CONCRETE QUARTERLY

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HANGING ROCK
Rojkind Arquitectos cantilevers a world-class concert hall over a Mexican beach

PERFECT SKIN
Steven Holl's concrete art school makes the cover of Vogue (and four pages of Concrete Quarterly)

TWO-TONE REVIVAL
The new buildings showing that concrete looks just as good in black and white

CONTENTS

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AGENDA

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

Continually recast

One of the things I've noticed during more than a decade as editor of Concrete Quarterly is how the definition of "concrete" seems to be constantly expanding. For inclusion in CQ, our very broad parameter is that a building should be "constructed from concrete" and – as space is always limited – demonstrate some particularly inspirational or innovative use of the material. But that seems to encompass an ever greater range of buildings.

Visual concrete has of course gained in popularity over the last decade – becoming almost a staple of the modern workplace, and of many of the most desirable bespoke homes. But concrete is often an essential structure for other popular aesthetics too – many of today's apparently brick facades would be little more than a heap of masonry without a solid concrete backing.

As with every architectural material, concrete's popularity has waxed and waned over the years. Our 70th anniversary last year, and the publication of our book, The World Recast: 70 Buildings from 70 Years of Concrete Quarterly, gave us an opportunity to reflect on how the bold, proudly exposed modernist experiments of the 1960s and 70s gave way to the pop finishes of postmodernism and the preference for concealed structures in the 1980s and 90s, before returning reinvigorated to meet the challenges of the new Millennium, albeit in a more refined form.

Fashions and aesthetic preferences will always change with the times and in reaction to what has gone before. But there are other things in play too, as global challenges such as climate change mitigation and adaptation, and more localised ones such as the housing shortage, drive innovation at a rapid pace. Concrete is no longer a material so much as a high-tech product with infinite recipes meeting specific client demands, whether economy and speed in a demanding market, robust and efficient structural solutions for city towers, or a perfectly crafted interior finish that will delight forever. Concrete construction encompasses a vast array of innovative design and construction solutions, and it's getting broader as digitisation becomes an increasing part of the process – from the formulation of the mix to construction on-site to digital components ready to slot into BIM models.

Which perhaps explains why it seems to get harder every issue to fit in everything we'd like to – though as an editor, it's certainly not a bad problem to have.

CONCRETE IS NO LONGER A MATERIAL SO MUCH AS A HIGH-TECH PRODUCT WITH INFINITE RECIPES

this is concrete

GRENFELL AND THE DANGERS OF COMPLACENCY

Stripping combustible cladding from high-rise buildings is a commitment to change, writes This is Concrete blogger Tony Jones – but it's only the first step. "[The Hackitt review's] legacy should extend to the scrutiny of all safety-critical elements, particularly structural components." Current guidance is "surprisingly ambiguous", and insufficiently explicit on the impact of failure on surrounding buildings. "Grenfell has taught the industry a powerful lesson about the dangers of complacency … Incorporating stronger safeguards against collapse will help us to establish a safer set of regulations that protect both a building's occupants and its neighbours."
www.thisisconcrete.co.uk

CONCRETE QUARTERLY

On the cover: Rojkind Arquitectos' Foro Boca concert hall in Veracruz, Mexico.
Photo: Paul Rivera
Produced by: Wordmule
Designed by: Nick Watts Design

mpa The Concrete Centre

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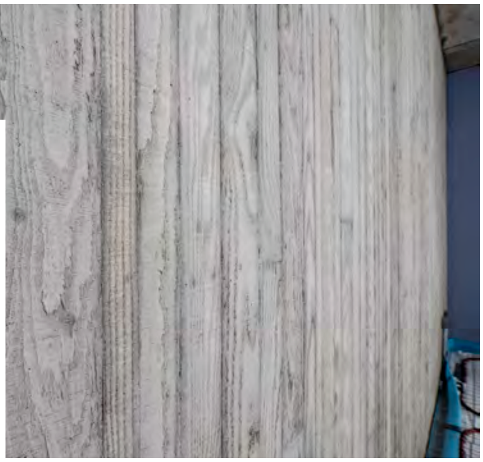
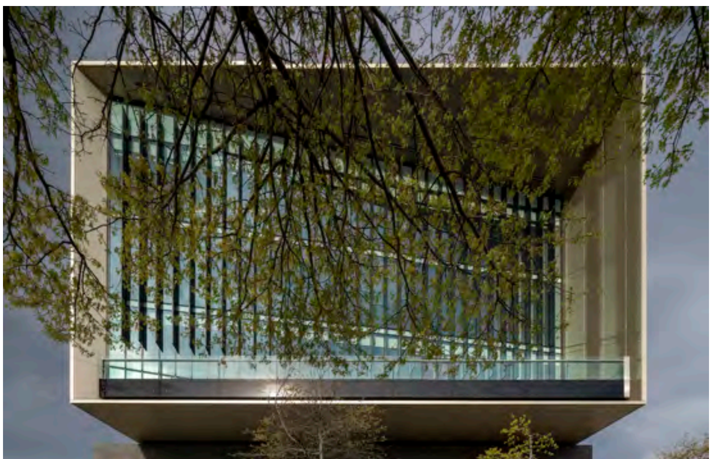


Great wall of Norwich

The University of East Anglia's new science and engineering facility has topped out. Designed by Fraser Brown Mackenna and constructed by RG Carter, the building has a boardmarked concrete feature wall running the height of the building.

Arch of triumph

The Almonte viaduct in Extramadura, Spain, designed by Idom, has won the top prize at the US's Excellence in Concrete Construction Awards. At 996m, the structure is the longest high-speed rail viaduct in the world and is supported on a 384m arch made of 80MPa concrete.



World's strongest library

Schmidt Hammer Lassen's central library is one of the first new public buildings to open after the 2010 and 2011 earthquakes in Christchurch, New Zealand. Large-scale concrete walls with high-tensile, pre-tensioned steel cables allow the building to sway then return to position during an earthquake.

Zumthor's retreat

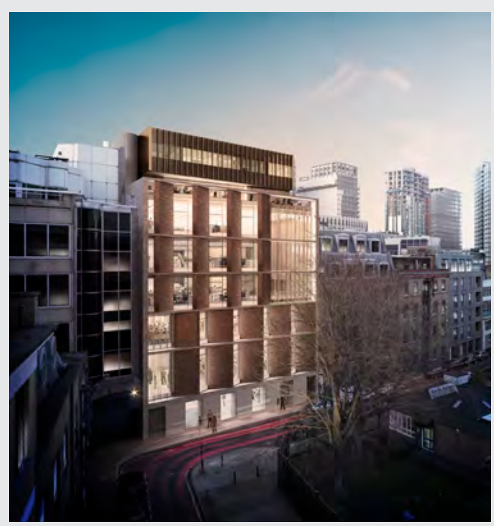
Peter Zumthor has completed his first permanent UK building. Secular Retreat in south Devon, designed with Mole Architects, is built of hand-rammed concrete forms on both interior and exterior spaces.

Images: UEA/RG Carter Construction; IABSE; Jack Hobhouse; Adam Mørk

PAY ATTENTION!

Our autumn Concrete Elegance lecture features two buildings from practices well known for attention to detail in concrete design. Bennetts Associates' HQ for the Royal College of Pathologists is a flexible, highly efficient building that will feature in CQ 267. Meanwhile, David Chipperfield's Inagawa Cemetery (CQ 265) is a contemplative space of earthy red concrete.

The lecture takes place on Tuesday 20 November at the Building Centre in London. concretecentre.com/events



Images: Keiko Sasaoka; Bennetts Associates

SKIN AND BONES

Steven Holl's Glassell School of Art in Houston moves seamlessly between precast panels on its striking geometric facade and an exposed structure of in-situ concrete within, writes Tony Whitehead

Photos: Richard Barnes

It is not everybody's concrete that gets to feature on the front cover of Vogue – so naturally the team at US-based McCarthy Building Companies were tickled to see their 8,000psi self-compacting mix supporting the substantial form of rapper DJ Khaled as he posed on concrete steps at the newly built Glassell School of Art.

But it was not such a surprising location for a fashion shoot. Part of the Museum of Fine Arts, Houston, the Glassell is a hip, contemporary building, surrounded by sculptures by the likes of Anish Kapoor. Designed by US star architect Steven Holl, the school's unusual plan and dramatic facades make it something of an artwork in itself.

The staircase favoured by Vogue, for example, forms part of a grand, triple-height forum lit by a spectacular skylight, and the school is L-shaped in plan, the longer side inclined to allow visitors to walk up to a roof-level event space. The 8,640m^2 three-storey school also includes 36 art studios, gallery spaces, auditorium and a double basement of parking.

But the most striking elements of the building are the facades. Constructed from giant, trapezium-shaped panels of white precast concrete, they are interspersed with similarly enormous sheets of translucent glass. The rhythmic puzzle of glass and concrete dominates the aesthetic – so it comes as a surprise to hear the building was not originally conceived in concrete at all.

"The L-shape and the slope [plan and section] – they were there from the beginning," says Olaf Schmid, Holl's project architect for the Glassell. "But the exterior was first envisaged as clad in perforated metal. Then Steven decided he didn't like that any more. For a while it was going to be plain grey concrete, and we went back and forth before finally choosing white."

This key decision was strongly influenced by the neighbouring sculpture garden, by acclaimed artist and landscaper Isamu Noguchi, which dates from the 1980s and features white concrete for its walls and planters. The notched character of the panels also references neighbouring art, specifically the sculpture by Eduardo Chillida that adorns the space created within the Glassell's L.

"Once we went for the concrete it became key to the expression of the building's skin and structure," says Schmid. "The large-scale precast panels pick up the angle formed by the sloping roof, and having these big elements fitting together – it's a very tectonic idea."

Precast concrete was chosen because of the dimensional precision and finish control offered by factory production. "At first we wanted to construct the whole building in precast," Schmid says, "but this proved impracticable. The building has some large spans, cantilevers and odd angles. It was just too difficult to figure out the connections, so the beams and cores became cast-in-place. The challenge then was to get the in-situ concrete to match the white of the precast."

They considered an acid-etch for the precast, but in the end chose a sandblasted finish. The in-situ concrete was also sandblasted, "so both the colour and the roughened surfaces help to tie the two kinds of concrete together".

Colour-matching concrete is challenging, however, and McCarthy conducted several test pours before settling on the mix that best mimicked the precast panels. Unfortunately this was not a mix that the local ready-mixed concrete supplier could produce – so, unconventionally, some 90 bags of white cement were added by hand to each truckload. Cemex, the ready-mixed concrete producer, provided a quality-control specialist on site to ensure consistency for all the white concrete pours.

