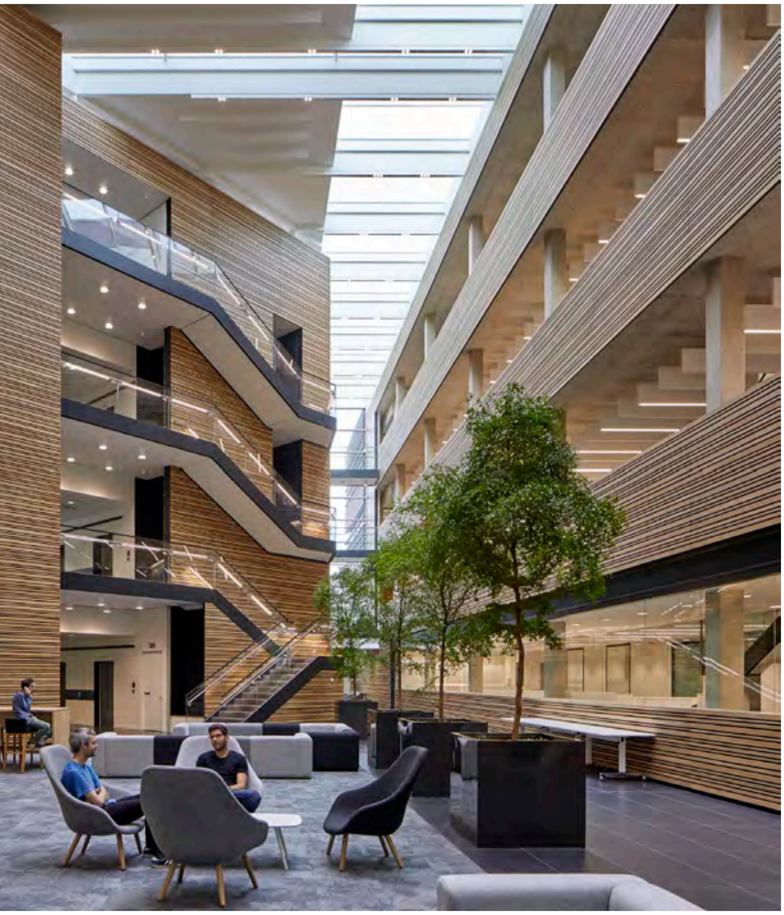
The other Make buildings on the campus have an in-situ concrete frame with flat slabs in order to minimise vibration, maximise clearance for high-level services, and give future flexibility for service penetrations. This also has the advantages of inherent fire protection and thermal mass. At the BDI, post-tensioning was used to minimise slab depths and speed up construction, and an asymmetrical structural grid of 7.5m x 6m, working with a planning grid of 1.5m, was deemed the best solution in terms of cost and flexibility of space. This allowed the mid-span columns to be aligned with the walls of the perimeter offices. The concrete soffits have been left exposed to optimise thermal mass and guide the building's aesthetic.

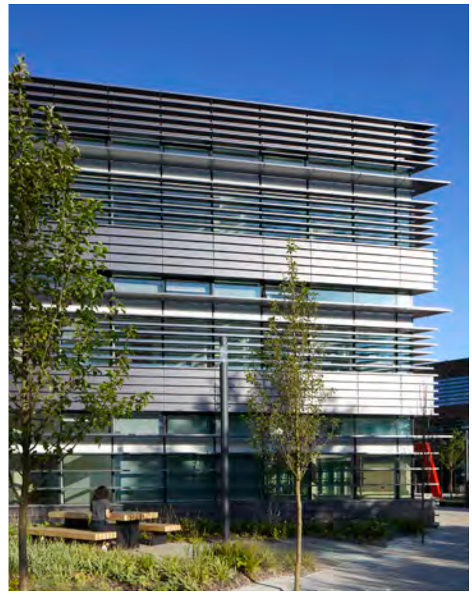
Externally the facade echoes the neighbouring Nuffield Department of Medicine Building, also by Make, with which it forms the Li Ka Shing Centre for Health Information and Discovery. It is veiled in horizontal grey polyester powder-coated aluminium bands and glazing, with the arrangement more open along the north elevation and more solid on the south and west, thereby limiting solar gain.

The labyrinth

Fundamental to the passive design is a subterranean concrete labyrinth located beneath the lower ground floor, which uses the thermal mass of the concrete to provide mechanically assisted summer cooling and winter heating. Labyrinths are still very unusual as a cooling strategy in the UK, and this is the first time that

THIS IS THE FIRST LABYRINTH TO BE USED BENEATH A RESEARCH BUILDING WITH SUCH A HIGH COOLING REQUIREMENT





Photos: Make Architects

FAR LEFT The labyrinth consists of a network of 2.1m-high tunnels

LEFT The atrium maximises cross-ventilation through the building

RIGHT The facade is veiled in horizontal grey polyester powder-coated aluminium

BELOW RIGHT The vertical precast panels have a heavily textured surface finish in order to increase the surface area

PROJECT TEAM

Architect Make Architects
Structural engineer Peter Brett Associates
Services engineer Long and Partners
Main contractor Mace
BREEAM consultant RES Design

one has been used beneath a research building with such a high cooling requirement. The design team worked closely together from the outset and used fluid dynamic modelling to determine the best overall solution for the building.

