

CONCRETE QUARTERLY

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BOLD AND BEAUTIFUL

Stunning visual concrete leaves its mark everywhere from the Stirling shortlist to the Shanghai docks

OXFORD FIRST

Zaha Hadid adds some snaking curves to the city of spires and quadrangles

WAVE OF VEGETATION

The new Paris sustainability research centre with a rolling meadow for a roof





Photo: Rob Parrish

AHMM and Heneghan Peng in Stirling race

Two education buildings that make spectacular and contrasting use of concrete are among the five-strong shortlist for this year's Stirling Prize.

At Burntwood School in south London (above), Allford Hall Monaghan Morris has reimagined an existing 1950s modernist campus with six new buildings that have already acquired iconic status, thanks to their dramatic facades of chamfered precast-concrete panels (see page 12).

Meanwhile, across London, Heneghan Peng's School of Architecture and Construction at the University of Greenwich (CQ 250)

is dominated by stylish and robust exposed-concrete exteriors, which have helped it to achieve a BREEAM Excellent rating, and perform the roles of structure, finish and teaching aid at the same time.

The Stirling Prize shortlist is completed by the Maggie's Lanarkshire cancer care centre by Reiach and Hall; NEO Bankside, Rogers Stirk Harbour's luxury housing next to Tate Modern in London; and the Whitworth gallery extension in Manchester by MUMA.

Read about Heneghan Peng's Greenwich University building at www.concretecentre.com/cq



Photo: Nick Cottridge

TOP OF THE CLASS IN LONDON AND LANCASTER

Inspirational and robust architecture for education is also the theme of September's Concrete Elegance event at the Building Centre in London.

James Dixon, associate director at John McAslan + Partners, will introduce the Engineering Building at Lancaster University (above), which has won numerous awards for its clever integration of structural, visual and sustainability requirements. The exposed in-situ concrete frame provides thermal mass – a key element of the building's BREEAM Outstanding rating – as well as a raw aesthetic

and the necessary compartmentation of fire, noise and vibration for the facility's various specialist activities.

Meanwhile, Paul Monaghan, director of Allford Hall Monaghan Morris, will tell the story of the dramatic transformation of Burntwood School in south London (see left). Exposed in-situ concrete interiors and faceted precast concrete cladding panels combine to create a series of highly attractive learning spaces.

Concrete Elegance takes place on 8 September. For more details, go to www.concretecentre.com/events

Stunning Japanese cultural centre lands WAN Award, as Concrete Society unveils 2015 shortlist

The WAN Concrete in Architecture Award 2015 has been won by the Konan Ward Cultural Center in Niigata City, Japan.

The building (pictured right), designed by Chiaki Arai, houses a library, concert hall and museum within an extraordinary concrete

structure of curving walls and complex geometries. Throughout the building, the concrete is textured with a variety of 3D patterns and pleating effects.

Judge Paul Zara of Conran & Partners said: "In terms of showing off with concrete, this does it for me. It's pretty stunning really."

The WAN Award recognises designs that explore the sculptural and expressive possibilities of concrete. This year's six-strong shortlist featured buildings from around the globe, including Thomas Heatherwick's

Learning Hub for Nanyang Technical University in Singapore (see page 7).

In other awards news, 16 UK buildings and structures have been shortlisted for the 2015 Concrete Society Awards, which showcase the use of concrete as a structural material. The shortlist includes a string of major London projects such as Bennetts Associates' 5 Pancras Square (CQ 249), Hugh Broughton Architects' Institution of Structural Engineers HQ (CQ 252), and Robin Partington's 3 Merchant Square.



Photo: Sergio Pirrone



On the cover:
Burntwood School
in south London
by Allford Hall
Monaghan Morris.
Photo: Rob Parrish



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Sticking power

I must admit that this issue of Concrete Quarterly has me stumped. It's hard to pick out a common theme, when our featured projects exhibit such a variety of forms and finishes that they defy categorisation. One thing they do all have in common is that they're all likely to be around for a while. You don't build such a stunning concert hall underground, as the village of Blaibach has done, if you're planning to knock it down in the short or even medium term. And is there any more vivid demonstration of permanence than Zaha Hadid's Investcorp Building in Oxford? Snaking around a young sequoia tree, which may itself live for another 250 years, it's a building that is clearly designed to last, withstanding the whims and fancies of contemporary fashion as surely as the rest of that city's architecture.

It's probably no coincidence that these projects have educational or cultural clients, who traditionally tend to have a longer term vision for their projects than developers. But even on the hardest-nosed commercial developments, considerations of sustainability and longevity are coming to the fore – a recent notable example being the BREEAM Outstanding concrete-framed buildings of London's new Pancras Square. Designed properly, a concrete building offers greater flexibility for the future than alternative methods, as well as being more adaptable to climatic conditions – as demonstrated by the geographical spread of these projects, from temperate Paris to hot, humid Singapore. Given that some forecasts predict south-east England may eventually have a climate similar to Marseille, it's reassuring to know how landmarks we're creating today can continue to protect us in an uncertain future.

[Guy Thompson](#)

Head of architecture, housing and sustainability, The Concrete Centre

EVEN ON THE HARDEST-NOSED COMMERCIAL DEVELOPMENTS, SUSTAINABILITY AND LONGEVITY ARE COMING TO THE FORE



WHAT ABOUT THE LAST-TIME BUYER?

The circular economy is making us all think about reducing waste and reusing materials, says This is Concrete blogger Guy Thompson, but what about recycling our housing stock? "We all know about first-time buyers but we now have a new phrase to complete the circle: 'last-time buyers', coined by retirement home specialist McCarthy & Stone."

There is an unquestionable shortage of homes for the over-50s, Thompson says – an obstacle not only for those wanting to downsize, but for the more efficient use of our housing stock. He is interested in two NHBC projects on the future needs of our ageing population: "There are parallels with health buildings," he points out, in the need to protect those less able to escape in the event of a fire, and for whom overheating and extreme events caused by climate change pose a particular threat. "These criteria inevitably lead designers to adopt concrete and masonry solutions to achieve high standards of performance – which will benefit all future occupants of these homes too."

Join the debate at www.thisisconcrete.co.uk

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ZAHA AND THE GIANT

Hadid's Middle East Centre at the University of Oxford is an extraordinary curving structure, designed to snake around a young giant redwood tree. Tony Whitehead reports





It would have been easier if the rather tight site for the new extension at St Antony's College, Oxford had not been home to a young sequoia.

Easier, but not necessarily better. Zaha Hadid's characteristically curvaceous design skirts around the giant redwood at a respectful distance – as well it might. A protected tree, it is a mere 100 years old and 80ft high, and it could take another 600 years to reach its mature height of 250ft.

The result is that the extension to the college's Middle East Centre is arced on plan, and the elevations feature Hadid's trademark curves as the building appears to grow gradually to a triple-height, predominantly glazed elevation which gazes out across the college grounds.

The extension, known as the Investcorp Building, is small but quietly spectacular, and while the exterior is dominated by a polished steel roof, the centre's essentially concrete construction is also very evident.

"We really like concrete," says Johannes Hoffmann, project associate with Zaha Hadid. "It has this natural quality, it can be crafted, and it ages gracefully.

"For these reasons we don't paint it, but leave it fair-faced. It means you have to work closely with the contractor to get the right methodology, the right shuttering and so on, but it is well worth it."

Entering the 1,127m² building via the lobby, it is easy to see what he means. The lift core is smooth exposed concrete, as is the ceiling above which is formed by the exposed first-floor slab.

Hoffmann explains that both of these elements are constructed from in-situ self-compacting reinforced concrete: "This helps to minimise blowholes and produce the smooth finish we wanted," he says. "We also used phenolic resin boards for the shuttering to give the concrete a slightly glossy finish."

