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What can be done to encourage the reuse of steel as the construction industry starts to engage with circular economy processes? In the latest Steel Intelligence supplement we look at the plethora of initiatives and research under way, from creating a market portal to the introduction of materials passports (p51-52). Reuse is also the theme of our building study on Ashton Old Baths in Ashton-under-Lyne, now reborn as offices with the insertion of a new steel structure within the former pool hall (p48-50 and above). Meanwhile in Cambridge, Marks Barfield's new primary school for the University of Cambridge is designed to be future-proof with flexibility to change both within and beyond its current footprint (p53-55). We finish with SOM's Exchange House, nominated by Maria Smith as a fine example of integrated architectural and engineering thinking (p56).

Pamela Buxton, editor, Steel Intelligence

RIBA J

NICK HARRISON

New ship in old bottle

Extensive use of steel enabled the insertion of a dramatic timber pod into a grand old swimming baths while protecting the listed structure itself

Words Pamela Buxton

One of the oldest and largest municipal swimming baths in England has been saved from dereliction and reborn as offices with the help of a lightweight structural steel solution.

Ashton Old Baths, in Ashton-under-Lyne, was built around 1870 in an Italian Romanesque style with a 37m high chimney tower and a grand pool hall. The grade II* listed structure had been out of use for 40 years and was on the Buildings at Risk register before the £2.7 million conversion project, designed for client Tameside Borough Council in partnership with PlaceFirst.

This conversion follows many unrealised attempts to find a new use for the landmark building, including a proposal to fill it with shipping containers that could function as offices. The final project presented multiple challenges for the design team. Not only was there considerable damage to the 2100m^2 building due to water ingress, but any new structure had to be constructed via a limited access opening just 3m wide by 2.7m high.

The architect, Modern City Architecture and Urbanism, favoured the idea of an independent structure within the pool hall that would leave the original building fabric as untouched as possible, according to director Neil Brown. Crucially this approach would allow circulation around the new curving structure and enable greater appreciation of the internal views of the historic pool hall, as well as being easier to construct.

The result is a timber-clad, pod-like form about 30m long and 11.5m wide. It provides three storeys of office accommodation topped by a roof terrace, and is located on the site of the pool, which was filled in several decades ago.

'We wanted to do something quite bold that was fitting to its context,' says Brown. 'We felt something more organic would be more appropriate than a blocky shape. By curving the envelope, it dramatically enhanced the views.'

Steel was utilised both to stabilise the water-damaged structure and to create the new office intervention. A timber frame was considered but rejected because of the cost and the difficulty of fitting the components through the relatively small access door.

'We proposed a lightweight solution that would deal with the constrained access and minimise the interventions in a cost-effective way,' says Kevin Gilsenan, director of structural engineer Renaissance.

Another option, a steel frame with a concrete floor deck, was also rejected because of cost and the deeper floor build-up, which would have compromised the desire to maintain space between the pod's roof terrace and the old roof. Instead, a simpler all-steel solution delivered by steelwork contractor BD Structures, combined with a lightweight plywood floor, gave a structural zone of 200mm compared with the 300-400mm of the composite solution, enabling more generous headroom of 2.6m.