The labyrinth is designed and used as the primary cooling medium. The building is naturally ventilated with assisted mechanical ventilation, supplied via the thermal labyrinth. No additional mechanical cooling is provided in occupied areas.

The labyrinth works by pulling outside air in through three separate air corridors that are 1km long in total. In summer, it uses the stable temperature of the concrete tunnels to pre-cool the air before it enters the air-handling units. This air is then distributed via floor plenums and extracted via the atrium using the stack effect. The conditioned air from the labyrinth is supplied via an underfloor displacement ventilation system, with the air supply rate calculated to offset the thermal heat gains of the occupied spaces.

In winter, the air is warmed by the tunnels, before it is heated by waste heat from the data centre, and by warm air returning through the process via a thermal wheel. Once this process is completed, any additional heat is provided by a conventional heating coil using high-efficiency condensing boilers, thereby significantly reducing the energy typically required to condition air and achieve thermal comfort. The payback time of the labyrinth in terms of energy cost savings is estimated to be approximately 26 years; the building's design life is 60.

The initial design intent for the labyrinth was to have an in-situ concrete outer structure with the "maze" of walls built out of blockwork. The nominal design height to achieve the necessary volume of air movement was only 1,200mm. However, to increase air volumes and performance, and to satisfy CDM regulations, this was increased to a safe working height of 2,100mm.

The building sits in an area with a very high water table, and waterproof concrete was used to create the basement cofferdam, which included the raft slab and perimeter walls of the labyrinth, directly below the basement. This was designed so that no groundwater could penetrate the labyrinth.

For the internal walls, vertical precast panels were lowered onto locating lugs cast into the in-situ raft slab. These vertical units were cast with a heavily textured surface finish on both sides in order to increase the surface area of the concrete, thus maximising its exposure to the air and further improving the efficiency of the thermal mass.

The concrete lid to the labyrinth was also made of horizontal precast panels that took support from the precast walls below. The precast option reduced the installation time to just four weeks. This was then covered with insulation and a layer of in-situ concrete to create a platform for the basement.

One of the challenges faced during construction was rainwater ingress, because any long-standing water could create bacterial growth that might contaminate the airflow in the finished building. The labyrinth, being at the base of the building, would act as a natural sump for rainwater until such time as the building above was weather-tight.

To reduce this risk, a temporary waterproof membrane was applied to the basement slab above the labyrinth. This, combined with regular checks, ensured that water ingress was kept to a minimum. However, in hindsight, it would have been better to put a waterproof concrete topping over the B1 slab and reduce the subsequent thickness of void former and insulation that sat on it.

The key lesson for anyone considering using a labyrinth is to incorporate it from the concept stage so that it can be captured within the project cost plan and factored in to all planning details.

Photos: Rory Gardiner

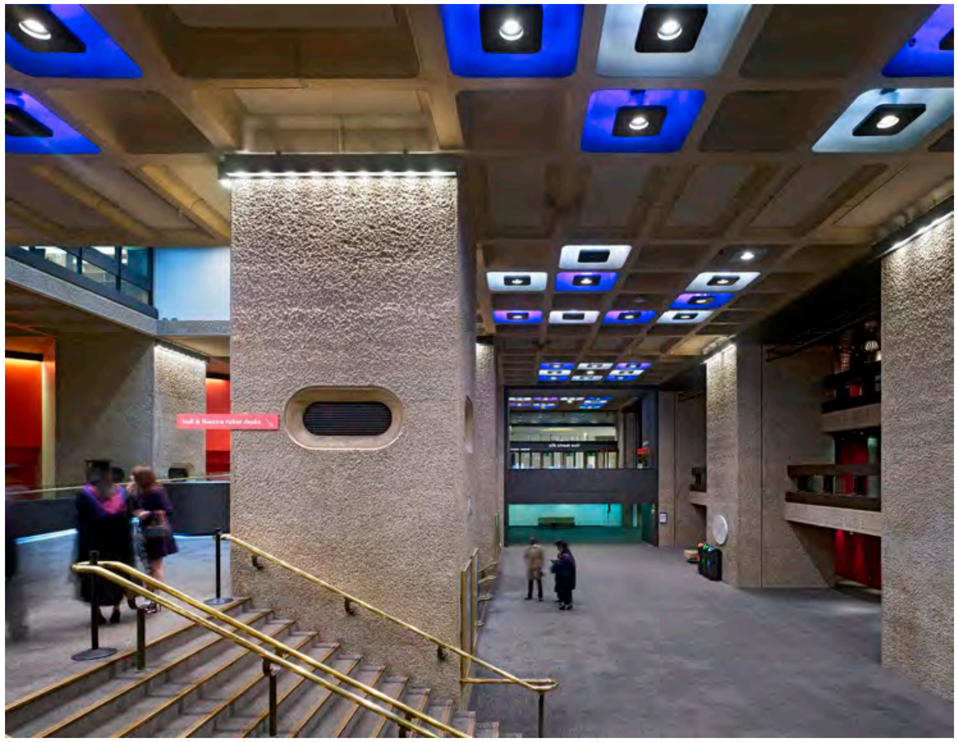
INTO THE ROUGH

Roughly textured concrete is enjoying a renaissance. Elaine Toogood explores the different aesthetics and the techniques used to create them

