CONCRETE QUARTERLY

SUMMER 2015 | ISSUE NUMBER 252

GRAIN SUPREME
Board-marked concrete leaves a big impression in the reception of IStructE's new headquarters

McASLAN vs THE MACHINES
The new Lancaster University building than can withstand anything engineers throw at it

SURFACE OR SERVICE?
The hidden power of exposed concrete soffits in active heating and cooling systems


Photo: Iwan Baan

Awards shortlists run thick with concrete

Concrete buildings have made an impressive showing on recent awards shortlists, with Steven Holl's Reid Building in Glasgow (above) one of the frontrunners to win Scotland's top architecture prize, and concrete frames featuring in four of the six finalists for the Building Awards' Sustainability Project of the Year.


Photo: Sutherland Hussey Harris

The Reid Building (CQ 248) – a series of fluid in-situ concrete spaces linked by three vast light wells – is one of 24 projects shortlisted for the annual RIAS Awards. It is joined on the list by Sutherland Hussey Harris' Edinburgh Sculpture Workshop, a £3m project marked by a distinctive 20m-high triangular concrete tower (left), currently hosting a sound-art work called Concrete Antenna.

Meanwhile, this year's Building Awards, which took place on 22 April in London, recognised the environmental benefits of concrete-frame construction in its prestigious sustainable building prize. The winner was Bennetts Associates' Five Pancras Square at King's Cross, London, which makes extensive use of concrete to provide thermal mass. Also on the shortlist were Haworth Tompkins' Everyman Theatre in Liverpool (CQ 248), Allies and Morrison's Ash Court in Cambridge, and Duggan Morris' Ortus building in south London.
Find out more about the Reid Building and Everyman Theatre in the CQ archive at www.concretecentre.com/cq

THERE'S NO 'I' IN CONCRETE ELEGANCE …

As CQ went to press, Adam Knight of Hugh Broughton Architects and Bruce Martin of Expedition Engineering were set to reveal the secrets of this issue's cover star at May's Concrete Elegance event. The IStructE HQ in London is a true collaboration between architect and engineer, and the structural experts who visit the building will doubtless pause at its showpiece concrete staircase, both to admire its light elegance and to wonder how exactly the open treads are supported.

The event also hears about another inspired collaboration – the DLR Lexicon library in County Dublin (right, CQ 251). Louise Cotter of architect Carr Cotter & Naessens and engineer Karel Murphy of Horganlynch will explain how the beautiful exposed interiors simultaneously deliver environmental and structural goals.

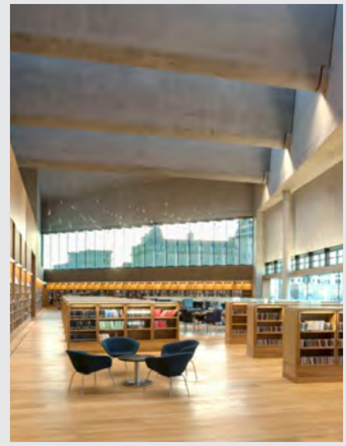
Photo: Dennis Gilbert

The next Concrete Elegance is on 8 September. For more details, go to www.concretecentre.com/events. Read about the DLR Lexicon in CQ 251 at www.concretecentre.com/cq


Photo: James O Davies, English Heritage

Hanging Gardens of Basingstoke listed

English Heritage has awarded grade II-listed status to a number of iconic post-war concrete offices, including Arup Associates' Mountbatten House in Hampshire.

The development, built between 1974 and 1976, is famed for its brutalist style and tiered roof gardens – lending it the nickname "The Hanging Gardens of Basingstoke".

In total, 14 offices built between 1954 and 1984 gained listings, including other concrete landmarks such as MEA House by Ryder & Yates in Newcastle; Bank House in Leeds by Building Design Partnership; Space House in London by Richard Seifert; and St James's House in Birmingham by John Madin.

CONCRETE QUARTERLY

On the cover:
The IStructE headquarters in north London by Hugh Broughton Architects. Photo: James Brittain

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A material of many faces

This issue of Concrete Quarterly seems to me to be packed with apparent contradictions. It struck me again and again how concrete is used by building designers inside and out in many different ways and for very different reasons, often within the same building. Concrete's sheer versatility – reassuringly robust but infinitely mouldable, as comfortable performing structural gymnastics as providing surface glamour – leads to some surprising juxtapositions.

The IStructE HQ's 6m-high wall is simultaneously a conspicuous structural element and a startlingly beautiful surface finish, while at Lancaster University's Engineering Building the robustness of a concrete structure designed to withstand fire, explosion (and students) belies the painstaking care that ensured the formwork marks were left in exactly the right place. Aesthetics are also in the spotlight in this issue's Focus section, with a peek at the upmarket finishes of the Victoria Beckham flagship store. But again, this is alongside a piece on the techie world of building services and the role of concrete in active cooling systems.

At 432 Park Avenue, meanwhile, the eternal human quest to defy gravity meets down-to-earth commercial imperative, with a rigid concrete structure used to scale new heights while maximising value for its developers. And such extreme verticality contrasts with our Structures piece on green roofs, where a growing number of horizontal surfaces are being turned into secret gardens on the London skyline.

AT 432 PARK AVENUE, THE ETERNAL HUMAN QUEST TO DEFY GRAVITY MEETS DOWN-TO-EARTH COMMERCIAL IMPERATIVE

The reason behind these contrasts is perhaps best summed up by Rab Bennetts in our Lasting Impression slot, when he describes the best concrete architecture as a blend of "art and craft and science". It is, and it's all the richer for it.

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

TIME FOR EXTREME MEASURES

When people talk about resilience to climate change, it can sound like we need a kind of magical construction method, writes Andrew Minson on the This is Concrete blog. "Buildings will have to cope with hotter summers and colder winters, floods and droughts." The fear is that many will choose to ignore the issue until it's too late – at The Concrete Centre's Ecobuild seminar on climate change and thermal comfort in March, speakers reported that many building owners remain unconvinced of the risk posed by overheating, for example. Such attitudes must change, argues Minson, or the consequences could be "potentially devastating" for many UK citizens.

One solution is building with greater thermal mass, which absorbs excess heat in the summer and also store warmth for the winter – proof that designing for both hot and cold weather need not be contradictory. "The real problem is not devising resilient building methods," says Minson. "It's finding the resolve to act now."

Join the debate at www.thisisconcrete.co.uk

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DON'T MISS AN ISSUE

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READY FOR ANYTHING

The robust concrete frame of John McAslan's Engineering Building at Lancaster University will help it to withstand fire, explosions, vibration, noise – and the future too. By Tony Whitehead

The engineering departments of universities can present designers with some very distinctive user requirements – and the new facility at Lancaster's famously modernist campus was certainly no exception.

For a start, designer McAslan and Partners had to come up with a building that was virtually fire-proof: "You are accommodating activities such as welding, soldering, and people working on petrol engines," explains project architect Paul Hughes. "There are also chemical engineering labs, and a 3D-printing facility which requires the storage of potentially explosive plastic and metal powders."

The building also had to be able to contain and compartmentalise noise and vibration to a high degree. "Obviously you don't want clanking from the heavy engineering department to disturb people in offices and teaching rooms," says Hughes. "There is also an issue with the transmission of vibration from machinery. As well as being undesirable in itself, vibration is a particular concern when you have people in other parts of the building using high-power microscopes."

Given requirements like these, it is perhaps easy to see why the natural solidity and fire-resistance of an in-situ concrete frame with concrete floor slabs was chosen as the basis for such a building. But Hughes says concrete was an apposite choice in others ways too. "As it houses a centre of technical excellence, we wanted to celebrate the engineering aspects of the building itself. So some of the services are exposed and the accommodation is set out on a rigorous and rational exposed concrete grid which helps to define the atrium space between the two wings of the building."

Finally, says Hughes, the use of concrete contributes significantly to the environmental performance of the building, which has achieved the highest BREEAM rating of Outstanding. "Like much of the frame, the concrete soffits are exposed, and this enables the thermal mass of the concrete to absorb heat during the day. This can either be stored to reduce heating requirements in winter, or released overnight to enable the concrete to help keep the building cool again the following day" (see box, overleaf).

In plan, the 4,700m^2 building comprises two long rectangular wings. The southern wing houses four storeys, the northern wing three, and these are set parallel to each other with a highly glazed atrium between. The 60m-long wings are "slipped", meaning that, at each end, one wing extends some 15m beyond the other (see plan, overleaf). At the eastern end of the building this "slipped" space has been used to create a new square-like public realm defined by a frame of glass-reinforced concrete (GRC). At the western end, the space is used as a service yard.

Set out on pad foundations with a ground-bearing slab, the frame comprises 400mm^2 columns spanned by post-tensioned floor slabs. Most of the office space is housed in the south wing where the slabs span 10.5m and are 350mm thick. The labs and workshops are housed in the north wing, where the floors have a 12m clear span and are a little thicker – 400mm – to permit the slightly longer spans and also to cope with the heavier loads associated with machinery.

