STEEL SPOTLIGHT: Structural Steel Design Awards 2017

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The Leadenhall leads th

With its support system for all to admire on the outside, this wedge-shaped skyscraper epitomises honest, legible architecture and structural engineering at its finest

RUBY KITCHING

The Leadenhall Building is a 224 m tall office block in the City of London, which has been designed with a sloping southern elevation to ensure protected views of St Paul's Cathedral and the Palace of Westminster are preserved.

A perimeter braced steel 'megaframe' is the main structural system and means it does not need a central core for stability. The megaframe is made up of a diagrid with extra columns added where necessary. With panoramic lifts located on the north elevation, office floorplates are vast open spaces, the largest of which measures 43 m x 48 m. With spans up to 16 m, there are only up to six internal columns per floor.

The building's façade consists of a triple-layer glass 'skin' where the outer layer of glass is separated from an inner layer of double-glazing by an externally ventilated cavity containing blinds that respond to the sun's movement. The megaframe also occupies this space.

"The fact that the main structure is outside the cladding is important to the architecture," explains Arup associate director Damian Eley. "It's an idealistic approach that is difficult to realise because of all the thermal issues and complex cladding interfaces. But it creates better internal spaces (fewer columns) and is visually powerful on the outside because you see the steel columns and braces properly, not hidden behind cladding or regularly interrupted by floorplates."

The team worked collaboratively to optimise the megaframe design and node details (where the members intersect) to ensure installation and connection would be standardised and simple.

"The greatest structural challenge was to come up with a complete set of connection details for the megaframe, which resolved the many different geometrical relationships in a consistent and elegant way," Mr Eley recalls. "This required a really close multi-disciplinary effort between engineer, architect and steelwork contractor, working with a common digital model."

The bare legs of the building are shown off to maximum effect below level five as the floors and glazing are stripped away to create a public plaza at street level. Within this volume, the few occupied floors are suspended via hangers. Since the megaframe is unrestrained over this height of 28 m, the megaframe members have to be strengthened using stiffening plates to increase their buckling resistance. This was carried out with great sensitivity to maintain the proportions of these members and their bold aesthetic.

Main contractor Laing O'Rourke pushed for as much of the steel structure to be pre-fabricated as possible. Some 80 per cent of the building was constructed off-site, reducing waste and time on site and improving quality and safety. Precast concrete was also used instead of in-situ above level five.

"The lightweight precast composite floor system was a significant innovation that helped the process," Mr Eley says. "No topping was required, so it was clean and the floors were fast to construct. The role normally provided by shear studs was achieved through a ductile shear tab detail, pre-welded to the beams, so site welding of studs was also eliminated."

INTRODUCTION

The objective of the Structural Steel Design Awards (SSDA) is to recognise the high standard of structural and architectural design attainable in the use of steel and its potential in terms of efficiency, cost-effectiveness, aesthetics and innovation.

Seventeen projects made the shortlist in this, the 49th year of the SSDA. Judges presented five awards, six commendations and six merits at a gala ceremony held in London on 4 October 2017. The Leadenhall Building was also awarded the first ever Project of the Year accolade.

The judging panel included: chairman David Lazenby, representing the Institution of Civil Engineers; Richard Barrett and Joe Locke, representing the steelwork contracting industry; Professor Roger Plank, representing the Institution of Structural Engineers; and Christopher Nash, Bill Taylor and Oliver Tyler, representing the Royal Institute of British Architects.

©Thomas Graham/Arup

Analysis of the structure at design stage revealed that it would move northwards due to its weight during construction. Instead of adjusting the structure's geometry to account for this movement from the start, the building was erected straight, but was closely monitored for movement. "We decided to counter the significant sideways movements – more than 200 mm – by going back later and shortening the megaframe braces, rather than trying to preset the frame at the outset," Mr Eley adds. This allowed the megaframe nodes to be fabricated with a simple orthogonal geometry and improved the overall accuracy of construction.

The Leadenhall Building echoes the principles of legibility, clarity, flexibility and openness developed by architect Richard Rogers on game-changing buildings such as the Pompidou Centre in Paris and the Lloyds Building, which sits just across the road on Leadenhall Street. Conceived by Rogers Stirk Harbour + Partners, the Leadenhall Building

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AWARD The Leadenhall Building, London

Architect Rogers Stirk Harbour + Partners

Structural Engineer Arup

Steelwork Contractor Severfield

Main Contractor Laing O'Rourke

Client C C Land

is a stunning new addition to the London skyline. It was also completed on time and budget. SSDA judges commented: "This world-class project is an exemplar for large commercial buildings."

