CONCRETE QUARTERLY

SPRING 2015 | ISSUE NUMBER 251

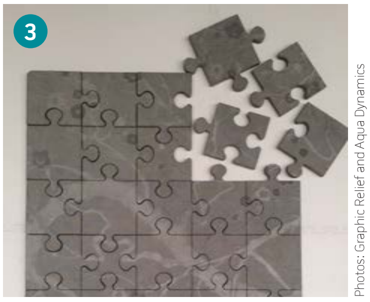
EMERALD GREEN
The DLR Lexicon in County Dublin rewrites the book on stylish, low-energy libraries

ARCTIC ADVENTURE
London practice DRDH builds two blocks of ice in Norway's frozen north

HAUS RULES
The concrete building methods behind the UK's most innovative Passivhaus projects

Game on at Ecobuild ...

The Concrete Centre is inviting Ecobuild visitors to come and play with concrete's many finishes and textures – literally, in the form of tactile games such as this jigsaw produced by Graphic Relief: 1 An iguana pattern by Timorous Beasties is moulded into the concrete. 2 3 Aqua Dynamics' 0.4mm water jet cutting beam completes the puzzle.



Photos: Graphic Relief and Aqua Dynamics

Concrete's carbon intensity slashed by 9%

The concrete industry has published its seventh Sustainability Performance Report, which reveals that the carbon intensity of concrete has dropped by 9% since 2008, and by 22% against the 1990 baseline.

The report, which has been published annually since 2008, also shows that the industry is a net user of waste. An increase in the use of waste as a fuel source and a reduction in waste to landfill have pushed the net waste ratio to 79 – which means that it uses 79 times more recovered and waste materials than it sends to landfill.

The data represents an estimated 80% of UK concrete production. Among other findings, it reveals an increase in the use of recycled and secondary aggregates. Certification to responsible sourcing standard BES 6001 has risen to 91% with some sectors having achieved certification for 100% of production.

The industry has also launched a series of resource efficiency action plans, intended to bring a holistic approach to managing the impact of a construction project over its lifetime.

For more details and to download the report, go to www.sustainableconcrete.org.uk

ESSENTIAL GUIDANCE ON TALL BUILDINGS PUBLISHED

The Concrete Centre and the Fédération internationale du béton have published a new technical guide on constructing tall buildings.

Tall Buildings has been published in response to the growing trend for high-rise construction – London alone has more than 200 towers in development.

The guide is aimed at structural engineers, whether new to, or with some experience of, building tall.

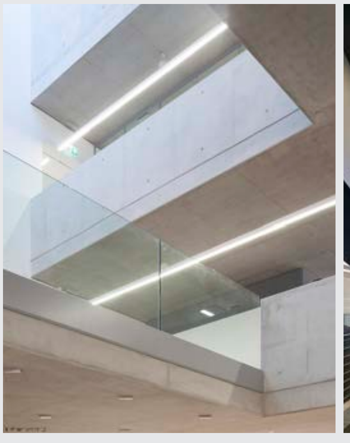
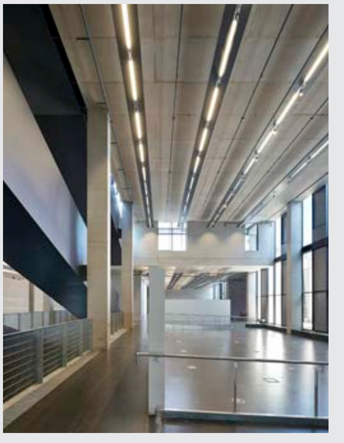
Tall buildings can be purchased from www.concretecentre.com/bookshop

WORK STARTS ON CONCRETE-PRINTING ROBOT

Skanska and Loughborough University have embarked on an 18-month programme to develop the world's first commercial concrete-printing robot.

The Loughborough team have already developed a 3D concrete printer fitted to a gantry and robotic arm, which can make complex structural components and architectural features.

Skanska hopes the project will establish a 3D printing supply chain. Collaborators include ABB, Foster + Partners and Lafarge Tarmac.

Photos: Andy Matthews Photography; Hufton + Crow

TAKING THEIR PLACE IN HISTORY

January's Concrete Elegance event at the Building Centre in London focused on two projects where concrete played a key role in weaving new landmark buildings into historically sensitive surroundings.

Paul Mullin of Rick Mather Architects and Steve Haskins of Engineers HRW explained how structural concrete gave an elegant and robust form to the East Ham Customer Service Centre and Library (above left, CQ 248). This was integral to providing a civic presence that was in keeping with the existing Edwardian town hall complex.

Meanwhile, at the new library and School of Architecture and Construction at Greenwich University (above right, CQ 250), the project team had the difficult task of building a major development in the heart of a Unesco World Heritage Site. Roisin Heneghan of Heneghan Peng Architects and David Lankester of consulting engineer Alan Baxter & Associates showed how the design manages both to embed itself into the urban fabric and to declare its own civic stature on the northern approach.

The next Concrete Elegance event is on 13 May 2015. For more information, go to www.concretecentre.com. Read about both these buildings at www.concretecentre.com/cq

CONCRETE QUARTERLY

On the cover:
DLR Lexicon in Dún Laoghaire, County Dublin by Carr, Cotter & Naessens. Photo: Dennis Gilbert

mpa The Concrete Centre

The Concrete Centre is part of the Mineral Products Association, the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and silica sand industries.
www.mineralproducts.org

Lasting monuments

There is perhaps a first in this issue of Concrete Quarterly: an exemplar building dating all the way back to 1865. At Seven Pancras Square, rated BREEAM Excellent, architect Studio Downie has wrapped a new building around the grade II-listed Stanley Building, built as accommodation for artisan workers and an early example of the use of concrete to reduce the risk of fire and make housing cheaper. BRE's current use of a 60-year study period increasingly looks to be in need of revision to take proper account of building lifespans – the 150-year-old Stanley Building is surely evidence that today's concrete buildings may last far longer than 100 years, surviving the fads and fashions of successive generations.

It's this rich but often hidden history that makes concrete such a fascinating material – something architect Simon Allford discusses in our Lasting Impression slot, from the Romans to Second World War pillboxes.

I found myself transported back in time in another way too, as the projects in these pages brought to mind the title of my O-level physics textbook, "Heat, Light and Sound". This could be a neat summary of the roles that concrete is being put to by building designers. At DLR Lexicon, County Dublin's smart new library, its thermal mass absorbs heat to cool the building. Meanwhile, at the Bodø concert hall in Norway, hundreds of pristine precast cladding panels reflect the Arctic light to give the facade a glacier-like quality, and in the ground-floor nightclub, concrete forms a rippling black-painted acoustic curtain. This is another building designed to withstand the elements for "a couple of hundred years" – writing another chapter in the long history of concrete.

THE STANLEY BUILDING IS SURELY EVIDENCE THAT TODAY'S CONCRETE BUILDINGS MAY LAST FAR LONGER THAN 100 YEARS

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

this is concrete

TAKING THE LONG VIEW

The words "green" and "sustainable" are often used synonymously, says This is Concrete blogger Tom De Saulles, but there's been a subtle divergence in their meaning. "Green design continues to relate largely to the sourcing and production of construction materials, while sustainable design is evolving to more explicitly include a whole-life approach." The importance of issues such as climate change resilience, durability and embodied CO_2 is shown by the inclusion of a series of credits for adaptability in the latest version of BREEAM. "Ultimately, it is up to designers to make informed decisions regarding embodied CO_2 and long-term building performance," says De Saulles, adding that help is at hand with the development of Environmental Product Declarations, which include end-of-life impacts. "Perhaps the starting point should be to test options in terms of their likely whole-life performance, an approach that will become more straightforward as whole-life thinking becomes embedded in design and assessment tools."
Join the debate at www.thisisconcrete.co.uk

CONTENTS

DON'T MISS AN ISSUE

Concrete Quarterly is now available as a free digital edition. Subscribe at www.concretecentre.com/cq with your email address and we'll send you a download link every quarter.

