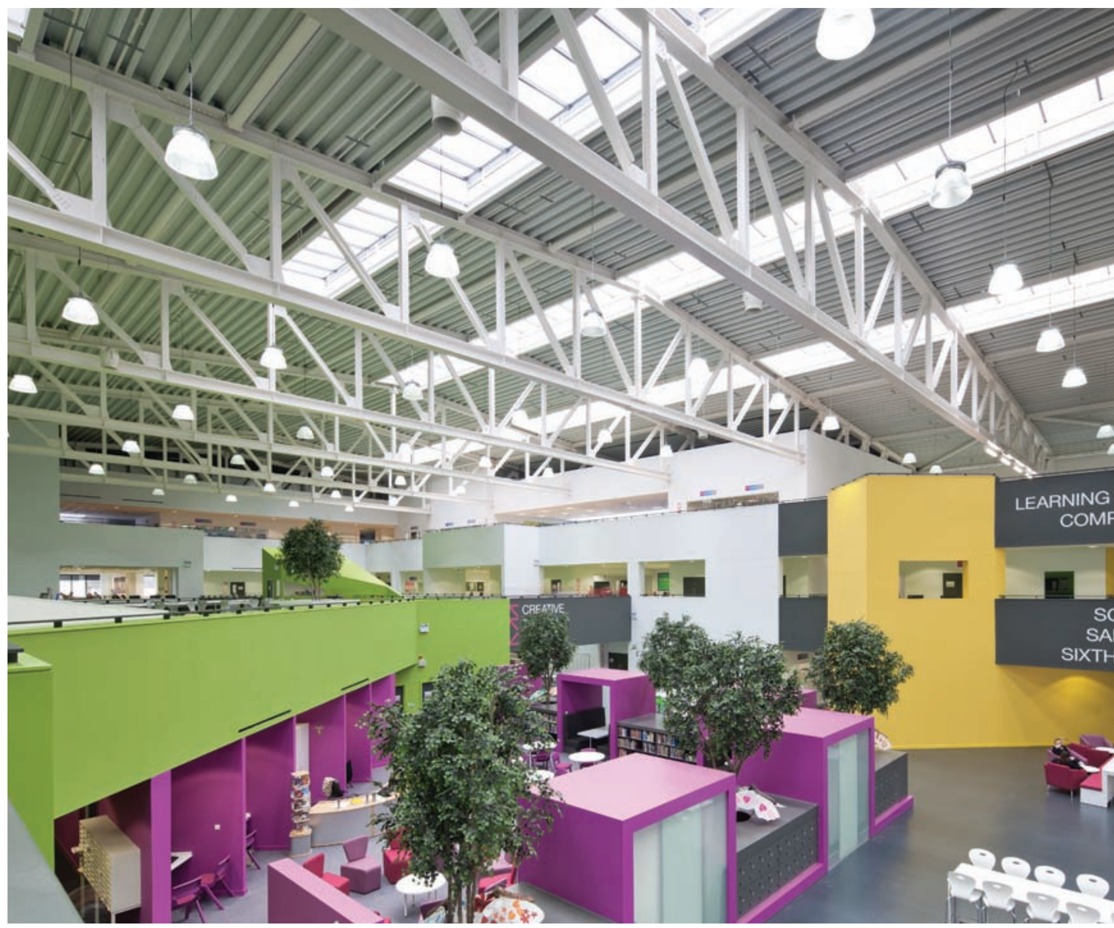
Steel Intelligence



DAVID BARBOUR

In our latest Steel Intelligence supplement, we look at two innovative approaches to tried and tested building types. At St John Bosco Arts College in Liverpool, BDP took future-proofing to an extreme in its school-in-a-shed design, conceived as a huge column-free space for maximum flexibility. Allford Hall Monaghan Morris has produced a new twist on the student housing tower for Urbanest, which gives lucky residents some of the best views around of central London. Inspired by the form of an Eames stool, the tower combines a sandwich of uses with the help of a hybrid structural solution. We also consider the implications of introducing Level 2 BIM and talk to Hanif Kara about choosing the Leadenhall Building as his steel icon.

Pamela Buxton, editor, Steel Intelligence

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Thinking inside the box

St John Bosco Arts College in Liverpool has been built to such a flexible design that it could be turned to a completely different purpose should the need arise. You wouldn't know it, but it's one big steel shed

Words Pamela Buxton **Photographs** David Barbour

With its giant steel frame and column-free interior, BDP's design for St John Bosco Arts College in Liverpool is perhaps the ultimate in flexibility.

