STEEL FOCUS: NEO BANKSIDE

Capturing Bankside's X factor

The diagonal steel bracing on Rogers Stirk Harbour & Partners' Neo Bankside is a core part of its identity — and because of its prominence, it had to look exactly right

Text by Pamela Buxton **Photographs by** Edmund Sumner

When Rogers Stirk Harbour & Partners suggested running steel bracing diagonally across the facade of apartments in the upmarket Neo Bankside development, the client was unsurprisingly a little cautious. Yet with the vast majority of the first phase sold, the wind-bracing structure has turned out to be a selling point rather than a problem.

"It provides a strong identity to the building and architecturally embraces the Rogers idea of showing structure on the outside," says Nick Gray, development executive of Native Land, which is developing Neo Bankside in joint venture with Grosvenor.

"Typically people look for apartments where you can see the structure expressed," he says, adding that apartments with views of the bracing nodes are proving particularly popular.

The development, on Holland Street close to Tate Modern on London's South Bank, consists of four diagrid pavilions ranging from 12-24 storeys and containing a total of 217 units. These are arranged to allow pedestrian routes through the site towards the river, with the lowest block closest to the modestly scaled nearby almshouses towards Southwark Street. The bulk of the massing is closer to the Tate and the site of its Herzog & de Meuron-designed extension. Each pavilion has a similar plan, resembling a stretched hexagon.

Red steel beams frame the inside of the lift hallways.

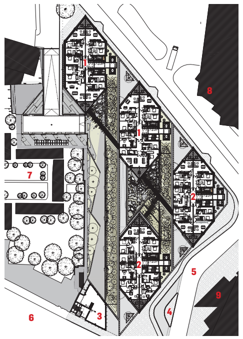
It was important that the buildings had a simple presence, says RSHP senior director Graham Stirk, who led the design team. "The notion of the diagrid was something that could create a sense of unity throughout the development. We need to create something that's quite structured and ordered to let the asymmetric Herzog & de Meuron building do its thing."

Originally, the steel was to be an expressed perimeter diagrid within the plane of the cladding. But it was decided to move the bracing to the outside of the building — as an exoskeleton — to allow it to operate purely as a bracing system. In this way, it is isolated from any gravity-carrying load, with the exception of the steel winter gardens which it supports at the two "prows" of each building. Externalising the bracing also cut costs significantly.

The final structure has led to fewer shear walls within the plan, enabling the developer to respond better to market demand and future needs. "Creating open floors without shear walls was very important," says Stirk. "We always believe that things change."

Legibility of structure was also vital, both from the outside and the inside, where the expression of the exterior is clearly visible in the diagonal bracing. Choice of colour was important in enabling people to "read" the building — the primary structure is in an iridescent grey, while secondary structure such as the winter garden and the subsidiary structure of the lift is red. As the building is occupied, the diagrid's strong visual structure gives an overriding framework that is robust enough to take an array of curtains and blinds.

Phase one is complete. Of the 91 apartments, only seven, plus the penthouses, are yet to be sold. The remaining two buildings are on site and are due to complete in spring 2012. A five-floor office will follow on Southwark Street by next autumn. Native Land hopes to realise total residential sales worth £400 million.



Level 1 plan

1 Phase 1
2 Phase 2
3 New office building
4 Drop off
5 Sumner Street
6 Southwark Street
7 Almshouses
8 Herzog & de Meuron Tate Modern extension
9 Bankside 1

PROJECT TEAM
Client Native Land/Grosvenor
Development manager Native Land
Architect RSHP
Structural engineer Waterman Structures
Contractor Carillion Construction
CDM consultant Capita Symonds
Contractor's architect John Robertson Architects
Steelwork contractor Watson Steel Structures

Steel bracing supports the winter gardens at the prows of each building.

STEEL CROSS-BRACING

Unusually, the cross-bracing is in both compression and tension. The bracing consists of 400 x 200mm oval hollow sections stretching up to 13.3m between the nodes. Nodes occur at reinforced column locations at every three floors. Vertical beams on each side of the stair core transfer the load to the nodal floor of the bracing.

