CONCRETE QUARTERLY

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ROSE-TINTED SPECTACLES
David Adjaye's LA boutique and Texan art gallery expand the possibilities of pink concrete

KINGSTON'S CLIMBING FRAME
How Grafton Architects concocted the London university's concrete colonnade and courtyards

SKELETAL SKYLINE
Could Zaha Hadid's pioneering Miami tower revolutionise the way we build tall?

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CONCRETE QUARTERLY

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The Webster, Los Angeles by David Adjaye Architects. Photo by Dror Baldinger

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Two worlds collide

We're exploring a strangely under-explored type of construction in this issue of CQ. Hybrid – the combination of in-situ and precast concrete – is what made possible Grafton Architects' stunning multifunctional Town House for Kingston University (page 6), where the structure was completed in little over 12 months.

Hybrid concrete construction is the best of both worlds: the consistency and predictability of factory systems, without the inflexibility or prescriptiveness of a completely modular system. Precast is used for the repetitive elements or as permanent formwork, while in-situ supplies bespoke flourishes and cuts the transport costs associated with large volumes. It makes for buildability, collaboration and early decision-making at design stage, and maximises efficiency and safety on site by removing the programme risks of inclement weather and the safety hazards of working at height.

So why isn't it used more often? In some ways, this is an illustration of how insular the construction industry can be, both within national borders and narrow disciplines or trades. Hybrid has long been common in parts of continental Europe, where it is considered "the" way to build using concrete. It was used by the French contractor Bouygues when it came to the UK in the early 2000s, on projects such as the Home Office headquarters at Marsham Street in London.

The fact that it didn't become the norm in the UK is partly down to a traditional reluctance to embrace new methods of construction, and because, back then, different kinds of concrete contractor were not used to working together – in-situ and precast tended to go it alone.

Thankfully this is no longer the case, as the growing number of hybrid buildings shows – this issue also features The Ray, AHMM's London office for LinkedIn (page 14), as well as Zaha Hadid Architects' One Thousand Museum in Miami, which pushes the concept in an exciting new direction (page 12).

The government has been trying to encourage the greater use of off-site construction for many years. One thing that has held it back is the perception that factory systems are always lightweight, as well as repetitive, uninspiring and untried. Hybrid can overcome these stumbling blocks, combining two well-established techniques to achieve infinite possibilities. If we are going to realise the enormous potential of off-site, we need to explore every possible solution – those both further afield and right in front of us.

HYBRID HAS LONG BEEN COMMON IN CONTINENTAL EUROPE, WHERE IT IS CONSIDERED "THE" WAY TO BUILD USING CONCRETE

EVENTS

LEARNING IN LOCKDOWN

The Concrete Centre's events programme continues despite the pandemic, with a rich and varied selection of online webinars and e-learning courses scheduled over the coming weeks. Topics include low-carbon design and specification, post-tensioned floors, and detailing to Eurocode 2. The inaugural Concrete Futures lecture on 9 June will now take place online, with presentations from leaders in the field of bioreceptive concrete, including the team behind UCL's living facade panels (pictured). Later in the year, The Concrete Centre's sustainability conference will also shift to an online format, with a full programme of live and pre-recorded events to be announced.
concretecentre.com/events

Photo: Sarah Lever

Images: 1. Historic England; 2. UrbanR; 3. UrbanImages / Alamy; 4. Paul Clemence

ROUND-UP: GLIMMERS IN THE GLOOM

With the world in flux, it's mildly comforting to learn that some aspects of the future will look a lot like the recent past. Two recent high-profile project announcements show how existing concrete structures can be reimagined and put to entirely new uses. Haworth Tompkins has won planning permission to convert Arup Associates' grade II*-listed Legal & General HQ in Surrey 1 into a retirement community. The £215m project will see the postmodern 1990s building, which has a reinforced concrete frame and classically inspired precast colonnade and central rotunda, repurposed to house 130 apartments. Meanwhile, UrbanR has got the go-ahead to transform a 1960s car park beneath Cavendish Square in London into a £150m health and wellbeing destination 2. Also grappling with our concrete heritage, the Twentieth Century Society has called for the listing of two pioneering London social housing schemes: Berthold Lubetkin's Sivill House (1962-66), a 19-storey tower with a geometric concrete facade in Bethnal Green; and the stepped precast terraces of the Whittington Estate (1972-78) in Highgate, designed by Peter Tábori 3. Finally, something completely new: photos have been released of Thomas Heatherwick's Little Island project 4 in Manhattan. The undulating public park is being built in the Hudson River on a series of piles that resolve into vast precast planters.

INNOVATION: CARBON-CAPTURING ALGAE

"What excites me about this carbon reduction project is that we can do it now"

As group director of alternative resources for HeidelbergCement, Jan Theulen is involved with a wide range of projects designed to help the company achieve CO_2 neutral status by 2050.

HC – which operates as Hanson in the UK – has initiatives looking at carbon capture and low-carbon cement formulae, and other projects sourcing alternative fuels for its plants. But one of the most intriguing and, one senses, one of Theulen's favourites, lies almost 100 miles north-west of Marrakesh – at Safi on the Atlantic coast.

Here, next to HC's largest plant in Morocco, are row upon row of long plastic tubes filled with a carefully mixed cocktail of algae and brine. Waste CO_2 from the cement plant is bubbled through the water and the algae thrive on it, absorbing up to twice their own weight in the gas as they grow and reproduce.

"The Safi site is ideal for this project," explains Theulen. "The algae like the mild maritime climate, and the good hours of light and sunshine. And we like the availability of non-arable land and a skilled, reliable workforce."

Once the algae has absorbed its fill of CO_2, it is pumped from the tubes and filtered from the brine. "It is then dried in a solar dryer," says Theulen, "similar to the ones used to dry dates and fruit in the region. It's essentially a box with a fan to direct a flow of sun-heated air over the algae." The result is dried algae flakes, rich in nutrients such as Omega 3 and 6 fatty acids: "These can be sold as fish food or chicken food to help offset the costs of the project."

At present, the plastic tubes of the algae farm cover just one hectare, but Theulen wants to scale up to 400ha, when the algae will consume about 10% of the plant's CO_2 output. Modest beginnings do not worry him unduly. "In the past I have worked extensively setting up alternative fuel supplies derived from waste for our cement plants, also starting small. I know it takes time, you need to get local entrepreneurs involved, you need to build robust supply chains, you need to demonstrate a good business case to make it happen. And so once we

Photos: HeidelbergCement

have created an efficient algae business, we can then hand it over to companies in that market. After all, we are not fish-food producers."

Theulen himself is a mechanical engineer who has been with HC for 30 years. He was originally on capital projects to design and set up new plants, but has focused on environmental initiatives for the last decade. "What excites me about this project is that we can do it now. As an engineer, I don't like to just talk about things. I want to make them happen."

■ **Interview by Tony Whitehead**

LASTING IMPRESSION

DAVID HILLS

LONDON'S VERY EARLY ADVENTURES IN CONCRETE, AND A WALL TO REMEMBER

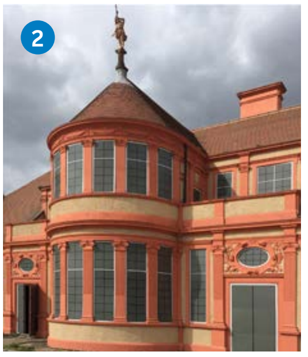
I lived in the Barbican 1 (1965-76) for ten years, and it gave me a real respect for concrete. It's pick- and bush-hammered, so you know that every square inch has had the same care and attention lavished on it as a stone building. Barbican concrete is also the toughest stuff you can imagine – the difficulty of putting up shelves was quite incredible.