Once the basement car park was complete, the first rows of precast units and glass panels could be placed (see box, overleaf). An in-situ perimeter beam was then cast on top of the panels, which proved structurally complex. The floors of the Glassell are built from hollowcore extruded-concrete plank-shaped units which rest on the beams. "In the upper floors though, the facade kinks in and out," says Schmid, "so the perimeter beam has to widen to accommodate that. Where that happens, the bearing point of the planks gets pushed back from the facade, introducing a torsional force – meaning that the beam grew in size. In some cases it had to be tied back to the spine centre of building with another cast-in-place element."

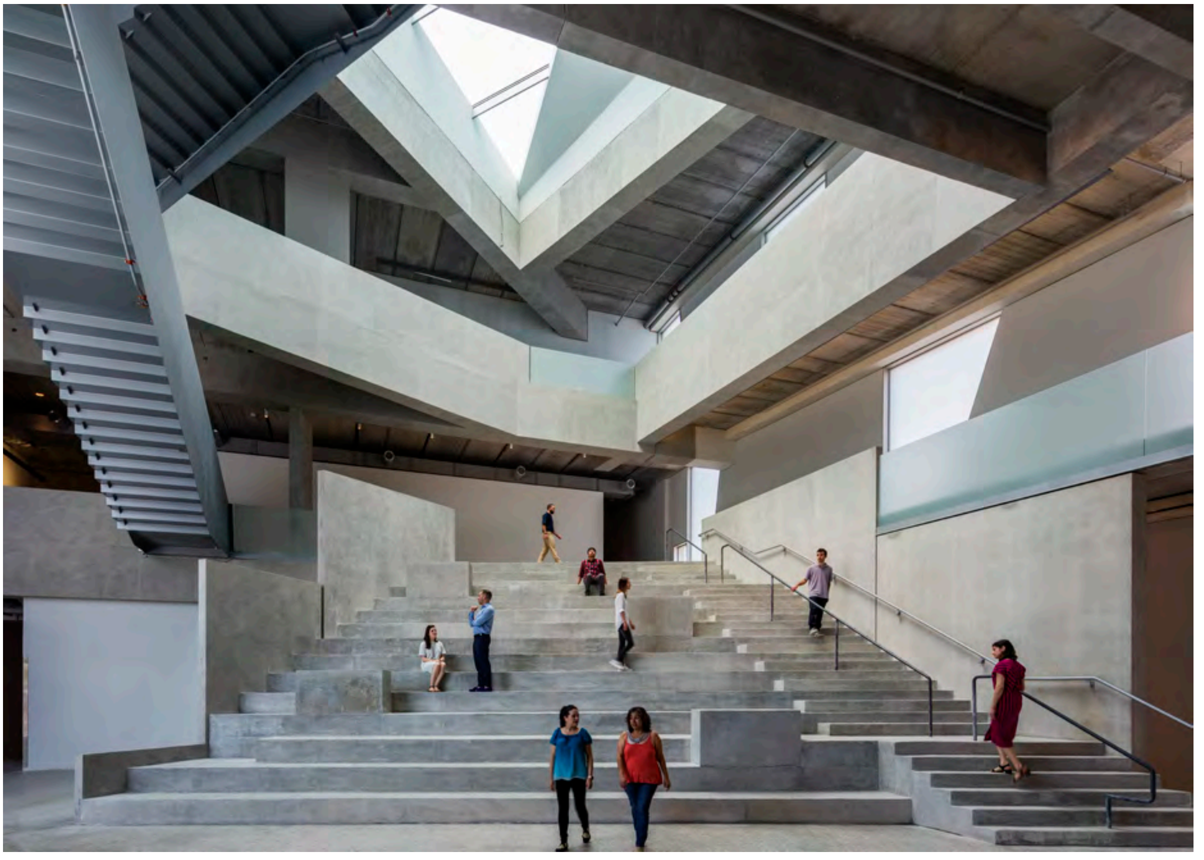
The central support for the beams and floor slabs comes not from in-situ columns but from precast "wall columns", as Saman Ahmadi, principal at associate architect Kendall/Heaton, explains: "These are actually made in a similar way to the facade panels, but like much of the interior concrete, they are natural grey, not white."

There are several other differences: "The concrete of the facade panels is only visible on the exterior of the building," says Ahmadi. "The team did consider having the concrete exposed on the interior of some of the facade panels, but it would have been more expensive to sandwich insulation inside the panels and, in any case, simple interior insulation covered by plasterboard suited the school's requirements for attaching art to the walls."

So while the facade panels are only sandblasted on the exterior face and edges, the interior wall columns are sandblasted on both sides and the concrete left exposed. "These panels are also made from a stronger concrete because of the extra structural work they do supporting the floors," he adds.

The hollowcore units that make up the floors span up to 9.1m and weigh up to 9.1 tonnes each. Routinely seen making up the floors in multi-storey car parks, they are known as a rapid and inexpensive way of creating floors – though Schmid says that because of the torsional issues created by the irregular perimeter beam, "it might, with

THE LARGE-SCALE PRECAST PANELS PICK UP THE ANGLE FORMED BY THE SLOPING ROOF – IT'S A VERY TECTONIC IDEA



LEFT The forum is characterised by a large in-situ staircase, triple-height atrium and huge triangular skylight

BELOW Construction photo showing the building's distinctive plan and section – taken during the casting of the level-three ring beam

PROJECT TEAM
Design architect Steven Holl Architects
Associate architect Kendall/Heaton Associates
Structural engineers Guy Nordenson and Associates, Cardno
Contractor McCarthy Building Companies
Precast concrete manufacturer Gate Precast

hindsight, have been easier, structurally, to go for a cast-in-place slab. But we liked the expression of the exposed planks on the ceilings and we have been able to use the grooves between them for lighting tracks."

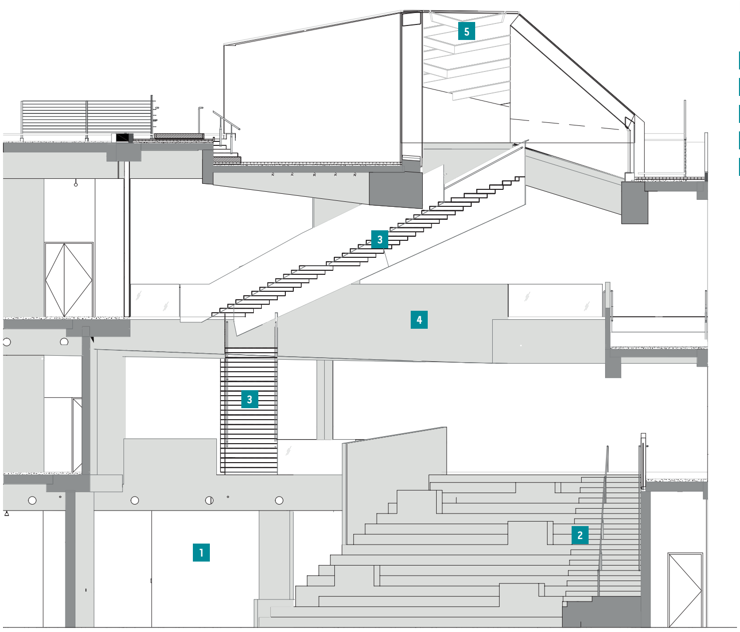
Other electrical conduits, and piping for a water heating and cooling system, have been laid on top of the planks before being covered with a 9cm layer of concrete. There is no false ceiling or raised floor, and Schmid says that exposing the concrete floors helps to control the building's environment. "It means the air is in contact with the thermal mass of the concrete, which helps even out temperature swings. We are big proponents of this and use it whenever we can. The climate in Houston is challenging – it can get very hot. But running cold water through pipes buried in the ectopic slab cools the building very efficiently. It is particularly effective where you have sunlight falling directly onto the floor and thermally activating it. Then the water cooling comes into its own and transfers out large amounts of heat very efficiently."

Because the local climate is also very humid, it is important that the slabs do not become too cool, however. "Condensation is a risk, so the slabs are not allowed to cool to the dew point," says Schmid, adding that the radiant slab cooling is boosted with more traditional air-conditioning when required.

Far from all of the servicing at the Glassell School of Art is hidden, however. In most of the teaching studios, an industrial look prevails with considerable amounts of ductwork visible on the ceilings and walls. In some studios, the use of specialist equipment and materials requires additional exhaust ventilation, and this is provided via a plenum through a series of holes cast into some of the facade panels. Each hole is fitted with a bird screen and is sloped to drain rain away from the plenum.

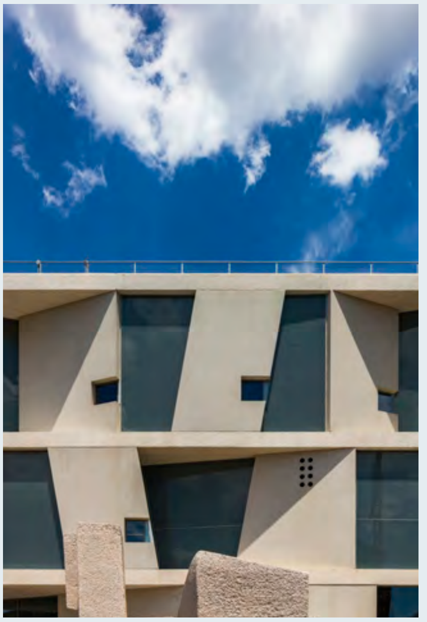
In contrast, there are virtually no services visible in the more public areas, particularly in the forum, which is characterised by a large feature staircase, triple-height atrium and a huge triangular skylight.

"Holl's office wanted this uncluttered so the services have been routed up from the basement levels to feed each of the two sides of the building,"



EAST-WEST SECTION

1 Lobby
2 Forum steps
3 Stairs
4 Concrete guardrail
5 Skylight



TOP RIGHT All of the 178 precast panels are subtly different. Their design was inspired by the Eduardo Chillida sculpture in the foreground

LEFT In most of the studios, ductwork is left visible – but in the public spaces it is concealed

says Ahmadi. "This leaves the feature concrete in the forum area clear."

The forum includes some of the largest beams in the building, which span from the corners of the L to make the triangular openings on level one and two for the skylight. The longest of these is a post-tensioned beam of some 21.3m with a section 1,370mm high and 660mm wide. This beam was placed monolithically with the entire skylight structure due to the way the 100 post-tensioning cables interacted with other skylight beams.

Like much of the building, the design of the staircase below the skylight evolved over time. Originally conceived as precast, it is now in-situ with the exception of some precast vertical panels that rise from it. "It was always going to be difficult to make large steps like this into a seamless staircase," says Winston Hesch, McCarthy's project superintendent.

He explains that a grey 8,000psi self-compacting mix was chosen to help create a smooth airhole-free finish, but as always with in-situ concrete, the final result came down to attention to detail. "We had skilled carpenters making the formwork, we triple-checked every measurement, we poured in small flat sections, and we got a result we are really proud of."

To create the treads, the forms were stripped a little early while the concrete was relatively soft, and trowel-finished before being finally being given a grit polish. The result is pleasingly monolithic – and smooth enough for even a fashionista's posterior.

