CONCRETE QUARTERLY

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CASTING OFF

INSPIRATION

APPLICATION

Elaine Toogood
Senior director, MPA Concrete
& The Concrete Centre

Invisible touch

This issue, we have an spectacularly inert building on our cover. The Ray Dolby Centre is designed to house some of the most sensitive equipment in the world, and the level of vibration transmission is 250 times lower than human perception. Nevertheless, the scientists working there say they do notice how quiet the laboratory spaces are and how little sound is transferred from outside.

That got me thinking about the way we experience buildings, with all of our senses. You don't necessarily need to be able to see the structure to tell what it's made of. If you walk into a thermally massive building on a hot day, it should immediately feel cool. If you're in a structure that provides natural acoustic isolation, you probably feel calmer.

The occupant experience gained in prominence as part of the wellbeing and healthy building movement. But I've noticed that design considerations such as the quality of the indoor environment and providing access to nature have been given greater urgency as essential factors in climate resilience. After all, when we talk about adapting buildings for climate change, what we're really talking about is keeping people healthy in a future of more frequent flooding, overheating, droughts and wildfires.

In June, the UK Green Building Council published its Climate Resilience Roadmap – a very welcome initiative and a huge undertaking, to which I was asked to contribute because of my work providing guidance to improve property-level flood resilience. At the launch, I was struck by London climate resilience lead Emma Howard Boyd's description of buildings as "our first line of defence", driving home the message that keeping people safe starts with how we design, build and adapt.

WHEN WE TALK ABOUT CLIMATE RESILIENCE, WE'RE REALLY TALKING ABOUT KEEPING PEOPLE HEALTHY

As we come to the end of another UK summer of record-breaking temperatures, it's more apparent than ever that we need to make sure the homes we build today will be comfortable year-round in future conditions.Thermal mass is valuable, but so is good design – to provide appropriate ways of "purging" the heat from the structure. For homes, this typically means natural, night-time cooling, which ideally means they should be dual-aspect to enable cross-ventilation. There's a good example of how architects are taking thermal comfort on board at Juniper House (page 34), where most flats are dual-aspect and the south facades have deep balconies and recessed windows.

Fortunately, humans are much less demanding than scientific equipment, and designing safe, comfortable buildings is not rocket science. There is a nice synergy between the way a narrow footprint can provide cross-ventilation, while bringing in daylight to support our mental health. Nature-based solutions are not hard to integrate into urban space – replacing hard surfaces with permeable block paving is a simple way to capture and clean rainwater as part of a sustainable drainage system. This can support street trees, even during drought, but also helps to manage flood risk – another synergy.

At the Dolby Centre, I love how the architects have managed to squeeze 3,000m^2 of outdoor space into the plan. That should help to make sure that this highly technical building engineered for machines will be hospitable to humans too, today and in the future. ■

CONCRETE QUARTERLY

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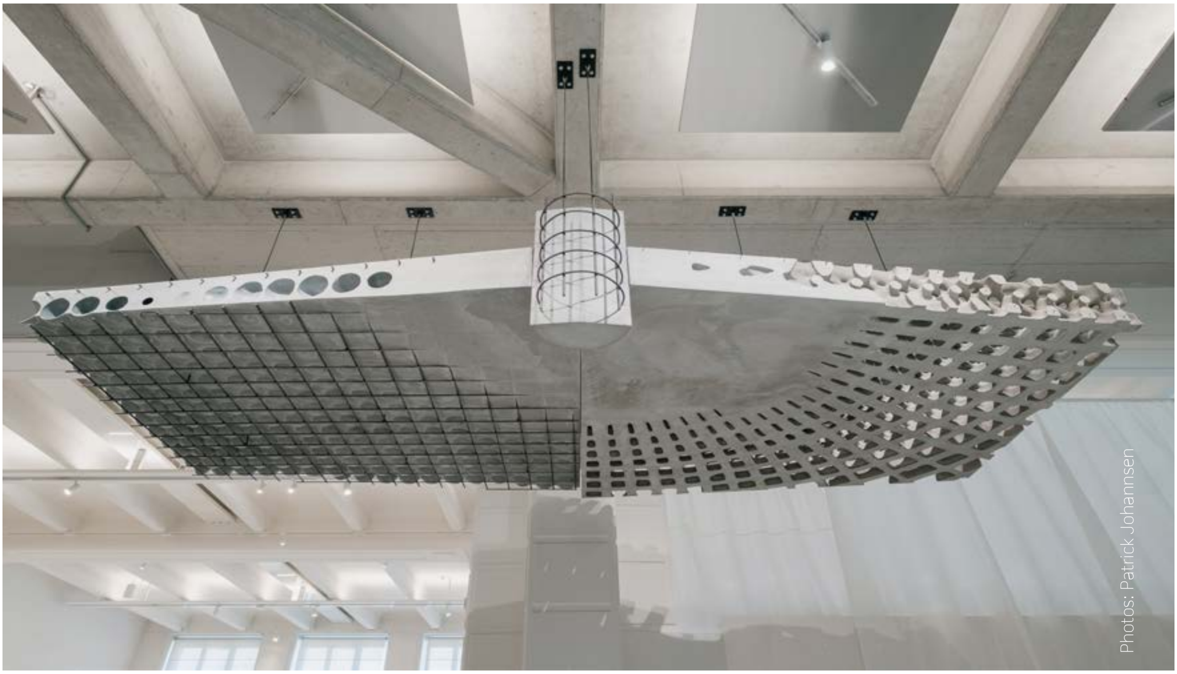
Ray Dolby Centre, Cambridge, by Jestico + Whiles
Photo: Kilian O'Sullivan



Photos: Patrick Johannsen

INNOVATION

VARIABLE DENSITY CONCRETE

RESEARCHERS AT STUTTGART UNIVERSITY AND ENGINEERING CONSULTANT WERNER SOBEK ARE EXPLORING TECHNIQUES FOR MAKING CONCRETE VARIABLY POROUS, CONCENTRATING MATERIAL WHERE IT'S REQUIRED, TO PRODUCE LIGHTER, MORE EFFICIENT STRUCTURES

ABOVE
The 250mm slab on display at the Vienna Technical Museum comprises two halves: one using hollow concrete spheres and the other created using soluble formwork

The bones in your body are sophisticated structural elements. The classic bone shape – slim in the centre and wider towards the joints – has evolved to cope efficiently with the forces acting upon it. But look inside and you find further refinement: a variably porous structure allows bone to be denser where strength and stiffness is required, or lighter where it is not.

"We are aiming to do something similar with our graded concrete," says Lucio Blandini, head of the Institute for Lightweight Structures and Conceptual Design (ILEK) at the University of Stuttgart and partner at engineering consultant Werner Sobek. "A floor slab, for example, does not usually need to be completely solid throughout. So we have developed methods for creating 'pores' or cavities in a controlled way, so material can be concentrated where it is most needed."

Two very different ways of achieving this have been used to

YOU MIGHT MAKE THE SLAB SOLID WHERE IT CONNECTS TO A SUPPORTING WALL, BUT INCREASE THE CAVITIES TOWARDS THE FLOOR CENTRE WHERE WEIGHT IS LESS HELPFUL

create M212, a prototype developed by ILEK and Werner Sobek, and now on display at the Vienna Technical Museum. It is a 250mm-thick slab, the left half of which has been lightened by using carefully distributed hollow concrete spheres. The other half has been made by pouring concrete around specially developed soluble formwork.

Both sides of M212 contain much less concrete than a standard slab. The left side has 217 hollow spheres, each 15cm in diameter, reducing its weight by 30%. The side with the soluble internal formwork is almost 50% lighter than a standard slab.

The ability to vary the concentrations of cavities allows concrete to be more efficiently used, says Blandini. "So you might make the slab solid where it connects to a supporting wall and maximum stiffness is required, but increase the cavities towards the floor centre where weight is less helpful."

Using less concrete reduces resource consumption, lowers the carbon footprint of elements and, by making them lighter, can help reduce the size and weight of a building's entire structure.

