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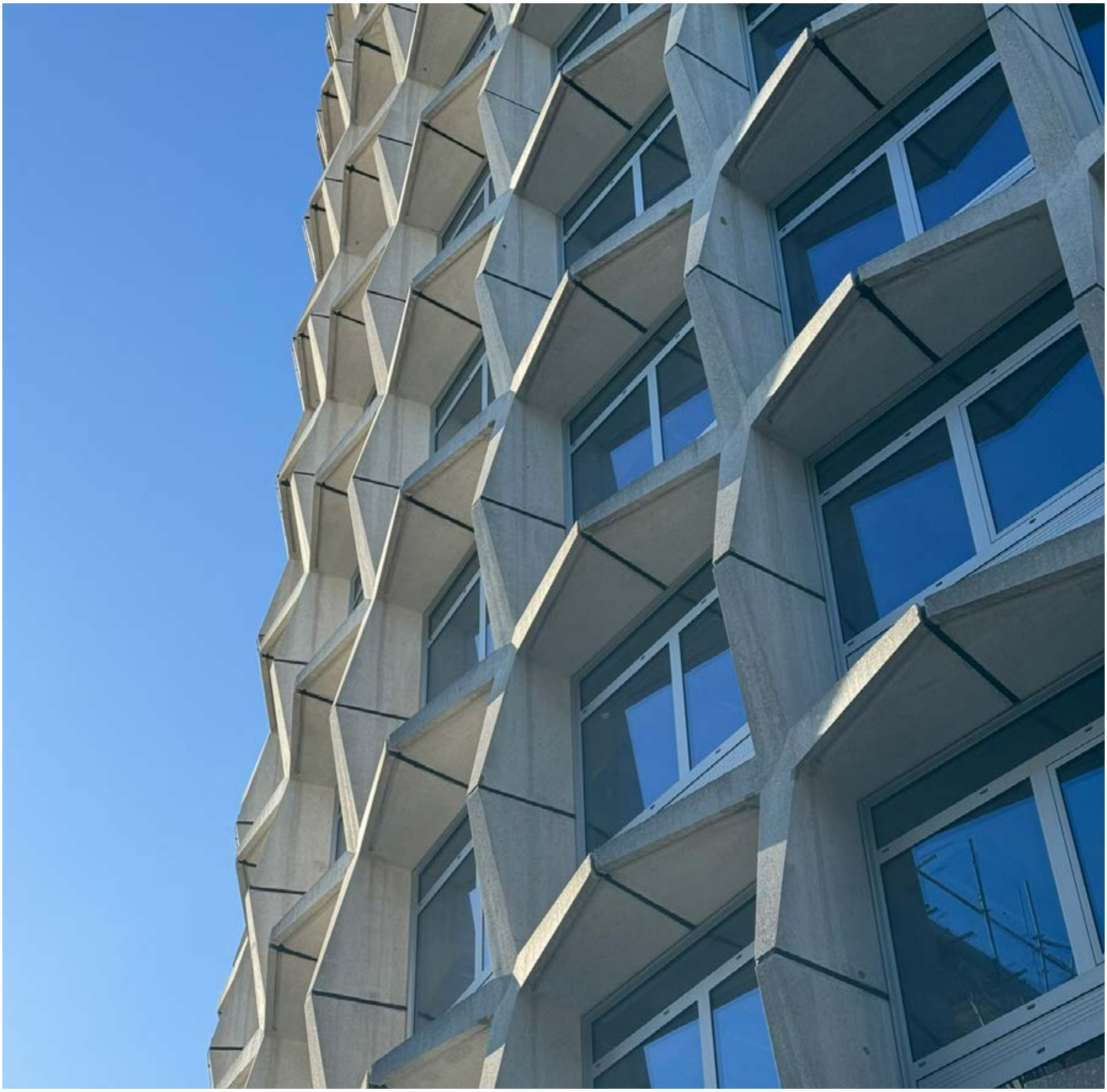
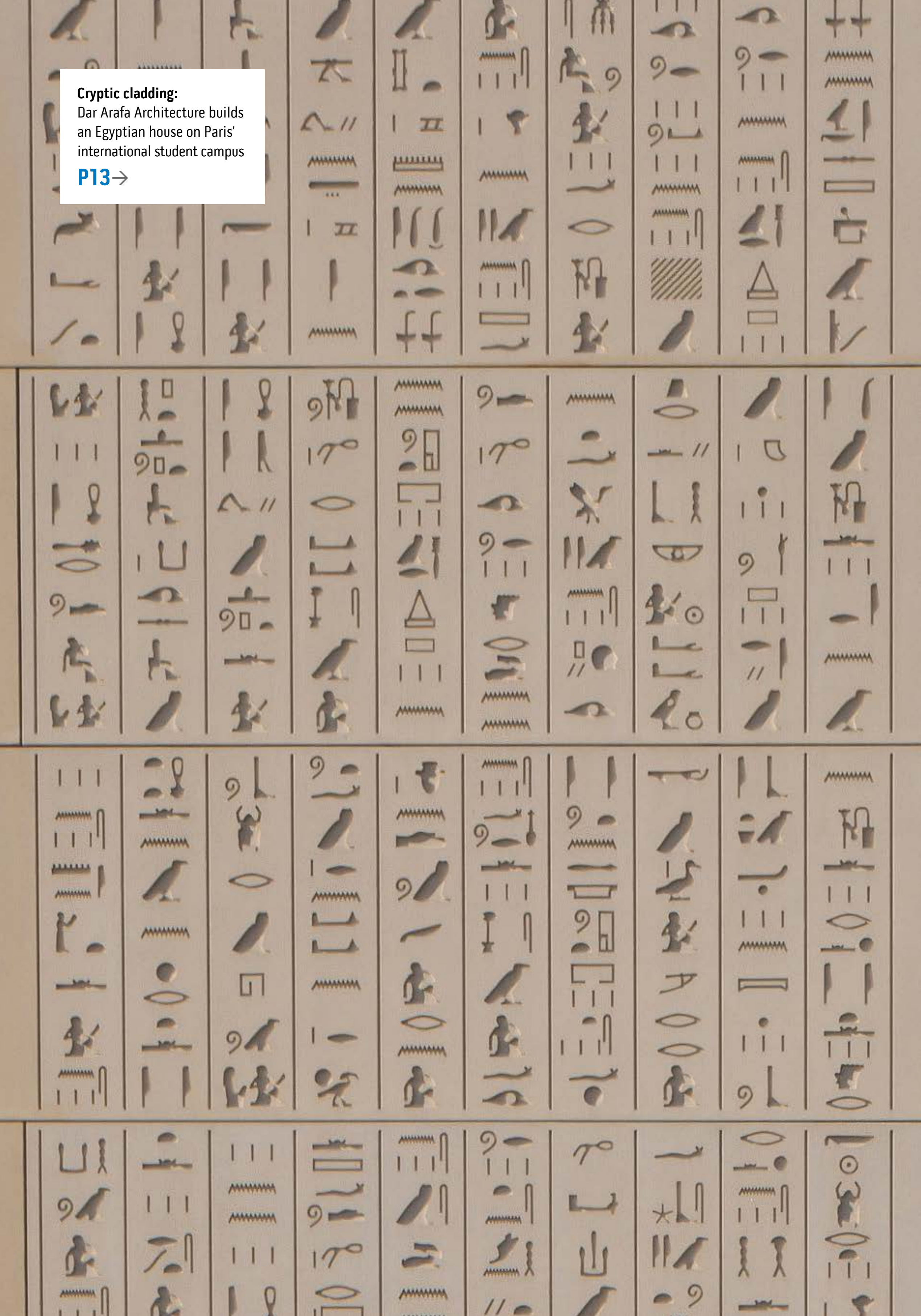


SPACE ODYSSEY →
Squire & Partners helps an icon of sixties London to get back in the groove

HOUSE OF EGYPT →
The story behind the precast hieroglyphs at Paris' international campus

CUT OUT AND KEEP →
Extracting and reusing structural elements for a more circular world



Cryptic cladding:
Dar Arafa Architecture builds an Egyptian house on Paris' international student campus

P13→

CASTING OFF

INSPIRATION

APPLICATION

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

Different circles

We're fully in the swing of event season, and it's great to be out and about, meeting people in person and having lots of conversations about sustainability and concrete. This is undeniably a challenging time for construction, and many people I speak to are grappling with how to achieve carbon targets amid the uncertainties of the current market.