Contemporary construction methods often dictate that the surface of formed concrete is smooth. But rough textures offer a variety of alternative aesthetics, which are becoming increasingly popular. Arguably, the simplest means of creating heavily textured concrete is to cast it against a textured surface. A huge range of effects can be achieved with flexible form liners, either pre-formed or bespoke. The defining characteristic of this process is that the surface remains intact, with aggregates hidden behind a smooth paste of cements. For deep textures, the best results are produced by casting horizontally with liners placed in the base of the mould, which reduces the risk of leaving the recesses unfilled.

Smooth concrete can also be given a rough texture after the formwork has been struck with "post-finishing" techniques to remove or break part of the surface and expose the aggregate. Depending on the technique used, the texture can vary considerably.

OPPOSITE The textured internal concrete surfaces of Mole Architects' The Houseboat were created by shot-blasting the in-situ concrete surfaces to reveal natural aggregates. The external photo shows the concrete frame under construction



RIGHT Bush-hammered concrete is one of the defining characteristics of the Barbican estate in London

BELOW Peter Zumthor's Bruder Klaus Field Chapel in Germany, created from rammed concrete made using aggregates from the surrounding fields

Photos: Getty Images/VIEW Pictures; Seier+Seier/Flickr

Surface retarders are proprietary liquids or gels that prevent the surface of new concrete from hardening. For formed concrete, a coating (known as a negative retarder) is applied to the inside of the formwork in place of a release agent. Once the formwork is struck, the soft surface of the unset mortar that has not set is washed or brushed away to reveal a plane of exposed aggregate. The amount of surface removed or "depth of etch" is controlled through the grade or strength of retarder, with the option to reveal much of the undamaged shape of the coarse aggregate. Timing is critical with this method and a warmer ambient temperature and higher strength of concrete will reduce the window of opportunity to remove the surface before it starts to harden again. This technique is therefore more often used in the controlled conditions of a precast factory rather than on site, although retardants are commonly used for unformed in-situ concrete.

Shot and grit-blasting can be used to create rough textures on hardened concrete, including in-situ concrete. Such abrasive blasting is generally used to remove surface coatings but can also reveal either small or large aggregate, depending on the amount of mortar removed. Workmanship should be tested in advance to agree standards and techniques. The Concrete Society publication Visual Concrete – Finishes suggests that a heavy, or deep, abrasive blast is best carried out when the concrete is still relatively weak – for example, one to two days after placement – whereas a light abrasive blast may take place between three and seven days later. Concrete can of course be abraded much later than this, but the process, like the concrete, will be that much harder.

As with any post-finishing technique, an allowance for extra cover is required to ensure the minimum designed depth is maintained, and of course the size and type of aggregate used is in the mix is fundamental to the final aesthetic. The textured internal concrete surfaces of The Houseboat in Poole by Mole Architects were created by shot-blasting the in-situ concrete surfaces to reveal natural aggregates from the Mendip hills.

There are many examples of mid-20th century precast and in-situ concrete structures featuring heavily textured surfaces, many created by tooling the concrete once it had hardened. These finishes include bush-hammering and point-tooling as well as those with a needle-gun finish. All are

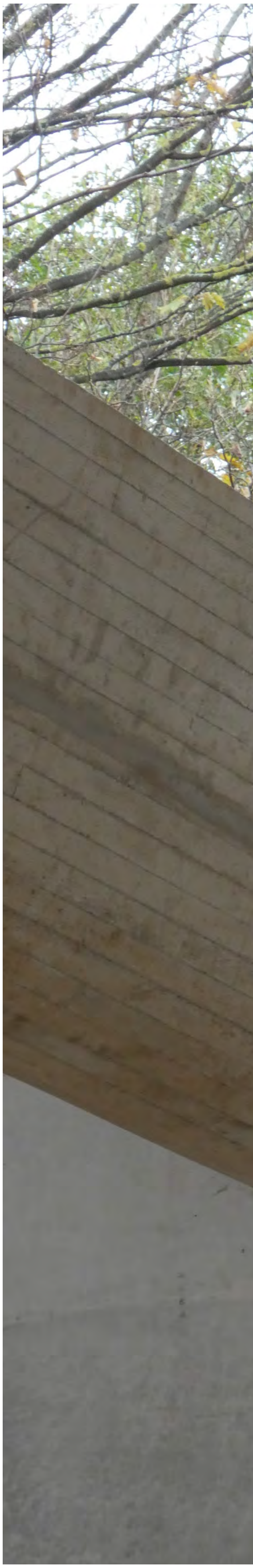
RAMMED CONCRETE IS RATHER NICHE, BUT HAS A STRONG AESTHETIC APPEAL REQUIRING CLOSE ATTENTION TO MIX, PROCESS AND TESTING

