

# CONCRETE QUARTERLY

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#### WHAT'S IN THE BOX?

A windowless white atrium intrigues art lovers at a southern French gallery

#### STILL SWINGING

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Catch up with the latest issues of Concrete Quarterly – as well as our archive stretching back to 1947 – at [www.concretecentre.com/cq](http://www.concretecentre.com/cq)



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

## Buildings are not coke cans

**As we gear up for Ecobuild, I can't help wondering where the next game-changing idea will come from, with sustainability now such a confirmed part of the mainstream.** A burning issue being discussed in Europe is the "circular economy", the ideal of a world in which everything is recycled and nothing is wasted. For construction, this would be a seismic change.

While a shift in focus to whole-life impacts is welcome, the danger is that policy-makers will focus only on waste and recycling, and fail to see the bigger picture. The creation, destruction and ownership of buildings has very little in common with that of cars, washing machines or coke cans. Their composition is more complex and, crucially, their life is much longer. Simply designing a building to be recyclable is to ignore, and thus squander, the sheer amount of energy and investment that goes into it, whatever materials are used. It also ignores the snail's pace of replacement, particularly for housing, and the emotional attachment that we form to buildings – we want them to last.

We ought to encourage the design of buildings to last longer, and be more adaptable. After 120 years, a building may be standing in a completely different context though its structure is perfectly sound. There is a growing recognition that reuse can be a more sustainable option in all senses – environmental, economic and social. I'd like to see some of that thinking inform the industry's next big step-change.

THE ARGUMENT ALSO IGNORES THE SNAIL'S PACE OF REPLACEMENT, PARTICULARLY FOR HOUSING

## LOOKS LIKE WE'RE IN FOR STORMY WEATHER

**"We are in the eye of a perfect storm," says This is Concrete blogger Guy Thompson, posting on resilience to climate change.** "Our building solutions must reduce energy and use carbon, but we need to fight a parallel war against more immediate effects such as flooding and drought, as well as longer-term impacts such as overheating." The direction of government policy across Europe is making this harder, warns Thompson, as economic concerns are prioritised over social and environmental ones. "This is understandable during times of economic crisis but can be dangerous in the long term. Failing to reduce emissions may cost us dearly later on. A genuinely efficient approach would see us building more with less as well as more for less."

**Join the debate at [www.thisisconcrete.co.uk](http://www.thisisconcrete.co.uk)**



**On the cover:**  
Collection Lambert in Avignon, France. Photo by Laurent Berger  
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Wordmule  
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[www.mineralproducts.org](http://www.mineralproducts.org)



**Precast precision at the Crick**

The Francis Crick Institute, Europe's biggest biomedical research centre, is nearing completion in London. Detailed forensic analysis was needed to ensure the precast reinforced-concrete frame achieved the laboratories' very stringent vibration limits.

**¡Felicitaciones!**

The 2016 Pritzker Prize has been awarded to Alejandro Aravena. The Chilean architect is known for dramatic concrete structures such as the UC Innovation Center in Santiago.



Photos: Francis Crick Institute; Nicolas Saiegh; Studio Gang Architects

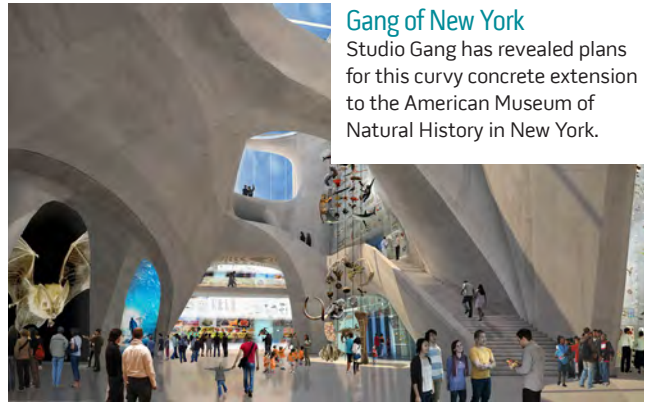


**New bamboo**

A professor at the Swiss Federal Institute of Technology Zurich claims a newly developed material made of bamboo fibres could replace steel in concrete reinforcement. Dr Dirk Hebel says the product can be formed into rods, is highly sustainable and loses nothing in performance.

**Gang of New York**

Studio Gang has revealed plans for this curvy concrete extension to the American Museum of Natural History in New York.



Photos: Simon Kennedy, Hélène Birnet

**CONCRETE ELEGANCE**

January's event at the Building Centre in London celebrated the beauty of concrete domestic interiors. Featured projects included Ingersoll Road in Shepherd's Bush by McLaren Excell (CQ 254), the Concrete House in Mile End by Studio Gil (left) and Covert House in Clapham by DSDHA (right, CQ 251). The projects explore the aesthetic potential of in-situ concrete – not only on walls and soffits, but also for bespoke furniture. **For details of future events, go to [www.concretecentre.com/events](http://www.concretecentre.com/events)**



# GRANDCHILD OF THE REVOLUTION

Essex was the apotheosis of the 1960s university campus. So how would Patel Taylor add a student centre fit for the 21st century? By being both sensitive and a little bit brutalist, finds Tony Whitehead





**The University of Essex was built in the late 1960s, and, wandering its paths and pavements today, it is easy to feel the radical optimism of that time.** Architecturally, it is one of the best of the concrete campuses. Its bold buildings are unashamedly brutalist but tempered by the Utopian vision of its original designers, the Architects Cooperative Partnership. A placid lake graces the centre of the campus' multi-level layout, and its towers and courtyards overlook each other a little like those of an Italian hillside town.

It is a legacy that has been enthusiastically embraced by architect Patel Taylor, designer of Essex's new £26m Silberrad student centre. "The wonderful thing about the Essex campus is that it gives us the opportunity to use in-situ brutalist concrete as a sensitive contextual material," says project architect Roger Meyer. "Back in the 60s, the university deliberately chose concrete to differentiate itself from the older, more traditional universities of stone and brick. We follow on from that, giving us the chance to express the forms of the building in a really pure way with structure and external expression as one."

The three-storey Silberrad centre (named after a university benefactor) houses accommodation for a range of student services and also staff offices for the university council. It is situated next to the lake, which was extensively surveyed before work commenced. New sheet piling backfilled with earth now holds the lake some 10m back from its original edge. This allowed the plinth for the new building to be cast behind it on top of a series of continuous flight auger (CFA) concrete piles, topped with pile caps and ground beams.

From across the lake, students have a fine view of the new building, the dominant features of which are the three long concrete slabs that form the ceilings of the ground, first and second floors. All are cantilevered to some degree, projecting from the external walls of the building.

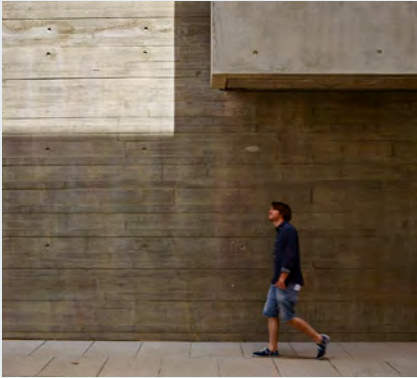
"The structure is read as a series of slabs with stone piers in between," says Meyer. "The external wall is set in, and where the most prominent slab comes out at second floor level it is supported by slender concrete columns, forming a sort of external room and a new entrance to the university's reception."

Because the slabs are cantilevered – up to 3.9m at the second floor – care had to be taken to avoid "droop", he adds. "The engineers did a great job pre-cambering the cantilevers, so that as the concrete dried out and the building settled, the slab came down to that nice straight horizontal line."