Normally when school designers talk of the need for flexibility they are referring to multiple use areas, such as circulation spaces wide enough to incorporate learning areas, or classrooms that can be reconfigured or expanded using movable partition walls.

But at St John Bosco, BDP has fulfilled client Liverpool City Council's desire for a building with an easily removable interior school configuration that could be put to a completely different use if it ever ceased to be needed as a school.

Located in the suburb of Croxteth, the 1100-student Catholic girls' school is part of a programme of four new 'big box'-style schools, conceived following the scrapping of earlier Building Schools for the Future plans.

'The client came to us with the idea of a very simple building, effectively a shed, giving it a longer-term life should the school ever cease to be viable, since it could easily be gutted for different uses,' says BDP architect director Mark Braund. Glulam was considered for the main trusses at an early stage but discounted on cost grounds in favour of steel. Having rejected a dual span option on the grounds of future inflexibility, a single-span portal frame was swiftly identified as the most spatially efficient structural solution. After trying different square and rectangular configurations, the design team settled on a 55m wide by 91m long footprint rising three storeys with roof lights to bring daylight into the heart of the column-free space.

Four permanent staircases in precast concrete are incorporated as part of the perimeter walls, delivered by main frame steelwork contractor James Killelea & Co as part of its steelwork package, which included the concrete floor slabs and lift shafts.

'The challenge was the frame stability during the three conditions of steelwork erection, semi-permanent education use and final shell and core arrangement. We worked hand in hand with Killelea to ensure all conditions were suitably designed and

detailed,' says Danny Sinclair, associate partner at structural engineer The Alan Johnston Partnership.

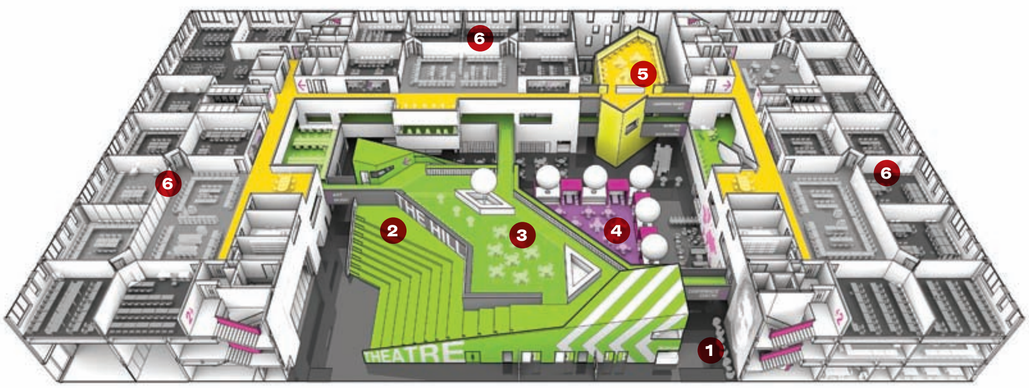
Within the huge $11,100m^2$ structure, a 'landscape' of school accommodation is inserted arranged around 'The Hill', a large multi-functional assembly space. This forms a device to split the ground floor into key areas, including a Learning Resource Centre, informal and formal dining area, and an amphitheatre with a seating terrace. BDP's aim was to create an exciting mix of learning and social environments suitable for different pedagogic approaches. Around the perimeter are two floors of classrooms with 2.7m floor to ceiling heights. Further in, most of the accommodation is open plan with no corridors, increasing the level of visual interest and views across the school.

Crucially, the academic frame –

Left Exterior of St John Bosco Arts College, which delivered 15% more space through the use of its simple big box structural concept.
Above The column-free interior space gives maximum flexibility for configuration of school space and future alternative uses.

Steel Intelligence
St John Bosco Arts College

SECOND FLOOR PERSPECTIVE



1 Entrance
2 The Hill
3 Cafeteria
4 Learning resources centre
5 Salesian pod
6 Perimeter classrooms

an interior structure of columns and precast hollow core floor planks – is fully demountable and separate to the main frame. This cold-rolled steel framing system was delivered by steelwork contractor Hadley Group, who also provided the terrace steps.