©David Butler

COMMENDATION The Curve, Slough

Architect
BBLUR architecture and CZWG architects

Structural Engineer Peter Brett Associates

Steelwork Contractor
Caunton Engineering Ltd

Main Contractor Morgan Sindall

Client Slough Borough Council

The Curve is a library and community venue, located next to a busy junction in Slough town centre. The 90 m long and 15 m tall building has a curved 'tube' structural frame and opens onto two new public squares at either end.

3D BIM was used to ensure a high level of coordination between architectural, structural and services design. The lightweight steel frame and composite floor solution was flexible in accommodating the building's irregular column grid, and was able to achieve large spans using slim members and, where exposed, formed part of the building's architecture. Only a single mobile crane was required to perform all lifting operations on the project.

"The low weight of the construction compared to a reinforced concrete form provided significant savings in the deep concrete foundations," says Caunton Engineering director Geoffrey Taylor, adding that significant carbon savings were also made.

MERIT A400M MRO Facility, RAF Brize Norton

Architect AWW Architects

Structural Engineer Arup

Steelwork Contractor
Billington Structures Ltd

Main Contractor Balfour Beatty

Client Defence Infrastructure Organisation

This steel-framed maintenance hangar spans 67 m and covers an area of 22,000 sq m. It has three aircraft bays, equipped with overhead cranes and other facilities. Metallic blue cladding reflects the sky and a curved roof inspired by the rolling countryside helps this facility recede into the landscape. The design considered the impact it would make on the operational environment of RAF Brize Norton airbase. A radar impact assessment indicated that radar-diffusing cladding at high level on the sides of the building facing the runway would be required.

"Hangars are not known for their design qualities. What makes this special is that, despite being a functional building, built to a tight budget, it manages to be an attractive one that fits in with its wider context," says AWW Architects associate Ian Hunt.

©Balfour Beatty

A positive environment

More discreet than traditional lattice framed transmission towers, the T-Pylon, with its single column, two arms, a pair of horns and 'diamond earrings', brings a new personality to our landscape

RUBY KITCHING

Reinvented for the 21st century, the T-Pylon is an electricity pylon that is cheaper to build and maintain and occupies a smaller footprint than its predecessor, making it much more sustainable.

It was the winning design in an international competition organised by the Department of Energy and Climate Change (DECC), electricity company Nationalgrid UK and the Royal Institute of British Architects (RIBA). The competition was held to find an alternative to the traditional lattice tower, considered by many to be a blight on the landscape. By redesigning the pylon, it is hoped they will become a more accepted addition to our surrounding area. T-Pylons have now been erected at Nationalgrid UK's training site at Eakring, Nottinghamshire.

Some 20 m shorter than a lattice tower, the T-Pylon consists of a circular hollow steel shaft, which tapers from 2.1 m diameter at the bottom to 1.1 m at the top. Steel thickness varies from 22 mm to 14 mm. Similar in form to a wind turbine shaft, the T-Pylon's shaft has benefitted from manufacturing and installation efficiencies developed in the wind industry. A cast iron node connects the top of the shaft to two arms to create the 'T' shape. At the ends of each arm, a cast iron 'horn' detail forms the single connection between the main T-Pylon structure and the array of overhead lines.

"T-Pylon is designed so that we can route overhead lines with gradual turns instead of large sudden changes in direction that have characterised existing routes with lattice pylons," explains Nationalgrid UK overhead lines and cables technical manager Mike Fairhurst. "The T-Pylon helps us move towards more sweeping curves that follow the landscape".

The position of the lines are fixed by a diamond-shaped insulator configuration. It is this prismatic arrangement of conductors, which permits the reduction in height of the pylon.

"The old lattice tower design hasn't changed in the last 100 years. Today we can optimise production [processes] and materials to create a better design," says business development manager Mette Mikkelsen for Bystrup, the architect and structural engineer for the scheme.

She continues: "It is 36 per cent shorter, easier to install, has a reduced magnetic field, and is a revolutionary, but simple new design. Sleek and slender, with "diamond earrings", it is more aesthetically pleasing than its predecessor". A YouGov survey carried out in 2015 revealed that 23 per cent of the public felt more positively towards the T-Pylon than a lattice tower.

Cost savings derive from the efficient use of steel. With only a steel shaft bearing onto the ground, the structure only requires a steel monopile for its foundation. Simple foundations and superstructure also make the units quick to install.

Bystrup worked closely with the steelwork contractor during design development to ensure connections and details were optimised for design, manufacture and installation. The design relies heavily on the single horn node transferring the conductor array loads to the arms of the tower.

"One of the biggest challenges was that all insulators would be attached to one critical point [on the main transmission tower]. Usually, every insulator has its own attachment point. After several simulations and full-scale prototypes, the design was validated and accepted," Ms Mikkelsen says.