For this to work, the cantilevered slab is cast pitched up, though the angle of the pitch has to be finely judged: "The concrete first depresses the formwork, then it might lift as formwork is taken off

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**THE ENGINEERS DID A GREAT JOB PRE-CAMBERING THE CANTILEVERS, SO THAT THE SLAB CAME DOWN TO THAT NICE STRAIGHT HORIZONTAL LINE**



## Finishing school

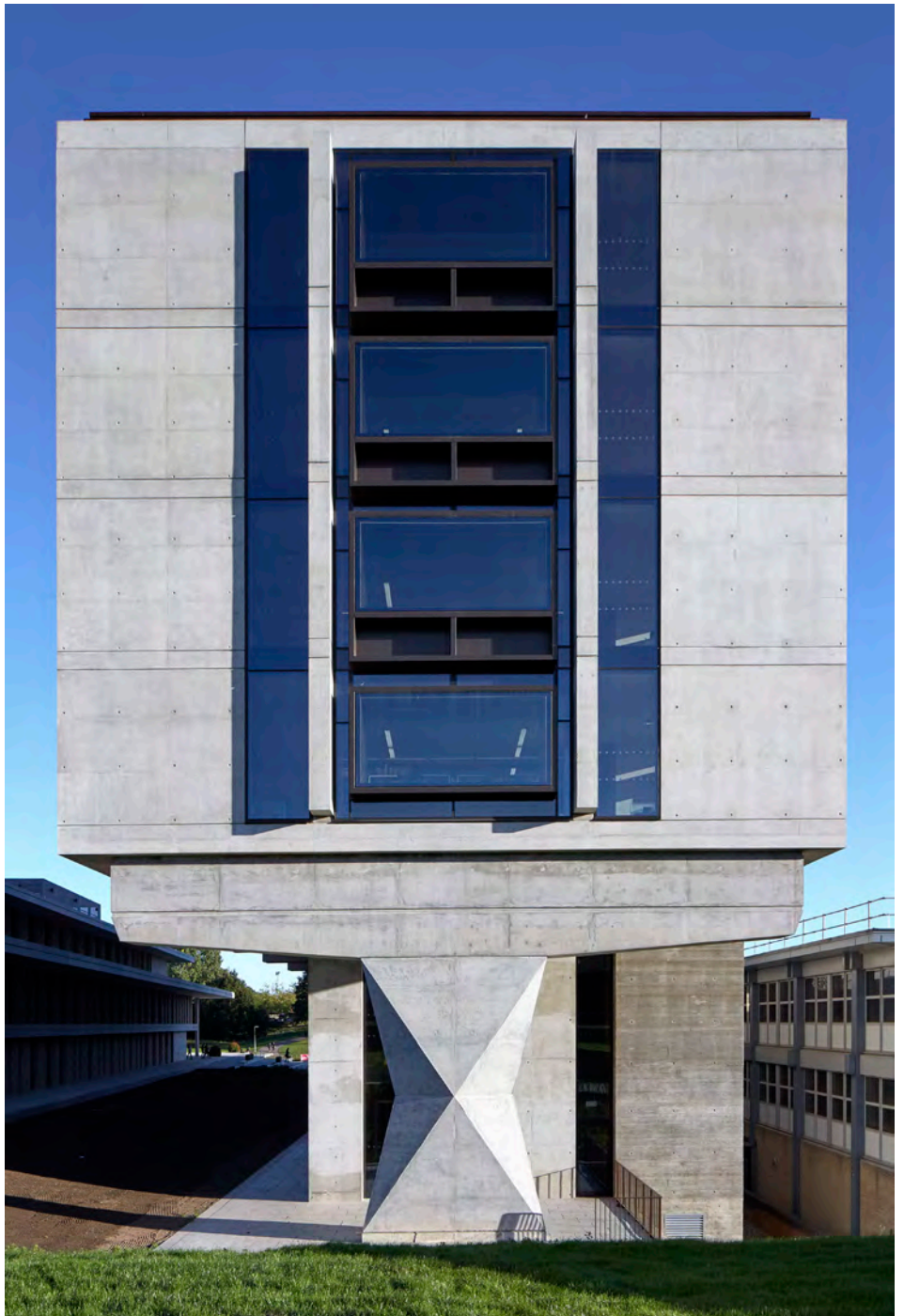
Achieving a consistently high-quality finish throughout the Silberrad centre presented a particular challenge for the construction team. Contractor Kier and concrete contractor MJ Gallagher, developed a detailed strategy to ensure the design aspirations were met.

"We were taken to various buildings where visual concrete had been used successfully," says Kier's project manager Mark Turner. "Different projects for walls, soffits and columns. Our job was to match those standards for every element."

The mix, designed by structural engineer Techniker in conjunction with concrete consultant David Bennett, was predominantly C35-45 with 60% GGBS added – both to reduce embodied carbon emissions and also to produce the required pale finish. "But as much as you might have the perfect mix on paper you have to actually put that together using locally available aggregate and sand," says Turner. "We spent a good number of weeks meeting with the batcher at the plant, trying sample mixes, doing sample pours and making small changes to mix design."

One issue was that the concrete tended to perform slightly differently in slabs, walls and columns, partly because of the different forms used for each element. "For example, the board-marked walls around the cores [above] were made traditionally, but we found that the longer striking times associated with GGBS meant that in winter especially we were having issues with delamination. The boards were sticking and pulling the face off the concrete." The solution was to increase the proportion of ordinary Portland cement for the board-marked elements.

Elsewhere the formwork comprised paper-lined Wisaform boards, and their smooth finish is most evident on the exposed soffits. Board positions were detailed by the architect to ensure a regular pattern throughout. This involved close integration between the concrete-placing team and the formwork contractor, adds Turner. "It's important that the same teams work on the project throughout. They've done the samples, know how to pour it, how long to vibrate it. With a job like this, you can't just have anyone turn up."



and then settle as it cures more fully," says Meyer. "That's where the art of the engineer comes in."

In addition to the pre-cambering, the slabs were thickened for the cantilevered section. "Internally the slabs are typically 275mm thick, but externally this is increased to 350mm," he says. Reinforcement was also dense in these areas, with bar at 100mm centres.

To prevent cold-bridging, the slabs are thermally broken at the building envelope, and they are edged with a 200mm upstand or parapet to give a more substantial feel. The top

slab forming the roof of the Silberrad centre is planted with grass and shrubs, helping to make it attractive for those looking down from the higher levels of the campus.

Inside, the central columns are arranged on an 8m x 3m grid over 400mm-diameter circular concrete columns, with small perimeter wall columns at 3m centres. "It's a simple layout which allows for flexibility in the future," says Meyer, explaining that the whole-life performance of the building was very much in mind during the design process. "Even while we were designing, the

requirements changed slightly. So the standardised grid makes it easy to use temporary partitions. The heating and ventilation system operates through a raised floor and is designed so that the ducts and vents can be moved relatively easily – for example, to accommodate different furniture layouts if the use of the spaces changes in the future.”

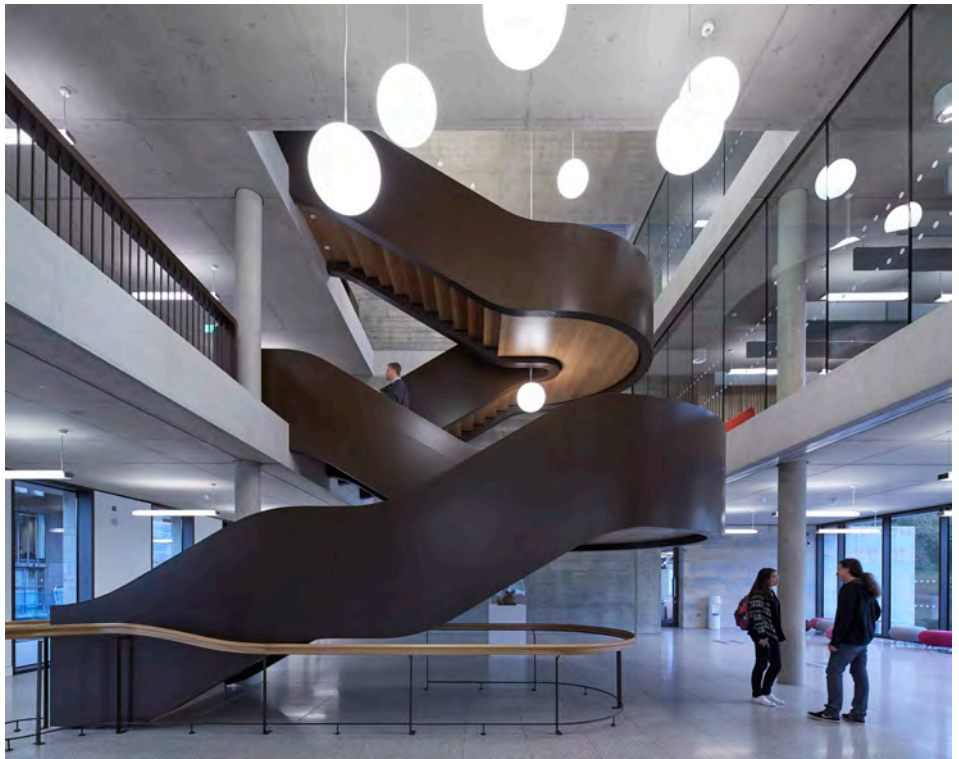
The two concrete cores are set at the third points of the building and feature a traditional board-marked finish. Careful coordination has ensured that, though the pattern is random, the horizontal line of the boards remains matched and level, and that bolt holes are centrally located in each board.