"Post-tensioning allowed us to reduce the depth of the slabs while retaining their ability to span and give us column-free space below," says Hughes. "A number of advantages flow from that, including increased ceiling height, reduced weight and reduced concrete usage overall."

All the columns are situated on the perimeters of the two wings, but while those on the external walls are buried within brick piers, those on the atrium side are very visible – as are 600mm-high

POST-TENSIONING ALLOWED US TO REDUCE THE DEPTH OF THE SLABS WHILE RETAINING THEIR ABILITY TO SPAN AND GIVE US COLUMN-FREE SPACE BELOW

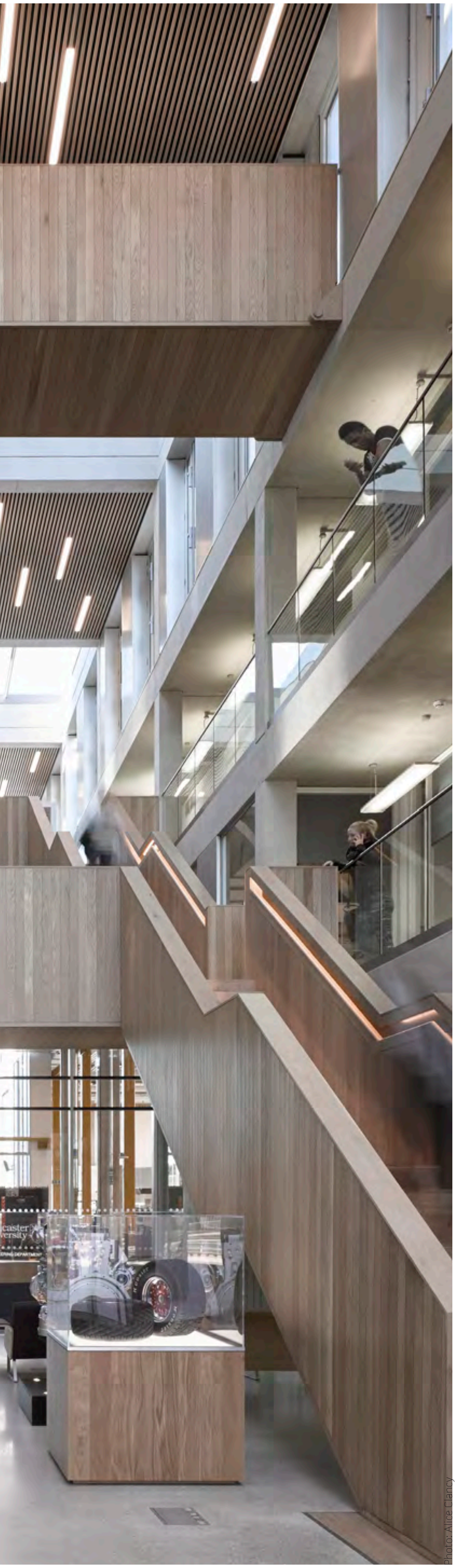
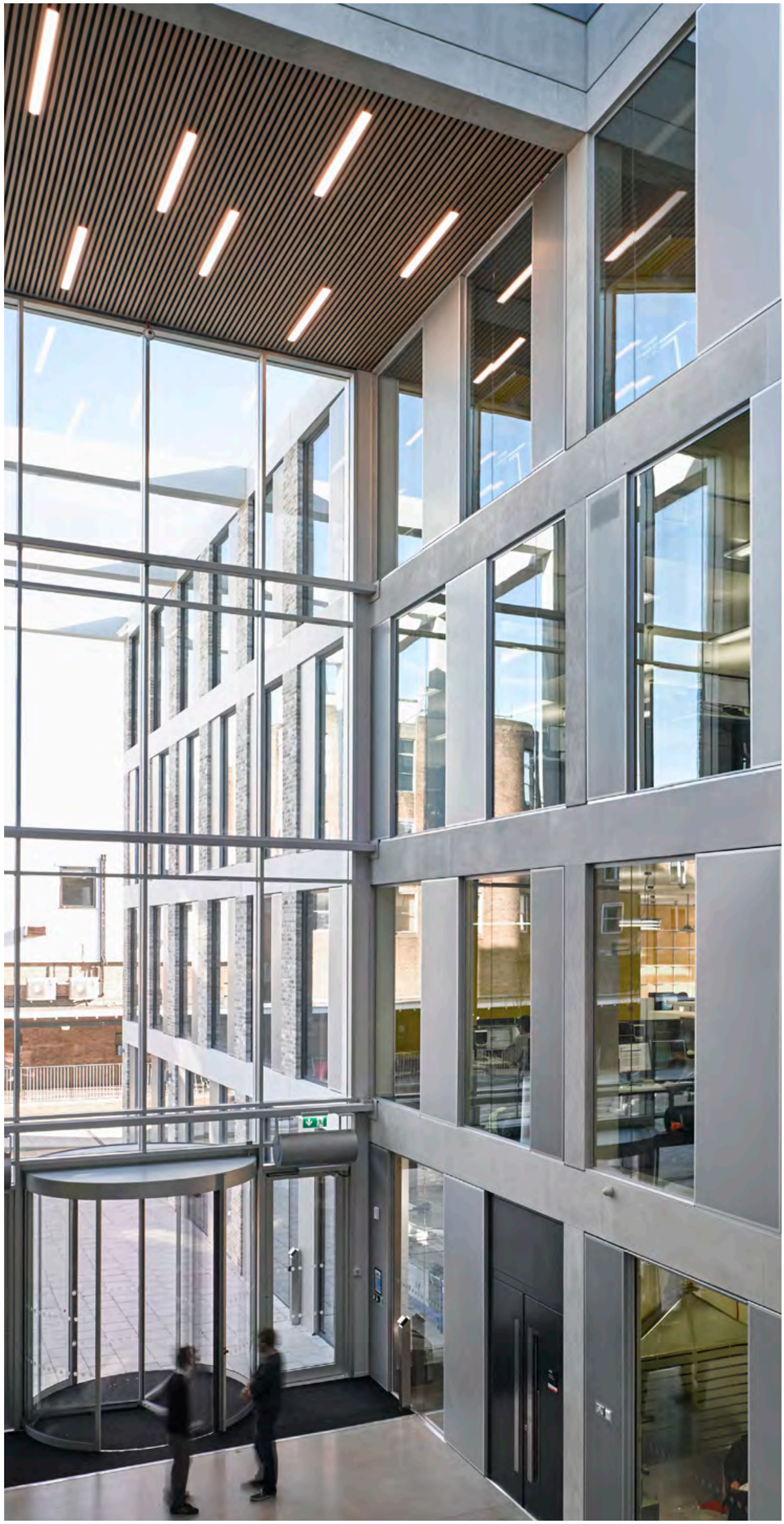


Photo: Alice Clancy



Photos: Nick Guttridge

upstand beams that define the boundary between each storey, and which were cast monolithically with the floor slabs.

"Having these visible upstand beams allows the different slab thickness of the north and south wings to appear the same when viewed from the atrium," says Hughes. "The extra 200-250mm also accommodates the raised floors which contain most of the electrical and heating services."

The slab edges also appear to be visible on the exterior elevations, but as Hughes explains, this is an illusion. "If the beam extended all the way to the exterior there would obviously be a risk of cold-bridging – so what you see from the outside is actually GRC cladding with insulation between it and the slab proper behind.

"Aiming as we were for BREEAM Outstanding, we have been careful with the building envelope. It is very highly insulated and achieves U-values as low as 0.1W/m^{2}K."

Inside, the "engineered" look created by the exposed concrete is boosted by some exposed services including some of the heating and ventilation pipework and the pipes which supply gas to the laboratories. But this wasn't just an aesthetic consideration. From an environmental point of view it is important that the building enjoys a long and useful life, points out Hughes,

Precision for engineers: perfecting the mix and formwork

While substantial buildings with significant amounts of high-quality visual concrete are becoming increasingly common in UK cities, projects like Lancaster University's new Engineering Building are relatively unusual in more rural areas – a fact that created special challenges for Chesterfield-based concrete contractor Hampsey.

"Lancaster may be a city in name, but it has a small population and the area is basically rural," says managing director Greg Hampsey. "The local concrete plants are not the most modern and not particularly geared up for larger, more specialist jobs. This means that if you are constructing concrete to a very specific colour and finish, you have to be very careful – both with the mix and how it is poured."

Hampsey worked closely with concrete consultant David Bennett, and also with two local suppliers to achieve a consistent, workable concrete that would deliver on the architect's aesthetic requirements. "Workability was key," says Hampsey. "For example, the upstand beams visible from the atrium had to be cast monolithically with the slab. The spec required any blowholes to be below a certain size so it was necessary to poker (vibrate) the beam. Do this too much though, and the concern is that the concrete will run out into the slab. Too little and you risk voids, honeycombing, or unacceptable blowholes."