"Because we wanted to ensure the system purely developed axial loads, we wanted a high degree of symmetry and we wanted to develop a single nodal arrangement in all locations," says Steve Fuller, director at structural engineer Waterman.

This family of node connectors can accommodate members joining in a pure horizontal plane or at different planar angles, as required according to their position on the building. The solution was a four-pinned nodal propeller around a central, circular hollow section spindle 350mm in diameter. This spindle is attached to a vertical steel section 4.5m in length.

Both the spindle and the column had been preinstalled into the concrete main frame. The steel bracing sections taper and are attached to the spindle shaft with a Macalloy fork. The diagonal bracing is linked at each floor by a support tie that goes through the cladding into the concrete frame. One of the biggest challenges was co-ordinating the sequence of spindles, bracing, glazing and tie-backs.

"Normally the steel frame connects to itself. But on this, the bracing connects into the nodes and the concrete. So you're relying on every node as a separate in-cast item. They have to be spot-on or it won't line up," says Frances Walker, contracts manager of Watson Steel.

At the two "prows" at opposite sides of each block, the apex of the node supports the single-glazed winter gardens on a system of props and hangers. The winter gardens have sliding screens and act as buffer zones between the apartment and the exterior. This steel structure is suspended from the bracing's nodal structure towards the top of each tower at the lower of the two penthouse levels. At the base, the building is anchored on sturdy tie-downs into a precast concrete plinth.

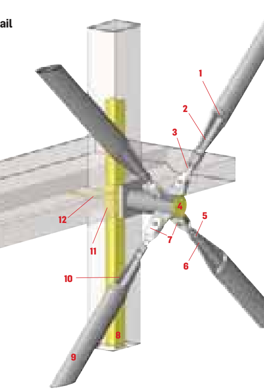
The bracing system presented engineer Waterman with considerable movement and thermal issues. Movement was resolved by a close tolerance specification for the pins, which were match-fitted to ensure a close fit. Thermal stresses are locked in to ensure that the bracing doesn't expand and contract at the nodal positions.

Colour was a factor. The steel is an iridescent, gunmetal grey — any darker would have affected the thermal characteristics. Four layers were applied, the last in-situ with a roller.

Design of the bracing system was refined in close collaboration with steelwork contractors.

"We had very good and interesting meetings with Watson Steel in Bolton trying to improve the design of the nodes and bracing. Watson's were excellent and helped us to reduce costs," says RSHP associate Simon Davis.

Node detail



1 Brace end plate
2 Threaded receiver socket
3 Fork end lock cover
4 Spindle
5 Threaded torsion bars
6 Brace end lock cover
7 Fork and pin
8 Embedded steel stanchion
9 Oval hollow section brace
10 Tapered stiffener
11 Cheek plate to embedded section
12 Threaded anchor bars

Units with views of the steel crossbracing are proving popular.

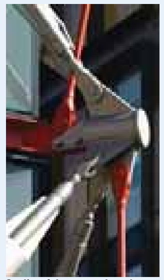
WELDED JUNCTIONS

The close proximity of the bracing to the apartments meant that great attention was paid to the quality of the welds. Steelwork contractor Watson Steel Structures and RSHP worked closely together on this, with Watson creating a mock-up at the site and experimenting to get the effect the architect wanted.

"Welded junctions in steelwork show the construc-tion of the elements, so the key for us is not to eliminate them visually but ensure their sizing is appropriate to the steel sections being joined, and that their quality and uniformity is as good as possible," says RSHP's Simon Davis.

"This required a close understanding of the junctions, load paths of the steel elements, and Watson's fabrication methods. Certain key, or more delicate, junctions were rearranged as an outcome of this collaborative process and had prepped (chamfered ended) connections to control the visual impact of the welds."

"To have 90% of the steel on show, up close and personal because of the windows, is quite unusual," says Watson Steel Structures contracts manager Frances Walker. "We did a lot of cosmetic work with a lot of cover plates... it had to look beautiful."



Quality of the exposed steel junctions was a priority.

In particular, they came up with a way of concealing the welds inside the head of the spindle and were also able to reduce them on the forks from 20mm to 4mm.