“The result of using the boards is a rougher texture,” says Meyer. “The main design feature of the interior is a cantilevered steel and oak staircase which has a very smooth polished appearance – so the board-marked walls form a contrasting backdrop.”

They also contrast with the circular columns which, like the external columns supporting the entrance canopy, were formed using a disposable tube system to produce a seamless smooth finish.

More smooth concrete forms the exposed soffits, where the pattern of the 8ft x 4ft Wisaform boards is clearly visible. “Using concrete in this way, you have to draw and detail everything or the pattern won’t look good,” says Meyer. “We also wanted to avoid having services tracking on the outside of the concrete, so conduits – for the lighting, for example – were cast in. Again it means you have to go into a lot of detail in the services quite early in the project.”

The mix for the project was developed after discussions with The Concrete Centre and



**OPPOSITE** The north elevation of the library extension is supported on a two-storey facted concrete column

**ABOVE** A cantilevered staircase in steel and oak contrasts with the exposed-concrete walls, floors and soffit

consultant David Bennett (see box, opposite). “The concrete includes quite a bit of GGBS to achieve the pale shade of concrete we wanted,” says Meyer. “In addition, the contractor experimented quite a bit with the mix to ensure it would work with local supplies and perform during the colder months.”

Because the soffits are exposed, the thermal mass of the concrete slabs helps to minimise heating and cooling requirements. “The slabs absorb heat during the day and pay it back at night,” Meyer adds. “The slab helps in another way too, since the cantilevers outside the envelope provide shade and cut down on solar gain.” The structure has made a significant contribution to the environmental performance of the building which is currently rated BREEAM Very Good.

Essex is not the only campus where a bold approach to concrete architecture is being revisited. New developments at Lancaster and Loughborough, for example, have also embraced the confident mood of 1960s academia. But, if anything, today’s concrete designs are even more forward-looking than their groundbreaking predecessors. Energy-efficient, and with the flexibility to cope with changing future requirements, they are more subtle, more sustainable, and more user-friendly than those they now complement.

#### PROJECT TEAM

**Architect** Patel Taylor  
**Structural engineer** Techniker  
**Contractor** Kier  
**Concrete contractor** MJ Gallagher  
**Concrete consultant** David Bennett  
**Landscape precast** Sterling Services



## The big read

In addition to the new student centre, the construction team also extended a library next to the site. The extension makes deliberate architectural references to the existing concrete building, picking up on the dominant structure of two-storey columns with four storeys of

accommodation cantilevered above. The new wing connects to the existing library across the 1963 concrete core, using breakout panels designed into the original building.

The concrete finishes in the library, including the exposed smooth soffits and board-marked walls, are identical to those in the Silberrad centre. However, the aesthetic is softened by oak lining to various concrete elements (see left) and this also helps to produce an appropriately soft acoustic for the library spaces.

Of particular interest is the single large external column on the north elevation, which rises two storeys to support the four cantilevered floors above it. This feature has angled facets, a little like a cut diamond, and the issue of how to construct an appropriate form exercised the ingenuity of both contractor and concrete specialist.

“It was quite a challenge and MJ Gallagher did consider opting for a metal form manufactured off site,” says Kier project manager Mark Turner. “But in the end it was made from standard shuttering and formwork. It took a while, and trial models were made to ensure all the angles were correct, the joints would work and we would get the required finish. It’s just a very cleverly detailed mould, and it worked.”



# BLANC CANVAS

A neoclassical gallery in the south of France is reborn with a series of luminous white-concrete spaces, writes Pamela Buxton

**A spectacular, all-concrete atrium is one of the key elements of a €12m extension of Collection Lambert, a gallery founded by art collector Yvon Lambert in Avignon, France.** Paris practice Berger & Berger won the prestigious commission in 2012 and completed construction of the gallery in just 18 months. This challenging project doubled gallery accommodation to 6,000m<sup>2</sup> by sensitively reworking the collection's 18th-century Hôtel de Caumont home and extending it to include the neighbouring mansion of Hôtel Montfaucon.

The works involved four structures to link the two buildings and improve displays and circulation. All these interventions are of concrete and were mainly prefabricated for reasons of economy, speed, technical efficiency and durability. The most spectacular feature is the 8.2m-high atrium, which reveals its material nature in its interior finish. As well as being a stunning visual space, the atrium plays a vital role in the circulation around the enlarged gallery. Architect Laurent Berger describes

it as a "knee" joint, pivoting to link the Hôtels de Caumont and Montfaucon from basement up to first-floor level. As such, all visitors pass through the space as they pass from the entrance towards the Montfaucon area of the gallery.

"It's visually important. Although it isn't the entrance, it creates an identity for the buildings as the space where every public visitor goes through," says Berger. The architects also had greater material freedom in the atrium compared with the galleries, he adds, where they needed to consider the walls' function as a display backdrop. "As we were free of the constraints of the presentation spaces we were able to be very, very simple with the goal of showing the structure of the building itself," he explains. "For the visible parts of the atrium from the inside we were looking for an effect of massiveness with the prefabricated panels."

In addition to its structural role, the concrete's

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**FOR THE INSIDE OF THE ATRIUM WE WERE LOOKING FOR AN EFFECT OF MASSIVENESS WITH THE PREFABRICATED PANELS**



white finish is part of the deliberate use of white throughout to amplify and reflect the light within a neutral setting. "The whole building is variations of white made by variations of materials in each room," says Berger. "We were aiming to have a vibrating white building."

The concrete atrium is arranged symmetrically between the two buildings it links, with its windowless, exterior walls protruding into a point.





**ABOVE LEFT** A white concrete staircase winds up through the atrium

**ABOVE** The atrium is crowned by a 3.85m-diameter oculus

**ABOVE RIGHT** The atrium links two neoclassical buildings



Photos: Laurent Berger

It was constructed using prefabricated concrete panels measuring 1.5m x 9m, and 25cm thick. Each weighs two tonnes and was craned into place with tolerances of just 1cm – one of the biggest challenges of the construction. The panels were then attached to each other with metal fixings.

Internally, the white concrete panels are given a distinctive appearance due to the inclusion of Carrera marble pieces, ranging from 1cm to 5cm in width and inserted into the moulds by hand before the concrete was poured. Each wall panel was then polished, with the marble pieces appearing slightly transparent in contrast to the brighter and whiter concrete. The terrazzo floor has the same marble aggregate inserts.

A concrete staircase leads up through the top-lit atrium, which terminates in a 3.85m-diameter oculus. This is set into a concrete ceiling formed in four decreasing circles edged in neon lights. The ceiling was cast on site using 39 formwork panels of many different sizes and shapes.

The other main in-situ concrete challenge was the staircase and atrium bridge, which took three months to cast and required an enormous formwork. The architects specified the same whiteness of concrete but with a rawer finish, without the marble insets or polish to offset the polished walls and floor: “We decided to make it more roughly finished so that there is a subtle contrast with the walls and the terrazzo floors.”

Externally, the gallery’s visible walls are clad in Estremoz Portuguese marble cut from a single sheet, with a concealed opening mechanism allowing large artworks to be admitted into the gallery directly from Boulevard Raspail. The abstract effect of the blank external walls achieves the desired contrast with the facades

of the two original buildings.