The horn node resistance to fatigue was analysed in detail, particularly under the effects of high winds and vibrations. These nodes, as well as the ones that connect the arms to the tower shaft, were cast in one piece to achieve the highest performance characteristics. Non-visible, internal bolts connect them to the T-Pylon structure.

Mr Fairhurst adds that design development of the T-Pylon challenged traditional ways of thinking and working, especially in terms of long-term maintenance.

"The decision, taken very early on, to move away from traditional tower access for construction, repair and maintenance removed the need to provide climbing and external access to the structure. This has been one of the most innovative aspects of the project. All access for construction, repair and maintenance will be carried out from MEWPs. This significantly reduces the safety risk to personnel carrying out work."

AWARD T-Pylon
Architect Bystrup
Structural Engineer Bystrup
Main Contractor Balfour Beatty Power Transmission and Distribution
Client Nationalgrid UK

©Alex Upton

West Croydon's run-down bus station has been rebuilt with open concourses and an elegant canopy to give the area a much-needed lift. Its structure is formed from weathering steel, which provides an already bedded-in look and also introduce a sense of calm to the busy interchange.

One of the main challenges on the project was to control fabrication and construction tolerances. Since each weathering steel member was formed from steel plate, more checks were required than if off-the-shelf members had been used. Also, because the structure had to accommodate the fixed dimensions of prefabricated cladding panels, a tolerance of only 5 mm was permitted across the structure.

It incorporates a repeating module where canopy and supporting columns are linked by a curved haunch. This haunch is perforated with holes of different sizes to create an interesting visual effect that relates to the variation of stress across the member.

Price & Myers partner Tim Lucas comments: "Structural weathering steel provides a self-finishing, highly crafted architectural identity to the building.

"Much of the building's architectural design is expressed through this canopy, so the detailing was intricate and detailed, it even involved the bench supports becoming part of the structural system."

COMMENDATION West Croydon Bus Station

Architect Transport for London

Structural Engineer Price & Myers

Steelwork Contractor
B&W Engineering Services Ltd

Main Contractor Quinn London Ltd

Client Transport for London

Ms Mikkelsen adds, "By re-thinking material-use and surface treatment, we have developed a life-span program that lasts more than 80 years without any routine maintenance and additional surface treatment."

SSDA judges commented that the T-Pylon was a steelwork design classic.

MERIT
Wellcome Collection Dynamic Stair, London

Architect WilkinsonEyre

Structural Engineer AKT II

Architectural Metalworker
Clifford Chapman Staircases Ltd.

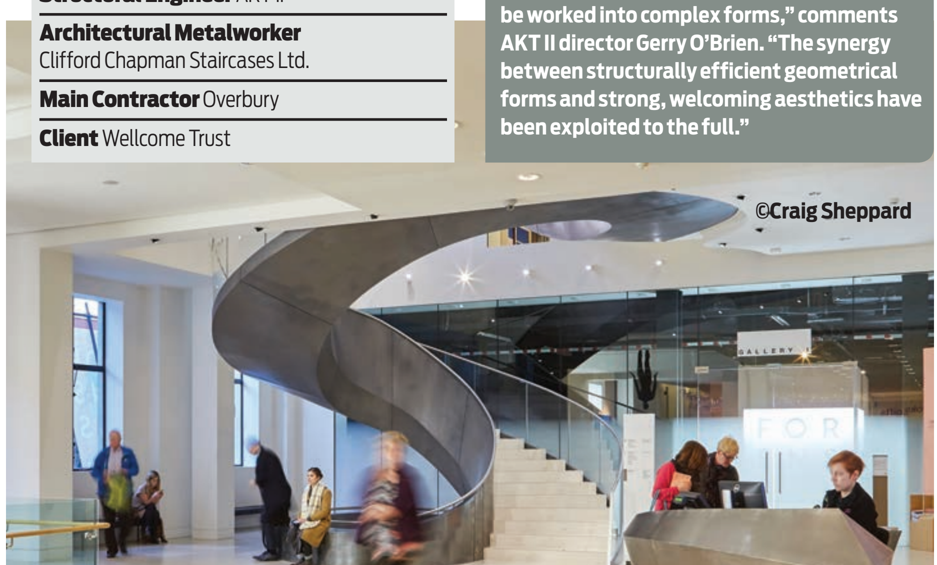
Main Contractor Overbury

Client Wellcome Trust

Combining engineering and art, the new 'dynamic stair' at the Wellcome Collection in London creates a new exhibit in its own right, enticing the public to visit the upper floors of this museum.

Since the ground floor could not be strengthened to support the stair, new structural members had to be installed to transfer its load back to the existing structure. The stair is made from 8 mm-thick steel plate and uses its inner balustrade and floor components as a structural monocoque. The design was refined and optimized using parametric modeling.