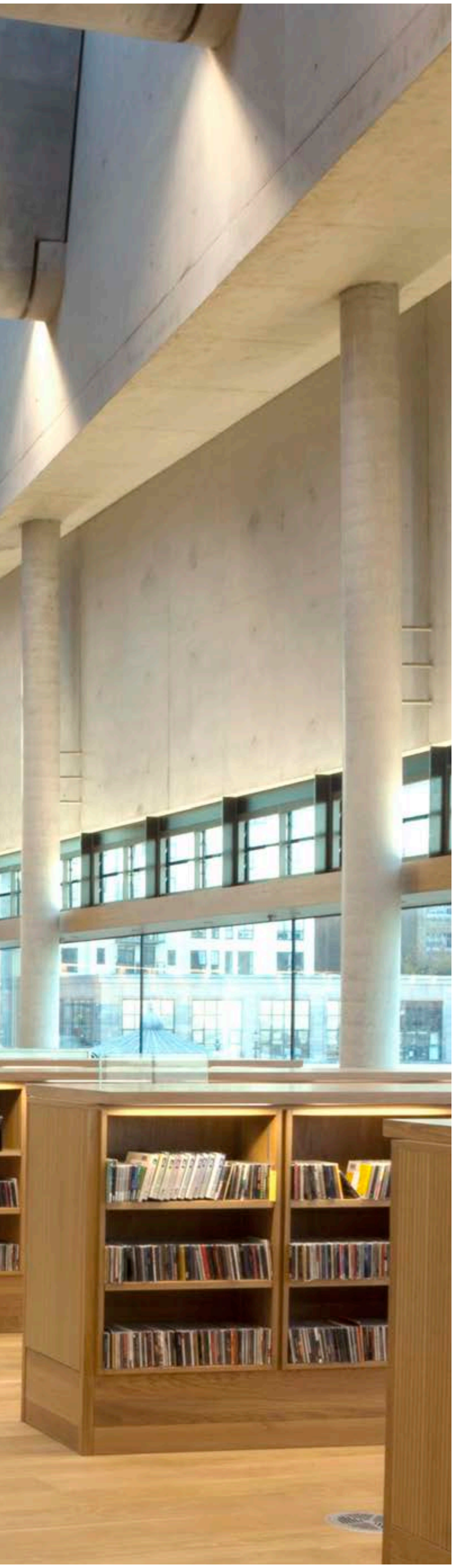


Photo: Alice Clancy

COMFORT READING

Concrete plays a leading role at the striking new library in Dún Laoghaire, not only as structure and finish, but also as a key part of an ingenious temperature-control strategy. By Tony Whitehead

Passengers arriving at the ferry port of Dún Laoghaire have a new landmark to appraise as they wait to set foot on Irish soil. The €36m (£27m) DLR Lexicon is the County Dublin town's new wedge-shaped library and cultural centre (the DLR branding deriving from Dún Laoghaire and Rathdown council). It is an imposing, 29m-tall building, clad in pale granite, with its narrowest elevation situated right on the seafront. Unapologetically modern, its huge double-height window looks boldly out to sea, and its clean, straight lines stand out starkly from the busy complexity of the port town around it.

And from a concrete point of view too, the building is remarkable, comprising an unusual structure, imaginative environmental features and a beautiful, painstakingly finished interior. The DLR Lexicon is, in fact, an object lesson in how concrete can simultaneously deliver structural, aesthetic and environmental goals.

"Concrete was really the only material we could use to achieve the types of volume and space we had in mind," says architect Louise Cotter of Cork-based practice Carr Cotter & Naessens. "The walls and structure are one, there are ambitious cantilevers, large volumes, and we wanted the building to be its own finish and structure. Concrete was the only thing."

At its tallest, the building has four floors and it provides a total of 6,520m² of accommodation, including reading rooms, study rooms, public spaces and a lecture theatre. But while most buildings of this scale would be built around a frame, the DLR Lexicon's structure operates more like that of a house. "The support for the building comes from the walls, which are solid, in-situ reinforced concrete, rather than a frame with something to fill in the gaps," says Cotter. "Concrete floor slabs are supported on upstand beams of reinforced concrete, and the roof is supported by 13 large precast concrete V beams, which tie the building together at the top."

Though it is more envelope than frame, Cotter says that all of the concrete "works hard structurally" (see box, overleaf). It also works hard environmentally. All that concrete gives the DLR Lexicon a significant thermal mass, and because there is generally no interior lining to the walls and ceilings, much of this mass is in direct contact with the air inside the building. This allows the concrete to act as a temperature moderator, storing heat in winter and coolness in summer.

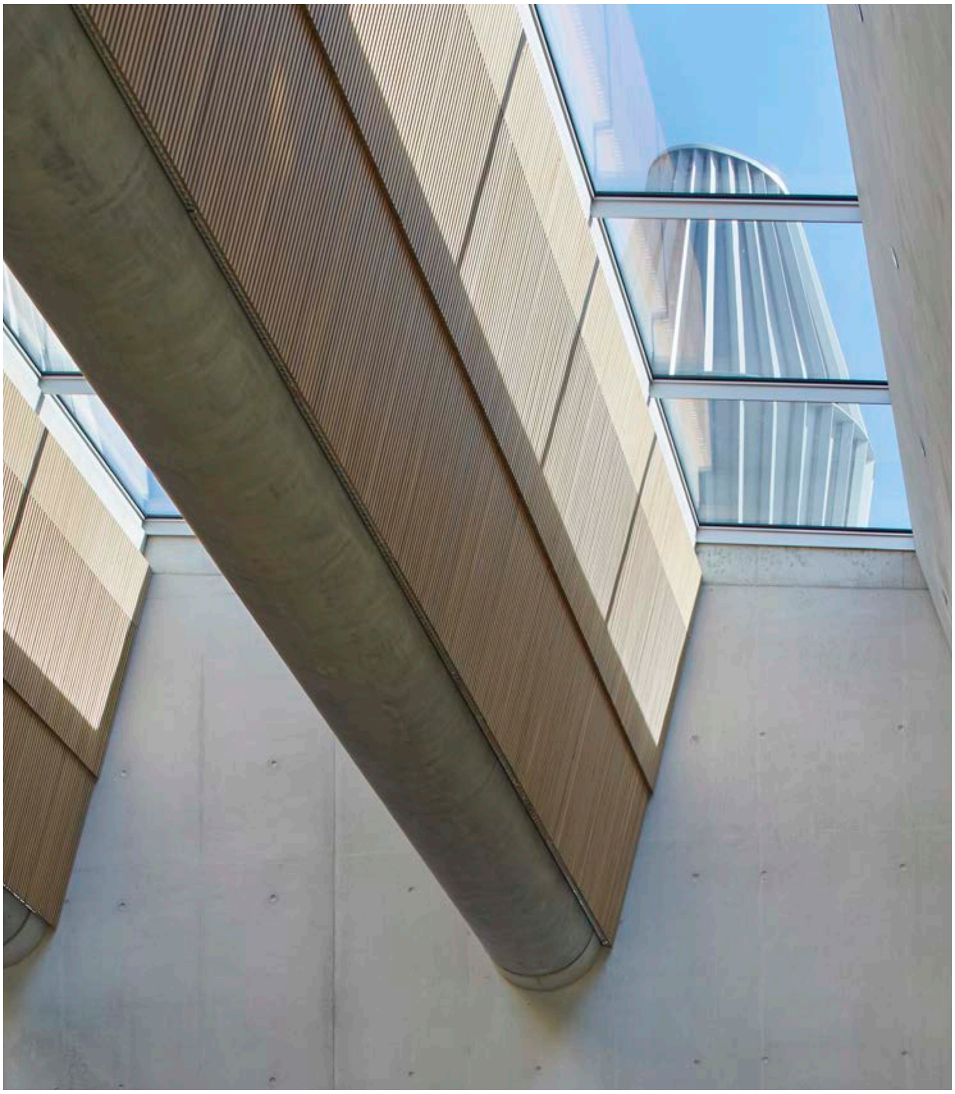
"The exposed concrete allows the thermal mass to work hard to even out temperatures," says Cotter. "The inverted T upstand beams to the floors allow the slabs to form a clear concrete soffit. And in general the only lining to the concrete is timber, a European oak, and it's always there for a purpose – where people touch the building, or to store books, or to modulate sound."

This passive temperature control strategy is boosted and controlled by an unusual ventilation feature. Running in a line down the central spine of the building are nine reinforced concrete shafts, each with openings on every floor, and within each of these chimney-like structures there is an upflow and downflow shaft. The shafts add to the total thermal mass of the building, and the air flow through them enhances the concrete's natural ability to cool warm air and heat cold air.