LIFT CORES

These are expressed separately to the main building on the east of each pavilion. A stand-alone steel tower would have required a great deal of structure to withstand the wind forces.

Instead, the architect was able to use a much lighter steel structure by anchoring it back to the main frame on every floor with projecting steel beams that take the wind load. The lift tower's deadload is taken on four stanchions. The result is a lightweight, delicate and highly glazed pair of scenic lifts with great views of the Tate, the river and beyond.

A lift core with St Paul's Cathedral in the background.

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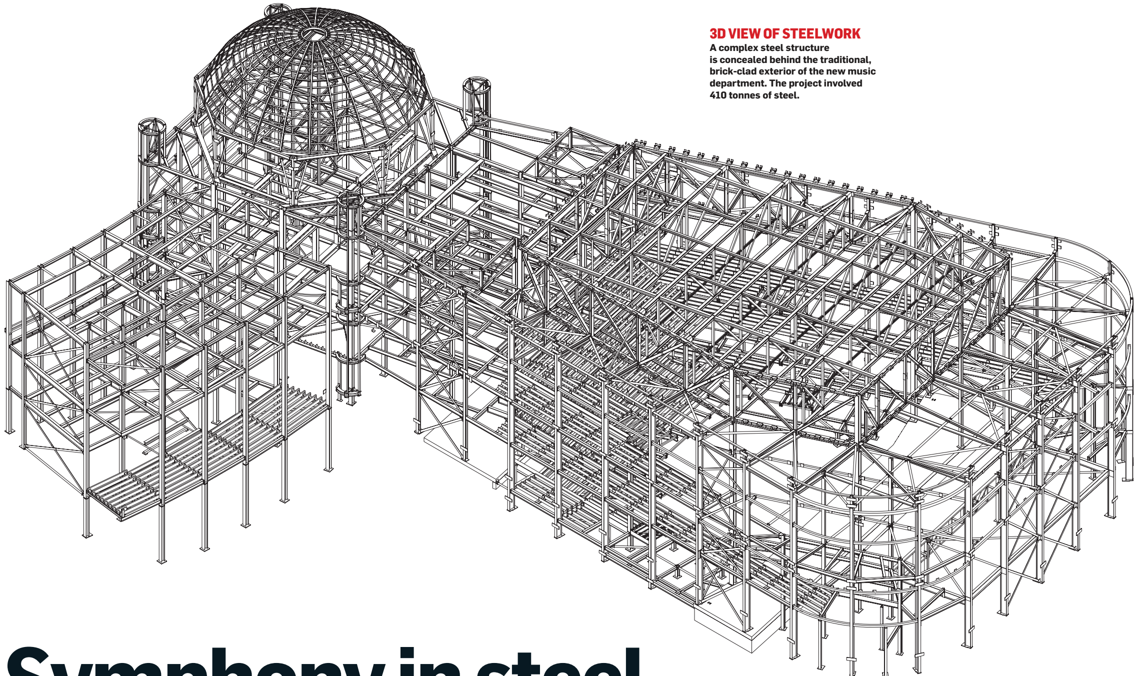


3D VIEW OF STEELWORK
A complex steel structure is concealed behind the traditional, brick-clad exterior of the new music department. The project involved 410 tonnes of steel.

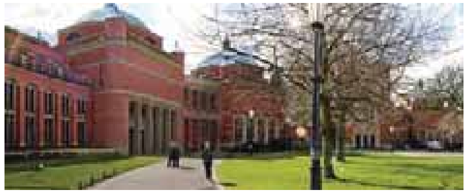
Symphony in steel

When designing a new music department for Birmingham University, Glenn Howells Architects faced the double challenge of creating a new brick-clad building that would live in harmony with its Edwardian neighbours, and introducing a complex steel-framed dome to the design

Text by Pamela Buxton

At the start of the last century, Birmingham University embarked on the construction of a crescent of grand buildings designed by Edward Ingress Bell and Aston Webb — architect of the Admiralty Arch — and financed with the help of philanthropist Andrew Carnegie. Unfortunately, the money ran out before the final building was built. Now, more than 100 years later, the missing link in the redbrick crescent is under construction.