As a conservation architect, I've taken that respect for concrete into my work. One project I really enjoyed was at London's Royal Albert Docks, the last vestiges of which are the Dock Manager's Office and Central Buffet 2 (1882), designed by William Lascelles. Lascelles patented this extraordinary prefab system, which involved nailing reinforced concrete panels to a timber frame. He even teamed up with the eminent architect Norman Shaw on a pattern book of 50 or so buildings – offices, houses, village halls – using the system. The panels are 3ft by 2ft by 1.5in, and the ornamentation is all attached in the same way. They are basically arts and crafts buildings made from concrete, and there's an interesting contemporary review in The Builder lamenting that this new material is rehashing existing aesthetics rather than expressing its own unique qualities. Half a century before Le Corbusier, they were already having this conversation.

The Mission Church 3 in Dilston Grove, Southwark (1911), comes just 30 years later, but is unashamed to celebrate the rawness of concrete. It was designed by Wembley Stadium architects John Simpson and Maxwell Ayrton, and while it's still evoking a historical style, it embraces the textural qualities of concrete in a way that few architects did until much later. The interior has this austere feel, like a Franciscan friary – when you're up close, you can see the day joints and the burnt spar aggregate in the concrete, which gives it a very particular grey colour. It's a very direct evocation of the material.

Another work I came across professionally is the Ramsden Memorial 4 in Aldershot. When they replaced the Victorian barracks in 1962, William Mitchell (see below) created a garden wall incorporating pieces of the demolished buildings, so there are bits of broken-up brick amid these bush-hammered and grooved cast-concrete surfaces – a linear pattern that's reminiscent of Picasso's Guernica. It feels imbued with the spirit of all the people who have been through the barracks, and the lives lost in various campaigns. Now it's languishing in the middle of a housing estate – it needs a bit of recognition.

David Hills is a partner at Purcell



Photos: 1. Dennis Gilbert / VIEW ; 2,3,4. David Hills

FROM THE ARCHIVE: SUMMER 1973

WILLIAM MITCHELL'S X-RAY CEILING

William Mitchell, who died in January at the age of 94, was one of the most prolific concrete sculptors of the post-war era, and his works – which adorned everything from shopping centres to cathedrals – featured regularly in CQ throughout the 1960s and 70s. Even so, his ceiling mural at Clatterbridge Hospital in Liverpool, completed in 1973, still had the capacity to surprise (and delight) our correspondent. "This is the first time that we have ever featured (or seen) a decorative concrete ceiling, but now that we come to think of it, the idea has tremendous possibilities, particularly if the ceiling is going to be lit." (Here, the work was accentuated by lighting concealed behind timber coving on the walls.)

Mitchell carved the design into 51mm-thick foamed polyurethane mould liners, against which the 279mm-thick roof slab was then cast using a standard mix. Because supports for the moulds would have spoiled the pattern, a system was devised involving cantilevered runs for barrows constructed over the ceiling.

For CQ, the finish ceiling was "doubly attractive" because it was functional, forming part of the reinforced concrete armour of the hospital's radiation therapy unit – one of the most advanced in the country at that time. It also responded to a therapeutic need identified by the hospital director, giving patients something to gaze up at and distract them while they were undergoing treatment.

For more examples of William Mitchell's work, search the CQ archive at concretecentre.com/cqarchive

ORIGIN STORY

DUKE OF YORK RESTAURANT

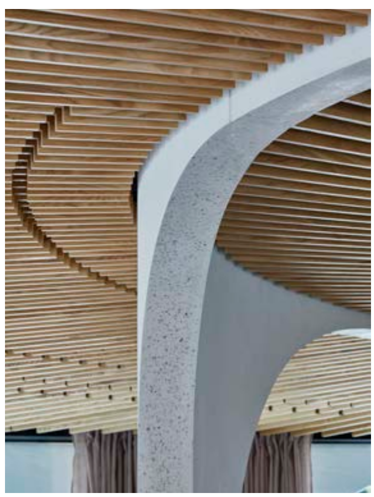
ALAN DEMPSEY OF NEX ON A DESIGN THAT UNFURLED FROM A GRADE II-LISTED WALL

We were always conscious of how to intervene in this kind of public space in a way that is sensitive to its context but also unapologetically contemporary. The site for the restaurant is a square next to the former Duke of York's barracks in Chelsea, opposite the King's Road, and it's all grade II-listed. We really didn't want to lose that public space – if anything we wanted to enhance it. The neighbouring parade ground has this amazing ribbon of trees all the way round it, but it was interrupted by our site, so we thought maybe there was a way to green that gap, and give people another perspective over the whole space. That resulted in thinking about the roof as a public space, directly connected to, but slightly removed from, the square and parade ground.

Our other starting point was a grade II-listed wall, which was originally part of the military asylum but since the barracks' redevelopment had become a bit of an odd appendage to the square. We needed to address this wall but we didn't want the building to have a distinctive front or back – it needed to be approachable from any direction. We came up with the notion of continuing the wall, but curling it into a ribbon: a layered space from outside to inside, from the square to a central service core, with large openings on all sides.

As we looked into the idea of the wall, materiality became increasingly important. We considered brick, structural steel, or a steel frame with cladding. But it really needed an integrity to it, to be both structure and finish. We felt a precast concrete solution gave us these benefits. It has a sense of solidity but at the same time it can span 10-12m openings, and it meant we could minimise the work done on site.

But we also wanted it to convey the sense of a ribbon – so it needed to be as slender as possible. In engineering codes, you quickly come up against a 200mm minimum thickness for structural concrete columns and walls, but we worked very closely with AKT II to get that down to 150mm. As a public roof space, it's carrying significant loads, but it does it effortlessly, which belies the sheer quantity of reinforcement in the columns and how hard the connections are working.



Photos: James Brittain

We chose a white concrete, with an off-white fine aggregate of quartz and a coarse aggregate of dolomite. The front and back surfaces have been acid-etched to give a slight lustre to the quartz – with curved concrete, you really want to do as little finishing as possible. But within the arches, we heavily ground and polished the reveals to show the pale-grey and blue dolomite stones. Conceptually, it reinforces the idea of a continuous ribbon being cut to form these openings.

The structural glazing is a unique system: these big, curved panels, 3.2m high and 9.5m wide, lower into the basement on a counterweight, just like a sash window. They depend on extremely low tolerances in the concrete frame, which was another reason why we chose precast. We had to coordinate very closely between the glass manufacturer in Switzerland and the concrete manufacturer in Derby to be certain that the elements would all fit together precisely on site.

The windows give a sense of performance – the restaurant (called Vardo) is a great place to watch the world go by, and to be seen as well. The way we've had to abandon these gathering places in the last few months is a real reminder of how they are the essence of the culture of cities. With its open facade and roof, Vardo was meant to come into its own in spring and summer. We'll have to save that for another year, but hopefully it will be lively and animated very soon.

Alan Dempsey is founding director of London-based architect Nex. Interview by Nick Jones

AN OPEN UNIVERSITY

Grafton Architects' hybrid concrete structure sets the stage for some monumental spaces at Kingston University, writes Tony Whitehead

It is a slightly odd but undeniable fact that a university's status is profoundly tied up with the type of property it occupies – red-brick, plate-glass or even ivory tower. So it's understandable that when universities commission a new building, they are particularly keen to get it right.

The new Town House at London's Kingston University, for example, is the sort of high-profile mixed-use building that has in recent years become increasingly popular with academic institutions. Its six storeys house lecture theatres, study rooms, dance studios, an auditorium, a library and a cafe.