appropriate for creating a rusticated, bumpy surface that may or may not reveal the shape of the coarse aggregate. More recently, health and safety concerns have limited the use of these techniques to very controlled situations, often factory-based. A notable recent in-situ example is 21 Caroline Place by Amin Taha Architects (CQ 260, summer 2017), where the specifically sourced white aggregate was exposed on the soffit and walls of the basement interior by bush-hammering away 30mm of the surface. Another example is the hammered ribs found at Walmer Yard, a housing development in London by Peter Salter.

It is also possible to achieve texture within the cast surface of the concrete itself simply by lack of compaction or by using special mixes to create holes or gaps, such as no-fines concrete. Rammed concrete would fall into this category. Rammed concrete is a method for compacting fairly dry, hand-batched concrete, rammed manually into the formwork in layers to create a highly individual stratified and often crumbly textured concrete. A well-documented example is the Bruder Klaus Field Chapel in Mechernich, Germany, designed by Peter Zumthor using aggregates from the surrounding fields. This method of placing concrete is not suitable for reinforced concrete, and so walls must be wide enough to provide the necessary stability to support themselves, as well as to provide sufficient space in the mould for the concrete to be tamped. The amount of concrete that can be placed in one day is restricted, thereby creating numerous horizontal layers. This combination of labour intensity and structural limitation renders the method difficult to produce at scale. It is therefore rather niche, but has a strong aesthetic appeal requiring close attention to mix, process and testing to create the desired effect. It has been specified by Zumthor again for the walls of Secular Retreat, a project currently under construction in the Devon countryside.

At a recent Concrete Elegance presentation for The Concrete Centre, Ian Bramwell of Mole Architects, the architect of The Houseboat and executive architect of both Secular Retreat and Walmer Yard, referred to creating the concrete as an "artisan" process. This is a term often used in the food world for activities such as bread-making, and usually intended to express care, expertise and quality of ingredients. As Bramwell says, perhaps creating highly textured concrete is less about being rough and more like baking very "well-bred bread".

For guidance on achieving exposed concrete, download Visual Concrete at concretecentre.com/ publications



TOP The new visitor centre at Yorkshire Sculpture Park is set into the landscape of a former quarry

MIDDLE Its sawtooth roof is formed as a series of inclined reinforced concrete beams spanning 10.5m over the gallery

ABOVE Within each 1.2m lift of formwork are four sub-layers, each containing a different concrete mix

RIGHT The concrete beams have curved profiles that draw light into the gallery and across their board-marked surfaces

PROJECT TEAM
Architect Feilden Fowles
Structural engineer engineersHRW
Main contractor William Birch & Sons
Concrete contractor Northfield Construction

Photos: Feilden Fowles

◀ Visitor Centre and Gallery, Yorkshire Sculpture Park

The new gallery and visitor centre at the Yorkshire Sculpture Park is set into the hillside of a former quarry, a location that has informed and inspired its construction and appearance. It was conceived as "a sculptural element, emerging from the earth", says Fergus Feilden of architect Feilden Fowles. 'We wanted the building to read as being 'of the land' with texture and layers like geological strata."

Cement-stabilised, rammed earth was investigated as an option, but was discounted due to detailing constraints dictated by the material, which would have compromised the architectural design intent and reduced durability in comparison to concrete. "Rammed earth needs to be protected to be durable," explains project engineer Chris Stobbart at engineersHRW. "Walls using this technique are typically made with 'good boots and a good hat', with the rammed earth raised above the external ground on an upstand with well-drained footings and with generous overhanging eaves at the top to protect the walls. Concrete was able to offer increased durability with less risk to the client and more flexibility to achieve the desired architectural finish."

Rather than physically ram the concrete in place, the walls were constructed using reinforced concrete poured in shallow layers. Within each 1.2m lift of formwork are four sub-layers, each containing a different concrete mix with varying pigments and aggregate. The formwork was pre-treated with retardant so that, once struck, the face of the concrete could be jet-washed to expose the aggregate and provide the layers of rough texture required.

engineersHRW specified structural parameters for the mix within typical limits for reinforced concrete. By testing and developing sample panels, the contractor determined that it could achieve the desired architectural appearance with a standard S3 consistence class. This provided a mix that was well graded to give an even distribution of aggregates without segregation.

The compressive strength of each mix was confirmed by cube testing. The sub-layers within a 1.2m lift were each poured before the sub-layer below was fully cured thereby allowing them to blend together to give a better shear interface. "Some small variation in stiffness between layers is expected due to the use of different aggregate types," says Stobbart, "but since each layer is relatively long and consistent between vertical joints, local stiff points within a wall panel are avoided. Otherwise, they could lead to cracking."