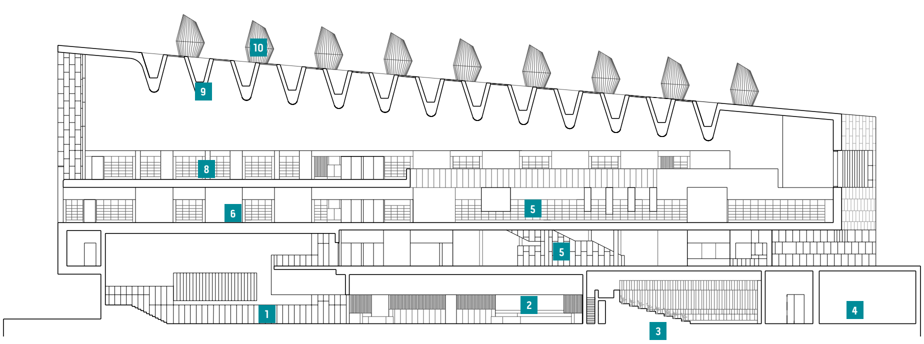
At the top of each shaft is a distinctive cowl, nine of which can be seen on the building's flat roof, where their steamliner looks contribute a nautical flavour to the overall aesthetic. Inside the cowls, explains Cotter, is a thermal heat transfer system: "So you have warm exhaust air drawn up through the shafts, but that heat is used within the cowls to warm up cold air which is then drawn down the shafts to supply fresh air to the building."

Other environmental measures include passive solar design to optimise solar gain in winter and shaded windows to guard against overheating in summer. Such heating as is required comes from

CONCRETE WAS REALLY THE ONLY MATERIAL WE COULD USE TO ACHIEVE THE TYPES OF VOLUME AND SPACE WE HAD IN MIND



ABOVE The roof is supported by 13 concrete V beams. In the background can be seen one of the distinctive cowls that crown the passive ventilation shafts (these are also shown in the sectional drawing below)



IN SECTION

1 Staircase	2 Cafe bar	3 Auditorium	4 Car park
5 Living room	6 General lending	7 Children's lending	8 Reference section
8 Concrete V beams	10 Ventilation cowls		

Smooth operator

With so much concrete visible in the interior of the building, it was essential that a high-quality and consistent finish was achieved. "But we very much relied on good workmanship," says project architect Louise Cotter, "as we didn't have the budget for expensive pigments or fancy formwork. We took advice from concrete consultant David Bennett, who was involved at the beginning, in the design process, and also on site."

The results are impressive, with a smooth, consistent appearance to the concrete throughout. So how did Bennett go about ensuring that the finish was as good as it is?

"It starts with the specification," he says. "You have to make it clear to the supplier that a consistent aggregate size really matters, and that because colour is important they mustn't change the source of the sand."

The formwork used at the DLR Lexicon was medium-density overlay double-sheeted ply – fairly standard, but under Bennett's regime, meticulously prepared. "You can't whack and bash," he says, stressing the importance of regularising tie holes and attending to seals.

The large walls meant that concrete often had to be poured into quite deep forms, so a tremie pipe was used to prevent aggregate separation and air becoming trapped. Concrete was carefully vibrated and striking times precisely calculated and adhered to.

"Air temperature is crucial," says Bennett. "The GGBS mix is slower to cure, so in summer it is fine but in winter it takes longer. Having said that, the winter wasn't too bad. Dún Laoghaire has a fine microclimate – so much so I now recommend it to friends for holidays."

Bennett also trained operatives in repairs. "It is essential to wait," he says. "As concrete dries out, the OPC [ordinary Portland cement] re-absorbs CO_2 and calcifies on the surface. It gets four shades lighter, so if you repair too soon, having first matched the colour, the patch will look too dark."

Finally, all concrete was cleaned using a fine abrasive pad. Bennett says that the results pleased client and operatives alike. "It looks great and I think the guys on site took a lot of satisfaction seeing what they could create by taking extra trouble over the details from beginning to end."

a biomass boiler supplied with wood-chips from neighbouring parks in Dún Laoghaire.

On the exterior, the concrete walls are covered with an ethylene propylene diene monomer (EDPM) membrane and 160mm of insulation. There is an 80mm air gap between this and the granite cladding, reducing the U-value to 0.15W/m^{2}K.

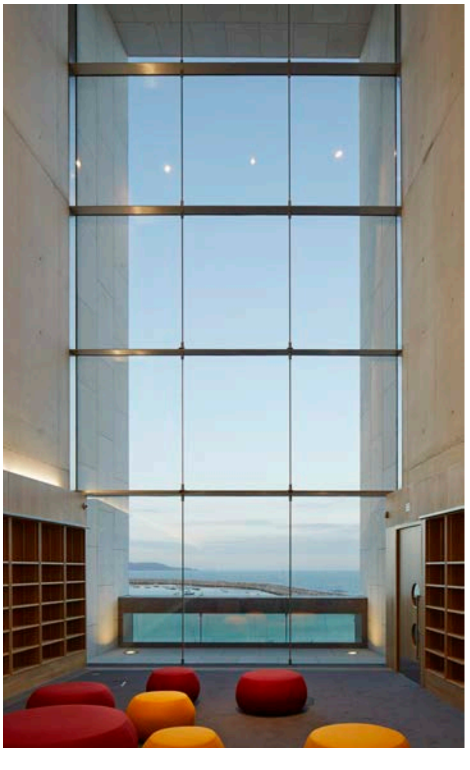
Concrete boosts the environmental performance in other ways too. The mix included up to 50% ground granulated blast furnace slag (GGBS), with a consequent reduction in Portland cement and the CO_2 emissions associated with its production. "The GGBS also produces an attractive pale concrete which helps optimise natural daylight within the building," Cotter adds.

Natural light was also a factor in determining the roof design: "Light from above is important because walls are used for bookshelves and this limits where windows can be placed. We considered having a solid roof with clerestory roof lights but found that would not let in enough light – so we went for the V beams with glazing in between." The shape of the precast concrete V beams allows light from glazing above to slant into the reading rooms, and the 13 huge Vs also provide a stunning design feature for the high-ceilinged library below.

Placing them was not easy, however. The beams are 4m high and 3m wide at the top. They also become longer towards the wider end of the building, so that while the shortest span is 7.3m, the longest span (and beam) is a massive 19m. Manoeuvring these monsters into place, with some weighing more than 40 tonnes, took two 350-tonne cranes working in tandem with a third smaller crane used for prodding the beams into their prepared slots on top of the concrete walls.

"You can imagine the coordination involved," says Cotter, who admits the process was far from relaxing. "We had guys on the roof shouting and pointing, the crane drivers in three-way contact with each other on walkie-talkies. It was quite something to watch – we drew some big crowds."

The whole process was made even more challenging by gusts of wind blowing off the sea, but the beams were eventually all successfully placed. They are quite something to look at, and should any of the DLR Lexicon's readers lose interest in their books, a spot of ceiling-gazing will prove more than ordinarily rewarding.



A shell by the sea

The DLR Lexicon's unusual shape stems primarily from the irregular and sloping site on which it is built. The result is that the building is tallest as it faces out to sea, and wider and shallower as it spreads towards the town.

"The building itself is a complex shape and so the transferring of the loads tends to be complex," says structural engineer Karel Murphy, partner with Horganlynch Consulting Engineers. "The load does not transfer simply down the structure. There are columns, but predominantly the load is transferred through large spanning walls and concrete floors, as opposed to elemental frames."

One result of this approach was that the tall vertical walls needed substantial temporary restraint – not only while the in-situ reinforced concrete was reaching full strength, but until they received the permanent support offered by floors and roof beams. The site's exposed coastal location meant that wind was also a design consideration.

"The mix contained 50% GGBS, which does slow the curing time a little," says Murphy, "but in terms of propping and unpropping, other factors influencing stability, such as completion of floors, were more important."

She adds that the nine ventilation shafts that run in a line down the spine of the building help to stabilise the structure. "The mechanical engineers use their flow and return, and we use them structurally. Effectively they act like lift cores, supporting floors and also one end of the roof beams at the top."

Murphy says that plans were also made to create the building's massive V beams from in-situ concrete: "We could have done it, but propping would have been a problem. You would effectively have had scaffolding right from ground level up through the whole building and it would have sterilised too much of the site. As it is, the precast solution has worked well, with a very consistent shape and finish – especially at the curved base of each beam, where it would have been challenging to achieve the same results in situ."

One of the most complex parts of the structure is an area of the third floor that projects out from the building. This space, supported by cantilevered beams and external columns, features a 35m-long window (above) and offers spectacular views out to sea. However, the window has no mullions to support the wall above. The external columns, it transpires, help to support the floor of this area but are not needed to support the wall. "The concrete wall actually spans the 35m above the window to give an uninterrupted view," says Murphy.