Particularly noticeable on the ground floor are LED lights set flush into the concrete soffit above. These strips are aligned with each other and also with the pattern made on the concrete by the phenolic resin boards. "It was more than usually challenging to find a board pattern that worked with the lights, because these are straight features and the building is curved," says Hoffmann. "In the end we did the best we could. It meant cheating a little but the result is good."

Also made from the same self-compacting mix is one of the centre's most striking features: a curving V-shaped column (see box, overleaf) which rises from a piled foundation to support the slab at two points. As it rises through the lobby, this column (or columns) curves in two planes, one of which follows the shallow arc of the building as it bends around the sequoia. Together with the lift core and concrete walls it provides support for the first-floor

IT WAS CHALLENGING TO FIND A BOARD PATTERN THAT WORKED WITH THE LIGHTS, BECAUSE THESE ARE STRAIGHT FEATURES AND THE BUILDING IS CURVED

slab, meaning that the majority of the space on the ground floor is column-free.

The Middle East Centre extension actually connects two existing Victorian houses – 66 and 68 Woodstock Road – and in so doing adds considerably to its size. The upper storeys comprise a library and reading rooms but much of the building is actually below ground where basement levels house substantial book storage and archive rooms as well as a 117-seat auditorium and lecture theatre. These areas effectively sit within two concrete boxes, the walls of which have been cast up against sheet-metal piling.

“When you are storing valuable archive material and books, damp is a concern so the walls and slab of the storage room are made from waterproof concrete and also feature drained cavities,” says Hoffman. “The same happens in the auditorium which is timber-lined and so must also remain completely dry.”

Both of these areas also contain a concrete labyrinth below floor level to provide energy-efficient temperature control for the basement rooms: “In the auditorium air is mechanically dragged through the maze to moderate the temperature before being released into the auditorium. We use a similar system

RIGHT

The centre skirts around a young sequoia tree, which could keep growing for another 600 years

PROJECT TEAM

Architect Zaha Hadid Architects

Contractor BAM Construct UK

Structural engineer AKTII

Concrete contractor

Thames Formwork

Precast concrete supplier

Rhino Precast



V for visual concrete

Achieving the required finish on the interior visible concrete was one of the most challenging aspects of the job, according to project manager Bill O’Meara of BAM Construct UK.

“We did quite a lot of trials to establish the best mix design,” he says. “It wasn’t straightforward. For example, we needed an extra fine sand to help create the smooth finish, but we found that there was not a sufficiently consistent supply in the Oxford area. Our supplier’s solution was to arrange for suitable sand to be brought in from Dagenham.”

Even though a self-compacting mix was used, extra measures were taken to reduce voids, such as pumping concrete from below to force air from the formwork. “We did this for the supporting walls, only one side of which were visible,” says O’Meara. “We could use the hidden side to make a hole in the bottom of the shuttering to connect to the pump.”

Most of the shuttering used to create visual concrete on the project was phenolic resin board, but the unusual shape of the curving feature V column (pictured) meant that a bespoke GRP mould in four sections was commissioned. The joints were carefully positioned to align with the top of the adjacent glazing and to give the look of columns created from five large blocks. As a pump hole would have marred the appearance of the V column, in this instance concrete had to be placed from above, meaning that extra care had to be taken to avoid air becoming trapped.

Another issue for the contractor was the creation of inverted troughs in the underside of the first-



floor slab to house lighting strips. “The LED lighting is set flush into the concrete soffit,” says O’Meara. “So when we laid the decking for the slab, we fitted specially made nylon inserts about 1,200mm long and 80mm deep to cast the spaces for the lighting to fit into. The inserts tapered slightly to allow for easy removal after casting, and at the back of each insert we fixed a conduit for the wiring to go directly to the back of the light.”

He explains that the 80mm-deep cavities made significant cuts into the 300mm-deep slab and that this had some structural consequences: “Because we had to cut the reinforcement to fit around the lights, it meant beefing up some of the reinforcement in the slab to maintain its strength.”

for the archive storage rooms where a constant temperature is important for conservation. Both systems are self-contained.”

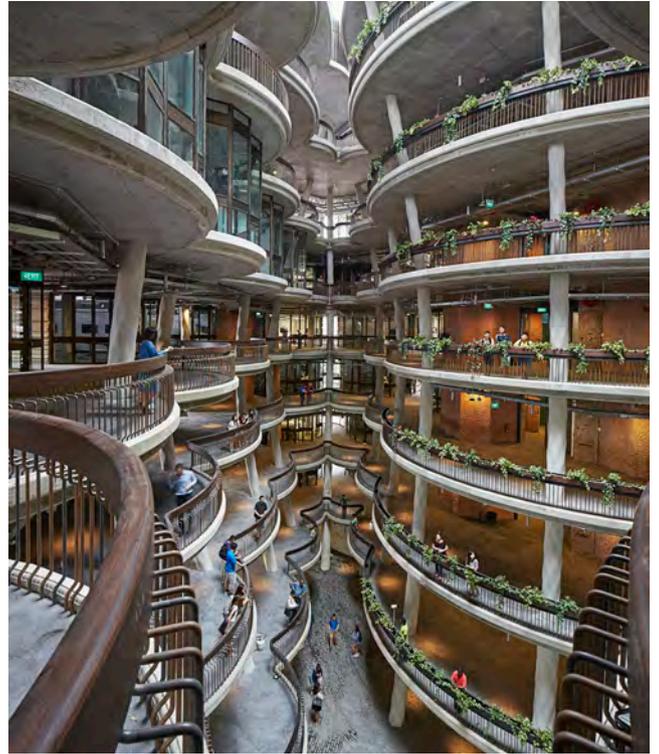
The auditorium contains some precast elements, including stairs and concrete planks that span 10m between retaining walls to form its ceiling. Covered by a timber lining, the planks are not visible. Sitting in the basement auditorium, however, it is slightly surprising to think that the space above the planks is occupied not by the upper storeys but by ground-level turf.

Hoffmann explains that this is because the long section of the basement levels is set at right angles to that of the floors above – a manoeuvre which, given the size and restrictions of the site, enables the new building to provide a remarkable amount of additional space while maintaining greenery above and, of course, preserving the young giant redwood.

“It made it difficult for the contractor, because during the construction process everything had to go through the central core stairway, which was naturally a bottleneck of sorts. However, BAM coped really well with this and it was also down to them that our special requirements for the concrete worked out as we wanted.”

Admiring the new building from the lawn outside, with the sequoia reflected in the polished steel roof, it is hard not to wonder whether the tree’s potential vastness might one day threaten its neighbour’s existence.

Hoffmann explains that measures have been taken – with concrete once again providing the solution: “There are concrete piles which enable the foundations to bridge above the roots of the tree. It has plenty of room to grow.”



RIPPLES OF DELIGHT

Almost every concrete surface in Thomas Heatherwick's stunning Nanyang Learning Hub in Singapore incorporates an ingenious visual effect, writes Andy Pearson

"We were given a brief to design the new learning centre with no corners and without corridors," says Danaï Sage, an architect at Heatherwick Studio. The studio's response is an eight-storey teaching block, formed of 12 oval towers that rise up like the hives of some monstrous insect.

Concrete features extensively in this unconventional scheme for Nanyang Technical University in Singapore, with the floor slabs, stair cores and structural columns all cast in situ, and the cladding formed from precast panels. With the exception of the floor slabs, almost all of these exposed concrete surfaces have been embellished in some way.

This is immediately evident on the facades, which are wrapped in rows of striped 2m-wide, 3m-high concrete panels. The towers' floor plates increase with elevation, and Sage says these stripes help to emphasise the outwardly curving form. All 1,050 panels were manufactured in Malaysia using adjustable moulds to form the 10 different radiuses

needed. A silicone liner was placed into the mould to create an undulating finish and the stripes then added by positioning additional silicone strips onto the liner, creating indents in the panel surface. These stripes were painted with concrete setting-retarder to slow the rate of curing, which meant that, when the mould was struck, the stripes of uncured concrete could be washed from the surface to expose the aggregate beneath.