The jet-blasting was accommodated by increased cover to the reinforcement bars. This increased cover together with the wide spacing of the reinforcement, also enabled adequate compaction of the textured concrete when poured in such shallow layers.

Concrete subcontractor Northfield Construction built four sample walls in its yard to test out different construction techniques, including tests for shot-blasting, types of retardant and curing times between pours. Part of the north wall in the building was also used as a construction trial. Only after such careful consideration and testing was the final combination of mixes and finishing processes scheduled for construction.

The project also includes structural concrete exposed internally with smooth, in-situ walls enclosing the gallery space. Its sawtooth roof is formed as a series of inclined reinforced concrete beams spanning 10.5m over the gallery. The curved profiles draw north light into the space and across their timber-board marked surface. Each profile incorporates a slotted lighting track and cast-in fixing points for the gallery to suspend artworks. As well as the gallery space, the building includes a restaurant, shop and public foyer. It is due to open in September.

CASTLE IN THE SAND

Structural engineer McNamara Silvia had its work cut out to build Herzog & de Meuron's sculptural concrete tower on Miami beach, writes Andy Pearson

Photos: Field Condition; Model: McNamara Silvia; Floor plan: Fortune International Group

A sliver of beach is all that lies between the Atlantic Ocean and Jade Signature, a 62-storey luxury oceanfront tower in the Sunny Isles Beach neighbourhood of Miami, Florida. The recently completed scheme features 192 luxury apartments, all of which span the full width of the building, affording their occupants views out of both the ocean to the east and the city skyline to the west.

Designed by Swiss architect Herzog & de Meuron the tower is supported on a concrete structure clearly expressed on the facades by sculpted vertical columns and projecting floor slabs, which provide the apartment's large outdoor terraces and shade the glazed facades from the Miami sun.

It is not the sun, however, but the hurricane-force winds that posed a major challenge to the project's structural engineer McNamara Silvia: "The structure is designed to deal with some of the highest winds anywhere in the world," says principal Andrew Sullivan.

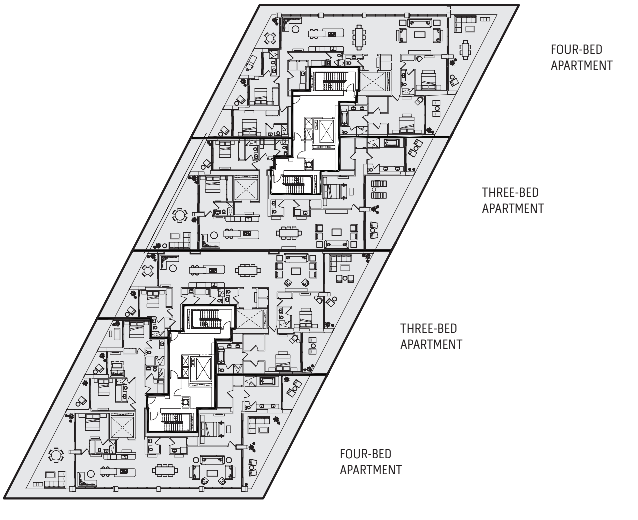
The tower is unusual in that its footprint is a parallelogram, minimising the shadow it casts on the beach to the east and capturing the greatest amount of direct sunlight for the ocean-facing apartments. As a consequence, the building's beachfront elevation is angled approximately 45 degrees to the beach. The apartments, however, are arranged perpendicular to the beach (see floor plan, right). "The design is all about maximising views, which meant we had to be careful about where we placed the shear walls," explains Sullivan.

To preserve these views, the building's two reinforced-concrete lift cores and the integral shear walls, which are key to resisting lateral wind forces, are also at a 45-degree angle to the main elevations. "The building's configuration meant that it behaved in the wind as if it was a square building instead of a rectangle," says Sullivan.

In addition to its distinctive footprint, the tower is unusual in that it tapers gradually from bottom to top on its east and west facades, which means its floor plates become progressively narrower. "The perimeter columns stack, but they are offset by 3in [75mm] all the way up the building to account for the smaller floor plates," says Sullivan.

