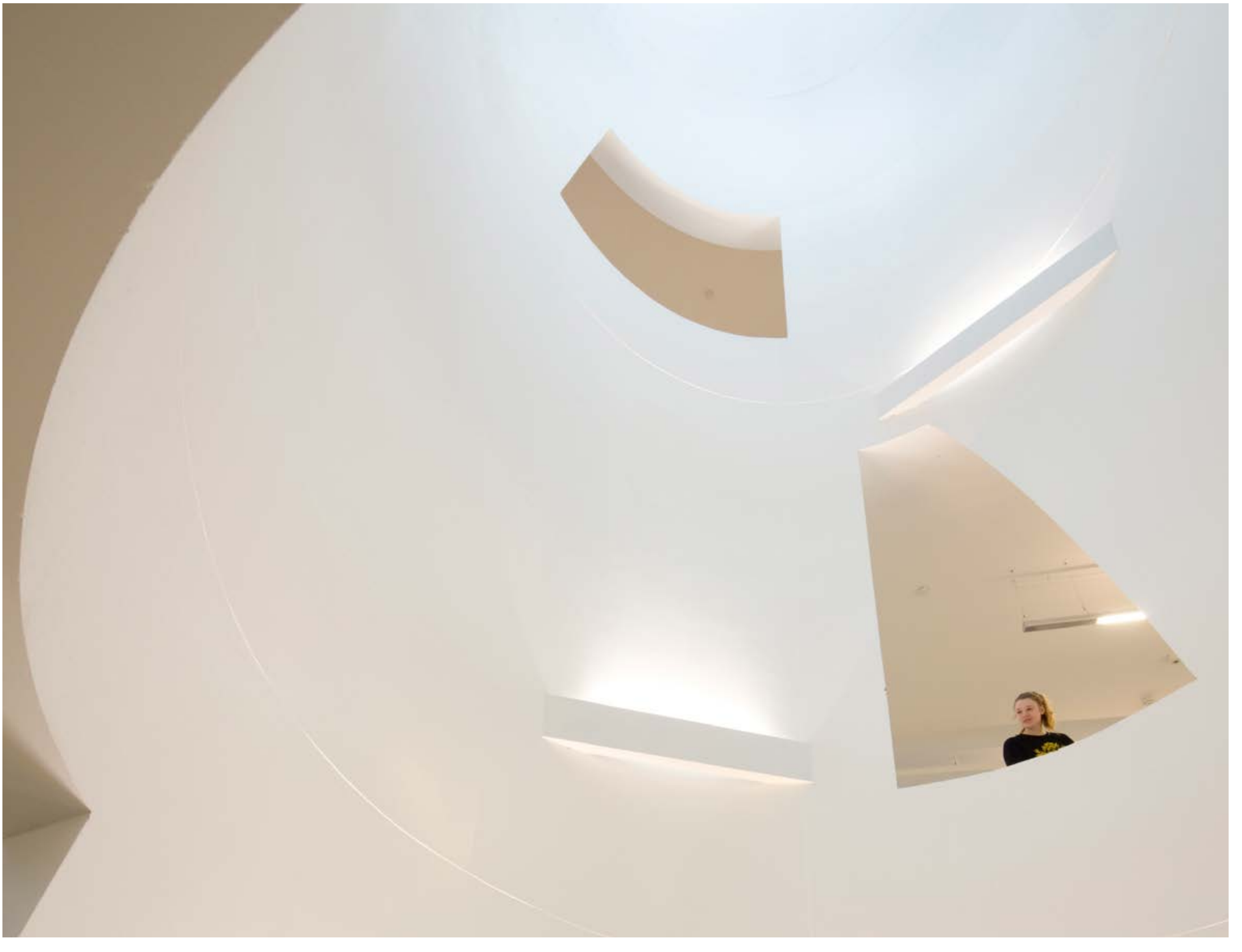
CONCRETE QUARTERLY

SUMMER 2014 | ISSUE NUMBER 248



HOLE HEARTED
Three vast concrete voids are the key to Steven Holl's new building for the Glasgow School of Art

HOT STEPPERS
Take your project to the next level with a showstopping concrete stairway – we show you how

AIMING LOW
Our new Structures section kicks off with expert guidance on getting the most out of low-carbon concrete

Southend's Forum to the fore at British Precast Awards

The Forum in Southend-on-Sea by architect ADP has been selected as the best project at the British Precast Best Practice Awards 2014, with concrete supplier Decomo UK praised for its high-quality installation of the building's precast concrete facade.

Presented at British Precast's 50th anniversary dinner in May, the awards also recognised J&P Building Systems with an innovation prize for developing a new design methodology that simplifies the calculation of load capacity and fixings of precast stairs.
Read a case study of The Forum at www.thisisconcrete.co.uk

Visualisation: Hayes Davidson and Herzog & de Meuron; Photo: Ben Veasey

Tate's 'twisted pyramid' takes shape

Tate Modern's new extension is taking shape on London's Bankside, with its concrete cores complete and the lattice of columns that form its external shape rising to the penultimate floor.

Designed, like the original gallery, by Swiss architect Herzog & de Meuron, with structural engineering by Ramboll, the new building rises 11 storeys in the form of a twisting pyramid. This superstructure is now being covered in concrete panels, which will be clad in a perforated brick facade to match the existing gallery.

The building is due to open in 2016, and will include galleries, seminar spaces, a media lab, restaurant, roof terrace and members' room.

Eva Jiricna puts a spring in Somerset House's step

Czech architect Eva Jiricna has completed a staircase in ultra high performance concrete (UHPC) at Somerset House's West Wing building in London – the first use of this material for cantilevered stair treads.

Ductal was specified to complement the grade I-listed neoclassical building with a modern take on the cantilevered stone staircase. UHPC was used for the treads of the 104 steps and the landings for the four-storey structure, which is supported from a central newel of stainless-steel latticework and has curved glass balustrades. The structural engineer was Techniker.

P12 Focus on concrete staircases

Photo: Peter Cook

Get to grips with sustainable drainage systems

The Concrete Centre is holding a two-day conference on sustainable drainage systems (SUDS) on 24-25 June in Northampton, for design professionals and local authorities seeking to understand the latest guidance and practical developments.

Among projects featured will be a SUDS scheme in Malmö, Sweden (left), which has not only addressed stormwater flooding but is also a renowned example of urban greening.
For further details and to register, go to www.concretecentre.com/events

Barbican and Manchester lectures now online

Online videos are now available of the presentations from spring's Concrete Elegance lecture. The event, which took place at The Building Centre in London, featured talks on Trafford Town Hall in Manchester and Milton Court/The Heron at the Barbican in London.

Paul Norbury from 5plus Architects explained how the grade II-listed town hall was refurbished and extended to create high-quality office and conference facilities. The building has an exposed concrete frame and post-tensioned concrete floors, circular columns and stair cores.

Meanwhile, David Walker discussed how his practice created new performance and teaching spaces for the Guildhall School of Music & Drama at the Barbican, as well as a 36-storey tower with 295 apartments. The main volume, the 625-seat concert hall, is clad in polished white concrete.
The next Concrete Elegance lecture will take place in the autumn. For more details, and to watch the videos, go to www.concretecentre.com

CONCRETE QUARTERLY

On the cover:
The Reid Building in Glasgow by Steven Holl Architects.
Photo: Alan McAteer

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

THIS IS CONCRETE

Looking good, not just on paper

Welcome to the 248th edition of Concrete Quarterly – the first to be available in our new digital format.

Ever since its launch in 1947, CQ has been one of architects' favourite "feel-good" publications, a magazine written by people who love concrete, for people who love concrete. We hope CQ will remain as inspirational as ever, but we are also pleased to reinstate some of the more technical content that CQ historically offered, to return to its traditional balance of high design and practical delivery. This issue's inaugural Focus section concerns staircases – so if you'd like to understand the technical challenges behind Eva Jiricna's Somerset House stair (left), for example, turn to page 12.

I have always seen concrete as a material that lends itself easily to architects and engineers working hand in hand, not to mention closely with specialist contractors at delivery stage. That's why we have included a new Structures section for engineers, which opens with a guide to specifying sustainable concrete. Throughout this issue, there are many examples of where close collaboration has led to the creation of highly sustainable and genuinely inspiring buildings, where the designers have made use of concrete's inherent aesthetic and physical properties to stunning effect.

CONCRETE LENDS ITSELF EASILY TO ARCHITECTS AND ENGINEERS WORKING HAND IN HAND

We hope that architects, engineers and the rest of the project team will find much to enjoy in these pages – paper or electronic – and we welcome your feedback and suggestions for future issues. Going right back to CQ's earliest years, issues had to be cancelled on several occasions due to post-war paper shortages. I like to think that its editors would also have leapt at the chance to produce a digital issue if they could …

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

TO PAINT OR NOT TO PAINT?

Bare concrete surfaces can be beautiful just as they are – so why paint them, wonders architect Elaine Toogood on the This is Concrete blog. "Having seen the construction photos of the gorgeous surfaces of Glasgow School of Art's Reid Building, I was surprised (and a little saddened) to learn that they were all to be painted white," she begins.