The spheres were made by putting a small amount of fibre-reinforced grout inside a spherical silicone mould and then rotating it in a centrifuge. "This forces the grout to the inner surface of the mould, coating it to a depth of around

LEFT
The lightweight hollow spheres are about 3mm deep and made from fibre-reinforced grout

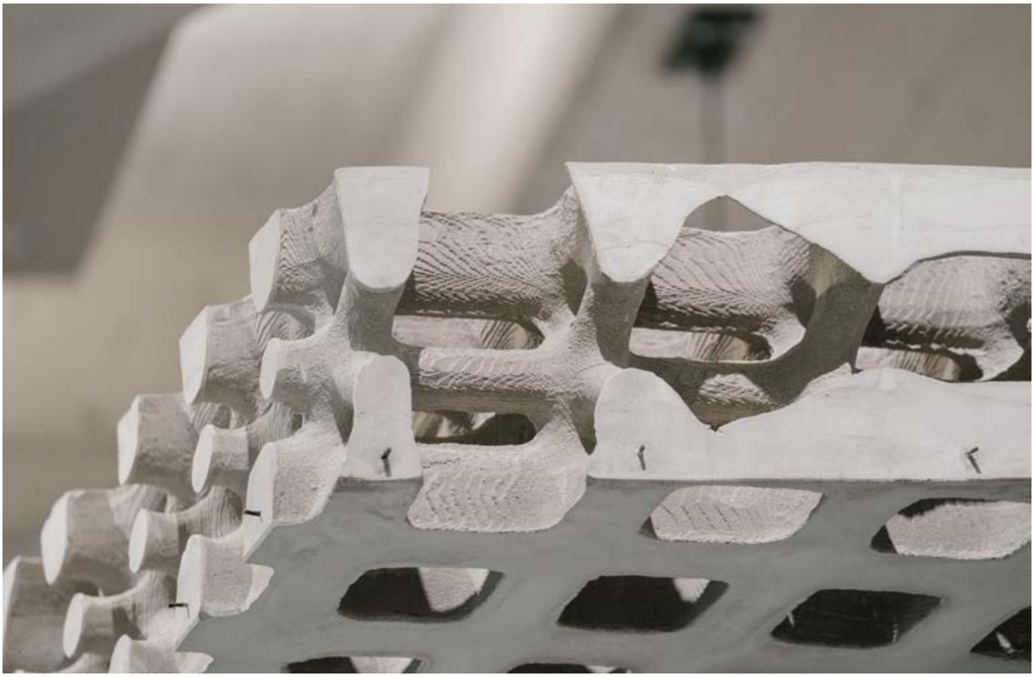
1-3mm," explains Daria Kovaleva, project lead at ILEK. "Remove the moulds, and you are left with lightweight hollow spheres that can be distributed throughout an element. In M212, we've used the reinforcement grid to hold the spheres in place, and to stop them rising to the surface of the wet concrete. The advantage over polystyrene void formers is that the element is fully mineral, so is easier to recycle."

The other side of M212 is equally ingenious. The soluble internal formwork is created with a specially developed 3D printer, which uses sand, water and an organic binder based on cornstarch. "The forms are then set with the help of infrared lamps," says Kovaleva. "In this state they are solid enough to resist the pressure of concrete poured around them." Once the concrete has cured, the element can be hosed down or immersed in water to dissolve the formwork, which can then be recycled. This leaves a pattern of cavities in the cured concrete, determined by the CAD file.

The complex geometries that result are not always compatible with the use of steel rebar. For M212, the concrete is reinforced with basalt fibre rebar instead. "The pattern created by the process can be attractive," adds Kovaleva. "So as well as its material efficiency, architects are showing interest in its aesthetic possibilities."

Clever stuff, but can technologies like these really make it out of the lab and onto a construction site? "We're very focused on making this happen," says Blandini. In fact, some

ABOVE
The reinforcement grid holds the spheres in place, preventing them from rising to the surface of the wet concrete



ABOVE
The soluble internal formwork leaves a complex pattern of cavities, determined by the digital design programmed into the 3D printer

20,000 spheres are currently in production, and will be integrated into a project under construction at the university campus. The research building for the Cluster of Excellence on Integrative Computational Design and Construction for Architecture will include a foundation slab with 30cm spheres and ground-floor slab with 15cm spheres, covering a total area of 1,200m^2. "It's been a challenge, getting this technology peer-reviewed and managed through building regulations, but we recognise the importance of refining not just the technology but the whole process of applying it on site."

"As we move from research to application, we are talking to both architects and precast producers," adds Kovaleva. "Building designers are interested in solving the problem of sustainably producing something that is structurally complex. Manufacturers are attracted by the potential to reduce the weight not only of structural elements but also facade units, where cavities in concrete can be used to increase insulation."

Variably dense material could clearly have many applications. And as so often with good ideas, nature thought of it first. ■

Interview by Tony Whitehead

LASTING IMPRESSION

NATALIA MAXIMOVA

A CONCRETE JOURNEY THROUGH THE TUMULTUOUS 20TH CENTURY, FROM UNFIT SOVIET HOUSING TO AN UNFORGETTABLE WAR MEMORIAL AND A NEAR INVISIBLE LISBON CHURCH

Growing up in the Soviet Union, I've always had an appreciation of both the limitations of concrete and its possibilities. New high-rise neighbourhoods were usually made from precast panels, often badly put together, with gaps in the walls. My introduction to concrete was aged about six – I vividly remember moving into an apartment at the top of a nine-storey precast block, and my dad spending hours trying to put some shelves on the concrete wall.

At the same time, public buildings and sculpture could be quite expressive and powerful. I was 12 when I visited the Salaspils Memorial in Latvia, then still part of the Soviet Union, commemorating the victims of a Nazi concentration camp. It was the same material as the housing complexes we lived in, and its brutality and rough texture were accentuated by the rain. There was also beauty to these colossal figures – no sentimentality, just pure expression of suffering, raw pain and unbroken spirit.

When I first came to Britain on an architectural scholarship, there was no apparent love for concrete buildings and 1960s architecture

BELOW
The Salaspils Memorial by sculptors Levs Bukovskis, Olegs Skarainis and Janis Zarinš. The park, on the site of the Kurtenhof concentration camp in Latvia, opened in 1967

Photo: Robin McElvie / Alamy Stock Photo

Photo: Arcaid Images / Alamy Stock Photo

held a strongly negative connotation. Many amazing buildings from that era were not celebrated enough, including the Roger Stevens Building, which I first discovered by accident on a visit to the University of Leeds. I was totally flabbergasted by its scale, aplomb and the freedom of the composition. I think British architecture is in its comfort zone when it's either organic and pretty, or austere and controlled. This is a rare building that sits in-between, with modernist rigour but also an amazing fluidity. Listed in 2010 as grade II*, it is currently undergoing a facade preservation project – a treatment it truly deserves.

As I started working more closely with concrete (for the University of York's Campus East Gateway, CQ 283, Summer 2023), I began

ABOVE
The Roger Stevens Building by Chamberlin, Powell and Bon for the University of Leeds. Completed in 1970

to explore and appreciate the different techniques, and found myself seeking out new buildings. When I went to Lisbon last year, a colleague recommended the Church of the Sacred Heart of Jesus. Unmistakably brutalist and urban, it sits on a small plot crammed into the city grid, with overlapping levels and stairs linking two neighbouring streets. The degree of coordination and integration – of light, services, different angles and views – and the control and richness of details are incredible. It has this compressed energy that you feel you must obey. Interestingly, my children, who were 17 and 11, didn't enjoy it at all! They felt it was gloomy and prescribed – that the building told you what to do and when to be quiet.

The same day, we visited the Gulbenkian Foundation, a modernist art complex set in its own gardens. The polarity was fascinating. From the same era, it is built using the same materials and similar techniques but to a very different effect. The spaces are generous and very democratic, and outdoors and indoors flow together seamlessly. You feel like you can occupy it any way you want. My children loved it. ■

Natalia Maximova is a partner at Sheppard Robson

TOP
Church of the Sacred Heart of Jesus, Lisbon, by Nuno Teotónio Pereira and Nuno Portas, 1962-67

RIGHT
The Calouste Gulbenkian Foundation, Lisbon. The main building was designed by Ruy d'Athouguia, Alberto Pessoa and Pedro Cid, and completed in 1969

Photos: Ludovic des Cognets; John Mendes / Alamy Stock Photo

From the archive: Winter 1959

THE NEW SHAPE OF PARIS

"Leaving Paris by the Pont de Neuilly and driving out north-westwards, there suddenly appears before you, white in a morning sunlight, this new shape – dazzling, unexpected, immense. Its great curves dwarf the avenue trees and the avenue houses, and on its slopes small busy men look like skiers on a mountain side."

This dazzling new object, then in the final stages of construction, was the Centre National des Industries et Techniques, a vast exhibition hall that epitomised postwar France's new-found economic bounce. It was "by far the biggest building in Paris, covering some five and a half acres", and marked the birth of the La Défense commercial district on the west bank of the Seine.

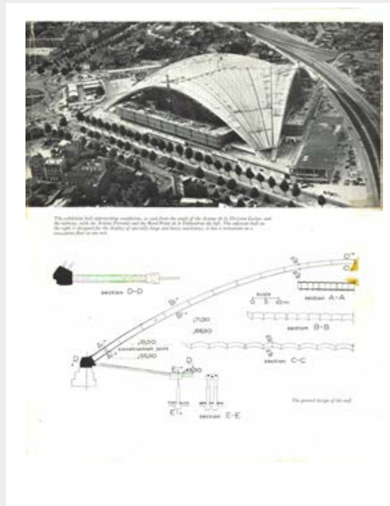
And then there was its shape – an equilateral triangle in plan, rising up into a vaulted dome, like a billowing sheet pegged down at the corners. It was made entirely in structural concrete, with each arching side stretching for 218m. This was (and remains) the longest known span for a thin-shell vaulted structure.

