CONCRETE QUARTERLY

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Elaine Toogood
Director, architecture and sustainable design, The Concrete Centre

That net-zero look

At The Concrete Centre, we've just completed a six-week programme of events that featured the launch of the UK concrete industry's sustainable construction framework. It's been full-on and focused on many different facets, from lowering embodied carbon and maximising material efficiency, to how concrete fits into a circular economy and the contribution it makes to social outcomes and biodiversity. (You can find recordings of all the sessions at concretecentre.com/sustainabilityseries2023).

So, having had my nose in the detail for the last few weeks, it's been refreshing and inspiring to turn to CQ and be reminded of just how gorgeous concrete can be. In the right hands, this material can provide so much architectural expression, through its sheer range of forms, colours, tones, textures and patterns. For an ample demonstration, look no further than the richly varied detailing of our twin headliners at the UCL East campus, Stanton Williams' Marshgate and One Pool Street by Lifschutz Davidson Sandilands (pages 16-29).

For me, this is also a reminder that quality is part of sustainability too, and how our buildings aren't just there to protect us but to help us thrive. A truly sustainable building is one that will last, and to last it has to be loved. It has to stand the test of time not only physically, but in every other way too.

As architects, we really need to understand building materials in order to use them to their full potential. There isn't one type of any material, least of all concrete – one of its paramount strengths is that it can be formulated to meet the specific requirements of a project, whether aesthetic or performance or endurance.

This is what makes it endlessly adaptable and such a fantastic canvas for creativity.

Concrete formulation is the scene of rapid evolution, as the industry works towards the goal of net-zero emissions. Our Application feature (pages 34-39) explains some of the supplementary cementitious materials and alternative binders that are becoming available or are in development – blends that have lower embodied carbon, but also bring other performance benefits and are suited to different applications and exposure classes, depending on their chemistry. I'm looking forward to seeing what aesthetic possibilities new cements might offer too – wider use of clays might lead to pinker tones, for example.

To deliver the high quality that's vital to creating buildings that people love – and continue to love – we need to make sure that the materials we choose today are the right ones for the challenges they will have to stand up to in the future. Specifying concrete encourages designers to delve into technical detail – but it doesn't have to be daunting. There is plenty of support available for specifiers, from manufacturers and through The Concrete Centre's publications and events.

The sustainability agenda is changing construction rapidly and permanently. I am excited and optimistic about the architecture that it will deliver.

BUILDINGS AREN'T JUST THERE TO PROTECT US BUT TO HELP US THRIVE. A TRULY SUSTAINABLE BUILDING IS ONE THAT WILL LAST, AND TO LAST IT HAS TO BE LOVED

CONCRETE QUARTERLY

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One Pool Street, UCL East, by Lifschutz Davidson Sandilands. Photo by Paul Riddle

Photos: Chiara Becattini, Mike Cartier

INNOVATION

ESSENTIAL HOMES

MATERIAL IMPREGNATED WITH CEMENT IS THE KEY TO THIS PROJECT TO CREATE DURABLE, WATERPROOF HOMES FOR REFUGEES. JUST ADD WATER

A small, unusually shaped concrete dwelling is attracting attention at the 2023 Venice Biennale of Architecture – the result of a partnership between the Norman Foster Foundation and Holcim. Designed primarily in response to the global refugee crisis, the Essential Homes project offers a sturdier, longer-lasting alternative to the tents traditionally used as emergency or temporary accommodation.

"It is estimated that there are currently some 100 million displaced people in the world," says Christophe Levy, scientific director of the Holcim Innovation Center near Lyon. "But whether as a result of geopolitics or natural disasters, their need for

WE WORKED WITH SIR NORMAN FOSTER TO SEE IF WE COULD CREATE INEXPENSIVE ACCOMMODATION THAT WOULD ALSO PROVIDE COMFORT, DIGNITY, AND LAST MUCH LONGER THAN A SIMPLE TENT

emergency shelter is often long term: years or even decades.

"So we worked with Sir Norman Foster to see if we could create inexpensive accommodation that was quick and easy to build, but which would also provide comfort, dignity, and last much longer than a simple tent."

The key to the Essential Homes structure is CCX: a cement-impregnated material manufactured by UK-based firm Concrete Canvas. Supplied on a roll, the product can be placed over a frame, formwork or even inflatable shapes, and then simply sprayed with water to create a hard concrete shell.

"It is a brilliant product and I wish I could say Holcim had developed it,"

says Levy. "It comprises geotextiles sandwiching a layer of high-density cementitious mix with a little sand. The magic in the design is the way in which absorbent polymers – like those used in baby diapers – retain water so that you do not have to be too careful when activating the concrete. Just hose it down and the polymers optimise the water-to-powder ratio, ensuring the concrete is always perfectly hydrated."

The example home in Venice measures 9m x 6m and is 3.4m high. The structure comprises a steel frame supporting a permanent formwork of 600mm-thick corrugated cement board, curved into a catenary shape. Six 1.5m-wide strips of CCX were layered over this

and sprayed with water to create a 103mm-thick outer shell.

One of the original and still the most popular uses of CCX is to line irrigation channels, Levy says, so it is ideal for making the temporary home waterproof.

The vertical ends of the structure, one of which is inset to create an entrance porch, are made from Holcim cement board, and the company also supplied a lower-carbon cement for the CCX. Around 20% of the cement content has been replaced with limestone.