Surface detail is also a feature of the in-situ concrete panels that line the building's four stair cores. Here a collage of 700 images created by the illustrator Sarah Fanelli has been turned into a concrete relief using just 18 silicone moulds, which were arranged in different combinations to avoid noticeable repetition. The relief was produced by first milling the collage into MDF panels. A reusable silicone mould was taken of each panel and these were then simply used to line the stair's concrete formwork. A red pigment was also added to the concrete on the stair cores,

PROJECT TEAM

Design consultant

Heatherwick Studio

Lead architect

CPG Consultants

Main contractor

Newcon Builders

Civil and structural engineer

TY Lin International

CLOCKWISE FROM TOP LEFT

Striped precast concrete cladding panels emphasise the building's curving form; the columns in the atrium are inclined at varying angles; a collage by Sara Fanelli is cast into the red-pigmented concrete stair cores



says Sage, "to give it a bit more warmth".

Even the surfaces of the inclined columns that support the building's floor plates are textured, with a rippled finish similar to the facade panels. And you won't find any obvious corners here either: the columns are faceted and have slightly different inclines at each level, creating the impression that they curve as they rise up through the building's central atrium.

Go to P12 for a guide to specifying visual concrete

NOUVELLE VAGUE

A sustainability research centre near Paris has been crowned with a graceful landscaped park on a bed of undulating concrete. Nick Jones reports on one of the most ambitious green roofs in Europe

Just to the east of Paris, there lies a bucolic place of undulating meadows punctuated with wooden cabins and mosaic bursts of red, yellow and white flowers. Office workers can escape the sclerotic sprawl of the suburbs and stroll back and forth along its contoured paths, taking in views of nearby woodland from the higher points. It is reminiscent of a mountain landscape, says Jean-Philippe Pargade, a “souvelement du sol”, or uprising of the earth.

Except it's actually a roof. This striking carpet of green, rolled out over three distinct waves of monolithic in-situ concrete, stretches for 200m across the top of the Bienvenüe building, a new centre for sustainable development research in the satellite town of Marne-la-Vallée. For Pargade, the building's architect, the roof is the culmination of a design process that had to reconcile a number of competing demands: the need to create open, public space while bringing cohesion to a disconnected patch of urban realm; the need to cater for a diverse range of demanding functional requirements while also being a model of energy efficiency; and the need to create both a space of quiet contemplation and a showcase of structural virtuosity.

One of the key problems to address was the building's context. Marne-la-Vallée is a 1960s new town that has swollen to house a population of over 280,000. “The public spaces are stretched out and there is no link between the various districts,” says Pargade. In recent years, Marne has attempted to create a clearer sense of identity for itself with the development of Cité Descartes, a campus housing faculties for the Université Paris-Est as well as a number of national research centres. The buildings here read like a roll call of France's most renowned

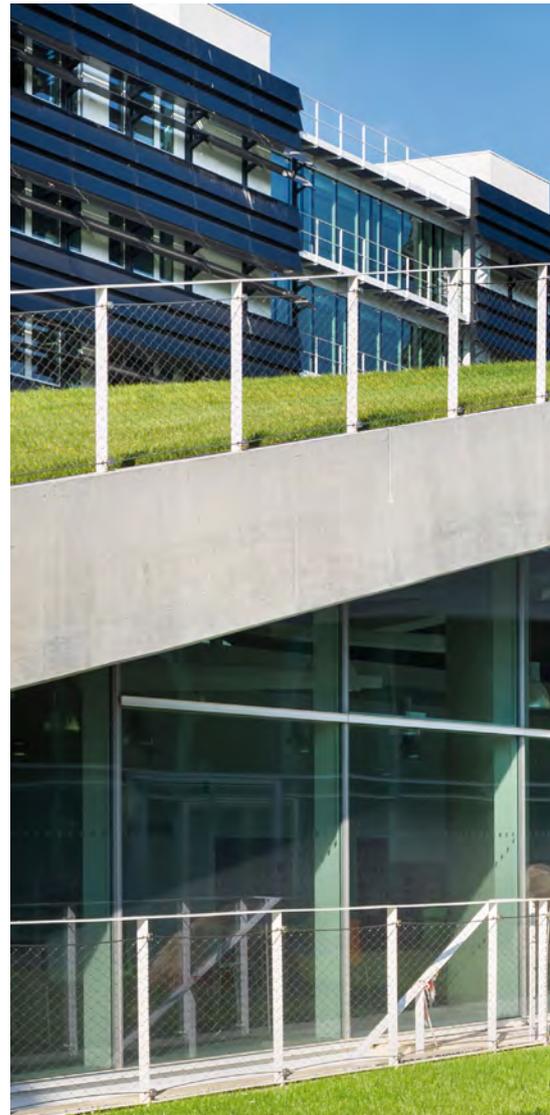
architects: there's an ICT faculty by Dominique Perrault, a structural engineering school by Chaix et Morel and an architectural school by Bernard Tschumi. But until now there has been little sense of a connected campus, with each piece of architecture simply expressing its own personality.

The Bienvenüe building is the latest attempt to bring cohesion to both Cité Descartes and the wider town. The 40,000m² building incorporates a variety of functions including 25,000m² of offices, 10,000m² of chemical and material laboratories, a 250-seat auditorium and a 1,700-seat restaurant. These have been arranged in a seven-storey block, which houses the auditorium and many of the labs and offices, and a lower curtain-walled entrance building. The taller block defines the northern edge of the campus, and shields the site from the busy Boulevard Newton, while the lower entrance block presents a long curtain-walled facade directly opposite the structural engineering school, creating a public square.

As the building is the headquarters of the French equivalent of the BRE (see box, overleaf), sustainability was critical. It has achieved France's two main energy performance certificates – NF HQE Bâtiments Tertiaries and Bâtiment Basse Consommation – through a mixture of passive methods, user control and innovative technologies. Key to this strategy are the concrete frames of both blocks, which are left largely exposed to harness thermal mass. Likewise, the vast green roof, with its insulated concrete deck, retains heat in winter and cools in summer. Both buildings are naturally ventilated with openable windows, but extra heating and cooling for the energy-demanding labs is provided by geothermal energy drawn from an underground water table, backed up by mechanical ventilation with air exchangers.

Natural light is maximised through insulated south-facing glazed facades – which are protected by mobile brises-soleils operable by occupants – as well as the lower building's unique roof design. The three undulating waves result in a number of “failles” or faultlines where one hill meets a neighbouring dip, allowing natural light to be drawn

FOR PARGADE, THE INCLUSION OF MORE GREEN SPACE FOLLOWS A LONG TRADITION OF INTERTWINING ACADEMIA AND FORMALISED NATURE





Photos: Sergio Grazia



ABOVE

The deep-plan building is split in several places to help draw natural light in

LEFT

The planting includes long furrows of flowers and evergreens. Wooden cabins by Japanese artist Tadashi Kawamata will also be added to the lawns

PROJECT TEAM

Architect Pargade et Associés
Contractor Léon Grosse
Structural engineer SNC Lavalin
Landscape designer David Besson-Girard

deep into the building. The concrete deck also cantilevers 2.7m over the entrance, sheltering the facade from the sun.

But sustainability wasn't the only driver for the striking green roof. For Pargade, the inclusion of more verdant space was essential to creating a unified campus, and follows a long tradition of intertwining academia and formalised nature. "I took as a reference point the University of Virginia campus in Charlottesville founded by Thomas Jefferson – a homogenous campus that was designed to symbolise 'the authority of nature and the power of reason.'" The roofs raised walkways also created a visual link to areas beyond the campus, such as the woodlands of the bois de Grace et de Grange.