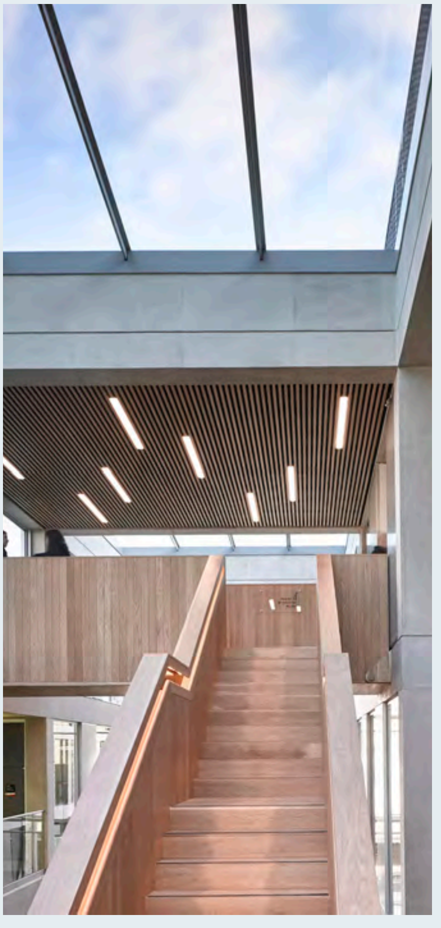
Similarly, the columns required a crisp, clean finish – so the formwork was constructed without arrises to allow true right-angle corners with precise edges to be created. "Working without arrises means there is a greater risk of spalling at the corners," explains Hampsey, "so we left the concrete for 48 hours minimum before striking to allow the corners to completely harden." He adds that the 50% GGBS mix slowed curing times so that the concrete was left to cure for even longer in winter – up to 72 hours.

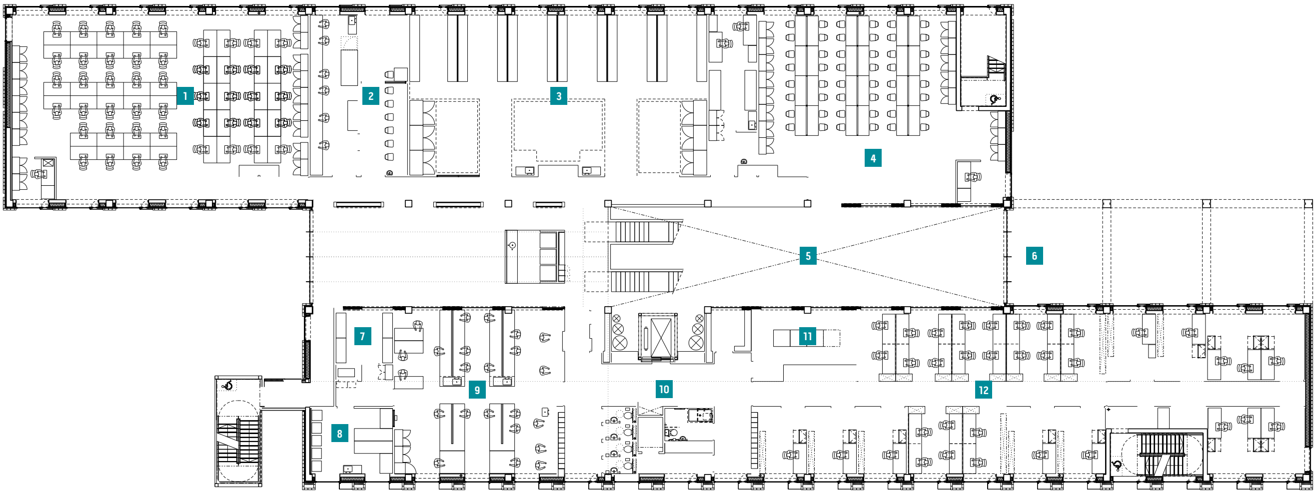
When constructing the formwork, Hampsey also had to take into account the long, relatively narrow proportions of the building. "The architect required a specific pattern running the 60m length of the building, so there are places where the perspective means that any deviation from the line on the soffits would be very visible and very obvious."

The solution was to add a an extra layer of "non-structural" 8ft x 4ft plywood boards, aligned with string lines and placed on top of the floor slab "structural" table formwork. The technique also allowed the architect's detailing of formwork panels around columns to be handled with relative ease.

Naturally the formwork was also central to the finished appearance of the concrete and a number of options were considered before paper-faced boards from Pourform, which give a matt tone to the concrete, were selected for the extra layer of boards.

The use of bonded post-tensioned slabs also meant that the design work was frozen at an early stage. "We worked with our regular PT engineer, Structural Systems, and once they knew what they needed to about other trades – the services and fixings that were to attach to the slab – they then worked to accommodate these in the design and positioning of the tendons. For the most part these ran both ways across the slabs about 1.4m apart."





IN PLAN (SECOND FLOOR)

1 Embedded systems / Undergraduate drop-in
2 Engineering research lab
3 Engineering project lab
4 Electronic engineering lab
5 Full-height atrium
6 Main entrance
7 Gas lab
8 Clean room
9 Engineering research lab
10 Core
11 ISS comms room
12 Open-plan office

ABOVE LEFT
A GRC frame defines a public square-like space in front of the main entrance

BOX, LEFT
Formwork was created without arrises to create precise right-angled edges on the columns and beams

BOX, RIGHT
Exposed soffits play a central role in the natural ventilation system

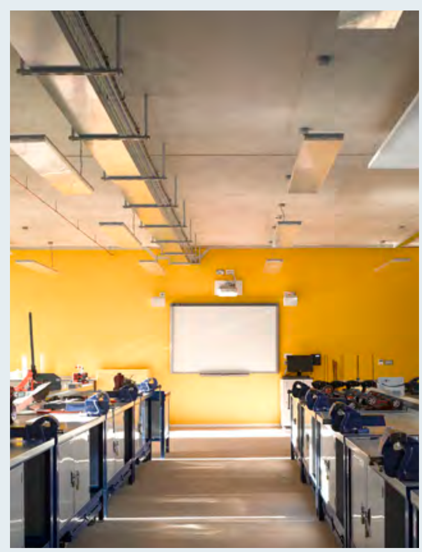
Ventilation: harnessing the sea breeze

Ventilation is always the key to maximising the temperature-moderating effect of concrete's thermal mass, and at Lancaster this is controlled by a number of energy-efficient design initiatives.

Office, teaching and workshop areas are for the most part naturally ventilated, via secure, manually operated doors backing onto the perforated aluminium panels that form part of the building's exterior cladding. Some of these, however, are automatically controlled by a building management system.

Meanwhile, low-velocity "shunt" fans are employed in high-density areas, pushing and pulling air into the atrium, which provides a heat sink in winter. In this way air can be encouraged to flow gradually over the exposed concrete columns and soffits, to remove or distribute heat as required.

Ingenious use has also been made of the building's coastal situation. Because one wing of the building is higher than the other, this creates a stepped section at the atrium which has been put to work to aid ventilation. Architect Paul Hughes explains: "The prevailing south-west wind blows in off Morecambe Bay over the higher, southern wing of the building. This lowers air pressure immediately above the building and promotes natural stack ventilation in the summer."



"so adaptability is key. The good thing about exposed services is that it makes it relatively easy to reconfigure the building to meet future needs."

The industrial feel is tempered by the use of timber panelling on staircases, some of the atrium's ceiling panels, and on the bridges which connect one wing to another on the upper levels. The softer timber surfaces also help to moderate sound, and large glazed panels work to contain noise while permitting views into the various laboratories and workshops. "It was important that the activities that happen here can be seen, allowing people to take an interest in the work of others and to share ideas," says Hughes. "For the same reasons the atrium also functions as exhibition space."

It is all a far cry from the days when engineering tended to take place in garage-like bunkers or hangars. This is a light, open and welcoming building, and with its limited palette of materials – concrete, pale brick and grey aluminium – its aesthetic has been neatly edited to fit in perfectly with the 1960s-built Lancaster campus. As a work of engineering though, it is a world away from those technically flawed times – a building of efficient subtlety which should inspire its occupants for generations to come.

PROJECT TEAM
Architect John McAslan & Partners
Contractor Eric Wright Construction
Concrete contractor Hampsey
Structural engineer Structural Systems
GRC contractor GB Architectural
Concrete consultant David Bennett Associates

Photo: CIM Group and Macklowe Properties

MANHATTAN SLIMLINE

Innovations in concrete frames have prompted a new wave of super-slender towers to rise over New York. Andy Pearson reports on the tallest yet

432 Park Avenue is tall, very tall. In fact, at 425m, it is the third tallest building in the US and the tallest residential building, not just in New York but in the whole of the western hemisphere.

Surprisingly, however, it is not the 96-storey building's height that is its most remarkable feature – what distinguishes 432 Park Avenue from most of Manhattan's skyscrapers is its slenderness. A tower is considered slender by New York's building codes when its ratio of height to its narrowest side is greater than 7:1. But this building is part of a new generation of super-slim towers currently rising over Manhattan, and has a footprint of just 28.5m in each direction, giving it a height-to-width ratio of 15:1, more than double the code definition.