'The design of the structure allows the flexibility to remove/dismantle the internal semi-permanent education elements while retaining the external cladding and inner leaf construction,' says Sinclair.

Rooflights and areas of triple height curtain walling make the space feel well lit by daylight, according to the architect.

'It's a really impressive building to be in – a large, highly detailed structure with an industrial nature juxtaposed with the aesthetic of clean sharp lines and a creative mix of open plan and cellular teaching and social spaces,' he said. 'There was a concern that it could look too functional but the structure adds to the tapestry of the building which with the lighting creates a visual datum, with colour and supergraphics knitting it all together into a cohesive whole.'

While there are a few overseas precedents for this kind of approach to school design, BDP found that workplace and retail rather than education spaces were more useful reference points when designing such a flexible building.

Delivered for £18 million, the school has 15% more area than a traditional BB98 compliant school, according to the architect, thanks largely to its simple building format. Costs came in at £11.91/m^2 compared with the £17.50/m^2 BSF funding model. The school has won an RIBA Regional Award.

'It's clearly a very useful building typology that delivers something extraordinary for the budget we had,' says Braund.

He sees it as a 'fantastic' model that suited the client school's desire to engage more directly with the surrounding community.

'It grabs people's attention. The big box concept would not be right everywhere, but for a school with a vision to change the way it interfaces with the community, this approach does the job in a really exciting and engaging way,' he says.

'Fundamentally it's an envelope that contains a function. That's what gives it life.' ●

HOW HUGE TRUSSES MADE WIDE SPANS WORK

Eleven huge trusses create the 55m wide column-free spaces that are so crucial to the future flexibility of the school building. These flat bottomed steel trusses are set on a 7.65m grid with consistent falls on either side of the roof ridge, rising from a depth of 1.7m at either end to 4m in the middle.

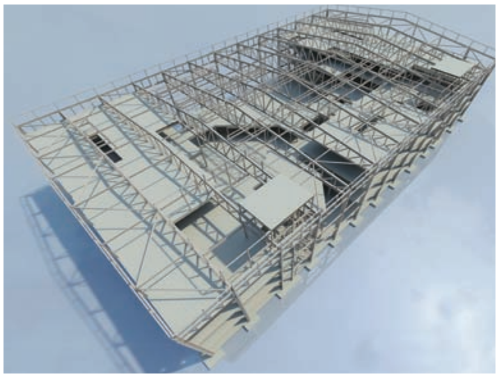
Such huge spans meant each truss was assembled from three sections. These were set out and bolted together on the ground and then hauled into position using a double crane lift, each truss supported by a 686mm deep column.

On top of the trusses is a structural steel roof deck, with a perforated internal face for acoustic damping.

'The main challenge was the logistics involved in building up the main roof trusses on such a restricted site, while at the same time erecting the support steelwork and installing the precast concrete elements,' said Killelea contracts director Bob Allan.

'As the trusses were too big to transport we had to deliver them in pieces and build them up on site just in time for erection with the rest of the steelwork and concrete.'

In total, Killelea's main structure comprised 900 tonnes of steelwork with 3,500 separate components put together with more than 38,000 bolts.



RENDER FROM THE ALAN JOHNSTON PARTNERSHIP REVIT MODEL

Credits
Client Liverpool City Council
Architect and landscape BDP
Structural engineer The Alan Johnston Partnership
M&E engineer A&B Engineering
Steelwork contractors James Killelea & Co (main structural frame); Hadley Group (internal steel framing system and terrace)

Left Roof lights bring light into the heart of the deep plan, with the steel roof trusses clearly visible.