Photos: Dennis Gilbert

PROJECT TEAM

Architect Carr Cotter & Naessens

Structural engineer Horganlynch

Concrete consultant David Bennett Associates

Contractor John Sisk and Son

Precast V beam supplier Banagher Precast Concrete

ABOVE

The 35m-long window is uninterrupted by mullions, thanks to the concrete structure

LEFT

Recessed windows help to reduce solar gain

FROZEN MUSIC

London practice DRDH delivers ice blocks to the Arctic with a concert hall and library for the Norwegian town of Bodø. By Pamela Buxton

The new concert hall and library in the Norwegian town of Bodø are remarkable in many ways. First, they are designed by a small UK practice, DRDH, which secured the commissions via an open competition for the masterplan. Second, their scale is remarkable for this diminutive town, located north of the Arctic Circle and with less than 50,000 inhabitants. And third, they are distinctive for extensive and creative use of concrete, not only for the superstructure but for the hundreds of bespoke, precast cladding panels that give the buildings their austere, glacier-like quality.

The buildings create a new cultural quarter with a more urban character than its surroundings. They consist of a 6,300m^2 city library on the harbourfront with Stormen, a 11,200m^2 auditorium, occupying the block behind. When viewed from the harbour, the buildings' common design vocabulary suggests they are linked, but in fact, they are separated by a road.

"We were interested in the experience of the two buildings as a single entity when seen from the harbour, their whiteness reflecting the extraordinary and constantly shifting light of the Arctic sky," says DRDH co-director Daniel Rosbottom, referencing Turner's Venice painting, San Giorgio Maggiore – Early Morning.

Stormen in particular presented a challenging brief, with three auditoriums to cram onto a tight site and the need to address both harbour and town. DRDH's solution was to stack the main auditorium on top of the outer walls of the two smaller halls, which have a box-in-box construction. A combination of in-situ and precast concrete was the practical and obvious solution for the structure. "If you're building a concert hall you want weight and mass," says Rosbottom.

Keen to avoid an object building with little relation to its surroundings, the architects responded to the disparate neighbouring roof lines in the variegated massing of the concert hall. The scale of the flytower, for example, addresses that of a 1960s building opposite, rising up high over the loggia entrance but balanced by two other towers – one in each new building. Stormen was designed first, effectively forming the context for the three-storey library which shares its visual language but has a quite different, landscape-like character inside.

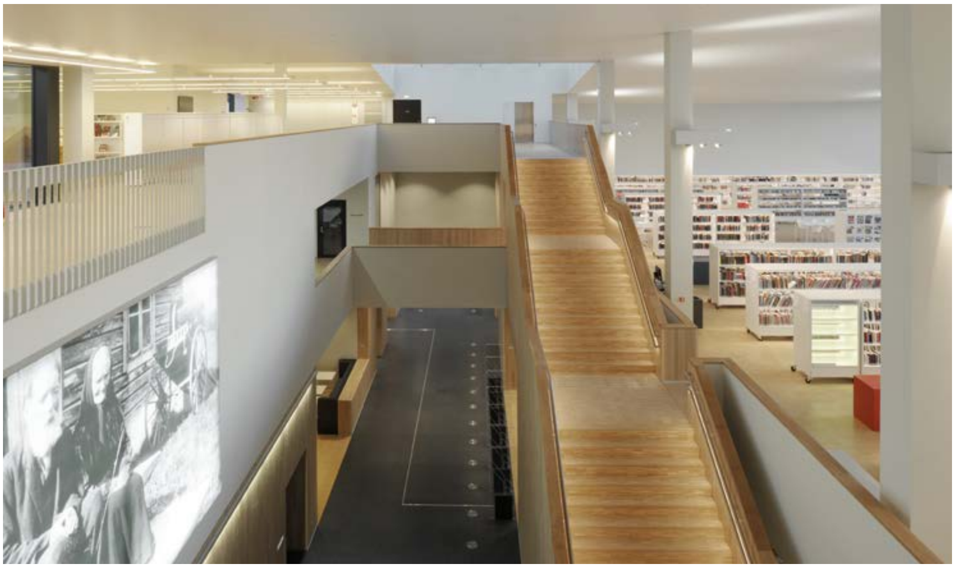
Although the architects were respectful of the context, they did resist the client's initial preference for insulated rainscreen cladding, which is used extensively locally. Instead, they specified large-scale concrete sandwich panels for both buildings, precast in central Norway, with single-leaf panels used on concrete shear walls.

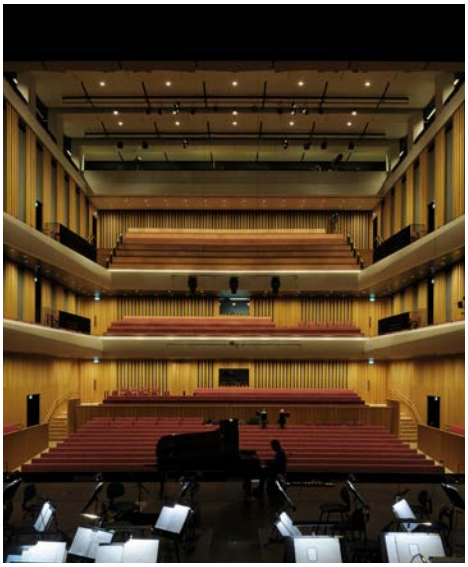
This decision was driven by many factors. Norway has a well-established concrete industry and concrete is robust enough to withstand the tough, maritime Arctic climate. Precast concrete could also create the huge 10m x 4m cladding panels and 15m-high fins with a minimum of joints.

These practical considerations formed a happy marriage with aesthetic priorities. DRDH thought that, unlike relatively flimsy rainscreen cladding, the monumental feel of the massive "stones" of concrete gave the necessary civic quality for a building designed to last a couple of hundred years.

The architects worked closely with Sintef – the Norwegian equivalent of BRE – on the detail of the panels in order to create a "beautiful concrete skin", using a white marble aggregate to give a stone-like effect. Panels have a sandwich construction of 150mm inner concrete, 200mm insulation and an outer leaf of 110mm. A double-seal system ensures water-tightness at the joints. Rather than a hung facade, the cladding acts as a self-supporting external skin tied back at the floor slabs.

With each of the 674 panels separately drawn and very few repeats, the process was a considerable undertaking for both architect and fabricator Overhalla Betongbygg, which prototyped a full-scale corner of the building in its factory. When stacked, the 2m-wide spandrels and larger panels wrap around at the corners to create interlocking returns. In the harbourside elevations of both





Photos: David Grandorge

CLOCKWISE FROM TOP LEFT
Both buildings use precast concrete with a white marble aggregate; the glazed facades are fronted by 15m-high fins; the buildings give a civic presence to the harbour; Stormen contains three concrete-framed concert halls; the library interiors use a palette of white concrete and timber

PROJECT TEAM
Architect DRDH
Structural engineer Norconsult
Concrete structure contractor Rheinertsen
Facade concrete contractor Overhalla Betongbygg

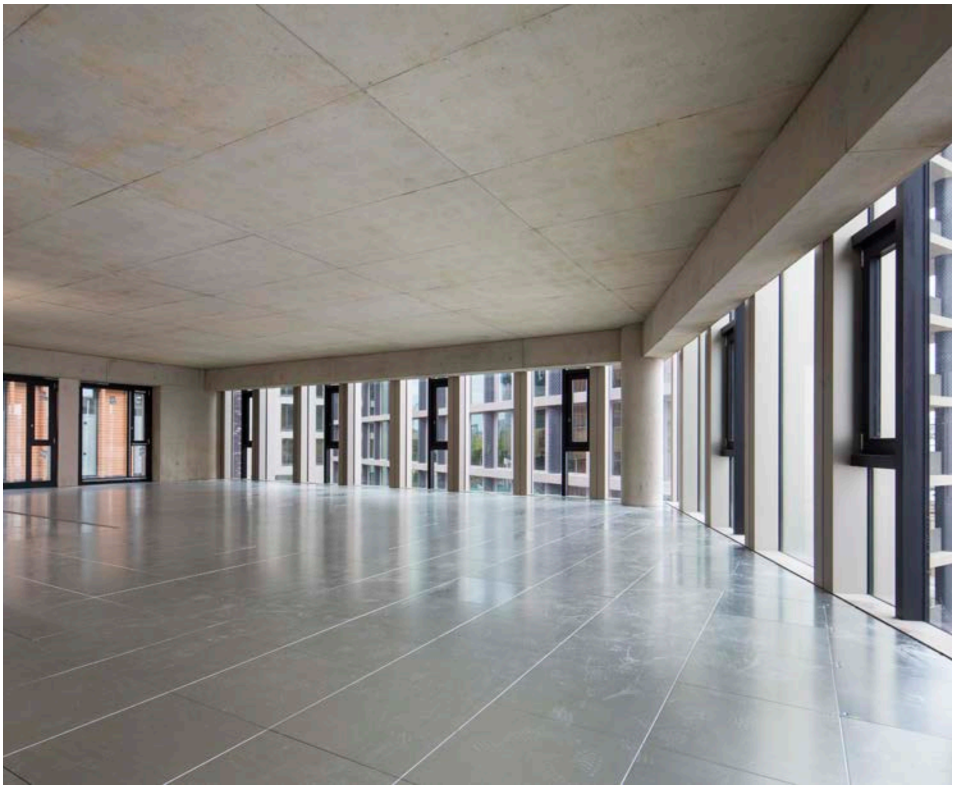
buildings, tall, narrow concrete fins up to 15m high are used to temper the large glazed facades.