The second new concrete building houses a bookshop and office and sits between the two historic courtyards on the site of a 1970s extension. The third houses a grand exhibition room on the ground floor of the Rue Violette, known as the “high ceiling room” which completes the enclosure of the Montfaucon courtyard. This creates 5.8m of wall space, enabling it to house some of the largest pieces in the collection, hung via horizontal steel rails set into the prefabricated concrete structure behind the plasterboard-lined gallery walls. Its ceiling is deeply coffered to admit and reflect the degree of light necessary for display without allowing it to directly reach the walls or floors.

On the Rue Violette elevation where the upper 3.5m of the walls rise above the historic wall, they were cast in situ. This is the only time that the new concrete is visible externally. On the courtyard elevation, they are again clad in Estremoz marble.

Another major element of the project was the creation of a 400m<sup>2</sup>, L-shaped gallery running around two sides of the Montfaucon courtyard on the first floor. Here, the architects inserted a concrete portico to support the roof and walls, enabling the removal of internal supporting walls in order to create the larger exhibition space.

The extended gallery opened in July 2015. As well as linking the two buildings, the redesign means that the Lambert can now, for the first time, exhibit its entire collection in one location.

#### PROJECT TEAM

**Architect** Berger & Berger

**Structural engineer** Bollinger + Grohmann

**Quantity surveyor** VPEAS

**Contractor** Léon Grosse



Photos: David Millington

# BOXING CLEVER

Levitt Bernstein's precast-concrete grid solution for a Manchester primary school ensured both elegance and a speedy build. By Andy Pearson

**The timescale for designing and constructing the new junior facility for Withington Girls' School was challenging.** To ensure it opened in time for the 2015 school year, the building had to be completed within 18 months of the project team's appointment. This meant that architect Levitt Bernstein had only months in which to develop a design for the two-storey building, which was to be constructed in the grounds of the existing school. "We wanted to get the contractor on site in August 2014, during the summer holiday, to enable the separation between the construction site and school to be established before the pupils returned," says project architect Gillian Harrison.

Levitt Bernstein chose an established precast-concrete system. This used precast-concrete

panels, manufactured to bespoke dimensions and delivered to site ready to be craned into position. "This met the need for speed, both in enabling the scheme to be designed quickly and allowing it to be built quickly," says Harrison.

The structure consists of three concrete fin walls, each made up of six panels: three at ground floor mounted on an in-situ concrete slab; and three at first floor supported off the junction of the wall below and first-floor concrete floor planks. Precast planks also make up the structure for the green roof. The cross-walls are spaced evenly between two brick-clad precast-concrete flanking walls.

The facade of each room is further subdivided into three bays by two vertical precast-concrete columns. The bays contain a section of curtain walling, one of brickwork, a window and a precast-concrete louvre covering the ventilation intake. The only exception is the school hall, which has large glazed sliding doors that open up to the grounds. "The school lent itself to a rectilinear solution because it is made up of classrooms of identical

size," says Harrison. "The volumes are articulated in the facade so that it reads as a series of boxes".

A central corridor splits the accommodation, with six classrooms and an IT suite on the first floor, and a double-height entrance, two further classrooms, an office, storage rooms, a changing area and the hall at ground level – the latter two each spanning two bays. To avoid any columns in the hall, the fin wall separating the two classrooms above is used as a deep beam, with the concrete floor planks hung from the base of the wall.

The brick-clad external flanking walls are also part of the precast solution. To speed construction, courses of half-brick were placed into a mould before concrete and insulation were added to form a brick-finished, insulated sandwich panel. Once the foundations were in place, the structure was completed within weeks, enabling the finishing trades to start on site protected from the weather.

That the building opened on time vindicated the architect's concept of accentuating the geometric repetition of a precast-concrete frame. "The solution was selected for its time-saving benefits, but in addition it provides most of the finished wall and ceiling surfaces, exposed thermal mass to help moderate the internal environment and, in some areas, acoustic and fire separation between rooms," says Harrison. "It is ticking all the boxes."



## CLOCKWISE FROM LEFT

The structure is based on three double-height precast-concrete cross-walls; The brick cladding was added to the precast-concrete panels in the factory; The school hall is the only space to span two boxes

## PROJECT TEAM

**Architect** Levitt Bernstein  
**Structural engineer** Civic Engineers  
**Main contractor** Seddon Construction  
**Precast concrete contractor** Buchan Concrete Products



Photos: Harunori Noda



have only been made possible by BIM. The architects started by interviewing professors to establish the ideal height and size of each room. This wealth of programmatic data was fed into the model, along with daylighting and natural ventilation requirements, resulting in a series of different-shaped volumes that burst dramatically from the building's facade. These rooms are arranged in an irregular network of street-like corridors, all of varying, digitally calculated widths and some open to the elements.

The open nature of the reception space reveals this complex spatial planning immediately on entering the building. Deep concrete beams bear down from the soffit like an inverted maze, following the layout of the floor above. Reinforced-concrete pilotis are placed at the points where this grid intersects with the larger spaces in the basement – the two grids actually bear no relation to one another.

One thing that does unite all three floors is the use of exposed concrete. Concrete is an obvious choice for a music school because of its sound insulation qualities, but here it is also used in a palette with timber and glass to diffuse and reflect sound differently in different spaces. Yamanashi says that leaving the concrete exposed is therefore not only a physical expression of the structure, but also of the sound.

The mix specified used a limestone aggregate, which is rare in Japan. Equally rare was the architects' relaxed attitude to blemishes. "In Japan, concrete is faked on a routine basis at a high cost by covering colour unevenness – like repairing a painting." In this building, however, such variations in finish were embraced. "It has given a gentleness, softness and warmth, similar to mud plaster walls." It's a welcome natural touch in a building that could only have been designed in the digital age.

#### PROJECT TEAM

**Architect and structural engineer** Nikken Sekkei  
**Contractor** Shimizu Corporation

# WALLS OF SOUND

A Tokyo music school has been named the best new educational building in the world. Nick Jones finds out why

**Rarely has form followed function in a building quite so closely.** At the Toho Gakuen School of Music in Tokyo, each room has been precisely shaped to its purpose, the proportions tailored to a specific instrument or ensemble. The result is an ingeniously orchestrated layout and a truly dynamic building. It clearly impressed the judges at last year's World Architecture Festival, who named it the best new educational building on the planet.

Toho Gakuen is one of the most famous music schools in Japan, but its existing facilities were little more than a procession of small rooms located along a gloomy corridor – a space that felt more like a prison than a conservatoire, according to Tomohiko Yamanashi, project architect at Nikken Sekkei. The aim was to instil a sense of freedom, while making sure that the sounds stayed locked in. To that end, the architects arranged the new building on three storeys: the ensemble rooms (the loudest spaces) are self-contained in a basement, there's an airy, open campus on the ground floor, and a complex web of lesson rooms above.

The bespoke acoustic spaces on the first floor

#### CLOCKWISE FROM TOP LEFT

Irregular-shaped lesson rooms project from each elevation; A courtyard draws daylight into the heart of the building; The first-floor layout is revealed in the ground-floor soffit



# PLAYING THE LONG GAME

Assessing lifecycle CO<sub>2</sub> is set to become easier with the development of new tools for designers and specifiers, writes Tom De Saulles

For concrete buildings, the broad whole-life carbon dioxide (CO<sub>2</sub>) merits can be quite compelling, but at present, the challenge remains one of validating these in a quantifiable way. From 2016, the syllabus for GCSE Chemistry in schools will cover the lifecycle assessment (LCA) of materials and products – a significant step, highlighting how mainstream this technique for assessing environmental performance has become since its origins back in the 1960s. Fifty years on, LCA is the tool being used to produce Environmental Product Declarations (EPDs) for construction materials and products, offering robust environmental information based on a common set of rules.

EPDs offer a useful means for comparing material options, allowing those with favourable attributes, particularly in whole-life terms, to be identified from the outset. This is not the whole story though, as there is also a need to consider how materials measure up in terms of their contribution to overall building performance – that is, their interaction with other aspects of the design. This presents a significantly more challenging task, particularly given the complexity and variety of lifecycle scenarios that could ultimately play out.