BIM kicks in

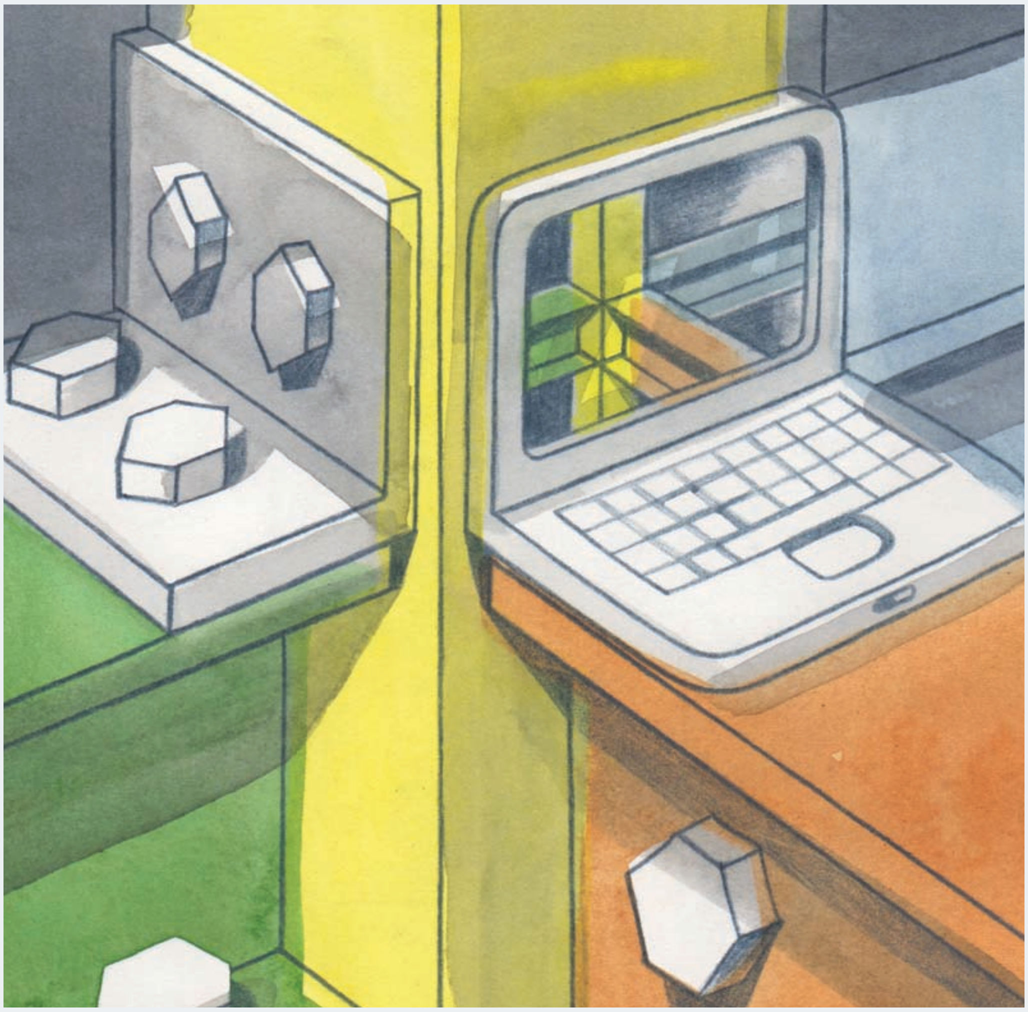
In 2016, 3D BIM will become a requirement for government projects. Steel engineering expert Dr David Moore looks at what that will mean for the design of steel-framed buildings

Words Dr David Moore **Illustration** Toby Morison

In less than a year, all centrally procured government building projects in England will be required to adopt collaborative 3D BIM, followed in April 2017 in Scotland, as part of the Construction 2025 procurement strategy.

The implications of introducing electronic Level 2 BIM are likely to be far more significant for the broader construction team than the steel construction industry itself, which had been using 3D modelling as a preference well before the change was announced in 2011.

Steel's clearly defined nature is well suited to BIM, with its components of columns, beams and decks giving easily identifiable geometries and properties. Few other materials lend themselves quite so easily to that 3D modelling, particularly continuous ones.



Encouraging collaboration

As a result, the steel industry is already well prepared for the wider use of BIM. The process hasn't yet lived up to the promise of its potential, but this move by the government to require the use of collaborative electronic communication could drive positive change in an industry that is not traditionally collaborative in how it works. Crucially, it should encourage an earlier engagement of specialist subcontractors with all the supply chain involved in the programme from an early stage, a rare scenario in today's procurement system, even on central government projects.

Only then can the full benefits of BIM be enjoyed, with each consultant and contractor adding to each others' models to produce a linked, federated building model that can be interrogated from all angles and aspects. In theory this means using it for clash detection, for example potential clashes between structural and M&E systems, so that these can be resolved using the model rather than later on site, saving both time and money.

All too often, however, fabrication of the steel frame has begun before the specialist M&E contractors have been appointed, so at the moment some of the advantages of using integrated BIM to avoid clashes are lost.