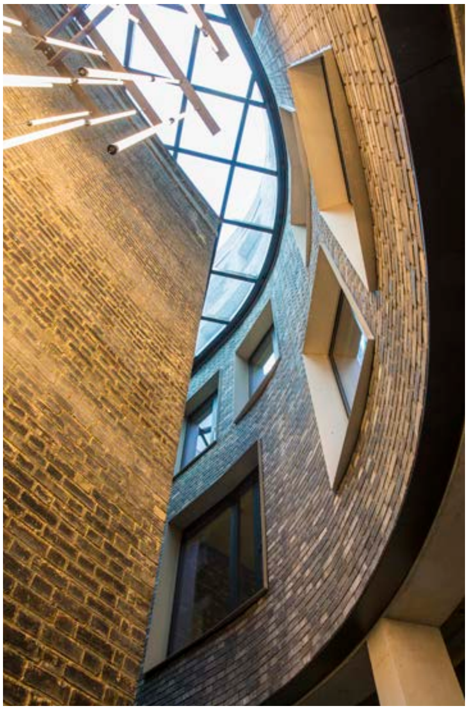
"The stacked nature and large scale of the elements recalls the archaic and monumental constructions of classical architecture," says Ewan Stone, DRDH project architect for the Stormen.

Instead of a uniform finish, the panels are treated to give variation in tone to maximise the play of the Arctic light. The base of the buildings, the western elevation of each tower and the front face of all fins and coping stones are all polished and the rest brushed. On the fly tower, the panels are cast with a different texture based on Norwegian timber house cladding.

Concrete is also used as part of the interior design, with soffits exposed on the ground and first floor of the library. More unusually, it is used to form an acoustic curtain in Sinus, Stormen's ground-floor nightclub. The external wall of this hall was cast in situ but the internal wall is precast concrete with an acoustic waved profile formed using a polyurethane formwork. The effect is a rippling, black-painted concrete curtain.

The two buildings were completed last autumn, some seven years after DRDH's initial competition success. The result is a cultural complex that uses the mass and texture of concrete to begin a new tradition of civic architecture in this Arctic town.





Photos: John Sturrock

SON OF STAN

Pancras Square's latest office building had to fit in with the area's hip reputation but also pay heed to its concrete history, writes Andy Pearson

In one of Europe's largest regeneration projects, a once-rundown 67-acre site next to King's Cross station is being recast as a hip, vibrant London postcode. So when Studio Downie Architects was commissioned to design a serviced office building at the very heart of the development, it knew that extensive use of exposed concrete would be needed to fit in with the cutting-edge vibe.

What made the Seven Pancras Square commission unusual was that the plot included an existing building, known as the Stanley Building. This is a grade II-listed, five-storey block, built in 1865 to provide accommodation for artisan workers. Concrete is a feature of this building too; in fact the Stanley Building is an early example of the use of concrete in housing to reduce the risk of fire and to make construction cheaper.

The architect's innovative design for the new scheme embraces the Stanley Building – literally – with a brick and glass-clad office that wraps around, and integrates with, the refurbished block to create a unique 50,000ft^2 workplace. "Contemporary and heritage elements combine to differentiate this building from other serviced offices," says Chris Binsted, Studio Downie's project architect.

Separated from the listed building by a simple ribbon of glass, the new building includes a reinforced concrete frame supporting six post-tensioned concrete floor plates; a series of in-situ concrete shear walls on the northern elevation enclose service risers and a lift shaft and provide structural stability. The reinforced concrete solution allowed the floor plates to be column-free to give the client flexibility in the arrangement of the serviced offices. "So the floors can be configured to be cellular or open plan," explains Binsted.

To create what the architect describes as a "contemporary studio aesthetic", soffits and shear walls have been left exposed. Piped and cabled services, suspended in a spine beneath the soffit on each floor, help to reinforce this studio feel.

The large areas of exposed concrete also contribute thermal mass to the building to support its passive servicing strategy. Detailed modelling was carried out at concept stage to optimise passive thermal, solar and daylighting performance. This approach helped the scheme to secure a BREEAM Excellent rating – quite an achievement given that the 150-year-old Stanley Building was included in the assessment.

With so much exposed concrete, a good finish was of paramount importance. "We selected a finish based on value that still gave us the quality and consistency of joint lines and consistency of finish and colour," Binsted says. "We were also keen to avoid any remedial works to the concrete because that could have changed its characteristics." In response, contractor AJ Morrisroe developed a solution based on pouring the concrete for each floor in a single operation. This ensured the uniformity of finish demanded both by the architect and by the presence of the Stanley Building, one of the quiet pioneers of concrete history.

CLOCKWISE FROM TOP LEFT
The reinforced-concrete structure allows the floors to be column-free; the new block blends seamlessly with the 150-year-old Stanley Building; a striking lightwell links the old and new buildings

PROJECT TEAM
Architect Studio Downie
Structural engineer Arup
Contractor BAM Construction
Concrete frame contractor AJ Morrisroe

MASTERS OF WARM

DSDHA's family home half-concealed in a south London garden shows concrete at its cosiest, writes Nick Jones

Photos: Hélène Binet

Exposed concrete tends to be used for its cool, industrial aesthetic. But can it also be warm, natural – even homely? This is what architects Deborah Saunt and David Hills, partners at DSDHA, wanted to show when building their own family home in Clapham, south London. "Concrete is a beautiful material in the eyes of architects, yet often considered harsh by the public," says Saunt. "We were keen to see if we could literally live with concrete and still enjoy it."

The Covert House has been built in a partitioned back-garden plot. Planning conditions dictated that the structure could be no more than one storey high, forcing Saunt and Hills to dig downwards – hence "covert". The subterranean lower floor necessitated an impermeable concrete structure, but the architects decided to take this as a starting point to fully explore the material's domestic side. The walls and soffits are all left unfinished, part of a simple palette that includes white resin floors, white metalwork and joinery, and a showpiece in-situ white-concrete spiral staircase.

That this creates a sense of warmth rather than austerity is a testament to the quality of the in-situ concrete work carried out by White Rock Engineering. This had to be extremely precise while often appearing the opposite. Bespoke formwork was used for each detail, and the contractor was working to extremely high tolerances, creating 100mm-thick walls in places with minimum deviation. But shuttering joints are deliberately unaligned with architectural features, the elegant ribbed ceiling to the main floor does not match the wall panels, and blowholes under 10mm were left unfilled. "Where the lateral layers between pours are visible, there is a languid, almost landscape sense," adds Saunt. "Children even say the patterning on the soffits is like cloudscapes."

Even so, such an imposing concrete structure could still appear forbidding, particularly as the main living space and bedrooms are on the below-ground level – accessed via the spiral staircase – and the self-compacting mix included 30% pulverised fly ash, giving a darker, slightly smoky quality. However, some clever interventions give the interiors a sense of lightness and accentuate concrete's natural properties. Mirrored window reveals blur the boundary between garden and interiors, creating kaleidoscopic refractions of the greenery. And lightwells, concealed from outside view, draw daylight deep into the building, giving a lustrous quality to the patinated walls. The effect is more that of a garden pavilion than a basement.

The use of concrete helps to create a good home in another sense too. The thermal mass of the structure and the surrounding earth prevents summer overheating and reduces energy demand in winter. Add in the underfloor heating (which is even built into the in-situ staircase), and the Covert House really is warm in every sense.