Concrete is key to 432 Park Avenue, providing both structural strength and weight. "On slender and tall buildings, the weight of the structure is very important," says Silvian Marcus, director of building structures at WSP Group, the structural engineer behind this and several other of Manhattan's super-slender towers. "You will never see a slender building with a steel structure – it will vibrate like a tuning fork because it doesn't have enough weight."

Crucially, concrete also allows the designers to maximise the floor area of the apartments and, ultimately, give developers CIM Group and Macklowe Properties the greatest return on their investment in this prime site. Addressing the unique structural challenges of slender towers without sacrificing sellable space is a key issue – particularly managing the building's response to the high winds circulating so far from the ground.

All tall buildings sway in the wind, but the height and slenderness of 432 Park Avenue increased the risk of excessive movement in the upper floors during relatively common wind events. The oscillation itself is not the problem – it's the change in speed that occupants will sense, just as passengers in a car feel its acceleration and deceleration. This is even less acceptable for a residential building than for a commercial one, Marcus points out. "With an office, you can evacuate if there's a hurricane, but people have to feel safe in their homes regardless of the weather. It's impossible to stop the building moving but you can control the movement so the majority of people will not feel it."

To make the tower's structure stiff enough, WSP came up with an innovative structural solution based on two square concrete tubes placed on their ends, one inside the other. The smaller, inner tube is the building's 9m x 9m concrete core while the outer tube is formed by the tower's perimeter beam-and-column concrete frame. The two tubes are connected on every 12th floor to enable the entire structure to work as one. These stiffening beams are too big to be accommodated on the residential floors so they are in the plant

Images: DBox for CIM Group and Macklowe Properies

OPPOSITE
432 Park Avenue is 425m tall and 28.5m wide, giving it a height-to-width ratio of 15:1

TOP
Every floor has six 3m x 3m windows on each elevation, maximising views for the tower's well-heeled residents

ABOVE
A CGI showing the finished tower's exposed concrete exterior. Insulation is placed on the interior face of the concrete, within the occupied space

rooms instead. "At each mechanical floor we have connections between the backbone and the outside tube," explains Marcus. The double-storey plant rooms play another key role to improve the building's aerodynamics – they are unglazed, allowing wind to pass through the building at regular intervals over its height, a solution developed through wind-tunnel testing.

The concrete perimeter structure is fully exposed in response to the architect's wish to be true to the material. It also enabled the developer to save on the cost of cladding. But, most important of all, it saved space. Adding a facade and its supports would have increased the depth of the walls by 250mm on each elevation. Using fair-faced concrete instead enabled the engineers to push the structure to the perimeter of the building to maximise the area within.

The perimeter frame is very stiff, even after the building's architect, Rafael Viñoly, punched six, 3m x 3m windows through it on each floor and on each elevation to give residents those all-important views out. The frame structure also enabled the 250mm-thick concrete floor slabs spanning the 9.1m between the exterior and the tower's core to be constructed free from structural beams to give its occupants complete flexibility in how they configure their apartments.

YOU WILL NEVER SEE A SLENDER BUILDING WITH A STEEL STRUCTURE – IT WILL VIBRATE LIKE A TUNING FORK BECAUSE IT DOESN'T HAVE ENOUGH WEIGHT

With its 760mm-thick reinforced-concrete walls, the core is what Marcus refers to as "the building's backbone". Here, once again, the structural design has been developed to minimise the cross-sectional area and achieve the greatest possible floor area. Conventional floor-to-ceiling height for residential towers in New York is 12ft (3.7m), but at 432 Park Avenue it is 15ft 6in (4.7m). While the additional metre does add to the prestige of the apartments, more importantly it enabled the designers to add a second return to the core's access stairs to keep the core compact. "Adding a double loop to the stair gave us 250 square feet of additional space per floor," explains Marcus – a significant gain when multiplied over the tower's 89 floors.

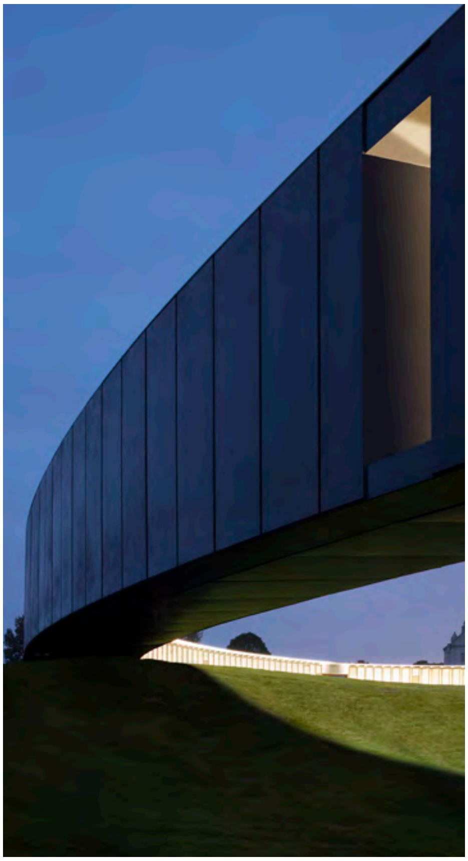
Getting the concrete mix right was critical for the structure. The concrete needed to have a very high compressive strength of 16,100 pounds per square inch (111MPa); it also had to be white in colour to meet the demands of the architect. WSP considered using fly ash as a part-replacement for cement in the mixture but this addition would have coloured the concrete grey. In the end, the team replaced approximately half of the cement with metakaolin, a treated form of the clay mineral kaolinite, which increased the compressive strength of the concrete while lightening its colour. "We worked for almost a year to find the right mix," says Marcus.

The building's concrete structure was cast in-situ, the height of the building necessitating that the concrete be pumped upwards from the street. "If we'd have placed the concrete in a bucket and lifted it to the upper floors it would have set by the time we came to place it," Marcus points out, laughing.

With the structure complete, the engineers added more weight to the top of the building – 1,300 tonnes, in fact – to further limit the building's acceleration. This was in the form of two tuned mass dampers, located in the uppermost plant room on the 84th floor. Supported on diagonal springs, the concrete dampers work because their mass moves more slowly than the building sways, dampening its acceleration by 15%. "People want to feel they are living in a solid home, not in a boat," says Marcus. "Slender structures have such a small plan area, we had to mobilise everything possible to achieve that."

Tall Buildings, a guide published by The Concrete Centre and the Fédération internationale du béton, is available from www.concretecentre.com/bookshop

PROJECT TEAM
Architect Rafael Viñoly Architects
Structural engineer WSP Group
Contractor Lend Lease
Concrete contractor Rogers & Sons



Photos: Tim van der Velde; Aitor Ortiz

FORMS OF MEMORY

New projects at WW1 cemeteries are using the symbolic power of concrete to express the meaning of the conflict 100 years on. By Nick Jones

Building materials have always played an important role in the way that the First World War is remembered, from the red Accrington brick of Edwin Lutyens' Thiepval Memorial Arch to the endless rows of identical Portland stone headstones that stretch silently across the northern French and Belgian countryside. To mark the centenary of the war, several cemeteries have commissioned new projects to help preserve the conflict in the collective memory of future generations. But now their architects are turning to concrete to give expression to the human tragedy that unfolded on Flanders Fields.

At Tyne Cot cemetery near Passendale, the largest burial ground for Commonwealth forces anywhere in the world, Belgian practice Govaert-Vanhoutte has built a new reception and visitor centre. At first glance, it appears almost as a sort of anti-architecture: the simplest rectilinear volume of precast concrete, lying deliberately low in the flat landscape and clearly subordinate to Herbert Baker's 1927 cemetery. This is reinforced by the tone of the concrete: "The grey is an abstract and neutral colour, and gives a sober effect," says architect Damiaan Vanhoutte.

However, there is an underlying power to the design. For all its modesty, the centre is precisely positioned on an important axis between the cemetery and Passendale church, giving it an authority in the almost-featureless landscape. The eye is also drawn to an in-situ concrete wall that flanks the pavilion, its rough-hewn board marks evoking the make-shift wall of a trench.

There is more abstract symbolism going on too: "There is a kind of repetition to the board marks, which is a reference to the number of soldiers," says Vanhoutte. "It is a connection between architecture and the multiplicity of graves." The pavilion itself also has a metaphorical dimension, he adds, in the way that it hangs suspended above the sloping site at one end: "It is the balance between life and death, war and peace."

A similar, albeit more dramatic, gesture is made at Philippe Prost's International Memorial at Notre Dame de Lorette, the largest French cemetery from the conflict. Here, a 328m-perimeter ring of dark concrete overlooks the Artois plains where 600,000 soldiers lost their lives. For a third of its diameter, the monument cantilevers out over the landscape, a feat made possible through the use of ultra-high-performance reinforced-concrete sections, which were prestressed and post-tensioned. "This cantilevering reminds us that peace will always be fragile," says Prost.