One solution is to make use of the materials we already have in our built environment. It certainly feels like there is a shift towards greater consideration of the potential of existing structures, partly driven by planning policy. For inspiration, check out our cover project: Richard Seifert's Space House office tower, which has been renewed and expanded as a super-modern workplace.

But there are many factors in play that determine whether retention of an existing structure is viable. Concrete frames tend to be able to outlive other building components, but sometimes a building just isn't useful enough in its current form, and it needs to come down.

Today, almost all concrete from demolished buildings is recycled, most commonly as unbound material for ground works, but also in new concrete. But these are not the only options, and the industry is exploring some very promising alternative strategies – finding ways to retain concrete's value for as long as possible is one of the five pillars of the refreshed UK Concrete Sustainable Construction Strategy.

In recent issues of CQ, we've spoken to scientists and innovators who are developing new techniques for reprocessing and upcycling crushed concrete to make new products, and even new cement. Our Application feature in this issue (page 34) focuses on a different opportunity: reclaiming concrete elements and using them in new structures, in much the same way as precast components are used today. There is something very exciting about the prospect of chopping up an existing structure and repurposing it, and there are already some brilliant examples. But there is also much we still need to understand about where the greatest value of an obsolete concrete structure actually lies. Is it always as a "donor structure" providing components for new buildings? Or might crushing it, as a source of new lower-carbon cementitious material, prove more effective?

THERE IS SOMETHING VERY EXCITING ABOUT THE PROSPECT OF CHOPPING UP AN EXISTING CONCRETE STRUCTURE AND REPURPOSING IT

Right now, the only thing we do know is that we need to use less of everything – we need to stop and think, "does this need to be new?" If you don't want to waste food, you look in the fridge to see what you've already got before deciding what to have for dinner or heading to the shops. We could take the same approach to the built environment. The default for many years has been to demolish and rebuild from scratch. In a decarbonised, circular world, that default will need to shift. We may not know how emerging technologies will evolve, but we do know that taking time to understand what we have will always be the right decision – as only then can we work out how to retain it at its highest value. ■

CONCRETE QUARTERLY

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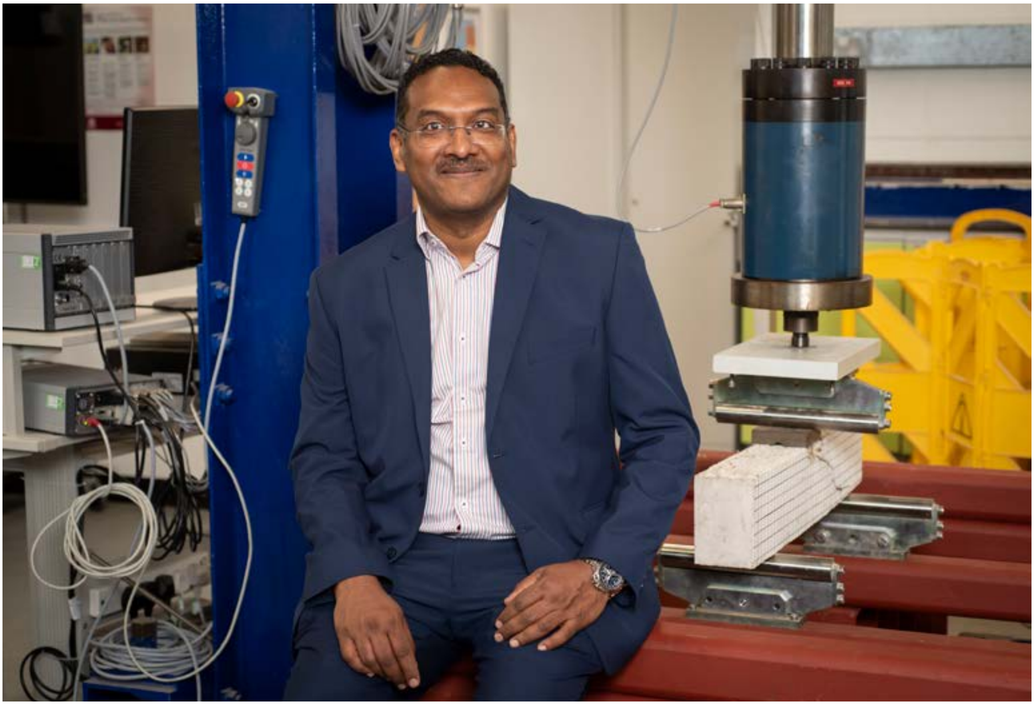
On the cover: Space House, London, by Squire & Partners. Photo by Gareth Gardner



Photos: Paul Burroughs

INNOVATION

SELF-HEALING ANTI-CORROSION CONCRETE

THE UNIVERSITY OF EAST LONDON'S CONCRETE LAB IS FORMULATING NEW SELF-HEALING MIXES, AND PUSHING THEM TO THEIR LIMIT

ABOVE
Dr Ali Abbas in his lab at the University of East London, where he subjects samples of self-healing concrete to real-world conditions

At the University of East London, Dr Ali Abbas is inflicting highly controlled damage on cubes and cylinders of concrete. The cracks his machines create are only just visible, less than 1mm wide, similar to those that first appear in old or distressed concrete. "We then monitor the cracks to see how our new concrete formulation is performing," says Abbas. "All being well, the cracks repair themselves."

Self-healing concrete relies on a bio-chemical phenomenon known as microbially induced calcite precipitation (MICP). Originally developed in Holland, it has since been progressed by a number of British universities. "Bacterial spores are added to the mix and then

LEFT
Cylinders with lengths of rebar, used for testing corrosion-resistance of self-healing concrete. The cylinder in the centre also contains calcium nitrate, which is known to have an anti-corrosive effect

THIS NOT ONLY SAVES THE COST OF MAINTENANCE OR REPLACEMENT – IT SAVES THE CARBON ASSOCIATED WITH PRODUCING NEW CONCRETE

remain dormant until cracks appear," explains Abbas. "When they do, the bacteria are exposed to water and oxygen, and begin to precipitate calcite which seals the crack."

If you can seal cracks at an early stage, he says, this stops them getting wider, protects rebar from moisture ingress, reduces corrosion, and results in longer-lasting structures. "This not only saves the cost of maintenance or replacement – it saves the carbon associated with having to produce new concrete."

But getting innovation out of the laboratory and on to real world building sites is not straightforward, he adds. "It requires the sort of research we are doing here. If we are to decarbonise concrete and make an impact in the outside world, this kind of work is absolutely vital."

Abbas speaks from experience. A structural engineer by training, he completed his PhD (modelling cracks in concrete) at Imperial College London. He then spent four years working in Atkins' R&D department: "We were concerned with heavy-duty infrastructure: the nuclear industry and also London Underground. I realised that we have to find ways to make this stuff last longer as replacing it is so costly, economically and environmentally."

The close study of the corrosion

resistance of healed cracks is a good example of UEL's real-world focus: "Most testing of MICP to date has been carried out on unreinforced concrete" says Abbas. "Sealing cracks with MICP should protect rebar – but does it? To find out if it really works we have cylinders with a length of rebar down the middle, and we pass a current through that to accelerate any corrosion that might occur."

In fact, the mix Abbas is currently testing involves a little more than just MICP: "We've also added calcium nitrate which is known to have an anti-corrosion effect, helping rebar last longer. So if we combine this with MICP, we should get an extremely resilient and long-lasting concrete. But, again, we have to check. Do the mixes work well together? In addition, the mix

ABOVE
Concrete cubes which have been cracked and left to heal. The top left cube was not made with the bacterial spores and has not healed; the others were, and the cracks are now barely visible

LEFT
Dr Abbas with senior technician Chris Donovan, sitting on the rig he built to crack the concrete samples

includes GGBS to lower its carbon content, so once again we have to check these ingredients perform as they should when all are present."

Results so far are encouraging. "The good news is that the calcium nitrate admixture (sold as NitCal) does not kill the bacteria – in fact it seems to help it perform better," says Abbas. "Setting times are, if anything, reduced and there is no reduction in either compressive or tensile strength. It may even be that, over time, strength is improved."

And the effect on corrosion? "Depending on the dosage, concrete containing NitCal lasted 6-8 times longer before becoming corroded – and the severity of corrosion was reduced by 30-50%. Concrete that also contained the crack-healing admixture showed a crack-healing efficiency of 90% with a further significant reduction in corrosion."