But the decision is understandable for many reasons, Toogood concedes – and not just to appease those to whom unadorned concrete does not appeal. She was won over by a recent Concrete Centre seminar on the BREEAM outstanding offices of London's NC1, where Bennetts Associates' Peter Fisher explained how white-painted concrete soffits are integral to the low-energy strategy of 5 Pancras Square. "The thermal mass of concrete is unaffected by a finishing coat, so painted internal concrete surfaces can continue to assist in reducing heating and cooling loads – but with improved light reflectance, so potentially reducing energy loads for lighting too," says Toogood.
Join the debate at www.thisisconcrete.co.uk

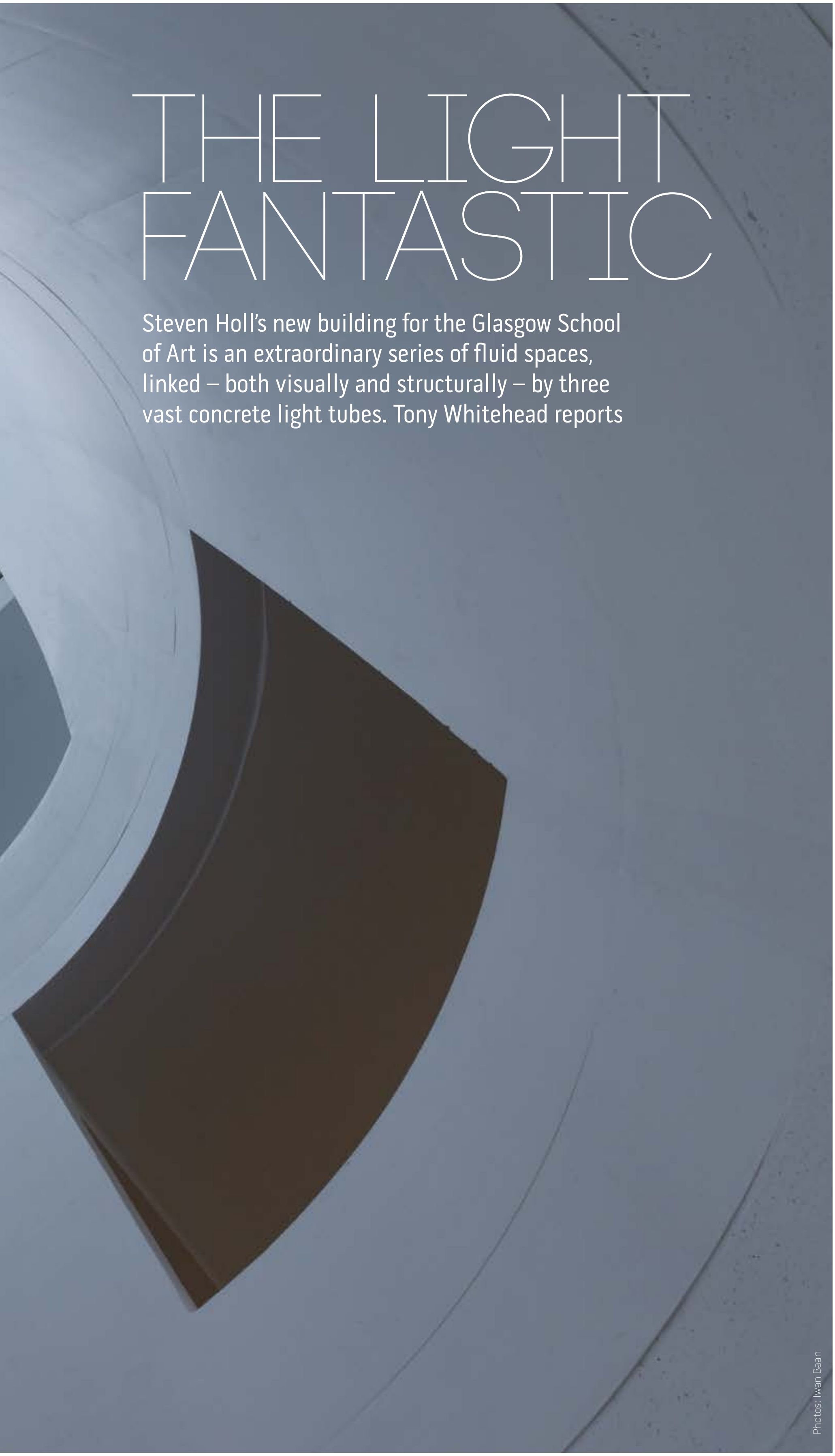
CONTENTS

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.

THE LIGHT FANTASTIC

Steven Holl's new building for the Glasgow School of Art is an extraordinary series of fluid spaces, linked – both visually and structurally – by three vast concrete light tubes. Tony Whitehead reports



Photos: Iwan Baan

The recently completed Reid Building at the Glasgow School of Art is the first in the UK to be designed by the internationally renowned New York architect Steven Holl, but that's far from the only thing that distinguishes it. It is truly an unusual building. From the street it looks simple enough: a striking laminated glass box with regular angles and flat surfaces. But go inside and you will find an interior to boggle the mind: there are strangely long spans across the spacious studios and many different levels with mezzanines, balconies and cantilevered overhangs. The views stretch from top to bottom and back to front.

Visible staircases bridge the gaps, winding up through the building as in an etching by Escher. Most extraordinary of all, three huge 5m-diameter concrete tubes slope at angles through the building's centre, offering curved surfaces to abut the planar walls, and featuring extravagant cut-outs through which light pours and air is circulated.

Getting all this to fit together structurally and aesthetically is clearly testament to the construction team involved. But credit must also be given to the unending flexibility offered by concrete, the material from which the 123,000ft^2 Reid Building is primarily constructed. "Really, the language of this building is made for concrete," says Dominik Sigg, project architect with Steven Holl. "It is such a versatile material."

The starting point for the design team was how to deal with the daunting task of creating a building across the road from the existing art school – a masterpiece by Charles Rennie Mackintosh. "The way we approached this was to go for a complementary contrast," says Sigg. "The Mackintosh building has thick walls with a slender structure inside. So we have done the opposite – a thin glass skin with heavy concrete bones. It makes the existing building stand out even more, and both buildings maintain their own integrity."

Using concrete has other benefits too, he adds. One is its contribution to the building's environmental strategy – it is rated BREEAM excellent. "Most of the concrete has 50% GGBS [ground granulated blast furnace slag] to reduce the carbon content – and of course the substantial thermal mass moderates interior temperatures and saves heating and ventilation costs."

In all, 28,000 tonnes of concrete were used in the project and its thermal mass has been optimised by leaving virtually all of the above-ground concrete – including walls, soffits, floors and the huge light tubes or "driven voids" as the architect calls them – exposed, with just a simple coating of white paint.

What this also meant was that the concrete finish was a major consideration for both designer and contractor. In the driven voids, steel formwork and a self-compacting concrete mix were used to give

THE MACKINTOSH BUILDING HAS THICK WALLS WITH A SLENDER STRUCTURE INSIDE. SO WE HAVE DONE THE OPPOSITE …

REID BUILDING IN SECTION

1 Driven void
2 Design studios
3 Offices
4 Dye lab
5 Refectory
6 Offices
7 Exhibition space
8 Services area
9 Workshops
10 Storage

Structural challenge

The three concrete tubes that run at a 12° angle through the upper floors of the building not only have a big impact on the internal light quality – they are so large that they have a significant effect on the way the structure behaves. "The front of the building features cantilevered overhangs of up to 7m, these cutbacks having been derived from the proportions of the Mackintosh building opposite," explains Derek Roberts at Arup, principal engineer on the project. "When these forces are combined with the effect of the sloping voids themselves, that causes the building to want to slew forwards towards the street."

To prevent this, and maintain the building's structural integrity, it was necessary to pull back these forces through the structure where they could be "held" by the rear wall.

"The only available load path into the rear wall is through the circumference of the voids," says Roberts, "but as the cut-outs tend to impede the structural integrity of the voids, we had to make doubly sure that a consistent load path was identified and detailed. It was vital to ensure that connections through the voids were strong and stiff enough to transfer the large forces involved, while maintaining the high level of spatial interconnection from the cut-outs that the building demands."

a smooth, light-reflective finish (see box, right); elsewhere the surfaces are more textured.

The floor slabs are reinforced in-situ concrete with soffits formed with traditional 8 x 4 inch plywood sheets arranged in an even pattern. "Originally this was also specified for the walls," says Peter Unwin, project manager with contractor Sir Robert McAlpine, "but we did some mock-ups and found that we got blow holes which stood out a bit too much once the wall was painted white. We tried some other options and Steven Holl flew over from New York to see the results first hand."

In the end, Holl opted for walls formed with a sawn-board finish made from 2-inch softwood strips. "The softwood is somehow more absorbent and so you get fewer voids, and within that rough board texture they are less noticeable anyway," explains Unwin. "Steven also liked the contrast between the rough cut finish and the smoother surfaces of the driven voids."

If the finish is vital to the building's appearance, its unusual interior layout is also key. Essentially, the building is supported off three internal concrete walls running from back to front, 15m apart. But the detail is rather more complex, as Arup's Derek Roberts, the project's principal engineer, explains: "The building is very open – allowing light to suffuse the space and also to encourage a creative crossover between various artistic disciplines," he says. "But this does lead to an unusual and challenging structure. For example, the supporting walls have the driven voids running through them, and the floors have cut-outs to give views into the atrium and to other floors. The driven voids neither hang off the floors nor support them, but are rather integral to the whole – and yet these too have cut-outs which affect their structural strength. The structure really defines the internal architecture. There is incredible variation, with barely a floor or beam repeating itself."