But the concrete ring also suggests permanence – both as a symbol of eternity, and in a more literal sense. "This monument was built to resist the passage of time," says project architect Lucas Monsaingeon. "Ultra-high performance concrete guarantees its transmission to future generations."

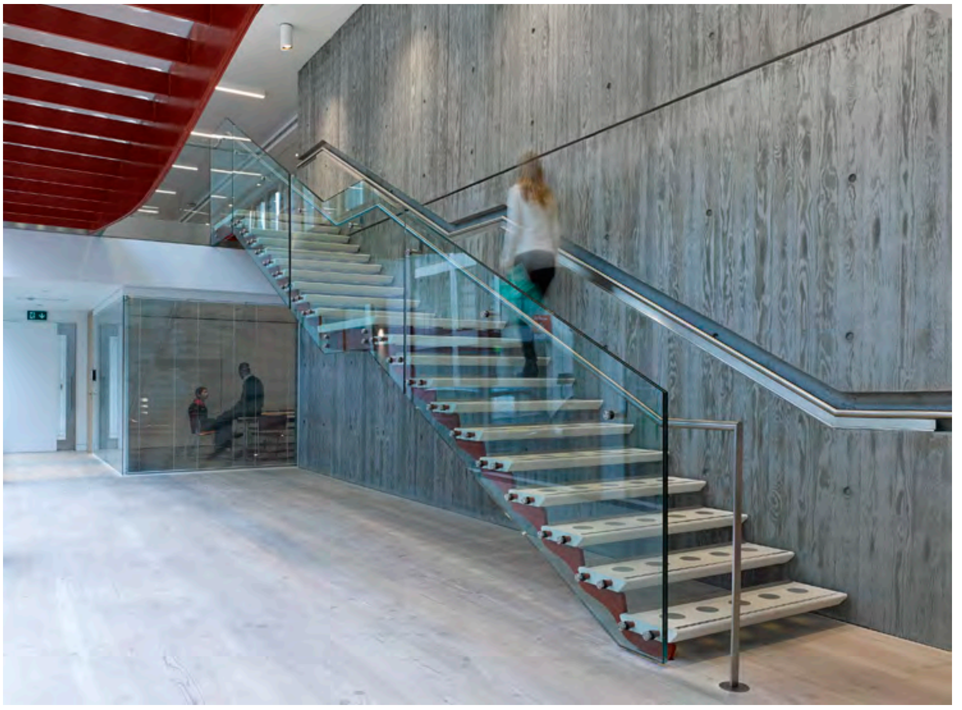
TOP LEFT
The concrete wall flanking the Tyne Cot visitor centre is meant to evoke a trench

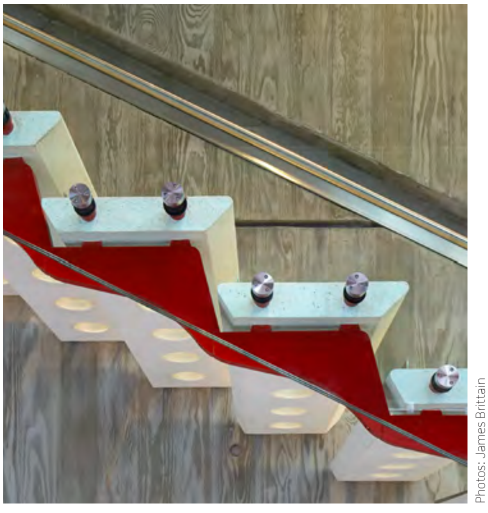
BOTTOM LEFT
The centre is designed to be subordinate to Herbert Baker's cemetery, but still carries an authority in the flat landscape

ABOVE RIGHT
The International Memorial at Notre Dame de Lorette is a 328m-long ring that cantilevers over a sloping site

PRAY FOR GRAIN

Achieving the immaculate board marks on the feature wall at IStructE's new HQ required patience, skill and a fair bit of faith, writes Nick Jones





Photos: James Brittain

"It was absolutely terrifying – the most terrifying morning of my life," says Adam Knight, director at Hugh Broughton Architects, only half-jokingly. "You don't know the result for another four or five days, so you just walk away and try to get some sleep."

The cause of Knight's apprehension was the pour for a 6m-high in-situ concrete wall at the Institution of Structural Engineers' new headquarters in Islington, north London. The building is a 1960s office that has been drastically reconfigured to include modern, open-plan workspaces, an auditorium, a library and other facilities. But the "moment of drama", as Knight puts it, is provided by the reception area, which has been cleared of structural elements to create a spacious atrium behind a double-height glass frontage. And stretching out across the back of the atrium is that vast concrete wall.

This is where the fear set in. The wall supports an elegant precast-concrete-and-steel staircase and together they form a showpiece for the headquarters, demonstrating how construction materials can be used in new ways. Any innovative approaches that failed would be evident not only to passers-by, but also to all of the institution's expert visitors.

The idea behind the wall was to show how timber shuttering – so often used to create a raw aesthetic – could be specified with self-compacting concrete to create a precise and beautiful pattern. The team trialled a number of different timbers, before opting for Douglas fir, which was sanded and brushed to bring out the grain. The boards were then varnished and finished with a release agent that causes the concrete to react differently to sapwood and harder areas, thereby creating a striking "zebra-like" colour contrast within the grain of the finished surface. The desired effect required a precise balance between the different surface treatments.

The stair was a further complicating factor. This feature is an impressive feat of engineering in its own right – with its apparently effortlessly light structure relying on interlocking precast-concrete treads to support itself, and the treads themselves reduced in thickness to just 65mm thanks to an extremely dense reinforcing-mesh design. But while the job of making the staircase stand up fell to structural engineer Expedition, it was the connection with the wall that was adding to Knight's concrete-pour anxiety.

The wall had to incorporate perfectly positioned steel sleeves for the rods of each tread, as it was decided that casting into the wall would leave a superior finish to drilling. But even if this was carried out with complete precision, the sheer quantity of steel in the formwork involved posed additional challenges. "There was so much structure and reinforcement – traditional concrete wouldn't have been able to fit through the spaces. During the pour, I was watching and hoping that the self-compacting concrete would find its way into every corner."

CLOCKWISE FROM TOP
The wall supports an open staircase; the precast-concrete stair treads are held up by interlocking steel plates; the grain pattern forms a backdrop to the open-plan first floor and streetscape

PROJECT TEAM
Architect Hugh Broughton Architects
Structural engineer Expedition Engineering
Contractor Scott Osborn
Concrete consultant David Bennett Associates

So was the finished wall worth the sleepless nights? The viscosity of the self-compacting concrete has left a meticulous finish, with a neat inset handrail, precise tie holes and a sharp 20mm joint between the two pours. And the cool grey of the 30% fly ash mix appears in clearly contrasting shades, leaving a crisp grain clearly visible from the street. In short, Knight can rest easy ...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WHAT LIES BENEATH

Surface heating and cooling using pipes embedded close to the soffit is proving an increasingly popular technique. Tom De Saulles looks at the merits of this approach

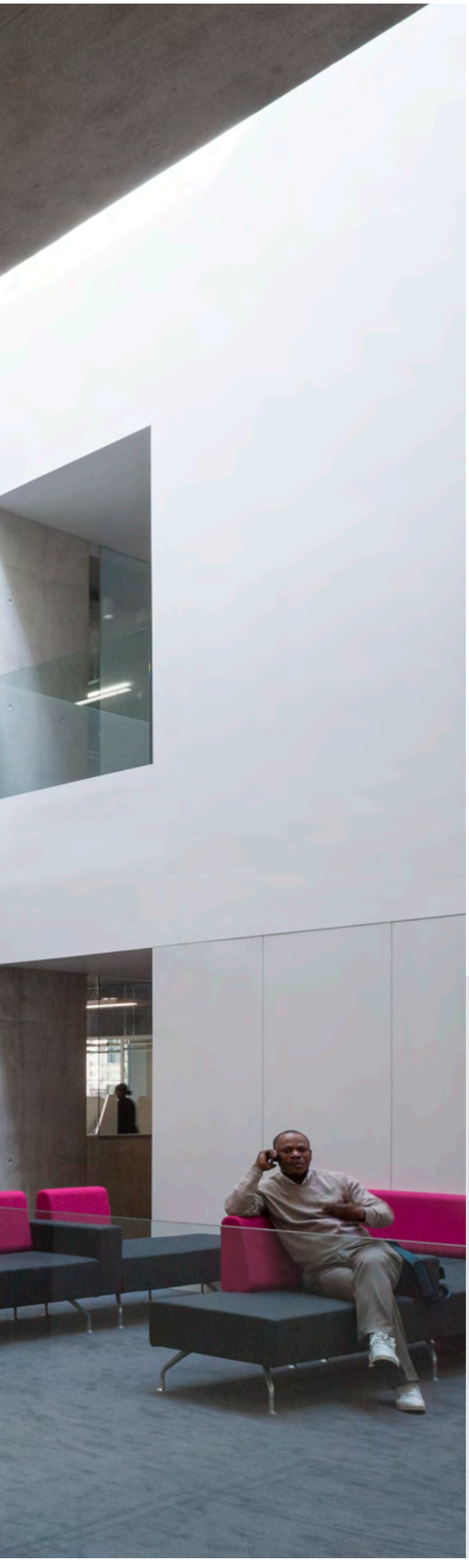


Photo: Andy Matthews Photography

There is an old adage that goes something like: "Since time began and things were made, nothing has changed in the building trade." It's a great line that still resonates, though perhaps a little less true than in previous years. One area where change is quite apparent is in the increasingly multifunctional nature of concrete floors, expanding to include aesthetics and building services alongside their primary structural role – a good example of lean design, where a product is much more than the sum of its parts.