Abbas stresses that research like this must keep a steady eye on real-world applications: "This work has been funded by Innovate UK and carried out with industry partners including JP Concrete and Sensicon, where we are working with innovation director Vighnesh Daas. They are incorporating our findings into their product ranges, so hopefully we will soon be able to test how these formulations perform in actual structures." ■

Interview by Tony Whitehead

SETTING TIMES ARE, IF ANYTHING, REDUCED AND THERE IS NO REDUCTION IN EITHER COMPRESSIVE OR TENSILE STRENGTH. IT MAY EVEN BE THAT, OVER TIME, STRENGTH IS IMPROVED

LASTING IMPRESSION

ALAN STEWART

THE LDS DIRECTOR PICKS THREE GOLIATHS OF THE BRUTALIST AGE, FROM A SPACESHIP IN MEXICO CITY TO A BIRMINGHAM SIGNAL BOX – ALL OF THEIR TIME, YET SOMEHOW TIMELESS

I was born in Mexico City and lived about four streets away from Praxis House, the home-studio of architect Agustín Hernández Navarro. It was my first experience of brutalist architecture. The house lies in one of the forested valleys on the west side of the city, where many of the homes are makeshift structures that seem to hang from the cliff face. In this context, Praxis House was almost like a spaceship. Its futuristic form, heavily influenced by pre-Colombian architecture, rises on a single shaft of concrete from the forest canopy. It's an amazing example of how you can use concrete to create any shape your mind can think of.

Brutalist buildings often appear in quite odd locations. Marcel Breuer's Pirelli Tire Building in New Haven, Connecticut, is on the edge of an Ikea car park but has been successfully retrofitted as a designer hotel. Like Praxis House, the character of the building relies on the three-dimensional possibilities of concrete. It's not just about a dramatic shape, but also the depth and rhythm of the facades. As a

Photo: Alexandre Guirkinger

ABOVE
Praxis House by Agustín Hernández Navarro, Mexico City, 1970

practice, we've looked closely at how brutalist buildings use profiled concrete to cast sun and shadow throughout the day – you can see their influence in the moulded details at One Pool Street (CQ 284). Another reference project for us is the grade II-listed New Street Signal Box in Birmingham, which has horizontal bands of ribbed concrete, punctuated by pure vertical elements. In itself, very brutal, but it plays to the harsh environment it's in.

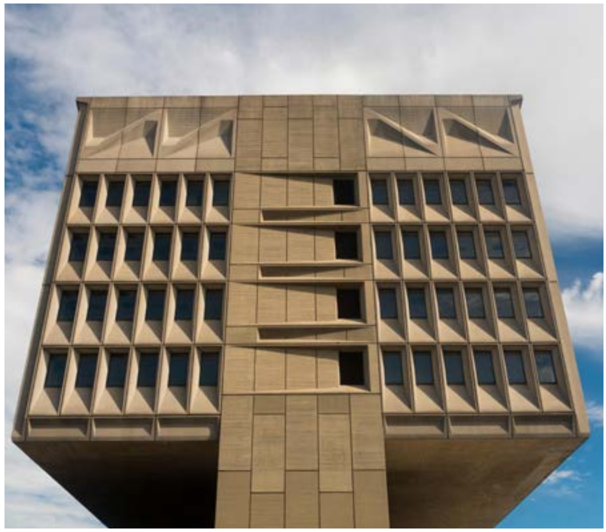
These buildings are all relics of their time, in the sense that you could never build like that today. But they're also somehow timeless – like a good watch, they just keep going. The fewer that remain, the more we need to hold on to those that do. It's very hard to justify the embodied carbon wasted by demolishing these loose-fit structures that could be useful for hundreds of years. The Pirelli Tire Building shows how something designed for office use can become a hotel, or just as easily co-living or student housing. The rooms are well proportioned, they have good windows, and the thermal properties are just incredible – Hotel Marcel, as it's now known, is the first Passivhaus hotel in the US.

It will be interesting to see how the next stage of the Birmingham Signal Box's life plays out. It has been decommissioned and is being used as a training centre by Network Rail, but it would be a terrible shame if it fell into disuse. It could make a great exhibition centre or a community hub. The flexibility is there – it just needs the right vision. ■

Alan Stewart is director of Lifschutz Davidson Sandilands

BELOW
Pirelli Tire Building by Marcel Breuer, New Haven Connecticut, 1970

BOTTOM
New Street Signal Box in Birmingham by Bicknell and Hamilton, 1964



Photos: Randy Duchaine / Alamy Stock Photo; Arcaid Images / Alamy Stock Photo

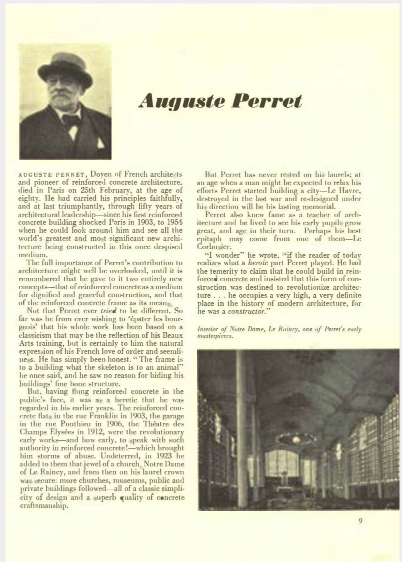
From the archive: Spring 1954 and Autumn 1985

FRANCE"S CONCRETE CITY

Le Havre is a city with two "sacred monsters", according to Jean-Christophe Masson, the architect of the Alta Tower (page 32). One is Auguste Perret, the man who gave the northern French port, heavily bombed during the Second World War, its ordered, classically proportioned streets. The other is Oscar Niemeyer, whose 1980s Volcan cultural centre rises like a ship's funnel from the Quai George V. Both architects used concrete as their medium, to very different effects. The result is a city – now recognised as a Unesco World Heritage Site – that has become a poster child for post-war planning and modern architecture.

Perret is perhaps the lesser known of the two. But on his death in 1954, CQ wrote: "He gave to architecture two entirely new concepts – that of reinforced concrete as a medium for dignified and graceful construction, and that of the reinforced concrete frame as its means." In early 20th-century Paris, such ideas verged on the heretical: "The reinforced concrete flat in the rue Franklin in 1903, the garage in the rue Ponthieu in 1906 were the revolutionary early works…which brought him storms of abuse. Undeterred, in 1923 he added to them that jewel of a church Notre Dame of Le Rainey, and from then on his laurel crown was secure." By the time of the Le Havre reconstruction, his ideas had evolved to incorporate innovative precast elements, from which he built a unified grid of generously sized apartment buildings, with shops and restaurants at street level. The city, CQ concluded, would be his "lasting memorial".

Niemeyer's Volcan came three decades later – the first notable addition to Perret's city plan, and a very different approach to architecture. "Here are the authentic marks of the Brazilian master: bold and curvaceous geometric forms of dramatic simplicity exploiting the sculptural possibilities of reinforced concrete – Brasília come to Europe … The building succeeds, surely, simply because it is a monument in its own right, making no attempt … to be part of the town fabric or to blend harmoniously with it."



Auguste Perret

AUGUSTE PERRET, Doyen of French architects and pioneer of reinforced concrete architecture, died in Paris on 25th February, at the age of eighty. He had carried his principles faithfully, and at last triumphantly, through fifty years of architectural leadership—since his first reinforced concrete building shocked Paris in 1903, to 1954 when he could look around him and see all the world's greatest and most significant new architecture being constructed in this once despised medium.

The full importance of Perret's contribution to architecture might well be overlooked, until it is remembered that he gave to it two entirely new concepts—that of reinforced concrete as a medium for dignified and graceful construction, and that of the reinforced concrete frame as its means.

Not that Perret ever *tried* to be different. So far was he from ever wishing to 'épater les bourgeois' that his whole work has been based on a classicism that may be the reflection of his Beaux Arts training, but is certainly to him the natural expression of his French love of order and seemliness. He has simply been honest. "The frame is to a building what the skeleton is to an animal" he once said, and he saw no reason for hiding his buildings' fine bone structure.

But, having flung reinforced concrete in the public's face, it was as a heretic that he was regarded in his earlier years. The reinforced concrete flats in the rue Franklin in 1903, the garage in the rue Ponthieu in 1906, the Théatre des Champs Elysées in 1912, were the revolutionary early works—and how early, to speak with such authority in reinforced concrete!—which brought him storms of abuse. Undeterred, in 1923 he added to them that jewel of a church, Notre Dame of Le Rainey, and from then on his laurel crown was secure: more churches, museums, public and private buildings followed—all of a classic simplicity of design and a superb quality of concrete craftsmanship.