But it is more than simply a space for students to meet, study and recharge laptops. It is a signature project – intended to become the building that people primarily associate with the university. It is now Kingston's "front door", its distinctive presence in the town, and the medium through which it seeks to engage with the local community.

All of this is reflected in the distinctive design from Pritzker Prize-winning Grafton Architects. "The client really wanted no barriers between itself and the town," explains Grafton director and project architect Gerard Carty. "So the colonnades of the outer layer give the building a monumental style and a civic presence, but they are also permeable. Passers-by walk underneath and through them, and they can see in. There's no 'them and us'."

This dramatic concrete colonnade is certainly striking, and its brutalist echoes firmly associate Kingston with the democratic new accessibility offered by the universities and polytechnics founded in the 1960s and 70s. The choice of concrete as the main construction material is absolutely central to this effect, evoking the iconic campuses of, for example, Lancaster and East Anglia.

Interestingly, the building was originally conceived by Grafton as an in-situ concrete frame with precast colonnades, but this was changed to a predominantly precast hybrid structure after discussions with the client, contractor Willmott Dixon and structural engineer AKT II. "Originally the interior frame had in-situ slabs articulated with beams to reduce the depth needed for the larger spans," says Carty. "The overall shape and design didn't change much with the switch to precast, but it did involve a seismic shift in our thinking about how to deliver it."

BEING PRE-STRESSED AND VARIABLE IN DEPTH MEANS YOU END UP WITH A 'BONY' DESIGN – WHICH IS VERY EFFICIENT

As Carty says, one of the key concerns for the architect and AKT II was the long spans required to create some of the interior spaces: "For example, there's quite a large double-height lecture theatre and a courtyard-cum-auditorium which is triple height and requires spans of more than 15m. We had to find a cost-effective way of spanning these spaces which stayed true to the design intent."

The solution for the interior frame involves 550mm^2 precast columns arranged on a 6.4m grid running along the front of the building. A similar arrangement supports the rear of the structure and these shorter spans are bridged mainly by pre-stressed, hollowcore slabs 225mm deep. But in between, and where longer spans are required, these are achieved using 229 precast, pre-stressed "double T" beams cast in C60 concrete and weighing up to 18 tonnes each.

As Carty admits, the double T system is more usually to be found in multistorey car parks: "But in fact they are very efficient and several advantages result from using them," he explains. "Firstly we can vary the depth of the downstand part of the T depending on the span and loading involved – so we have three variations: 610mm, 810mm and 1,010mm-deep including the 'tabletop' formed by the TT."

The depth of the tabletop is 60mm and above this is a 115mm-deep reinforced structural screed. This effectively creates a hybrid precast/in-situ slab of 175mm above integral downstands which vary between 550mm and 950mm depending on the space they are spanning.

"Being pre-stressed and variable in depth means you end up with what we call a bony design – very efficient in terms of material usage," says Carty. "Another environmental positive is that they are made with standard steel moulds that can be used repeatedly, so there is none of the waste that would result from throwing away used timber forms."

The Ts also perform a vital acoustic function: "Since we have in the same building a dance studio with loud music and also a library, it was essential to have sufficient sound absorption. The T shape helps break up sound waves as they hit the ceiling and, importantly, we have placed sound-absorbing woodwool slabs between the verticals of the Ts."

At first glance, these grey woodwool downstands blend into the grooved soffit created by the

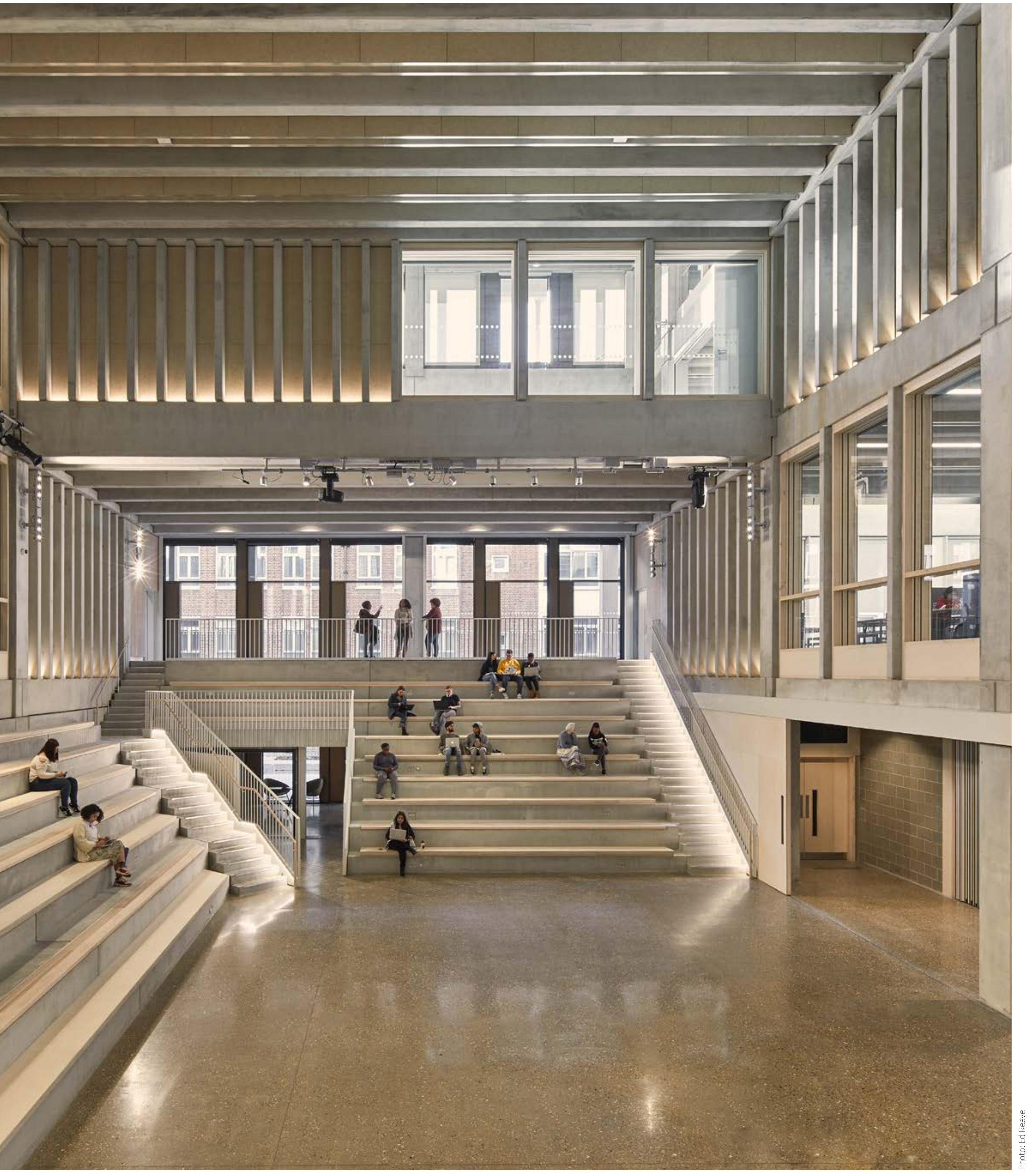


Photo: Ed Reeve

A kit of concrete parts

Above the in-situ ground-floor slab, all the concrete construction for Town House was carried out by PCE, a company that, while it does not manufacture precast elements itself, has developed a specialisation in designing, procuring and installing them.