The roof was also a pragmatic solution. The Bienvenue building's various functions, from offices to the entrance foyer to the vast testing pad for innovative materials (see box, overleaf), required spaces of different heights, and the peaks and troughs of the roof are merely a reflection of this. "I wanted to create a very strong link between the building's design and its contents," says Pargade, "what the English call 'affordance', or the capacity for an object to express its use." ►



Just as important was the need to express a unique structure – in a nod to the structural engineering school across the way. The roof was designed by structural engineer SNC Lavalin essentially as a bridge in three sections, with the central section supported on 1m-diameter fixed circular concrete columns, and the end sections mounted on 70cm-diameter neoprene pads to counter any movement.

Great care was taken in the construction of this curving bridge, in order both to show off the quality of the structural engineering and to ensure a monolithic finish to the exposed soffits and external canopy. The formwork comprised of 20cm-wide steel beams, installed in lengths of

3-4m in a transverse direction; these naturally deformed slightly to follow the curvature. The beams were then covered with 125cm x 250cm Bakelite panels to create a smooth finish to the concrete soffit. Dense steel reinforcement was added, before C40/50 concrete was poured to a depth of 60cm. The whole process took eight months.

The roof was then readied for planting. A 12cm layer of insulation and a waterproofing membrane were added to the concrete deck, followed by a layer of soil between 26cm and 30cm deep, depending on the vegetation. Landscape gardener David Besson-Girard has designed beds of red, white and yellow flowers including tulips and



Photo: Laurent Delahousse

A cathedral of experiments

Named after Fulgence Bienvenüe, the civil engineer behind the Paris Metro, the Bienvenüe building is the headquarters of the Institut Français des Sciences et Technologies, des Transports, de l'Amenagement et des Reseaux, or IFSTARR. This organisation conducts research into transport, infrastructure and various other aspects of sustainable development.

The new building contains labs that explore everything from the impact of noise on health to innovative new materials. But its pièce de résistance is a massive 60m x 10m testing pad, designed to measure the strength and durability of new types of concrete and related materials.

"It is our cathedral of experiments," says IFSTARR director Helene Jacquot Guimbal – "It is rated among the best three in the world." Materials are submitted to intense resistance tests and measured in 3D "to the micron" by high-performance instruments. Due to the high stresses involved, the test slab had to be immensely rigid, so was constructed out of an ultra-resistant C80/95 concrete.

And the testing doesn't stop there. "Our labs are even capable of curing certain diseases within the material and accelerating ageing," says Guimbal, "because it's not possible to wait 30 years to discover a reaction."

LEFT The concrete wave overhangs the entrance by 2.7m, shielding the south-facing curtain wall from the sun

fritillaries, bordered by long furrows of evergreens, in the manner of a formal French park.

Slightly more unusually, the gardens are also dotted with mysterious organic-looking wood cabins designed by Japanese artist Tadashi Kawamata. Pargade describes these as "a furtive presence that add to the sense that this is a natural environment". It is, but of course it is also entirely man-made, the result of innovative structural engineering and sustainable technologies. As researchers stroll across the lawns, away from the hubbub of the campus below, harvested rainwater irrigates the plants around them – nature and academia working quietly, side by side.



Photos: Atelier Deshaus

UNDER THE UMBRELLA

Shanghai's new art gallery shelters its collection beneath a soaring exposed-concrete structure that's both gritty and graceful, writes Nick Jones

There can be beauty in repetition. For the Long Museum West Bund in Shanghai, China's largest private art museum, local practice Atelier Deshaus has created the whole structure out of a single recurring element – an exposed-concrete wall that curves outwards in a rounded T to form part of the roof structure as well. These half-arches, which practice principal Liu Yichun refers to as “vault umbrellas”, repeat and link together to create a gallery that is both graceful and gritty.

The grittiness stems from the fact that the Long Museum involves the preservation of an existing industrial structure. Located on an old wharf on the banks of the Huangpu River, the museum is built around a vast old coal hopper, which has been retained as a sort of abstract sculpture. The new building rises from the concrete foundations of an old warehouse, which were

on a rigid 8.4m grid. Liu hit upon the idea of the concrete semi-vaults as a way of using this existing structure, paying homage to the site's industrial heritage but also adding a degree of flexibility to the plan. The walls still follow an orthogonal layout but interlink in a complex arrangement, with some umbrellas rising 8m and others extending the full three-storey height of the building. The result is a more compelling interior, with various changes in level and long vistas across unexpected voids.

The umbrellas comprise two 200mm-thick concrete walls sandwiched around the basement pillars for strength. Above ground, this leaves a 400mm cavity, within which almost all of the M&E, including air-conditioning ducts and lighting cables, is concealed. Openings for lights are cast into the soffit. The tricky bit came with the curving arch. Liu spent a lot of time with the structural engineers working out how far each cantilever could extend. “The lower the arc starts, the better the structure carries loads. So where the point that the arc starts was higher, we had to thicken the walls. Casting also proved a challenge: “The form of the vault umbrella is actually an ellipse, which made casting on site extremely difficult. We cast

a model in the factory first, using a steel formwork and bent wood to match the curves we had set. This could then be used repeatedly.”

The choice of exposed concrete – onto which paintings are hung directly – was partly influenced by the site's industrial heritage, but also due to its elegance. Liu notes the way its homogenous nature allows the horizontal and vertical planes to blur, adding to the grace of the arches. He opted for a mix with a high mineral content and no coal ash, giving a lighter finish – even though the concrete supplier was worried that this would prove less compactable. For Liu, it was just another aspect of his umbrellas' gritty charm: “I like the blisters.”

PROJECT TEAM

Architect

Atelier Deshaus

Main contractor

Shanghai Xuhui Waterfront Development, Investment & Construction Company

Structural engineer

Tongji Architectural Design Group

CLOCKWISE FROM TOP LEFT

Artworks are hung directly on the exposed concrete walls; the “vault umbrella” cantilevers out on both sides to form a roof canopy; the gallery is built around an old coal hopper on the former industrial site

THE BOLD AND THE BEAUTIFUL

Concrete can provide stunning visual finishes, but it must be considered from the earliest design stages. Elaine Toogood outlines the golden rules

Beauty, it is said, is in the eye of the beholder – a phrase worth remembering when embarking on the specification of visual concrete. Concrete can perform its principle functions of structural support and fire protection without needing to look particularly attractive, and even the best quality visual concrete is likely to have some marks and tonal variation. This is all part of its material quality, its “natural beauty”. Understanding, describing and agreeing the desired standard of finish is essential to a successful outcome.

This article provides an overview of the key considerations for the creation of good-looking “formed” finishes. For more information on “unformed” finishes such as exposed concrete floors, see CQ 250.

The fundamentals: early design decisions

■ **Look at other examples of concrete** Visit some of the many contemporary examples of visual concrete. Take the design team and client in order to manage both your and their expectations of the types of finish achievable. It is very useful to benchmark an existing project, or part of it, as a quality reference. This is a simple way of conveying your expectations to the construction team at tender. Ideally the buildings should be of similar scale and reasonably local, but this is not essential. What is essential is that the type of construction be similar – that is, precast or in situ. References should also relate to equivalent parts of the building, so internal examples are used for proposed internal locations.

■ **Establish if precast or in-situ concrete is required** The desire for a particular colour or texture could determine where and how the concrete is made, and so it is recommended that the choice of manufacturing route is made early. Both ready-mixed concrete cast on site and pre-manufactured (precast) concrete offer visual concrete solutions, but with different aesthetic possibilities.