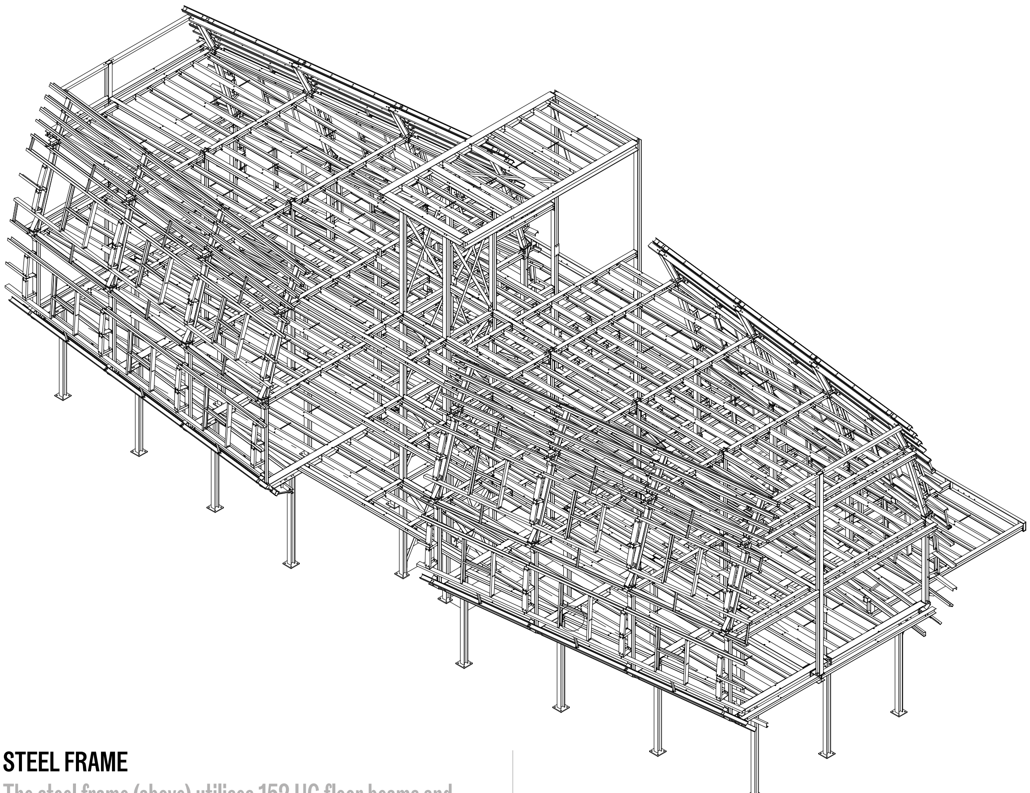
'If it had been any bigger it would have swamped the original building... We were keen that the intervention sat as an object in the space,' says Gilsenan. 'We worked with the architect so that it tapers on plan and you can look up and appreciate the original fabric.'

The pod is glazed at ground floor level to maximise daylight from the upper windows and give the appearance that it is 'almost floating in the space', says Brown. Above this, the structure is clad in plywood and western red cedar, swelling out into a barrel-shape

JAMES MADDOX (2)

Opposite A new steel structure enabled the conversion of the Victorian pool hall for office use.
Above The pod-like intervention is clad in plywood and western red cedar.
Left Exterior, showing the neo-Italian Romanesque building's distinctive tower.

We proposed a lightweight solution that would deal with the constrained access and minimise the interventions in a cost-effective way



BD STRUCTURES

STEEL FRAME

The steel frame (above) utilises 152 UC floor beams and columns within a 3.6m x 6m grid that ties in with the spacing of the original roof structure and supports. These are designed with minimal thickness to reduce the impact on the main hall, assisted by two rows of internal columns, which avoided the need for heavier beams. The structure rises above the top storey to form a 1100mm high balustrade for the roof terrace.

Structural engineer Renaissance wanted to keep the new foundations within the footprint of the infilled swimming pool to minimise intervention to the existing building fabric. Piled foundations were inserted beneath the columns through the infill and into the sandstone under the building to a depth of 15m. A transfer structure was created at first floor level to support the cantilevering upper levels.

'Every piece of steel is different because it follows a curve on plan and in section. Each connection had a different angle and geometry,' says Chris Heys, managing director of steelwork contractor BD Structures.

Constructed with bolted connections throughout, the pod was erected in six weeks with the help of a mini-crane. The process was slowed by the logistics of feeding 831 fabricated items – a total of 65 tons of steel – plus associated construction equipment through the narrow access point. The substructure and superstructure packages cost less than 15% of the overall pod building cost.

with the aid of cantilevered facetted columns. Brown feels it enhances the cathedral-like space. 'As you walk around you get different views and vantage points and the sense of volume is always maintained,' he says.

The new office pod was only possible because the cost-effective steel repairs to the historic fabric minimised the interventions required. Years of steam rising up from the pool and condensing meant water ingress had caused widespread rotting of the beams and support posts of the roof trusses, potentially leading to the need for propping and extensive replacements.

Renaissance created a 3D model to analyse the implications of the damage and discovered that only members with greater than 30% loss of section required strengthening. The firm then developed a steel flitch plate that took the load off the timber. Not only was this reversible, but it avoided the need for temporary works or the removal of the existing building fabric.