The good news is that these issues should become more soluble as new design tools are developed in response to BS EN 15978 for assessing the environmental performance of buildings. Developed by the same European technical committee behind EPDs, this standard came out in 2011 and is likely to become the dominant calculation method used by the construction industry, bringing together all the elements of whole-life assessment into a single methodology. Among other

attributes, this will enable any synergies or trade-offs between embodied and operational impacts to be rapidly assessed for a variety of design solutions and lifecycle scenarios.

## New guidance

Unsurprisingly, such a holistic approach is not without its headaches, as it must combine the complexities of all the various building design disciplines into a single, interactive assessment tool, which is why the industry is not quite there yet. But there are some encouraging signs, with Sturgis Carbon Profiling for example, aiming to deliver a UK-wide implementation plan for delivering whole-life carbon reductions in accordance with BS EN 15978 by mid-2017.

For concrete buildings, the broad LCA benefits that such tools are likely to highlight will not come as too much of a surprise, as the inherent durability and operational merits are already accepted design doctrine for many. To help quantify these benefits, and highlight other less obvious lifecycle benefits, The Concrete Centre has published a new guide, focusing specifically on the CO<sub>2</sub> performance of concrete buildings and their whole-life footprint.

The guide helps to bridge the current information gap in terms of what we broadly know now and what forthcoming LCA tools will be able to validate more accurately at a project-specific level in the future. The guide sets out the various ways that concrete can directly or indirectly be employed to reduce CO<sub>2</sub> emissions at each stage in a



Photos: Tim Crocker

**ABOVE** Elizabeth II Court's refurbishment by Bennetts Associates introduced an external courtyard on the site of a former car park (see below right). In keeping with modern needs, 250 parking spaces were cleared, and ample cycle parking has been provided

building's lifecycle, showing the indicative savings that can be achieved.

The opportunities described fall into five areas:

- 1. Lean design** Multitasking with concrete to allow other materials to be designed out or minimised
- 2. Operational energy** Using concrete's thermal mass to reduce energy use
- 3. Maintenance** Using concrete's resilience to minimise the need for maintenance and repairs
- 4. Reuse** Reducing the impact of new-build through the ability to reuse and adapt concrete buildings
- 5. End-of-life** The absorption of CO<sub>2</sub> into concrete by carbonation at end-of-life and following recycling.

### The lean approach

"Lean design" in the context of this guide centres on the potential to design out finishes such as suspended ceilings and floor finishes through the use of visual concrete – for example, exposed soffits, polished concrete floors or fair-faced walls. Research undertaken by the Waste and Resources Action Plan (WRAP) shows that avoiding the need for suspended ceilings can save around 10kgCO<sub>2</sub>/m<sup>2</sup>, with a higher figure of around 20kgCO<sub>2</sub>/m<sup>2</sup>

for avoiding floor finishes. These figures do not include ongoing maintenance and replacement impacts that would also have been avoided.

Alongside these savings is a potential reduction in operational CO<sub>2</sub>, which a visual concrete finish can deliver through exposing thermal mass contained in the structure. This helps to regulate the internal temperature, reducing the need for mechanical cooling and associated plant. Over time, a sizable CO<sub>2</sub> saving can result which, in the case of an exposed soffit, may be sufficient to offset the embodied CO<sub>2</sub> in the floor slab several times during the life of the building.

### Refurbishment and reuse

Refurbishment, in preference to new-build, is an increasingly pragmatic option and arguably the principal means for optimising whole-life performance. The CO<sub>2</sub> savings that can be realised from extended a building's life are of course largely project-specific, but essentially equate to that of a new concrete frame – that is, the avoided element in a reused building. Based on a range of published studies, the initial embodied CO<sub>2</sub> figure for the superstructure of an office is generally around 200-250kgCO<sub>2</sub>/m<sup>2</sup> and, as a point of interest, is applicable to both concrete- and steel-frame buildings, both of which have a similar CO<sub>2</sub> footprint. This figure provides an indication of the embodied CO<sub>2</sub> savings that can be achieved. For other building types the figure may vary slightly – for example, hospitals and schools are likely to

## ▲ Elizabeth II Court

Winchester, Bennetts Associates, 2009

Hampshire County Council's headquarters is a good example of how a client's need for increased space and improved energy efficiency can be fulfilled through reuse – here saving around half the embodied CO<sub>2</sub> and cost associated with new-build. The 1960s concrete-frame structure was retained and adapted to meet modern needs, which included a significant upgrade to the fabric performance, resulting in a reduction in annual emissions from 100kgCO<sub>2</sub>/m<sup>2</sup> to 35kgCO<sub>2</sub>/m<sup>2</sup>. Year-round comfort was also improved, helped by passive design measures that centre on the use of exposed soffits and natural ventilation.



## THE DEMOLITION AND CRUSHING OF CONCRETE RESULTS IN A SURPRISING AMOUNT OF CO<sub>2</sub> BEING ABSORBED INTO THE NEWLY FORMED CONCRETE AGGREGATE

be about 5% and 10% higher respectively.

A prerequisite for reuse is the ongoing viability of the frame in terms of its layout, slab-to-slab height, floor loads, servicing etc. While less of an issue in high-rise housing, these considerations are especially relevant to commercial projects, particularly where a change of use is planned. It is fortuitous therefore that these are often broadly satisfied in concrete-frame buildings despite little or no consideration being given to future reuse in the original design. A likely explanation for this is that many existing buildings broadly conform to what is termed today as a “long life, loose fit” approach, which combines the use of durable materials with a format that is not tailored too tightly to the building’s original function.

Alongside this is the potential to upgrade concrete

structures cost-effectively, including the ability to extend and add floors. In terms of their remaining structural life, condition surveys of older concrete-frame buildings often provide a favourable outcome in terms of their ongoing viability and suitability for refurbishment, albeit subject to any minor repairs or localised strengthening that may be required.

### End-of-life

Moving finally to the end-of-life stage, it is a little known fact that the demolition and crushing of concrete results in a surprising amount of CO<sub>2</sub> being absorbed into the newly formed concrete aggregate due to carbonation. During the in-use phase of the building, this naturally occurring process is purposefully limited to the surface layer of concrete, preventing corrosion of any embedded steel reinforcement. When concrete is crushed, however, its surface area increases substantially, allowing CO<sub>2</sub> to be absorbed much more rapidly.

Although the deconstruction and demolition process can be comparatively brief, the resulting carbonation is an important consideration when evaluating the whole-life CO<sub>2</sub> performance of concrete buildings. To put it into context, end-of-life carbonation accounts on average for a useful 5% reduction in the cradle-to-gate embodied CO<sub>2</sub> of

structural concrete. Looking beyond the building lifecycle to the secondary life of recycled concrete, carbonation continues even when used in groundworks, leading to an ultimate reduction of around one-third of the original cradle-to-gate CO<sub>2</sub> value.

Although concrete’s whole-life virtues are quite significant, it is probably going to take the arrival of new, comprehensive LCA building design tools to put these firmly on the map. But it is encouraging that the design conversation has already shifted markedly towards whole-life CO<sub>2</sub> thinking and away from a cradle-to-gate approach. The development of LCA building design tools to BS EN 15978 will help bring all the pieces of the sustainability jigsaw together and should prove effective in cutting through sustainability rhetoric.