Solving the panel puzzle

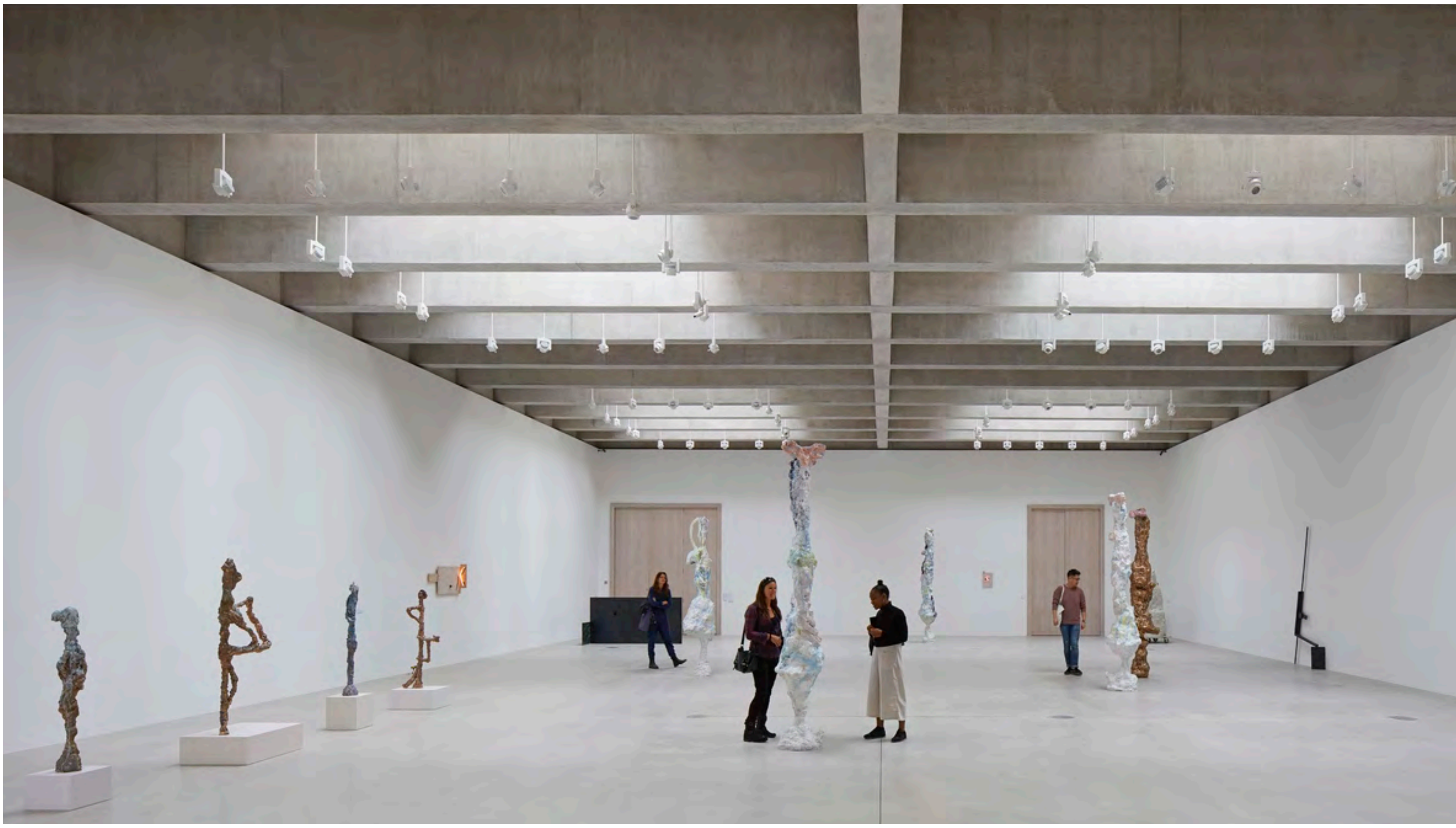
The 178 precast reinforced concrete panels that make up the facades of the Glassell School of Art are 300mm thick, up to 5.2m high and weigh up to 19 tonnes. All are subtly different, however, meaning that the manufacturer, Gate Precast, had to create a bespoke timber mould for each before transporting the finished units horizontally by road from its facility some 200 miles north of Houston.

Once on site, they were treated with reverence by the contractor, McCarthy Building Companies: "We would pick them up carefully with two cranes at first to minimise the forces acting on them, and then unsling the second crane to finally position each one," says Winston Hesch, project superintendent at McCarthy.

The exact placement of each panel was a key concern. "The panels are cast with sleeves or holes in the bottom and top," explains Hesch. "These fit onto rebar dowels. So for each panel we would have, for example, some 40 rebar dowels sticking up from the slab and our concern was how to keep these within tolerance so the panel would slide on neatly."

The low-tech solution to this problem proved highly reliable: "Gate would send us the formwork from the top and bottom of the panel, and we would use it as a template for the dowels." It worked so well that, with practice, McCarthy could place a panel in just 30 minutes.

When the panel was perfectly aligned it would be braced prior to final fixing. "Small holes leading from the sleeves allowed us to inject grout to fix the rebar. We could then place rebar dowels in the top sleeves and erect formwork for the beam over the top of the panel."



FOBERT'S COVE

Pamela Buxton finds out how Tate St Ives' new extension was smuggled ingeniously into a clifftop

If ever there was a project that celebrates concrete, it's Tate St Ives, designed by Jamie Fobert Architects (JFA) and shortlisted for the 2018 Stirling Prize. This largely subterranean 1,320m² extension to Evans and Shalev's Cornish gallery delivers 500m² of exhibition space in a splendid 5m-high, column-free room created with a concrete base, walls, beams and roof slab, and lit from above via six concrete "light chambers".

The exposed concrete of the roof and its light chambers are key to the character of the space, which fulfills Tate director Nicholas Serota's wish for a gallery that feels like it's in Cornwall. Not only does the design reference local fishermen's lofts-turned-artist-studios and the distinctive form of Cornish hedges, much of the concrete uses secondary aggregate locally sourced from the china clay industry.

The completed £20m gallery is a happy ending to a lengthy saga that began with JFA winning a design competition for the extension back in 2005, and then when a new site was found after vociferous local opposition, winning a competition for that too in 2012. This second, narrowly adjoining site is positioned up the cliff from the original 1993 gallery, and would have required visitors to ascend two levels to reach it. Instead, and mindful of the sensitivities of blocking sea views, JFA proposed excavating in order to create a gallery at the same level as the original – a monumental task given the extreme hardness of the blue elvan stone on the site, and the difficulties of removing so much excavated material – 977 lorry loads in total – through St Ives' notoriously narrow and overcrowded roads.

JFA clustered accommodation such as toilets, staff facilities, art preparation and plant in a four-level stack including a goods lift accessed from the highest level that resolves long-standing difficulties in bringing in large art works. Clad in artisanal ceramic tiles, the uppermost staff and goods entrance pavilion is the most externally visible part of the extension, along with a public garden created on the gallery roof.

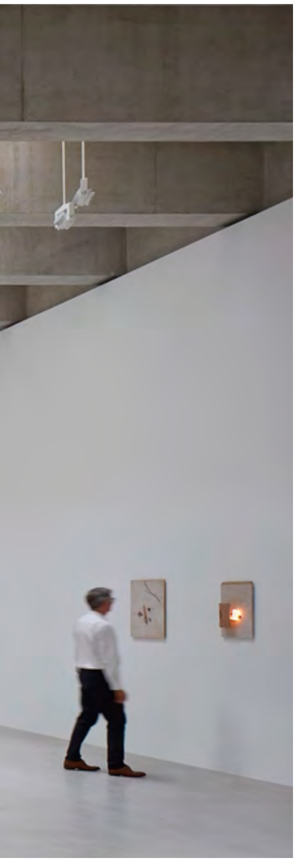
But it's the subterranean gallery that's the real showstopper. The Tate had asked for a 300m² gallery so it could stage large exhibitions in a single space or subdivide it as each show required. JFA suggested extending the gallery to 500m² with six roof lights to give a better proportioned, less square space. This is equal in size to the original building's five galleries put together.

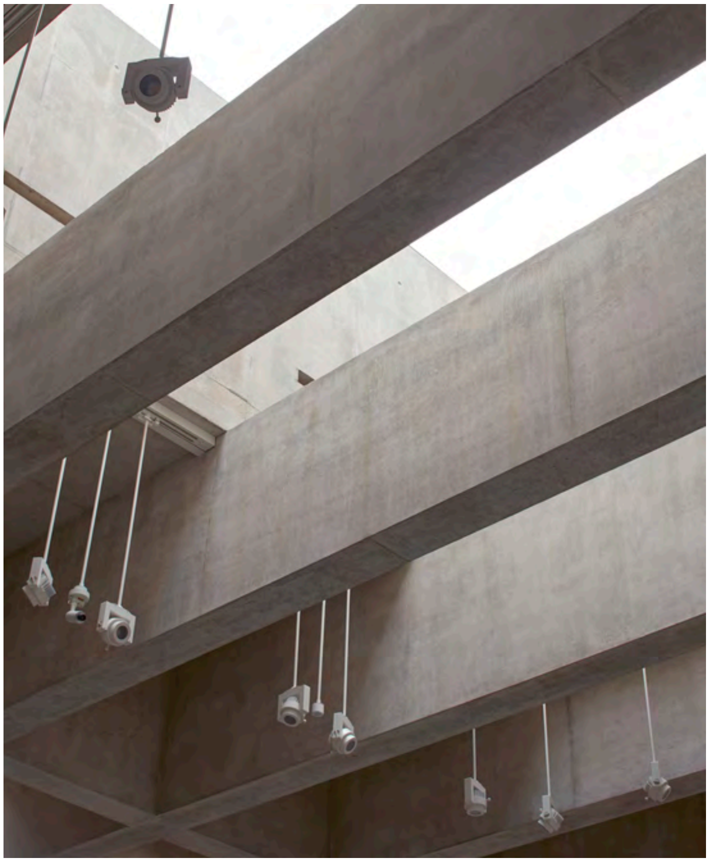
According to engineer David Derby of Price & Myers, reinforced concrete was by far the best material to form the new gallery, with a deeply ribbed concrete slab spanning the 17m width of the gallery and providing thermal mass as well as strength. "It is durable in the harsh maritime environment and highly suitable for below-ground structures. All the reinforcement in the gallery roof was galvanised and all the tie wire was stainless steel to avoid problems with rust staining on the surface of the formwork," he said.