Floor spans of 15m are 60% longer than might be expected for the 300mm-thick slabs, he adds. Care had to be taken that they did not flex too much, so Arup worked to incorporate what are effectively reinforced concrete beams into features such as parapet walls. "There are some downstand beams as well which have been discreetly placed so they don't look like beams, and even a few columns," adds Roberts. "But the end result is that we have successfully stiffened the floors without using obvious beams or hybrid slab systems."

This approach did present a challenge for the contractor, however, as support for the structure is, in places, quite high up. For example, the cantilevered section on the south elevation is supported partly by the parapet walls above the slabs. "This means we had to cast the slabs and hold them in position for some time while we cast the parapets, which were effectively beam sections, and then let them gain strength before releasing the falsework," says Unwin. The high percentage of GGBS in the mix also meant that curing times were longer than usual. "It became clear that some areas would have to be supported pretty much until we had reached the top of the building."

The only precast elements at the Reid Building are the stairs, which form such dramatic features as they connect levels and bridge between different areas. Spanning up to 10m, these were made in sections comprising a supporting spine and blocks of around four steps. "We had to do it that way because of the weight," says Unwin. "We had tower cranes on site but nothing that could cope with a whole flight of stairs, which would have weighed about 14 tonnes." Once in place, the stairs were finished with an epoxy grout to achieve a seamless connection with the floors.

Indeed, the Reid Building owes much of its character to these smooth connections between the various concrete elements: the curved driven voids, the textured walls and spectacular stairways all knit together so beautifully that the building's interior almost appears to have been carved from a single block, or conjured up by some gigantic 3D printer. Mackintosh would surely have approved.

P12 Our new Focus section turns the spotlight on staircases

BOTTOM LEFT
A network of concrete staircases form bridges between different areas of the building

BOTTOM RIGHT
The glass exterior contrasts with the neighbouring Mackintosh building

PROJECT TEAM

Architect Steven Holl Architects
Structural engineer Arup
Contractor Sir Robert McAlpine
Concrete contractor Cidon Construction
Quantity surveyor/project manager Turner & Townsend

Photo: Arup

Versatile voids

Running from roof to basement, the Reid Building's three "driven voids", as Steven Holl describes them, perform a number of roles. They allow light to penetrate from above and spread into every floor via large cut-out sections. They act as chimneys to help cool the building when needed, drawing air up from all levels and expelling it via closable louvres at the top. And they are also integral to the building's structure.

Each tube runs at 12° to vertical from the ceiling to ground level before kinking back on itself at an angle of 15° as it descends into the basement levels. All three are 5m in diameter with 300mm-thick walls and are constructed from heavily reinforced self-compacting concrete. Unlike the rest of the building, where timber board or plywood formwork was used, the tubes were made with a system of steel formers, with plywood grillage inserts with thin curved edges to create the cut-out shapes. These were made by concrete contractor Cidon from models supplied by Arup.

Exterior steel forms were then placed, with no ties between the inner and outer forms – the strength of the steel being sufficient to hold the shape firm. In order to minimise bubbles and voids, the pipe supplying the concrete was dropped between the outer and inner reinforcement cages to the base of the form and lifted up like a tremie pipe as the level of the concrete rose.

This technique, combined with the use of self-compacting concrete, resulted in a very smooth, glassy surface. "The finish is pretty much as struck," says Peter Unwin, project manager at contractor Sir Robert McAlpine. "The mix poured in almost like soup, and there was no requirement for any agitation. The result is a very fine surface with very little need for any extra filling or finishing."

THE NAKED CIVIL SERVANT

Exposed concrete brings civic dignity at an affordable price to an east London council's new multi-purpose facility, writes Steve Elliott

Elegant economy, combining architectural aesthetic with construction efficiency, is a widely shared aspiration. Rick Mather Architects' new East Ham Customer Service Centre and Library provides a masterclass in achieving it. The £12.5m centre is part of the redevelopment of the London Borough of Newham's East Ham conservation area, which includes the grade II-listed Edwardian town hall. Fronting the busy Barking Road, it brings together a library and a range of frontline services into one purpose-built facility.

The initial design cue were taken from the existing town hall and technical college and from the Methodist Central Hall which stood on the site until 1969. The external solid walls of the new building feature handmade red Leicestershire thin bricks that, depending on the articulation of the facade, are either vertically stacked or stretcher coursed. The larger expanses of brickwork are punctuated with areas of brick rib work which, in some locations, are carried across the windows. The architects have also marked the building's entrance with a run of vertical terracotta baguettes and an expanse of terracotta panelling. "We wanted the building to have a civic presence that took forward its architectural heritage, not only with materiality but also with its scale and detailing," says associate partner Paul Mullin. "In this way the building's deceptively simple square plan typology is able to draw upon its immediate and historic context."

Internally, the centre provides its own context, with plenty of robust exposed concrete. The

PROJECT TEAM
Architect Rick Mather Architects
Structural engineer engineersHRW
Contractor BAM Construction
Concrete frame Getjar
Cost consultant Currie + Brown

CLOCKWISE FROM FAR LEFT
A rooflight floods the central void with daylight; a stepped concrete staircase links the three storeys of the building; the sloping form of the concrete rooflight is one of the interior's most dramatic visual elements; the external walls are clad with handmade red Leicestershire thin bricks

accommodation is arranged over three levels, with a set-back top floor that contains plant space. Large floor plates with clear sightlines are arranged around a central void that is flooded with light from above, and full-height windows allow natural light to penetrate deep into the plan. The interior spaces are easily navigable and offer a welcoming non-institutional environment. They are also fluid to encourage integration between services on different floors, and highly flexible in order to help future-proof the building.

The high-quality finish of the concrete is prominent throughout the centre. The most appealing aspects are the sloping form of the concrete rooflight and the dramatic three-storey stepped staircase. Affectionately known as the "half-pipe" and the "Harry Potter stair" by the client and contracting team, both features emphasise the sculptural capabilities of concrete.

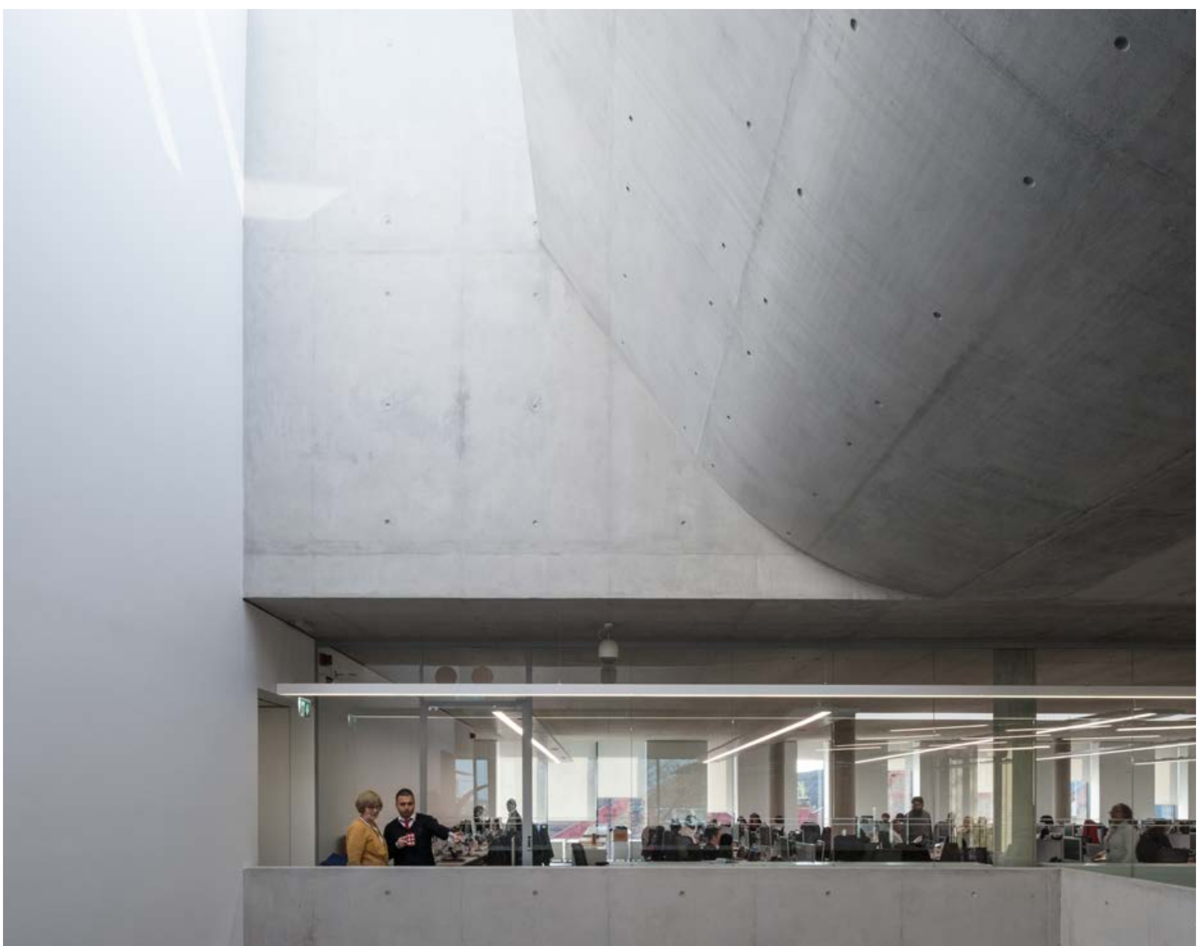
The potential of concrete to deliver both architectural elegance and construction economy was identified early in the project. "The principal reason for selecting concrete was the added value it gave to the project as a whole," says Mullin. "It met the objectives of a demanding client while upholding the architectural intent of simplicity, coherence, robustness and elegant form."