But Perret has never rested on his laurels; at an age when a man might be expected to relax his efforts Perret started building a city—Le Havre, destroyed in the last war and re-designed under his direction will be his lasting memorial.

Perret also knew fame as a teacher of architecture and he lived to see his early pupils grow great, and age in their turn. Perhaps his best epitaph may come from one of them—Le Corbusier.

"I wonder" he wrote, "if the reader of today realizes what a *heroic* part Perret played. He had the temerity to claim that he could build in reinforced concrete and insisted that this form of construction was destined to revolutionize architecture . . . he occupies a very high, a very definite place in the history of modern architecture, for he was a *constructor*."

Interior of Notre Dame, Le Rainey, one of Perret's early masterpieces.

9

NIEMEYER AT LE HAVRE

The Cultural Centre, Place Carnot, Le Havre, France

Photos: Georges et Samuel (The GS Studio)

ORIGIN STORY

MAISON D'EGYPTE

WALEED ARAFA OF CAIRO-BASED DAR ARAFA ARCHITECTURE EXPLAINS HOW HE INTRODUCED ANCIENT EGYPT TO LE CORBUSIER ON PARIS' INTERNATIONAL STUDENT CAMPUS

The Cité Internationale Universitaire de Paris (CIUP) is a unique location, established in the 1920s as a place where the young people of the world could learn and live together. There are 43 campus houses across the CIUP park, including famous modernist buildings such as Le Corbusier's Fondation Suisse (1933) and House of Brazil (1957). When we reached the shortlist for the Maison d'Egypte, I declined any new paid commissions and asked everyone to wait for me while I conversed with Corbusier!

It started in 2018, when the Cité made 1,915m^2 of land available to Egypt's Ministry of Higher Education. The terms of the competition required an Egyptian architect to work alongside a French practice.

At the time, if you Googled "Egyptian architect" my name would come up, as I had just finished one of my most successful projects, the Basuna Mosque in Sohag, Egypt. I got a phone call from Bassem Shahid, a young Egyptian architect who lived in Paris, and he told me about the project. I thought it sounded like a scam, but then I found I had 10 emails, all from big, reputable practices. I like working with small teams, so decided to go with the first firm, SAM Architecture.

I was attracted by the idea of exploring Egyptian architecture outside its usual context. My masters degree had focused on the mosque in Britain. Because Britain does not have a long history of mosque building, the typology is not comfortable there yet – it hasn't taken on the architectural language of its place. Conversely, that can help us to understand what a mosque is: by taking something out of its historic context, you can more clearly see its essential qualities. That sparked an idea in my head for the Maison d'Egypte. France has a strong character, and Paris has an even stronger character. This would force me to try to understand what Egyptian architecture really means.

For me, it felt very obvious to start with a monolith. The architectural historian Sigfried Giedion said that the Egyptians were the first people to manipulate rock into stone as an architectural material. So stone was going to be the thing. We could carve out what we needed to, but the building had to look like a single piece of stone.

TOP
The precast facade is made from self-cleaning concrete, pigmented to resemble Egyptian sandstone

ABOVE
The hieroglyphs were created using marine ply moulds, and quote ancient texts on the power of learning

Of course, we had to factor in the local environment. Paris has a lot of stone buildings, but not all of them are in great condition due to the weather. SAM's principal Boris Schneider suggested that we use precast concrete, which appealed to me as a modern form of processed stone. We could add pigment and acid-etch the finish to resemble Egyptian sandstone and, crucially, we could specify a self-cleaning surface. It was also important to us that, as much as possible, the external concrete should be structural, not just cladding. We wanted to use it in the same way as the Egyptians used stone: as building blocks.

The use of precast introduced the possibility of incorporating hieroglyphs into the main facade. I worked with Egyptologists Salima Ikram and Anne-Claire Salmas to choose the texts, from ancient scripts about the pursuit of knowledge, and scale them to the correct proportions according to the canon of Egyptian writing. In a happy coincidence, the building is a similar height to the Luxor obelisk in the Place de la Concorde, which features probably the most famous hieroglyphs in Paris, so we were able to compare the spacing for each character. When we were sure everything was right, Decomo Belgium made the negative moulds from marine ply.

Another important element of Egyptian-ness was natural light. People often don't realise how dark northern Europe can feel to Mediterranean visitors: your vitamin D levels go down, you feel depressed, your bones hurt. We wanted single-loaded corridors, which are very rare in the Cité, and configured the space so they all look over the naturally ventilated atrium. The nine-storey curtain wall faces east, so gets lots of light, which is reflected and enhanced by the smooth concrete surfaces of the core walls. Summer heat is controlled by the shade from a mature red-beech tree. We worked with landscape designer Emma Blanc to understand how the tree behaved season by season, the light paths and angles – without that, we wouldn't have had the courage to make a fully glazed facade.

The atrium also provides ideal conditions for an Egyptian garden, full of palms, lotus and papyrus – all plants that are loaded with symbolism. Papyrus was the first medium for writing, and Maison d'Egypte will hold workshops in papyrus-making and calligraphy. It is another way in which the building introduces students from all corners of the world to ancient traditions. ■

Interview by Nick Jones

ABOVE
The single-loaded corridors and Egyptian garden are bathed in east light from the nine-storey curtain wall

PROJECT TEAM

Architects Dar Arafa Architecture, SAM Architecture

Structural engineer Batiserf

General contractor Sicra Île de France

Precast concrete Decomo Belgium


Photos: Gareth Gardner

THE NEW SPACE AGE

The rebirth of 1960s icon Space House as a 21st-century office inventively reuses both its pioneering hybrid structure and its precast cladding. Nick Jones reports

Completed in 1968, Space House is often viewed as the little brother of Centre Point. Standing like retrofuturistic bookends at either end of London's Covent Garden, the two office towers were both designed by Richard Seifert and George Marsh for developer Harry Hyams, their shared DNA evident in the geometric grid of their structural precast concrete facades.

ABOVE
Squire & Partners has added two storeys to the tower – an extension that involved temporarily removing the top ring of precast panels and inserting a new layer below

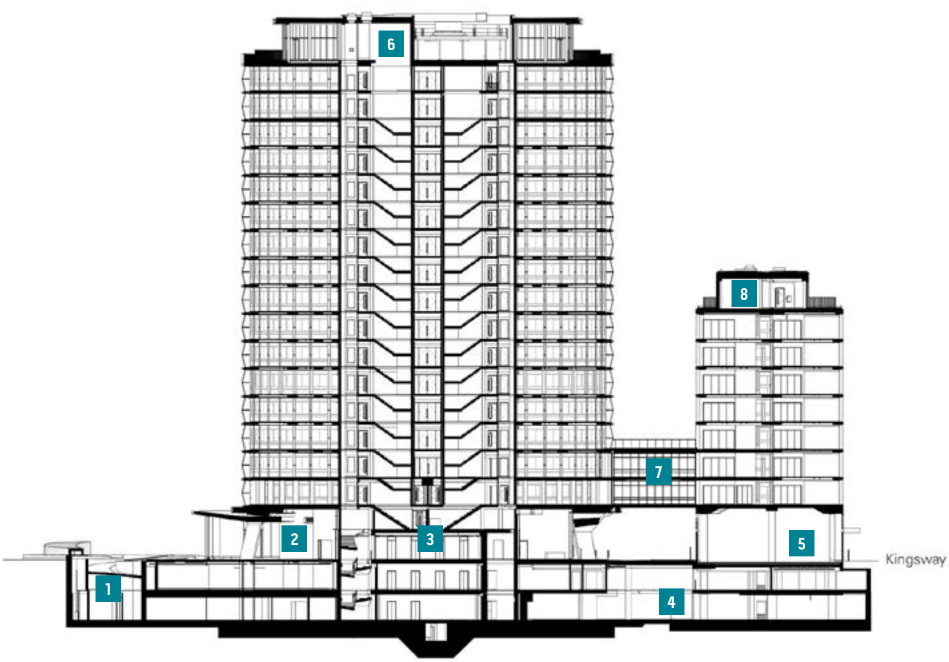
But whereas Centre Point was recently retrofitted as a residential tower (CQ 261), Space House has taken a different path. A major renewal project led by developer Seaforth and architect Squire & Partners has both restored the original vision for the grade II-listed tower and adjoining seven-storey block, and updated it for a digital, more carbon-conscious age. Having spent much of its life as a rather dowdy headquarters for the Civil Aviation Authority, the workplace inside Space House has been thoroughly modernised, complete with WiredScore Platinum, Fitwel and BREEAM Outstanding ratings – the latter a first for a listed building in London.