3D MODEL

FLOOR PLAN (LEVELS 26-34)



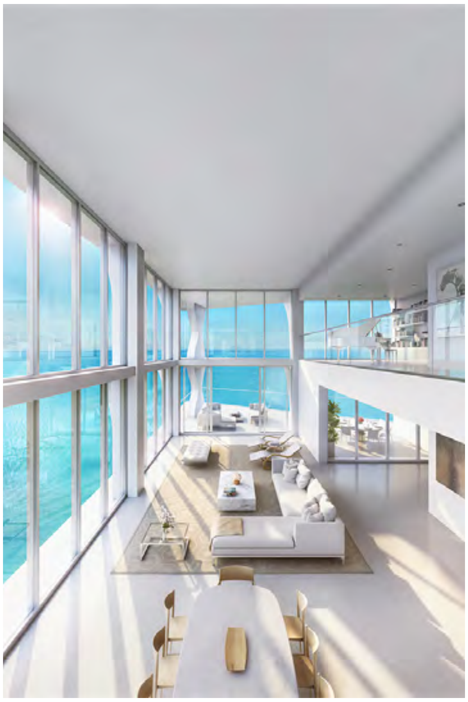
CLOCKWISE FROM OPPOSITE Sculptural columns support the tower's 6m-deep balconies; The beachfront elevation is at a 45-degree angle to the sand; A 3D model shows how the tower tapers gradually as it rises; The plan shows the parallelogram shape and asymmetrical position of the cores; The lobby opens out onto the beach, via the pool

The perimeter columns also change shape from floor to floor. "A sweeping column might turn into a column with less of a sweep and then into a rectangular column and even into an hour-glass column," he adds. In the words of Herzog & de Meuron: "The project uses structure in the most basic way, a structure that you have anyway, and turns it into something sculptural".

Where possible, the engineers took advantage of the form of the columns to help support the tower's expansive balconies. "The sweeping columns helped because some of the trapezoidal-shaped balconies are fairly deep – up to 20ft [6m] – so where we had the opportunity we used the sweeping columns to help prop the cantilever," says Sullivan.

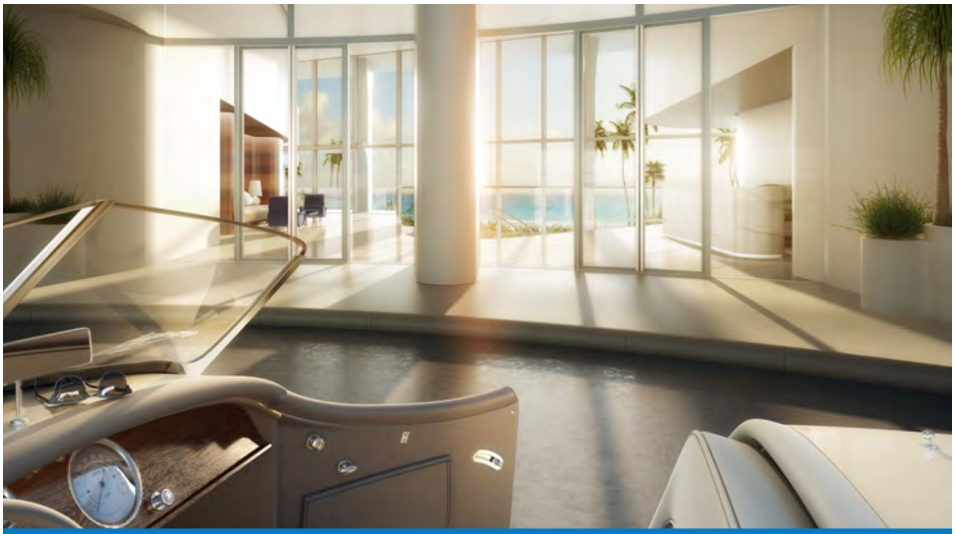
Perhaps the most unusual aspect of the scheme, especially to those familiar with the ground conditions in this area of Miami, is that the residents' parking is located underground. Burying the car park, rather than housing it in a podium at the tower's base, as is the case with most neighbouring developments, allows Jade Signature's residents access to the lobby area from the street – the lobby opens out onto the swimming pool, the pool onto the beach, all of which are at the same level.

"The designers wanted a project that when you pulled in off the main road you didn't have to drive up a big podium to gain entry. They wanted people to be able to pull up to the front door and be able to see the beach and water," Sullivan says. "We were involved early in the project, mainly in regards to coming up with a good, cost-effective scheme to create a 40ft-deep [12m] excavation right on the beach for the underground parking."



Visualisations: Fortune International Group

ABOVE CGI showing one of the double-height "sky villas" near the top of the tower



HOW TO BUILD AN UNDERGROUND GARAGE ON A BEACH

Ground conditions on the ocean-front plot where Jade Signature was to be constructed were far from ideal. The site was covered with about 4.5m of beach sand, overlaying a 3m layer of peat on top of layers of limestone and sand. In addition, the ground was saturated, with groundwater just 600mm below the surface.

Before excavation of the parking garage could commence, contractor Suffolk Construction worked with foundation contractor Malcolm Drilling Company to stabilise the ground around the perimeter of the excavation site and also beneath the site. For this, they used a low-strength, low-permeability form of concrete created in-situ with a technique called deep soil mixing. The plan was to create what the contractor terms "a giant, waterproof bathtub" to protect the excavation from groundwater infiltration during construction.

Malcolm Drilling designed a 2.7m-diameter hybrid auger specifically for the project. As the auger bores into the ground it crushes the limestone and mixes it with the sand while simultaneously injecting cement slurry into the mix as a binder. The pulverised limestone and sand serve as a natural aggregate to create a column of concrete-like material that eventually hardens. Malcolm Drilling repeated this process hundreds of times to form the bathtub's four, 3.6m-thick walls.