Visual precast concrete

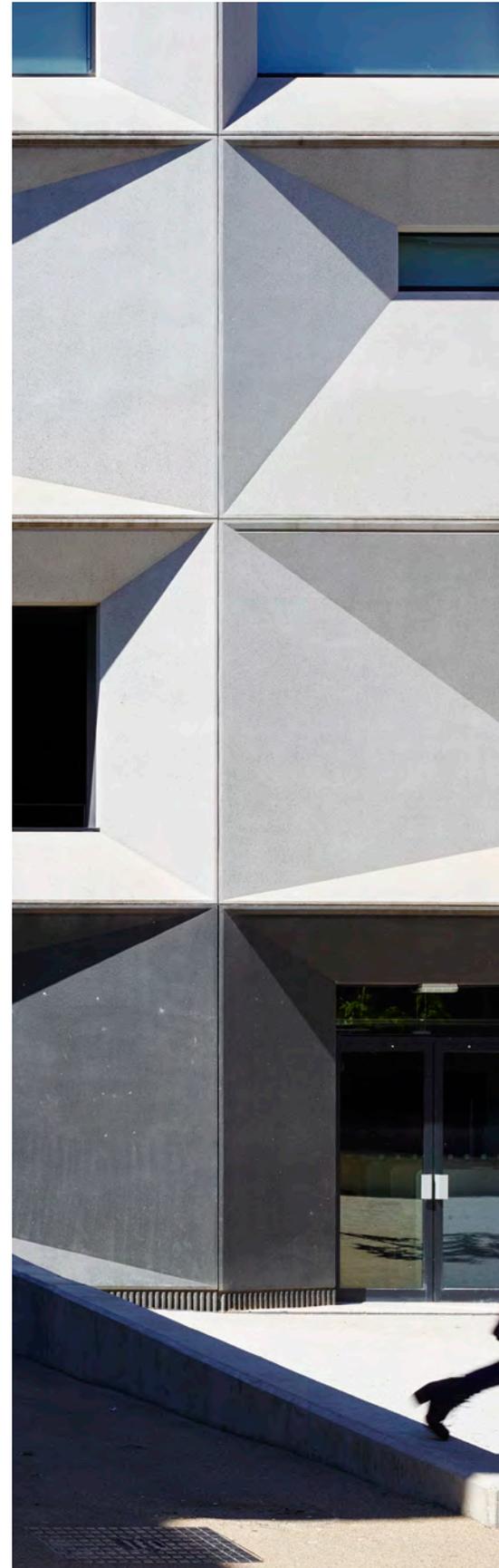
There are many precast concrete products designed to be on show. This includes off-the-shelf units such as blocks and paving, but also larger precast elements made to order. Architectural precast offers a wide range of colours and textures, often with mixes developed to mimic stone – hence the term “reconstituted stone” or “recon”. It is possible to achieve a high degree of quality control and replication through factory-based processes. Specialist manufacturers offer samples for reference, using a wide range of combinations of aggregates, pigments and finishing techniques. Precast concrete is typically the route to choose if white concrete is required, for example. Cladding is a common use for these products but bespoke structural elements are also available.

Most structural precast is not intended to be left exposed, but good aesthetic results are achievable. Structural precast is usually made to order, often with some properties predetermined by the method of manufacture – for example, hollowcore floors of a standard width and depth. Colours are typically limited to shades of grey with either a matt or satin sheen as-struck texture. In this regard, the finish is similar to standard in-situ concrete, except that it is usually cast face-down. The standard of finish should be established pre-tender in discussion with manufacturers as it will inform processes of manufacture, storage and handling.

Visual in-situ concrete

Ready-mixed concrete is mixed or manufactured in a batching plant not far from site, for direct delivery to be cast-in-situ. Often, concrete made in this way is concealed, but good aesthetic results can be achieved through careful specification, manufacture and workmanship. Site-batched concrete is not typically recommended for visual concrete due to the challenges of adequate measurement and mixing.

Most in-situ concrete is supplied in shades of grey, the colour determined principally by the cementitious content. Higher percentages of ground granulated blast furnace slag (GGBS) produce a lighter colour, while fly ash (FA) gives a deeper grey. Colour can vary slightly between suppliers and between different parts of the country as ready-mixed concrete plants mainly use





◀ Burntwood School

Wandsworth, south London
Allford Hall Monaghan Morris, completed 2014

AHMM's Stirling Prize-nominated transformation of Burntwood school merges a 1950s modernist campus with six new buildings. A range of both in-situ and precast visual concrete finishes are on show throughout the project, but its most striking feature is the sculpted facades of the four new curriculum buildings.

The reinforced precast concrete panels are 3m and 4.5m long to align with a typical classroom and structural module of 7.5m, while providing the flexibility for smaller modules. They were cast at Techrete's facility in Lincolnshire.

The base panels are acid-etched black concrete with mica fleck, while the upper panels use an off-white cement with dark aggregate fleck, and are also heavily acid-etched. To address considerations of staining and weathering, final detailing of drip edges and a corduroy base was also developed with Techrete.

locally available course and fine aggregates. Hence, consistent supply is essential for visual concrete. Coloured concrete can also be obtained by adding pigments to the ready-mixed concrete.

Pattern and texture

The texture of in-situ concrete is typically dictated by the formwork facing material. The selection and construction of appropriate, good-quality formwork is fundamental to achieving an attractive finish. Impermeable linings such as steel, polypropylene, glass reinforced plastic (GRP) and high-density overlay (HDO) board produce a smooth, shiny surface, whereas timber, unsealed plywood, paper-faced or medium-density overlay (MDO) boards give a matt finish. Pattern or texture can also be created by lining the formwork – proprietary form liners are available with either established or bespoke textures or patterns. Timber is often used as a form liner to create a board-marked finish.

Post-finishing can also be used to change the concrete's surface texture, and techniques such as acid etching and polishing are commonly used for architectural precast. Concrete can be shot or grit-blasted, the degree of texture dependant on the depth of mechanical abrasion. Water jet-blasting is also possible on freshly struck concrete, to expose the aggregates, but a more controlled

CONCRETE CAN BE SHOT
OR GRIT-BLASTED, THE
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FAR LEFT Hilltop House in Oxford by Adrian James Architects uses precast concrete specified for an exposed finish

LEFT Hugh Broughton Architects specified self-compacting concrete for a feature wall at the Institution of Structural Engineers headquarters in London. It was cast in situ in formwork made from Douglas fir to leave a beautiful board-marked surface

and recommended method is to apply a surface retardant to the inside of the formwork, where the depth of reveal is determined by the type of retardant. Point tooling is possible but requires time to implement safely.

Specification

The National Structural Concrete Specification (NSCS v4) is a sound basis for the specification for concrete, especially when including visual concrete. It incorporates both standards and guidance in one document and usefully includes a detailed description for each of the finishes stipulated by BS EN 13670 for visual in-situ concrete (that is, plain and special).

Whether the NSCS or NBS specification is used, it is a good idea to include a short section on the specific requirements for the visual concrete elements. This ensures they are all in one place, so better communicated, and makes it easier to price and control. It is best to clearly define the extent of the visual concrete and indicate the areas where the greatest care should be taken. Design intent drawings should include formwork setting-out, 3D sketches of details, extent of cast-in services, corner and edge profiles and tie-bolt positions.

Typically +/- 1.5mm is the tolerance stipulated for good-quality visual concrete, but this can be tightened up with double-boarded formwork. The tender documents need not be specific about the type of release agents used, only that they “suit the concrete mix and facing material” and are “correctly applied to manufacturers guidance”, the final selection being determined through trials on sample panels. Chose spacers appropriate for visual concrete, especially in slabs, and stipulate that day-work joints should not be visible. This can be difficult where large expanses of concrete are on show, such as in atriums or staircase shafts. Here it is worth considering introducing a shadow gap at the day-work joint position.