It has grown too. Squire has added two storeys to the tower and an extra level to the block, creating panoramic offices, a "clubhouse" and rooftop terraces. A double-height 1,500m^2 event space has been carved from the vast basement car park, and lift capacity increased by 50%. This ability to discover and create new space in Space House owes much to the inherent strength of the existing frame – a pioneering hybrid of in-situ and precast concrete, which required little additional stiffening.

"We could strip away and add these different elements," says Chris Railston-Brown, director of development at Seaforth. "That's what makes it so suitable for

THE BUILDING HAS GOT REALLY STRONG BONES. THAT'S WHAT MAKES IT SO SUITABLE FOR RETROFIT

BELOW
In all, 48 exact reproductions of the original cruciform units were designed and manufactured



SECTION

1 Bicycle ramp
2 Cafe / bar
3 Reception
4 Event space
5 Retail / restaurants
6 Rooftop terraces
7 Skybridge
8 Clubhouse

retrofit – the building has got really strong bones."

As with many similar retrofits, the project began with a trip to the archives. Handily, the structural engineer on the scheme, Pell Frischmann, had been responsible for the original building. "We were lucky to have almost a complete set of drawings which were really essential to understanding the form and behaviour of the structure," says Luke Riddoch, principal engineer at Pell Frischmann. "And we had the archive calculations, which gave us the existing loading constraints and the original design codes."

The archive showed that the circular floor plates consisted of a "bicycle wheel" of precast prestressed ribs – or spokes – made from high aluminium cement

(HAC) concrete. These act compositely with six main in-situ beams, also radiating from the centre, and a thin structural screed. Although typical concrete strength at the time was around 14MPa, the archive revealed that at Space House it ranged from 30 up to 55MPa on the precast units.

But, as Railston-Brown points out, "you still have to verify that what you've got is what you think it is". The only way to do that was by surveying the actual building, ranging from rebar scans to analysis of chloride content. A crucial assessment was the fire integrity of the slabs, which had been designed for 60 minutes of resistance but required 90 minutes to meet modern standards. Pell Frischmann also wanted to verify the condition of the precast ribs, as HAC concrete tends to become porous over time. This can lead to a reduction in strength, says Riddoch. "But our inspections determined that they

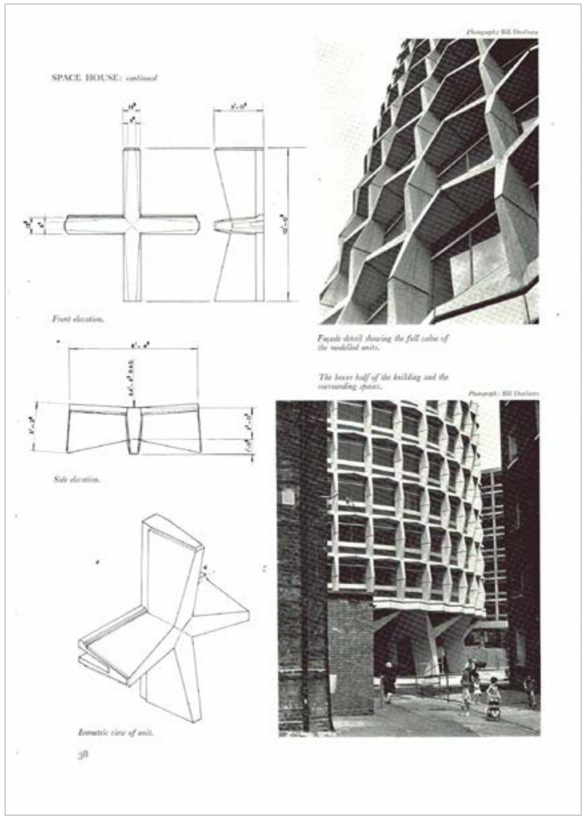
BELOW
Pell Frischmann's original hybrid structure of in-situ and precast concrete required little additional stiffening

were generally in very good condition structurally, with very little sign of corrosion of the tendons."

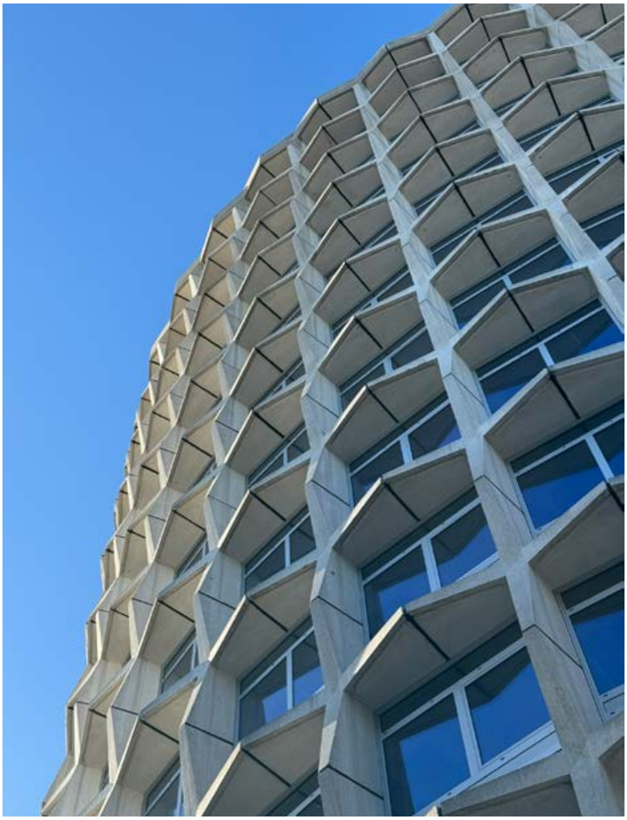
The calculations were helped by the fact that office work is a lighter business these days. "Old offices were designed for live loads of about 5.5-5.8kPa because they had a lot of heavy equipment and stacks of large paper files," says Railston-Brown. "Now they're designed for 3.5kPa, so we were able to recalculate the live loads and then use that to increase the dead load on the tower itself."

Even with the structural capacity confirmed, the team still needed to convince Camden council of the virtue of extending a listed building upwards. Using more archive material – including Marsh's original watercolour designs and four early photographs from a 1967 issue of *Concrete Quarterly* – Squire made the case that the new floors would serve to reinstate the intended silhouette, which had been blighted by accretions of rooftop plant.

Following the same logic, the architects proposed a concrete structure, with one new level clad in precast panels precisely replicating the floors below, and a setback rooftop level providing space for terraces. "We argued that, in listed buildings, if something is broken, sometimes a facsimile is the right answer," says Squire partner Tim Gledstone. The plant would be rationalised, with much of it moved to the basement. Equipment that needed to be on the roof for energy-efficiency reasons, such as air-source heat pumps, could be concealed by the setback top floor.



ABOVE
Space House first featured in CQ in Autumn 1967. Archive photos from the magazine were used to help convince Camden council that the two-storey extension was in keeping with the original architectural intent



ABOVE
Each of the openings in the original facade was 3D-scanned – leading to the discovery that there were more than more than 100 different window sizes