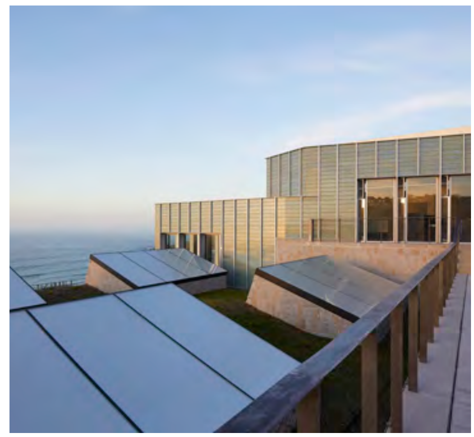
An option with central columns had been considered but discounted as it would have led to relatively small savings while compromising the space. Each full-width beam is 300mm wide and 1.2m deep, spaced 1.7m apart to enable cherry picker access through them to the roof lights.

Precast options for the beams were explored, but this was impossible in a single piece because of the winding St Ives roads – and it would have been difficult to splice two sections together without

GALLERIES HAVE TO BE INCREDIBLY NEUTRAL SPACES, BUT YOU DON'T WANT JUST A WHITE BOX – YOU WANT TO GIVE IT CHARACTER







Photos: Hufton + Crow; Dennis Gilbert VIEW; Price & Myers

CLOCKWISE FROM TOP LEFT
The gallery is a column-free 500m^2 space; the in-situ beams are 1.2m deep; a tile-clad pavilion is the main external expression of the extension; a section shows how the gallery has been embedded in the cliffside with sculptural rooflights above

PROJECT TEAM
Architect Jamie Fobert Architects with Evans and Shalev
Structural engineer Price & Myers
Environmental and M&E engineer Max Fordham
Contractor BAM Construction
Concrete subcontractor Thames Valley Construction

a visibly obtrusive join. Instead the beams were cast in situ, followed by the first slab, with the air-handling running on a level with the plant housed in the facilities stack of accommodation. A second roof slab above the ducts was insulated and clad.

The design and position of the 3.5m-high tapered light chambers was optimised through extensive testing. These are tilted to the south to admit warmer light, with the deep chambers sufficient to avoid direct light on the artworks. Blinds can be activated accordingly to achieve the required lux levels, including the 300 lux maximum for national collections. The result is a "beautiful" soft indirect light on the concrete, says Fobert. "When you walk in, you still know you're in daylight. We've created a daylight gallery that really works, which isn't easy."

It was important that the visible concrete had a slightly rugged air with a sense of depth, rather than looking perfect when viewed from the ground. The design team wanted a pale colour, so used china clay aggregate from a single Cornish source in a mix containing 35% ground granulated blast furnace slag for the exposed roof and stairwell. The concrete floor is topped with a screed containing a very fine aggregate of sand that, combined with a ground finish, gives a warm, soft effect.

"Galleries have to be incredibly neutral spaces to anticipate endless curating of shows. But you don't want just a white box – you want to give it character," says Fobert. He drew inspiration from the robust, no-nonsense Cornish vernacular, in particular, the rough-and-ready nearby Porthmeor artist studios, whose high cellars and timber joists were once used by fisherman for setting their nets. "It references Cornwall but isn't a pastiche of a fisherman's loft. It's a much bolder statement … For me, the very deep concrete beams are what gives it its character," he says. "If it had been a timber ceiling, or plasterboard or metal, I don't think it would have had the strength of character and the boldness you get from a single casting of concrete. That felt really right for Cornwall, and for St Ives."

FINS AND FINESSE

The metallic facade of London's Atlas building relies on a unique concrete structure, writes Andy Pearson

PROJECT TEAM
Architect Make Architects
Executive architect Design Delivery Unit (Scott Brownrigg)
Structural engineer WSP
Contractor Mace
Concrete frame contractor Morrisroe

The Atlas building has a unique appearance. The 38-storey residential tower, under construction at 145 City Road, appears to be formed from a series of 12 giant vertical aluminium fins. The fins are orientated north-south so that the outer elements form the metallic facades of the tower's east and west elevations, and the spaces between them are filled with glass.

The concept was created by Make Architects, but it is Scott Brownrigg's Design Delivery Unit that has the task of seeing the 302-apartment scheme through to completion. "The tower appears as if you've taken a very thin building and pulled it apart, like a concertina, to reveal glazing between the solid elements," says Scott Brownrigg director Peter Griffiths.

The fins also appear to provide the tower's structural support – an illusion the Design Delivery Unit has worked hard to maintain. The tower is actually supported on a concealed, robust concrete frame. "While these elements appear as a series of fins, structurally they don't actually run through the building," explains Griffiths.

RIGHT The 302-apartment tower is 37 storeys high

BELOW The building form appears like a concertina, with glazed elements between the "pulled apart" aluminium fins

Images: Scott Brownrigg

The tower's concrete frame is fundamental to the success of the building. This is because the southern tip of the site is crossed by two tunnels, one serving the London Underground's Northern Line the other Network Rail's Old Street line. Loads imposed by the tower are kept clear of these tunnels by cantilevering the structure over the subterranean Victorian engineering. Giant concrete beams supporting the cantilevered section of the tower are hidden below ground in the tower's basement; these transfer loads from the cantilevered perimeter to a strengthened section of the central concrete core.

An additional benefit of using a concrete structure is that the mass provided by the concrete frame (and by increasing the thickness of the ground-floor slab and the mezzanine first-floor slab) helped give the structure sufficient inertia to dampen the ground-borne vibrations from the underground trains. "Concrete was the optimum solution because it worked on a number of fronts," says Griffiths.

The concrete core extends the full height of the tower, from its piled raft foundation, through the concrete basement box, all the way to the penthouse apartments 38 floors up. It houses three lifts, a staircase and the service risers, as well as incorporating a number of outrigger walls running east-west to provide lateral stability.

Post-tensioned concrete floor plates link the core to a series of reinforced-concrete perimeter columns. It is a solution that not only provides maximum flexibility when it comes to dividing the floors into various apartment configurations, but is also critical for servicing the apartments. "The apartments feature comfort cooling using fan coil units hidden in the ceiling," says Griffiths. "Concrete gives a nice clean soffit on which to manage all of the services."

The scheme is due to complete in summer 2019.

Photos: Jaime Navarro and Paul Rivera, courtesy of Rojkind Arquitectos

BREAKING THE WAVES

Veracruz's new concert hall is like a mighty breakwater, tumbling down to the Gulf of Mexico, writes Nick Jones

The breakwater that stretches out from Veracruz, Mexico's largest and oldest port, suggests a town that's used to being battered – by the northerly winds that whistle in off the Gulf of Mexico, or the tropical storms that bombard it for four months of the year, not to mention the English and Spanish pirate ships that spent much of the 17th century plundering this part of the coast.

But now this spit of land – with its concrete boulders cascading down from either side – has provided the inspiration for the regeneration of a formerly neglected part of the city. Foro Boca by Rojkind Arquitectos is both a concert hall and the breakwater writ large. This huge 5,400m^2 venue, which will host social programmes for low-income children as well as high-quality orchestral concerts, is organised into nine trapezoidal volumes that seem to tumble like rocks towards the beach. Not only does this series of heavily reinforced concrete forms break down the scale of the building on the beach front, it enables a fluid sequence of double and triple-height voids to unfold within, centring on the stunning 966-seat auditorium.

Concrete was an obvious choice as a structural and aesthetic material, and not just for the way its craggy solidity echoes the wave-breaking rocks. Rojkind wanted to use a material that could be locally sourced and handled by a local workforce, as well as being able to resist to the harsh conditions of the exposed coastal location. With this in mind, a bespoke low-permeability mix, resistant to marine sulfates and chlorides, was specified.

The structure was cast in situ using different depths of timber formwork fixed in a variety of angular arrangements. The result is a geometric pattern of board markings, with rhythmic bands running in different directions, and a texture that captures the changing light and shadows of the coastal skies. Carefully timed pours ensured a consistent colour, but the finish is suitably rugged for its windswept location and utilitarian inspiration. "We were interested in the way it would develop a patina over time," architect Michel Rojkind has explained, "similar to the nearby rocks."

One of the most dramatic aspects of the design is the entrance block, which takes the form of a massive cantilever, anchored by the huge volumes behind, and hovers just 2m above the public plaza. This compressed space provides shelter from the elements as well as a theatrical sense of contrast when visitors step inside the soaring, roof-lit triple-height lobby. The interiors are also dominated by boardmarked concrete, which is complemented by timber bridges and walkways that crisscross the column-free spaces. There is a sense of fluidity and continuous movement, says Rojkind – just like in music or in the nearby waves.

CLOCKWISE FROM TOP LEFT

The cantilevered entrance block hovers just 2m above the plaza; the interiors contrast boardmarked concrete with timber fittings; the nine trapezoidal volumes break down the mass of the building

PROJECT TEAM

Architect Rojkind Arquitectos
Structural engineer EMRSA
Contractor Ingeniería y Desarrollo Arquitectónico