The use of embedded water pipes to provide surface heating and cooling is becoming a common element, though even this is not entirely new – it was first tried back in the 1930s by Frank Lloyd Wright in America and Oscar Faber in the UK. This proved effective, though the steel pipes used in these early systems eventually failed due to corrosion. With the arrival of plastic pipes made from materials such as cross-linked polyethylene (PEX), this problem has been overcome. PEX has been used in underfloor heating for some years, and is now being incorporated into the exposed concrete soffits of low-energy buildings too, for the purpose of both heating and cooling. Only a few years ago, this would have been considered unconventional, but it is now becoming a mainstream construction technique used in a variety of building types, including speculative office developments.

Surface heating and cooling using the soffit is simple, discreet and more energy-efficient than conventional air conditioning, which raises the question of why it has only recently started to take off. The answer may partly lie in the British Council for Offices' Guide to Specification. In 2009, this raised the recommended internal summertime temperature to a more easily achieved 24°C, making the comparatively modest cooling output of surface-based systems a far more viable option.

Essentially, the system comprises plastic pipes located about 60mm above the soffit and arranged in a serpentine pattern across the floor slab, with spacing of around 150mm. Typically, the pipes are fixed to the steel reinforcement prior to the concrete pour. During the summer months (or whenever cooling is needed), chilled water is pumped through the pipes, at a temperature close to that of the occupied space. This is made possible by the large surface area for heat transfer provided by the soffit, and allows the use of efficient sources of heating and cooling, such as ground-water and ground-coupled heat pumps. Thermal mass provided by the floor slab also plays its part by attenuating peak heat gains and smoothing out the cooling demand across the day. This in turn allows the building's cooling needs to be met by a relatively small building services installation and also by natural ventilation if required. The combined effect is lower capital and operating costs, plus less space needed for plant.

THE SYSTEM COMPRISES PLASTIC PIPES LOCATED ABOUT 60MM ABOVE THE SOFFIT AND ARRANGED IN A SERPENTINE PATTERN ACROSS THE FLOOR SLAB

◀ East Ham Civic Centre

East London
Rick Mather Architects, completed 2014

Surface heating and cooling is a key feature at Rick Mather Architects' East Ham Civic Centre (CQ 248). The £12.5m building uses 350mm-thick thermally active concrete slabs, containing pipework linked to 20 geothermal boreholes and a heat pump system. This approach, combined with an open-plan floor plate, helps to deliver an uncluttered internal space, with visual connections to the campus and high street outside. Servicing is largely addressed through the installation of raised access floors, which also improve flexibility. The floor void is used for supplying mechanical ventilation throughout the occupied space, while stale air is discreetly extracted via the building's atrium. Lighting is provided by units suspended from the soffit, with the electrical cabling routed in conduits located in the neutral zone of the slab.

◀ **White Collar Factory**
City of London
Allford Hall Monaghan Morris, due for completion 2016

AHMM's 22,000m^2 urban campus is an innovative and sustainable workplace clustered around a public courtyard, with five additional low-rise buildings and three restaurants. The design features surface heating and cooling integrated within a generous 3.5m-high concrete soffit, which will work with the ceiling's thermal mass to provide a comfortable working environment. Additional thermal mass will be provided by exposed perimeter blade columns integrated within the facade, helping to declutter the space. Openable windows will deliver natural ventilation when the outside temperature is between 14°C and 25°C, predicted to be about 50% of the time, with mechanical ventilation operating for the remainder.

When considered from the perspective of the developer and operator, there is a more subtle benefit over many passive cooling techniques: risk. The ability to continually regulate the soffit temperature regardless of what the weather is doing outside ensures greater control of internal conditions and the ability to avoid overheating – something that can be more difficult with a passive approach reliant on natural ventilation.

In many ways, surface heating and cooling offers the best of both worlds. Active water cooling provides better control and cooling output, while still being able to take advantage of free cooling from passive ventilation whenever conditions permit. Examples of this approach can be found at Romero House, the headquarters of CAFOD in London and Vanguard House at the Daresbury Science and Innovation Campus in Cheshire. Both buildings incorporate a surface-based system linked to a borehole/heat pump arrangement and, when possible, make use of night-time ventilation in summer to maximise energy efficiency.

Locating services

While surface-based systems avoid the need for elements such as radiators and fan coil units and their associated pipework, they also introduce the problem of what to do with overhead services normally hidden by a false ceiling. Happily, there are a number of standard solutions that can be used to address this. These include:

- **Grouping systems** such as lighting, fire alarms, and sensors into a services raft suspended from the soffit
- **Using floor voids, perimeter bulkheads and ceiling voids** in corridors for ventilation ductwork
- **Using the cores** in hollowcore slabs for pipes and cabling
- **Integrating services into the design of in-situ or precast floors** – that is, casting in rebates and conduits for wiring, pipes, ventilation grilles, smoke alarms, lighting etc.

System limits

The overriding limitation on cooling performance with surface-based systems comes from the risk of condensation forming on the soffit if the surface temperature is allowed to drop too low. This limits the supply temperature in summer to around 14°C, which in turn restricts the soffit temperature to about 19-20°C. Fortuitously, chilled water supplied from boreholes is around 14°C so it can be used without the need for mechanical cooling. The corresponding maximum cooling output is a relatively modest 65W/m^2, but given the large soffit area, this is sufficient to maintain comfortable conditions in most building types.

Floor and soffit options

Usefully, surface heating/cooling does not limit the range of design options for concrete floors, with both precast and in-situ solutions proving equally suitable. For many, a straightforward off-the-shelf solution using precast may be the preferred option. This can be supplied in the form of hollowcore or lattice girder units, both of which provide similar thermal performance, but a different visual finish. The lower cost hollowcore option is produced using an extrusion process, giving a slightly more utilitarian appearance to the soffit that is usually painted. Lattice girder units are cast on a steel bed, giving a smoother surface, more suited to a fair-faced finish if required. This approach has been used at the Manchester Metropolitan University Business School where the concrete used to form the lattice girder units was tailored to create a light finish, using a combination of 75% white cement and 25% ordinary Portland cement. Whichever precast system is used, both benefit from the pipework being installed under factory conditions, where it can be pressure tested before site delivery.

Alongside these proprietary precast systems, there is also the option of using in-situ concrete floors, as at East Ham Civic Centre (see page 13). Alternatively, bespoke precast floor units can be specified, such as those used at IFDS House in Basildon, originally built for Barclays Bank. These two approaches offer design flexibility, including the option to specify a profiled slab, which can increase both the span and cooling output, and is not currently available with the standard precast systems. Post-tensioning can also be used without interfering with the embedded pipes. The drawback, as always with a bespoke approach, is the need for more upfront design and, in the case of in-situ floors, an increased potential for damage to the pipework during construction. However, consultants and suppliers can help with the design, and ensure that the build programme runs smoothly.

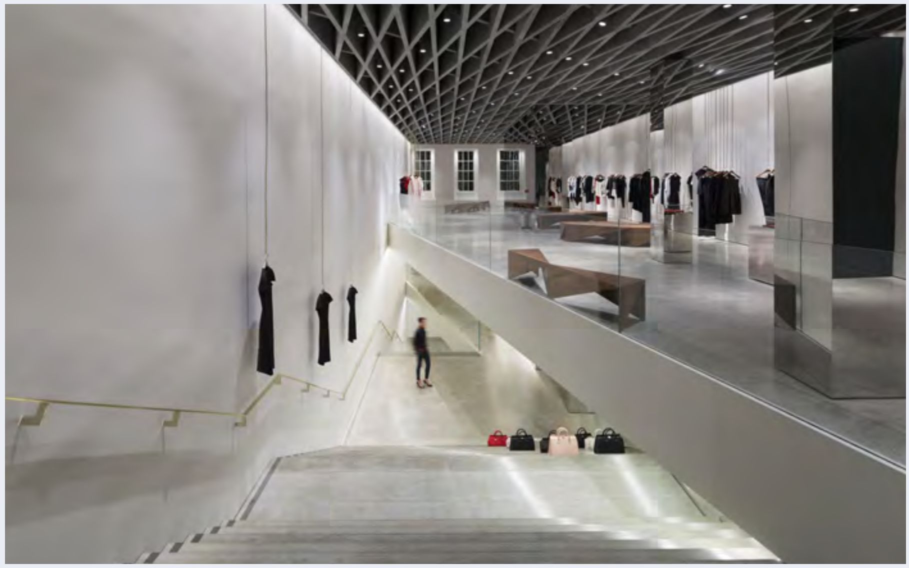
The growing uptake of surface heating/cooling in concrete floors is testament to the synergy that exists between the two, which is helping to meet requirements for comfort, energy efficiency and whole-life performance both in terms of cost and carbon dioxide emissions.