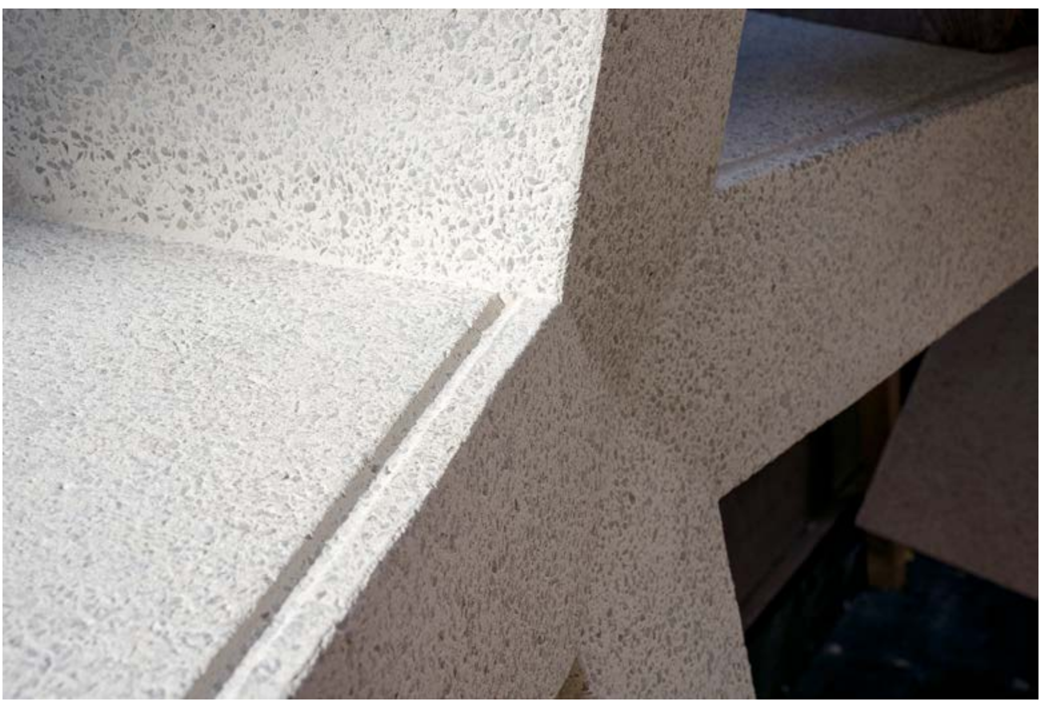
In all, 48 exact reproductions of the original cruciform units were designed and manufactured, using data derived from archive drawings, 3D scans and material analysis of existing panels. In what may well be a first-of-its-kind reuse technique, the top ring of original T- shaped panels were removed, cleaned and repaired, and then reinstalled as the new building crown (see box, page 28). "We saw it as a chance to treat the building more like a living museum, where we could go back through the steps, and piece together the process of making the cruciforms," says Gledstone. "With such a rigorous modular design, there are very easy signposts to follow."

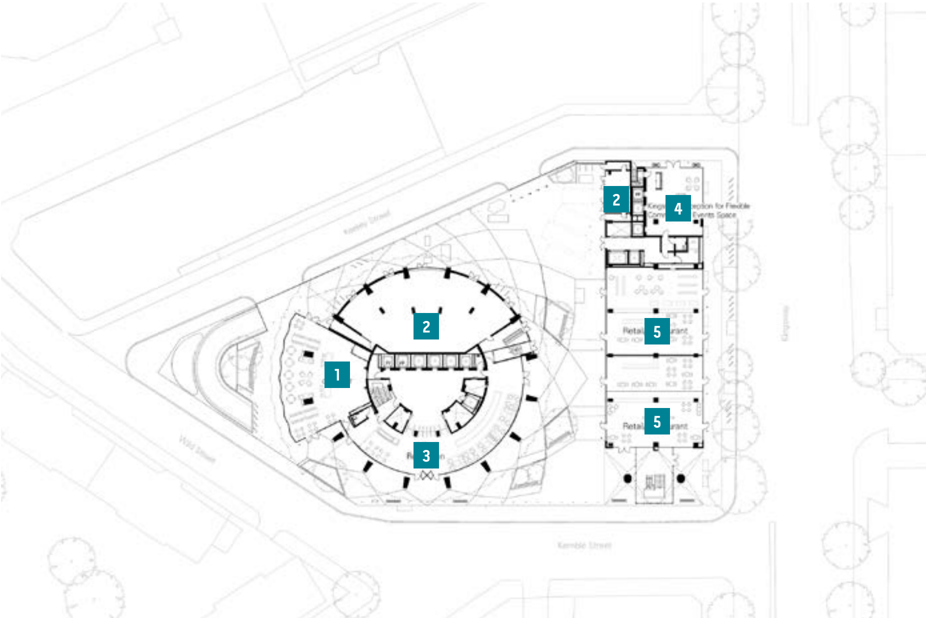
On the block, the setback clubhouse also has an in-situ concrete structure, with cladding replicating the precast tiles of the existing building. Here, the structural frame below required some strengthening, partly because the removal of a mezzanine at ground-floor level has reduced lateral stability. A transfer structure takes the load of the clubhouse down through the perimeter of the block, while the Y-shaped pilotis and the basement shear walls have been stiffened.

The existing precast facades were in good condition – as at Centre Point, these have just been gently cleaned using sodium hydroxide gel and hot water. Upgrading the tower's sliding windows to an energy-efficient automated system posed more of a challenge. Each of the original windows had been made individually, resulting in tolerances of +/-20-30mm. "We 3D-scanned every single opening on the tower, and ended up with over 100 different window sizes," says Railston-Brown, in a process that Gledstone describes as "both very futuristic and pretty analogue". The windows were separated into six groups according to size. Each was given a barcode, with all of the scanned dimensions of its unique location and fitting requirements. The external detailing around the windows was then designed with a small tolerance incorporated to deal with the variety.

Internally, the modernisation also began with the bones of the building. False ceilings, installed when the CAA moved in, have been removed, revealing the "bicycle wheel" ceiling radiating across the circular, column-free floorplates. "The HAC has left a beautiful

BELOW
The surface of the replica cruciform units was grit-blasted to match the texture and finish of the original panels





GROUND-FLOOR PLAN

1 Cafe / bar
2 Electrical substation
3 Reception
4 Block reception
5 Retail and restaurants

patina, so the surfaces were essentially finished," says Railston-Brown. "The in-situ beams had old chalk marks and even some funny notes from the builders. We've actually preserved all of that and just sealed it in, so it's still there for the future tenants to see."

Not only do the exposed soffits tell the story of the building, they also maximise floor-to-ceiling heights and provide an organising system for the exposed services, which in turn avoids the need for raised floors. Track-mounted linear lighting, sprinklers and active chilled beams alternate every three spokes. "It gave us a simple formula to work with," says Gledstone, adding that the chilled beams needed a bespoke "mini" design because of the way the spokes taper towards the core. The exposed design increases future flexibility too, he points out. "We've untangled the building and put it back in a way that you can easily unthread and redo as required.

Maybe the sprinkler system will last 50 years, perhaps the chilled beams can be upgraded in stages. It's an open engine now – we've taken the bonnet off the beautiful car."

The chilled beams are part of an energy-efficient heating and ventilation strategy that also includes air-source and water-source heat pumps. It helps that natural cooling was built into the original building. The sliding windows and open floorplates provide ample opportunities for cross-ventilation – Railston-Brown says that the spaces will benefit from full natural cooling for 30% of the year. In the warmer months, this will work in tandem with the exposed soffits to provide passive cooling. "The building can automatically open the windows by up to about 100mm at night, and that will allow it to breathe, to cool down the structure and thermally load it for the next day."

At the base of the tower, outmoded space has

BELOW
The "bicycle wheel" ceiling provides an organising system for the exposed services. Track-mounted linear lighting, sprinklers and active chilled beams alternate every three spokes

ABOVE
The tower and seven-storey block are linked via a skybridge, as well as new retail and exhibition space below ground level

given way to new uses. Space House was born in a city where the car reigned supreme, with its own petrol station and two levels of parking. These have been converted into the Filling Station restaurant and a cycle centre with 600 spaces and 62 showers, with one of the three parking ramps retained as an entrance for cyclists.

An unusual added advantage of the original tower is that it contains a huge electrical substation at ground and two basement levels, covering almost a third of the floorplate. "It meant there was a huge amount of private realm on the ground floor that was sort of public, but it wasn't quite clear," says Gledstone. "We were able to give fantastic amounts back, and create a double-height event space to establish a connection between the two buildings that had never really existed."

The modular approach of the original construction allowed them to "unzip" the structure by simply saw-cutting the precast planks of the intermediate floor between basement levels one and two, taking away the floors beneath the forecourt where there was less structural load.

The substation also had an extensive ventilation system, which ran all the way up the building and dispersed via the roof. This has been rerouted to exhaust at ground level, with the space on each floorplate reclaimed for two new lifts, increasing capacity by 50%.

A lightwell on the north side of the core – "a bit like staring down the Death Star" – has also been filled in and converted to toilets, meaning that the reconfigured tower meets British Council for Offices standards without any reduction in usable floor area.

Pell Frischmann calculated that the remodelling of Space House has reused 16,500m^3 of concrete, equivalent to approximately 10,000 tonnes of embodied carbon. It also measured the new structure's embodied carbon (lifecycle stages A1-A5) at below 50kgCO_2e/m^2, comfortably under the LETI 2030 target. According to services engineer Atelier Ten, operational carbon will be reduced by 46% in the tower extension and 70% across the rest of the scheme, compared with a notional regulation-compliant building.