The scheme was devised by three titans of French architecture: Robert Camelot, Jean de Mailly and Bernard Zehrfuss, all past winners of the nation's prestigious Prix de Rome. But the actual business of getting the roof to stay up was the work of structural engineer Nicolas Esquillan.

The structure was a double shell designed in three fan-shaped sections. Inside, there were no columns – an engineering feat to match the cutting-edge machinery on display. "The great umbrella sections of the roof – sharper and more distinct than outside – soar up dizzily to their 150ft high crown," marvelled CQ.

The shells – parallel in form and spaced 2-3m apart – fanned out from 7m-high corner abutments in vaults made up of 18 "undulations". At the dip in each undulation, they were joined by a precast concrete web, with transverse webs at 9m intervals, forming a structure "similar to a plane wing – with great lightness and resistance to bending, torsion, buckling and stresses in all directions".

Browse through nearly 80 years of *Concrete Quarterly* at concretecentre.com/archive



Photos: Ste Murray

ORIGIN STORY

DEVALERA LIBRARY

KEITH WILLIAMS' PRECAST-CLAD LIBRARY AND GALLERY HAS ESTABLISHED A CULTURAL BASTION ON THE EDGE OF THE HISTORIC IRISH TOWN OF ENNIS

Glór, in the county town of Ennis, is County Clare's flagship arts venue. Since opening in 2001, the 485-seat theatre has played host to everyone from the Irish National Opera to country music legend John Prine. But it always had one slightly unusual feature. "The main entrance was curiously sited, facing away from the park and historic town centre," says Keith Williams, founder and director of London-based Keith Williams Architects. When the practice won a 2015 competition to design a library and municipal art gallery next to Glór, it was an opportunity not just to establish a new cultural nexus, but also to reorientate it towards the town. "It was about improving visibility and really redefining this edge of Ennis."

The result is the DeValera Library and Súil Gallery (meaning "eye" in Gaelic), completed in 2024. The three-storey linear building occupies a narrow site to the west of Glór (meaning "voice"), splaying out like an axe head to the south. The library takes up most of this plan, while Súil sits to the north, nestling against the theatre. Here, a colonnaded entrance portico acts as a new front door for Glór, presenting a welcoming face to visitors walking across from the park. "We wanted to create a new civic frontage that united all three buildings," says Williams. The voice would be joined by the eye and the written word. "We call them the primary colours of the arts – the visual, the literary, and performance."

The main elevations of the new buildings are wrapped in a sweeping 10m-high wall of precast concrete. "Glór is quite a lightweight structure, with areas of render and metal cladding, and we felt we needed to contrast with that. We wanted to show that this was an important civic building that would be around for half a century and more. In Ireland, big public buildings – the courts, churches and bridges – tend to be in pale stone, often Irish limestone. We wanted to continue that tradition, but reinterpret it and make it feel more contemporary."

The single-skin white precast panels are up to 6m x 1.5m – "as big as we could reasonably make them and get them to site" – with a continuous joint 4m above ground level. The upper panels are polished while the lower band is acid-etched with ribbed elements. "The factory conditions allowed us to get incredibly fine jointing details and finishes – the ribbed texture is

BELOW
The white precast panels are up to 6m high. The upper section is polished while the lower band is acid-etched with ribbed elements

very, very finely wrought." The panels curve gently as the facade follows the line of the site, before bending more sharply around the wider southern end of the building.

The question of the role of public libraries in a digital world loomed large over the project. "Fifteen years ago, everybody was predicting the end of the book. That hasn't proven to be the case, but what the balance between books and other types of media will be in 20 or 50 years' time, we can only guess at. Our approach has been to create a host space that allows flexibility and change."

Internal columns have been kept to a minimum, with grids of up to 9.8m x 7.8m. A 250mm-deep two-way spanning slab is supported on 550mm-deep downstand beams, with services running in the raised floor above the slab.

The structure has been left largely exposed, with the downstand beams a defining feature of the interiors. High-quality phenolic-faced boards were used in the front-of-house areas to leave a smooth sheen. Proprietary sleeves were used for the formwork for the round columns, which were cast in single, floor-to-floor pours.

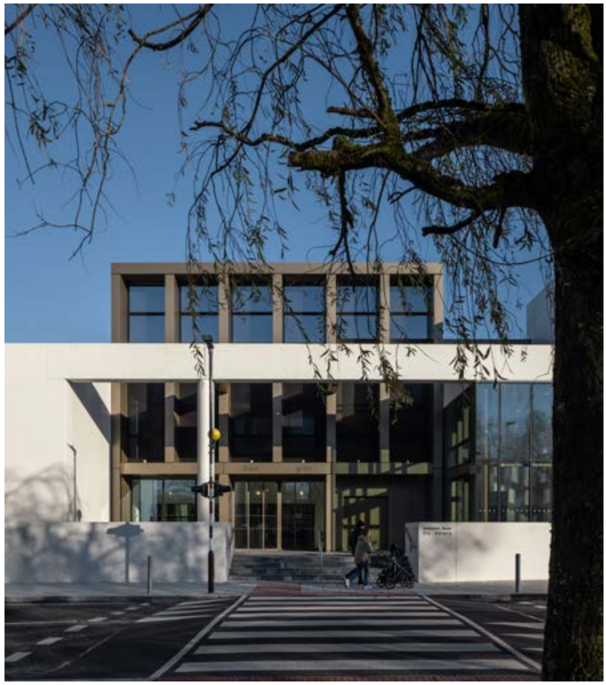
BELOW
The building reorientates the cultural hub back towards the park and town centre. The roof of Glór is visible behind the library

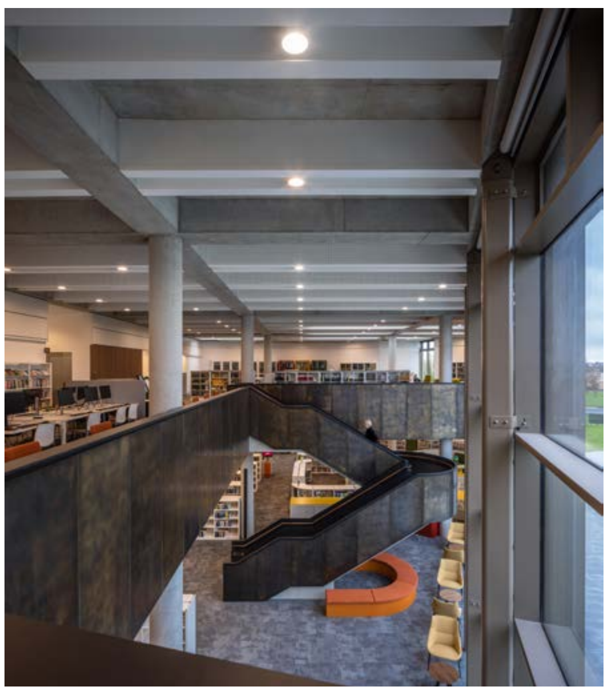
The structural concrete includes locally sourced aggregates and 20% GGBS, in addition to 15% limestone powder, which reduced the cement content of the concrete, and therefore its embodied carbon. This was measured at 750kgCO_2e/m^2.

The thermal mass of the exposed concrete also helps to reduce energy consumption. "We wanted to create an almost entirely naturally ventilated building, and having a structure that acts as a heat sink and cool store is a very good way of doing that," says Williams.

Early indications suggest that, in Ireland at least, the demise of the library has been greatly exaggerated. It regularly receives 800 visitors a day, and over 1,000 on weekends – not bad for a town with 27,000 residents.