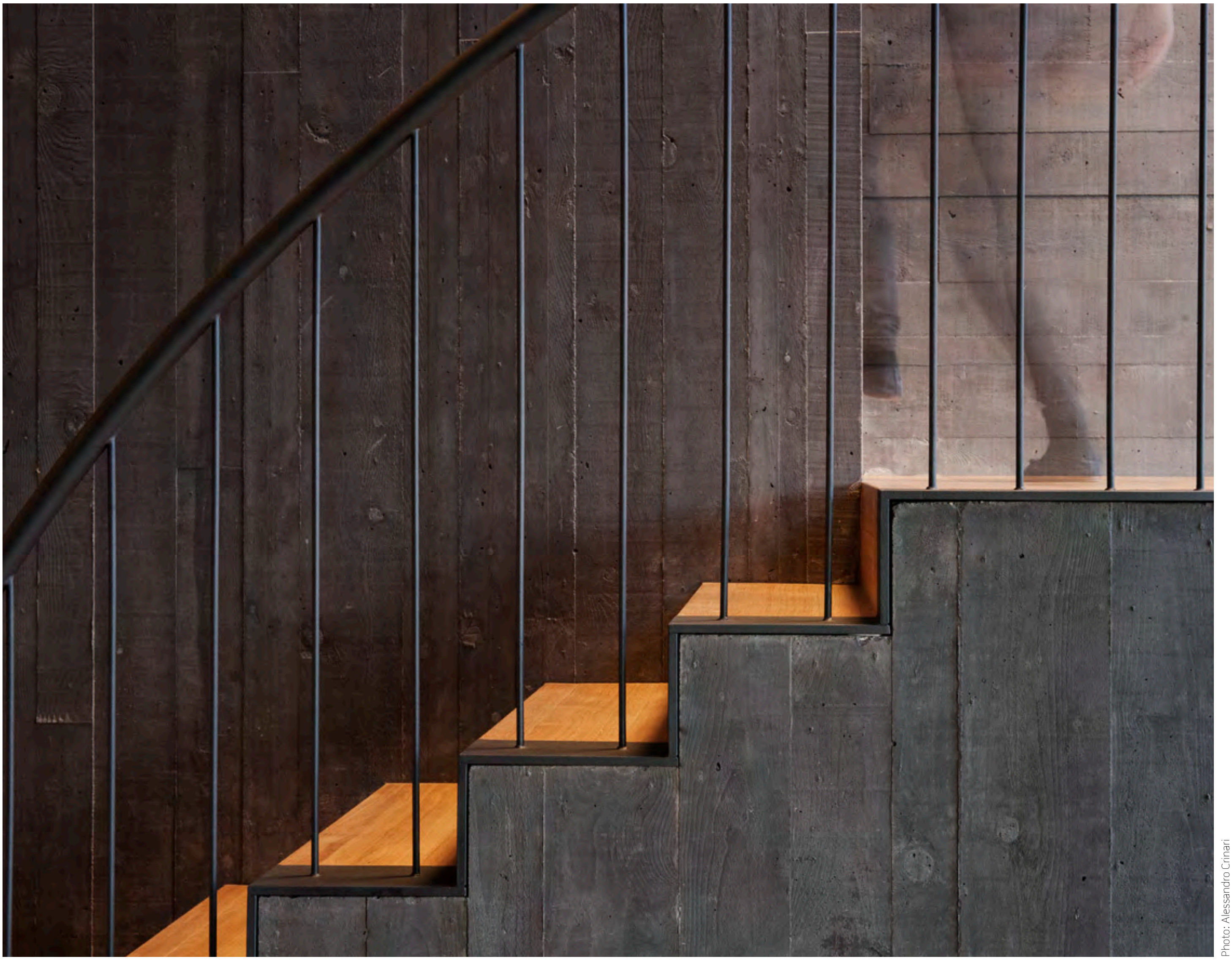


Photo: Alessandro Crinari

BACK TO BLACK AND WHITE

ABOVE Villa Comano in Lugano, Switzerland by Attilio Panzeri & Partners. The exposed structure is made from in-situ concrete pigmented black with iron oxide and Pozzolanic cement

There are different ways to darken or lighten concrete at either end of the spectrum, writes Elaine Toogood

Before committing to an aesthetic of black or white concrete, it is essential to ensure that the desired outcome is achievable using the chosen method of manufacture.

White concrete is created using white cement. But since sand and even coarse aggregate contain some fine material that can migrate to the surface of the concrete, to create pure white concrete it is usually necessary to use white fine and coarse aggregate as well, in order to avoid any hint of colour. White aggregate is essential where it is to be exposed on the surface. Spanish dolomite is often used to create a good white concrete surface, particularly with an acid-etched finish. It should be noted that as aggregates are a natural material, polishing the surface can occasionally reveal off-white stone.

In the UK, white cement and aggregates are not stocked as standard in ready-mixed concrete plants, so white concrete is generally an architectural precast product, produced in the

WHITE CONCRETE IS GENERALLY AN ARCHITECTURAL PRECAST PRODUCT, PRODUCED IN THE FACTORY USING SPECIFICALLY SOURCED WHITE MATERIALS

◀ Two St Peter's Square, Manchester by SimpsonHaugh (2017)

Two St Peter's Square is a 12-storey office development in the heart of Manchester's revitalised civic quarter. The polished white precast-concrete facade establishes an elegant presence in a historic location among listed buildings including Manchester Town Hall.

Overlooking St Peter's Square, the facade forms a sculpted grid of precast concrete with deep vertical reveals that frame and shade full-height glazing. SimpsonHaugh says the aim was to reflect the weight of the Town Hall directly opposite, and reinterpret the Town Hall extension's monolithic facade and deliberately repetitive rhythm. The reveals are angled in three directions across the elevation, directing views out to the historic buildings around. The facades have been created using Techrete C195, a Portland Stone mix with neutral aggregates, which has been polished around the window reveals

At the gable ends, ornate precast-concrete tracery screens offer both decoration and shading. On the St Peter's Square elevation, three motifs reinterpret stone details found in the Town Hall and extension, based on local references such as the Lancashire Rose. Overlooking Princess Street, just one motif is repeated: the cotton bud, a symbol of Manchester's industrial heritage and a reference to the nearby cotton warehouse buildings. For the tracery panels, an acid-etched finish with fewer exposed aggregates was specified to give a more understated effect. Mica contained in the mix brings a slight sparkle, while hand finishing has ensured a consistently smooth surface.

Photo: Daniel Hopkinson

factory using specifically sourced white materials.

Ready-mixed concrete can be made "whiter" using a cement containing ground granulated blast-furnace slag (GGBS), a near-white cementitious material that lowers the carbon footprint of concrete and improves its durability. BS 8500, the British standard for concrete specification, allows a maximum of 70% cement replacement with GGBS, but up to 50% is more common for practical reasons. Greater quantities are unlikely to achieve a noticeably lighter surface due to the fact that GGBS delays strength gain, and longer periods in formwork tend to have a darkening effect on concrete.

Small quantities of white pigment can also be added for extra whiteness. Titanium dioxide, for example, is widely used in products such as ceramics, paints and toothpaste. According to BS EN 12878, the grade most appropriate for colouring concrete is anatase. For ready-mixed concrete, carefully measured doses are usually added directly to the concrete mixer or agitator, ideally in liquid or granulated form to aid colour distribution. But just as with GGBS, the concrete is only made lighter, not white, due to the presence of non-white aggregates and grey cement.

Achieving black concrete comes with a different set of considerations. Black cement does not exist, and since cement is essential for the creation of concrete it will always have some degree of greyness. Concrete can be made darker using fly ash, a dark grey by-product of coal-fired power stations. BS 8500 allows a maximum 55% replacement with fly ash, but this is typically limited to around 30% or less. Adding the black inorganic pigment iron oxide is an effective way to create very dark grey concrete, the tone of which can be further darkened using sealant. Architectural precast manufacturers often use pigment in combination with white cement to create greater consistency and repetition. A practical maximum dosage is 5%. Designers may be tempted by pigments that are blacker than iron oxide, such as carbon black, but this is not advised as it is more prone to fading.

A more common way to achieve long-lasting near-black concrete is to specify architectural precast concrete with naturally black fine and coarse aggregate, such as black basalt, exposed on the surface – for example in the highly polished facade panels of the Dyson Building at the Royal College of Art in London by Haworth Tompkins. At Lanterna in east London (overleaf), the black aggregate was exposed using a surface retardant, applied to the inside of the formwork. After striking, the grey surface laitance was washed away to reveal the black stones. A post-finishing process is recommended when trying to achieve a dark colour, not only to remove the lighter grey cement on the surface, and therefore expose the dark aggregates, but also to reduce any impact of efflorescence. ▶

Using a permeable formliner can also deepen the tone slightly, as water from the concrete is permitted to freely drain from its entire formed face. The darkening effect of water loss, normally evident at formwork junctions, is therefore evident across the whole surface. A combination of all three techniques – fly ash, pigment and permeable formliners – was used to create the near-black in-situ concrete for the curved facades of V&A Dundee (CQ 265, Autumn 2018).

Creating solid colours in black or white polished concrete floors requires an altogether different technique. Pigmented surface hardeners, available in a wide range of RAL colours including various shades of near-black and white, are trowelled into the surface of the fresh concrete floor. This creates a durable 2-3mm depth of solid colour, which can again be enhanced with the right choice of sealant.

Finally, it is possible to create concrete that is both black and white, by exposing black aggregate on the surface of otherwise white concrete. To achieve a two-tone effect at distance, however, requires a sufficient size of each area of colour, exposing the aggregates in some areas and not others. This can be done using stencils or by masking the surface prior to treatment, or by lining the formwork with paper on which the pattern has been printed in retardant to control the location of colour, precisely and in advance. This process was used to create concrete at the Danish National Archives in Viborg (below).

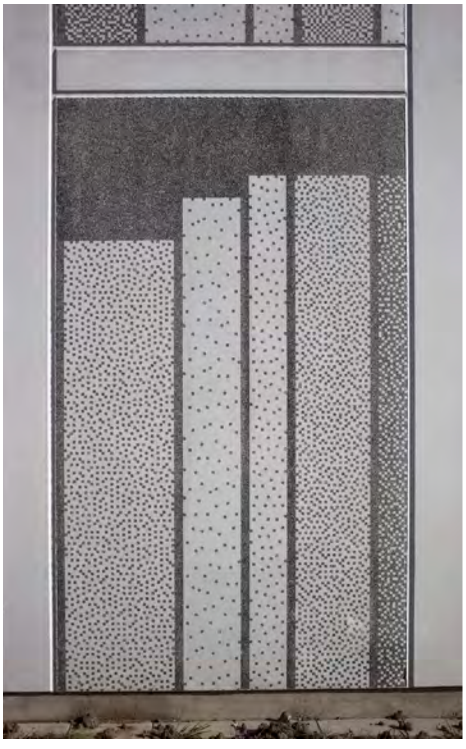


Photo: Graphic Concrete

ABOVE The facade of Schmidt Hammer Lassen's extension to the Danish National Archives has a book pattern designed by textile artist Grethe Sørensen. The precise pattern of black aggregate is revealed using a formliner with digitally printed retardant, a process patented by Graphic Concrete