Tom De Saulles is senior manager, building sustainability at The Concrete Centre

An accompanying article on natural ventilation and a review of the East Ham Civic Centre were published in CQ 248: www.concretecentre/cq
Concrete Floor Solutions for Passive and Active Cooling can be downloaded from www.concretecentre.com/publications

This season's must-have finish

Elaine Toogood explores the increasing use of concrete in high-end retail, residential and business projects



ABOVE Farshid Moussavi's interior for Victoria Beckham's store in west London includes polished concrete floors and staircase and a latticed cast-concrete ceiling

BELOW At Louis Vuitton's Miami store, sparkling white Ductal has been moulded into the company's signature flower pattern

It is no longer unusual to see exposed concrete where there is a need for energy efficiency and cost-effectiveness – often with some fine aesthetic results. But recently I have noticed an increase in the use of exposed concrete for building types where style has far more influence on material selection, such as retail, restaurants and office reception areas. These are spaces in which first impressions count more than most, where interior design is used to make a statement, perhaps about a business's core values and aspirations. So what might the appeal of concrete be in these situations?

I suggest that authenticity plays a big part. Exposed, unadorned structure expresses a truth about the building and provide an essential understanding about its construction. As Adrian James, architect of the award-winning Hill Top House in Oxford, says: "There is nothing showy or flash about concrete; it has a raw purity which is rare in this age of materialism and bling."

Concrete speaks of solidity and permanence, attractive qualities to be associated with. It is also practical, providing robustness and durability in places that are often heavily trafficked or require low spread of flame. Such characteristics are valued in fire-escape stairs or plant rooms, but "front-of-house" concrete can be designed to create high-quality surfaces, even luxurious ones. Check out the beautiful board-marked wall at IStructE's new headquarters, featured on our cover and on page 11.

Grey is a great neutral backdrop against which to set materials for sale or display. In addition, the natural variation of concrete provides depth and interest, with a subtle, non-repeating pattern. It is remarkable how many other finishes try to capture this liveliness, attempting to replicate the "look" of concrete. When there is even a concrete-patterned carpet, the look is clearly in vogue.

While they may meet an aesthetic requirement, concrete-effect surface treatments can typically only come close to offering the benefits of real concrete – thermal mass, for example, is optimised by exposing concrete surfaces. New-builds offer the opportunity to design concrete structures to be exposed from the start, and there are also refurbishment projects where existing finishes are being ripped out, often to use the thermal mass but also simply to obtain the concrete aesthetic.

Concrete doesn't always come in shades of grey either. Architectural precast offers many variations of colour and form, while glass-reinforced concrete and emerging technologies such as ultra-high-performance concrete can allow designers to obtain the look and feel of concrete in situations where heavy structural elements are impractical. This is particularly useful for retail and other fit-out or retrofit works. These potentially thinner, lighter sections expand the possibilities of formal expression using concrete – as on the facade of Louis Vuitton's Miami store (below).

As technical advances continue, the opportunities to use concrete will expand – and more and more people will discover its potential to play a starring role on high-quality projects of all kinds.

Elaine Toogood is senior architect at The Concrete Centre

IT IS REMARKABLE HOW MANY OTHER SURFACE FINISHES TRY TO CAPTURE THIS LIVELINESS, ATTEMPTING TO REPLICATE THE 'LOOK' OF CONCRETE

Photo: Josh Klinect

Photo: Courtesy of IKO PLC

THE GROWTH OF THE GREEN ROOF

Dusty Gedge explains the benefits of this increasingly popular construction method and the key role of concrete in creating a biodiverse roofscape

Looking over the skyline of London these days, wherever I see a crane I know that a green roof is likely to be installed on top of the building. This wasn't the case 15 years ago. Green roofs have become mainstream in London and are gaining traction outside the capital too. A slow shift in focus to green infrastructure has ensured that soil and vegetation within the urban realm, especially on buildings, has become a popular way to help our cities adapt to climate change.

Concrete is an important structural material for the construction of green roofs on modern buildings. A concrete slab is easy to install and will give the required structural loading for any given green roof.

Benefits of green roofs

Vegetation and soil on roofs can provide a range of benefits. They help to ensure building integrity by protecting waterproofing membranes from deterioration, reducing the impact of UV light and frost/thaw and perhaps extending the membrane life beyond the standard UK guarantee of 20 years.

Environmentally, green roofs have a role to play in helping cities adapt to climate change, through reducing the urban heat island effect during heat waves, and mitigating flash floods during intense summer storms – the deeper the substrate the greater the capacity to store rainwater.

They can also provide biodiversity benefits that may not always be recognised by the construction industry. These include visual amelioration, reduction in noise pollution, and removal of airborne particles. There is perceived to be competition from sustainable technologies such as solar panels for the use of roof space, but with good design, the two technologies can work very well together, leading to improved performance of both, as with recently piloted bio-solar roofs.

Designers sometimes express concern over the potential fire risk associated with dry vegetation, but guidelines published by the Department for Communities and Local Government in 2013 have clarified this issue. The UK's Green Roof Code follows the guidelines of the German Landscape Research, Development and Construction Society (FLL), which has specific requirements regarding fire, including the amount of organic material permitted in substrates, and the need for firebreaks and in some cases irrigation, depending on the type of green roof to be installed.

Photos: Dusty Gedge

ABOVE
Riverbank House in the City of London has an extensive green roof planted with sedum

ABOVE RIGHT
An intensive green roof – essentially a full-scale garden – over Cannon Street station in central London

RIGHT
The rubble roof at the Laban Dance Centre in south-east London, which has attracted over 100 wildflower species

THE THREE MAIN TYPES OF GREEN ROOF

	Extensive	Semi-intensive	Intensive
Use	Ecological landscape	Garden / ecological landscape	Garden / park
Type of vegetation	Moss / succulents / herbs / grasses	Herbs / grasses / shrubs	Lawns / herbs / shrubs / trees
Benefits	Water / thermal / biodiversity	Water / thermal / biodiversity / amenity	Water / thermal / biodiversity / amenity
Depth of substrate	60-200mm	150-250mm	150-1,000mm
Weight (saturated)	60-220kg/m^2	150-350kg/m^2	Greater than 200kg/m^2
Maintenance	Low	Periodic	High

Types of green roof

There are a range of green roof types and potential vegetation cover, but these fall into three overall categories:

■ **Intensive** This category refers to full-scale gardens and parks installed on roofs, which require the same high level of maintenance as at ground level (hence the term "intensive"). These have been part of the mainstream for many years – one of the oldest examples in the UK is Kensington Roof Gardens, laid out in 1936-8. There is also a sub-category, referred to as "semi-intensive", which require slightly less maintenance and structure to

Photo: Diane Cook and Len Jenshel

ABOVE The Muse, a family home in Islington, north London has a green roof with varying soil depths for native habitats, including two wildflower meadows, a hazel coppice and a hawthorn thicket

WHEN TREES ARE TAKEN INTO CONSIDERATION, LOADS CAN BE UP TO 1,000KG/M², AND EVEN GREATER DEPENDING ON THE DESIRED PLANTING

support the soil and vegetation. They tend not to have intensive lawns, trees and shrubs but consist of Mediterranean-style planting needing periodic irrigation and maintenance.

GREEN ROOFS IN LONDON

Under the London Plan, developers in the capital are encouraged to include living roofs and walls where feasible. Individual boroughs such as Islington, as well as local authorities in cities including Sheffield and Brighton also encourage such roofs through the planning process.

An audit of green roofs in London carried by the Green Roof Consultancy for the Greater London Authority in summer 2013 found that there were nearly 700 green roofs in central London alone, covering more than 175,000m². Black redstarts, the protected bird species that first prompted interest in green roofs in the capital, have been seen on many, in addition to a number of rare bees, butterflies and insect species. Green roofs are here to stay and will be increasingly required as a planning condition of development.

With growing concern regarding climate change, there will no doubt be increasing interest in retrofitting vegetation on to roofs in the near future. The Green Roof Consultancy estimates that over 10 million m² of green roofs could be installed on existing buildings in the capital.

■ **Extensive** This type of green roof has become mainstream in the construction industry over the last 15 years. It is relatively shallow in depth and planted with a variety of drought-tolerant plants, from succulents such as sedum to wildflowers, and generally inaccessible except to provide the low maintenance required.

■ **Brown roofs** These aim to mitigate the loss of biodiversity on a site by recreating the natural habitats of local species. Although a good idea in principal, there are several issues with simply providing a growing medium and leaving it to be colonised by plants and animals. For example, if invasive species become dominant, it can create serious maintenance problems. Equally, the desired plants may take a long time to establish themselves or fail to make it up to roof level at all.