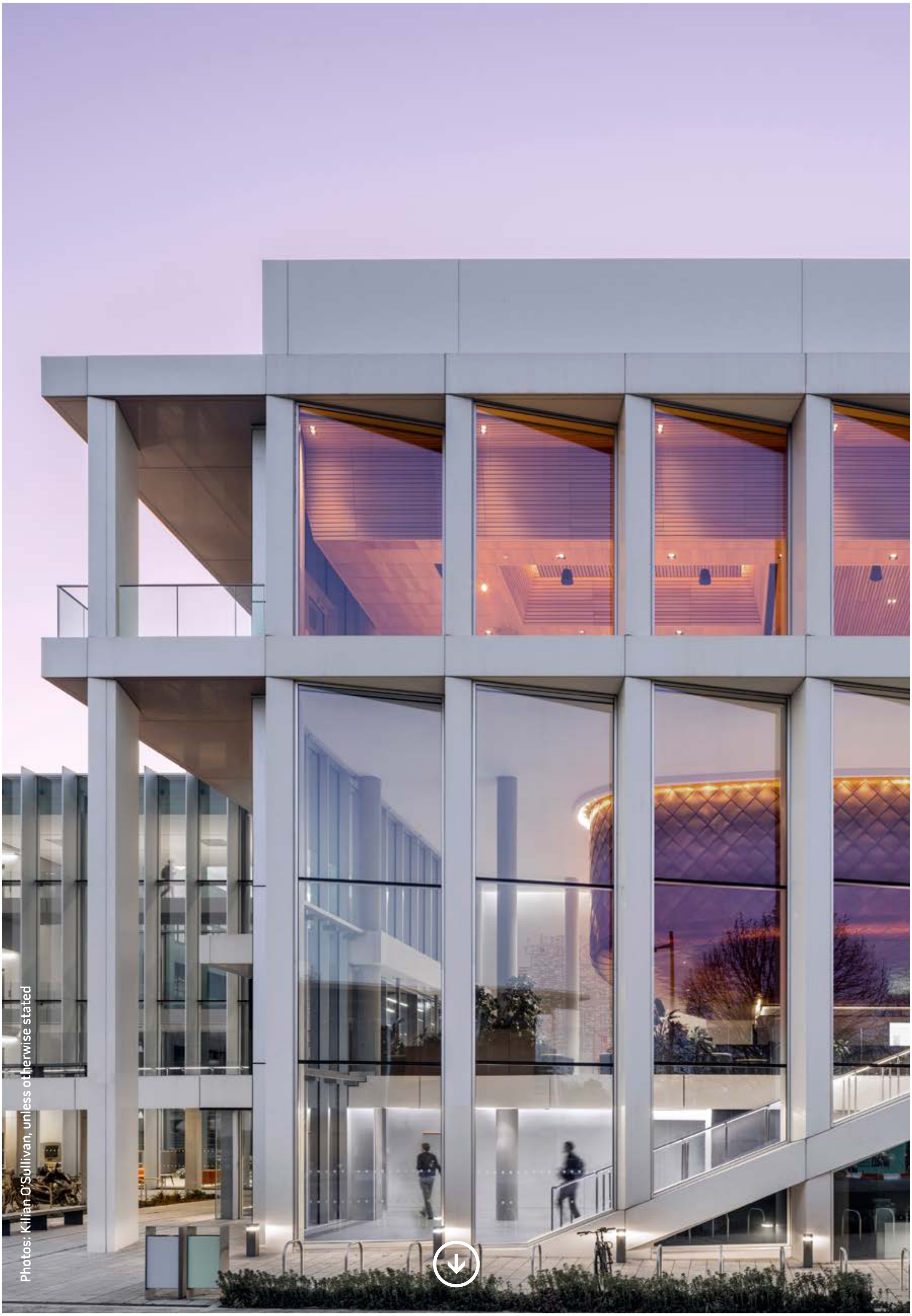
This popularity has had knock-on benefits for Williams: "A couple of months ago, I was staying in a hotel in Limerick, the nearest city. The receptionist said to me, 'My boy loves that building – he plays in it all the time'. And I got an upgrade to a massive suite! Normally you don't want to admit you're an architect in case someone takes a dislike to your building ..." ■





TOP RIGHT
The colonnaded entrance portico acts as a new front door for Glór, as well as the library and gallery

RIGHT
The exposed two-way spanning slab is a defining feature of the interiors



Photos: Kilian O'Sullivan, unless otherwise stated

NO FALSE MOVES

Jestico + Whiles' Ray Dolby Centre in Cambridge is one of the most vibration-resistant environments in the UK, thanks to its rigid concrete frame and raft slab. So how did they make it so flexible?

Photo: Ståle Eriksen

ABOVE
Wide, processional stairs lead up from the park to the entrance plaza and into the reception, elevated to first-floor level

It's the first paradox of laboratory design: the smaller the particles that scientists want to study, the bigger the structures needed to house them. The world-famous Cavendish Laboratory in Cambridge is at the forefront of quantum science, exploring the sub-atomic world in order to unlock the secrets of dark matter and the origins of life itself. It's where Ernest Rutherford split the atom and Crick and Watson decoded DNA.

↓

The Cavendish's new home, however, is at the other end of the physical scale. Designed by Jestico + Whiles, the Ray Dolby Centre occupies a huge plot of land on the Cambridge West Innovation District. Its main frontage stretches for 175m – roughly the length of two football pitches. Turn the corner and it's another 100m walk to the back of the building. The whole thing is wrapped in polished white precast concrete: a rhythmic procession of loadbearing fins in front of the glazed entrance facade, and panels up to 8m x 8m on the side elevations (see box, page 25). "The concrete finishes really came from the brief," says Jude Harris, director at Jestico + Whiles. "The philosophy behind it was always to make it seem like a timeless building."

The huge footprint generates an internal floor area of 33,000m^2 over five levels, housing facilities for 1,100 staff and student. As well as laboratories, these include 260 offices, 16 workshops, six large courtyards, a cafe and library. Visitors enter via a wide, processional stair that leads up to an entrance plaza and on to the first-floor reception, a double-height space dominated by two huge bronze scale-clad lecture theatres. Unusually for such a sensitive research facility, the front of the building is almost entirely open to the public. Anyone can walk downstairs to the ground-floor library, or wend their way up to the top-floor cafe.

But most of all, this is a building devoted to highly specialised lab space. "There are 172 labs, all of which are bespoke," says Marie Chuet, project director for main contractor Bouygues UK. "They all have different specifications. Some of them have very, very high vibration resistance. Some have very strict temperature control, to just 0.1°C. Some are clean rooms where the air is highly filtered." Other areas needed to be completely non-magnetic, requiring the use of non-ferrous stainless steel reinforcement in the slabs and walls (see box, page 27). Some of the equipment is so delicate and finely tuned that areas of road had to be resurfaced to minimise vibrations.

THE CONCRETE FINISHES CAME FROM THE BRIEF. THE PHILOSOPHY BEHIND IT WAS ALWAYS TO MAKE IT SEEM LIKE A TIMELESS BUILDING

The most controlled environments are in the basement, where a raft slab with a thickness of up to 3m has reduced vibration frequencies to a level more than 100 lower than a hospital operating theatre (see box, page 30). But with nearly 7,000m² of labs to accommodate, the architects have had to place highly sensitive equipment throughout the building. At the same time, these spaces needed to be extremely flexible – a theme that emerged consistently from the in-depth interviews that the design team carried out with the Cavendish physicists. "Every lab will change on average every seven years," says Lynden Spencer-Allen, director at structural engineer Ramboll, and a specialist in the design of laboratory buildings. "And the science that they're doing in 15 years could be extremely different to what they're doing now."

Such exacting criteria could best be achieved with an in-situ reinforced-concrete frame of flat slabs and columns, says Spencer-Allen. "It's the mass, the stiffness, the flexibility of the slabs." The typical structural grid throughout the building is a relatively small 6.8 x 7.2m, but this ensures that the frame remains rigid, so labs can be located on higher levels. The flat slabs allow services to be reconfigured without the risk of running into downstand beams. Upper floor slabs are typically 300mm deep, but this rises to 475mm in areas where vibration control is critical, and 700mm for the ground-floor slab. Spencer-Allen points out that the short spans ensure the floorplates are as

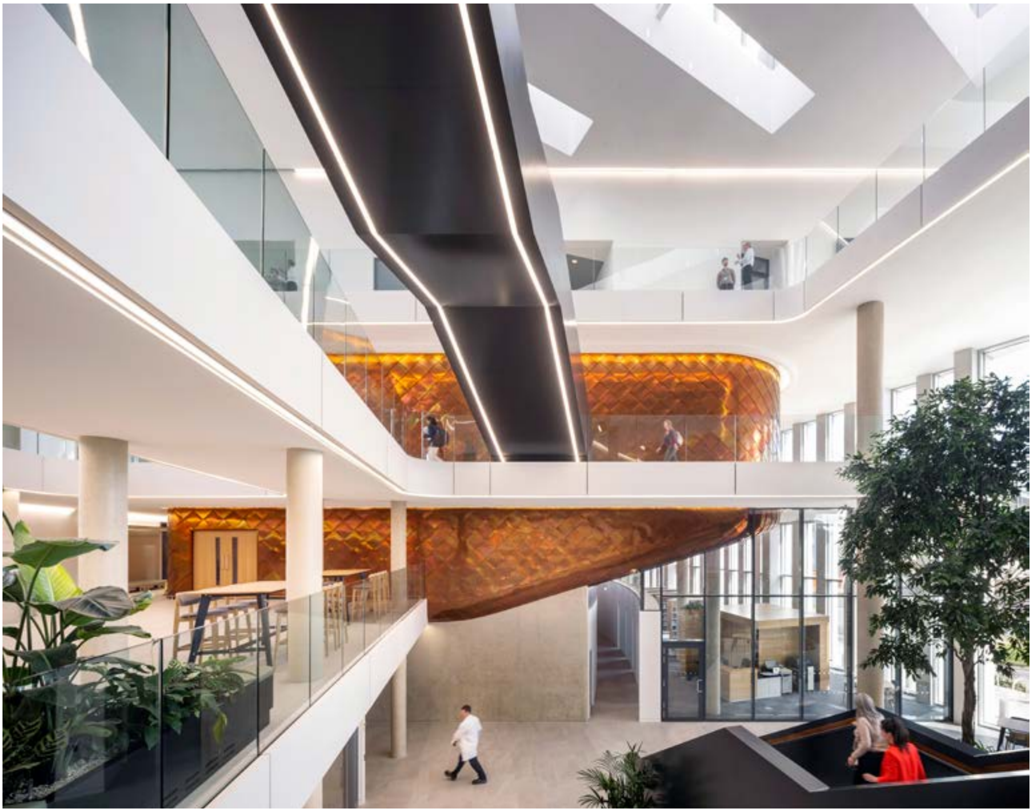
Photo: Ståle Eriksen

ABOVE
The building includes 710 cycle parking spaces. Most are concealed beneath the raised entrance plaza to maintain a clear active frontage

ABOVE
The large central courtyard is raised to second-floor level, above an interstitial service floor. Gentle mounds create sufficient soil depth for small trees

material-efficient as possible. A 50% GGBS mix in the slabs also helps to reduce the carbon impact – a crucial factor for the university, which is aiming to reduce its carbon emissions by 72% between 2016 and 2030.