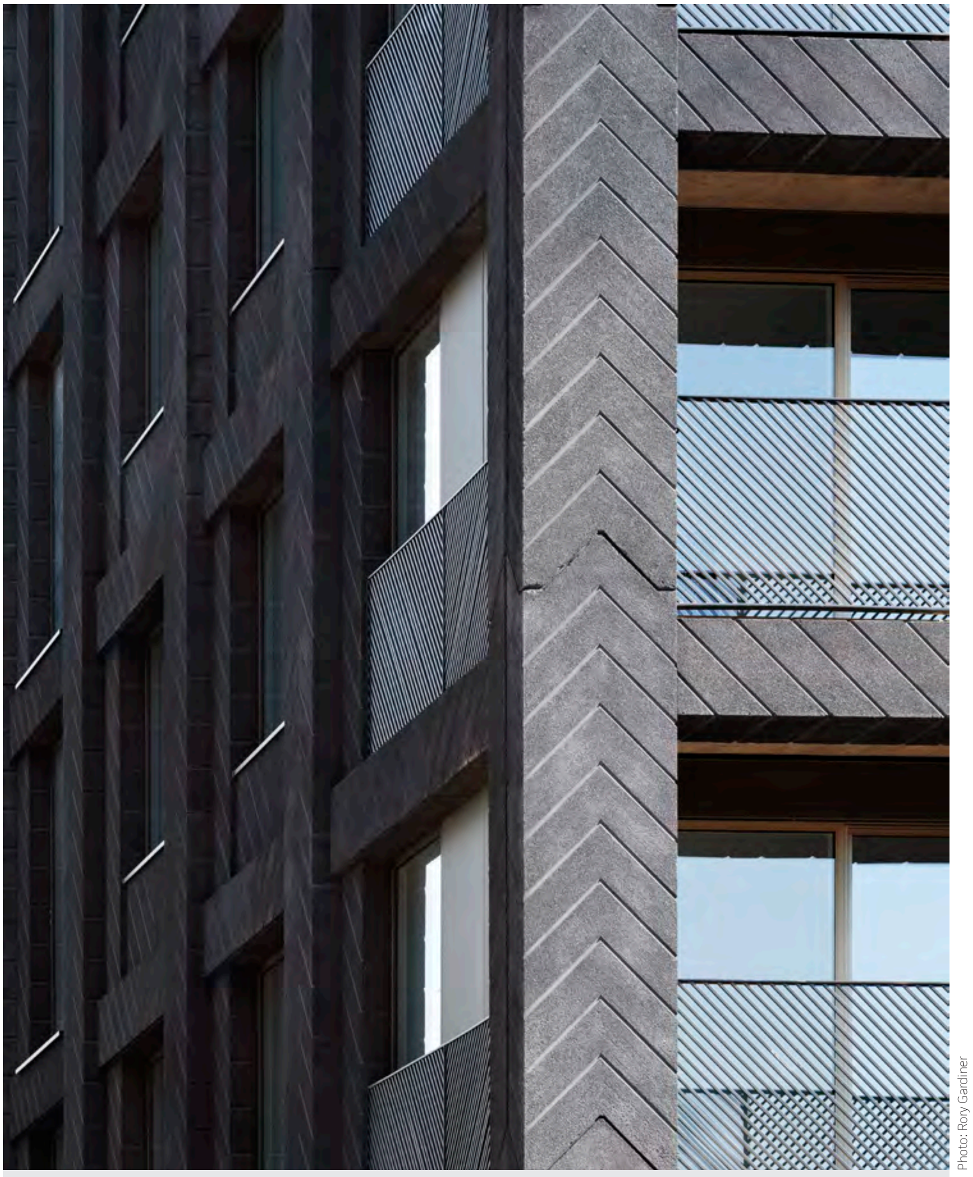


Photo: Rory Gardiner

▲ Lanterna, Fish Island Village, east London by Lyndon Goode (2018)

Lanterna is a striking black-concrete building in a mixed-use canal-side development in Hackney. "We specified textured black concrete to bring a strong sense of drama to the building, which acts as a backdrop to a new public square, says Simon Goode, director of architect Lyndon Goode. "The colour also references the industrial heritage of this area of east London – a centre of tar processing in the 19th century."

The concrete's through-colour was achieved using fine and course black basalt aggregate and a black powder dye in the mix. "Inspired by local street art, we wanted to imprint the facade with herringbone grooves wrapping in and out of the reveals and around all elevations. We designed the facade as a series of standardised components, just small enough to be made offsite at Cornish Concrete Products' workshop in Truro and craned into position on site."

The biggest technical challenge was ensuring the intricate herringbone pattern was aligned across panels, particularly in light of tolerances in concrete construction. To achieve this, the entire cladding structure, including every groove, was modelled in 3D software. Cornish Concrete referred to this 3D model to hand-build timber moulds for each component.

"We wanted a rough, textured finish to the faces of the precast panels, with a contrasting smooth finish inside the grooves," says Goode. To achieve this, Cornish hand-painted retardant onto the flat planes of the mould, missing out the triangular extrusions that form the grooves.

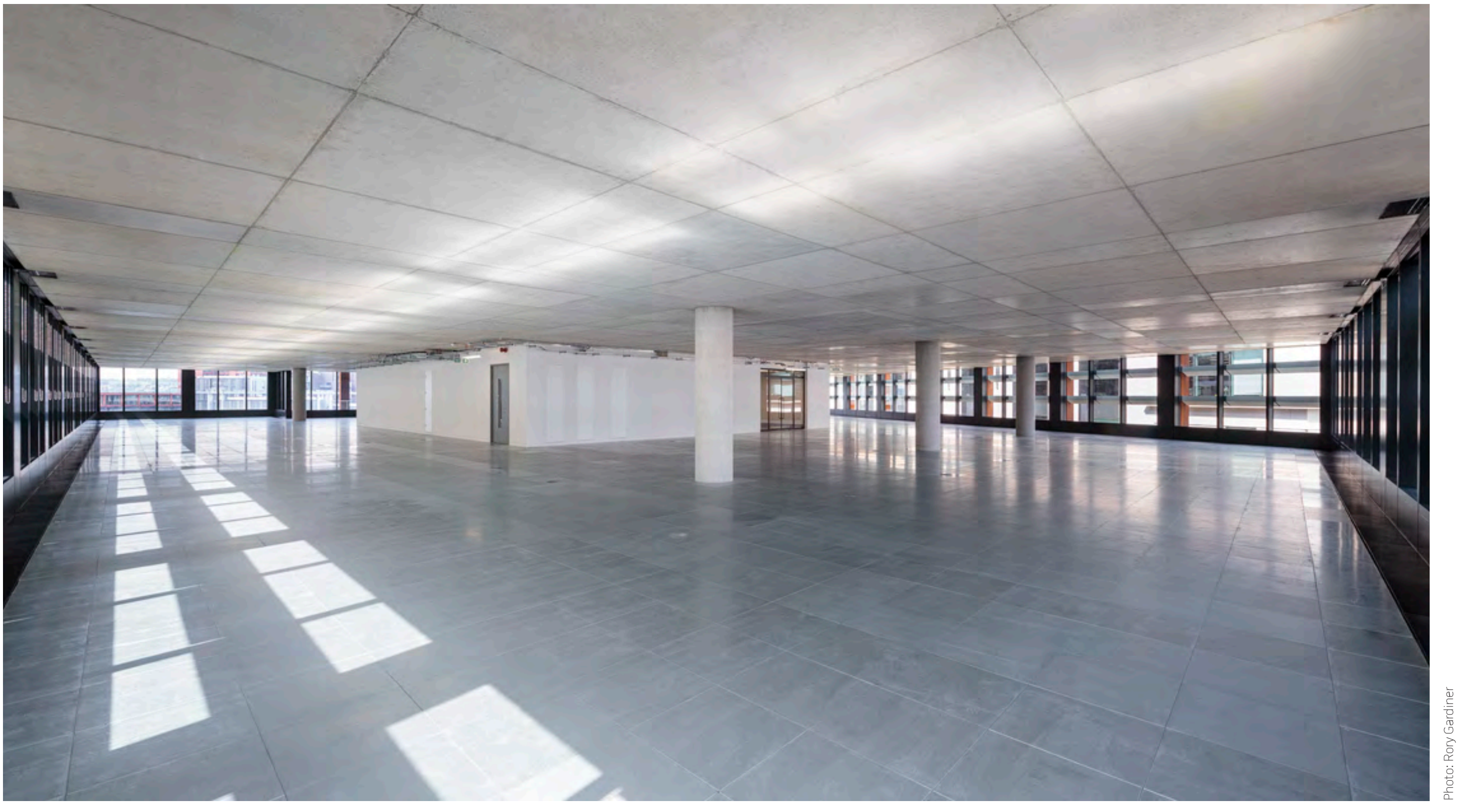


Photo: Rory Gardiner

PLEASE RELEASE ME

ABOVE 4 Pancras Square by Eric Parry Architects, where the post-tensioned slabs are exposed as soffits. The concrete contractor specified a concrete mould oil release agent for use with the plastic-faced ply lining of the formwork system

The use of an appropriate release agent, correctly applied, is critical to creating a good, consistent surface quality, writes Elaine Toogood

Applying a release agent to the face of the formwork is like greasing a cake tin. Without it, the formwork cannot easily be removed or released from the hardened concrete.

According to the Concrete Society publication Visual concrete – Planning & Assessment there are essentially two types of release agent: barrier and reactive. These are further divided into eight categories, though developments in this field mean that some products do not easily fall within these categories. Not all release agents are suitable for creating visual concrete and selection will be based on many factors, including compatibility with form-facing material, concrete specification and expected site conditions. A good release agent will also help maximise the number of times that a form can be used.

Barrier release agents work by creating a layer between the form face and the concrete. Oils with surfactants are general purpose release agents for many different types of formwork, including steel, and are often used in the precast industry. None of the other barrier types such as neat oils, mould cream emulsions, water-soluble emulsions and barrier paints are recommended for high-quality finishes, although barrier paints may be part of a preparatory treatment for timber and plywood before it is first used, to extend the life of the formwork.

Most of the reactive types of release agents are suitable for visual concrete and are categorised as chemical release agents, surface retardants and other specialist release agents, including those based on vegetable oil (VERA). They allow the formwork to be struck by creating a very thin layer of unhardened concrete or "soap" on the surface that must be brushed away when the formwork is struck. Chemical release agents are a popular choice, but can lead to dusting if over-applied. Although recommended for high-quality finishes, they may not be appropriate for concrete containing silica fume or high amounts of admixtures. VERA fall under the category of other specialist release agents and are recommended for visual concrete, with the added advantage of being non-toxic and biodegradable, and reportedly with a low incidence of blowholes and blemishes.

Design professionals do not need to specify the release agent that is to be used, but rather provide a performance specification. This directs the contractor to select one appropriate for creating high-quality visual concrete surfaces, that has little or no detrimental impact on the appearance of the concrete and that suits the choice of formwork facing and concrete used. Consultation with the manufacturer and form-facing material supplier will be necessary, to select the best product and method of application for the specific project. Biodegradable and non-toxic products may also be identified for health and safety reasons.

The selected product or products should then be tested with a full-scale mock-up panel or in a non-critical location of the structure to review the results and trial the method of covering the formwork before final selection. Release agents should be applied in accordance with manufacturers' guidance – they are often sprayed or applied with a soft brush – to create a thin, uniform and complete coating. Once satisfactory results have been established, the standard of workmanship must be rigorously maintained to ensure consistency. Incorrect application, whether too much or too little, can lead to abrupt changes of colour or tone in the surface of the concrete. The surface of the formwork should be cleaned and a coating of release agent applied before every use.