Steel was also used to strengthen the pool annex structure, which had a heavily corroded steel filler joist floor, also due to prolonged water ingress. Renaissance's surveys found that many of the joists had corroded with 30-50% loss of cross section. To avoid intervention to the slabs themselves, it was decided to insert new intermediary steel beams where needed at mid span to strengthen the filler joists concrete slab. This effectively broke the span down from 3.5-4m to 2m.

'This meant we didn't have to do repairs to the existing slab,' says Gilsenan.
This new structure carries the new imposed and super dead loads only, leaving all existing loads to be carried with the existing structure. This use of additional steel insertions avoided lengthy and more expensive repairs that might have used up too much of the project budget.

In total, 605m^2 of new office accommodation has been incorporated in the building. ●

Credits
Client: PlaceFirst in partnership with Tameside Borough Council
Architect: Modern City Architecture and Urbanism (MCAU)
Heritage consultant: Heritage Architecture
Structural engineer: Renaissance
Contractor: HH Smith & Sons
Steelwork contractor: BD Structures Ltd

Encore, encore

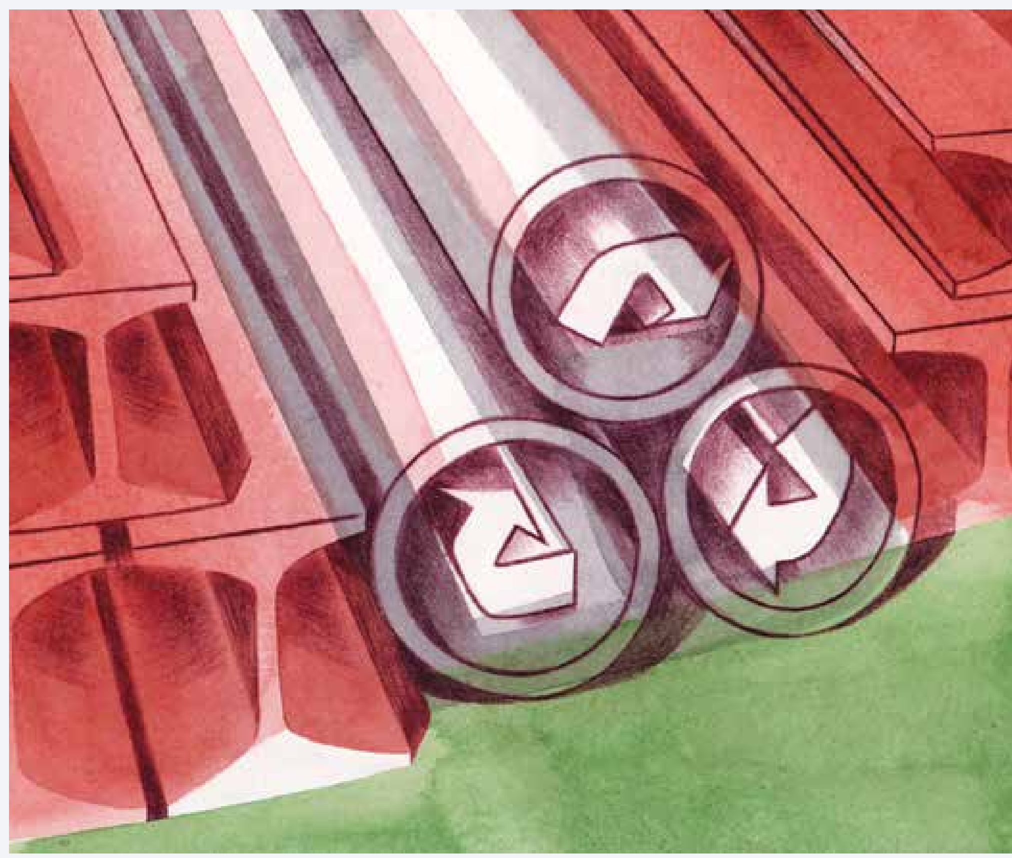
What can be done to encourage steel reuse? Pamela Buxton looks at the potential of integrating steel into a circular economy

Words Pamela Buxton **Illustration** Toby Morison

As construction begins to engage with the circular economy principles of promoting resource productivity and reducing waste, what are the implications for steel?