The world envisioned in Marsh's watercolour designs, with cars whizzing along the Kingsway, may have faded into distant memory, but it left behind some strong bones. Space House shows how they can be preserved and fleshed out for a very different future. ■

For more on reusing existing concrete elements, go to page 34

PROJECT TEAM
Developer Seaforth
Architect Squire & Partners
Structural engineer Pell Frischmann
Services engineer Atelier Ten
Main contractor BAM Construction
Precast concrete contractor PCE

How Space House crossed a new frontier in the reuse of cladding

It's not quite accurate to describe Space House's two new floors as an extension. Externally at least, one of the extra levels has actually been inserted between the top two rows of precast units.

While the existing loadbearing facade consisted of cruciform modules up to the 15th level, the crown of the building was formed from a ring of T-shaped units, and one of the heritage requirements was that these had to be retained. To introduce the facsimile level, the T-units would have to be removed, new cruciform units installed, and then the T-units reconnected on top.

The process followed a carefully coordinated sequence, designed to limit the time the existing structure, and particularly any of the high aluminium cement (HAC) concrete used in the floorplates, was exposed to the elements.

This started with the demolition of the existing roof slab. The T-units were then removed and holes drilled into the cruciform units below for new connections. The T-units were stored offsite, where they were cleaned and prepared for reinstallation, which involved drilling dowel holes and cutting out the back of the modules to enable connection to a new perimeter ring beam.

Meanwhile, the new cruciform units were installed. These had been designed to exactly match the originals. Even with geometric details from the archive drawings, this involved a lengthy testing process. "We undertook petrographic analysis of samples from the existing units to understand the existing cement content," says Pell Frischmann's Luke Riddoch. Various cement colours and aggregate sizes were trialled before a pale mix with 10mm aggregate was chosen. The surface of the units was also grit-blasted to match the existing texture.

The challenge, Seaforth's Railston-Brown explains, was understanding not only what the original mix contained and how it had aged – but also how any new elements would age. "We were trying to design a concrete mix that wasn't necessarily going to look identical on day one, but would look identical in a year or two, when it had weathered. It was a very long back-and-forth process." This was all the more important because the new elements would be surrounded on both sides by existing units.

The installation of the units was carried out by just four operatives in less than a week. Once they had been tied together and temporarily propped, the new level 16 slab could be cast. This was made from post-tensioned concrete, both to reduce the load on the structure below and to maximise headroom in the new workspace. With the structure now weathertight, the T-units could be brought back to site and slotted into place. The level 17 slab could then be cast, ready for the new setback level and rooftop terrace – a solution to satisfy heritage requirements, maximise reuse of existing elements, reduce waste and provide tenants with panoramic views across London.

PROBLEM SOLVED

At the Hive, the Technology Partnership's new building in rural Cambridgeshire, Sheppard Robson has ditched the accepted methodology for designing science parks and instead delivered something more like a gallery, with swaths of pristine exposed concrete.

"We realised this building was going to live or die by how good the concrete was," says David Ardill, partner at Sheppard Robson.

Photos: Hufton + Crow

There was a lot of upfront work to coordinate cast-in services, plan the shuttering and ensure the finishes were of the highest standard. Different mixes were tested and a full-scale mock-up of a wall was constructed. Temperature controls were critical, because the casting would span different seasons. The use of a 50% GGBS mix, which tends to cure more slowly in winter, threw in another curveball. "A lot of different technologies were used to achieve the same finish," says Harry Hobbs, managing director of concrete contractor Whelan & Grant. "There are 120 columns in the building, and I feel like if you walked through any part of it, you'd see the same consistency."

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APRES PERRET

The twisting Alta Tower is architect Hamonic + Masson's response to the "sacred monsters" of Le Havre – Auguste Perret and Oscar Niemeyer (see page 12). A matrix of inclined precast concrete columns and 400mm-deep balcony edge beams reflects "the grid and order of Perret", whose buildings were based on an expressed structure of repeating 6.4m-long units. But as the tower rises, it appears to turn through more than 90 degrees. This adds a curve to the silhouette that echoes "the form and sensuality of Niemeyer".

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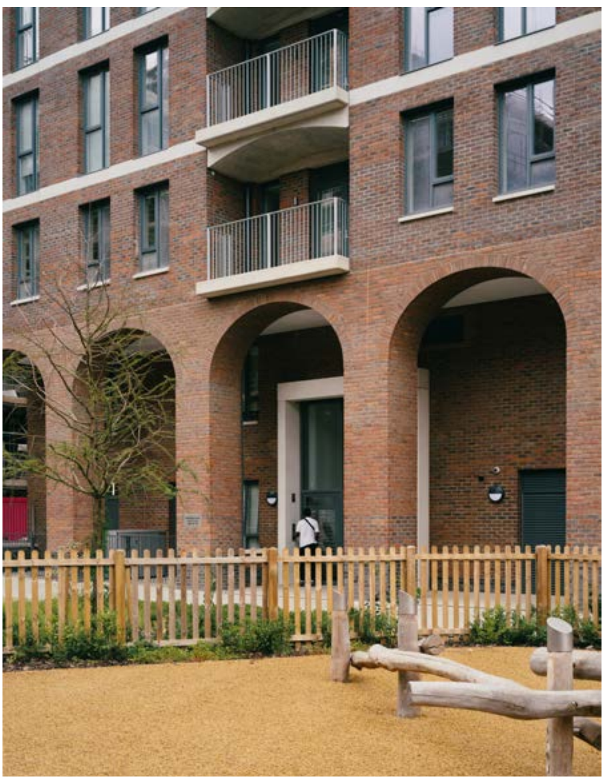
Photos: Hamonic + Masson & Associés

FOR ALL AGES

Mae Architects' multigenerational residential building at the Aylesbury Estate in south London shows how small pockets of well-designed outdoor space can animate the streetscape and enhance sociability. Curving in-situ concrete balcony soffits, inspired by John Soane's nearby St Peter's Church, inject a strong sense of civic character, while 3m-wide walkways give residents space to sit outside and enjoy the courtyard garden.



Photos: Tim Crocker

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EPFL's Re:Crete footbridge uses 25 concrete blocks that were cut from the in-situ reinforced concrete structure of an existing local building. The blocks were mortared and strengthened with two post-tensioned cables. Photo: Smart Living Lab

Reusing concrete elements

Reusing complete structures is not the only route to a circular economy. Emily Halliwell explains how extracting and repurposing concrete components can open up a world of possibilities

A circular economy is one in which resources are kept at their highest value for as long as possible. For concrete frames, reusing them in-situ will typically result in the lowest carbon emissions. There are many examples of concrete buildings being adapted and repurposed, with changes of use and layout, enabling the frame to be used for many more years. This is not always feasible – for example, where there are very low ceiling heights or constrained layouts. In these cases, the default option is demolition, though not usually landfill: in the UK, nearly all concrete from demolished buildings is recycled, often used as aggregate in new concrete or hardcore. However, recent research has demonstrated an alternative, with the potential to keep concrete resources at a higher value for longer: reusing concrete elements in new structures.

Prototypes

Across Europe, a number of projects have used reclaimed concrete elements in new structures, including Återbruket in Gothenburg, Sweden, a housing project where 50-year old hollowcore slabs from a demolished IKEA store will make up 80% of the loadbearing floors. Barriers do exist to the wider use of this approach, with concerns about cost and feasibility. To help resolve these, and to show the potential cost and carbon savings, researchers at Ecole Polytechnique Fédérale de Lausanne (EPFL) have developed three prototype structures. These include a footbridge (Re:Crete), an office floor (FLO:RE) and a community pavilion (rebuiLT). Each prototype uses different types of elements, from 1200 x 400mm blocks to 3D assemblies of columns and slabs, extracted using saw-cutting from existing buildings – referred to as "donor structures".

Donor structures

Identifying suitable donor structures is key to enabling wider reclamation of concrete elements. Efficiencies can be achieved by using them on the same site. When developing a scheme, designers may have the opportunity to assess existing structures to identify whether they can be reused in-situ. One outcome of this assessment might be that the existing frame does need to be demolished, but could be a source of components for the new building. This minimises travel distances, and maximises embodied carbon savings.

ABOVE
On EPFL's FLO:RE scheme, dry connections without concrete or grout are used so that the structure is fully demountable

A lifecycle analysis of the FLO:RE prototype found that, compared to an equivalent in-situ 220mm-thick reinforced concrete slab, there were carbon savings of 80% when the structure was built within 140km of the donor structure. This increased to 92% if it was built within a 20km radius, and 94% if it was built on the same site.