**For references to the figures provided here, and for further information, see Whole-Life CO<sub>2</sub> – Benefits and Opportunities of Concrete Buildings, published by The Concrete Centre**

**BELOW** The facade of Elizabeth II Court was updated to meet modern needs. The project was praised by the Carbon Trust as a flagship for what can be achieved through intelligent refurbishment rather than demolition and new-build



Photo: Tim Crocker

# MARKS OF DISTINCTION

The use of exposed concrete stands or falls on the quality of the finish – which is why it's essential to understand the effects created by different formwork facing materials

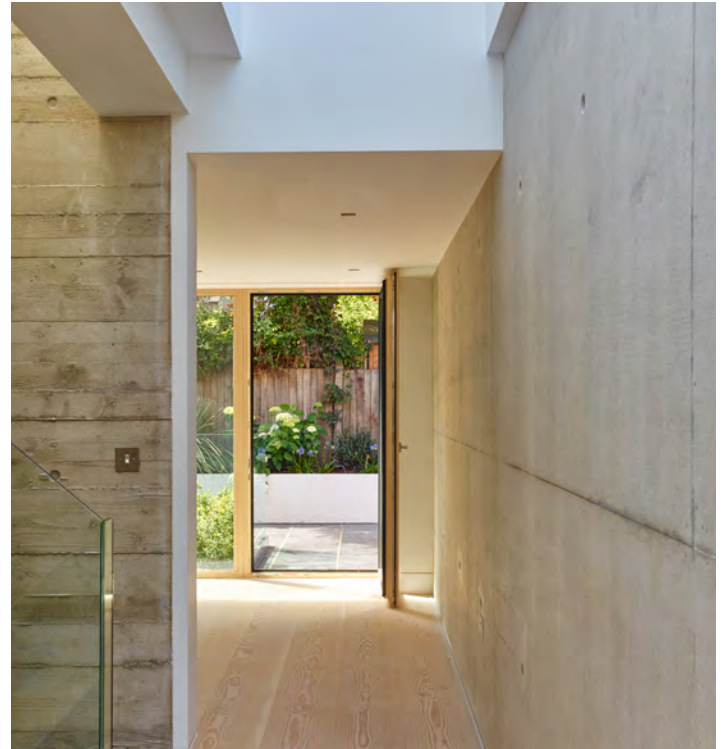
The selection of a formwork facing material is arguably the most significant decision when specifying exposed in-situ concrete. It is this inner surface that dictates the texture, surface and sometimes the tone of the as-struck concrete.

Formwork, or shuttering, has typically been constructed using load-bearing sections of timber, which led to a proliferation of board-marked concrete. Today it is more common to see smooth concrete in which the joint lines between plywood panels are expressed. Engineered timber boards manufactured especially for use as formwork come in a range of factory-applied surface treatments to extend their reuse capability and to smooth over the grain. Each type gives a different finish to the concrete. This may be the determining factor for selection, but other criteria should also be taken into account, such as reuse and cost. Guidance should be sought from specialist formwork and falsework suppliers.

As a general rule, materials that breathe or are permeable, such as timber, fabric or paper-faced ply, will produce a matt finish and are less prone to blow holes. Impermeable materials such as phenolic film-faced boards (PFF), steel, plastic and glass-fibre-reinforced plastic (GRP) produce

## ABOVE AND BELOW LEFT

Richard Dudzicki Associates' Eco Lodge in Chiswick, west London features both smooth and board-marked exposed concrete



Photos: Timothy Soar

concrete with a shiny surface and a greater likelihood of blow holes.

In theory, you can cast concrete against almost any material, so long as you can remove it afterwards. Form liners can be fixed to the formwork boards to impart their pattern and shape onto the face of the concrete. For example, elastomeric sheets or "rubber mats" such as polyurethane are flexible and can be peeled off the surface of the concrete, enabling deep profiles and patterns to be formed. An extensive range of different patterns and textures are available or can be made to order. Board-marked concrete can be created in this way or with real timber fixed to the inside of the formwork sheets.

The longer the concrete is in contact with the formwork facing, the more impact this will have on the tone or colour. For example, tannin from medium-density overlay (MDO) boards may impart a brown colour to a soffit if left for a long time. This highlights the importance of taking a holistic approach to design to create high-quality visual concrete. Considerations include strength-gain requirements and the concrete mix.

Great care and attention is required in the assembly and fixing of formwork facing for visual concrete, so that the desired tolerances and grout-tight joints are achieved. There must be rigorous selection of undamaged boards, which should be protected, as well as the correct selection of release agent. For a high-quality finish, the specification and workmanship of the formwork facing should be considered as carefully as if it were the final finish of the structure – because in effect it is.

## Facing facts

**Phenolic film facing (PFF)** is impervious due to its high resin content. The more resin, the more the plywood is protected and the greater the potential reuse. These film coatings create a very smooth, shiny surface to the concrete, and sometimes a slightly marbled pattern. They are often used for stair cores and slip form.

**Medium-density overlay (MDO)** boards have a film of paper impregnated with resin but with far lower saturation levels, allowing the formwork to breathe, giving a matt or satin sheen.

**High-density overlay (HDO)** leaves a shinier finish and can be reused more often than MDO.

**Unsealed plywood** leads to greater levels of water absorption producing a slightly darker toned, matt concrete surface, often with a timber grain pattern. It has a limited number of reuses and is prone to tannin release so not recommended for fine finishes. High-quality birch-faced ply can produce a good finish but should be sealed before use.

**Controlled permeability formwork (CPF)** is a polypropylene fabric system that produces a darker concrete. The surface has the fine texture of the fabric and potentially very few blow holes. **Steel** is commonly used for prefabricated forms such as columns, and can be used multiple times. When new, it produces a shiny, mottled appearance similar to PFF.

**Plastic lined circular cardboard forms** are often used to create a good, smooth and shiny finish on circular columns.



# CONCRETE POOL DESIGN

It's not enough to specify "waterproof" – a successful swimming pool structure is a lot more complicated than that, says Jenny Burridge

This feature highlights key aspects of the design and construction of swimming pool structures in reinforced concrete. This guidance is based on Eurocodes BS EN 1992-1-1 and BS EN 1992-3 and the corresponding UK National Annexes, but it is not exhaustive – further advice can be found in The Concrete Centre book on concrete basements and CIRIA publication C660 (see "Key references"), because basements and swimming pools have many aspects in common.

The required watertightness of the structure depends on the location of the pool, whether it is above any other habitable space and what that space is used for, and whether any supplementary waterproofing is used. Generally, if the pool is not above any habitable space, the watertightness of the concrete alone should be sufficient, provided the concrete has been specified correctly and the workmanship and detailing have been carried out

appropriately. If the pool is above a space that is used – changing rooms, for example – then it is prudent to add additional waterproofing measures, normally in the form of a waterproofing liner.

Here we assume that the structure of the pool should be watertight, but not necessarily waterproof. There is a subtle difference.

## Watertightness

Watertightness is a critical consideration in pool design. The structural engineer should discuss and agree watertightness requirements with the client. Imprecise phrases such as "waterproof" construction are best avoided. Instead, the engineer should agree the degree of leakage that can be tolerated using the classification of tightness classes shown in table 1 (left). Tightness class 1 is the most usual class for swimming pools and limiting crack widths is normally sufficient to achieve this. To meet tightness classes 2 and 3, liners and/or pre-stressing will also be required. In addition to correct design, watertightness also depends on the use of an appropriate concrete mix and good workmanship on site. Good compaction of concrete is essential.

## Durability and selection of materials

Concrete should be specified in accordance with BS EN 206 and BS 8500 Parts 1 and 2. Well-compacted concrete is essential for durability. Generally, the thickness of members should be at least 250mm to permit good compaction, but not excessive because the minimum reinforcement increases with the thickness of the concrete.

The likely exposure classes for different elements are noted in table 2 (below left). Cover requirements in BS EN 1992-1-1 and BS 8500 will generally apply. It is good practice to use nominal cover ( $c_{nom}$ ) of 45mm from the face in contact with water and 75mm from any face cast against soil.

## Basis of structural design

### Design situations

These are dealt with in a general way in BS EN 1990. For pools constructed partially or fully below ground:

- the adverse effects of soil and groundwater pressures on the walls and base should be considered during construction and in service.