Concrete mix

BS 8500 stipulates five methods of specifying concrete. While good results are possible using high-strength concrete by “designation” (performance) only, for in-situ concrete it is advisable to use a “designed” concrete, limiting the allowable components and proportions of the mix to those suitable for visual concrete, while still allowing the contractors and suppliers some input into the design. The following recipe is recognised as suitable for achieving visual concrete and forms the basis of a designed mix specification.

TYPICAL VISUAL CONCRETE MIX	
Cement content	Minimum 350kg/m ³
Sand content	Not more than twice the cement content
Total aggregate	Not more than six times the cement content
Coarse aggregate	20mm max. Size not more than 20% to pass through a 10mm sieve
Consistency	125 to 150 slump S3
Water-cement ratio	0.5 or less

Alternatively there are proprietary concretes, including self-compacting concrete products, specifically designed to be used for visual concrete. These have been used successfully on a number of recent high-profile projects.

The specification included at tender can be regarded as a trial mix to be tweaked as necessary prior to construction through the process of supply and approval of sample panels and mock-ups. The exact proportions are likely to vary between projects depending in part on the properties

of local materials. A full-size mock-up is to be recommended and is an invaluable way to agree workmanship, final detailing and release agent. As a minimum, a review of the first pour of visual concrete should be included in the programme to provide an opportunity to adapt the specification or processes if necessary.

Workmanship

The importance of good workmanship cannot be overemphasised in the process of achieving visual concrete. It is a good idea to begin a pre-tender collaboration with specialist contractors and suppliers. Appropriate site procedures should be established and rigorously enforced to maintain consistent quality. This includes the preparation, storing and construction of formwork and ancillary elements; the delivery, placing and compacting of concrete; and its subsequent striking, curing and protection. Cleanliness on site, and in particular of the formwork, is of paramount importance, as is good communication between all trades before and after the concrete is cast.

These efforts in preparation and installation should significantly reduce the risk of unwanted blemishes and colour variation on the surface of the concrete. However, there may still be areas that would benefit from post-finishing. Although much can be done to improve the surface of concrete, it must be implemented by a skilled operative, or the finish may end up looking worse than if it had been left alone. Most specifications include a clause to avoid making good or any remediation without prior agreement with the architect. This doesn't mean that it won't be required, just that the extent and means need to be established beforehand.

So with some preparation, collaboration and understanding, beautiful concrete is very achievable. Fortunately, unlike in many other areas of life, concrete requires little further attention to maintain its good looks over time, thus providing enduringly rewarding results.

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▲ Blaibach Konzerthaus

Bavaria, Germany

Peter Haimerl Architektur, completed 2015

Konzerthaus, a new 200-seat concert hall designed by Peter Haimerl in the Bavarian village of Blaibach, is full of surprises. Externally, its partially buried form tilts up to create a dramatic granite protuberance in the town square. But there's even more of a shock inside, where the all-concrete subterranean concert hall utterly defies expectations.

Rather than a gloomy cave, this is an uplifting space, created with pleats of highly textured, in-situ concrete with the grainy appearance of marble. Concealed lighting within the walls and beneath the seats illuminates the concrete interior – where only the wooden stage breaks the material's expanse.

Haimerl was inspired by the delicate strength of Gothic churches. "You feel the lightness – it isn't oppressive," says Haimerl, who was inspired by the delicate strength of Gothic churches.

"I wanted a modern Gothic aesthetic."

He chose concrete primarily for its aesthetic and acoustic qualities, specifying a stiff yet lightweight foam glass mix. This was made using cellular glass from recycled bottles to give the desired, roughly textured, grainy effect. "The surface looks more like a natural stone and feels much warmer to the touch," he says.

This hard surface is also ideal for performance acoustics, as are the concrete strata, which are faceted to create the optimum acoustic environment for classical music. Horizontal "cuts" allow the architect to incorporate more than 50, 6m-wide insulated boxes behind the concrete walls and beneath the seats to absorb bass tones, and conceal LED light fittings so that the audience sees only slits of light between the strata. The untreated, "grizzled" surface of the concrete absorbs middle tones while reflecting rather than absorbing the high ones.

An in-situ approach was essential to create the complex interior form of the 560m² concrete hall. The installation was highly challenging, especially as this particular concrete mix is not very common.

TOP LEFT Concealed LEDs within the in-situ concrete walls illuminate the wooden stage

TOP RIGHT A tilted granite block is all that marks the concert hall's entrance in the town square

ABOVE RIGHT The untreated "grizzled" surface of the concrete helps the acoustics by reflecting high tones and absorbing middle tones

The architect brought in a car-building company to configure the formwork, which was created using 3,000 different timber elements. "We needed a preciseness which you couldn't get with other formwork," he explains.

The intricate pouring, which took place over a six-week period, was complicated by the need to integrate the insulation and lighting boxes and tubing for radiant heating into the formwork. The resulting concrete ranges in thickness from 50mm to 600mm.

The outcome, both visually and acoustically, exceeded even the architect's expectations for his first concert hall: "It's fantastic," says Haimerl. "Much better even than we hoped."



Photos: Hufsan + Crow

CONCRETE FRAME SOLUTIONS

Concrete floor structures can be divided into five main types. Jenny Burrige provides a guide to choosing the right solution for your project

Two of the first questions to be answered when considering the structure of a building are “what is the grid?” and “what is the floor construction?” This article looks at five typical floor construction types and provides a guide to the appropriate column spacing for each. Typically concrete frames are used for spans of about 4m to 15m. Longer and shorter spans can be achieved, but this range covers the majority of what is required by engineers and architects to realise their designs.

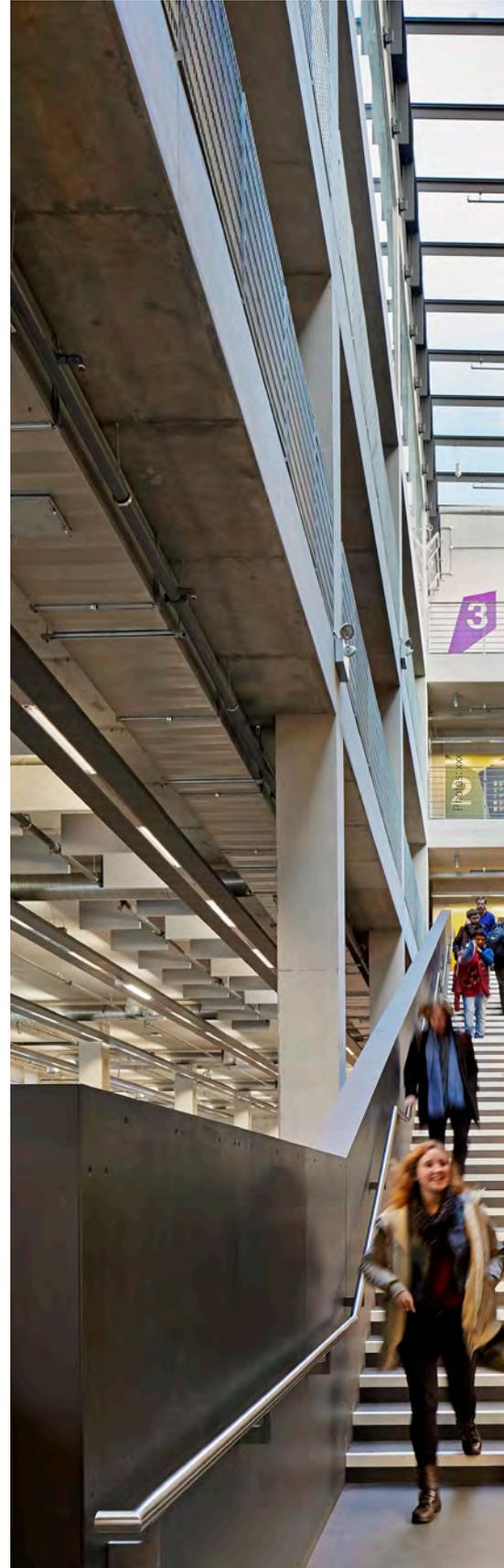
The five typical floor construction types covered in this article are flat slabs, post-tensioned (PT) flat slabs, hollowcore slabs, one-way slabs and ribbed slabs. These can all provide the benefits of concrete

frame construction – thermal mass, durability, robustness, fire resistance – but some are more suited to certain applications than others.