As with in-situ reuse, assessment and testing are important for determining the condition of a structure. As-built information can assist with identifying the best way to reuse existing elements, particularly if the reinforcement within the concrete is to be used as part of the new structural scheme. There is a wide range of testing techniques available, and reusing structural elements may enable greater use of destructive testing than is possible in cases where the structure is reused in-situ. Designers can find further guidance in the second generation Eurocode 2, which includes an annex on the assessment of existing concrete structures.

Consideration should also be given to how best to use the donor structure. For the FLO:RE prototype, elements were cut from a continuous slab and used as a simply supported slab. This meant that the critical section was at mid-span, where the largest bending moment was located. As the reinforcement within the concrete is determined by whatever is in the donor structure, the span was limited to 3m in the new structure, approximately 75% of the donor slab span.

Careful planning can result in cost and programme savings, and enable more of the existing structure to be reused. The 3D structural elements in the rebuiLT pavilion came from a donor structure that also supplied three other projects. A total of 137 reinforced concrete elements were extracted, allowing for optimisation of the sawing pattern used for deconstruction.

New structures

In principle, reclaimed concrete elements can be used in much the same way as precast elements. Connections are key in precast concrete structures – particular consideration needs to be given to tying, to ensure the robustness of the frame and prevent disproportionate collapse. To achieve this, precast concrete connections often rely on in-situ toppings or grouting. On EPFL's FLO:RE scheme, dry connections (without concrete or grout) are used so that the structure is fully demountable, facilitating further reuse in the future. While this approach works for the prototype, larger schemes would need to consider vertical tying and fire protection requirements.

Laing O'Rourke's D-Frame is a fully demountable and reusable precast concrete system, designed to suit the typical loading and layout of an office building. Working with Imperial College, the company developed innovative jointing methods to achieve the required robustness. The system uses bolted connections, allowing for quick assembly and disassembly with minimal extra cost. Low-strength grout is included where necessary – for example, for diaphragm action. Testing has shown that this may be removed easily through hydrodemolition: using low-strength grout enables the grout to be removed without damage to the higher-strength concrete. It also showed that disassembly of the D-frame by unstitching is significantly safer, quicker and cheaper than traditional demolition techniques, as well as enabling reuse of the concrete frame elements.

A similar approach has been adopted for Circle House in Denmark (CQ 278), a housing scheme made of precast components that can be reconfigured in different ways. The development will include two and three-storey terraced houses, and five-storey tower blocks. Similar to the D-frame, the system is connected using bolts and screws with a lime-based mortar for durability, acoustic and fire requirements. This may be removed using a pressure hose, enabling the easy disassembly of the units for reuse in a different location or configuration. ■

Emily Halliwell is senior structural engineer at The Concrete Centre

BELOW
Developed by 3XN, the Circle House research project uses bolts and screws with a lime-based mortar for durability, acoustic and fire requirements. This may be removed at a later date using a pressure hose

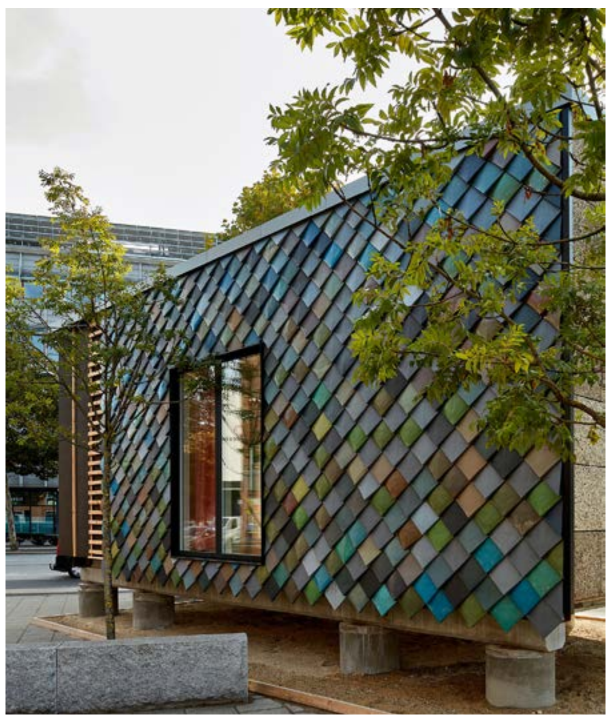

Photo: Tom Jersø

FINAL FRAME: POLISH ARMY MUSEUM, WARSAW

Architect WXCA has added a low-lying extension with coloured-concrete walls to the Polish Army Museum, part of the Warsaw Citadel. The in-situ concrete's pink hue draws on the red brick of the Citadel, a 19th-century former barracks. In order to break up the monumentality of the 7.5m-high walls, some of the concrete was cast with a military-inspired chevron pattern created using rubber moulds.

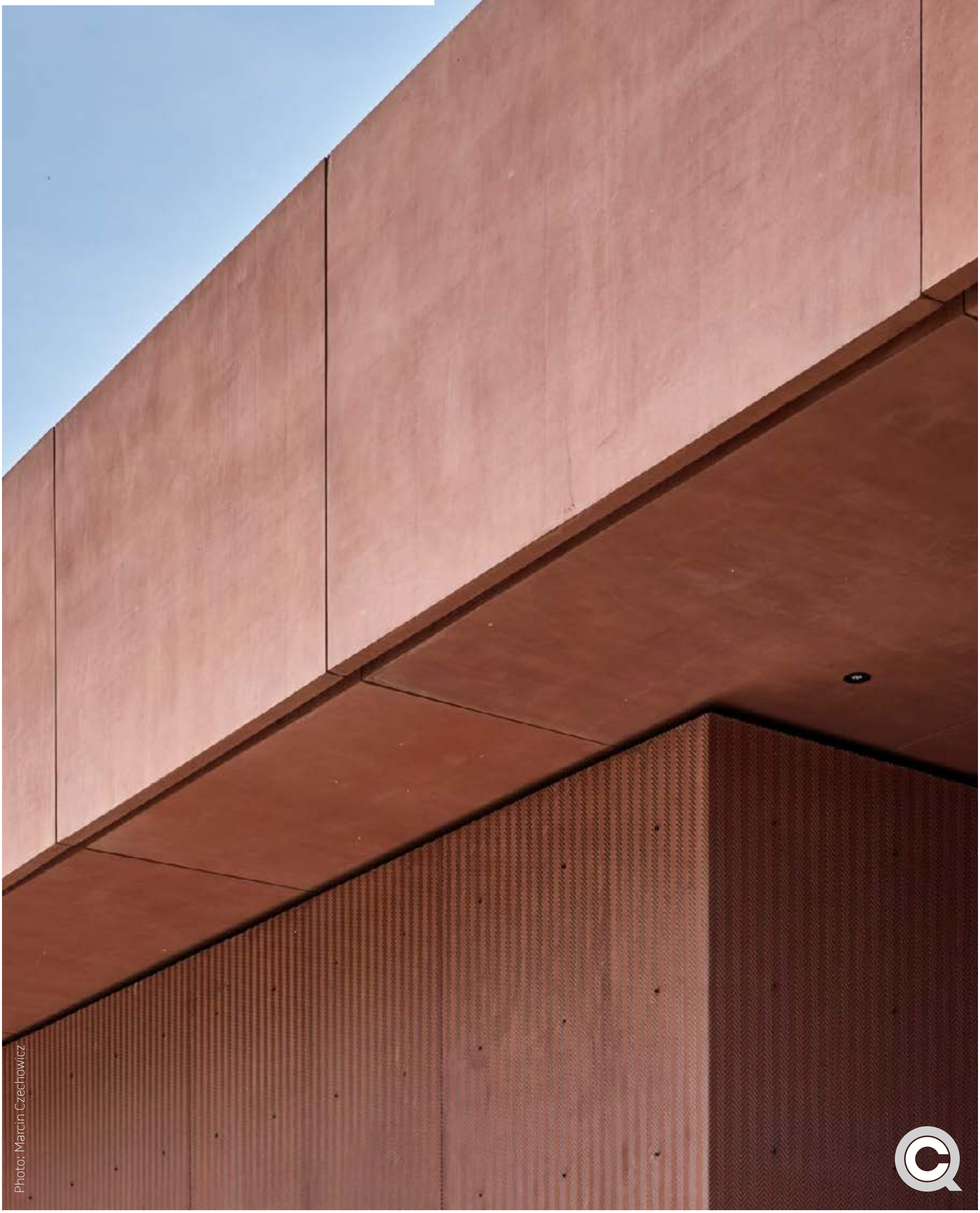

Photo: Marcin Czechowicz