But with wider use of BIM imminent, procurement attitudes will hopefully begin to change. To this end, the British Constructional Steelwork Association (BCSA) is actively engaging with the main contractors group UKCG to promote earlier adoption of steelwork in the supply chain.

BCSA is also introducing a BIM compliant certification scheme later this year to show which steelwork contractors are trained in BIM software and processes.

Increased use of BIM from next April will require careful preparation for all those in the design and construction team.

At the start of the project, the client needs to set out as part of the contractual process what it requires from consultants, contractors and subcontractors in terms of electronic information so that there is broad agreement on which file languages, formats and naming systems to use across the supply chain. The BSI's BIM standard PAS 1192-2: 2013 sets out how the process can be applied.

One change and potential cost may be that each of the partners in the project will need a BIM manager who understands the issues, particularly the specialist language and terms which can be hard to get to grips with. They can then talk easily to another BIM manager in the project chain.

For architects, the main advantage is the chance to gain a better understanding of the building design through the co-ordinated model, and the chance to spot clashes between elements at an earlier stage. There is a common misconception that specific BIM software exists, but in fact any software that imports and exports data is BIM software. Most practices already use modelling software and have all they need, as long as they can export it to the main contractor.

Questions of copyright

Increased information sharing has however prompted unresolved issues about copyright and liability in the case of a mistake being passed down the supply chain through the model. The Construction Industry Council's BIM Protocol on the terms of conditions for BIM (2013) includes a clause which would appear to undermine the process by saying that you can't rely on someone else's model in case errors are introduced via changes in software platforms. This would have insurance implications and would suggest that subcontractors would have to carry out their own checks. But this could be resolved by doing a simple test at the onset to check that files aren't corrupted.

When it announced its strategy in 2011, the government was seeking savings of 20-30%. Clients will benefit from no longer needing to produce their own operations manual, since the final output of the BIM process will be a manual for operating and maintaining the resulting building better.

Progress won't happen overnight, but over time, the co-ordinated use of electronic communications should change the way the construction industry operates for the better. The steel industry is ready – it's up to the rest of the construction team to fully embrace BIM too in order to gain the maximum benefit from the process. ●

Dr David Moore is director of engineering at the BCSA

HANDS ON: Architects and engineers on increased use of BIM and its suitability for steel-framed buildings

As an architect and BIM champion at BDP, my experience has been that structural engineers and steelwork contractors are well advanced in terms of BIM development – as a kit of parts, steel fabrication lends itself very well to the principles of BIM.

By setting the 2016 target, the government has significantly accelerated the adoption of BIM Level 2 within the construction industry and we expect private clients also to require Level 2 compliance. This may lead to changes in procurement attitudes with specialists such as steelwork contractors becoming involved earlier on in the design process. One of the significant obstacles to those not yet using BIM will be the investment in additional hardware, software and training, and it will take several months to achieve the same effectiveness with the new ways of working, all at the same time as delivering the actual project on time, efficiently and cost-effectively.

These are both challenging and exciting times but we are on the BIM journey now and there is no turning back.

Alistair Kell, director of information and technology, BDP

It's not really a big change for us as we use BIM anyway on our large transport projects. The bigger challenge at the moment is convincing contractors that they should be engaged to a greater degree; using the BIM data themselves for 4D, 5D and procurement, and we are actively involved in helping contractors with this.

The real focus of BIM Level 2 is on collaboration and if you don't have all the team in place early enough, it can only go so far. Early appointment of critical subcontractors and suppliers is important, and contractors need to recognise this. Fortunately, steelwork contractors do tend to be involved early and model to a high level of information.

For architects, the crucial thing is knowing what level of detail to achieve, and it can be a challenge to ensure that the models in shared use have an appropriate level of detail for everyone and don't end up too rich. People new to BIM (including architects) often think they need to know all the software tools but this is based on modelling to a high level of detail which isn't always necessary, or desirable.

Neil Sharpe, partner at WestonWilliamson + Partners

3D collaboration is a very positive change and feels like a natural progression – other industries such as the automotive and aerospace industry have been doing it since the early 80s. The entire workflow becomes a lot more efficient in BIM and the more you use it, the more benefits you see for the design team and the project as a whole. There have been clear benefits for steelwork in particular because it requires a lot of detailing and interfaces – some hidden, some visible – and a lot of design effort needs to go into avoiding clashes by making sure the building systems will work around it.