Levy and his team are now thinking about how the design could be developed further. "It could easily be made longer. It is simple to cut doors and windows in the thin concrete. It could interconnect with other such structures. Maybe it could be made higher, with a mezzanine. Already the whole structure can be recycled – but I think we could work towards making the frame removable so it can be reused. When you go inside this building, it is a really pleasant environment with good headroom, natural light and storage at each side. To create a small home like this, in just days, with unskilled labour and for around €20,000 – the potential, I believe, is very great."

And as for CCX: "There is so much you can do with it. I recently visited the slums of Manila where many people live under rusting corrugated steel sheets. They leak and are very noisy in the rain, and they become unbearably hot in the sun. A layer of CCX could be an inexpensive way of helping with all three problems." ■

Interview by Tony Whitehead

TO CREATE A SMALL HOME LIKE THIS, IN JUST DAYS, WITH UNSKILLED LABOUR AND FOR AROUND €20,000 – THE POTENTIAL, I BELIEVE, IS VERY GREAT

LASTING IMPRESSION

GREG SHANNON

3D PRINTING OFFERS AN EXCITING FUTURE, BUT IT HAS ALSO BEEN SHAPED BY UNLIKELY HISTORIES, FROM POST-REVOLUTION RUSSIA TO 1960S CHICAGO

One of my favourite concrete buildings is the Marina City residential complex in Chicago (Bertrand Goldberg, 1961-68). It's known for the parking decks that rise up the first 19 storeys of both towers – I love the way there's a direct ratio of parking to housing literally mapped out on the edge of the building, like one of those ornaments of layered sand. It was very innovative in its aspirations, essentially a 1960s take on the 15-minute city. Chicago was facing the same problems as many urban centres, with suburbs stretching further and further out. Marina City was an attempt to redress that, housing 1,000 people in the heart of downtown. Even with all that parking, it was claimed that 80% of the residents walked to work.

The cylindrical form of the Marina City towers is part of what appeals to me about concrete as a material. It's not pretending to be stone, it's being used on its own terms. You can chart a lineage to some of the 3D-printed systems emerging today. One of the best I've seen is House Zero, a three-bedroom prototype in Austin, Texas (Lake Flato, 2022).

Photo: Rupert Oberhäuser / Alamy Stock Photo

ABOVE
Marina City in Chicago – once the tallest residential towers in the world (Bertrand Goldberg, 1961-68)

It has simple, elegant interiors based around these interlocking silos of exposed concrete, and it's striking how it echoes a mid-century modern aesthetic.

Even as architects become free from rigid geometries, it's fascinating to see certain forms reverberating through different eras and societies. House Zero uses new digital and robotic tools to exploit the plasticity of concrete, but in section it really reminds me of the Melnikov House (Konstantin Melnikov, 1929), famous as one of the only private homes built in Moscow during the Soviet era. It might seem an unlikely connection, but in drawings of the Melnikov House you see the same interlocking cylinders, the same slender rectilinear canopy.

The Melnikov House isn't actually concrete at all. As with many inter-war buildings, it was conceived as concrete, but built from what was available at the time – brick and render. Again, the historic parallels are intriguing: one era struggling with a lack of materials, the other trying to find technological solutions as it runs out of resources. Melnikov made use of salvaged clay; some 3D-printed projects are exploring the use of raw earth. It's like history is turning in on itself.

We are still in the first paint thickness of the potential of 3D printing – a little space race with different versions of concrete emerging all over the world. But at its heart are themes and forms that have been preoccupying architects for a century or more. It will be exciting to see where it leads. ■

Greg Shannon is director of LTS Architects

BELOW
House Zero, in east Austin, Texas (2022), designed by Lake Flato using ICON 3D-printing technology

BOTTOM
The Melnikov House in Moscow, designed by Konstantin Melnikov (1929)

Photos: Lake Flato; Zoonar GmbH / Alamy Stock Photo

From the archive: Autumn 1970
ANTI UGLY CAR PARKS

This issue offers a reminder of how car parks often find themselves at the forefront of debates about urban living. Marina City (page 10) proposed a solution to the suburban exodus from 1960s Chicago. The 9th Avenue Parkade in Calgary (page 32) highlights current concerns about air pollution and whether we need cars in urban areas at all.

In 1970, the question was one of simple aesthetics. Battle lines had been drawn the year before, when Britain's most famous town planner Colin Buchanan had lamented that too many were "ugly in appearance, overpowering in scale and unpleasant in usage". Now CQ waded into the debate. "It needs little visual awareness to see what the multi-storey car park can do to our towns. Quite often they are a disruptive element in a street, a great gash in the townscape in no sense related either in scale or elevational treatment to buildings on either side."

CQ decided to take a constructive approach to the problem, highlighting three "well-mannered" examples. "Fortunately there are those enlightened authorities and designers who have built comparatively unobtrusive car parks – if not entirely or partially sunk into the ground, then at least designed with an eye for the neighbours."

Raven Meadows in Shrewsbury was praised for its facade of white concrete fins, while an Arup-designed facility in the new town of Cwmbran, Monmouthshire was noted for how it hugged the landscape, its ramp following a natural fall in the ground. Greek Street, Leeds, was the most intriguing, designed to harmonise with the buildings on either side, but also all-mechanical. "The driver simply leaves his car at one of the four entry bays and is free to go immediately. All subsequent parking operations are done mechanically, and the car is delivered for collection to the exit bay where the motorist simply gets in and drives off."