Flat slabs

Flat slabs are probably the most common type of concrete frame construction. Formwork accounts for about half of the cost of an in-situ concrete frame and a flat-slab construction ensures that the formwork is simple and repetitive, minimising the associated cost. Flat slabs also simplify the fixing of services, because the soffit is flat, as well as the junction of any partitions to the soffit.

Flat slabs provide a slim construction, which reduces floor-to-floor heights in comparison with types of construction that include beams. This can reduce the overall height of the building and thus the area of cladding required. As cladding makes up about 20% of the cost of a building, the saving can be significant.





LEFT Heneghan Peng's School of Architecture and Construction at the University of Greenwich has in-situ flat slabs of varying depths – some up to 450mm thick

Within limits, flat slabs can accommodate columns that are not on regular grid lines. However, the whole of the slab is generally sized on the longest span, so an irregular grid can cost more. The most efficient layout is a regular square grid with shorter spans around the perimeter of the building.

Post-tensioned flat slabs

Post-tensioned flat slabs offer the same benefits as flat slabs but tend to be slimmer, saving about 50-75mm on slab depth and reducing reinforcement by about two-thirds. This reduces the weight of the building and thus the size of foundation required. It can also further reduce the building height and cladding area. It is particularly worth considering the use of post-tensioning for longer spans as this is where the greatest savings can be achieved.

The most efficient layout for a post-tensioned flat slab is a regular square grid with a cantilever around the perimeter.

Hollowcore slabs

Hollowcore slabs are precast elements, typically 1,200mm wide, with a hollow core running through their length to reduce weight. Hollowcore slabs are also prestressed to put a permanent compression into the concrete. This reduces the amount of reinforcement required and also the depth of concrete required. The only reinforcement needed in the hollowcore slab is the prestressing wires.

Hollowcore slabs are typically supported on concrete beams, masonry walls or steel beams. They normally have a structural topping to increase the robustness of the system, as this allows the diaphragm action of the slab to be fully realised. The graphs shown in figure 4 (overleaf) assume a 50mm-thick structural topping.

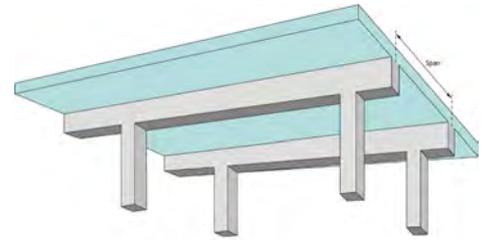
As a precast system, construction tends to be faster than for in-situ options. Hollowcore slabs are readily available and tend to be delivered on a "just-in-time" basis, so that the precast planks are lifted directly from the lorry into place.

Hollowcore slabs come with a pre-camber due to prestressing. The pre-camber is fairly regular, but cannot be guaranteed. And if two hollowcore slabs of different lengths are placed side by side, the two pre-cambers will not match and there will be a step. The top surface can be made uniform with the use of a structural topping, but the difference will be apparent in the soffit.

One-way slabs

One-way slabs are in-situ concrete slabs spanning typically onto concrete beams, or concrete or masonry walls. They are perhaps the simplest slabs to design and can be used for single or multiple spans. Multiple spans are the more efficient design.

FIGURE 1: COMMON FLOOR TYPES



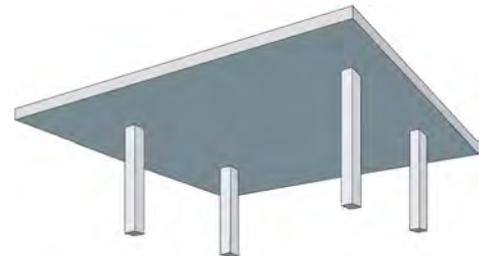
One-way solid slab



Precast and composite slabs



Ribbed slab (with band beams)



Reinforced or post-tensioned flat slab

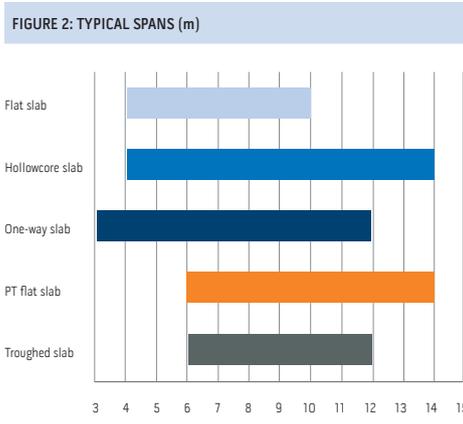
Troughed slabs

Troughed slabs are ribbed slabs spanning one way onto band beams of the same depth as the ribs. The troughs are typically formed using reusable formwork moulds. These can be fixed onto table forms, provided there is enough space to move the table forms around.

Troughed slabs offer the benefit of a reduced weight on the columns and foundations, and can be used for longer spans than normal flat slabs. They are better for vibration control, which can be useful for hospitals and laboratories. The ribs also provide a larger surface area, which in turn increases the efficiency of the thermal transfer if the thermal mass of the building is being used. ▶

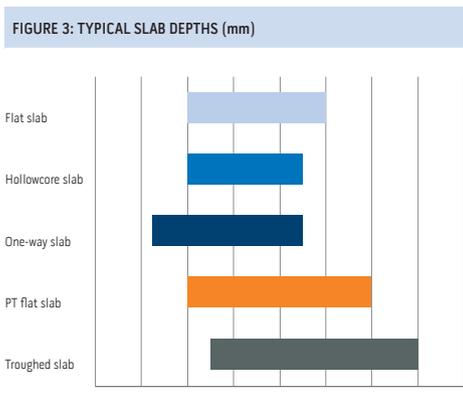


ABOVE Pancras Square in King's Cross, London. Both Seven Pancras Square by Studio Downie Architects (on the left) and One Pancras Square by Chipperfield Architects (right) have in-situ concrete frames with post-tensioned floor slabs



The ribs, however, do make the fixing of partitions more complicated and the depth of the slab tends to be greater than the other options detailed here, increasing the floor-to-floor height. The most efficient layout for a troughed slab is at a ratio of 4:3 rib span to band-beam span.