The decision to go with a concrete structure also fulfilled the architectural desire to remain in control. "With a steel frame, for example, the design detailing is placed onto the steel subcontractors, so retaining visual control of the primary structure detailing can be difficult," Mullin says. "Our approach enabled the architect to be at the centre of design coordination and therefore keep control of process. We could also retain control over the M&E detailing as we embedded this into the structure."

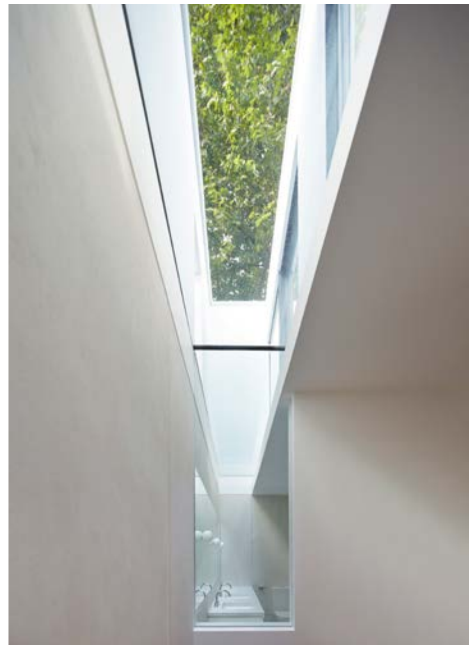
A concrete mix of C40 and C60 with 50% ground granulated blast furnace slag, limestone fines and omya filler was specified to give light tonal finishes. All structural elements used the same specification to ensure a consistent colour throughout, with sample panels produced on site to enable the team to explore detailing options.

In addition to looking good, the concrete also plays an active role in the environmental strategy. The 350mm-thick floor slabs contain heating and cooling pipework that is connected to 20 geothermal boreholes, supplemented by an air-source heat pump. This "simple ceiling approach" to environmental control is unfettered by M&E systems, further simplifying the internal spaces.

The brief for the centre was that it should combine civic presence and a light and welcoming accessibility. Exposed structural concrete has helped to deliver a building that manages to be both imposing and friendly, and all without breaking the bank.



Photos: Andy Matthews Photography



Photos: Hufton + Crow

IN MY BACK YARD

An ingenious sunken courtyard has enabled De Matos Ryan to build a two-storey garden house without annoying the neighbours, writes Andy Pearson

The Garden House successfully conjures up space where none existed before. At the bottom of a garden in Battersea, south-west London, architect De Matos Ryan has created a striking, minimalist two-storey annex that is all but hidden from view in a large, sunken courtyard. The catalyst for the project was a newly married couple's need to bring two families together in one home, requiring additional space to accommodate seven children. The solution is so successful that from the surrounding gardens the 179m^2 house appears no taller than the assortment of sheds it replaced.

The subterranean scheme is a clever architectural response to height restrictions imposed by the planners. Another requirement was that the building should not overlook the neighbouring homes. The architect has resolved this by creating a series of blank white facades at first floor level, which conceal light wells that illuminate glazed screens in the walls of each upper-floor bedroom.

In contrast to this solid upper level, the lower floor has large expanses of full-height glazing, which concertina back to open up the living spaces and kitchen to the courtyard.

Concrete features heavily in this covert scheme. In addition to forming the building's structural frame, it has been used to construct the walls and floor of the courtyard. Here its primary function is to keep both groundwater and the nearby River Thames at bay; the retaining walls have been designed to be high enough to survive a one-in-100-year flood. "The courtyard is like a swimming pool in reverse," explains Angus Morrogh-Ryan, a director at De Matos Ryan.

The retaining walls' construction was particularly challenging. A conventional solution of sheet piles hammered into the ground using a pile driver would have been too noisy for this site; a quieter option was available but its cost was prohibitive. So the contractor developed a solution, dubbed the Berlin Wall method, where an auger was used to create a series of holes into which H-shaped king posts were placed. The earth was then removed with a mechanical excavator, and timber sections were progressively slotted between the posts to retain the ground behind. "It was a crafted, labour-intensive solution that was rather beautifully done," says Morrogh-Ryan.

The timbers created a panel against which the concrete retaining walls could be cast. These are tanked internally to make them watertight. An inner concrete lining was then cast using an exceptionally smooth plywood shutter to create the extremely high standard of finish demanded by the client. The concrete lining appears to continue through the glazing inside the house, where it forms the back wall of the kitchen and the countertops.

A similar surface finish has been achieved on the courtyard floor. This too appears to continue inside the house to form the ground floor. In fact both floors are cast using similar pigments, but the internal floor also has underfloor heating embedded within it. The concrete theme continues with the bathroom vanity and bath tops, which are constructed from glass-fibre reinforced concrete.

There is also a concrete bench built into the courtyard wall, from where, on a sunny day, this discreet house and its concrete finishes can be quietly admired – if the tumult of family life allows.

PROJECT TEAM

Architect De Matos Ryan
Structural engineer Price & Myers
Contractor Noga Building Services
Quantity surveyor Marstan BDB
Garden designer Worsley Designs

CLOCKWISE FROM TOP LEFT

The courtyard wall and floor finishes appear to continue into the house; a lightwell draws daylight into the upper-floor bedrooms; the courtyard is sunk far below garden level

DRAMATIC ENTRANCE

CLOCKWISE FROM TOP LEFT
The facade includes 105 metal sunshades featuring portaits of Liverpool residents; the bar uses an informal palette of timber, exposed concrete and black steel; the concrete is marked with 75mm softwood shuttering

PROJECT TEAM
Architect Haworth Tompkins
Structural engineer Alan Baxter & Associates
Contractor Gilbert-Ash
Concrete formwork Mastercraft Construction
Quantity surveyor Gardiner & Theobald

Meticulous board-marked concrete steals the show in the foyer and bar at Liverpool's reborn Everyman Theatre, writes Nick Jones

Over the past 50 years, the Everyman Theatre in Liverpool has given breaks to many of the nation's favourite actors. Now, following the theatre's redevelopment by Haworth Tompkins, it is playing host to concrete in one of its more nuanced roles.

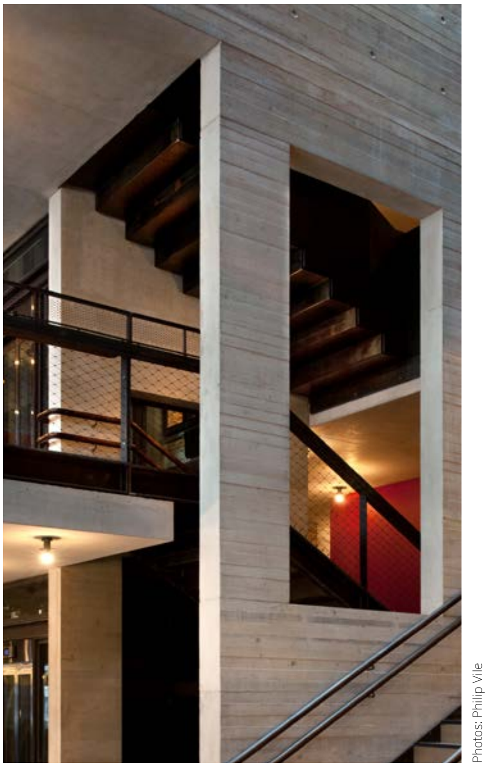
As its name suggests, the Everyman has always seen itself as a place for the people, where audiences could mix with actors and playwrights in a heady atmosphere of conviviality and creativity. The only problem was that the theatre's 1970s premises were looking increasingly tired and rundown. One of the key criteria of its £28m redevelopment was to retain that free spirit. "The ethos of the institution was always very informal and friendly, and we didn't want to make it more intimidating or upmarket," says Will Mesher, associate at Haworth Tomkins. "The use of natural and self-finished materials, rather than more polished finishes, was part of that."

The front-of-house areas, which include a foyer and bar, make full use of exposed concrete, as well as timber, reclaimed bricks and steel mesh. But the trick was to temper this informal, industrial aesthetic with a sense of civic scale. Mesher points out that, as one of only a few big civic institutions in Liverpool – and one that occupies a historic site next to the Catholic cathedral – the theatre needed to look refined rather than rough and ready.