The construction industry will need to pick up its skills and adjust its attitudes to enable a more collaborative way of working in terms of both how the building is procured and how information is exchanged. Each party will need to take responsibility for their part. As a work flow, it's a very front-loaded process for the wider design team, which is big change for the whole procurement process of a project.

Babak Tizkar, associate architect/ BIM manager, Wilkinson Eyre

Live, learn; with room to laze

A steel sandwich construction near London's Waterloo has a diverse filling, housing and teaching students at different stages of their education

Words Pamela Buxton

MILLER HARE

ROB PARRISH

Above Visualisation of 199 Westminster Bridge Road, with student residential accommodation above a sixth form college.
Right Sixth form college atrium, showing the steel structure of the third floor transfer deck.

Urbanest's latest student development is a hybrid in more ways than one. Not only does the 20-storey building incorporate teaching and accommodation provision, community workspace and a health centre, it is constructed using a sandwich of framing solutions with steel structure at the upper and lower levels and concrete in the middle.

Designed by Allford Hall Monaghan Morris on a former office site alongside London's Waterloo station, the project will provide accommodation for 1100 higher education students as well as a private sixth form college for 700, some of whom will live on site. The 6,000m^2 college, which occupies the lower four levels, is due to complete this spring while the upper residential rooms will be ready for the autumn term.

'AHMM is doing a lot of city sandwich architecture – buildings thrive on having lots of different uses,' says Vasiles Polydorou, senior architect at AHMM.

The design has to ensure clear separation between the college and higher education provision, with separate entrances and lift access to both sorts of accommodation. HE students will enter into a double-height common room before travelling up to their rooms, and will have the use of a further common room plus terrace on the top floor. College provision is centered around a four-storey, top-lit atrium for assembly and refectory use. There are two rings of classrooms, the inner overlooking the atrium and the outer around the perimeter. A health suite containing a swimming pool and gym shares the basement with the college.

The building form was inspired by Eames' turned Model A stool, designed for the Rockefeller Centre in 1960. In response, floor slabs at the new Urbanest building step in and out to give a turned form emphasised by horizontal ribbons of glazing and bands of rainscreen cladding, which provide reveals of around 500mm to shade the glazing. On the external elevations these are white, but for inner courtyard above the atrium they have more of what Polydorou calls a 'tweed' effect, with a weaving of darker colours at different depths. The concept, he says, was to make each a 'room with a view'.

The hybrid structural solution was driven by height, weight, programming and servicing issues. Since the overall height of the building was fixed to avoid breaching views towards County Hall protected by the London Views Management Framework, the structural frame had to be as efficient as possible to enable the client to accommodate its desired amount of student rooms.

Initial plans for a wholly concrete structure were rethought and a steel frame was used instead on the lower four floors, set out radially from two cores and supported by 62 steel columns. This was in response to both the wider spans required for the college floors, and the need to accommodate services horizontally through the building structure when these vertical risers came down to college level from above. With slab depth crucial, the ability of the steel structure to accommodate this servicing was a major advantage.

Built in just 13 weeks by Bourne Steel, the radial steel lower structure had the additional advantage of speed, being 25% faster to build than a concrete frame. This swift start was particularly advantageous logistically for a site on the busy Westminster Bridge Road.

'Typically, the college floors are a composite steel frame construction with concrete slab on profiled metal decking, while stability is provided by the cores and an additional stair core between the basement and third floor. Most of the steel beams are designed as downstand beams acting compositely with the slab above,' says Mitesh Patel, project director at structural engineer Ramboll.

The most crucial element was the transfer deck that unites the two structural systems, necessitated by the removal of an entire row of concrete columns at this level. According to Polydorou, managing this transition between the steel of the college grid and the concrete structure of the student grid and dealing with the servicing was one of the biggest challenges on the project.

'The third floor was designed as a transfer level to support the reinforced concrete columns which in turn support 15 concrete floors above. Steel allowed the flexibility of using shallower beam sections compared to concrete, and also allowed the integration of M&E services through openings within the beam webs,' says Patel.

Bourne also supplied steel for the uppermost 18th floor and mezzanine housing duplexes, social and study space, used this time because of its lighter weight and ability to accommodate the structural gymnastics required for the sloping roofline to avoid breaching sightlines. This led to an increase in height from 2.4m to 4.5m as the roofline slopes up away from County Hall.