The Dolby Centre may look like one enormous building, but it is actually nine independent structures. "The challenge was that we've got super-sensitive equipment and also equipment that produces a lot of vibrations, so separation is our friend," says Spencer-Allen. The building is divided into four parallel wings, each 28m wide, with the public zone in front. Each of the four wings has its own central utility building (CUB) – a lightweight four-storey volume that is plugged into the back of the building like a power pack, but structurally isolated with a movement joint. The CUBs feed each wing laterally across the soffits, with pipes and ductwork semi-hidden behind mesh ceiling panels. There are no vertical risers,



ABOVE
Two bronze-clad lecture theatres hang over the public entrance space

which again helps to reconfigure space. The ceiling panels are hinged for easy access, and the deep voids have been designed with spare capacity.

It is perhaps unavoidable that basement labs – windowless and sterile – have a dystopian feel. But this made it all the more important that the rest of building should feel open and connected, says Harris. "We wanted to put science on show. No one in this building should feel hidden away."

The public zone is a light-filled space, with fair-faced concrete walls and slender cylindrical columns. Various types of formwork were trialled, including marine plywood, phenolic-coated plywood and cardboard. The chosen system for the walls comprised metal shutters coated with vegetable oil, leaving a smooth finish, while the columns were cast using cardboard sleeves. The architects and contractor worked closely to benchmark the finishes, tie holes and joints – particularly the

Photo: Ståle Eriksen

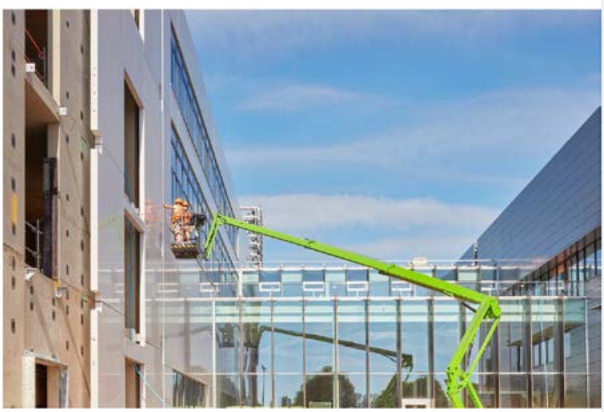


Photo:Paul Raftery

LET IT SHINE

Cladding the Cavendish

One of the most striking aspects of the Ray Dolby Centre is its almost gleaming white precast concrete facade. "We worked closely with Jestico + Whiles to achieve that polished finish," says Bouygues UK's Marie Chuet. The first panels were installed almost five years ago, and are still impressively white – a product of their fine white marble aggregate, white cement and five different grades of polishing: "The elements don't really stick to it."

In order to define the finish and establish a benchmark, the team built an 8m-high mock-up. "It was a two-storey cube, which allowed us to finalise the interfaces, connections and lifting details, and get validation from all the stakeholders – the architects, the university, the planning officers. Everybody was really interested in that finish."

The lifting details were of particular importance. In keeping with the scale of the building, the largest panels are 8m x 8m and weigh about nine tonnes. "Every move of every panel had a method statement," says Chuet. Some required two cranes to lift them into place.

In total, the facade comprises 1,000 panels, with 200 different sizes. "We have the fins that clad the columns, horizontal elements that act as brise-soleils, and big internal panels with cutouts for lift buttons. Every single one of them was uniquely poured and uniquely labelled."

ABOVE
The larger of the two lecture theatres is part of the in-situ concrete structure. It is supported on slender columns that rise up through the library

connections at the base of the walls, which have no visible kicker.

The bronze lecture theatres are both suspended from the frame. The smaller of the two, which hangs over the reception desk, is a lightweight structure, its weight carried to the ground via columns embedded in the precast fins on the main elevation. The larger 400-seat hall was cast in situ. The loads are transferred over the hall to the perimeter via 1.5m transfer beams, leaving the theatre largely column-free.

Behind the public zone, the above-ground workspaces are easily navigable and connected to the

A FORCE TO BE RECKONED WITH

How to build a non-magnetic reinforced concrete structure

A cryostat is a specialised cooling system that allows experiments to be carried out in temperatures as low as –150˚C and without magnetic interference. This posed a challenge for Bouygues UK during the construction of the ground-floor cryostat hall: how do you build a vibration-sensitive concrete structure without magnetic steel reinforcement in the slabs and walls?

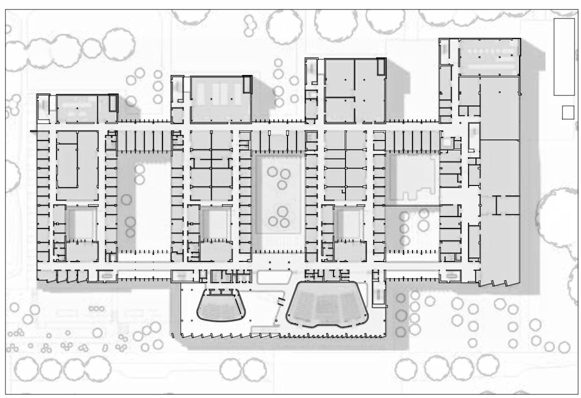
"We initially thought we could coat the rebar in epoxy," says Bouygues' Marie Chuet, "but we carried out some tests with the Physics department professors and they said, 'Nope, not good enough'." The only option that would not disrupt the scientists' work was a very specific grade of "austenitic" stainless steel, with high levels of nickel and chromium which alter its crystal structure. "The ties had to be stainless steel too, as even these would show up on the readings," adds Chuet.

The properties of austenitic stainless steel differ crucially in a number of areas. "It is not as ductile as normal steel, so it doesn't react to bending tools in the same way." Moreover, its magnetic strength can actually increase if it is bent or welded in the wrong way. The manufacture of the reinforcement was therefore a highly specialist task, requiring initial fabrication in Italy, then shaping at a specialist facility in Ireland. From there, it was delivered to site, where it was assembled and the physicists tested the magnetic fields one last time before the walls and slab were finally poured.

Photo: Paul Raftery

LEFT AND BELOW
The laboratory is divided into four wings, each served by its own structurally isolated plant building

Photo: Ståle Eriksen



outside world. A simple circuit of 3m-wide corridors – enough space to move laser tables and gas tanks between labs – wraps around the four wings, each ending with a full-length window so there are no dead-ends.

The wings are separated by three large courtyards, landscaped with gentle mounds to create sufficient soil depth for small trees to grow. At third floor level, three more smaller courtyards are cut into the plan, so all the offices have external windows. In total, the building contains 3,000m^2 of outdoor space, assisting with orientation and drawing daylight deep into the plan.

While the courtyards are used to generate visual connections, they're part of the separation strategy too. The central courtyard sits above a concealed interstitial floor that serves the basement clean rooms, while another acts as a buffer zone for the electromagnetic fields emanating from the labs below.

The upper-level courtyards also help to naturally ventilate the offices. Windows facing into the courtyards can be left open overnight, purging the heat built up during the daytime. The soffits and other exposed areas of the concrete frame contribute to this passive approach, acting as a sink for heat or coolth, depending on the season.

Photo: Ståle Eriksen

As you might expect from a building with some of the tightest temperature controls in the UK, the Dolby Centre is highly serviced, with a peak energy load of 220W/m^2. But the designers have worked hard to mitigate consumption and earn a BREEAM Excellent rating. As well as natural ventilation to the offices and workshops, a ground-source heat pump, sustained by a 20,000m^2 network of boreholes, provides all of the heating for both the Dolby Centre and the neighbouring West Hub (CQ 280, Autumn 2022).

The linear park between the two buildings is maturing into a welcoming green space amid the temples of science – Chuet points out that 107 trees have been planted during the project. Even during this summer's heatwaves, the plants are thriving and scientists have been lured from their labs to grab a coffee and loll on deckchairs. It's beginning to feel like a part of the city. That's the second paradox of laboratory design: the bigger these facilities get, the more human they become.