Steel recycling, as distinct from reuse, is well-established, with some 95% of steel sections currently recycled into products of equivalent or higher quality. Reuse, however, optimises whole life resource efficiency further by exploiting steel's inherent ability to be reused. But what are the barriers to this? And what can be done to encourage all participants, from steel producer and architect through to developer and end-user, to embrace this way forward?

The Steel Construction Institute (SCI) and Cambridge University are exploring the development of a portal for steel reuse as one of a number of ongoing research projects tackling the reuse of this and other construction materials. Last summer the Circular Building, built from steel and other fully reusable components (see overleaf) was showcased at the London Design Festival as a prototype for reusable buildings.



Designing for deconstruction

'The circular economy agenda is coming to the fore now and has given steel reuse impetus,' says Dr Michael Sansom, associate director of the SCI, which is also leading the EU research project REDUCE (Reuse and demountability using steel structures and the circular economy). This three and a half year initiative aims to encourage steel reuse by promoting design for deconstruction with advice on connection systems and greater standardisation of design.

According to Dr Sansom, while the environmental case for reuse is very clear, SCI research found that currently just 5% of steel sections are reused compared with the remainder of sections that are traditionally recycled. Both options, however, avoid the downcycling or incineration fate of many other construction materials.

'The idea of reclamation and reuse is not common practice and many organisations don't have the experience and skills to do it,' he says.

The SCI/Cambridge University research analysed the barriers to greater steel reuse such as access to the right type and amount of certifiable steel when required, and the cost, quality and programme implications of reusing steel. It found that there was often a disconnect between the perceived problems and reality.

'There's sometimes a perception that reused steel is somehow inferior,' says Sansom. 'As long as steelwork isn't severely damaged by fire, there's absolutely no reason why it couldn't be reused.'

A portal for reusing steel could tackle many of the issues around accessing reused steel. Demolition contractors could post details of steelwork from buildings they're working on for interested designers, contractors and developers to view and ultimately buy.

'It's very challenging for designers,' says Sansom. 'If they want to reuse steel they have to find the right section sizes in the right volumes and at the right location. This would be much easier if there were a bigger market with better availability.'

As well as providing access to reused steel, the portal could also make provision for

ARUP

CIRCULAR BUILDING
The Circular Building was erected in the forecourt of the Building Centre in London recently to demonstrate the potential for reusing building products. Delivered by a team including BAM Construct UK, Arup and the Building Environment Trust, the steel-framed prototype uses digital technology to tag all items with a code containing the necessary information to allow it to be reused.

future use by building a database of BIM structural steel models of new buildings, with each piece of steel and its CE marking identifiable. While this information is already available for CE marked buildings, a database would ensure it was available to future owners. This would make reuse more economically viable by removing the need for testing, since the model can provide the necessary data to ensure that those sourcing reused steel could be confident that it had the properties they require.

Several other initiatives are looking at this important issue of information, which is key to boosting steel reuse from the thousands of buildings that are demolished each year in the UK.

One of these is the Buildings as Materials Banks (BAMB) pan-European project, led in the UK led by BRE and BAM Group. This initiative proposes a Design Protocol for Dynamic & Circular Buildings to make sure buildings are designed to be easy to deconstruct. It is also exploring electronic materials passports as a one-stop shop for capturing material and performance information that will make it easier for developers, managers and renovators to choose circular building materials.

'If that's captured in a model or a passport, then in 20, 60 or even 100 years' time an engineer or architect will be able to look at that steel and know what stresses it's been under and have full confidence in knowing how it can be used in the future,' says Nitesh Magdani, group sustainability director at Royal BAM Group, who hopes this will help address the current hesitancy to consider reused materials.

BAM has explored circular economy approaches on several projects, including the Circular Building designed with Arup and constructed last year at the Building Centre in London (see above). It is currently setting up a database as a platform to assist circular building processes.

Incentives needed

'Hopefully in 20 years' time we'll have a marketplace ready to deliver products that have been used already,' says Magdani, adding that more needs to be done to incentivise CE practices.

These issues are just part of a complex picture according to Arup principal consultant Kristian Steele, who has been looking into steel reuse as part of the firm's engagement with the circular economy.

'Circular economy is an area of strategic importance to Arup. It's something we need to be at the sharp end of,' he says, adding that at the moment the market doesn't have all the solutions for that agenda.