This will normally require consideration of the pool when it is empty

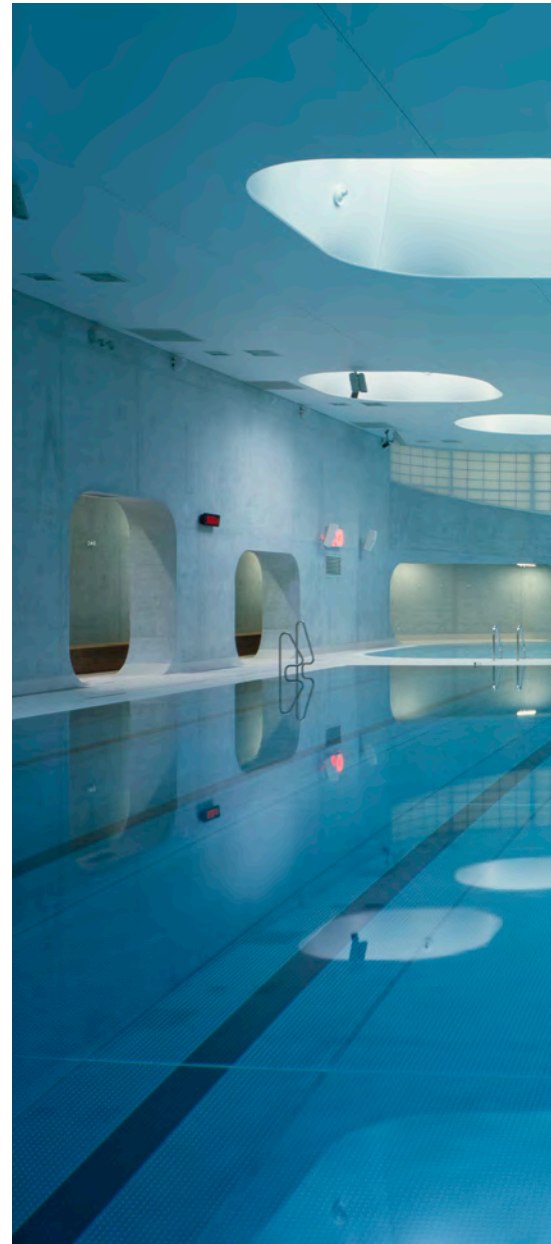
- for the design situation when the pool is full, no relief should be given for the beneficial soil and groundwater pressure effects.

TABLE 1: LIQUID TIGHTNESS CLASSES (BASED ON BS EN 1992-3)

Tightness class	Requirements for leakage
0	Some degree of leakage acceptable, or leakage irrelevant
1	Leakage to be limited to small amount. Some surface staining or damp patches acceptable
2	Leakage to be minimal. Appearance not to be impaired by staining
3	No leakage permitted

TABLE 2: LIKELY EXPOSURE CLASSES FOR DIFFERENT ELEMENTS (IN ACCORDANCE WITH BS EN 1992-1-1/BS 8500)

Element	Likely exposure class
Wall in contact with water	Cyclic wet and dry – XC3 and XC4
Surfaces in contact with soil (walls and slabs)	DC class depending on the aggressiveness of the soil
Outdoor swimming pools (walls and slabs)	XF1 for walls, XF3 for slabs
Swimming pools for seawater (walls and slabs)	XS3



ABOVE This swimming pool in Issy-les-Moulineaux, Paris was designed by Mikou Studio using Feng Shui principles – and plenty of exposed concrete

TABLE 3: WATERTIGHTNESS CLASSES

Tightness class	Suggested measures
0	Structure may be designed using the provisions of clause 7.3.1 of BS EN 1992-1-1
1	Width of any cracks that can be expected to pass through the full thickness of the section should be limited to $w_{k1}$ (see table 4, right)
2	Cracks that may be expected to pass through the section should be avoided unless special measures are incorporated (eg. water bars or liners)
3	Special measures will be required (eg. liners or pre-stressing)





### Structural design: serviceability limit state – crack widths and watertightness

Table 3 (below left) gives the crack width limits and recommendations for the watertightness classes from table 1. The approach to crack control and the performance implications of the chosen method should be agreed with the client.

#### Estimation of crack widths

Crack widths are normally calculated for:

- cracking caused by restraint to movement (also referred to as “imposed deformations”)
- cracking caused by loading.

Examples of imposed deformations include early thermal effects, autogenous shrinkage and drying shrinkage.

CIRIA publication C660 contains extremely useful information for the estimation of crack widths. The formulae for crack-width calculation are not included here so C660 should be consulted for fuller details.

#### Cracking caused by restraint

When concrete cracks, the full tension carried by both the concrete and the reinforcement just before the crack occurs must be carried by the reinforcement alone. Minimum reinforcement ensures that there is sufficient strength to take

### CONCRETE MIX

In water-retaining structures, mix design should aim at durability and minimising the risk of cracking. Strength is rarely critical. Watertightness and durability can be achieved using good-quality concrete alone without any special additives or admixtures, especially for waterproofing.

The following specification is likely to be satisfactory for most cases:

- Consistence class: S3
- Maximum water-cement ratio: 0.50
- Minimum cement content: 300kg/m<sup>3</sup> when aggregate size is 20mm, 320kg/m<sup>3</sup> when aggregate size is 14mm
- Maximum cement content: 400kg/m<sup>3</sup> for CEM I (OPC) concrete and 450kg/m<sup>3</sup> when ground granulated blast-furnace slag (GGBS) or fly ash is used
- Concrete strength class: C30/37

Use of cement replacement (GGBS or fly ash) is recommended as the heat of hydration will be less than that for pure Portland cement (CEM I) and this in turn assists in crack control. Suitable cement or combination types are CEM IIB-V (which contains 21-35% fly ash) or CEM IIIA (which contains 36-65% GGBS). If high proportions of cement replacements are used, there will be implications for early strength and abrasion resistance, which might impact the programme. When in contact with aggressive soil, provisions to resist sulphate attack are likely to determine the mix and a cement type CEM IIIB or CEM IVB could be used.

The loads should be established using the relevant codes. The designer will know the maximum depth of liquid that it is physically possible to store and it is recommended that this is the depth used in the calculations, even though for many pools this level is higher than the normal level of the water. Although slightly conservative, this approach will result in a reliable design.

#### Structural analysis

Design should be based on elastic analysis without redistribution. In rectangular pools, direct tension in the plane of the walls arises from the lateral load supported by adjacent contiguous walls. This should be taken into account in design. Where the pool walls are curved in plan, this will lead to hoop stresses, which in turn create in-plane tension.

TABLE 4: LIMITING VALUES OF  $w_{k1}$

hd/h	≤5	10	15	20	25	30	≥35
$w_{k1}$ (mm)	0.2	0.175	0.15	0.125	0.1	0.075	0.05

Where hd is the hydraulic head, ie the depth of the water above the concrete element under consideration, and h is the thickness of the wall or slab



Photo: Hugo Carvalho Araújo

**ABOVE** Carvalho Araújo designed this house in Viana do Castelo, Portugal with a rooftop concrete pool

this load. However, minimum reinforcement does not guarantee any specific crack width and additional reinforcement may be necessary.

Cracking occurs because there is restraint to movement, and the degree of restraint is another source of uncertainty. Restraint may be internal or external to the element. Internal restraint is caused by differential expansion and will generally be significant in thick sections. External restraint is either end restraint or edge restraint. The mechanism of crack formation in these two cases is different and this is reflected in the formulae used for the calculation of restrained strain. In the case of members restrained at ends, cracking occurs progressively.

Each crack occurs to its full potential width before successive cracks occur. In this case, crack-inducing strain is specifically related to the strength of the concrete and the steel ratio.

The amount of reinforcement required to limit the crack width to a given value will be considerably higher in the case of members with end restraint than in those with edge restraint. This is why the walls of the pool should be cast in successive bays, rather than alternate bays.

### Construction

■ **Joints** Swimming pools should not contain movement joints because they are a source of leakage and maintenance problems. Construction joints are inevitable, however, and are frequently the location of leaks. They should be detailed and built to reduce the likelihood of leaks. The reinforcement should pass through the joint and the surface of the first pour should be roughened to increase the bond strength and provide aggregate interlock. Powerful hammers should not be used as they may dislodge the aggregate particles. The joints should also be protected by water bars. These are pre-formed strips of durable, impermeable material – either metal or proprietary products made of rubber or flexible plastics such as PVC. They are wholly or partially embedded in the concrete during construction, located across joints to provide a permanent liquid-tight seal during the whole range of movements.

■ **Kickers** In liquid-tight construction, it is recommended that a kicker with a height of 150-250mm is built monolithically with the base slab. While some contractors may prefer kickerless construction to increase speed of construction, the additional risk of water penetration should

be avoided in watertight construction.

■ **Formwork ties** These should be selected carefully so that there is no risk of moisture penetration.

■ **Service penetrations** In swimming pools, service pipes are normally required to penetrate the concrete. They are also common locations where leakage occurs. The locations should be pre-planned and the pipes should incorporate puddle flanges (effectively a pre-welded water bar on the outer face). Casting a sleeve or boxing and locating the pipes subsequently will result in a greater number of interfaces and increase the risk of leakage. This should ideally be avoided, as should post-drilling the concrete.