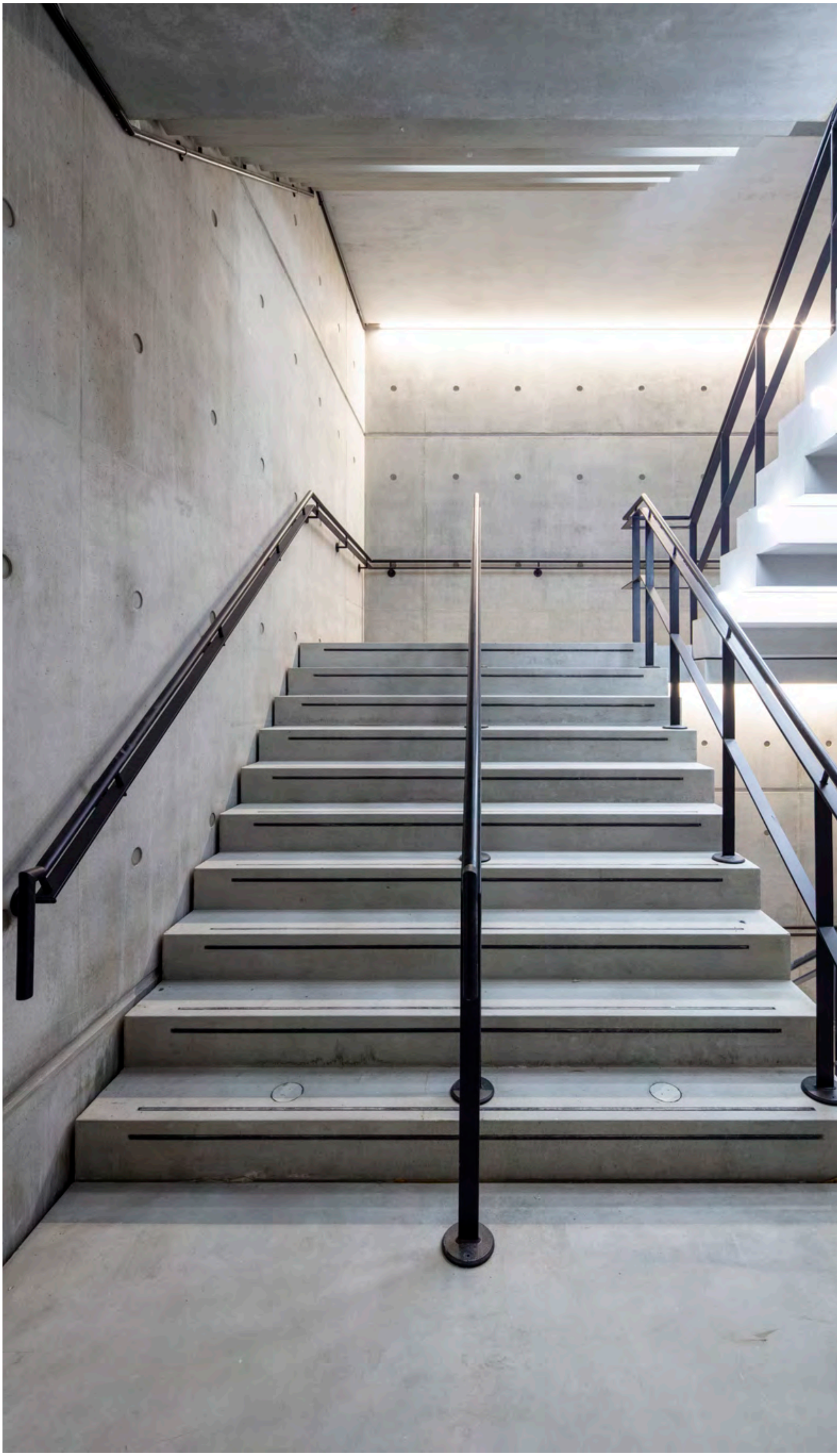


Photo: HB Reavis

CORE VALUES

Jenny Burridge examines the relative merits of the three main approaches to constructing the core of a tall building

Construction of the core is one of the most important aspects of the construction of a tall building. It provides the stability, vertical transportation in the form of lifts and stairs, and the main service runs up and down the building.

There are three standard ways of constructing the concrete core for a tall building: slipform, jumpform and precast. Each has its merits and considerations when designing. However, the choice of construction type is normally down to the contractor so the designer may not be sure in the initial design stages which option will be used.

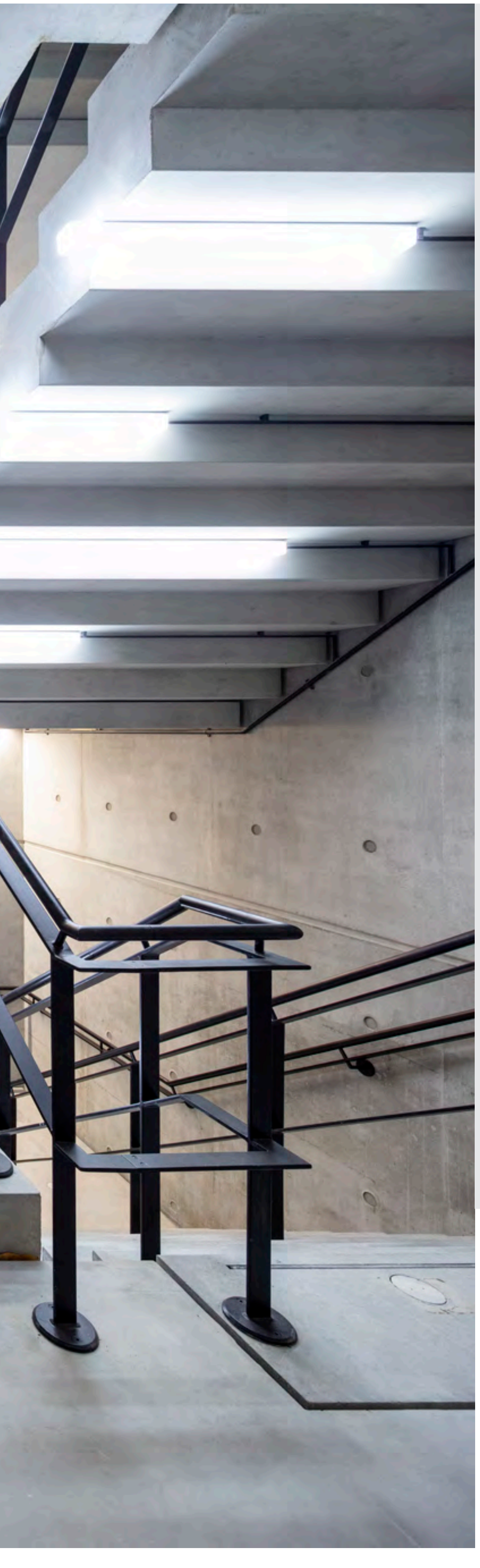
The main drivers for contractors are:

- Cost-effectiveness
- Safety of site operatives and the public
- Crane use
- Incoming logistics, lay-down and storage areas
- Vertical movement of operatives and materials
- Standardisation of structural elements and components, which facilitates repeatability.

Slipform

Slipform is the default option for commercial buildings as it is quicker than jumpform and so the passenger lifts, frequently on the critical path because of the number required in a commercial building, can be fitted earlier in the overall programme. However, the finish that is possible when slipforming is not normally good enough to be left exposed as visual concrete.

Slipforming is a continuous process, where the formwork is slowly and gradually moved up the core using jacks placed within the slipform rig. The rate of climb is about 250-300mm per hour and it is best used when there can be 24-hour working. This is not normally allowed in the centre of cities, so the slipforming is done for the allowable time during the day and the concrete is kept workable at the end of the day with a retarder in the mix. But even with 12-hour working, slipforming will create about a floor of core a day. This will mean that the core is normally well ahead of the rest of the floors and the designer should consider its stability in the temporary condition.



◀ 20 Farringdon Street, London (2018)

20 Farringdon Street is a new speculative office development on the edge of the City of London. The decision to expose the internal surfaces of the concrete core was taken early on for economic, practical and aesthetic benefits.

The design team and concrete frame contractor worked closely, pre-tender, to marry the logistics of constructing a jumpformed core with the aesthetic aspirations. A formal pre-construction report included concrete mix parameters, selection of formwork and release agent, day-joint detailing, tie rod and lifting eye aesthetics and final architectural concrete details as well as photographs of acceptable and non-acceptable details on exposed surfaces.

A pragmatic board layout was developed to achieve greatest cost and programme efficiency without pausing the cycle to adapt shutters or reline boards. Remarkably the team used the same MDO-faced ply boards for all 11 jumps or pours, assisted by a thorough grout washing regime prior to their first use and strict control of the release agent.

The jumpform system was based on a fully enclosed automatic, climb-as-one rig, customised to meet the aesthetic aspiration. The internal climber was fixed through the regular pattern of tie holes rather than the more conventional system of needing larger pockets or holes in the wall, thereby avoiding areas of patched-up concrete. Bespoke mitred corner panels were also used to avoid unsightly striking pieces or infill strips at the corners.

The stairs and landings were precast by Byrne Bros; the flights cast on edge so that the three formed sides would be visible, with the unformed, floated side hidden against the core wall. Telescopic structural connectors between landings and walls, and flights and landings provided a neat shadow gap detail. As the stair was to serve as access and circulation during construction for follow-on trades, the finished stair had a "Rolls-Royce" level of robust factory-applied temporary protection.

PROJECT TEAM

Architect Denton Corker Marshall Architects
Engineer Waterman Structures
Concrete frame contractor Byrne Bros (Formwork)

Slipforming requires greater management and quality control by the contractor than the other two forms of construction. A fairly new innovation is the use of GPS to help position the slipforming rig, but even so the tolerances are about 25mm in any direction. This is because the continually moving jacks can cause the rig to twist or skew.

Another fairly new innovation is to install a crane on top of the rig so that it is lifted with the rig. This makes the vertical logistics of getting personnel and materials up the building easier. The core under the rig can be used for access if the stairs are precast and lifted into place through the rig.

Since the jacks are connected to the reinforcement, the rebar requirements for slipformed cores may be dictated by the needs of the slipform rather than the permanent design.

The concrete required for a slipformed core depends heavily on the temperature conditions while it is being poured as it needs to be fairly quick-setting and, for the higher levels, it also needs to be pumped. This means that the concrete tends to need quite a high percentage of cement. For the Shard in London, 36 different concrete mixes were established before work began on the slipformed core to allow for different weather conditions and times of day.