So at Kingston the majority of the internal frame, including the double-T beams, was manufactured by Bannagher Precast Concrete, which appropriately enough, considering some of the long spans involved, has a particular expertise in pre-stressed bridge elements. Meanwhile some of the core sections were made by Shay Murtagh, and the architectural elements for the external colonnades were supplied by Techrete.

"We take a kit-of-parts approach," explains PCE's business development manager, Simon Harold. "We are focused on buildability and are happy to use hybrid systems – so although most of the concrete at Kingston University is precast, the slabs are actually composite – precast beams with an in-situ structural screed."

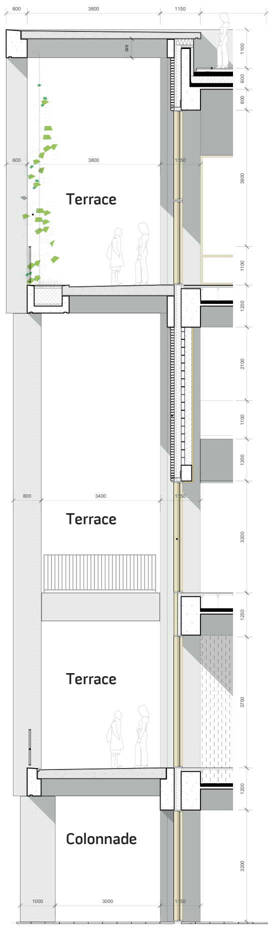
As Harold explains, the frame assembly technique is focused on speed and accuracy: "The internal columns have cast-in shoes and these feed onto bolts in the column or beam below. Once in place, the crane is released for the next job, and the column is fine-adjusted for verticality using the bolts. The mechanical connection is then encased in structural grout and the whole shoe is hidden within the raised floor above the slab."

Similarly, sleeves within the beams are fed onto dowels or bolts on columns and then grout-stitched together.

"At Kingston the structural screed reinforcement was tied into reinforcement projecting out of the top of the double-T slabs to enhance the composite action," says Harold. "We also needed to tie the screed into the stability elements of the building – the three cores – so these had Kwikastrip cast within them to make it easy to get the reinforcement out and connected up to the mesh in the screed."

PCE used ground granulated blast-furnace slag (GGBS) cement substitute in the mix to reduce the embodied carbon of the concrete. "For most of the elements we were able to use a relatively high proportion of GGBS, 40%," says Harold. "That would normally slow curing times and present problems for our suppliers. However, they were able to compensate for this by making adjustments to the super-plasticisers used, and by keeping the moulds warm."

In all, the interior frame of Town House comprises 229 double-T units, a further 318 beams, 275 columns, 50 solid wall units and 52 core sections. The exterior frame required a further 300 beams and columns, together with 175 mullion and spandrel panels. Despite these daunting numbers, an impressive time-lapse video on PCE's website shows the building's structure being constructed in a little over 12 months.



double-T structure. Closer examination reveals that the aluminium-framed woodwool slabs also carry features such as lights and smoke detectors.

The grooved aesthetic of the ceilings is repeated elsewhere in the building. In the ground-floor auditorium, for example, walls are formed from vertical exposed concrete mullions with more woodwool sound absorption placed between them.

The auditorium itself features a kind of amphitheatre, the giant steps of which can be used as meeting space or, when the auditorium is closed off by sliding doors, as seating for performances. In keeping with the utilitarian design of the ceiling, these steps are formed from football terrace technology – simply L-shaped precast elements placed one on top of the other. "We decided that bare concrete might be a little uncomfortable," says Carty, "so we've provided timber tops to the steps in maple, which is kinder to sit on."

Outside, the building envelope is created by walls of brick interspersed with architectural concrete mullions that frame the windows and stiffen the walls. "For the exterior concrete we developed a special mix with the supplier, Techrete," says Carty. "The planners wanted the building to be in sympathy with Surrey County Hall opposite, which features Portland stone – so the mix for the exterior mullions and the colonnades has a pigment to create the Portland colour, and a white dolomite aggregate with a grit-blasted finish to give it an attractive stony texture."

Town House's colonnade comprises some substantial elements – many of the columns are 12m high. However, it remains structurally independent from the interior frame, being simply tied back to it. The resulting absence of cantilevered slabs meant there were no issues with inserting insulation at the slab edges to prevent cold bridging.

The precast terrace slabs supported by the colonnade provide useable outdoor space for students and contain planters from which climbing plants are already growing. The plan is that vines will eventually entwine around most of the exterior columns, softening the architecture with greenery, and adding, perhaps, a touch of Ivy League style to Kingston University's new high-street presence.

■ More on hybrid structures, page 14

OPPOSITE TOP Many of the colonnade's precast columns are 12m high

ABOVE LEFT Section of the colonnade

ABOVE The terraces are structurally independent from the interior frame

PROJECT TEAM
Architect Grafton Architects
Structural engineer AKT II
Main contractor Willmott Dixon
Concrete contractor PCE
Precast frame suppliers Bannagher, Shay Murtagh
External frame supplier Techrete

Queens of cool

Concrete has featured strongly in many of Grafton Architect's award-winning designs – including the UTEC University Campus in Lima for which it won the inaugural RIBA International Prize in 2016 (CQ 259).

"The root of our liking for concrete probably stems from our early days when we were doing a lot of secondary schools in Ireland," explains director Gerard Carty, who has been with the practice – led by Pritzker Prize winners Yvonne Farrell and Shelley McNamara – since 1992. "Inexpensive, basic, concrete-framed structures with exposed blockwork walls were the order of the day. We learnt to value its resilience and robustness as well as the way that exposing the concrete cuts down on finishing and allows its thermal mass to be put to work."

This ability of concrete to absorb the excess heat that can be generated in highly populated buildings is particularly useful at Kingston University, where the large numbers of students and computers could easily overheat Town House in all but the coldest months of the year.

"The building skin is well insulated to reduce heating costs in winter, so it's important to have a way of regulating and releasing heat during the rest of the year," says Carty. "For this reason we've included a Thermally Active Building System (TABS) within the structural screed."

This involves a system of pipes that are laid directly on top of the double-T "tabletop" (see main feature) before reinforcing mesh and screed is added. Cold water can then be passed through the pipes when necessary to supercharge the cooling effect of the concrete's thermal mass.

"We did look at making it a heating system too, by also allowing warm water through the pipes," he adds, "but the heating requirement was so low we decided it would not be worth it."

The deployment of the TABS within the thermal mass of the concrete helped the building to achieve its BREEAM rating of excellent.

Photos: Ed Reeve; Dennis Gilbert

RUST ASSURED

Precast concrete and Corten steel prove an impressive double act at Walters & Cohen's latest project for the King's School, writes Nick Jones

The King's School in Canterbury is one of the country's most venerable public schools, with origins dating back nearly 1,500 years, and a list of alumnae that reads like a roll call of a certain type of Englishness, from Field Marshall Montgomery to David Gower. But for its newest building, it has stepped outside its medieval precinct in the shadow of Canterbury Cathedral to a site in the north of the city, where architect Walters & Cohen has created a strikingly contemporary courtyard building for the college's international students.

"We have done a lot of projects for King's, but this was an opportunity for us to do something that wasn't so sensitive in terms of the medieval context," says Giovanni Bonfanti, director of Walters & Cohen. "This was a little bit more freedom, so we decided to use materials that were more in tune with the site's industrial heritage – we immediately thought about concrete and Corten."