Greek Street car park was demolished 10 years ago to make way for a hotel. Cwmbran and Raven Meadows, however, are still with us, more than 50 years on.

Photos: Tim Crocker

ORIGIN STORY

BAYSIDE, WORTHING

ALLIES AND MORRISON HAS UNFURLED A TOWER OF BILLOWING BALCONIES ON WORTHING SEAFRONT, WRITES NICK JONES

"What jumped out at us when we looked at the site was that sits at the moment where the town beach starts," says Jonathan Stern, associate director at Allies and Morrison. "If you look at a map, it's precisely where the main road hits the beach."

Stern is describing Bayside, a wavy 15-storey residential tower on Worthing esplanade. The wider project contains 141 homes of a mix of tenures, predominantly in a U-shaped arrangement of six-storey buildings. But it is the 52m tower – the tallest building in the town – and specifically its cloak of undulating concrete balconies that has really shaken up the seafront.

Not that the idea was to undercut Worthing's reputation as one of the south coast's more genteel retreats, Stern adds. Rather, it was to strike a delicate balance between fitting in and standing out. "There was an aspiration from the council to produce a marker building, and it's a gateway into Worthing, and we felt something special could happen there," he says. "But then, if it's going to be a taller building, how do you make that work in the context of a historic seafront?"

The answer was to let the balconies do the work: "to read as the building and make the architecture". Inspiration came from the fine metalwork verandas of the bow-fronted Regency terraces that curve along the seafront, while the fluid form owes something to Wells Coates' art deco Embassy Court in Brighton, a few miles down the coast.

The deep balconies solve another problem too: "The question was, how do you make a building that is essentially very highly glazed, to maximise the sea views, feel like a building, not just a glass block?"

The balconies wrap around each floor in a continuous band of 225mm-thick reinforced-concrete and white metal railings. The storeys alternate between a regular 2.5m-deep projection, and an undulating form that cinches in at the middle of each elevation before bulging out in 3m cantilevers at each corner.

This serves the purpose of drawing light inside while giving each apartment both double-height and sheltered outdoor space. "There's a

TOP
The 15-storey building is the tallest in Worthing and forms an eastern gateway to the town

ABOVE
The pebbled beach comes right up to the edge of the building. All homes are above the 100-year flood level

sense of enclosure, which you need right on the seafront; however, where it cantilevers, you really feel like you're standing on the beach with nothing above you," says Stern.

The soffits have been left exposed, in the knowledge that less hardwearing finishes could quickly look shabby in a marine environment. "We wrote a very robust specification for the concrete, including the formwork," says Stern, "and spent a lot of time working with the formwork contractor to get the board layout working." Phenolic-faced MDO ply was used, with sealed birch ply for the balcony edges. The boards varied between 12mm and two layers of 6mm to achieve the various radii.

Each elevation has one movement joint at the centre and the balcony structure has been kept to a minimum – a single 300mm-diameter in-situ concrete column picks up each corner. To keep the slabs as thin as possible while avoiding deflections, each one was pre-cambered – a complex detail that had to be added to the formwork design. "It was important that there weren't any visible ridges where the camber was introduced," says Stern, "so it's a uniform pre-camber around the whole building rather than just locally where the slab might otherwise have significantly deflected."

The exposed tower frame uses a 40% GGBS mix, reducing embodied carbon. This also gives a light, warm-coloured tone to the soffits – more light cirrus than leaden storm clouds – mirroring the watercolour wash of the endless Channel skies. ■

ABOVE
The balconies cantilever out 3m at each corner on every other level, giving every apartment a double-height space


Photo: Paul Riddle

THE BIG EAST

UCL's East Bank campus heralds a new chapter for the Olympic Park. Nick Jones looks around the first buildings to emerge on a waterfront development devoted to culture and learning, and shaped in concrete

In the decade since the Olympics, a procession of academic and cultural institutions have headed out that way, to establish "East"-labelled offshoots along the banks of the River Lea. The new East Bank cluster has been seized on as a rare opportunity to break the bounds of constrained central London heritage sites, and to create spaces purpose-designed for 21st century work and life, but also for a future economy and climate that is rapidly changing and hard to predict.

ABOVE
One Pool Street (left) and Marshgate are linked by a pedestrian bridge at the southern end of the East Bank development

THESE TWO BUILDINGS FORM THE FIRST PHASE OF THE BIGGEST EXPANSION IN THE UNIVERSITY'S 200-YEAR HISTORY

The newest arrival is UCL East, the first phase of the biggest expansion in the college's 200-year history. Today, its two new buildings – Stanton Williams' Marshgate and One Pool Street by Lifschutz Davidson Sandilands – stand sentinel over the river, in front of the former Olympic stadium and London Aquatics Centre. Built for an initial 4,000 students, eventually they will be part of a 180,000m^2 campus for many more.

Their shared DNA is the East Bank design code set out by Allies and Morrison, which has steered architects towards masonry buildings inspired by the site's industrial roots. However, the teams at UCL have applied this in very different ways ...