### Inspection and testing

BS EN 1992-3 does not provide any guidance on inspection and testing, nor does it state any acceptance criterion for test results. In the UK, the procedure given in BS 8007 has been used successfully in the past and can continue to be used. The test procedure includes the rate of fill (not greater than 2m in 24 hours) and the length of the test (seven days). This may affect the programme, particularly if the pool does not pass the test first time. In this case, remedial measures will be required, followed by a further test.

### KEY REFERENCES

BS EN 1992-1-1:2004 Eurocode 2. Design of concrete structures – General rules and rules for buildings, British Standards Institution (BSI)

BS EN 1992-3:2006 Eurocode 2. Design of concrete structures. Liquid retaining and containing structures, BSI

Concrete Basements: Guidance on the design and construction of in situ concrete basement structures, by RS Narayan and CH Goodchild, MPA – The Concrete Centre, 2012

CIRIA C660: Early-age thermal crack control in concrete, CIRIA, 2007

BS EN 206:2013 Concrete. Specification, performance, production and conformity, BSI

BS 8500-1:2015 Concrete. Complementary British Standard to BS EN 206. Method of specifying and guidance for the specifier, BSI

BS 8500-2:2015 Concrete. Complementary British Standard to BS EN 206. Specification for constituent materials and concrete, BSI

BS EN 1990:2002+A1:2005 Eurocode. Basis of structural design, London, UK: BSI

BS 8007:1987 Code of practice for design of concrete structures for retaining aqueous liquids, BSI

# LASTING IMPRESSION HUGH BROUGHTON

## MINDBLOWING SIGHTS AND MULTISENSORY EXPERIENCES



The wonderful thing about concrete is that it has a solidity which flies in the face of our increasingly disposable modern world. It is reassuring both in its monumentality and in the certitude that it's going to be there for a really long time.

In 1984, aged 19, before I had any idea about architecture, I visited Dhaka in Bangladesh. I don't remember many of the sights in the city centre, but I definitely remember arriving at Louis Kahn's National Assembly Building (1982) 1 and it was a mind-blowing experience. It

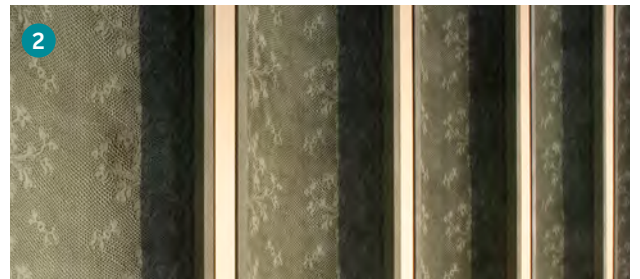
has a stunning concrete facade inlaid with strips of marble and shows off Kahn's inspirational manipulation of natural light. It feels like it's going to last for hundreds of years. In a country that was in many respects economically destitute, it gave a strong sense of hope. It made me think that if architects can do that, it must be a magical profession to be involved in.

In the age of the machine aesthetic, concrete still retains a strong sense of craftsmanship. My son was looking around Nottingham University and I managed to persuade him that we should go and have a look at Caruso St John's Nottingham Contemporary (2009) 2, where they cast lace into the exterior concrete. There's something delightful about the contrast between someone pouring concrete out of a mixer and the patterns of something as delicate as lace.

I also really enjoy the plastic potential of concrete – it allows you to dream, it's not a limiter. Dulles airport (1962) 3 by Eero Saarinen is one of my favourite buildings and has this incredible sweeping concrete roof. It captures the spirit of an age when flight was truly glamorous. That form could only ever be achieved with concrete.

Having done so much work in the Antarctic where people suffer sensory deprivation, I'm always looking for the extra sensory dimensions of buildings. You get that with concrete, which retains a very special kind of smell – there's a sense of earthiness. Smell is an extra dimension that we rarely think about when designing buildings.

**Hugh Broughton is director of Hugh Broughton Architects**



Photos: 1. Mahabur Rahman/Robin; 2. Richard Brine/View Pictures; 3. John Dalkin

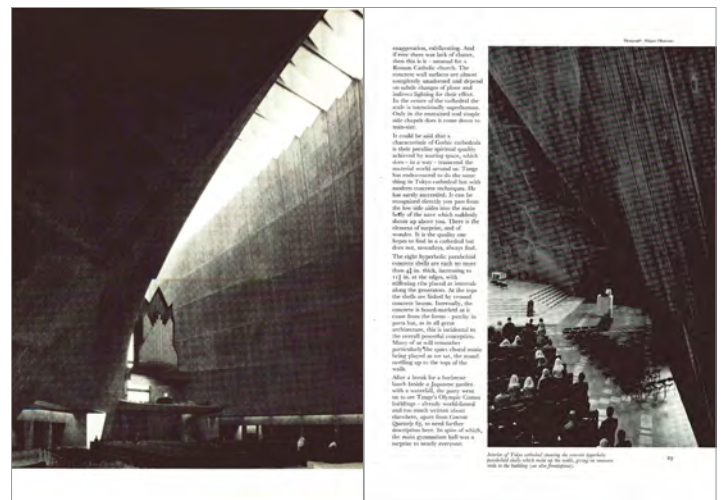
## FROM THE ARCHIVE: WINTER 1967

### JAPANESE GOTHIC

In October 1967, CQ editor George Perkins joined a group of 114 British architects on a tour of the Far East to see how modern concrete architecture was transforming cities such as Hong Kong, Chandigarh and Bangkok. The highlight, however, was a building that seemed to owe as much to medieval Europe as the Bauhaus: Kenzo Tange's Roman Catholic cathedral. "It could be said that a characteristic of Gothic cathedrals is their peculiar spiritual quality achieved by soaring space, which does – in a way – transcend the material world around us," observed Perkins, adding that Tange had "surely succeeded" in achieving the same thing with modern concrete techniques.

The interior was breathtaking. "The floor is diamond-shaped, from which plain concrete walls made up of eight vertical hyperbolic paraboloid shells soar to a great height to meet a cruciform roof with translucent natural lights." The scale, Perkins noted, was "intentionally superhuman" – an effect heightened by the use of concrete. The walls were board-marked and, unusually for a Roman Catholic cathedral, almost completely unadorned, relying on subtle changes of plane and indirect lighting to create an element of wonder. "It is the quality one hopes to find in a cathedral but, nowadays, does not always."

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...transparency, radiating. And of these there was lack of direct light. It is the contrast of Roman Catholic church. The concrete wall surfaces are almost completely unadorned and display subtle changes of plane and texture. The contrast of the translucent concrete is especially experienced clearly in the recessed and simple side-light where a corner shows its form.

It could be said that a characteristic of Gothic cathedrals is their peculiar spiritual quality achieved by soaring space, which does – in a way – transcend the material world around us. Tange had done this in the Roman Catholic church in Tokyo. The concrete walls are almost completely unadorned and display subtle changes of plane and texture. The contrast of the translucent concrete is especially experienced clearly in the recessed and simple side-light where a corner shows its form.

The right hyperbolic paraboloid concrete shells are such as appear to rise in the sky, with a diamond-shaped floor. The walls are board-marked and, unusually for a Roman Catholic cathedral, almost completely unadorned, relying on subtle changes of plane and indirect lighting to create an element of wonder. "It is the quality one hopes to find in a cathedral but, nowadays, does not always."

After a break for a lunchtime walk to the Japanese garden which is especially fine, the tour continues to the building's other main feature – the concrete wall surfaces. The contrast of the translucent concrete is especially experienced clearly in the recessed and simple side-light where a corner shows its form.

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**FINAL FRAME: CENTRE NATIONAL DES ARTS DU CIRQUE**

A series of 19th-century warehouses in Chalons-en-Champagne provides the surprisingly industrial setting for France's national circus school. And the theme has continued with two new buildings by architects Caractère Spécial and NP2F Architectes, which are clad in corrugated fibre-cement to echo the existing structures. They couldn't resist one circus-like piece of trickery though: a stunning cantilevered staircase that links two floors of the new school building.