More information can be found in **Economic Concrete Frame Elements to Eurocode 2**, published by The Concrete Centre. Further guidance on post-tensioned slabs can be found in CQ 251, spring 2015. There is also detailed information on which options are the most economical in the **Concept spreadsheet**, available for free download from www.concretecentre.com

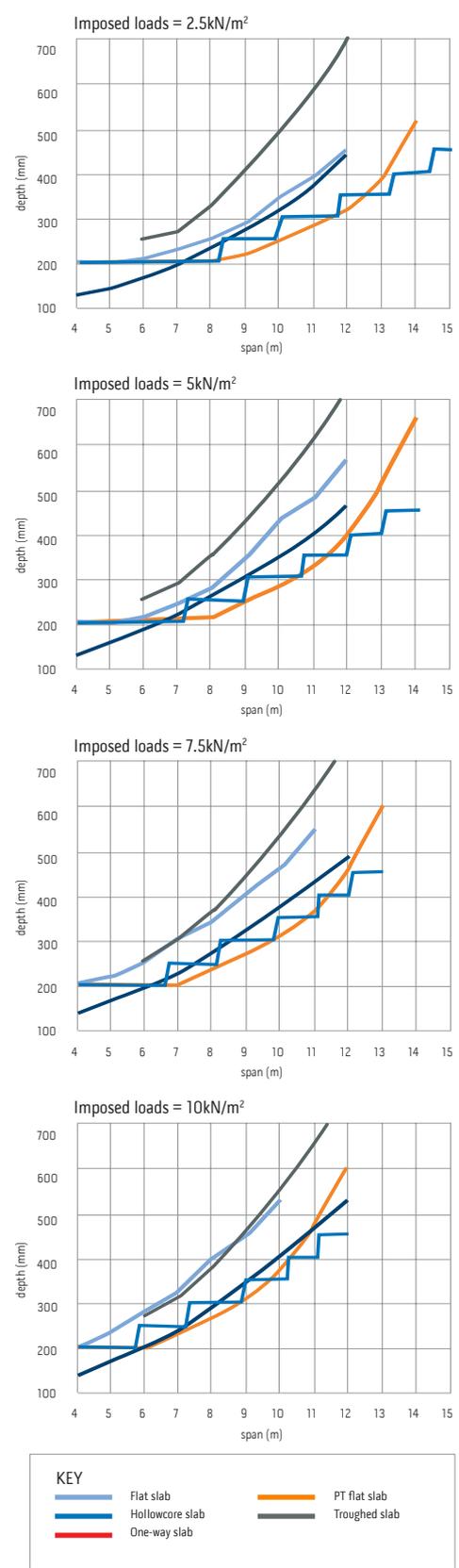


TYPICAL DEPTHS

Figure 3 shows typical depths required for different spans for each slab form. The design has been taken from Eurocode 2 using a superimposed dead load of 1.5kN/m², and C30/37 strength class concrete. The graphs assume that multiple square bays are considered, with the exception of the hollowcore slab, which is assumed to be a single span.

The graphs in figure 4 show the typical range of depths for different types of floor construction. It covers imposed loads of between 2.5 and 10kN/m². Typically residential uses would require 2.5kN/m²; offices, hospitals and schools 5kN/m²; plant rooms 7.5kN/m²; and libraries and exhibition spaces could be as high as 10kN/m².

FIGURE 4: ECONOMIC SLAB DEPTHS FOR THE STRUCTURAL FORMS



LASTING IMPRESSION

NÍALL MCLAUGHLIN

FRANK LLOYD WRIGHT AND THE RAIDERS OF THE LOST ARK



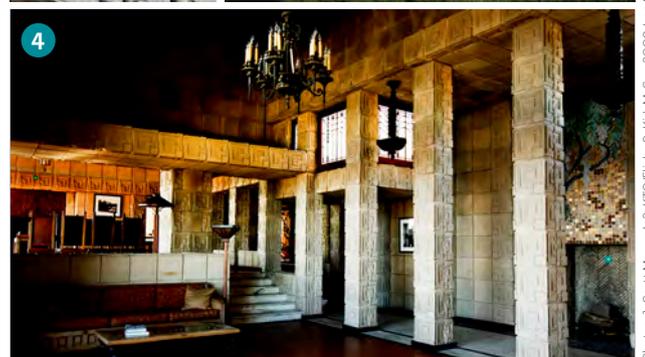
I'm mainly interested in precast concrete at the moment, so the buildings I'd like to talk about are the suite of 1920s houses by Frank Lloyd Wright in California: La Miniatura **1** in Pasadena (1923), the John Storer House in Hollywood (1924), the Samuel Freeman house **2** and the Ennis House **3** **4** in Los Angeles (1924), which relate to the tessellated use of complex precast concrete blocks.

I'm always slightly suspicious of the *béton brut* school – there's a kind of a machismo about the way in which it is used and the almost impossibly exacting demands of pouring in-situ concrete. What I like about the Wright houses is that he takes what concrete is good at, being a cast and moulded product that allows for a degree of repetition. In other words, you can build complexity into the mould, do it once and then get a number of quite complex blocks – the relationship between the labour of making the mould and the complexity of the outcome is very satisfactory.

I also like the almost tapestry-like way in which when a pattern is moulded and repeated in certain ways, building up a kind of layered warp and weft. It seems to speak to a moment when Americans were interested in Mesoamerica and an almost Inca primitive quality. Wright's houses have a pagan, arcane quality – it's like something out of *Raiders of the Lost Ark*.

Our Tapestry Building at King's Cross probably owes something to projects like the Storer house and the Ennis house, but the technique is quite different. We're working with highly sophisticated organisations that are factory-making products to exacting standards and installing them using very advanced forms of construction. I've a feeling that the houses that Wright built in California are almost the opposite. It's a much more vernacular and primitive use of the technology, a build up of blocks which you could probably cast and lift by hand.

Níall McLaughlin is founder of Níall McLaughlin Architects



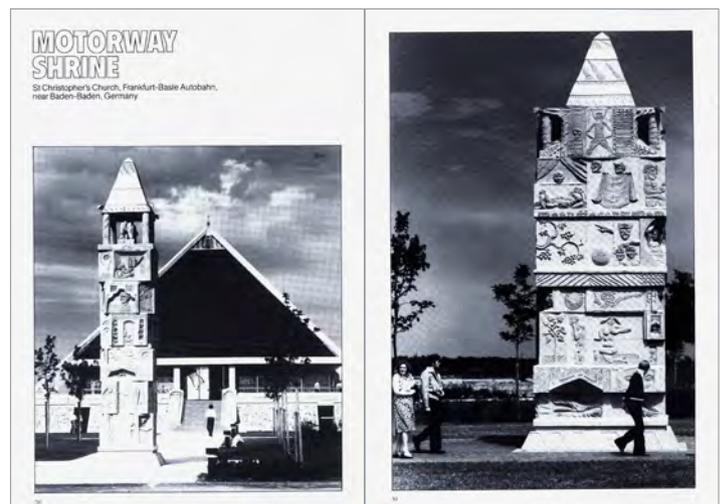
Photos: 1. Scott Mayoral; 2. KTD/Flickr; 3. Kirk McCoy; 2009, Los Angeles Times; 4. Liz O. Bayler; 2010, Los Angeles Times. Reprinted with permission

FROM THE ARCHIVE: SPRING 1980

HIGHWAY TO HEAVEN

On the Autobahn that links Frankfurt and Basel lies one of the world's more unusual places to take a motorway break. Just outside Baden-Baden, drivers can pull into Friedrich Zwingmann's St Christopher's church, a pyramidal temple surrounded by four ornately decorated concrete obelisks. They may not be able to get a pre-packed sandwich and a coffee, but they can at least pause and admire one of Europe's more virtuosic displays of cast-concrete sculpture. CQ was clearly impressed, declaring the church "the most elaborately ornamented concrete building yet to have appeared in this journal". The reliefs were unlike anything seen in European church architecture, but were instead reminiscent of pre-Columbian architecture in Mexico: "Some of the motifs bring to mind those on the ancient Temple of Quetzalcoatl dating back from about 200AD." What distinguished the church from other examples of concrete murals was that here they formed an integral part of the structure, which meant sculptor Professor Emil Wachter had to be constantly on site during construction. The concrete surfaces were cast against expanded polystyrene carved into "strong, vigorous motifs" depicting biblical scenes. The result, our correspondent felt was "a synthesis of art and architecture seldom seen today".

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FINAL FRAME: SEASHORE LIBRARY, CHINA

Vector Architects' in-situ concrete Seashore Library sits on a white-sand beach in Nandaihe facing out towards the East China Sea. The concrete, both internal and external, is marked with the grain of the timber formwork – a reference to the impressions left on the sand by wind and footprints. The two-storey building contains a meditation space, activity room and bar, but the centrepiece is a reading room with a fully glazed facade that opens onto the sea.