ABOVE
A model of the proposed UCL campus, with three further buildings flanking Marshgate. Development is expected to continue into the 2040s

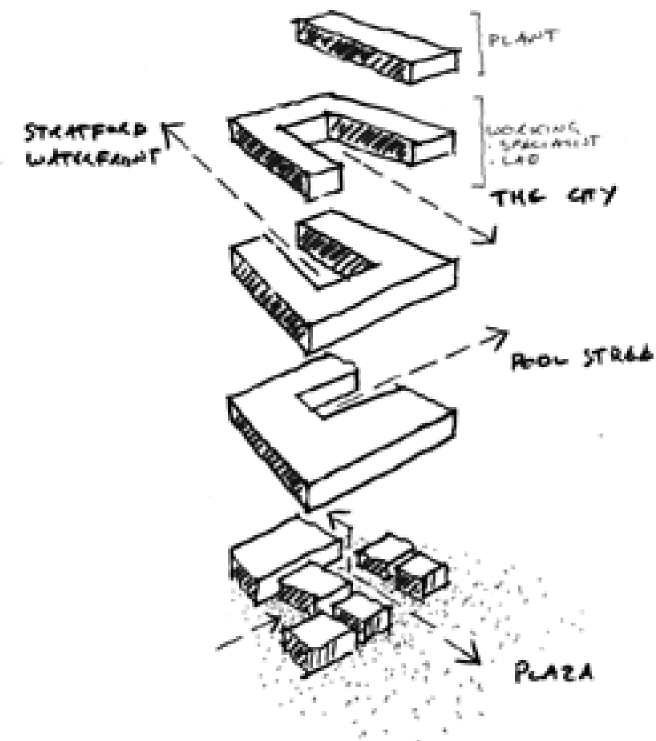
Photos: Hufton + Crow

Marshgate

With 35,000m^2 of teaching, research and collaboration space over eight floors, Marshgate is UCL's largest single building. It will house academics in fields ranging from the creative industries to robotics, green technologies and global health. "The building is like a university in itself," says Gavin Henderson, director of Stanton Williams.

From the outside, it appears immense and enclosed, like a vast cabinet beautifully crafted from sand-coloured concrete – a point of stillness next to the tangled chaos of Anish Kapoor's Orbit sculpture.The double-height ground level is in-situ concrete, with pronounced boardmarking on the main facades and acid-etched entrance reveals. Above, the treatment changes to huge precast panels and vertical fins, finished with a bush-hammered effect.

ABOVE
The eight-storey building's exterior combines boardmarked in-situ concrete at ground level and precast panels with a bush-hammered effect above



ABOVE
The accommodation is arranged in a series of horseshoe-shaped "neighbourhoods" around their own double-height collaboration space. These are stacked and rotated so that each neighbourhood faces a different direction, giving them their own distinct identity

A grand entrance on each elevation, framed in weathered metal, beckons people inside. The idea is for these to remain wide open for much of the year, extending the public realm that stretches down to the waterfront. Anyone can walk inside, through the double-height streets to the central atrium, with its cafe and community rooms interspersed with futuristic-sounding workshops and maker spaces. The spaces above are open to the atrium too, becoming progressively more private and specialist as the building rises. The gentle buzz of up to 2,500 people working, researching and grappling with the challenges of the future will cascade to the public arena below. Natural lighting and ventilation will add to the sense that this is simply a piece of the city brought inside.

UCL describes the ground floor as the "fluid zone", and this sense of spaces spilling into one another continues above. Most areas are cross-disciplinary and Stanton Williams has arranged the accommodation into a series of horseshoe-shaped "neighbourhoods", around their own double-height collaboration space (see left).

The main structure is based around a 9m x 9m grid and 300mm-deep flat slabs. "It's a flat slab building, which remains the most adaptable form of construction," says Henderson. "We have made as much use of the concrete as possible. There are no additional finishes: the structure is the architecture."

ABOVE
Double-height streets draw visitors into the naturally ventilated public atrium, which provides visual connections throughout the building

The in-situ frame uses a 40% GGBS mix and the piling 70%, averaging out at about 50%.

The regularity of the structure is celebrated in the rhythms of the architecture: all of the smooth, cylindrical columns share the same 1.2m diameter, and three tie holes run down the centre of each cast panel, like suit buttons. The holes are all precisely 8mm deep: "We had someone whose job it was for a year to make the plugs for the tie holes," says Kevin Kilcoyne, project director for contractor Mace.

The plywood formwork, used throughout the interiors, was similarly exacting and had to be rigorously checked for screw holes and other imperfections. Stanton Williams wanted all corners to turn sharply, so no fillets could be used to soften the edges of the formwork.

Much of the skilled carpentry that this required took place in an on-site factory, a huge 80m x 20m tent set up to provide safe, controlled working conditions at the height of the pandemic.

Ironically, the only walls to show evidence of boardmarking needed no carpentry at all. The double-height areas around the atrium were formed using GRP liners moulded from just six different planks selected by the architect. This, Kilcoyne says, was to minimise the use of timber and to maintain a high level of consistency.

These walls were actually the last elements to be cast, as Mace wanted to take them off the critical path due to their bespoke finish. Because the concrete here has a light brown pigment, the batching plant also needed cleaning after each pour. The only way to work this into the programme was to go back and pump down through the level-two slab, says Kilcoyne. "We bolted huge shutters through the slab and poured the self-compacting concrete through a hole in the slab, like a letterbox."

Around the atrium, the services are either embedded or recessed, reinforcing the sense of calm and order. The labs on the upper levels, however, reveal how much work the building is doing. Here, huge arrays of exposed services are suspended from the ceilings to be hooked up to cutting-edge equipment. All services have been designed with demand control and for future adaptability.