'Steel was important to accommodating the 6º angle as well as being lightweight,' says Polydorou. 'It's quite a dynamic structure.'

Lucky residents will benefit from splendid views of Westminster and across the capital. AHMM has provided five room types ranging from non-suite cluster flats to one-bed flats for college house parents. The faceted perimeter means these room sizes vary again depending on their location within the building. Floor to ceiling heights are 2.3m except for the rooftop duplexes where students will enjoy a 5.4m high living space with a terrace and a mezzanine bedroom. ●

Above The radial steel structure of the sixth form college at the base of the tower.
Below Construction work is progressing on the student development, which will be completed in time for the autumn term.

ROB PARRISH

STEEL ROOF

A steel structure on the 18th floor podium slab provided a lightweight top storey that could accommodate the geometry imposed by height restrictions driven by the protected views. Steelwork contractor Bourne modelled the hot-rolled steel frame using Tekla software. To achieve the right solution, the fabrication process involved a large amount of setting out and a high proportion of low volume batch fabrication.

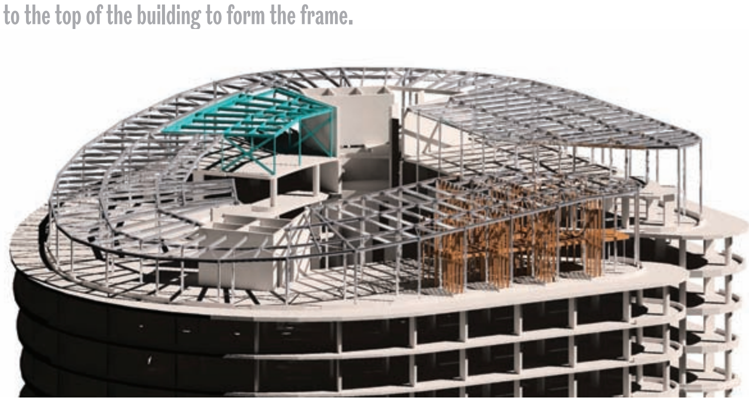
'It was critical that we found a solution that matched what the architect wanted to see and gave the planners what they wanted,' said Bourne's divisional manager Iain Griffiths.

Steel decking forms the roof itself while spans between steel beams provide lateral restraint. The sloping profile of the roof and radial column grid presented extra complexity and resulted in an array of beams splayed in all three principle axes, according to the structural engineer. The splayed perimeter beams support a coping that projects 1m from the edge and also restrains the facade mullions. The perimeter beams were designed for torsional connections at the ends and also to resist the loads induced by abseilers during maintenance.

'The roof is stabilised by a combination of the main concrete cores, vertical steel bracing elements along the wing tips and plan bracing within it to provide diaphragm action. The eastern wing of the roof consists of an inaccessible sedum roof and PV panels,' says Mitesh Patel, project director at structural engineer Ramboll.

The roof structure was also a major logistical challenge, with 800 pieces of steel craned to the top of the building to form the frame.

BOURNE CONSTRUCTION ENGINEERING (2)