The Bramall Music Building, designed by Glenn Howells Architects, provides a home for the department of music, with a 450-seat auditorium, a domed rehearsal room and various studios, offices and teaching rooms. The challenge was how to fit in with the surrounding grade II* listed buildings, while meeting contemporary standards of accommodation and acoustics.



Visualisation showing the Bramall Music Building completing the crescent terrace.

Rather than making a contemporary statement, Glenn Howells opted to continue the series of ceremonial pavilions and linking blocks without seeking to exactly replicate the neighbouring buildings. The new intervention has a carafe-shaped plan, in contrast with the T-shaped plans of the others, to better accommodate the auditorium at the rear.

"We had to exercise a bit of humility to try to sensitively interpret what's there," says project architect Will Schofield.

The building is steel framed to create the open plan area for the auditorium and the music rehearsal room's domed roof. Externally, it is clad in brick to complement the rest of the crescent. Masonry was initially considered for the dome, to replicate the neighbouring dome in the crescent, but this was discounted as it would be too heavy while timber was considered uneconomical.

At the front of the building is a double-height entrance foyer, made possible by 15m-long, 3.2m-deep Vierendeel trusses, which incorporate the second floor within their depth. This space is overlooked by a circular balcony. Above is storage at second-floor level and at third is the 15sq m double-height rehearsal room with the domed roof, which is capable of accommodating orchestras. The geometry of this space was complex.

"The challenge was to understand how you get from a square to an octagon to a dome and reconcile all that. We learned from looking at the other buildings," says Schofield.

Another issue was how to avoid sound colliding in one spot within the rehearsal space, which entailed breaking up the surface of the underside of the dome with timber louvres suspended from the steel structure, which act as quadratic residue diffusers. The exterior is being covered with rolled leadwork.

The auditorium has a reverse fan-shape and has to be flexible enough to cope with anything from unamplified lutes to fully amplified orchestras and electro-acoustic performances.

The Bramall Music Building is due to complete on schedule in March 2012. The £13 million project involved a total of 410 tonnes of steel.

PROJECT TEAM
Client University of Birmingham
Architect Glenn Howell Architects
Structural engineer URS Scott Wilson
Contractor BAM Construction
Steelwork contractor Robinson Steel Structures

MAIN ILLUSTRATION: ROBINSON STEEL STRUCTURES

The steel dome and auditorium under construction, with the crescent's original domed buildings in the background.

PHOTOS: PAUL MILLER

The dome contains more than 500 individual steel elements.

STEEL DOME

The 15m-diameter dome is divided into 24 segments, supported on eight steel columns. These are inter-spersed with eight arched windows that were brought to the site as precast units. In total, the dome contains more than 500 individual steel elements.

The construction of the dome was the most complex part of the project, according to project manager Scott Marsh of contractor BAM. First BAM considered installing the external leadwork and internal timber cladding at ground level and then lifting it up into place in either four or six segments. But this would have been too heavy to support.

Instead, Robinson, the steelwork contractor, built a 10-tonne temporary steel tower to support the ribs of the dome as they were installed. Half of these were pre-assembled — each segment consists of two curved radial members linked by bracing. These were installed in an alternating sequence, with the remaining, interspersing segments assembled in situ to complete the dome's ribs.

The ribs were then tied together with a compression ring at the apex. Only when the very last piece of steelwork had been bolted and tightened could the support tower be removed.

Robinson had never seen such a complex structure in terms of geometry and setting out lines.

"It was a very challenging job all round," says Robinson's contracts manager Richard Fry. "It wasn't just the complexity of the dome's construction, but the restricted access and the tight programme as well, which meant we had to have just-in-time delivery. We pre-assembled parts of the dome to give us more time on site to get the steelwork up."

Steelwork is now complete and work is progressing on the complex timber-louvred ceiling.

AUDITORIUM STRUCTURE

The 450-seat auditorium sits on a concrete basement level containing studios, plant room and storage.