Externally, the building subtly announces its public status through its use of finishes, which reference both the National Theatre and

PROJECT TEAM

Architect Stanton Williams
Executive architect Sheppard Robson
Structural engineer AKT II
Services engineer Arup
Contractor Mace
Concrete contractor Morrisroe
Precast supplier Techrete

BELOW
A two-storey pressure chamber, one of many highly serviced areas. All services have been designed with demand control and for future adaptability

ABOVE
A 3m-deep balcony cantilevers over the riverfront entrance. The building's public status is announced subtly, with double-height metal-clad entrances punctuating each solid concrete elevation

the Barbican. Like the boardmarking of the double-height ground level, the bush-hammered effect above was created using rubber moulds, this time for precast concrete panels. The bush-hammering derives from an unlikely source material: "One of the precast operatives took some of the gravel used for soakage in the French drain outside the factory," explains Kilcoyne. "He set up a panel with it, and that's how it started life."

The texture becomes less pronounced as the building rises, and the colour lightens too, from a browner tone to a Portland stone finish on the upper levels. The intended effect, Henderson says, is of the building emerging from the riverbed.

The precast vertical fins are also subtly thinner higher up and are individually oriented to control solar gain – part of a passive design strategy that also exploits the thermal mass of the structure to reduce the energy load. The facade units, which were delivered to site in various configurations, are bolted to upstands on the slab perimeter. Henderson points out that this is a more permanent solution than lightweight cladding – a reflection of the fact that Marshgate has been designed for a life measured in centuries rather than decades.

The whole-life carbon calculation for stages A-C, which is based on a shorter 60-year lifespan, was measured at 970kgCO_2eq/m^2. UCL is aiming for the all-electric building to be net-zero in operation by 2035. ■

Photos: Paul Riddle, Chris Hopkinson

ABOVE
White precast projections wraparound the towers on every level, controlling solar gain and disrupting wind patterns

One Pool Street

"You see the form of the building very clearly from afar," says Douglas Inglis, director of Lifschutz Davidson Sandilands. "But as you get closer, it starts to reveal more. There are lots of surprises and lots of detail."

Like Marshgate, One Pool Street is wrapped in panels of precast concrete, but to very different effect. Crisp dark-grey spandrels mark out the podium building, while curving white balcony-like projections define each floor of the 12- and 16-storey towers above. Closer inspection reveals repeated patterns cast into the panels: lozenge shapes running like a hem along the upper ground and first floors, recessed discs on the underside of the projections, a sawtooth profile to the central circulation core, complete with an imprint following the route of the stairs. "Precast concrete is an inherently homogeneous material which allowed us to introduce a lot of detailing at no additional cost," says Inglis.

One Pool Street shares the cross-disciplinary approach of Marshgate, but if anything has an even more diverse range of functions, housing everything from robotics labs to beehives. The towers contain 550 student bedrooms, while the three-storey podium below provides 5,000m^2 of academic space, a cinema and a public atrium with a shop and cafe. "It was a big brief," says Inglis. "But when you look at it from the outside, it doesn't necessarily strike you as a big building."

The precast detailing plays a part in breaking down the mass, allowing the building to act as a bridge between the solid masonry forms of the East Bank and the glass skyline of the Stratford International Quarter behind. The vertical sawtooth pattern emphasises the height and slenderness of the towers, while the facades are a grid of discrete components, with white grooved posts and sills, dark-grey spandrels and

BELOW
Three-dimensional precast details include a dimple effect that moves from positive to negative (see cover) and lozenge shapes that run along the upper ground and first floors

ABOVE
Landscaped external spaces include a 1,200m^2 terrace on top of the podium

full-width glazing. (These were manufactured as two-bay units, 5m x 3.5m, with glazing pre-installed.)

As with Marshgate, the idea of a "fluid zone", ushering the public in to a space that they might assume was private, was a key part of the UCL brief. However, LDS has approached it differently, using the white concrete of the central core to signal the glazed entrance beneath. "We want everybody to come through the front door," says Inglis. "Whether it's the public, whether it's students living above or whether it's the academics, we want everybody to come into the atrium and then make their way up through the building."

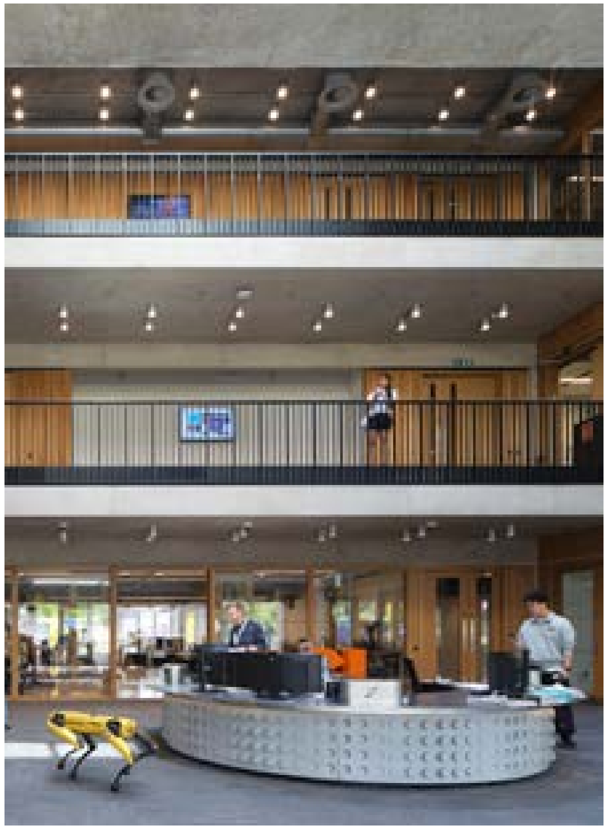
It was important to make the atrium warm and welcoming, says Inglis. Swaths of exposed concrete structure have been used as "a soft canvas" for richer finishes including colourful furniture and rubber flooring and European oak panelling. The concrete is light grey, achieved with limestone aggregate and a 25% GGBS mix, with LDS's own JW3 Jewish centre in north London used as a benchmark. The board layouts were designed by the architects to align with columns and the grid and an MDO formwork system was used. The concrete was left almost as-struck, finished with just a light sand and dust sealant. "We didn't want it to be too perfect. We like concrete that looks like concrete."