The finishes therefore had to be of an extremely high quality, evident in the meticulous detailing of the board-marked in-situ concrete walls and columns. Tests were carried out on 1m^3 samples to get the best possible finish from the 75mm softwood boards, and Mesher says the formwork was expertly produced by Mastercraft Construction.

Equal care was taken over the concrete's colour, which Haworth Tomkins wanted to be both warm and fairly pale. This was achieved through the use of 30-40% ground granulated blast furnace slag, which, by replacing cement, also contributed to the theatre's BREEAM "excellent" rating.

Such a high rating is unusual for an urban theatre, and the swaths of exposed concrete are central to it – by providing thermal mass and pre-cooling the incoming air to the 406-seat auditorium. Waste was also strictly controlled, with roof timbers and bricks from the original theatre making guest appearances. And Haworth Tomkins even wrote a walk-on part for the softwood shuttering, some of which reappears as wall linings and sliding doors.



Photos: Philip Vile

CONCRETE STAIRS: A STEP-BY-STEP GUIDE

Showstopping concrete stairways have been the star turn in a number of recent high-profile projects. Elaine Toogood outlines the main considerations facing designers

Concrete is a practical and cost-effective material for fire escape and accommodation stairs – but it also provides plenty of opportunity for the creation of highly individual feature stairways through its versatility of form, texture and colour.

Concrete's inherent solidity brings both a sense of permanence and effective acoustic dampening of footfall. The robustness and fire resistance of concrete stairs permits installation early in the construction phase with potentially little or no need for additional protection. This provides means of access and escape throughout the build process, with associated temporary works savings and health and safety benefits.

In the UK, the manufacture of prefabricated concrete stairs and landings is well established, with a substantial industry producing bespoke systems or standardised ones that can be tailored to suit project requirements. Elements are often cast in whole or half flights using pre-existing high-quality moulds designed to be reused multiple times. The moulds are adjustable to suit project specific tread and riser dimensions and the number of steps required. Alternatively, custom-built moulds can create more individual stair designs. The choice of formwork depends largely on how many stairs are required, their shape and finish.

Concrete stairs can also be cast in situ to produce seamless, free-flowing forms that are integrated into the surrounding structure. They offer a bespoke solution where the practical installation of precast elements might be difficult.

Many concrete stair manufacturers offer a design and manufacturing service, and designers are wise to discuss stair proposals with them at an early stage to allow the manufacturing process to inform detail development. This is especially important if the concrete stair is intended to be left exposed. It should be noted that responsibility for ensuring that the general layout and detail of the staircase configuration satisfies Building Regulations remains with the project architect or designer.

Described below are a number of areas that require special consideration when designing concrete stairs.

FINISHING TECHNIQUES FOR BESPOKE STAIRS INCLUDE ACID ETCHING, ABRASIVE BLASTING, POLISHING, AND EXPOSING AGGREGATE

Span and depth

The depth of concrete for stairs refers to the flight waist thickness and depth of the landings. A good rule of thumb for flights is span/25 (for simply supported spans). This can be reduced to span/30 if classed as continuous, as is often the situation for in-situ concrete flights and landings. Allowing a 200mm-deep zone for structural precast landings should be sufficient to accommodate either a halving joint detail or a screed topping to cover fixing brackets. Structural design will verify exact final dimensions.

A useful tool for structural engineers are the

DESIGN ESSENTIALS

Specifying stair dimensions

Designers should be aware that there is a discrepancy between Building Regulations and the current British standard on minimum dimensions of goings and the maximum number of rises on a stair flight. BS 5395-1:2010 provides a larger minimum going and allows more risers per flight than the 2013 edition of Approved Document K.

The relevant documents are:

- **Building Regulations Approved Document K: Protection from falling, collision and impact**
- **BS 5395-1:2010, Code of practice for the design of stairs with straight flights and winders.**

For more detail and a table of comparison dimensions, read The Concrete Centre's blog on stair dimensions at www.concretecentre.com.

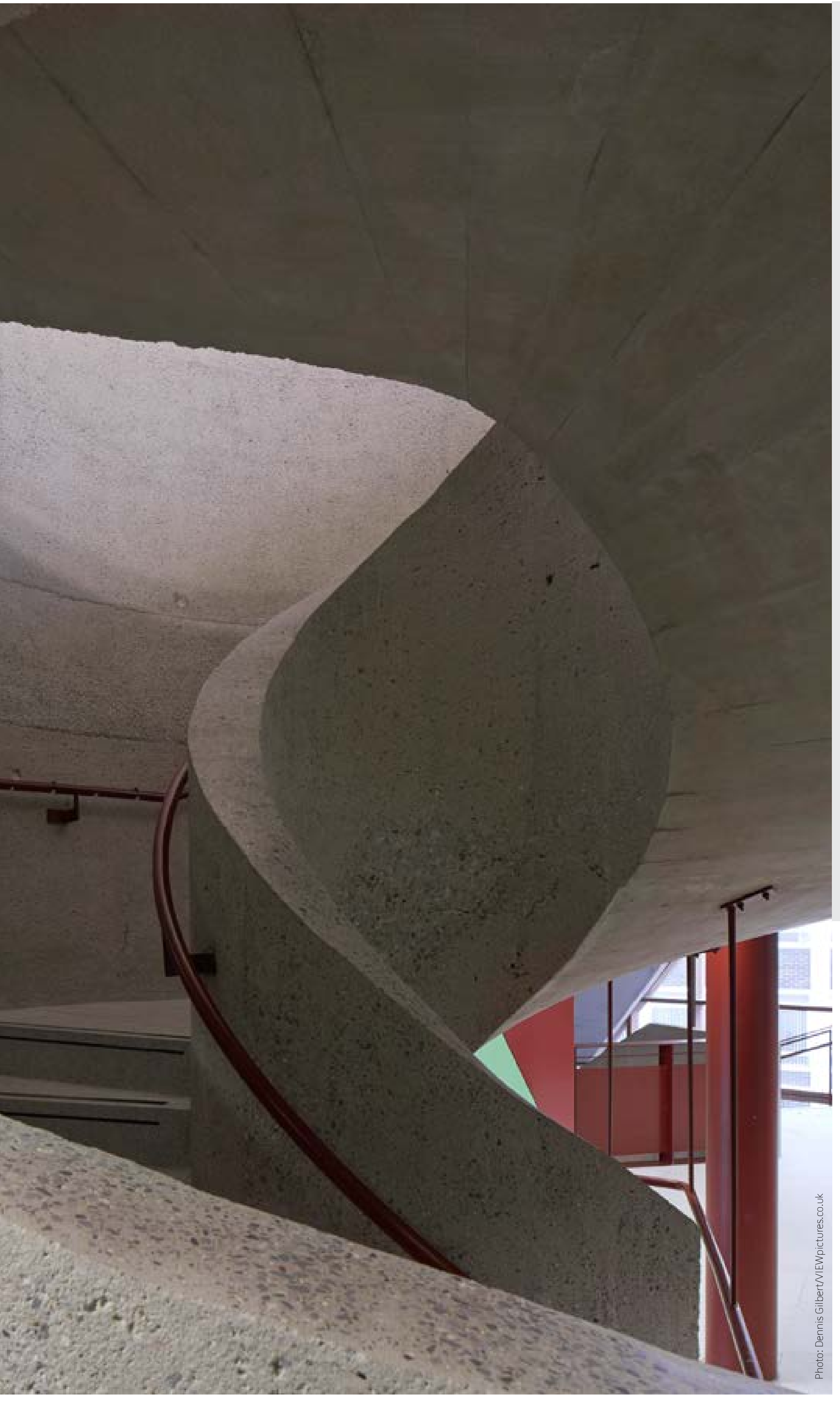


Photo: Dennis Gilbert/VIEWpictures.co.uk

Saw Swee Hock Student Centre

London School of Economics (2013)

The complex geometries of these helical staircases were a challenge to create in visual concrete cast in situ. The flights of stairs themselves were created first, providing a spiralling working platform for the formation of walls and balustrades cast along its edges. Unlike concrete elsewhere in the building, the formwork layout was not set out by architect O'Donnell + Tuomey, which gave contractor SDL more freedom to achieve the desired shape. A card lining on the inside of the curved formwork limited the impact of the uncontrolled joint locations on the surface of the concrete, while the vertical faces were heavily shot-blasted to remove the outer few millimetres of concrete. This post-finishing technique also serves to limit the visual impact of the day work joint between stair and upstand on the outside of the balustrade.

The sloping underside of the stair ply formwork, which is faced in medium-density overlay, was feathered to create the unique shape, and the concrete finished with a light shot blast. The rough "elephant hide" surface of the textured concrete stair enclosure is accentuated by the polished-smooth pale terrazzo poured onto the treads and risers and the top surface of the balustrade. The crisp-edged step coverings hide any damage caused by use of the stair during construction, and also conceal the potentially irregular internal junction between platform and upstand.

The concrete mix was initially specified to include 50% ground granulated blast furnace slag. During sample trials with the supplier, this evolved to include additional limestone fines to further lighten the colour.

RC spreadsheets available from The Concrete Centre, which enable rapid production of design calculations to Eurocode 2 and for BS 8110. Spreadsheet TCC 71 relates to stair design.