The roof steelwork is a series of eight 4.2m-deep trusses that span the auditorium. Within their span is a maintenance level of a single-spanning tension wire grid that can be walked on. The trusses also support the 300mm-thick concrete roof.

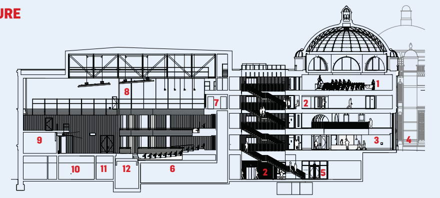
The trusses are picked up by four beams around the perimeter of the auditorium, supported on six columns.

Balcony seating at first and second-floor level and a control room are cantilevered off 500mm-deep beams in the main steel structure, supported by one internal column at the rear of the auditorium. Two more columns support the wings.

Two steel seating towers at either side of the stage can be moved to different positions on frictionless stainless-steel castors.

The construction team had to contend with limited site access after the partial collapse of a nearby bridge, which meant that the eight main trusses had to be made in two parts and then spliced together on site. Four massive trusses beneath the dome at second to third floor level also had to be spliced on the ground and then lifted into place.

Another difficulty was installing precast four-storey concrete walls that had to be threaded through the steelwork structure and the temporary supports and manoeuvred into place.



Section

1 Rehearsal room
2 Circulation
3 Foyer
4 Chancellor's court
5 Lower ground floor entrance
6 Plant room
7 Control room
8 Auditorium
9 Backstage
10 Electro-acoustic studio
11 Store
12 Stage lift

Rendering of the auditorium interior, which has been designed for a wide range of acoustic needs.

TATA STEEL
BCSA
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The British Constructional Steelwork Association
and Tata Steel

A guide to fire protection for architects

Even where specialist advice is available, a working knowledge of regulations and performance is crucial when you want to make the right design decisions

Text by Pamela Buxton

When it comes to fire performance technology architects should not leave it all up to the fire engineer. Knowing the pros and cons of various construction materials and how they can affect the design is essential.

Detailed, chunky timber structures, for instance, can perform well by slowly forming a char layer. However, slender timber is generally protected by fire-rated board and great care needs to be taken on the detailing of this and on maintenance over its lifetime. Meanwhile, the fire performance of concrete — with its variety of mixes and formulations — is hard to define.

Steel's great advantages are that it is non-combustible and that there is a tremendous amount of research into how it performs in a fire. "The good thing about steel is that we know a lot about it and how it behaves," says Florian Block, senior structural fire engineer at Buro Happold. "This means we can be confident in the way it performs."

Building Regulations

The Building Regulations for England and Wales set out the legal obligations for building designers. These functional requirements outline what must be done, but do not address how to achieve this. The government publishes a set of "approved documents" to explain how these requirements can be met. For fire, the relevant publication is Approved Document B (2006).

An example of a functional requirement that covers structural stability in a fire is that "the building shall be designed and constructed so that, in the event of a fire, its stability will be maintained for a reasonable period".

The regulations do not specify what a "reasonable period" is, but Approved Document B contains guidance on this. Structural fire resistance periods vary between 30, 60 and 90 minutes, according to the occupancy and the height of the building, and requirements change at 5, 18 and 30 metres. For example, an office that is less than 18m tall must maintain structural stability for 60 minutes during a fire. This can be reduced by 30 minutes if a sprinkler system is installed.

British Standard 9999: the Code of Practice for Fire Safety in the Design, Management and Use of Buildings, is an alternative to Approved Document B. It seeks to allow the development of solutions based on an understanding of the causes of risk to life and how these can be mitigated.

It classifies buildings according to a risk profile based on occupancy, fire growth rate, ventilation conditions and building height. It also introduces a new height category for buildings taller than 60m and generally allows more attractive trade-offs for automatic sprinklers installation and automatic fire detection than the approved document does.

The more unusual the structure, the more useful expert fire risk analysis can be

When to call an expert

This depends on the complexity of the building and the form of construction — the more unusual the structure, the more useful expert fire risk analysis can be in achieving an appropriate level of fire-protection. Where prescriptive guidance may be overly onerous (for example composite steel-framed buildings) or difficult to apply directly, fire engineering can be used to reduce the amount of applied fire protection required.