The site neighbours a 19th-century malthouse, which Nicholas Hare Architects has refurbished for the school as a theatre and performance venue. The red brick and slate roof of this building is echoed in the palette of its new neighbour, which has a cool-grey boardmarked concrete ground floor and vibrant Corten-clad upper storeys. This visual delineation reflects the programme within: the ground floor houses classrooms and study areas for the cohort of 11-16 year-old students, while the upper floors contain 34 en-suite bedrooms and flats for staff.

These spaces frame a large landscaped courtyard – the conceptual as well as literal heart of the building. "It feels very sociable," says project architect Rob Hill. "You can see through the building, you've always got a view through to the outside." Bonfanti adds that the courtyard is almost the first thing that visitors see: "I call it a Milan palazzo because it has clear proportions, it's a square, you enter through this portico and you immediately see this beautiful space."

The regular proportions were also key to the construction process, which involved a high degree

CLOCKWISE FROM LEFT
The palette of industrial materials was inspired by the neighbouring malthouse; the precast facade is boardmarked with larch panels; the central courtyard lends a sense of transparency to the building

PROJECT TEAM
Architect Walters & Cohen
Structural engineer Price & Myers
Main contractor R Durtnell & Sons
Precast concrete supplier Cornish Concrete Products

Photos: Dennis Gilbert, VIEW Pictures

of repetition and prefabrication. All of the external windows are the same and the bathroom pods are all identical. The exterior walls, meanwhile, have the appearance of in-situ concrete but are in fact precast – its panels based on the same 900mm x 3,800mm modules as the Corten above. The decision to use precast here was largely due to the project's fast-track schedule of less than three years from conception to completion, says Bonfanti. "It was quite refreshing to have to produce something so quickly. Literally within a few weeks we had a concept. And because we had to build everything very quickly, we tried to standardise as much as possible."

The loadbearing precast panels were created using larch panels as formwork. Bonfanti says that close attention was paid to the detailing: two different moulds were used to ensure that the panels didn't all look the same, while the four corners were all cast in single pours as massive 4.5m x 1.3m right-angled units to suggest the seamless appearance of in-situ concrete. The holes for the lifting eyes were concealed by a post-finishing process that mimicked the board marking.

Internally, the ground-floor structure is in-situ concrete, left exposed to harness the thermal mass as part of a natural ventilation strategy. The columns have the same larch-marked finish as the external panels, and use a near-identical 40% GGBS mix. A water-resistant additive gives the precast exterior a slightly more "core grey" tone, Bonfanti notes, adding that it will also age at a different rate due to its exposure to the elements.

The 300mm-deep first-floor slab, meanwhile, is finished as a smooth soffit. This projects into the courtyard as a continuous border of balconies, thermally broken at the building perimeter. The balconies add to the social function of the courtyard, as well as providing valuable shading for the glazed colonnade-like space below.

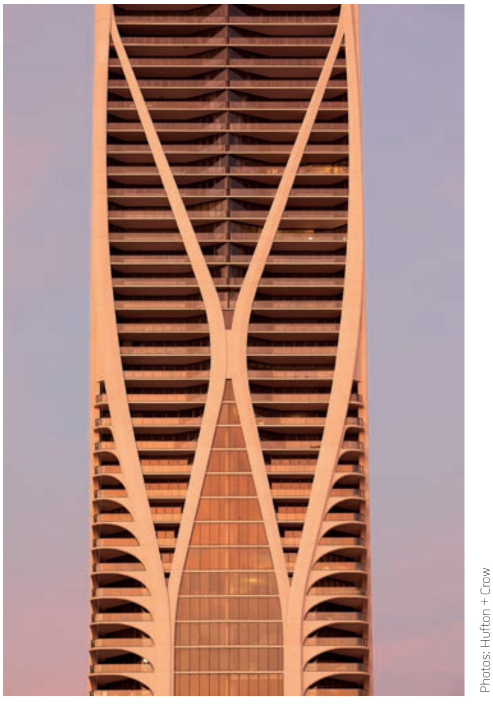
While the precast and in-situ concrete are both deftly handled, it is in the hidden space between the two that some of the building's smartest detailing occurs. Corten and concrete are not always the happiest of bedfellows, particularly in damp climates. "The rust, especially for the first six to eight months, is like ink basically," says Bonfanti. In order to avoid the steel staining the precast panels below, the architects devised a system involving a thin continuous tray to divert water along the base of the Corten into downpipes concealed behind the concrete. "It was a very complicated detail," says Bonfanti. "And it meant some of the panels had to be accessible. I always try to hide downpipes, particularly in a school, because kids try to climb them, but it is amazing how much more complicated it is than it looks."

This discreet flourish is a testament to the importance placed on materials throughout the scheme, and hopefully will ensure that the school's international students won't become too dispirited by the British weather. 'The building's very simple," says Hill, "but the palette of materials gives it such a character. When you see the Corten and concrete in the rain, that character really comes to life."

BECAUSE WE HAD TO BUILD EVERYTHING VERY QUICKLY, WE TRIED TO STANDARDISE AS MUCH AS POSSIBLE


SET SAIL THE
VIRGIN WAY

EYES IN THE SKY



Photos: Hufton + Crow

Zaha Hadid Architects' Miami tower reinvents high-rise design with a GRC exoskeleton that looks eerily like an insect's face ... By Nick Jones

The new tower at 1000 Biscayne Boulevard is recognisably a Miami luxury apartment building, with its expansive balconies and sun-drenched white concrete. But it's also something else entirely. This is a building wrapped in a continuous concrete exoskeleton unlike anything ever seen before – and built in a way that's never before been attempted on a building of this scale. As it looms over visitors to the neighbouring Museum Park – home of Grimshaw's new Science Centre and Herzog & de Meuron's Perez Art Museum (CQ 247) – the outline of the structure bears an uncanny resemblance to the face of a praying mantis, magnified to 62 storeys. This, it transpires, is how Zaha Hadid Architects does Miami deco.

The insect-like structure may look theatrical, but it is an entirely rational response to the brief, stresses ZHA project architect Chris Lepine. "It's a combination of optimising the structure and also expressing and reacting to the brief behind it," he says. This called for a high-end luxury condominium tower with extra-large units and uninterrupted expanses of floor space. With reinforced concrete such a prevalent part of the Miami cityscape, it was the natural choice for structural material, and the use of an exoskeleton enabled the designers to minimise the number of internal columns, as well as reducing the depth of the central core and shear walls. In a city notoriously susceptible to hurricanes, the rigid tube-like structure also offers high levels of wind resistance.

It was, in short, the perfect opportunity to test out an idea that had been kicking around at ZHA for a while. "There was a certain evolutionary trajectory," says Lepine. "We had done some competition schemes and design studies exploring this idea of synthesising architecture and structure and making that the main expression of the building. We knew we didn't want this to be an all-glass building, because glass would be very problematic in Miami's climate. So expressing the structure, making that the main element in front of the glass, seemed natural for this site."

The exoskeleton, replicated on each elevation of the square tower, begins as four columns at ground level. These bulge outwards to the corners of the plan, creating a linked brace around the podium, before returning to two more central columns. They then bifurcate again as the tower rises to form a kind of diagrid around the centre of the building where the lateral bracing needs to be strongest. For the top third of the building, where the structural load is lightest, the exoskeleton slims once more to two tapering corner columns.