ABOVE
More than 100 trees have been planted on the development, which includes a number of rain gardens, pocket parks and a large green space between the Dolby Centre and the West Hub

Photo: Bouygues UK / Amosu Oladotun

UNSHAKEABLE

Designing and building the UK's most solid slab

The basement of the Ray Dolby Centre has a good claim to being the most immoveable object in the UK, with a vibration rating of VC-H. To put this in context, vibration levels are measured on an exponential scale: VC-A refers to movement of 0.001mm per second (suitable for a general-use laboratory), VC-B is twice as low again, and so on. Most highly sensitive labs – such as the clean rooms at the National Graphene Institute in Manchester – are VC-D or E rated. VC-H is eight times lower even than that.

The key to this completely motionless state is the 50m x 30m basement raft, the eastern half of which is 2m thick, with some key areas as deep as 3m. Structural engineer Ramboll knew that if it got this slab wrong, the highly specialised microscopy labs above would fail to perform as specified. In a project with a £300m pricetag, that put quite a lot of pressure on their calculations.

Ramboll took borehole readings at 2m intervals down to 10m in order to understand the vibration profile of the site – a former meadow on a 25m-deep layer of Cambridge Gault clay. There were a number of concerns, including traffic along the nearby M11. The origins of a persistent spike in the measurements was found to be a speed hump on a bus lane, which had to be removed. The survey found that a depth of 8m was the sweet spot, with ground-level vibrations having dissipated. "Any deeper than that and you start to get diminishing returns."

Although a 2m-thick raft might sound like a lot of concrete, Spencer-Allen points out that it's more material-efficient than a piled option. The vibration analysis also enabled the team to optimise the depth of the slab, which slims to 1m beneath less sensitive zones.

A $10m^2$ test slab was poured, 8m deep, under what would become the entrance plaza. "That gave us the proof of concept," says Spencer-Allen. A testing regime was devised alongside the University of Southampton so that vibration could be continuously monitored throughout the project.

Pouring the basement slab brought challenges of its own. "The biggest risk was that cracks would develop because of the thickness of the slab," says Vlad Balanescu, civils project manager at Bouygues UK. "Even micro cracks can allow vibrations to pass inside the building."

A special mix was developed with 70% GGBS to allow the concrete to cure more slowly, and throughout the curing period, sensors closely monitored the difference between the core and bottom of the slab. "We installed tubes in the thickest parts of the slab to circulate cold water, and added ice to the concrete. When the ice company arrived, they thought it was for a pool party. They were a bit surprised." ■

PROJECT TEAM

Architect Jestico + Whiles
Executive architect NBBJ
Technical architect Jacobs
Civil and structural engineers Ramboll, BDP
Main contractor Bouygues UK

Photo: Ståle Eriksen

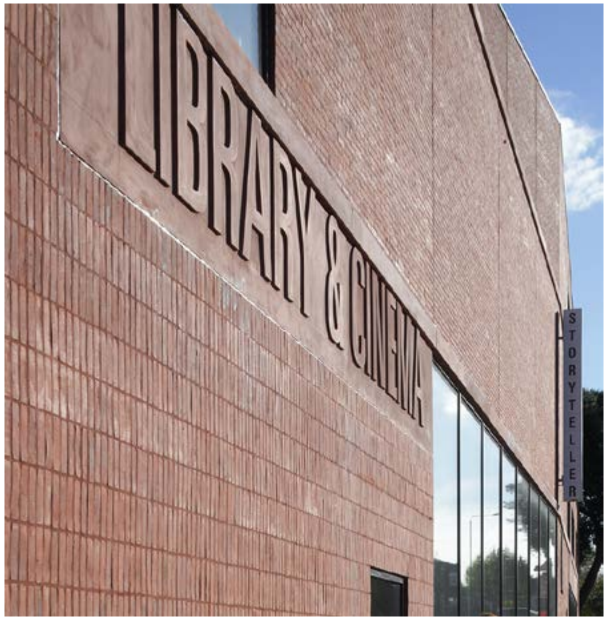
A KIND OF HUSH

At Sidcup Storyteller, which has won a RIBA National Award, DRDH Architects has used an in-situ concrete frame to separate and organise different functions within a library-cinema-housing hybrid.

Acoustically speaking, it would have made sense to put the cinema on the ground floor. "But as a public building, it was really important that the library came first," says project architect Paolo Scianna. "The frame was critical to achieving sound isolation. They can be playing a blockbuster upstairs and you can't hear it in the library at all."

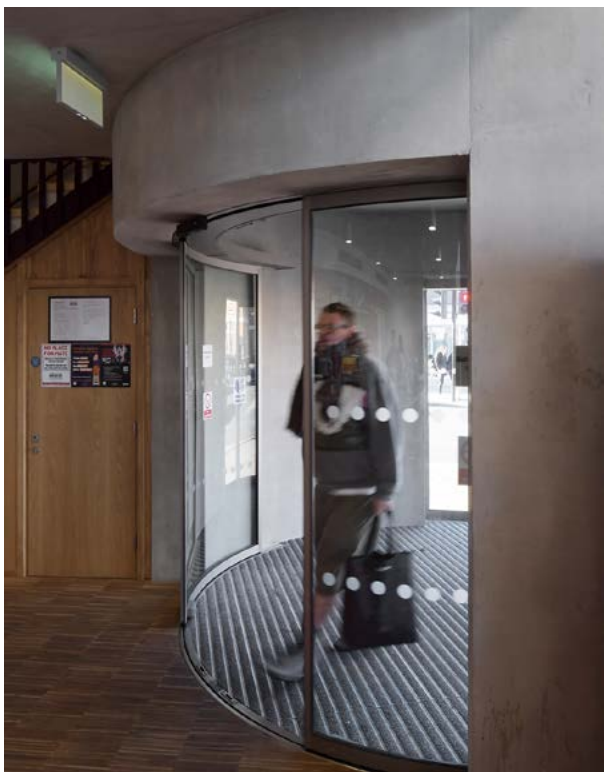
Large swaths of the structure have been left exposed internally;

Photos: David Grandorge



these elements were cast with MDO plywood formwork. A 40-50% GGBS mix was used throughout, which has lightened the concrete, as well as helping to reduce embodied carbon. The use of a coffered slab also meant floor depths were reduced by 25mm to 225mm.

On both the front and side elevations, the words “Library & Cinema” have been cast in, raised in relief from the precast concrete panels by 20mm. “We were thinking about high streets and permanence, and these buildings that still declare their function from a long time ago. Even if the function changes in the future, you always have this memory.”



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concretecentre.com/cq

TIGHT CORNER

Juniper House is a 91-home council-led development in Walthamstow, north London, which also squeezes a nursery and university facilities onto a triangular 0.4ha plot. "It was unbelievably constrained," says Justin Laskin, partner at architect Pollard Thomas Edwards.

The building had to be built with just one crane. The frame was in-situ reinforced concrete, while the facade includes very small precast and GRC elements: "The limit was always what two people could lift on site."

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concretecentre.com/cq

Photos: Nick Kane

OBJECT LESSON

Designed by de Blacam and Meagher Architects, St Paul's School in Monasterevin, County Kildare, is a dynamic sequence of voids, overlaps and roof lanterns.

The architects have given a rhythm to the corridors by inserting a roof lantern every 14m, directly above a pair of classroom doors. There are 12 lanterns in total, each 5m x 4m in area and rising 6m above the first-floor landings. The size of the structures allows daylight to flood in, framing the classroom entrances and spilling down through the voids to the ground-floor corridors.