"With a simple building that has a standard structure, it might well be that an architect in conjunction with a structural engineer and specialist manufacturers might develop an appropriate strategy," says Alan Wilson, senior engineer at Arup Fire. "But when dealing with complex designs, you're more likely to require expert advice."

A basic understanding of fire regulations can help architects decide how much specialist advice they require. Ideally, fire experts should be involved near the start of the project. Wilson says that this typically results in greater design freedom and ultimately a more cost-effective solution, despite the cost of having consultants involved from the onset.

Fire protection materials

To meet requirements for structural stability in the Building Regulations, a multi-storey, steel-framed structure will usually require fire protection.

New products and increased competition mean that the cost of fire protection has come down a lot over the past 20 years. The past decade has seen a huge swing towards the use of thin film intumescent coatings in new buildings. Once a niche product, these accounted for more than 70% of the market in 2010, according to the Construction Markets survey carried out each year on behalf of the steel construction sector. This was followed by board (25%) with a relatively small percentage of spray and other niche products.

Most intumescent coatings are applied on site, although off-site application has increased in popularity in recent years and now accounts for about a third of total use. Intumescent coatings are paint-like materials that expand when heated to form a char with excellent insulating properties. They can be water based, which is mostly used on site, or solvent based, which dominates the off-site market.

If applied on site, these coatings can be used to create decorative finishes — although this may cost more. Aesthetic finishes are also possible when applying a coating off site, however this is more problematic because of the difficulty of repairing any damage on site to the same standard.

Off-site application of intumescent coatings can be more expensive in terms of up-front costs than on-site alternatives, but can have benefits where site access is difficult or restricted and may save costs in the long run.

Boards are available in two types: heavy duty boards, which take decorative finishes for aesthetic use; and lighter, cheaper boards for situations in which aesthetics are not important.

Sprays are lightweight products that are easily and cheaply applied, but are not decorative. Their use has declined in recent years, but they are still used — particularly in large buildings that require high periods of fire resistance.

Guidance

The Association for Specialist Fire Protection offers extensive guidance on specifying fire protection systems. This includes the publication Ensuring Best Practice for Passive Fire Protection in Buildings, which describes itself as "guidance intended to offer architects, designers, constructors, building occupiers and others, effective and feasible recommendations and selection criteria for the use of passive fire protection systems in buildings".

FOR MORE INFORMATION
www.asfp.org.uk

CASE STUDY
PROJECT GREEN, NOTTINGHAM

Fire engineer Arup
Architect Maber Associates

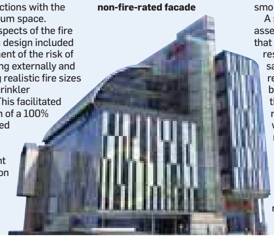
In this office building, which is still under construction, Arup was able to reduce the amount of fire protection on the outside of the building from what would have been required if it had followed prescriptive guidance. As a result, it was able to install far more glazing.

The building is greater than 30m in height. It is served by three staircases and incorporates a central atrium void that connects the ground level to all upper areas of the building. An important design aspiration was to include large areas of glazing on the external facade and maintain open connections with the internal atrium space.

Crucial aspects of the fire engineering design included an assessment of the risk of fire spreading externally and determining realistic fire sizes based on sprinkler activation. This facilitated the adoption of a 100% non-fire-rated facade. An alternative arrangement for ventilation of fire-fighting shafts at basement level removed the need for dedicated smoke shafts.

A structural fire engineering assessment demonstrated that 60 minutes of fire resistance was sufficient to satisfy the functional requirements of the building, compared with the prescriptive recommendations, which would have required 120 minutes of resistance.

Use of a mechanically assisted ventilation system for the fire-fighting lobbies on the levels above ground resulted in reduced shaft sizes.



Sprinkler activation contributed to use of a non-fire-rated facade

Site image of the ME Hotel atrium steelwork showing protected members in white and the unprotected members in grey above.