ROOF: RAMBOLL

THIRD FLOOR TRANSFER DECK

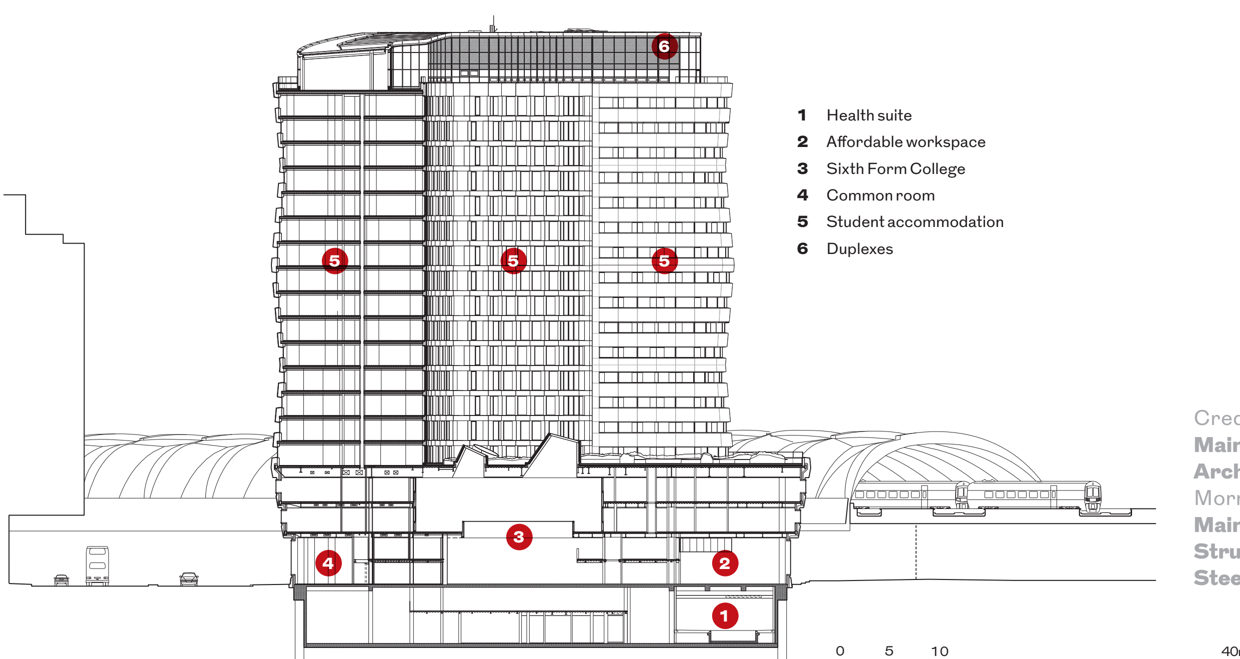
The third floor transfer deck is formed by 44 fabricated plate girders ranging from 1000mm to 1250mm deep and weighing up to 19 tonnes each. These transfer the load from the concrete upper structure to the steel columns below.

The longest single member spans 19.5m across the base of the atrium. The heaviest section – at 21 tonnes – is made of 700mm wide by 85mm thick flange plates with an 85mm thick web plate.

All transfer beams here are at the same level as the top of the slab and designed as non-composite, says Mitesh Patel, project director at structural engineer Ramboll: 'Typically, the transfer beams cantilever out past the perimeter steel column below, picking up the full length of the concrete column above and supporting the cladding line on the building perimeter,' he says.

Bourne Steel divisional manager Iain Griffiths reveals that the fabrication process was further complicated by the need to provide beam stiffening to the service penetration holes and the notched tapered end detail.

Cross section



1 Health suite
2 Affordable workspace
3 Sixth Form College
4 Common room
5 Student accommodation
6 Duplexes

Credits
Main client Urbanest
Architect Allford Hall Monaghan Morris
Main contractor Balfour Beatty
Structural engineer Ramboll
Steelwork contractor Bourne Steel

Beauty, purity and muscularity

Hanif Kara reveals why he is so seduced by RSHP's Leadenhall Building

RICHARD BRYANT. COURTESY OF BRITISH LAND/OXFORD PROPERTIES

Towers evoke a response in society that mixes optimism, progress, pride, bemusement, bafflement and a touch of awe like no other typology. As a structural engineer, I will surprise no-one by picking one of my two favourite 'hip not bling' towers – Leadenhall Building and St Mary's Axe – as my icon. My choice is Leadenhall, both for the purity of its expression of steel and a profile that avoids crowding the sky – while beautifully exposing the construction method.

It delivers a lot (1 million ft^2) with an inviting public realm and technical indexes beyond the conventional, but it's the muscular steelwork I most adore, delivering a structural order with a megaframe where each floor steps 750mm. This took precision of design, fabrication and planning to another level.

My early days on oil rigs give me a good measure of the gigantic forces the engineer has dealt with, in particular the design of the connections which will have exhausted the best brains at Arup, which were continually directed by the surgical scalpel of Graham Stirk's relentless talent of working from the detail out. Contractor Laing O'Rourke and steelwork contractor Severfield both clearly and passionately delivered.

Engineers talk about the additional structural optimisation that would have been possible if the primary bracing had faced the opposite way, but to me that is minor conversation. Guided throughout by British Land construction director Richard Elliot, the final result is almost an industrial product, a compelling masterpiece that will be a springboard for us all in many ways. ●

PAUL RAFTERY

Left Eastern profile of The Leadenhall Building.
Above 'Muscular' steelwork in the view from Level 45.