Jumpform

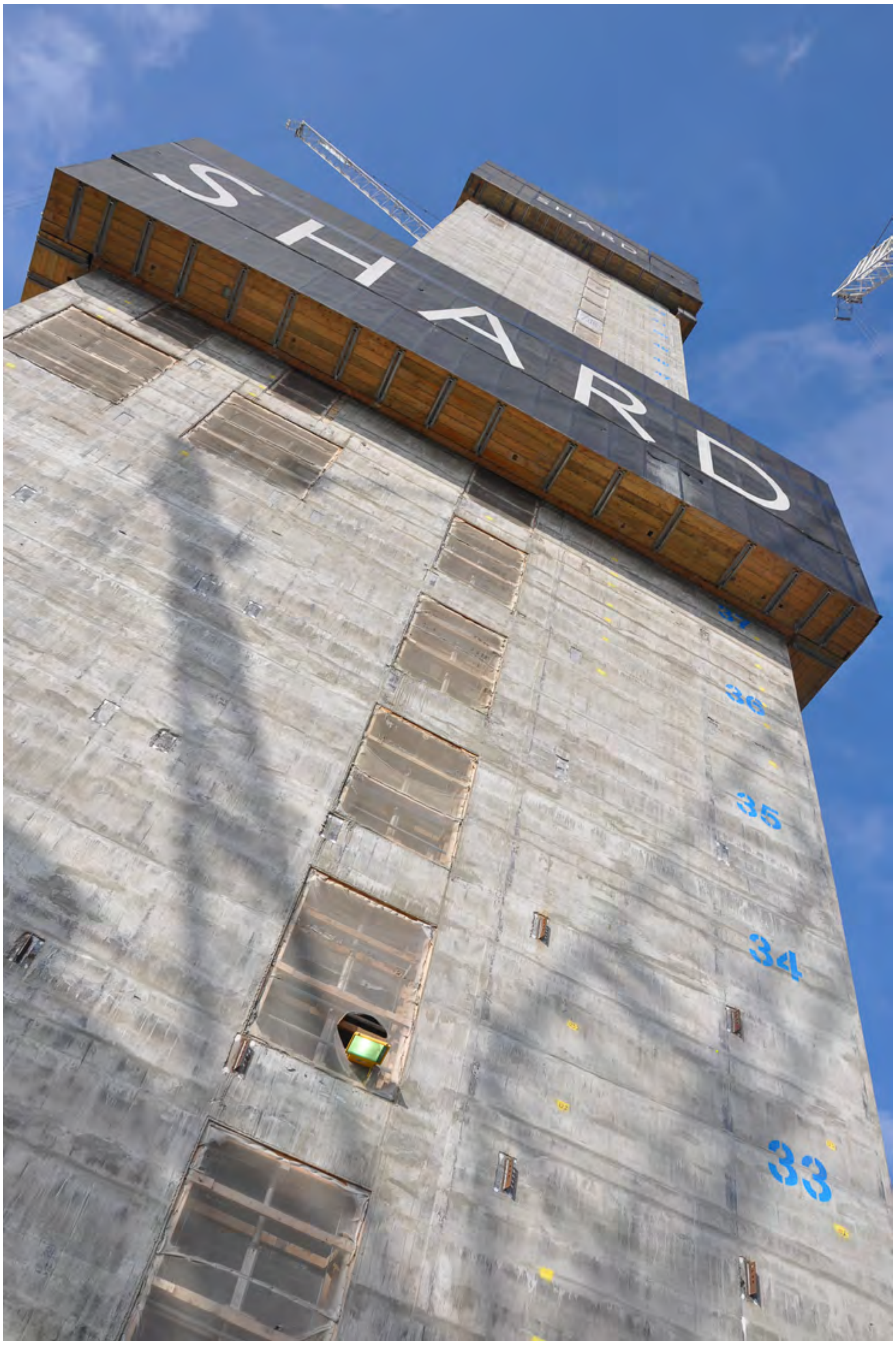
Jumpform is another method for forming in-situ concrete cores. In this case the walls are cast in storey lifts rather than continuously as is the case with slipforming. The jumpform rig is a complete system which includes the formwork and access platforms for fixing the reinforcement, concreting and any post-concreting work.

Jumpform is the default option for high-rise residential buildings as fewer passenger lifts are typically needed compared with offices and therefore fitting out the lifts is less significant for the critical path. The jumpforms are normally a storey high and therefore require one lift per storey, taking about five-to-seven working days per cycle.

Jumpforms can be either top hung or side hung. If top hung, this is normally done in the form of a closed box which makes for a safe working space. If the forms are side hung, these are clamped to the side of the core walls and when moved, pushed up from the bottom on rams pushing against climbing shoes fixed to cast-in anchors. All the load from the jumpform rig goes through these cast-in anchors,

FIGURE 1: SUMMARY OF CORE OPTIONS

Attribute	Slipform	Jumpform	Twinwall	Precast unit
Concrete required	Good strength gain, but needs retarder if not 24-hour working	Early age strength	As per structural requirements	As per structural requirements
Wall thickness (typical)	200-450mm	200-800mm	200-400mm	200-300mm
Average cycle times	250mm per hour	Four days	Two days	One day
Concrete finish	Typically not exposed. Making good likely	Can be exposed. For high-quality surfaces, construction methods to be adapted to suit	Can be exposed. High-quality finishes possible subject to discussion with manufacturer	Can be exposed. High-quality finishes possible subject to discussion with manufacturer



RIGHT For the Shard in London, 36 different concrete mixes were established before work began on the slipformed core to allow for different weather conditions and times of day

so if there is a clash between the anchors and an opening, the rig will be more difficult to design. Openings at corners should be avoided if possible because of the clash with the cast-in anchors.

As the core goes up more slowly than with slipform, the jumpform rig tends to be just ahead of the rest of the floor plate. This means that access is via the working deck and therefore no hoist is required specifically for the core access.

If big cast-in plates or anchorage points are required within the core walls, then jumpform tends to be a better solution than slipform as they are easier to fix in place due to the greater time in the programme.

One of the benefits of using jumpform is that high-quality finishes are possible (see case study, previous page), as the concrete is poured against a normal static formwork shutter rather than one that is moving.

Precast options

There are two main precast options for concrete cores in current use in the UK. These are twinwall and volumetric precast core units.

Twinwall is a hybrid concrete solution where the precast element consists of two skins of concrete containing the main reinforcement spaced apart with lattice girder rebar. The twinwall elements are brought to site and lapping rebar fixed to provide continuity. In-situ concrete is then poured between the two precast outer skins to form the solid wall. As it is a partially precast solution, this is very fast on site, with cycle times similar to those for slipform construction.

Volumetric precast concrete core units are a fully precast solution where the core is constructed offsite and brought to site in a just-in-time manner and lifted into position from the lorry. The core units are then bolted together to provide the required robustness. Each core unit is normally half the storey height so two core units are required for each level.

Both systems can provide a high-quality finish that can be left exposed, or with very little additional finishing. Both require fewer personnel on site so have safety advantages. However, they cannot be used at great height as there would be too much wind for the crane to lift them into place. Both methods been used up to about 22 storeys.

Conclusion

As with all forms of construction, the best outcome is provided when there is early discussion with the contractor. The construction of the core will affect the design and the design will affect the construction. While there are standard defaults for using one of these options, contractors have preferred methods of working and there are always innovations that will inform the decision. The finish and the speed of construction required are other important factors, so should be discussed with the contractor as soon as possible.

Jenny Burridge is head of structural engineering at The Concrete Centre. This article was prepared with help from Don Houston, director at Byrne Bros

FURTHER READING

Tall Buildings, The Concrete Centre and the Fédération internationale du béton (fib), 2014

Concrete Tall Buildings, free to download from www.concretecentre.com, 2018

LASTING IMPRESSION MEREDITH BOWLES

A MOLE'S-EYE VIEW OF MODERNISM

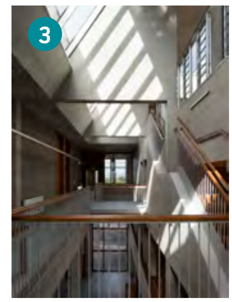
As a diagram of functional modernistic expression, I think Denys Lasdun's Charles Clore House 1 (1976) at University College London is terrific. It's successful in a way that you wouldn't necessarily expect, because it's a really big building [its elevation is 230m long] and it's sitting in streets of Georgian townhouses. But the fineness of detail – both of the board-marked concrete and the bronze anodised cladding above – makes it work.

I've long been a fan of Peter Zumthor's work. The Bruder Klaus Field Chapel 2 (2007) is built out of rammed concrete – the same technique we are using on his Secular Retreat project in Devon – and the richness of the expression and the contrast between the inside and the outside, which could only be achieved in concrete, looks absolutely extraordinary – both as an imaginative feat and in terms of the actual experience.

Grafton Architects' University of Limerick medical school and residences 3 (2012) is a heroic bit of modernist architecture that could only be achieved with concrete. There are cantilevered floors and a fantastic section around a four-storey atrium. I'd love to go to Peru to see the UTEC building they did afterwards. Because of the climate, it's able to be much more open, exposing more of the structure – but actually it's all there in the Limerick building. Once you go inside, you experience the space and the structure and material in a way that is incredibly rich and exciting.

There's a different version of modernism in the 1950s buildings of Colin St John Wilson and Leslie Martin in Cambridge, such as Martin's Harvey Court student halls at Gonville & Caius College 4 (1962). There's a really interesting marriage between brick and concrete, where the concrete is used inventively – you couldn't have cantilevered the construction without it – and in an expressive but not overwhelming way, while the brick makes it relate better to the historic context.

Meredith Bowles is principal and design director at Mole Architects



Photos: Institute of Advanced Legal Studies, University of London; .mw/Flickr/CC BY-NC-ND 2.0; Alice Clancy; Nick Jones/Wordmule. Portrait by Onur Pinar

FROM THE ARCHIVE: AUTUMN 1976

GIVE US AN H

In 1970s Oxbridge, the H-frames of Arup Associates' Philip Dowson were becoming as ubiquitous as future Cabinet ministers. By the time he designed the Sir Thomas White Building, Dowson had been honing the system for over a decade on university buildings in Oxbridge and beyond. Now, with St John's, one of the wealthiest Oxford colleges, as his client, he took the opportunity to perfect it, lavishing the block of study-bedrooms with a frame "rich in architectural pleasures".

The richest of these pleasures was the high-quality white precast concrete, which was made from grey limestone aggregate and white cement and then bush-hammered. The frame was finely detailed, creating "an overall texture of great intricacy and depth … which stops short of being over-elaborate". As at the earlier Leckhampton House at Corpus Christi in Cambridge, the edges of each frame were sliced off to create eight-sided window openings, while the junctions between the standardised elements were exaggerated to show the method of construction. Latticed screens behind the double glazing added another layer of interest.

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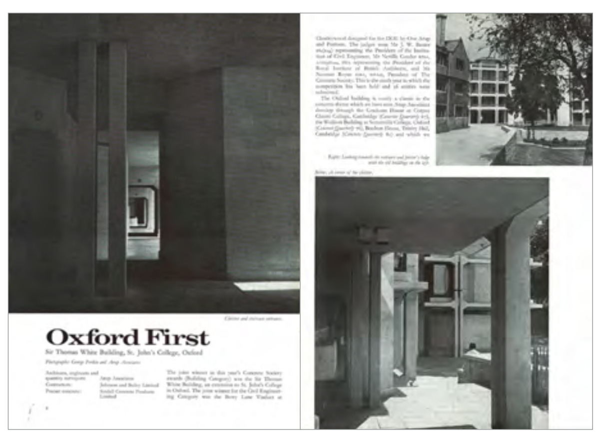

Oxford First

Sir Thomas White Building, St. John's College, Oxford

FINAL FRAME: AMOS REX, HELSINKI

JKMM Architects has renovated Lasipalatsi, an iconic example of 1930s Finnish modernism, to provide a new home for the Amos Anderson Art Museum, now called Amos Rex. The former office and cinema complex has been extended with a series of subterranean galleries that bulge up into the public square above. Passers-by can walk over the mounds, which are clad in geometric concrete tiles, and peer in through circular windows at the artworks below.

Photo: Tuomas Uusheimo