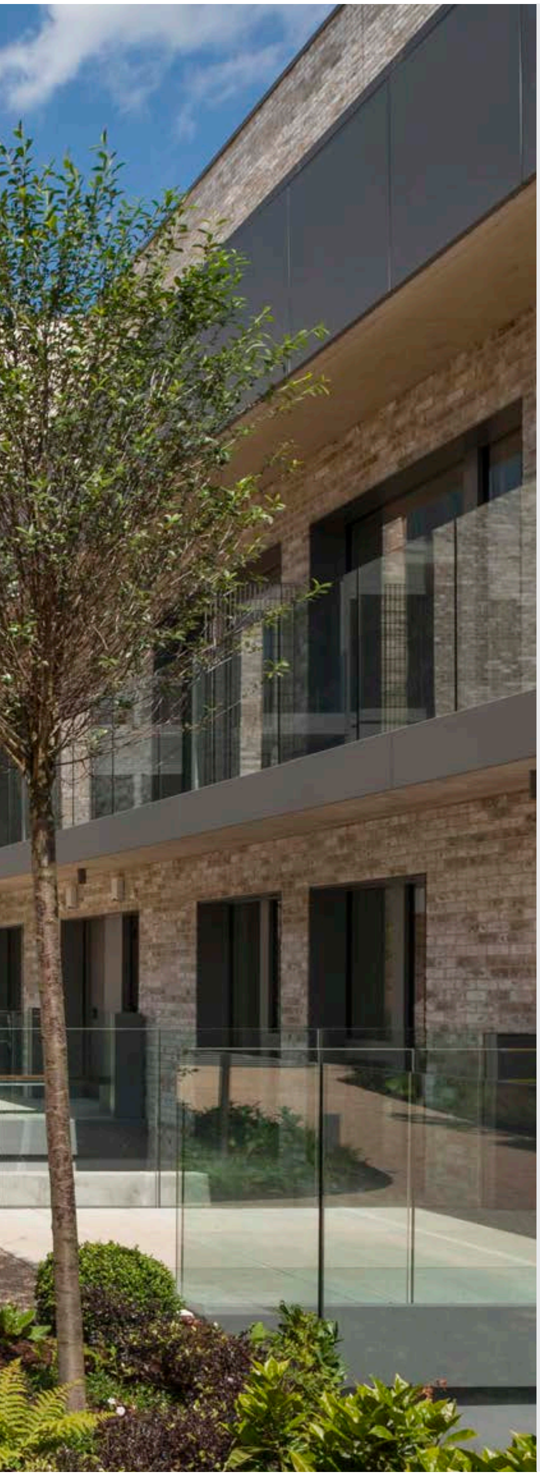
CLOCKWISE FROM TOP LEFT
Lightwells and full-length glazing illuminate the lower level; the spiral staircase was cast in situ; mirrored window reveals blur the boundary between house and garden

PROJECT TEAM
Architect DSDHA
Structural engineer Price & Myers
Contractor Whiterock Engineering

KEEP IT TIGHT

Concrete's inherent solidity provides a simple and robust air barrier, making it the base for a number of Passivhaus solutions. Elaine Toogood outlines the key approaches

Passivhaus has been growing in popularity in the UK over recent years – a fact borne out by the sheer scale of Rick Mather Architects' Chester Balmore scheme in north London (see box, above right). The techniques behind the energy-efficient design standard are based on rigorous attention to detail, and careful coordination and sequencing to achieve high levels of fabric thermal performance. And as this article will demonstrate, a variety of concrete



◀ Chester Balmore

Highgate, north London
Rick Mather Architects, completed 2014

"This scheme demonstrates that you can design a building to meet the specific demands of a particular site and still achieve the Passivhaus criteria of super-insulation and high levels of airtightness," says Tim Paul, an associate at Rick Mather Architects. He is talking about Chester Balmore, the UK's largest Passivhaus mixed-tenure residential scheme, with its mix of 53 council rent, shared ownership and private homes for developer Camden council.

This ultra-low energy scheme has been sympathetically designed by Rick Mather Architects to fit seamlessly into the upmarket Dartmouth Park conservation area of Highgate, north London. The design manages to fit enough one-, two- and three-bed flats and maisonettes onto the compact triangular site to cover the £10m cost of the development without it looking overcrowded or out of context with its neighbours. "We had to ensure there were sufficient homes on the site with the right balance between affordable and market sale housing in order for the scheme to stack up financially," says Paul.

To break up its mass, Chester Balmore is divided into three blocks. The most prominent corner of the site is occupied at street level by commercial units with four floors of flats above; the two five-storey blocks to the rear incorporate a mix of maisonettes and more apartments. Each block is set into the sloping site, keeping its height to a minimum to respect the area's three-storey brick-built Victorian terraced housing and Edwardian mansion blocks.

In addition to helping to define its height, the scheme's neighbours also dictated that the Passivhaus project would have to be constructed using brick, outwardly at least. "The conservation officer was adamant this would be a brick building," says Paul.

The scheme was built by contractor Willmott Dixon, which engaged Passivhaus specialist Architype to adapt the design. As this was the contractor's first attempt at Passivhaus, Architype sought to reduce the number of trades on site by standardising construction details and minimising junctions between different materials.

To make construction still simpler, where possible Architype used construction methods and materials with which Willmott Dixon's subcontractors

Photos: Rick Mather Architects

were already familiar. Together they developed a modified brick-block cavity-wall construction capable of achieving the super-insulation levels required by Passivhaus, based on a 250mm-wide cavity filled with expanded polystyrene balls.

"Site control is important for Passivhaus. When you have a scheme as complex as this, the aim is to use as few products and systems as possible to keep construction simple and ensure the process does not compromise the building's performance," says Architype associate Elrond Burrell.

Following its philosophy of simplification, the practice eliminated all timber-frame elements from the upper floors of the blocks by developing a solution based on a concrete frame supporting concrete floors. Similarly, the party-wall construction changed from masonry block to in-situ concrete; this had the added benefit of improving both airtightness and acoustic performance. "Within reason, we maximised what could be built using poured concrete," says Burrell.

The use of so much concrete for Passivhaus construction is not without its challenges, however. In particular, the design needs to incorporate thermal breaks to minimise cold bridging on balconies, terraces, parapets and retaining walls. For example, Schöck structural thermal breaks have been used to support the scheme's concrete balconies from the concrete frame. "You have to avoid concrete elements bridging the thermal line because they can let a lot of heat escape from inside the building," Burrell explains.

But such challenges were successfully resolved: Chester Balmore was completed last June, and is now fully occupied with residents benefiting from the comfort and low energy bills of Passivhaus levels of insulation and airtightness.

and masonry methods can be used to help meet Passivhaus goals.

The Passivhaus approach was first developed in Germany in the 1990s. It relies on ultra-low levels of air permeability, which means that all schemes require mechanical ventilation with heat recovery. This keeps heat loss so low that little additional heating is needed, beyond passive sources such as the building occupants.

Key elements of Passivhaus construction include very high levels of insulation, low or "no" thermal bridging and high-performance windows. Orientation, form and the overall layout of the building also have a role to play. The Passivhaus approach is not material-specific.

Although originally a standard for new housing, certification of different building types and retrofits is now possible. ▶

ORIENTATION, FORM AND THE OVERALL LAYOUT OF THE BUILDING ALL HAVE A ROLE TO PLAY IN PASSIVHAUS DESIGN

Concrete and masonry solutions

■ **External insulation** The first certified Passivhaus project in England was Underhill House in Gloucestershire, a precast concrete structure with external insulation (see images, below and right). Externally rendered insulation on solid-wall construction is a simple way of reducing cold bridging – the internal structure is effectively cloaked in an insulating layer, extending beyond window and door frames for added performance.

The concrete itself provides inherent, durable airtightness, and provides an opportunity for in-situ monolithic junctions between walls, floors and roof. This avoids a need for the complex lapping and folding details of some applied airtightness barriers, and the concrete details are simpler to construct successfully.

ABOVE: Underhill House in Gloucestershire, the first certified Passivhaus project in England

ABOVE: This terrace of three Passivhaus homes was designed by Parsons + Whittley Architects to fit seamlessly alongside traditional cottages in north Norfolk. They have a cavity-wall construction, with inner skins of dense concrete block supporting a 300mm fully filled cavity, clad externally with 10mm brickwork or 200mm flint-faced masonry

Three Passivhaus construction methods

1 External insulation
Underhill House, Gloucestershire

A concrete structure with a continuous outer layer of insulation has excellent airtightness and a simple means of reducing cold bridging.

2 Cavity-wall construction
Golcar Passivhaus, West Yorkshire

A wet plaster finish over the inner leaf of block work provides a robust airtightness barrier and can enhance thermal performance in other ways.