'Over time these things will come forward. Reuse is a useful strategy – although just one among many for achieving greater circularity – and in particular applications I think it has the potential to be applied more,' he says. 'The research shows that designing for reuse is a potential solution for reducing carbon emissions.'

According to Steele, reuse starts with enabling easy and cost-effective deconstruction. This requires a minimum number of fixings which can be removed mechanically. A simple, standardised structure would also help, as well as a tagging system that identifies steelwork properties both virtually through the BIM Model and physically – a method already embraced by some in the shipping industry. Steele also suggests that disassembly plans should be mandatory for all buildings as an easy way of recording the necessary information to enable a circular economy approach.

The creation of a steel reuse portal and the outcomes of other research such as advances in information tracking will undoubtedly make reuse more practical. But without carbon taxation or legal requirements there isn't a simple way of making it widespread – yet – according to SCI's Dr Sansom.

He suspects that a major step change in business model – as radical as that delivered by Uber and Airbnb in their industries – will also be needed to make this happen.

'All technical barriers are surmountable. It's just a case of whether there's sufficient drive, economic or otherwise, to make it happen.'

By exploring the BIM-spurred potential for information tagging and the feasibility of a steel reuse portal, he is hopeful the steel industry will be in a good place when reuse does become viable on a larger scale.

'Its time will come. It makes sense for us to do the right thing and plan for it now,' says Sansom. 'Steel's doing brilliantly in the recycling loop. We're now trying to go to the next level.'

Radiating flexibility

A new primary school in Cambridge uses a lightweight steel structure to ensure it can adapt with the changing demands of the coming decades

Words Pamela Buxton **Photographs** Morley von Sternberg

Future-proof may be an overused claim these days, but Marks Barfield's University of Cambridge Primary School makes a very convincing case for being just that.

With built-in capability for internal reconfiguration, extra ventilation provision for 2050 climate conditions and an expansion strategy, this highly unusual school is well prepared for all kinds of change.

This flexibility is due in no small part to a lightweight steel structure chosen to suit both the need for reconfiguration and the soft ground conditions of the former farmland site on the outskirts of Cambridge.

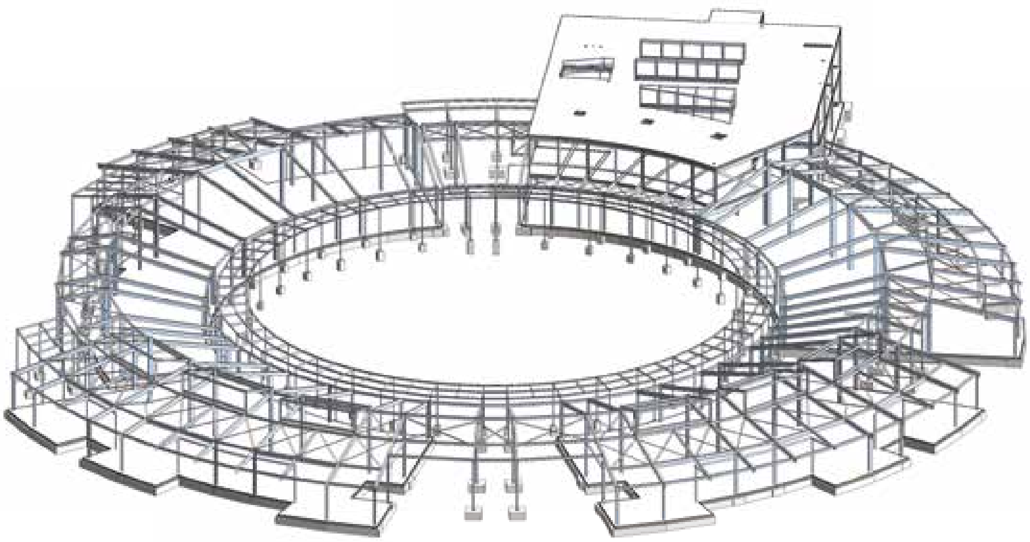
'We wanted the minimum weight of building and didn't want to spend a lot of money in the ground,' says Marks Barfield managing director Julia Barfield.

'Steelwork helps in that respect, as well as making sure the school had future flexibility. A steel frame enables walls to be moved to create new learning layouts independent of the structure.'