CASE STUDY
ME LONDON HOTEL, ALDWYCH, LONDON

Fire engineer
Buro Happold
Architect
Foster & Partners

This hotel and residential refurbishment for Meliá Hotels International includes a 10-storey steel structure, the upper eight storeys of which form an atrium with a triangular plan.

Buro Happold was able to reduce the amount of fire protection without compromising the robustness and safety of the building by using a combination of tools: first, an analytical model that described the heat transfer from a fire at the atrium base to the steelwork; second, a numerical model of the atrium structure to calculate the response of the structure during a fire.

This process allowed the engineer to identify which steel members would need fire protection and how much would be required. The result was that all structural members below the base of the atrium required fire protection to an 120-minute standard dropping to 60 minutes for all members up to one level above the base of the atrium. From there to the roof level, only the three corner columns required 60 minutes fire protection.

Steelwork requiring protection is coated with an intumescent paint, which can be applied offsite to make site work easier.

Above: Interior of the ME Hotel atrium, which is located in the building's former courtyard.

Left: Buro Happold used analytical and numerical models to calculate the distribution of steel temperatures that would happen during a localised fire at the base of the atrium.

What architects should know about fire protection of steel structures

Florian Block, senior structural fire engineer at Buro Happold offers these guidelines:

■ Steel structures often behave better in fire than suggested by standard fire tests, because of the development of alternative load paths. On the other hand, complex and unusual steel structures might behave worse than standard fire tests suggest, owing to thermal expansion of the surrounding materials. These factors can be assessed by structural fire engineers, and this can deliver significant safety and aesthetic benefits and cost savings if considered early.

■ If specifying intumescent coating as fire protection, architects need to be aware that intumescent paint expands to many times its thickness when heated up. Since it only works properly if it is able to do so, architects need to leave a gap around the structure, which is often overlooked. The size of the gap depends on the fire resistance period and the type of intumescent coating used. The Association for Specialist Fire Protection recommends a gap of 50 times the initial paint thickness, which would normally lead to gaps of 25-75mm unless specified differently by the intumescent paint manufacturer.

■ In cases where a compartment wall is built on the underside of a steel beam, the wall should continue past the beams to the underside of the floor slab, unless the beam is protected to at least the same standard as the compartment wall using fire protection other than intumescent paint.

■ Guidance documents such as Approved Document B or BS9999 suggest roof structures do not require fire protection. While this might be true for the top storey of multi-storey buildings, it is not always true for complex roof structures covering larger assembly buildings such as exhibition halls, stadiums and arenas. In these buildings, the fire protection requirements of the roof structure need to be carefully assessed by a structural fire engineer.

Intumescent coating being applied offsite in the factory

CASE STUDY
40 SPRINGARDENS, MANCHESTER

Fire engineer Arup
Architect Aedas

40 Springardens is a nine-storey, steel-framed office building, which includes a central atrium and two levels of basement parking. It is close to other buildings and is protected by sprinklers.

The structural fire resistance requirement in Approved Document B was 120 minutes. However, time equivalence analysis demonstrated that 60 minutes was sufficient to ensure that the structure would retain its stability in the event of a fire.

Smoke control provisions in the atrium were installed after an engineering assessment defined an appropriate amount of ventilation, and allowed the use of toughened glazing to enclose the atrium instead of fire-rated glazing.

In addition, an assessment of the potential for fire spreading externally eliminated the need for fire-rated construction for the external facade.

Prescriptive code recommendations would have required two fire-fighting shafts in the building. A single fire-fighting shaft was justified on the basis that coverage to all parts of the floor plate could be achieved within 60m from the dry riser in a single fire-fighting shaft. By providing a single shaft, the other stair core in the building did not require additional space for lobby ventilation or openable vents to the stairs. This reduced the area of the stair enclosure.

The smoke shaft size was reduced from 3sq m to 0.6sq m using a mechanical smoke shaft system designed on the basis of a clear layer smoke management system. This solution provided increased lettable floor area and a performance in excess of the guidance documents.

An engineering assessment judged toughened glazing would provide adequate fire protection in the atrium.

40 Springardens is a redevelopment of Amethyst House in Manchester's city centre.