3 Insulated concrete formwork
Recent project by Leathwaite

This is a simple construction solution for achieving excellent airtightness and low thermal bridging.

An externally insulated, solid, structural wall could be constructed using precast, in-situ, hybrid twin-wall or concrete-block methods.

■ **Cavity-wall construction** Arguably, this requires a little more consideration of detailing to reduce cold bridging than externally insulated solid-wall construction, but this is aided by the availability of low-conductivity wall ties and other innovative masonry products.

Internal render or plaster has been shown to be an excellent method of achieving high levels of airtightness with blockwork, as has a parging coat underneath a plasterboard finish. And as with most methods of construction, the use of tapes to seal around windows and other penetrations is essential to achieve the high levels of airtightness required for Passivhaus.

For any building aiming to reach Passivhaus standards, it is essential to identify a continuous airtightness barrier in the detailed design, and to work out a sensible means of achieving it on site, including careful sequencing to avoid subsequent breaches.

The first Passivhaus built with masonry cavity walls in the UK was Denby Dale, West Yorkshire – usefully, the design and construction process has been documented in a blog by Bill Butcher, a Passivhaus consultant and director of the Green Building Store (www.greenbuildingstore.co.uk), which developed the scheme. Butcher's blog about a more recent project, currently under construction, in the neighbouring village of Golcar (see image, left), is also a valuable source of guidance for high-performance masonry cavity-wall construction.

■ **Insulated concrete formwork (ICF)** This is another construction method that benefits from in-situ concrete's monolithic nature and long-lasting airtightness. The continuous, permanent insulation layers – both internal and external – also provide a readymade solution to reduce cold bridging. It is therefore not surprising that there are Passivhaus-approved products in ICF.

Elaine Toogood is an architect at The Concrete Centre

Key references

Publications available from The Concrete Centre providing guidance on design for high thermal performance include:

- Thermal Performance – Part L1A 2013
- Building Low Carbon homes – Guides 1, 2 and 3 (Masonry, Concrete Frame, Insulating Concrete Formwork)
- How to Achieve Good Levels of Airtightness in Masonry Homes

Useful sources of further information are:

- www.passipedia.org
- www.passivhaustrust.org.uk
- www.greenbuildingstore.co.uk/page--building-a-passivhaus.html
- www.passivhausblog.co.uk/golcar-passivhaus

THE LOWDOWN: BIM

Concrete is helping to lay the foundations of BIM

Suppliers are getting to grips with the quantity and quality of data needed to make universal project models work from design through to operation, writes Andrew Minson

The construction industry is on the cusp of a revolution in technological collaboration. The government's April 2016 deadline for the use of building information modelling (BIM) across project teams on all centrally procured projects has been a vital catalyst. This has helped to place the UK at the forefront of the implementation of industry-wide BIM – as opposed to isolated client-specific or project-specific BIM.

I say "on the cusp" because we are still awaiting the delivery of the rules and framework for level 2 BIM. This is being developed by NBS (which is owned by RIBA Enterprises), in a project funded by the government via Innovate UK (formerly the Technology Strategy Board).

Let's be clear: 3D modelling is itself far from new. What is revolutionary is the concept of collaboration through an agreed universal model, using the same protocols, systems referencing, data fields, and so on, across every project, no matter who is on the team.

But for project teams and their supply chains, this will be merely an evolution of current working practices on aspects such as data exchange and clash detection. Whatever the technology's most ardent advocates may say, BIM has not suddenly made clash detection possible – it just facilitates the process.

Another misconception is that a BIM design process requires a greater amount of data. In fact, it requires the same level of information, just in a different format.

Developing inputs

The concrete industry is actively working to develop the inputs that designers will need. For example, an Environmental Product Declaration (EPD) contains data on the environmental impact of a product, prepared in accordance with the British and European standard BS EN 15804 to facilitate comparison between different products. These documents are being compiled for generic concrete products (such as factory-made blocks, pipes, floors and columns) and for a typical cube of ready-mixed concrete.

The EPD will be one subset of the data provided for a BIM object, which will also include information from the relevant product standard, the project specification and the declaration of performance, which is available for any product that is CE marked. The concrete industry will also develop 3D BIM objects for precast products.

Clearly, this needs to be in an agreed format so that suppliers know how to deliver the information and project teams can use the data without having to reformat or re-enter it. The data templates have yet to be agreed upon, but this process is underway.

Changing data needs

A further level of complexity is that only a limited amount of data is needed at the beginning of a project, but product-specific data will be required for construction. And perhaps clients will request a complete, manufacturer-specific data set in the as-built model. Hence, it is possible that partially completed or cut-down templates will also be needed so that concept models are not overwhelmed by unnecessary data at the outset.

The concrete industry is already playing its part in this evolution of working practices. Where necessary, manufacturers will embrace the technological revolution by ensuring they have the software and expertise to collaborate on the project BIM model itself.

By working together, the whole project team will be able to deliver better value for clients. And it is arguably the client who will experience the greatest change as a result of BIM, with the as-built model an invaluable asset management tool. It is this client driver – the government being the biggest client of all – that will ensure BIM becomes a reality.

Andrew Minson is executive director of The Concrete Centre and British Precast

ANOTHER MISCONCEPTION IS THAT A BIM DESIGN PROCESS REQUIRES A GREATER AMOUNT OF DATA. IN FACT, IT JUST REQUIRES THE SAME INFORMATION IN A DIFFERENT FORMAT

POST-TENSIONED SLABS

This structural method can reduce the depth of a slab by 75mm, cutting material costs and creating space for extra floors. Jenny Burridge explains

In the UK, the use of post-tensioned slabs has become commonplace over the past 15 years, with the advantages increasingly recognised by clients, engineers and architects. Most slabs are still designed by specialists working for concrete subcontractors, but the basics of these systems should be understood by the building's principal engineers and designers if the full benefits are to be realised.

Post-tensioning is a method of putting a compression into concrete after it has been poured. This is effective because concrete is much stronger in compression than in tension, while steel is strong in tension. In normal reinforced concrete, an allowance is made for this by using steel bars to take the tension forces within the element. By putting a compression into the concrete, the tension stresses in the concrete are reduced or eliminated and therefore the amount of reinforcement required is significantly reduced, normally by about two-thirds.

Post-tensioning is carried out by tensioning tendons placed within the concrete using a hydraulic jack. When they have reached the required stress, the force is locked into the tendon with a split wedge against a cast-in anchorage. The tension in the tendon is equalised by a compression in the concrete, effectively putting each material into its strongest state.

Benefits

Post-tensioned concrete has the lowest structural thickness of any floor system. Post-tensioning reduces the required thickness of the concrete section – typically, a flat slab would be 50-75mm shallower. The thinner slab reduces the amount of concrete required, generating important cost and material savings. The use of thinner slabs can maximise floor-to-ceiling heights or reduce floor-to-floor heights, even allowing the introduction of additional floors with no increase in building height. Savings can also be made on the costs of cladding and services.

Minimising the structural thickness of the floor slabs lowers the self-weight of the building, which in turn reduces foundation loadings, resulting in smaller foundations and further lowering material costs.

Post-tensioning tends to be used to achieve longer spans, and yields the greatest benefit when used for spans over 6m.

Impact on floor layouts

When post-tensioned floors are used, care must be taken early in the project to avoid the problems of restraint. This is where free movement is restrained in the length of the slab under compression. For example, post-tensioning should not be applied between two cores as this causes the cores to take the load from the tensioning, so that the slab between them does not achieve the required compression. It is preferable, but not essential, to have a single core in the centre of the floorplate.

Where the restraining walls are arranged favourably and the floor is internal, the length of the floor without movement joints can be up to 50m. However, consideration should be given to the effects of shrinkage due to drying, early thermal effects, elastic shortening and creep in the design, as these can be greater than the movements in a normal reinforced slab.

While it is preferable to arrange the cores and shear walls to suit the post-tensioning system, this is frequently not possible, and there are measures that can be taken to overcome the problems of restraint. These include using infill strips, which are concreted after the initial shrinkage has taken place, or a temporary release detail which can be locked when the tensioning has been completed.

Bonded and unbonded systems

There are two forms of post-tensioning – bonded and unbonded. The bonded system is the most common in the UK, but the unbonded is also used and can be useful for some applications.

In a bonded system, several tensioning tendons run through a duct which is grouted up after the tendons have been fully stressed. The advantages are that the tendon can develop a higher ultimate strength, the system does not rely on the anchorages after grouting, and the effects of any accidental damage to the tendons are localised.