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Photos: Peter Cook

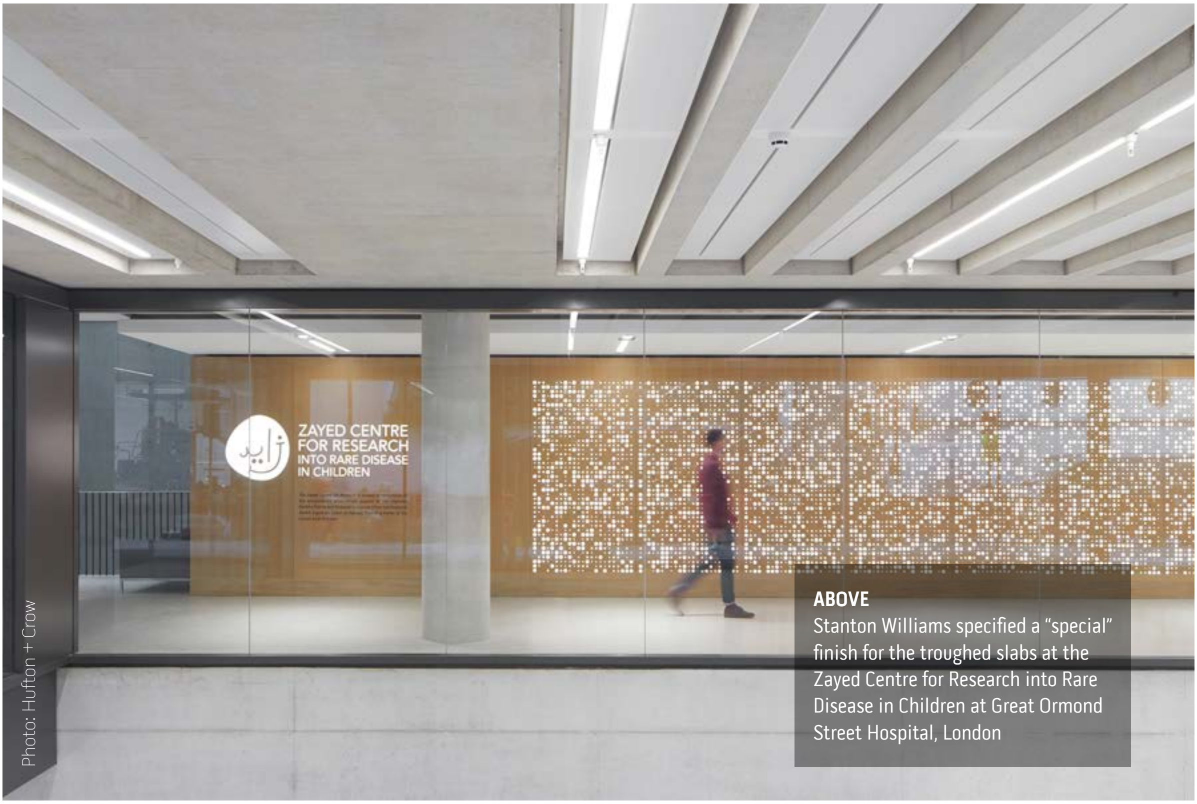

Photo: Hufton + Crow

ABOVE
Stanton Williams specified a "special" finish for the troughed slabs at the Zayed Centre for Research into Rare Disease in Children at Great Ormond Street Hospital, London

National Structural Concrete Specification fifth edition

The latest edition of the concrete frame specification includes detailed guidance on embodied carbon and visual concrete, and an all-new online interface to make it even easier for the whole project team to use. By Katie Puckett

The fifth edition of the National Structural Concrete Specification (NSCS) has just been launched – a comprehensive template covering every aspect of a concrete frame, from loads to reinforcement to finishes.

It's a significant update on the fourth, which was released back in 2010. Since then, embodied carbon has become a more urgent priority, many heads have been scratched about exactly what a "plain" finish should look like, and project documentation has moved from paper to the cloud. Just like its predecessors, the fifth edition is free to use and was developed through collaboration between clients, designers, contractors and concrete producers. Among the changes are compulsory environmental product declarations (EPDs), more detailed guidance on visual concrete (see page 41), and a brand-new online interface.

Paul Toplis, consultant at Price & Myers, was lead editor for the fifth edition, and worked on the fourth and third editions too. "The NSCS was originally developed because people wanted a really useful building specification, and to avoid having lots of different ones, all produced by different practices," he says.

At tender stage, contractors have limited time to get to grips with a specification and communicate it to their subcontractors, he points out. "Often people forget that the specification is a tool for everybody – that's why we've tried to make the NSCS feel as collaborative as possible."

Toplis remembers the wise words of the previous editor, the late Julian Maw. "He used to say that you have to be careful about writing specifications based on scars of things that have gone wrong in the past. That's why the NSCS is produced not by specification experts, but by a team of people from across the building industry, and hopefully enough of us to make sure it is balanced and fair to all parties."

As well as 15 years' worth of technical updates, the fifth edition reflects industry shifts. The proliferation of logistics warehouses and data centres is recognised in the tolerances section, with new "free movement" or FM clauses that separate the flatness of concrete floors from other surfaces – telehandlers, robots and server cooling equipment all require extremely level floors. Meanwhile, the growing use of offsite construction has been accommodated in the visual concrete specification, with sections on aspects such as lifting points.

One of the most significant areas of continuing evolution is sustainability. Arup associate Tilly Langley says that this is now woven throughout the fifth edition. "The industry knows it needs to change, but we can't do it overnight, so we're starting with some general nudges and ways we can help people to benchmark sustainability."

The NSCS is intended to raise the overall standard, and support smaller consultancies, by making some best practices the default. For example, rather than always specifying design strength at 28 days after casting, 56-day strength is now an option. "That's great for piles and pile caps and rafts which might not be loaded straight away," says Langley. "On one of our projects, we saved over 15% of the cement and a lot of material by changing the concrete mix and the structural layout."

It also requires that any product, component or constituent material within concrete has an EPD. "That means suppliers have to report, and that specifiers might notice that supplier A's EPD is much better than supplier B's, and decide to specify that instead."

Compared with 2010, today there is a much wider range of lower carbon concretes, including ternary blends with two different cement replacements, introduced in the most recent update of BS 8500. The fifth edition is aligned with BS 8500 so it includes these, and will allow the use of new components as they become available, such as calcined clay. There is scope to set an agreed maximum permitted embodied carbon rating, based on industry benchmarks. This is intended to shift the emphasis away from specific ingredients – for example, GGBS – and allow concrete

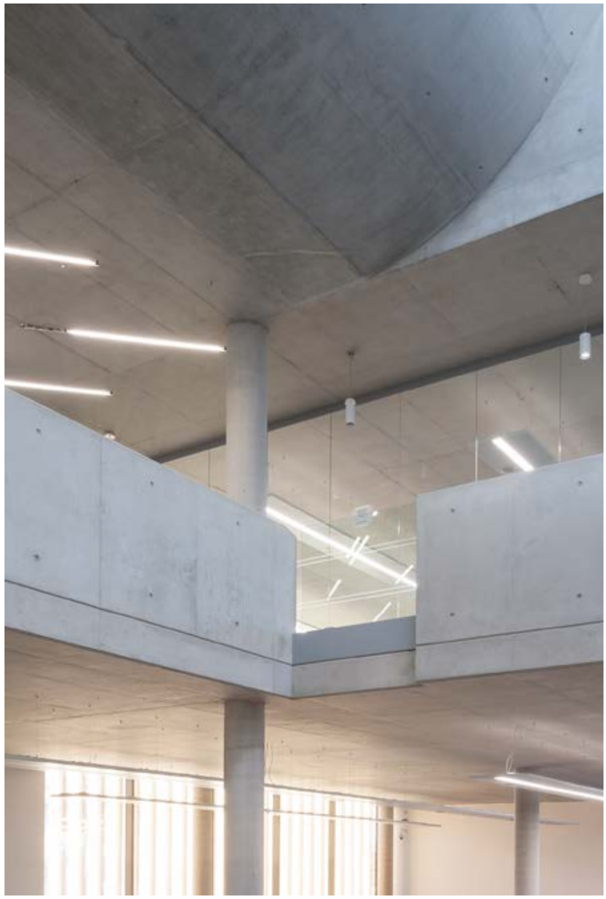

Photo: Andy Matthews

ABOVE
East Ham Civic Centre by Rick Mather Architects. Columns were specified with a "plain" finish while the soffits have a "special" finish

contractors and suppliers to find the best possible solution.

As for the sixth edition, there will never again be a 15-year wait. The advantage of being online is that the specification can be continually evolved and improved, as standards are updated or to add new features. One that is currently under development is a way of highlighting changes to a specification, and labelling them by collaborator. That will save people having to scrutinise two versions of a document to see what's different, says Toplis, and it will avoid misunderstandings and mistakes. For example, the contractor might adjust a mix depending on whether it is to be placed by skip or by pump. From the designer's point of view, the concrete will be almost exactly the same, but it's a crucial piece of information for the concrete supplier, so they need to know the request came from the contractor, he points out. "It's not that people don't try to understand, or they're difficult, it's just that sometimes we don't know what happens along the chain of communication from the top to the bottom of the industry."

Photo: Rob Parrish

ABOVE
At Moss House, University College Birmingham, Glenn Howells Architects and concrete contractor Thames Formwork spent about three months testing the specification with different suppliers and different formwork. The chosen mix was a 55% GGBS concrete, light in tone, cast against a laminate-faced board

How to use NSCS fifth edition

The NSCS is deliberately simple to use. It follows the same structure as the European standard EN 13670 on the execution of concrete structures, so that the two can be easily compared side by side. Several key format changes to the fifth edition are intended to make it even more accessible.

The fourth edition was in book form, and consisted of standard and project-specific specifications. The fifth is compiled online, displayed as a split screen, with the main specification text in the left-hand column, and the relevant guidance alongside on the right. It can be viewed either as a complete specification containing standard and project-specific clauses, or as a list of project-specific information only.

The combined view could be helpful for newcomers to the industry, says Toplis. "You can see the context really easily, and you've got the guidance as well. That's a very powerful tool to bring you the best thinking on any particular topic as you're entering the information for your project."

But it's also important for those receiving the specification to be able to quickly see what's different from the norm: "Otherwise, there's a danger that people might miss it. If you don't understand at tender, that doesn't help further down the line when you're trying to build a team where everybody is pulling together to produce the best building for the client, not watching their own backs."

Missing information will also stand out much more clearly online: "On screen, it will say "type text here", or it will show a blank on the PDF export. It might be that it doesn't matter and the answer is 'normal', 'none' or 'not applicable', but quite possibly it may matter and somebody has just forgotten about it."