To create the floor of the bathtub within the rectangle of walls, water was used as the drilling fluid until the auger had bored down to the level at which the basement floor was to be constructed. At basement floor level, cement slurry was again injected as a binder and the auger continued its journey downwards for another 6m. Again, the operation was repeated over the entire 69m x 46m footprint of the building to form the floor of the bathtub. In total, 2,000 deep-soil-mixed columns were used to create the walls and floor of the bathtub.

Before excavation of the dry soil inside the bathtub could start, a series of 45m auger-cast-in-place piles were installed into the ground through the base of the bathtub. These piles now carry the weight of the tower, however they were initially used to keep the concrete bathtub in the ground and to prevent it being pushed upwards by the pressure of the ever present groundwater.

Once the piles were in place, the dry soil inside the concrete tub was dug out to reveal the bathtub's deep soil mix walls and floor.

The creation of the deep-soil-mixed bathtub enabled Suffolk Construction to cast the 2.4m-thick concrete mat foundation on which the tower now stands in the dry, 11.5m below the water table. The mat was constructed with 2,900 tonnes of steel rebar and 7,500m^3 of concrete from 1,200 deliveries and poured over a 24-hour period. With the mat complete, construction of the tower on the beach could commence.

Coming up with a way to build a 425-car, three-storey garage in porous limestone and sand at the edge of the ocean was not without its difficulties. "Before this building was here you could have taken a shovel and by the time you'd dug down 2ft you'd have hit water," says Sullivan. "So keeping 38ft [11.5m] of ground water out of this space was a large part of the structural design" (see "How to build an underground garage on a beach", above).

Although the basement was probably the most challenging aspect of the scheme to construct, Sullivan says that creating the subterranean car park did help with the design of the foundations below. "The positive from the removal of all of the soil was that there was a load swap with the weight of the building that does not penalise your foundations."

With the tower's construction complete, many of the apartments are now occupied, giving their residents the opportunity to experience first hand the architectural use of concrete to create a unique living space on the ocean front.

LASTING IMPRESSION
ROGER ZOGOLOVITCH

GOLDFINGER, CORB AND ADVENTURES IN SPACE

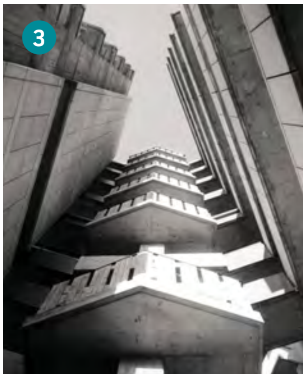
I have a very early recollection of the creation of the elevated section of the Westway 1 (1970), which always intrigued me as a prefabricated and prestressed model. In those days, you could wander beneath it and along the tow path of the canal, and suddenly Goldfinger's Trellick Tower 2 (1972) would emerge as a counterpoint to this marvellous piece of concrete structure, a monument of extraordinary beauty dominating the west London skyline.

When I was a student at the AA, Goldfinger came to give us a lecture. I have a memory of him arriving in the lecture hall carrying Sainsbury's bags and out of these he brought two models showing Trellick Tower's overlapping scissor section. I thought, "This dotty old guy up there holding these models, how does that affect my life?" But the more I thought about it, the more I understood the intelligence of this section. I became obsessed by the way that apartments can allow you to use them in volume – that's something we've used a lot in our approach to space.

Later, I was able to see Le Corbusier's Unité d'Habitation in Marseilles (1952), another piece of concrete wonder. It was a hot afternoon as I approached the building and I heard somebody singing – a single soprano, very beautiful and melodic. This sound poetry made the building even more romantic. There's a full-size mock-up of the apartments in the Palais de Chaillot in Paris, which reinforced the clever use of the space within this envelope, similar to Goldfinger. Lasdun does the same thing at Keeling House 3 (1955) in east London, which is triangular in plan and made up of duplexes. These experiences convinced me that concrete is not just a wonderful sculptural material, but also allows you to create space inside a building.

A favourite book of mine is on car parks across the world, which comes back to concrete as both a structural and a plastic material – and a heroic material. I was always amazed by the one under Bloomsbury Square 4 (1972), which is a double interlocking helix so you go down one helix and cross over and go up the other.

Roger Zogolovitch is the founder of Solidspace



Photos: Mark Cocksedge; 1. Joe Dunckley/Alamy Stock Photo; 2.Cinnead/Flickr; 3.RIBApix; 4. Stefan Lange Photography

FROM THE ARCHIVE: WINTER 1971

MADREPORIC SPONGES ON THE MED

Strange things were afoot on the Côte d'Azur in the early 1970s. First, a new village appeared in the rocky hills behind Cannes; and then another, cascading down a steep hill to the Mediterranean. What was striking about both of these developments was that there was not, as CQ editor George Perkin observed, a straight line or rectangle to be found on either of them: "All is sculpture, some houses look like caves." It was as if the ghost of Gaudí had taken a holiday at the seaside.