Finish

Standardised precast concrete stairs are produced to a high quality of finish and tolerance, usually in grey concrete and not necessarily designed to be left exposed. Specifiers should establish pre-tender which of the finishes offered by the manufacturer will meet the project requirements. One surface of the concrete stair will be a trowelled finish, depending on the orientation of manufacture. For example, stairs precast upside-down have formed tread and riser faces and a trowelled soffit to the flight. In all in-situ concrete stairs, the face of each riser and the underside of the concrete stair will be "formed" finishes and each tread will be the unformed trowelled surface. Such exposed stair

FIVE COMPELLING CASES

The design possibilities of concrete stairs are almost endless. This selection shows a range of approaches to form and finish.

1 Tate Britain

London (2013)

It is not immediately apparent how this extraordinary helical staircase was constructed. In fact, it is concrete cast in situ and clad in sheets of reconstituted stone, with an elaborate, prefabricated, polished latticework balustrade. Bespoke prefabricated permanent steel formwork was bolted together on site, the reinforcement fixed and then the concrete poured to create a solid base for the finishes. Individual tread and riser covers in reconstituted stone were pre-bonded and delivered to site in L-sections to set in place like floor tiles, while the curved underside of the stair is rendered. A short video about the making of the decorative upper balustrade by ConcreteBloc can be viewed at www.concretecentre.com.

2 Submariner's House

London (2012)

This striking red concrete stair threads its way through three storeys of a mews house, and was created by Jonathan Tuckey Design. The flights were cast individually in situ using pigmented concrete, which was mixed on site and pumped into each timber carcass one flight at a time. Since both riser and tread are exposed, careful attention to the detail and finish was required. The risers were cast against high-quality ply-form liners and each tread trowelled smooth before the concrete was fully cured. The contractor was John Perkins Projects.

3 New Stratford Library

University of East London (2013)

This helical stair by Hopkins Architects was precast in flights spanning between precast landings, each lowered into place within the in-situ concrete enclosure. The junction of each exposed halving joint is expressed with a grouted shadow gap. The elements were precast upside down, enabling cast-in recesses to tread and riser, and a multifaceted soffit was achieved through skilled hand trowelling. Lifting eye positions are hidden using discs of concrete. The staircase supplier was Cornish Concrete Products.

4 Zaha Hadid Design Gallery

London (2012)

Ultra high performance concrete (UHPC) offers the possibility of extraordinarily slender structural elements. Here, the tread structures, or ribbons, were precast in white UHPC, integrating the balustrade and handrail fixing. Each ribbon is self-supporting, suspended between concealed perimeter beams. Though the staircase narrows slightly as it descends, each element was cast using a single set of adjustable moulds. Structural consultant was Adams Kara Taylor, and precast concrete was supplied by Il Cantiere.

Photos: Hélène Binet; Dirk Lindner; Timothy Soar; Elaine Toogood; Will Pryce

treads require skilful execution to minimise the difference in finish to the adjacent riser.

Specialist suppliers can provide concrete stairs in a range of colours and textures using blends of aggregates and pigments. Finishing techniques for bespoke stairs include acid etching, abrasive blasting, polishing, and exposing aggregate through surface retardant. All except polishing can be used to improve slip resistance and are best specified through reference to samples.

Fixings and junctions

A commonly overlooked junction on exposed concrete staircases is the underside, where stair flight meets landing or half landing. There are many solutions for fixing stairs to landings depending on the floor and frame construction. Halving joints, where the stair and landing interlock using overlapping nibs of concrete, can provide a neat solution but are not practical for in-situ concrete landings. Factory-cast steel brackets or plates may be recessed or surface-mounted, with differing implications for the width of joint visible on the underside. Integrated or attached half or full landings avoid this issue, but the waist of the stair increases due to the extra span. Although this form can facilitate very quick installation of the whole stair structure, it is less efficiently stacked and transported.

Nosings and other inserts

Where contrasting nosings are required, these are most simply applied to the concrete surface after manufacture. Simple recesses can be cast in the concrete to receive inlaid materials, though this is very difficult to achieve on the unformed faces. Carborundum non-slip inserts can be cast into the precast concrete flights.

Lifting eyes

Lifting eyes are needed so that precast elements can be manoeuvred within the factory and also for placing on site. For many applications they are typically left or grouted up after installation, unseen against the side of the wall or under a stair covering. Their installation needs to be controlled on staircases featuring exposed concrete, especially since some of the eyes are likely to be located on the face of the treads. A neat solution is to cast in threaded sockets. The lifting eyes can then be replaced by decorative discs, for example, in stainless steel or a matching concrete finish.

Elaine Toogood is an architect at The Concrete Centre

5 Old Road Campus Research Building

Oxford (2008)

The concrete stairs in the atriums of this research centre, designed by Make Architects, were cast in situ against oversized phenolic-faced formwork. Self-compacting concrete was used to achieve a high-quality finish and to facilitate placement around the large amount of steel reinforcement required to create the 9m cantilever. The stair balustrades appear to wrap seamlessly into landing and laboratory enclosures, accentuated by gentle curves at all corners and a continuous horizontal rebated detail. The construction of the stairs was deliberately programmed so that it was not on the critical path for the rest of the building in order to facilitate the care and craftsmanship necessary for visual concrete. The result is an as-struck finish with few areas requiring remediation. The formwork was reused for a stair in another atrium on the site. The structural engineer on the project was Price and Myers, and the concrete contractor was Byrne Brothers. Watch project architect Justin Nicholls talk about this building at www.concretecentre.com.

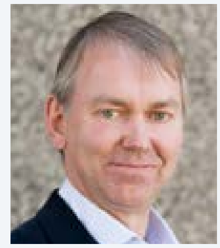
Key references

For a list of precast stair manufacturers, refer to the British Precast buyers guide, available from www.britishprecast.org

The Concrete Centre RC spreadsheets, available from www.concretecentre.com/rcdesign

Economic Concrete Frame Elements to Eurocode 2, pp140-141, published by The Concrete Centre and available from www.concretecentre.com/publications

Revised reg serves up new recipe for energy efficiency



The 2013 edition of Part L of the Building Regulations came into force on 6 April 2014 following a six-month delay. Tom De Saulles outlines the key changes

Two years ago, the government consultation on Part L included a proposal for a further significant cut to the CO_2 emissions from new buildings, which would have placed challenging demands on fabric performance and required much greater use of low-carbon heat and power systems such as photovoltaics. In fact, the final outcome is a relatively modest 6% improvement for housing and 9% for non-domestic buildings. This is partly a reflection of economic concerns and a recognition that the construction sector is still recovering from recession.

New energy target for housing

Alongside the revised CO_2 emissions target, a new target for fabric energy efficiency (TFEE) has been introduced for housing. This sets a minimum standard for fabric performance measured in kWh/m^2/y and underpins the government's fabric-first approach to reducing emissions by ensuring that new homes cannot rely too heavily on low-carbon heat/power systems to achieve compliance.

In practical terms, the revised emission targets can, in most cases, still be met without the need for additional costly technologies, although they do of course require a higher standard of fabric performance and the use of efficient building services. There are no specific implications for concrete and masonry buildings, but the uplift in performance demanded by Part L 2013 has increased the importance of minimising heat loss through thermal bridging. This makes the use of energy-efficient construction details a sensible policy wherever possible, particularly as they make a cost-effective contribution towards Part L compliance. The masonry sector has developed thermally efficient construction details, the latest of which have been produced by the Concrete Block Association (www.cba-blocks.org.uk) and Aircete Products Association (www.aircrete.co.uk).

THE UPLIFT IN PERFORMANCE DEMANDED BY PART L HAS INCREASED THE IMPORTANCE OF MINIMISING HEAT LOSS THROUGH THERMAL BRIDGING

Revised method for setting targets

Another change in Part L1A (which covers new housing) is the way in which CO_2 and energy targets are set. As before, these are determined by the performance of a notional dwelling of the same size and shape as that being assessed, but there is a brand-new set of fixed values for air permeability, boiler efficiency, U-values, psi-values and so on. This is referred to as the "elemental recipe" and can be applied wholesale, ensuring compliance from the outset. However, the recipe can be modified, so designers can use it more as a starting point for their own specification.

For new non-domestic buildings, Part L2A now includes a wider range of notional buildings for different daylighting scenarios: top lit, side lit (heated only) and side lit (heated and cooled).

Speculation on future changes to Part L

Towards the end of 2013, the government reaffirmed its commitment to the 2016 zero-carbon deadline for new homes, and the 2019 deadline for non-domestic buildings. However, the 2016 target is surely questionable given the lack of time left to address the legislative and practical issues involved. In reality it may slip, perhaps to 2019, thereby aligning the two targets.

It is likely that the next edition of Part L will be accompanied by the Allowable Solutions scheme. This is effectively a carbon-offsetting scheme, currently under development, which will bridge the gap between the zero-carbon goal and what can actually be achieved on site. It will take the form of a levy on developers, to be invested in programmes to develop offshore wind power or upgrade insulation in existing buildings, for example.

In terms of the fabric performance required by Part L, it seems unlikely that this will go much further, as the new requirements are already approaching practical limits. However, it is worth noting that there is talk of a tougher European target, which will seek to cut CO_2 by 40% by 2030. The current target of 20% by 2020 is close to being achieved, and the proposed increase may well have implications for building design further down the line.