The entire thing, including the gill-like cantilevered balconies that fan out from the lower section of the building, was created using permanent formwork made from glass-reinforced concrete – a world-first for a tower. ZHA had trialled this approach – more commonly used on bridges and tunnels, as well as some smaller scale buildings – on its Stone Towers development in Cairo, and even built a full-scale mock-up to demonstrate that it could be used successfully on high-rise projects. "The benefits are that all of the panels are factory-made so the tolerances, the geometry, the finish are all precisely controlled," says Lepine. "And as a system it's quite elegant: the casings come, you clamp them into place, you pour the structure, you leave them in place. So it's the external finish, the structure and internal finish all in one." The finish itself, which he describes as the supplier's "special sauce", has left a light-coloured, sandy surface throughout the building, which is both durable and dirt-repellant. "In-situ concrete wouldn't have been able to achieve a finish like that, certainly not economically," he says. "There was a point when we considered steel and then cladding it, but it just wouldn't have felt right to have a steel structure and then clad it with this finish."

ZHA also simplified the construction process by removing all of its trademark double curvature and twisting surfaces. "The plan is a square, so we looked at how the panels could be repeated: on the lower and upper thirds of the structure where it's largely straight there's repetition. It was always a trade-off between repeating elements and making additional moulds."

The tower still has a remarkably fluid appearance and this continues through to the interior. The lobby is designed to feel like a continuation of the outside space, with the GRC forms curving from walls into soffits and columns. The apartments too are defined by their relationship to the exoskeleton. "You're surrounded by it, and it varies from level to level," says Lepine. "It feels like you have your own unique chunk of the structure." This is accentuated by the fact that the finish is continuous from outside to inside, with the windows placed at the mid point: the glazing is "very seriously" sealed against the GRC with some anchor points cast in.

At the top of the tower, the structure folds in on itself almost like a funnel, within which ZHA has created a triple-height sky lounge. As the columns arch over and back downwards, a tracery of glass-reinforced polymer vaults the space, like a cross between a cathedral and a superyacht. It is easy to imagine the Beckhams popping up for a swim from the penthouse they have just bought for $24m.

Lepine admits that in terms of its aesthetics and unique environment, this is a very Miami building, but thinks its construction approach could be applied more widely. "I can certainly see this being used in the UK – for everything from office buildings to residential. It offers a high degree of flexibility in terms of the formal, structural aspects of the building, and it's a very good building strategy. Your external finish, your insulation, your structure, your internal finish can all be done in one go. There's not many products where you can do that. I wish I could patent it."

YOUR EXTERNAL FINISH, YOUR INSULATION, YOUR STRUCTURE, YOUR INTERNAL FINISH CAN ALL BE DONE IN ONE GO

CLOCKWISE FROM TOP LEFT

The tower looks down over Biscayne Park; the exoskeleton's central section bifurcates into two eye-like forms; the top of the structure folds over to create a vault-like space; the five-storey podium houses the lobby and residents' parking

PROJECT TEAM

Architect Zaha Hadid Architects
Local architect O'Donnell Dannwolf Partners
Structural engineer DeSimone Consulting Engineers

Best of both worlds? The benefits of going hybrid

Jenny Burridge explains how using precast and in-situ concrete together can often be the most buildable option

The government is currently championing the use of off-site construction as a way to improve productivity and reduce the number of hours required on site. Purely precast concrete systems are available, but there are also structural systems that use a combination of precast and in-situ concrete, with each type playing its part. This is known as hybrid concrete construction (HCC).

HCC can deliver very significant cost savings, through economic structures, increased prefabrication, faster construction and consistent performance. Although the structural frame of a building represents only 10% of the total construction cost, the choice of material has dramatic consequences for subsequent processes. Hybrid construction can reduce frame costs by using precast concrete for the repetitive elements, or to act as permanent formwork. In-situ concrete is more cost-effective for large volumes (due to reduced transport costs), for tying the frame together and for bespoke areas. Using the two together maximises cost efficiency.

The key advantage of HCC is its buildability. Because precast and in-situ concrete are used where each is most appropriate, construction becomes relatively simple and logical and important decisions are resolved at design stage.

RIGHT The Ray in London by AHMM has a number of setbacks created by cantilevering the post-tensioned slabs or by transferring the edge columns

OVERLEAF The in-situ concrete slab soffit is exposed throughout the building, contributing to the environmental strategy

FIGURE 1: SUITABILITY OF HYBRID OPTIONS

Hybrid option (see fig 2)	Ease of services distribution	Minimises storey height	Suitability for holes	Clear spans	Deflection control	Minimises materials	Soffit can be exposed	Maximises off-site construction	Temporary works minimsed
Type 1	✓✓	✓✓	✓✓	○	✓✓	✓✓	✓✓	✓	✓✓
Type 2	✓✓	✓✓	✓	✓✓	✓	✓	✓	✓	○
Type 3	✓	✓✓	✓	✓✓	✓✓	✓✓	○	✓✓	✓✓
Type 4	✓	✓✓	✓	✓✓	✓✓	✓✓	○	✓	✓✓
Type 5	○	○	✓	✓✓	✓✓	✓✓	○	✓✓	✓✓
Type 6	✓✓	✓	✓	✓✓	○	✓✓	✓✓	✓	✓

✓✓ Excellent ✓ Good ○ Can be used

Note on table and diagrams

The ideal combination of precast and in-situ concrete is influenced by project requirements. There is a wide range of possible options, a selection of which is presented opposite as representative of current UK practice. It is not intended to be an exhaustive list.

◀ The Ray, London, 2019

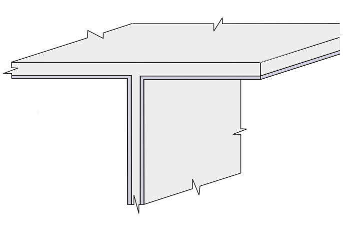
Hybrid concrete construction was used in the construction of The Ray, the UK home of social networking company LinkedIn. The building, by architect Allford Hall Monaghan Morris (AHMM), steps back in order to address the varying scale of the neighbouring buildings, and to create accessible terraces and allow natural daylight to flood all floorplates. Concrete was chosen as the frame material to provide thermal mass to reduce the servicing required. The structural frame is formed from post-tensioned slabs, with spans of up to 10.5m. The setbacks are achieved through either cantilevering the post-tensioned slabs or by transferring the edge columns. The hybrid section is in the lift and stair cores, which were formed using twinwall (see figure 2, type 1). Precast concrete sandwich panels were used for the brick facade. The concrete slab soffit is exposed throughout the building, contributing to the project's environmental strategy, while the use of ground granulated blast-furnace slag (GGBS) as cement replacement in the concrete mixes reduces the embodied carbon associated with the structural frame's construction, further enhancing the building's sustainability credentials.

FIGURE 3: RELEVANT PRECAST CONCRETE PRODUCT STANDARDS

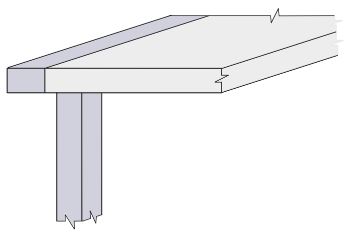
BS EN 1168:2005 (+A3:2011)	Hollow core slabs
BS EN 13224:2011	Ribbed floor elements
BS EN 13225:2013	Linear structural elements
BS EN 13369:2018	Common rules for precast concrete products
BS EN 13693:2004 (+A1:2009)	Special roof elements
BS EN 13747:2005 (+A2:2010)	Floor plates for floor systems
BS EN 14843:2007	Stairs
BS EN 14992:2007 (+A1:2012)	Wall elements
BS EN 15037 (parts 1 – 5)	Beam and block floor systems

This means, for example, that precast elements can be manufactured, stored at the factory and delivered just-in-time to site. They can then be lifted from delivery truck to final position in a single crane movement, eliminating the need for site storage and reducing crane hook time. HCC also offers all of the other advantages of off-site construction, improving both speed of construction and safety. By taking a proportion of work into the factory, it reduces the duration of on-site operations critical to the programme. The precast process takes place in a controlled environment, unaffected by weather and with no need for working at height. Rigorous inspection before installation removes causes of delay on site, while better buildability helps provide safer working conditions. HCC can reduce the potential for accidents by providing successive work platforms and a tidier site. If precast spandrel beams are used, they can provide immediate edge protection.