The specification is both free to use, and to store on CONSTRUCT's cloud. Designers create an account on the CONSTRUCT website (nscs.construct.org.uk), and click "Create New Project". They will then be taken to an online template, to which they can invite collaborators, or export as a PDF.

Photo: Mark Harrington / AKT II

ABOVE
A "special" finish was specified for the structural trees at the Marshall Building, London School of Economics. A mock-up helped Grafton Architects and concrete contractor Getjar to refine the specification, improving the finish by changing the release agent. "Plain" soffits were specified on the upper floors

Photo: Jack Hobhouse

Specifying visual concrete using NSCS

ABOVE
The Salvation Army HQ in south London by Tatehindle. The exposed surfaces were specified to be "C – fine smooth" under BS 8110, the relevant standard at the time, equivalent to NSCS "special"

When is a plain finish not a plain finish? That's one of the perennial questions that compilers of the fifth edition of the National Structural Concrete Specification have set out to resolve once and for all. "There's quite a lot of ambiguity in visual concrete," explains Paul McNamara, pre-construction manager at concrete contractor Getjar. "It's like describing something as 'grey' – it doesn't tell you very much."

At the heart of the issue is that an architect's perspective of visual concrete may be very different to the specialist contractor or concrete producer who is responsible for achieving it. Every aspect of the build will affect the desired finish, from the mix to the formwork to the vibration technique.

It is also very hard to describe in words, which has made previous specifications prone to misinterpretation. Colour is a common area of disagreement: "The spec might say 'uniform colour' but what is the uniform colour in concrete? It's never all one colour. Plywood and board layouts are another one. It might just say 'regular and even', but that could mean many different things to different people without further discussion."

The task for McNamara's visual concrete working group, consisting of architects, engineers and contractors with experience of delivering visual concrete, was to come up with agreed definitions – essentially, to rehearse all possible arguments so that future teams using the NSCS wouldn't have to. "We spent many sessions debating what's inherent – like natural variations in colour – and what's avoidable, like big blobs of dark grey concrete where the pump has been washed out in the middle of a pour." Some blowholes are inherent; honeycombing is a blemish.

The result is an optional visual concrete appendix, in the form of an interactive, step-by-step guidance document with prompts for every element of visual concrete that needs to be considered. Specifiers are encouraged to include visual examples and drawings, and contractors to provide samples, benchmarks and mock-ups.

One of the biggest topics was how to distinguish between a "plain" finish and a "special" one, the two classifications for visual concrete. Plain means a good quality, consistent finish, free of major blemishes – but it is a standard specification, not a customisable one. As soon as there are any specific requirements, that becomes a special.

"Architects are reluctant to ask for a special, as they think it'll be more expensive. So they say, 'we just want a plain finish, but we'll give you the plywood layout'. But that's then not a plain, it's a special. The problem is that if you start by calling it a plain, the contractor may stop listening and miss the fact that you want them to deliver it to a formwork layout."

The visual concrete specification is now presented in tabular form, allowing the architect to be more prescriptive, within the limits of each class.

Planning is key to achieving good visual concrete, says McNamara. That includes post-finishing, which should be embraced as a fact of life – many architects have horror stories of poor "making good" so they demand concrete be "as struck". "But post-finishing is nothing to be scared of when it's done well. It's an essential tool in producing good visual concrete, and not necessarily because the contractor's done a bad job.

Photo: Nick Kane

ABOVE
Pigmented concrete, such as the mix used on the precast facades of 333 Kingsland Road by Henley Halebrown, is always classified as a "special" finish. The growing use of precast elements is reflected in the NSCS, with new sections on visual aspects such as lifting points

Photo: Rob Parrish

It might get damaged during the build process, or in two years' time when the building is in use. Remedial works can be done very well, but they should be talked about and planned for."

Architects also need to be aware of the additional costs and time incurred by overspecifying – is a plain finish really necessary in a back-of-house plant room, or would an "ordinary", non-visual finish do the job? "Or maybe you're asking for 1mm steps between panels instead of the standard 3mm step, which is very difficult to achieve. The plain spec is there for a reason – it's achievable."

Ultimately, the fifth edition of the NSCS is intended to level the playing field, says McNamara. "We've tried through many, many workshops to bring as much definition as possible, so that everybody is very clear on what is expected. That way, the client knows what they're paying for, the architect is clear about what they want and what they will receive, and the contractor should be able to price, programme and deliver it correctly." ■

For examples of visual concrete projects with plain and special finishes, go to www.concretecentre.com/Specification/Visual-Concrete/Visual-concrete-example-projects.aspx

ABOVE
A "special" finish was specified for the waffle beams and slabs above the council chamber at Tower Hamlets Town Hall. Concrete supplier London Concrete produced a number of trial panels in order to benchmark the colour and finish, working closely with architect Allford Hall Monaghan Morris

FINAL FRAME: VET HOSPITAL TIRANA

Davide Macullo Architects has completed a 712m² animal healthcare complex in the Albanian capital. A series of loadbearing curving walls, made from reinforced concrete, create a fluid interior, with open areas, large treatment rooms and separate circulation zones for different species. The external walls support landscaped terraces, which serve as quiet, therapeutic spaces for the patients.

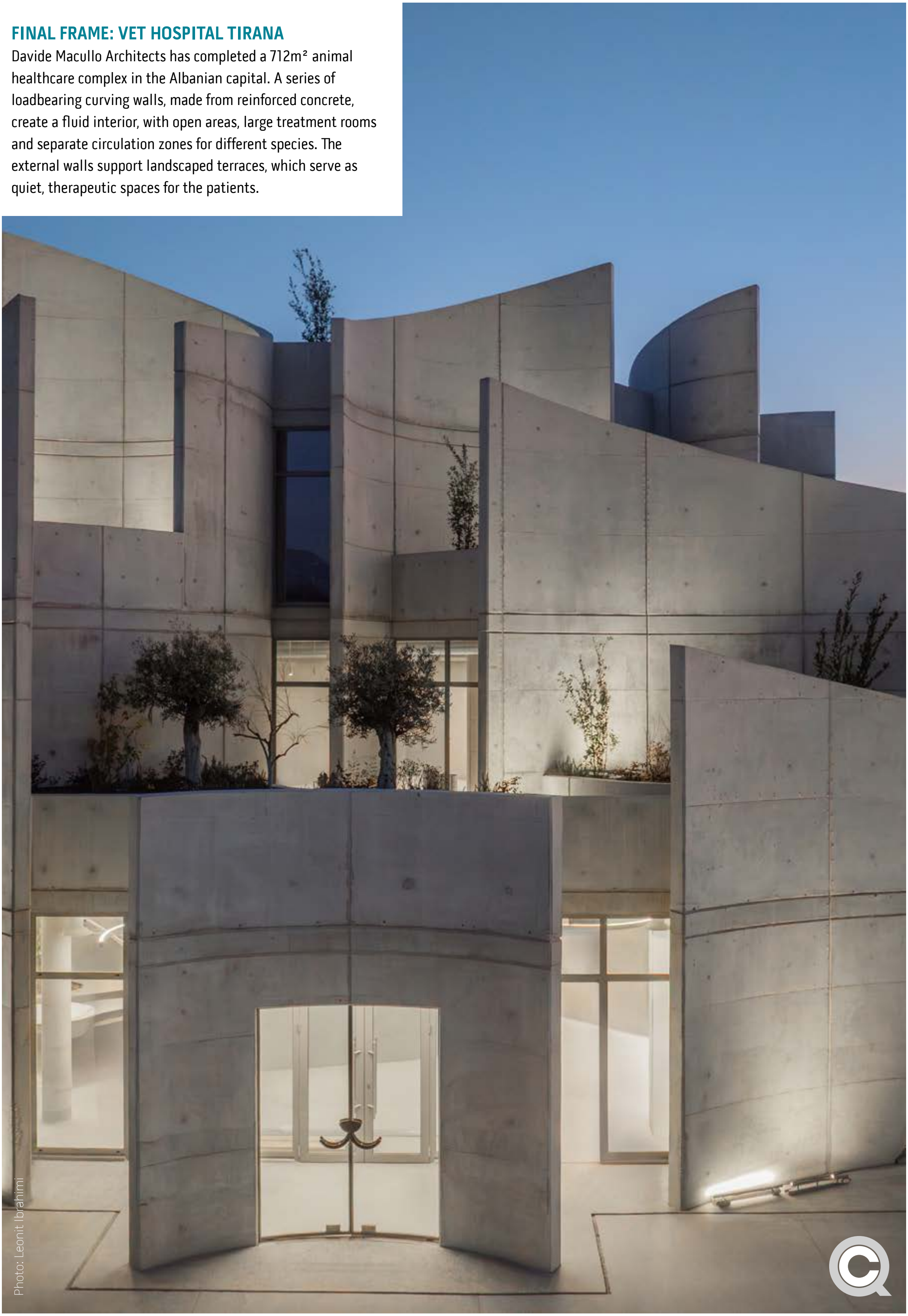

Photo: Leonit Ibrahimi