Tom De Saulles is senior manager, building sustainability at The Concrete Centre

SPECIFYING SUSTAINABLE CONCRETE

Minimising the environmental impact of concrete requires a detailed understanding of location factors and constituent materials. Jenny Burridge and Dr Chris Clear explain

Concrete, in its simplest form, is made by mixing a cementitious binder, aggregates and water. This is then poured into a mould, or formwork, where it sets to form the dense, durable substance we know as concrete. The proportions and types of binder, aggregate and water can be changed and admixtures or fibres added to give different properties to the concrete either in its liquid or hardened state. Choosing the correct concrete specification for the location and function of the concrete is the essence of specifying sustainable concrete. The relevant British standard is BS 8500-1, and this should be referred to when specifying concrete in the UK.

The biggest proportion of the embodied carbon dioxide (eCO_2) in concrete is from Portland cement, or CEM I. Aggregates, additions and water are naturally low in eCO_2. All constituent materials are also plentiful in supply locally and UK-sourced.

Specification methods

There are five methods for specifying concretes in BS 8500. These are given in figure 1, below.

Exposure classes

Stronger concretes tend to be more durable, but also higher in embodied energy, so it is worth thinking about the location and specifying accordingly. Concrete that is to be exposed to rain, frost or chemicals will require a different specification to concrete in an internal dry environment, and a mix that will endure for 100 years inside a building may not last as long in the sea. BS 8500 gives six exposure classes for different types of environment (figure 2). These are then subdivided depending on the severity of the environment.

Note that carbonation and chlorides affect the reinforcement in the concrete, and therefore do not apply to mass concrete. Freeze-thaw and aggressive ground affect the concrete matrix and therefore apply to both reinforced and mass concrete.

The durability required for these exposure classes is given in BS 8500 as concrete strengths and cover to the reinforcement. The stronger concretes tend to be more impermeable and therefore less vulnerable to penetration by water, chemicals, carbon dioxide (which leads to carbonation) or chlorides. The Concrete Centre's publication "How to Design Concrete Structures Using Eurocode 2: BS 8500 for Building Structures" provides a summary of the tables in BS 8500, giving concrete strengths, covers and allowable cement types.

Reinforcement will be more prone to corrosion where exposed to chlorides than just by carbonation. Therefore, if chlorides are present, the tables covering XD or XS exposure classes should be followed.

Aggregates

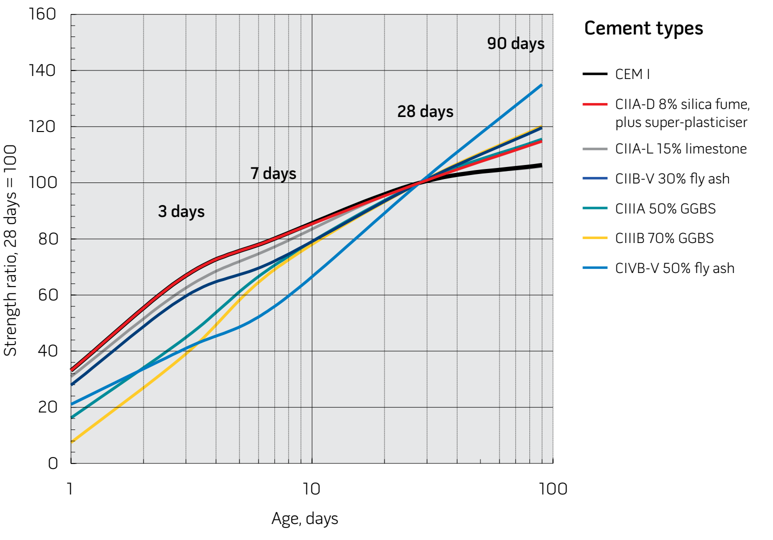
The biggest proportion of concrete is normally aggregates, typically making up around 70% of the total volume. These can be primary aggregates, quarried to be made into concrete; secondary aggregates, which are by-products of another process; or recycled aggregates which tend to be crushed concrete from demolition or

FIGURE 1: SPECIFICATION METHODS

Specification method	When should it be used?	Key considerations
Designated concrete	Mass or reinforced concrete where strength is important and there are no chlorides present. Foundations where there are no chlorides present.	Cannot be used if chlorides are present. This method allows the concrete producer flexibility to select the most appropriate materials to give the required performance.
Designed concrete	Reinforced concretes, particularly where there are chlorides present. Visual (fair-faced) concrete. Where lower-carbon concretes are particularly important.	This method allows the specifier to define the concrete required. The concrete producer has some flexibility in the mix design to ensure that the performance requirements are met.
Standardised prescribed concretes	Site batching where ready-mixed concrete cannot be used. (At maximum cement content, the highest strength class that may be assumed for structural design is C20/25.)	The strength of the concrete cannot be specified and the cement content tends to be significantly higher than that for a designed or designated concrete. Do not use this method if a lower-carbon concrete is required.
Prescribed concrete	Specialised concretes where the specifier takes full responsibility for the performance of the concrete.	The strength of the concrete cannot be specified. Suitable if a concrete technologist is specifying the concrete. There is no flexibility for the producer to account for any inherent variation in the materials used in the concrete.
Proprietary concrete	Can be used for a number of high-performance concretes such as self-compacting concretes, low-shrinkage concretes, coloured concretes or high-strength concretes.	The concrete composition is designed by the concrete producer to provide a certain performance. The composition of proprietary concretes is confidential to the producer.

LEFT
Trafford Town Hall in Manchester, by 5plus Architects, where 50% cement replacement was specified. Watch a recent Concrete Elegance presentation by the architect at www.concretecentre.com

FIGURE 4: THE EARLY AGE STRENGTH GAIN OF DIFFERENT CONCRETE MIXES



waste. Recycled aggregates are further sub-categorised as:

- RA (recycled aggregate), which is comprised of any inorganic material previously used in construction and can include a high proportion of masonry
- and RCA (recycled concrete aggregate) which is comprised of crushed concrete.

For the purposes of BREEAM assessments, secondary aggregates are considered as recycled aggregate.

Due to the crushing process, recycled aggregates contain a proportion of fine material that increases water demand and may increase drying shrinkage and creep of the hardened concrete. Coarse recycled aggregates can be used in concretes specified to BS 8500. For designated concretes, recycled aggregate can be used in the mix to the percentages shown in figure 3 without further specification. A greater percentage can be specified, but there should be rigorous testing of the aggregate to make sure that it does not contain anything deleterious to the reinforcement or concrete. The allowable limits for the use of secondary aggregates are much higher, with the exact percentage dependant on the type of aggregate and its use.

While recycled aggregate can be used in concrete, it may increase the eCO_2 because more cement is required due to the increased water demand. Recycled aggregate transported further than 15km by road is likely to have a higher eCO_2 than primary aggregate. Often the most sustainable use will be in other applications. All recycled aggregate that is available is fully used.

Cementitious material

Cement is not only made of Portland cement (CEM I) but can also include additions such as fly ash and ground granulated blast furnace slag (GGBS). These additions provide some useful benefits, such as durability, workability and lower heats of hydration. They are also products recovered from other industries, and are therefore low in eCO_2, and their use can reduce waste to landfill. Most modern ready-mixed concretes in the UK include an addition.

Concretes that contain high levels of additions have longer setting times than pure CEM I concretes, and are therefore more suitable for foundations or ground-bearing slabs. Lower levels of additions, up to approximately 35% GGBS or fly ash, should not significantly extend the striking times for suspended concrete slabs in reasonable weather. In cold weather the strength gain of concrete is reduced and therefore the percentage of additions that will still allow a striking time of about three days is also reduced.

Figure 4 shows the relative strength gain of concretes with different proportions and types of additions. All reach the required strength at

FIGURE 2: EXPOSURE CLASSES

Exposure class	Form of attack	Subclass	Example of location type
X0	No risk of corrosion or attack		Mass concrete not exposed to freezing or sulphates in the ground
XC	Carbonation	XC1	Internal
		XC2	Wet
		XC3	Damp, or cyclic wet/dry
XS	Chlorides in sea water	XS1	External concrete near the sea
		XS2	In the sea
		XS3	In the tidal zone
XD	Chlorides not from sea water	XD1	Possible spray from de-icing salts
		XD2	Permanently in salt water
		XD3	Areas where de-icing salts are used such as car park slabs
XF	Freeze-thaw	XF1	External vertical surfaces without de-icing salts
		XF2	External vertical surfaces with de-icing salts
		XF3	External horizontal surfaces without de-icing salts
		XF4	External horizontal surfaces with de-icing salts
ACEC	Aggressive ground conditions	AC-1s to AC-5m	Foundations in non-aggressive (AC-1s) to very aggressive (AC-5m) soils

FIGURE 3: PERCENTAGE OF RECYCLED AGGREGATES ALLOWED IN DESIGNATED CONCRETES

Designated concrete	Allowable percentage of coarse RA or RCA
GEN 0 to GEN 3	100%
RC20/25 to RC40/50	20%*
FND1	20%*
RC40/50XF	0%
PAV1 and PAV2	0%
FND2 to FND4	0%

* Except where the specification allows higher proportions to be used

28 days, as that is the specified time, but the concretes with higher proportions of additions take longer to gain early strength and continue to gain significant strength after 28 days.