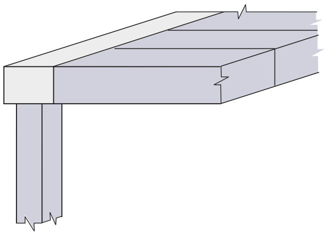
FIGURE 2: HYBRID OPTIONS EXPLAINED



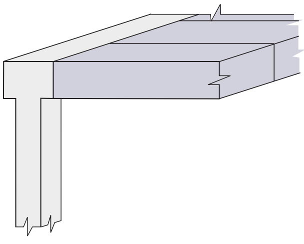
TYPE 1 Precast twinwall and lattice girder slab with in-situ concrete



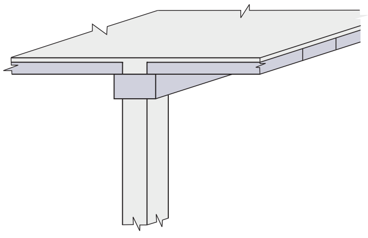
TYPE 2 Precast column and edge beam with in-situ floor slab



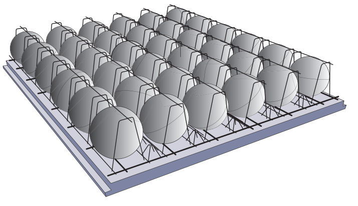
TYPE 3 Precast column and floor units with in-situ beams



TYPE 4 In-situ columns or walls and beams with precast floor units



TYPE 5 In-situ column and structural topping with precast beams and floor units



TYPE 6 In-situ columns with lattice girder slabs and optional spherical void formers

Some HCC techniques can reduce or eliminate following trades – for example, installing ceilings and finishes. If precast concrete is used for those areas of visual concrete, the workmanship required takes place under factory conditions. This enables even faster programme times but requires greater coordination and care in detailing and protection on site. The Town House at Kingston University (page 6) is an excellent example of the use of HCC to provide beautiful visual concrete, while enabling many of the add-on finishes to be eliminated.

Design

As both precast concrete and HCC are very well-established forms of construction, there is plenty of guidance for the designer. Eurocode 2 covers the design of in-situ, precast and hybrid concrete construction. There are also a number of product standards for precast concrete, which also cover the precast elements of HCC, some of which are listed in figure 3 (previous page).

The use of precast and in-situ concrete may well lead to individual elements being designed by different companies. Therefore, it is essential that there should be a single named designer or engineer who retains overall responsibility for the stability of the structure and the compatibility of the design and details of the parts and components, even where some or all of the design, including details, of those parts and components are not carried out by the named designer. This is particularly important for hybrid structures, where there is greater scope for misunderstandings.

It is the responsibility of the named designer, before incorporating any proprietary system as part of the structure, to ensure that the assumptions made in the design and construction of the system are compatible with the whole. This should include:

- an adequate specification for that part
- ensuring that any standard product designed and detailed by the precast manufacturer is suitable for that particular structure
- reviewing the design of any such part to ensure that it satisfies the design intent and is compatible with the rest of the structure.

The design of each component should include consideration of:

- its performance in the permanent condition
- the construction method and loading
- any temporary supports required during construction.

The design should be carried out following the requirements of Eurocode 2 Part 1-1, Cl. 1.3, which assumes:

- structures are designed by appropriately qualified and experienced personnel
- adequate supervision and quality control are provided in factories, in plants and on site
- construction is carried out by personnel having the appropriate skill and experience
- the construction materials and products are used as specified in Eurocode 2 or in the relevant material or product specifications
- the structure will be adequately maintained
- the structure will be used in accordance with the design brief
- the requirements for execution and workmanship given in BS EN 13670 are complied with.

The designer should state the design assumptions, which should generally include the following construction-related information:

- sequence of construction
- exposure requirements
- pour sizes assumed (if appropriate)
- concrete strength at time of striking formwork and back-propping requirements
- breakdown of loading including allowance for construction loads
- loading history assumed.

For more information, see Design of Hybrid Concrete Buildings by The Concrete Centre, available at concretecentre.com/publications

HCC CAN REDUCE THE POTENTIAL FOR ACCIDENTS BY PROVIDING SUCCESSIVE WORK PLATFORMS AND A TIDIER SITE

Photos: Rob Parrish; Timothy Soar

Adjaye's **red wave**

The architect has explored the possibilities of pink and red-hued concrete on a series of very different US projects, writes Nick Jones

The aesthetic potential of pink and red-hued concrete has been explored in a series of US projects by British-Ghanaian architect David Adjaye. The McCarter Switching Station in New Jersey, Ruby City art centre in Texas and The Webster retail store in Los Angeles, all completed in the last couple of years, use pigmented concrete in a variety of ways: both precast and in-situ, with different aggregates and finishes, and with some interesting regional variations.

At the McCarter in Newark, Adjaye wrapped the substation in a 600m-long precast-concrete wall and a canopy of 11m-high columns. Working with a local precaster, they developed a mix containing a mineral-based pigment added during the casting process. "It was a response to the regional vernacular, which is predominantly red brick," says Adjaye senior director Russell Crader. "We wanted to really try to pigment the concrete, not just add a tone to the finish."

The practice undertakes rigorous studies into the appearance of concrete, and experiments a lot. "Our process is heavy on learning," says Crader. "We've worked with different aggregates to change the hue of the red – it might be a local stone with a bit of a red tone or a black or brown that changes the pigment ever so slightly." This is evident on the precast facade at Ruby City, which is a deeper red than the substation, inspired by the San Antonio desert. "We used a local stone – the clay is heavy in nitrogen which is where the red comes from. And we added recycled red glass to really bring out that colour and make it more haptic and sensory."

In-situ concrete in the same tone is also used, for flooring and an external wall. Crader describes this as an inherently less controlled process, particularly in hot environments, where the amount of water added in the concrete truck can have a significant effect on the finished tone, making it paler. But having already manufactured the precast concrete proved invaluable: "You can learn a lot from your precast team about the mix design. They can test the PSIs in the factory, and all the qualities of the concrete."

These material explorations have perhaps reached their apotheosis at The Webster, a fashion boutique at the base of an eight-storey mall. The exterior is clad in pink precast panels, punctuated with deep perforations. This effect was created by using a salt additive in the form liner to draw out the moisture as the concrete cures – a process used for sidewalks in the southern US. "That's part of the joy of concrete, how the craft changes from region to region. You can't sandblast in some US jurisdictions, for example, you have to use walnut shell grit, so the textures change."

Inside the store, a switch to in-situ concrete explores the more fluid nature of the material (see cover). The soft pink walls are left exposed, with what Crader describes as a "slight furring" of the joints and boltholes. The idea was to create a sense of movement, with the walls almost falling into the terrazzo-like floor, which has larger chips of limestone, marble, and granite. "The aggregate almost comes to life – it's a play on what concrete can do."