While most of the podium is on a 5.5m x 5.5m grid, forming a solid base to the towers, in the atrium this extends to 13m x 8m to help make the space as flexible as possible for future uses. The slabs here were post-tensioned to maintain a slim 225mm depth. The floor build-up also includes a 600mm void above the slab that draws fresh air into a displacement ventilation system.

The towers are built with more conventional flat slabs, 200mm deep. A lot of the containment for lighting and fire alarm systems was cast into the concrete, which meant that the soffits could be exposed without services attached. This allowed for an unusual expanse of visible concrete in the student rooms, which tends to look cluttered and oppressive unless cabling and ductwork can be concealed.

The concrete works in tandem with windows, fully openable behind vertical fins, to maximise natural ventilation. The concrete's thermal mass moderates internal temperatures during the day and is purged at night, either through the windows (the shallow building form also enables cross-ventilation) or through the MVHR units installed behind bulkheads in each room.

This is part of a strategy that used 2050 climate models to mitigate against overheating and future-proof the building. The other main expression of this is the white precast projections that form a ring around each floor. These extend to a depth of 1m on the west and south elevations, limiting solar gain while allowing sufficient glazing to make the 10.5m^2 bedrooms feel light and spacious.



ABOVE
The main atrium and robotics space. The public is welcomed into this part of the building, which includes a shop and cafe

PROJECT TEAM
Architect Lifschutz Davidson Sandilands
Structural engineer AKT II
Services engineer Hilson Moran
Main contractor Vinci
Precast supplier Techrete

The articulated facade is also designed to break down the prevailing westerly winds as they sweep uninterrupted across the park. As soon as the wind hits the facade, it breaks the pattern, virtually eliminating the tunnel effect at ground level. The projection is shallower on the more shaded and sheltered east and north ventilations and dips inwards at the central core to draw light into the lift lobbies and help demarcate the entrance.

The multistorey wind break should help to make the outdoor areas pleasant spaces to spend time. These include a 1,200m^2 terrace on top of the podium and a separate roof area above the small adjoining service building. The hope is that these will provide both places to relax and an outdoor lab with biodiverse habitats for scientists to study.

The student towers at One Pool Street are rated BREEAM Excellent and the education facilities are rated Outstanding (design stage). ■

BELOW
Each floor is divided into two student clusters with a common room at either end. The soffits are exposed as part of the hybrid ventilation strategy

BEYOND WARDS

The chief executive's office at the new Tower Hamlets Town Hall offers an unusual take on civic interior design. A vintage x-ray screen looms behind the desk, while surgical lights hang from the ceiling. If this sounds more like an operating theatre than a modern local government workplace, that's because it once was. The town hall has been adapted by AHMM from the original Royal London Hospital, a building with a rich history dating back to the 1750s.

The opportunity to repurpose it arose after the Royal London moved to a purpose-built facility behind the

Photos: Tim Soar

site in 2012. AHMM has stripped out and refurbished the interiors and wrapped it in new-build elements to the east and south, including a six-storey, exposed concrete-frame block behind the main building. The upper levels of the extension provide open-plan office space for 2,470 council staff plus partner organisations, while the ground floor houses a showpiece council chamber and meeting facilities.

The grade II-listed hospital gave the architects challenges to grapple with, but also plenty of source material for creative inspiration. "We did a lot of research into the history of the hospital, trying to understand what the original finishes were, what the colours were," says Sam Scott, associate director at AHMM. "Then, once we started to strip it out, we really got to understand how the whole building was put together."

READ THE FULL STORY
concretecentre.com/cq

LONG STAY

The Canadian city of Calgary badly needed a new multistorey car park – not least so other parking spaces could be freed for development. But how to justify the carbon cost of building a large parking structure, while at the same time looking to a future with far fewer cars?

Calgary's answer is a 26,500m^2 convertible parking garage: one that accommodates 510 cars today, but is designed to be easily adaptable to residential or commercial uses in the future. The parking surfaces are arranged around a long central courtyard, so that the floors are only 12m deep and naturally lit from two sides, while the floor-to-ceiling height is 4m to accommodate future servicing requirements.

But by far most innovative feature is that the parking levels are not separated by ramps, or accessed by the traditional car-park spiral. "We were very focused on minimising waste in the future," says Joanne Sparkes, senior project architect with designer Kasian. "These features are difficult and wasteful to remove. So we have designed without them."

Kasian's solution is to have just one floor, but one that gently and continuously slopes up the 100m length of the car par. The continuous 1-2% gradient creates an elongated coil right up to what is effectively a seventh, top storey.