Unusually, the school was built not by a local authority or academy chain but by the University of Cambridge as part of its North West Cambridge Development of affordable housing and community facilities for staff and students. The first primary university training school in the UK, it is also the first piece of the masterplan to be completed.

The links to the university education department influenced the design of the school, along with a set of core educational principles including the need to create an open, inclusive pedagogy with democratic and non-hierarchical space which could be divided into smaller school communities as well as containing a variety of learning and

Left Steel cloister within Marks Barfield's University of Cambridge Primary School.



Above The radial steel structure provides a highly flexible internal layout.
Left Exterior view through the classroom clusters towards the interior courtyard.

PARMARBROOK

play spaces. The design was also informed by the school's desire for all classrooms to have level access to outside space, and by a Forest School-type approach to the outdoors.

Marks Barfield wanted its design to align with this educational ethos. It researched historic and contemporary examples from around the world, including the democratic organisation of Finnish schools as well as the Cambridge 'village colleges' pioneered by Henry Morris from 1922-54 and school designs by Herman Hertzberger.

The result is a circular ring of accommodation with a single storey of classrooms having access to either a 50m diameter inner courtyard – inspired by Cambridge college quads – or the perimeter outside space. Classrooms are arranged in three clusters of six classes plus an early years cluster. The outer radius stretches about 46m with an inner radius of 24.5m. Covered spaces between the buildings create sheltered play areas and routes between the two outdoor spaces.

The design team considered cross laminated timber (CLT) for the main structural frame, but felt steel had the advantage of allowing easier configuration of internal walls. Its light weight also reduced foundation costs, with the engineers using Vibro rather than traditional piling.

'The steel frame enabled us to articulate a radial grid and achieve a long span, open plan structure without any solid walls in the layout,' says Vishal Borhara, project director of structural engineer Parmarbrook.

Without bracing or shear walls, lateral stability was achieved through the fixed connections, and the challenge was to achieve this elegantly. 'The architect was keen on expressing a lot of these so we needed to keep them quite sleek,' he says.

The double-portal frame allows spans of up to 12m. The structure is arranged in three rows of columns spaced on a 5m grid on the inner radius, and 8m on the outer radius. Columns are a combination of universal column H sections and rectangular hollow section columns. According to Steve Worner, project manager at steelwork contractor William Haley Engineering, the biggest challenge was connecting the rectangular columns. This was achieved by pre-welding a stub onto the top of the column – concealed in the ceiling – which enabled a bolted connection to the beam sections to be made on site.

The inner courtyard is ringed by an elegant cloister (see left), providing more covered space and circulation as well as containing the artist Ruth Proctor's work We Are All Under the Same Sky within its glazed roof.

'We worked very closely with the structural engineers and steelwork contractors to make the structure as light and slender as possible,' says Barfield, adding that they were particularly inspired by a simple, glazed Arne Jacobsen canopy at a school in Denmark.

The only two-storey structure is the 35m x 26m communal block and entrance, which contains all the common parts and, as the civic face of the school, addresses the key approach road of Turing Way. Transfer structures enable a column-free main hall.

Internally, the circular plan means there are no dead end corridors, and provides for easier circulation. This is achieved via an internal, double-sided 'learning street' with library areas, storage and toilets. This 4.5m wide space can also accommodate university staff and students, with unobtrusive observation made easier by the decision to have no doors on the classrooms – they have wide openings onto the street. A number of rooms with doors are provided for occasions when more seclusion is required. The street also enables natural ventilation of the school through vents in the roof.

Classrooms average 60m^2 in compliance with BB99, significantly larger than the BB103 standards introduced subsequently, which stipulate 55m^2 as general and 50m^2 when there is a shared learning area. The university training function gave an extra 4m^2 per class, which was used to make a dining room in the communal block where pupils eat in mixed age groups.

While the architects describe the atmosphere as 'very serene and calm', it's early days yet for the three-form entry school, which won't be at full, 708 pupil capacity until 2019.