Locally sourced aggregate from the development site is sometimes used as a growing medium. There are some challenges associated with this approach, particularly as crushed reclaimed concrete retains very little water. However, it has been used with some success. The Laban Dance Centre in south-east London (pictured), built in 2000, was the first brown roof to use recycled crushed concrete from the demolition process, and since then over 100 wildflower species and a number of rare invertebrates have been recorded at the site.

Green roofs can be used to obtain credits in the Land Use & Ecology category of the 2014 version of BREEAM New Construction for enhancing site ecology.'

Engineering considerations

From an engineering point of view, an extensive green roof varies in saturated load between 70kg/m² and 200kg/m². However a saturated load of above 120kg/m² is recommended to ensure the widest environmental benefit.

Intensive green roofs are much heavier. These are more likely to be installed on podium deck roofs with the capability to take at least 300kg/m². When trees are taken into consideration, loads can be up to 1,000kg/m², and even greater depending on the desired planting.

On modern large-scale developments, concrete is the preferred material for roof decks. Many buildings currently under construction in cities have inverted roofs, where the insulation sits above the waterproofing. This approach is ideal because the green roof can sit above the insulation and replace the ballast (shingle and pavers) that is traditionally used to weigh it down. This can reduce the perceived additional cost of the green roof (see table, previous page). A green roof can be installed on a zero fall if necessary, with drainage layers in the roof build-up to ensure lateral drainage. The steeper the roof, the less consideration of drainage is required in the roof build-up.

There will be need for some maintenance access, even for the shallowest green roof, and this may require a fall arrest system and/or a parapet to ensure compliance with safety regulations.

Dusty Gedge is a wildlife consultant, specialising in green roofs. He is president of the European Federation of Green Roofs and Walls and the founder of Livingroofs.org and the Green Roof Consultancy: greenroofconsultancy.com

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LASTING IMPRESSION RAB BENNETTS

IN PRAISE OF JUST GETTING ON WITH IT

When my wife Denise and I were at college, we were very attracted to the engineers and builders – the rebels – rather than the fine artists. People like Auguste Perret, Owen Williams and Robert Maillart didn't have the social agenda of Le Corbusier or the brutalists, they were just building well. Williams said he didn't have much time for the architectural establishment, he just got on and did buildings and that idea appeals to me a great deal. Most of the avant-garde architects of the day were just doing small residential projects, but Williams was designing enormous buildings, like the Boots manufacturing plant in Nottingham 1 (1932) with its concrete structure and glass curtain-walling. Perret's most extraordinary building is the Church of Notre Dame at Le Raincy, Paris 2 (1923). It's just a concrete structure and glass – there's nothing else to it, and that's what is so beautiful.

I was also intrigued by the way Arup Associates did really good concrete structures, such as the Sir Thomas White Building 3 (1975) at St John's College, Oxford, which takes a kind of romantic approach, or Gateway House for Wiggins Teape [now Mountbatten House and recently listed – see page 2]. I was lucky enough to join Arup, and ended up working on Gateway Two 4 (1982). That was a lightbulb moment, the first time I realised that the exposed concrete structure was helping to keep the building cool. That is fundamental to an awful lot of what we've done as a practice since. It was really inspiring because it meant that the architecture of the interior was inseparable from the exterior, and the whole thing became far more integrated, and visually and architecturally a much richer experience. It's a combination of art and craft and science that is terribly important, coming together in this concrete structure.

Rab Bennetts is co-founder of Bennetts Associates

Photos: 1. Boots UK Archive; 2. Barnabas Calder/Twitter: @BrutalConcrete; 3 and 4. Arup Associates

FROM THE ARCHIVE: WINTER 1961

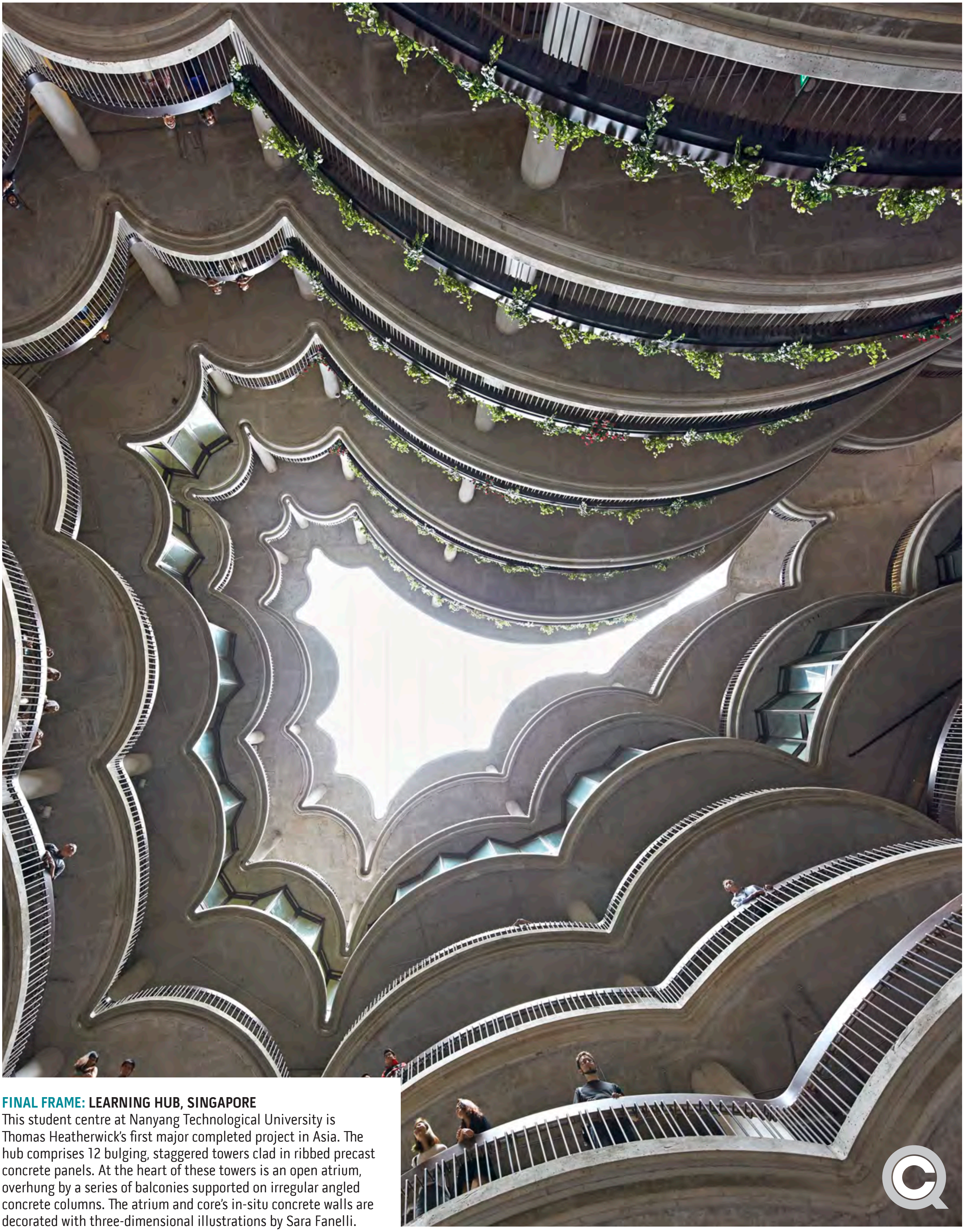
THE MUSCLES OF MILAN

"What makes a skyscraper stand up?" It's a question many New Yorkers have been asking as they look up at the wafer-thin 432 Park Avenue (page 8) with its astonishing 14:1 height-to-width ratio. But 54 years ago, CQ was pondering the same thought at Gio Ponti's altogether more substantial Pirelli building in Milan (height-to-length ratio, 2:1), then the tallest reinforced-concrete tower in Europe. The answer it found was "weight".

Behind the 32-storey tower's iconic form, with its distinctive cigar-shaped plan, was "a masterpiece of economic engineering". The structural design, carried out by Pier Luigi Nervi transferred the building's entire 60,000-tonne weight to the ground through four massive concrete piers and two triangular service cores at either end. Large-span concrete floors also played a key role, concentrating loads on these eight elements and ensuring that there was no need for intermediate supports of any kind.

The tower's mighty frame is fully revealed on the top three floors, "a magnificent open space where the rough concrete of the naked piers rises up to the topmost beams, with the floating roof clear above … Here one is fully conscious of the strength of bone and sinew that has gone into this elegant structure".

Access the full CQ archive at www.concretecentre.com/cq



FINAL FRAME: LEARNING HUB, SINGAPORE
This student centre at Nanyang Technological University is Thomas Heatherwick's first major completed project in Asia. The hub comprises 12 bulging, staggered towers clad in ribbed precast concrete panels. At the heart of these towers is an open atrium, overhung by a series of balconies supported on irregular angled concrete columns. The atrium and core's in-situ concrete walls are decorated with three-dimensional illustrations by Sara Fanelli.

Photo: Hufton + Crow