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Photos: @jamesbrittainphotographs

ABOVE The precast panels of Bureau de Change's Cast House in south London contain 65% GGBS, reducing the amount of embodied carbon and giving a whitewash feel to the concrete

Opportunities for lower-carbon concrete

Supplementary cementitious materials / additions and other binders will be crucial pieces of the net-zero jigsaw. Noushin Khosravi explains the available options and emerging technologies

Clinker is made by crushing and heating limestone or chalk with small amounts of other natural materials, such as clay or shale, in a rotating kiln to a temperature of 1,450°C. Portland cement (CEM I) is made by grinding this clinker together with gypsum to produce a fine powder.

Supplementary cementitious materials (SCMs) may be used as part of cements. When added at the concrete mixing plant, they are referred to as "additions", as they are added to cements such as CEM I (Portland cement) or CEM II/A-L (Portland limestone cement) that already contain a high proportion of clinker. These combination cements can be referred to as binary or ternary, depending on whether one or two SCMs are added.

UK cements may be categorised into two groups: "general purpose cements", with suitability established in the UK concrete standard; and "other binders or cements", with suitability yet to be established in the UK concrete standard.

Historically, combination cements have been used to maximise available materials, and to improve mechanical properties and durability. However, by substituting out some of the Portland cement clinker, SCMs are also an effective way of reducing the embodied carbon of concrete.

SCMs / additions

The main categories of SCMs are pozzolanic materials, latent hydraulic materials and mineral fines. The chemistry of an SCM influences the properties of the resulting concrete, which means that they are useful for different applications, and that the percentage of clinker that may be replaced will vary. An important aspect of using SCMs is to understand how to optimise mixes with higher clinker substitutions to achieve equivalent or better performance.

Pozzolanic materials are siliceous and aluminous materials that react with calcium hydroxide (lime) contained in cement to set, harden and develop strength in the presence of water.

Natural pozzolans have two main origins:

- volcanic, such as vitreous rhyolites from the Rocky Mountains in the US or German and Turkish trasses

- sedimentary clays and shales – some may be used as they are, while others, such as calcined clays. undergo a process of thermal activation.

The reactivity and properties of natural pozzolans varies considerably, and achieving consistent quality when using various sources can be a challenge. The water demand and workability of natural pozzolans is determined by the angular particle shape and internal porosity, although any issues can be overcome by efficient use of appropriate admixtures. The addition of pozzolanic materials (whether natural or a byproduct such as fly ash) generally results in higher durability, but may have lower resistance to carbonation which, for concrete reinforced with carbon steel, may require an increased nominal cover.

GGBS is a byproduct of the iron/steel manufacturing process. Molten slag from the production of iron in a blast furnace is rapidly cooled by high-pressure water jets, and instantaneously solidifies to form a granulate. This granulate is then finely ground to form GGBS for use as an addition to concrete.

As much as 95% of clinker can be replaced by GGBS. However, the most typical combinations are 36-65% and 66-80%, through the use of CEM IIIA and CEM IIIB respectively. Latent hydraulic materials (such as GGBS) do not require activation with lime (as a standalone material).

The inclusion of GGBS in concrete results in durability improvements such as resistance to sulfate attack, reducing the risk of alkali-silica reaction, improving the concrete microstructure, and increasing resistance to chloride penetration. This makes GGBS a highly effective addition for use in concrete in aggressive conditions.

GGBS is also very useful for controlling the heat of hydration in large concrete pours, thereby reducing the risk of thermal cracking and delayed ettringite formation. However, higher percentages of GGBS are not recommended for external exposure conditions subject to high abrasion and impact. GGBS

Photo: Jack Hobhouse

ABOVE
The concrete for the precast frame components at the University of Warwick's Interdisciplinary Biomedical Research Building contained both a limestone replacement and GGBS binder replacement, reducing overall cement content by 35%

concretes may have an increased carbonation rate compared to the likes of CEM I, so cover to reinforcement may need be increased.

Fly ash, a byproduct of the coal industry, is a fine powder, with mainly spherical particles. The resulting "ball-bearing effect" reduces water demand and improves consistency. The exact composition of fly ash is dependent on the nature of the parent coal. There is long history of its use in a variety of applications, including the manufacture of cement, concrete and blocks, road construction, and grouting. Typically, up to 35% of clinker is replaced by fly ash, through the use of CEM II/B-V.

Silica fume has very fine spherical particles, giving a large surface area. It is typically used to replace 6-10% of clinker, although greater proportions have been used in specialist applications. Silica fume is used to produce high-strength, high-performance concretes which are especially suited to abrasive environments.

Limestone, an abundant resource in the UK, is the main example of mineral fines. Mineral fines are generally considered

BELOW
Austrian cladding company Rieder has replaced 50% of the cement in its facade systems with local pozzolanic materials. It has used the panels on its new headquarters, a former bus garage in Maishofen

ABOVE
The precast panels at Sheppard Robson's Campus East Gateway at the University of York use a mix containing 30% fly ash, both to lower the carbon content and create a smooth, consistent appearance

as non-reactive or with very small reactivity but have also been found to aid in the hydration reaction of other SCMs. The maximum allowable replacement level is 20%, as part of a multicomponent cement – that is, a mix containing clinker and two additional SCMs, for example GGBS and limestone. Such ternary combinations are included in the 2023 revision to BS 8500. Testing carried out to support their introduction found that this results in concrete with similar or improved properties, as well as more efficient use of resources such as GGBS.