If more accommodation is needed for four-form entry, Marks Barfield has a strategy to create six more classrooms by pushing the art room, nursery and reception classes from the inner to the outer ring of the radius. ●

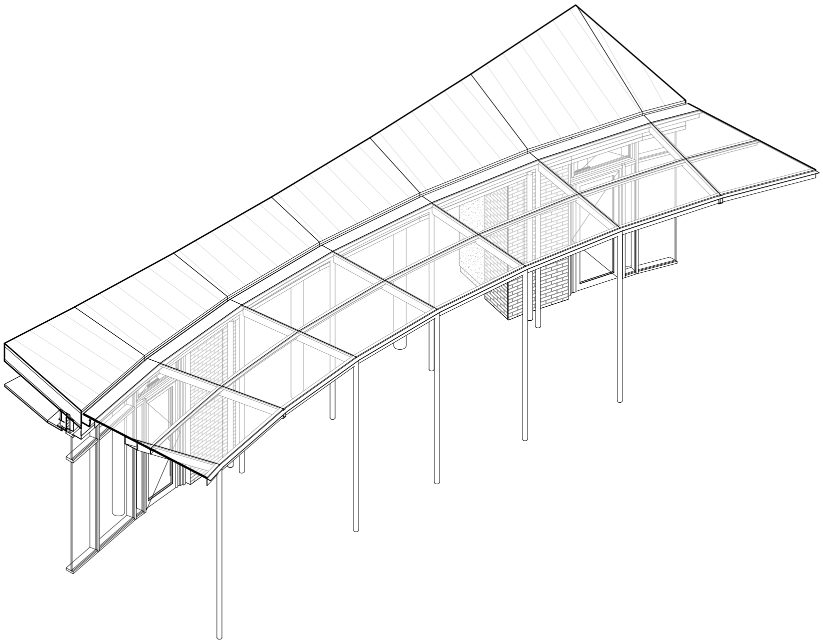
Left A transfer structure enables a column-free sports hall within the two-storey communal component of the radial school.

MARKS BARFIELD

GLAZED CLOISTER

A 2.7m wide, circular glazed canopy (right) forms the inner ring of the school around the courtyard. The steel structure, which is independent from the main school frame, needed to be particularly sleek and elegant in design with unobtrusive connections so as not to overwhelm the integral artwork of 67 images of skies from around the world. These are laminated as digital screenprints into the canopy glazing units, and the structure was specially designed to cater for the tolerance of the glass, according to structural engineer Parmarbrook's Vishal Borhara. The canopy rises from 3.7m high closest to the main building to approximately 3.9m on the inner edge of the ring.

The structural steelwork was devised following close collaboration between steelwork contractor William Haley Engineering and the design team. It was formed using circular hollow section columns spaced approximately 4.07m (inner radius) and 4.57m (outer radius) and with rectangular hollow section rafters. Facetted T-sections span between the rafters to support the canopy. All connections are bolted.



Credits
Client: University of Cambridge
Architect: Marks Barfield Architects
Structural engineer: Parmarbrook
Main contractor: Willmott Dixon Construction Ltd
Steelwork contractor: William Haley Engineering Ltd

Architecture meets engineering

Maria Smith, architect and founding director of transdisciplinary architecture and engineering practice Interrobang, on SOM's Exchange House in the City of London

PORTRAIT: MORLEYVONSTERNBERG

ALAN WILLIAMS

I've had a soft spot for SOM's Exchange House in Broadgate since I studied it at the University of Bath, where architecture and engineering are taught together. It's an excellent example of a truly integrated architecture and engineering team working to create something ingenious and beautiful.

This is a building that's a bridge and a bridge that's a building. It's a fabulous example of an onerous constraint generating something wonderful; here the requirement to build over the railway tracks outside Liverpool Street Station allowed the creation of something unique that might otherwise never have been conceived.

It's one of those difficult sites where you need an engineering-led solution that's also beautiful and considers the city fabric around it, and this might well not have been possible without such a close integration of architecture and engineering. As well as creating brilliant architecture, the building design enables a very large public space that ties into the masterplan for the whole area.

It's great that the design team was able to express the steel structure so strongly, which makes it very clear how the building works. There are four enormous tied arches – one on each of the key facades and two within the building. That the building was nestled in the centre of a masterplan of new buildings meant the planners didn't insist on stone cladding, allowing SOM to achieve a more Chicago aesthetic and express the structure.

The building recently won the American Institute of Architects' 25-Year Award for architectural excellence. It's still worth its salt after 25 years, and that's something to be proud of.

RICHARD WAITE

Left Detail of tied arch at SOM's Exchange House.
Above Overtly expressed steel structure.