WHERE THE RESTRAINING WALLS ARE ARRANGED FAVOURABLY AND THE FLOOR IS INTERNAL, THE LENGTH OF THE FLOOR WITHOUT MOVEMENT JOINTS CAN BE UP TO 50M

In an unbonded system, there is a single tendon running through a greased plastic tube, which is always free to move independently of the concrete. The advantages of this type of system include the ability to prefabricate tendons to the correct length. This allows for faster construction, particularly as there is no grouting operation to be carried out. Tendons can also be easily deflected around obstructions, which makes the system useful for curved sections. However, if the tendon is accidentally cut, the compression load is lost throughout its length and the anchorages are always "live".

Concrete for post-tensioned slabs

Post-tensioned slabs do not require particularly high-strength concrete, and often class C32/40 concrete is used. But for speed of construction, the concrete should have high early strength. This allows the initial tensioning operation to be carried

LEFT AND RIGHT
At the Fulham Riverside development in London, contractor Getjar used a post-tensioned system rather than traditional reinforced concrete to reduce the lower slab thicknesses from 600-700mm flat slabs to 185-200mm on beams. The upper residential storeys of the three blocks are supported from a 16m x 16m grid by a 850-1,300mm slab at fourth floor level.

Photos: Yohan Zerdoun; Marc Cramer

Photo: Getjar

TABLE: TYPICAL SPAN-TO-DEPTH RATIOS

Imposed load (kN/m^2)	Span/depth ratio (6m ≤ span ≤ 13m) for post-tensioned flat slabs	Span/depth ratio (4m ≤ span ≤9m) for a normal reinforced concrete flat slab
2.5	40	28
5	36	26
10	30	23

Photo: Tim Soar

LEFT AND ABOVE: At 240 Blackfriars Road, The use of post-tensioned slabs allowed AHMM and AKT II to minimise materials and add two extra floors within the same building height

out as quickly as possible, usually 24 hours after pouring to prevent cracking. Final stressing can then take place after three days, allowing striking of formwork. High levels of cement replacement are not normally specified for post-tensioned slabs due to this requirement for high early strength, although there are examples where up to 40% of cement replacements have been used successfully.

Alterations and demolition

Making structural alterations to post-tensioned slabs is no more difficult than for any other form of construction. This means that the benefits of existing post-tensioned floor construction can be used when altering existing buildings (for example, for the conversion of redundant office space into residential accommodation).

When it comes to minor alterations, post-tensioned slabs may be much easier to work with than other structural forms. The tendons are often spaced at well over 1m centres. Depending on the specific circumstances, the concrete can generally be cut out between the strands without the need for strengthening. This would allow the creation of an opening of $1m^2$, or perhaps even larger.

More substantial alterations can also be undertaken using tried-and-tested techniques. Procedures vary slightly depending on whether the slab has bonded or unbonded tendons.

There is only a very small additional risk associated with the demolition of a post-tensioned structure and the methods are similar to those used for normally reinforced concrete structures, with some modifications. A bonded slab should not require any significant changes of approach, with the benefit that demolition is slightly simpler because there is less reinforcement.

For unbonded slabs, a common approach is to prop the floor and then release the tension in the tendons. This can be done in several different ways. It has been shown by testing and experience on site that anchorages and/or dry packing are not ejected from the slab edge at high velocity. This is because the force is dissipated due to the friction between the strand and the sheath.

Jenny Burridge is head of structural engineering at The Concrete Centre

KEY REFERENCES

The most useful design guidance for post-tensioned slabs is the Concrete Society's Technical Report 43, which provides comprehensive advice.

Post-tensioned Concrete Floors – A Guide to Design and Construction, The Concrete Centre

The Post-Tensioning Association is an association of specialist post-tensioning contractors, designers with an interest in post-tensioning and suppliers for the post-tensioning industry. It has produced a number of guidance notes, which are available at www.post-tensioning.co.uk:

- GN01 – Post construction holes
- GN02 – Limit stress design
- GN03 – Procurement
- GN04 – Sustainability

LASTING IMPRESSION SIMON ALLFORD

BOMBS, BRUTALISM AND BIRMINGHAM

To me, the magic of concrete is its history. It's an ancient material, invented essentially by the Romans, but it's almost as if every era rediscovers it and refines its use. So it's got this permanence and yet it's an invented, liquid, mouldable thing, with this amazing thermal property.

As a child I first came across it running around the countryside going into disused pillboxes (1). Now people celebrate the extraordinary defences built in northern France, but you used to come across these amazing brutal structures everywhere. I wouldn't be at all surprised if the post-war obsession with brutalism was shaped by industrial wartime structures that were so everyday. Lubetkin was building air raid shelters in the 1930s. You still find them around central London, these concrete pop-ups to an underground world.

So in the brutality of war there was also innovation, and in a sense that spun on into the architecture of the last century. Over the years, you find infrastructure projects, industrial structures, seawalls, motorways, all made out of in-situ concrete in quite brave and magnificent ways. As a youngster, I always admired Birmingham's Spaghetti Junction (2) (1968-72) – in one sense a traffic nightmare, but in another the most amazing futurist structure.

As a young architect, one of the first buildings I visited was Le Corbusier's Unité d'Habitation in Marseille (3) (1947-52). The failures of post-war housing were drummed into me at college, so I expected to think it was magnificent but didn't work – but instead I thought it was magnificent and does work. The way we built with concrete was cheap, quick and ill-considered, but there it was cheap, quick and designed. It was an early lesson in the importance of not necessarily spending money on something, but spending time to think about it.

Simon Allford is a director at Allford Hall Monaghan Morris


1


2


3

Photos: Dave McAleavy/Shutterstock; Keystone/Getty Images; Edmund Sumner/VIEW Pictures

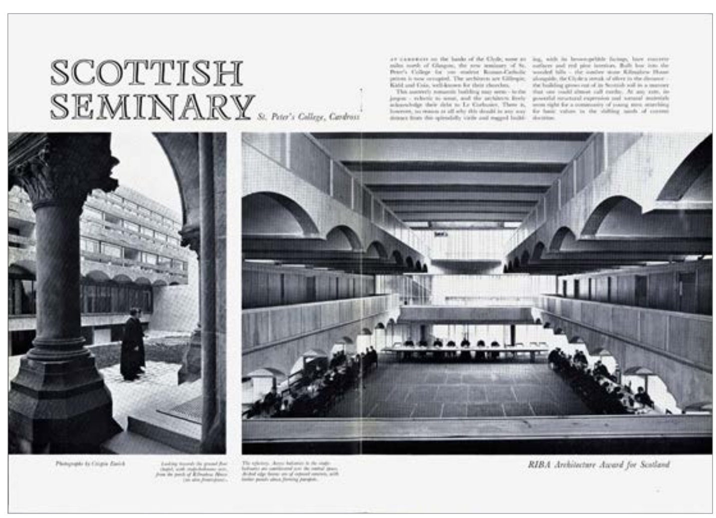
FROM THE ARCHIVE: SPRING 1967

A CASTLE ON THE CLYDE

"Splendidly virile and rugged" might seem an unlikely description for a convent and seminary, but that was CQ's verdict on St Peter's Kilmahew, near Glasgow, by Gillespie Kidd and Coia. "Its powerful structural expression and natural materials seem right for a community of young men searching for basic values in the shifting sands of current doctrine." The seminary was quickly established as an icon of Scottish brutalism – part Le Corbusier, part brooding castle – and CQ was particularly impressed by the as-struck finishes on its in-situ concrete interiors: "One cannot help thinking that over-careful concrete would have destroyed the elemental character of the seminary as a whole."

Perhaps CQ need not have worried – the building's elemental character has withstood far worse. Since the seminary closed in 1980, it has become an eerie modern ruin: overgrown, roofless and graffitied. But its raw power remains. Now, arts organisation NVA plans to turn it into an event space, and has signed up Avanti Architects, ERZ and Nord Architecture to help make that happen. There won't be any civilising of the brute however. "Our role is not to make people like it," NVA's Angus Farquhar recently told The Observer. "That would be the least interesting thing you could do."

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


SCOTTISH SEMINARY *St. Peter's College, Cardross*

RIBA Architecture Award for Scotland

FINAL FRAME: BAUHAUS MASTERS' HOUSES
Two of the 1920s Masters' Houses at the Bauhaus in Dessau, Germany have been reconstructed, but using in-situ concrete rather than the original blockwork. The buildings, designed by Walter Gropius for himself and the artist László Moholy-Nagy, were destroyed in a Second World War air raid, but have been reinterpreted through the use of in-situ forms, minimalist interiors and opaque windows, creating an abstract, ethereal quality.