Cement types tend to be blended at the concrete batching plant and normally the addition is either fly ash or GGBS, not both. Fly ash tends to make the concrete darker in colour and improves its workability; GGBS tends to lighten the colour and improve its reflectance.

Embodied carbon

The eCO_2 of concrete is highly dependent on the amount of Portland cement in the concrete. Figure 5 gives the embodied carbon of the different constituents of concrete. From this, it can be seen that a higher percentage of additions will therefore reduce the embodied carbon significantly.

Admixtures are chemicals added to concretes in small quantities to improve some aspects of its performance. These include water-reducing admixtures, also known as super-plasticisers. Super-plasticisers can reduce the embodied carbon of concrete by reducing the water/cement ratio, which increases the strength for a given cement content. Figure 6 gives an example of how a super-plasticiser may be used to reduce cement content, and hence the embodied carbon in structural concrete.

Responsible sourcing and material efficiency

The relevant standard for the responsible sourcing of construction materials is BES 6001, which can apply to all building materials and covers a range of environmental and social factors. The concrete industry has worked to BES 6001 since it was published in 2008. In 2012, when the latest available data was published, some 89% of all concrete produced in the UK was responsibly sourced.

The concrete industry is also a net user of waste, consuming 63 times more than it produces. Much of this is used as fuel in cement kilns, but it also includes recovered materials such as fly ash and GGBS, which are used instead of a manufactured product such as CEM I.

Photo: Jack Hobhouse

ABOVE The concrete frame of Duggan Morris Architects' Ortus learning centre in south-east London contains 50% GGBS. Watch a Concrete Elegance presentation by the architect at www.concretecentre.com

FIGURE 5: EMBODIED CARBON IN CONCRETE CONSTITUENTS

Material	Embodied CO_2 (kg/tonne)
CEM I	913
GGBS	67
Fly ash	4
Limestone	75
Aggregate	5
Reinforcement	427

FIGURE 6: REDUCTION IN CEMENT CONTENT WHEN USING WATER-REDUCING ADMIXTURES

Cement content (kg/m³) required for a C32/40 concrete with an S3 slump using marine sand and gravel aggregate

Cement type	No admixture	Water-reducing admixture	High-range water-reducing admixture
CEM I	315	285	250
CIIA-LL (15% limestone)	325	295	260
CIIB-V (30% fly ash)	335	300	270
CIIIA (50% GGBS)	325	295	260

Jenny Burridge is head of structural engineering at The Concrete Centre. Dr Chris Clear is technical director at the British Ready-Mixed Concrete Association

Key references

BS 8500-1: 2006, Concrete – Complementary British Standard to BS EN 206-1, Part 1: Method of specifying and guidance for the specifier, BSI

How to Design Concrete Structures Using Eurocode 2, chapter 11: BS 8500 for Building Structures, The Concrete Centre, 2008

Specifying Sustainable Concrete, The Concrete Centre, 2014

DESIGN ESSENTIALS

Tips for specifying sustainable concrete

- Do not over-specify strength
- Do not specify aggregate sizes below 10mm unless necessary
- Permit the use of recycled or secondary aggregates but do not over-specify. Recycled aggregates should only be specified when they are locally available
- Embodied CO_2 (eCO_2) of concrete should not be considered or specified in isolation of other factors such as strength gain
- Use of additions can reduce the eCO_2 of concrete and influence its appearance. When aesthetics are critical, specify the cement/combination to maintain colour consistency
- Permit the use of admixtures as these can be used to reduce the eCO_2 and the environmental impact of concrete, as well as modifying its physical properties
- Specify BES 6001, responsibly sourced concrete and reinforcement

LASTING IMPRESSION ALAN STANTON

FROM A FRENCH MONASTERY TO AN ITALIAN FURNITURE SHOWROOM

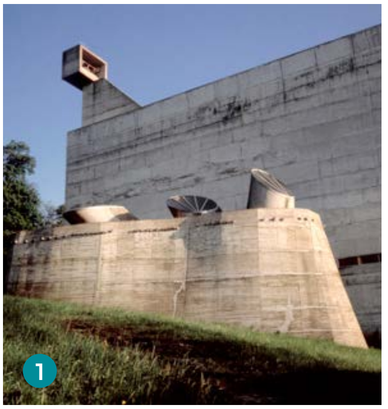
The way we design buildings is in many ways similar to how an artist works on a sculpture, so concrete is quite often an ideal material because it's very versatile and plastic. A building that exemplifies this is Le Corbusier's La Tourette monastery (1) (1959) near Lyon in France. It's very crudely built, but you really get a sense of the wonderful sculptural qualities of concrete. It can form itself to do all kinds of things throughout the building, and because it's all concrete, it has a tremendous integrity.

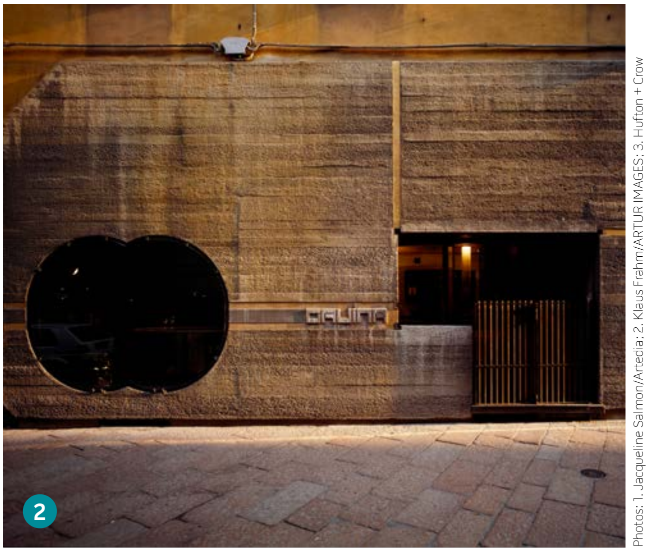
Another is Denys Lasdun's National Theatre on London's South Bank (1976), which we worked on about 15 years ago. Denys said to me, "We had a very limited budget, but what we did have was the luxury of space," and the concrete actually creates those spaces. The whole building is in rough board-shuttered concrete and you can light it to get a soft, almost furry quality. Certainly on the interior I think everybody loves it; the exterior is another question.

The other interesting thing about the National Theatre is that if you put concrete together with luxurious materials – Lasdun does it with stainless steel, lighting and a very beautiful purple carpet – then immediately you lift people's perceptions of it. The person who does this best is the great Italian architect Carlo Scarpa. I recently visited his Gavina showroom (2) (1963) in Bologna, in rough board-marked concrete with two big circular windows. There are grooves in the concrete where he's put gold leaf, and little bronze fittings around the windows – it ennobles the concrete, if that's not too grand a word.

At the Sainsbury Laboratory (3) [in Cambridge], we managed to get very high-quality fair-faced concrete, and by putting it with a rather beautiful limestone and timber and beautiful detailing, it just became a very, very special material.

Alan Stanton is co-founder and director of Stanton Williams





Photos: 1. Jacqueline Salmon/Artedia; 2. Klaus Frahm/ARTUR IMAGES; 3. Hufton + Crow

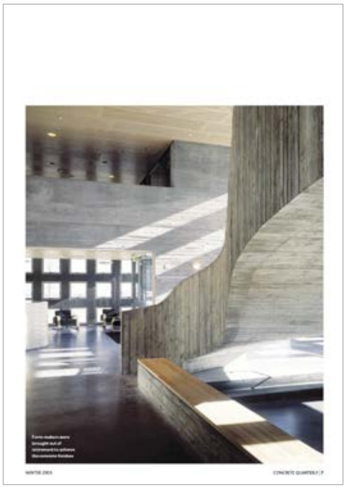
FROM THE ARCHIVE: WINTER 2003

5,500 HOLES IN CAMBRIDGE, MASSACHUSETTS

The Glasgow School of Art (pages 4-7) is not the first time that New York architect Steven Holl has set tongues wagging with a massive, in-your-face university building. Back in 2003, in the rarefied setting of the MIT campus in Cambridge, Massachusetts, Holl completed the Simmons Hall student housing block – a hulking 10-storey concrete honeycomb with more than 5,500 small square windows cut into its solid exterior. "The dormitory's massing resembles two Pac-Man figures set head to head," thought William Menking, writing for CQ.

As with the Reid Building, it is inside that the building really comes to life. "The most successful spaces are those that could only happen with concrete as a material," writes Menking. "The most impressive are the six multistorey group lounges that slice up, across and through the standard residential floors. These flowing spaces, made of thin poured concrete, suggest Bilbao crossed with La Tourette and cut diagonally through the building's walls and floors, often spilling into the hallways. They are expressed on the facade as large irregular openings that Holl labels 'amoebic', but which look for all the world like gaps in Swiss cheese."

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



FINAL FRAME: RW CONCRETE CHURCH
Nameless Architecture's church in the newly developed district of Byeollae, just outside Seoul in South Korea, uses concrete not only as the primary structural and finishing material, but also as a symbol for the durability of religious values. The imposing, box-like structure includes a 7m cantilever above the western entrance, which gives the facade the appearance of a vast concrete cross looming over the new suburb.

Photo: Rohspace/Nameless