ABOVE At the Ruby City art centre, recycled glass aggregate accentuates the red tone

LEFT The pink precast panels on the facade of The Webster in Los Angeles have a perforated finish created by using a chemical additive in the form liner

For more on how to achieve pigmented concrete, see CQ 256, available at concretecentre.com/archive

Flood resilience **starts at home**

Anti-flood measures are an essential part of our response to climate change, not just a topic for winter or for high-risk locations, writes Elaine Toogood

Adaptation is an essential component of responding to climate change, and flood resilience is a core consideration. Around one in six UK properties are currently at risk of flooding from coastal and fluvial flood events, and this is set to double by 2050 due to changing weather patterns and increased urbanisation. Designing out avoidable repair and maintenance and extending the usable life of buildings or components will be key to achieving a net zero carbon society – repeated replacement of water-damaged fittings and fixtures has little place in a circular economy.

The threat of water damage is not limited to identified coastal or fluvial flood risk areas. Surface-water flooding, burst water mains and blocked drains affect all buildings irrespective of location. Choosing a water-resilient structure reduces not only the potential damage from external sources, but also other events such as undetected leaky pipes.

Property-level flood resilience

Property-level flood resilience (PFR) refers to physical measures or building components that reduce the risks of flooding to people and damage to buildings, and speed up recovery and reoccupation.

PFR is increasingly recognised as an important part of the strategy for dealing with flood risk. Later this year, the Environment Agency is due to publish its revised National Flood and Coastal Erosion Risk Management Strategy for England. The draft proposals indicate a shift away from potentially limitless barriers and towards an acceptance that some areas will flood, with a greater focus on flood resilience at property level.

The Social Market Foundation think tank, backed by government insurance scheme Flood Re, has proposed that flood performance certificates could, like an energy performance certificate, become an essential part of the information provided at sale or rent of a property, identifying risks and resilience measures.

As part of the Department for Environment, Food and Rural Affairs' Property Flood Resilience Action Plan, construction industry research body CIRIA has produced a code of practice for improving the flood resilience of properties, with more detailed guidance due to be published later this year. It will primarily focus on measures that can be introduced to existing buildings, either during repairs after a flood, or in anticipation of one. But as with retrofit measures for improving energy performance, it is widely recognised that improving flood resilience is much easier when considered from the outset – that is, in new buildings rather than as retrofit measures.

Strategies for property-level resilience

Establishing the type of flood event likely to affect a property is fundamental to establishing an appropriate solution. The design strategy should be based on anticipated flood depth, likely duration and source of flooding, but also take project-specific factors into account such as the cost of construction, the cost and impact of repair, and recoverability after a flood incident.

The first step is avoidance: locating the property at area of least risk and/or raising the accommodation above the predicted flood level. The second is site layout: using the landscape to reduce flood risk or delay its impact on the building, without increasing risk elsewhere, using features such as bunds, sustainable urban drainage systems and storage. Mitigation is the final step, where the layout, choice of construction materials and detailing are developed to keep the water out as far as possible (resistance measures), and minimise damage and speed up recovery when it does get in (recoverability).

REPEATED REPLACEMENT OF WATER-DAMAGED FITTINGS AND FIXTURES HAS LITTLE PLACE IN A CIRCULAR ECONOMY

The strategies for improving the flood resilience of an existing property are far more complex than for a new-build. It is rarely practical to raise floor levels above the predicted flood level, and opportunities for external measures to delay water ingress can also be limited. Mitigation of the building fabric, fixtures and fittings are therefore the main area of focus – but the limitations of existing layouts and sheer range of construction types mean solutions must be tailored to specific situations.

This is one of the challenges of developing appropriate guidance for retrofit. Clearly flood doors, non-return valves and other applied or integrated barriers to water ingress play an important role. More fundamental are improvements to the building enclosure and surface finishes. One method, shown to work effectively at the flood resilience demonstration house at the BRE Innovation Park in Watford, is to line the inside of the ground floor and walls with

Images: BACA Architects

◀ Shipston, West Midlands, 2018-ongoing

"As a nation we end up with a cycle of flood-damage-patch-repair, and focus that dwindles away in the spring. Then comes the flood season, everyone is surprised and we are not prepared again," says Richard Coutts, director of BACA Architects. Its amphibious house, featured on Grand Designs, is often rolled out in the press as a solution for "living with water", but a development of 12 homes nearing completion just outside Stratford-Upon-Avon is far more significant as a prototype for new buildings at risk of flooding to avoid this cycle of flood damage.

One could be forgiven for not noticing the flood measures carefully embedded into the development. All principle floors are raised above the Environment Agency's plus-20% climate change fluvial flood level, providing a safe haven within the properties, and there are no bed spaces on ground floors. A significant aspect of the design is the space made for flood water across the site, using a number of complementary strategies.

All the houses use cavity-wall construction, with a concrete block inner leaf. The concrete ground floors are raised on a reinforced-concrete frame, leaving an accessible void under the buildings. Internal walls forming the staircases and halls are also blockwork. "Concrete performs well in a flooded situation,' says Coutts. "It is robust enough to be unaffected by being submerged and dries out at a reasonable rate."

This non-defensive flood-risk management approach is also being adopted by BACA on a 300-home development for Yorkshire Water, working with Harper Perry Architects.

a waterproofing layer and drained cavity, allowing incoming water to drain away. Such techniques, more commonly associated with basement construction, are increasingly recognised as useful.

It is possible to adopt a "sacrificial" approach, in which elements of a building and its fixtures and fittings are treated as expendable, to be ripped out and replaced after a flood event. But this must be considered very carefully to avoid unnecessary cost of replacement, quite apart from the waste created.

Flood-resilient structures

It is important that the structure is not compromised by a flood event, and crucially repeated events, as this is the most costly and disruptive part of a building to replace. A quick recovery with limited additional expenditure and resources is clearly desirable, and here concrete and masonry construction offer significant advantages. Its performance is not affected by being submerged, or from drying out. Unlike framed solutions, it can also be installed without voids and with very few joints, helping to keep water out. All the recommended and preferred wall and floor constructions in the current British standard, BS 85500:2015 Flood resistant and resilient construction, are made from concrete or masonry.

Concrete and masonry can be both structure and final finish, offering the ultimate in material efficiency both during construction and after a flood. The time taken to dry out some types of water-saturated masonry is sometimes seen as a disadvantage to speedy reoccupation, but this is not an issue with an internally lined and drained solution such as used at the BRE flood house.

Concrete itself is very slow to absorb moisture, and can even be water-resistant, as in basement and swimming pools. There are also numerous clear surface-applied sealants that can limit moisture ingress. Those used to working in concrete understand that it can be supplied in a wide range of colours and textures, often with the appearance of stone. Where an exposed concrete surface is not desired, it also provides an excellent, stable base for other surface finishes, whether robust and waterproof, or sacrificial.

Concrete and masonry walls, floors and stairs, can provide resilience at the core of any building, even if all other measures are not installed from the outset. They can facilitate the application of further resilience measures in the future, as risk of flooding increases, especially if a whole building strategy has been considered from the outset. By embedding good flood-resilience thinking and materials in this quite simple way, we are better preparing our building stock for the future. "Be prepared" has become a mantra for those living with the risk of flooding, and surely all architects and developers should heed this advice.

FINAL FRAME: BUHAIS GEOLOGY PARK, SHARJAH

On the al-Madam Plain south of the city of Sharjah, Hopkins Architects has designed five interconnected pods that will exhibit fossils and other artefacts from the desert region's rich geological history. The geometry of the pods was inspired by the fossilised urchins present on site, which have been translated into a series of segmented precast-concrete shells. To minimise disruption to the existing fauna and terrain, the pods only lightly touch the ground on in-situ reinforced-concrete foundation discs.

Photo: Hopkins Architects