The villages – Castellaras-le-Neuf and Port La Galère – were the work of the maverick Marseillais Jacques Couëlle, and were the very essence of organic architecture, their sprayed-concrete surfaces curving and arching as if shaped by the forces of nature. "My houses are living beings," Couëlle wrote. "They have a nervous system, a stomach, intestines, a heart. They are built like madreporic sponges."

Perkin was immediately impressed. "With its rock-like clusters of houses it is obviously one man's personal vision and a brilliant conception at that."

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FINAL FRAME: UREDDPLASSEN, NORWAY

Oslo-based studio Haugen/Zohar Arkitekter has designed this rest area next to a Second World War memorial on the Helgelandskysten Norwegian Scenic Route. An in-situ concrete slab forms a terrace facing the sea, while precast-concrete steps lead down to the shoreline. At one end of the terrace, the surface appears to sweep upwards to form the roof of an accessible toilet.

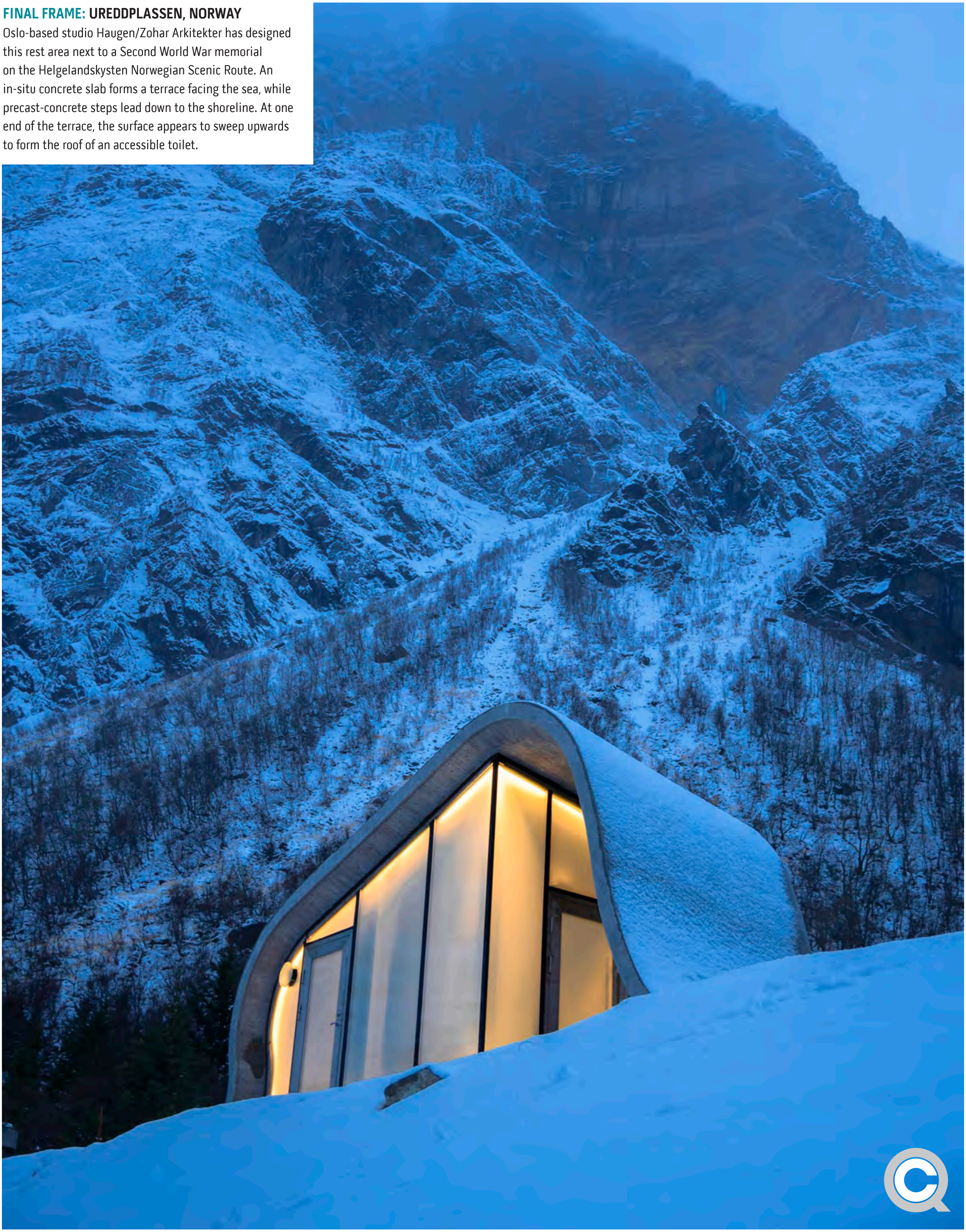

Photo: Steinar Skaar