Two SCMs that might be available in a considerable volume in the near future are recovered fly ash and calcined clay.

Recovered fly ash. The UK Quality Ash Association (UKQAA) has identified over 100 million tonnes of fly ash in stockpiles located at currently operating and recently closed coal-fired power stations. It is estimated that about 40 million tonnes of this has cementitious properties and can be processed to be used as clinker replacement. UKQAA has been working with the University of Dundee and technology providers to investigate the properties of processed deposits of such recovered fly ash. Initial findings indicate that recovered fly ash can meet BS EN 450 and ASTM C618 specifications. Despite the additional energy that is required for drying and processing, considerable carbon reductions are still achievable, because this is still less energy-intensive than clinker production and without the process emissions. Since the final product has very similar properties to normal fly ash, it is likely that the same replacement level of clinker – up to 35% – is possible.

Calcined clay. Clay materials are heated and ground to produce a reactive addition. The main challenges have been finding the right source of clay, optimising the heating process, and developing suitable admixtures to maximise clinker substitution. The current version of BS 8500 allows up to 55% of clinker to be replaced with calcined clay. In 2022, a two-year project, led by the Mineral Products Association and funded by UK Research and Innovation's Transforming Foundation Industries programme, set out to find the best sources of waste clays in the UK that are suitable for calcining. Similar projects have been undertaken on large infrastructure projects, such as HS2,[1] reflecting the concrete industry's prioritisation of the use of waste streams rather than virgin resources. The first year of the project focused on optimisation using two heating technologies. The second year focuses on pilot production and concrete durability testing.

Other binders

There are a variety of other binder technologies commercially available or under research. Most are proprietary products and are not yet included in BS 8500. Below are four examples of other binders – although there are more in development.

Alkali-activated cementitious materials (AACMs). At present, most AACMs rely on an alkali-activating combination of GGBS and fly ash, but future generations will probably be based on calcined clays. However, considerable quantities of an activator, normally sodium silicate, are needed to activate calcined clays. Further development of AACMs should take into account the limitations and environmental impact of alkali activators.

Magnesium-based cements. Many different binders derived from various sources of magnesium are under research and development. The most promising are based on globally abundant ultramafic rocks, comprised primarily of basic magnesium silicates. These technologies could capture carbon to form stable magnesium carbonate.

Photo: Solidia

ABOVE
Precast hollowcore slabs manufactured by Solidia. The US company uses calcium silicate clinkers to make concrete by carbonation rather than hydration

Belitic clinkers containing Ye'elimite, or calcium sulfoaluminate (CSA). CSA cements are produced via the same process as clinker but using less limestone and more aluminium as raw materials. The potential reduction in carbon emissions reduction increases with higher Ye'elimite content, but there are cost implications due to the requirement for more expensive aluminium-rich raw materials. These materials are normally fast-setting and are more appropriate for repair applications.

Carbonation-hardening cements. These technologies are based on manufacturing concrete products by carbonation instead of hydration. A well-known example of this technology is special calcium silicate clinkers (CCSC) made specifically for carbonation-curing by US company Solidia. These clinkers can be made in conventional cement kilns using common raw materials. It is important to consider the impacts of the captured carbon on the alkalinity of the resulting concrete, and the increased risk of carbonation-induced corrosion. These binders may therefore be more appropriate for unreinforced sections.

As demand for SCMs and other binders increases, new technologies are emerging. Assessment of an innovative

technology can be based on considerations such as:
■ whether it is local or imported
■ whether it is naturally occurring waste or a by/coproduct
■ carbon mitigation potential
■ impact on consistency
■ impact on concrete properties such as strength gain and durability
■ suitable applications
■ water demand
■ energy demand
■ scalability and stage of development (research, pilot, demonstration, commercialised)
■ inclusion in standards
■ cost.

While CEM I remains the most prolific cementitious material and will continue to be a key part of the solution, it is important that the whole value chain – government, clients, specifiers and manufacturers – works together to facilitate the procurement of these innovative cementitious materials. In many countries, there is a need for enabling policies to regulate the use of waste materials as SCMs, and for greater engagement with standards-setting bodies and suppliers by providing sufficient evidence of performance to further develop the market. This will be crucial in our efforts to deliver concrete with progressively lower carbon as we work towards net-zero. ■

Key references

■ Usage of supplementary cementitious materials: advantages and limitations | Journal of Thermal Analysis and Calorimetry (springer.com)
■ Eco-efficient Cements: Potential Economically Viable Solutions for a Low-CO_2 Cement-based Materials Industry (unep.org)
■ Making Concrete Change: Innovation in Low-carbon Cement and Concrete | Chatham House – International Affairs Think Tank
[1] Dhandapani Y, Marsh ATM, Rahmon S et al. *Suitability of excavated London clay as a supplementary cementitious material: mineralogy and reactivity*. Mater Struct 56, 174 (2023)

FINAL FRAME: SIXTH STREET VIADUCT, LA

Michael Maltzan Architecture's ribbon-like bridge stretches for 1km between Downtown Los Angeles and Boyle Heights, spanning the LA River, 18 rail tracks and the US 101 freeway. The structure is defined by 10 pairs of in-situ concrete arches of varying heights, rising up to 20m, and each leaning outwards by 9°. The design envisages a multi-modal future for LA beyond the car: five stairways and two cycle ramps connect the bridge deck to green spaces and recreational areas below.

Photo: Iwan Baan