"Steel was the only realistic option for the staircase, exploiting the strength and stiffness of the material and its readiness to be worked into complex forms," comments AKT II director Gerry O'Brien. "The synergy between structurally efficient geometrical forms and strong, welcoming aesthetics have been exploited to the full."



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A tight London revamp

Contemporary offices have been constructed behind a 20m tall retained façade in London's West End, marrying 1920s structural steelwork with modern design and construction

RUBY KITCHING

AWARD LSQ London

Architect make

Structural Engineer Waterman Structures

Steelwork Contractor Bourne Steel Ltd.

Main Contractor Multiplex Construction Europe Ltd.

Client Linseed Assets Ltd.

LSQ is an office building in London's Leicester Square. The existing 1920s building on the rectangular site had been adapted many times over the years, but needed a major overhaul to meet modern standards. With a Grade II-listed façade on all four frontages and occupying the western side of the square, the new scheme would need to address its heritage status and prominent location with a fresh perspective.

The decision to gut the inside of the building and rebuild the space threw up a number of issues. During the rebuild, the façade's existing perimeter steel frame and Portland Stone facing would need to be held in position by temporary steelwork, while above and below the retained façade line, a new three-storey mansard roof and extra basement had to be built. Existing steelwork, dating from various decades, had to undergo extensive laboratory testing to verify its properties prior to connecting it to new steelwork via brackets and on-site welding.

"The building was actually a collection of individual structures built across a period of circa 60 years, although they shared a common façade design," recalls Waterman Structures board director Jody Pearce.

The new basement was created by installing a secant piled wall inside the line of the retained façade. Shallow floor construction was used for the basement and ground floor slabs to minimise depth of excavation and maximise headroom. A new steel-framed core and perimeter columns (located behind the façade) form the new superstructure and create column-free office space with spans up to 12m. This structural system had to be flexible to marry with existing steelwork.

"The new steel structure introduced a new central core and enabled clear, open-plan floorplates, improving the office spaces within the building," says make architects partner Frank Filskow. "One of the key aspects of a façade retention scheme is the alignment of new floors with existing window openings. We promoted the use of a steel frame as it offered the flexibility needed to suit the various interfaces that occur with the existing façade."

A ring beam above level five supports the new mansard roof, since this new upper level's structure does not align with the main building's new perimeter columns. The ring beam, made from 650 mm × 450 mm x 25 mm thick jumbo box sections, also supports a new level of stone cladding.

Mr Filskow continues, "Coordinating the new roof with existing stonework which wasn't true or straight, as well as allowing the existing façade to move independently from the new structure, made detailing more complicated. However, the value derived from retaining the intrinsic character of the old building and bringing new life to it has been a great asset to the project."

In all, 2000 tonnes of structural steel and metal decking has been installed on the project. Since the site is bound by roads on all sides, bringing materials to site required

Central Square is a sustainable new office development in Leeds. Arranged in a horseshoe, it accommodates two levels of retail and 10 office floors around an atrium. The building reuses existing foundations and incorporates a low carbon combined heat and power plant for water and electricity, both helping the development to achieve the highest possible, 'Outstanding' BREAAM environmental rating.

Five 27 m-long tubular steel bowstring trusses stretch across the seven-storey atrium to support an inclined glazed wall with base connections exposed to form part of the building's architecture. A storey-height Vierendeel truss weighing 43 tons supports a balcony at level eight from where views over the atrium's 'winter garden' can be enjoyed. Office floorplates are of composite construction. Cellular beams span between steel columns and one of three concrete cores in the development.

"The client's requirement to offer the city's largest office floorplates with flexible services provision, built on and around a partly developed and extensive network of existing piled foundations led to a steel-framed solution," explains Elland Steel Structures business development manager Geoff Badge.


©Price & Myers

COMMENDATION
The Hurlingham Club Racquet Centre

Architect David Morley Architects

Structural Engineer Price & Myers

Steelwork Contractor Tubecon

Main Contractor ISG

Client The Hurlingham Club

This private members club's new tennis hall is a 38 m x 70 m indoor space set 1.5 m into landscaped grounds.

Topped by a curved roof with a sedum grass finish, it is a sympathetic addition to the area.

A series of tied-arch steel frames made from welded box sections at 16.5 m centres form the primary roof structure of the hall. The arches are Vierendeel trusses which support timber stress-skin roof cassettes. The 'tie' feature of the arches is provided by large diameter tension bars and, together with raking ties, create a highly efficient structure to span some 40 m. The trusses were fabricated in three sections with bolted splices connected on-site using a seating jig.

"The use of steelwork to form the structure allowed precise fabrication before being delivered to site," says ISG regional pre-construction director Justin Lowe.

"This was particularly important when considering the tolerances for the timber cassette roof structure. The build methodology negated the need for scaffold, with the cassette soffits carefully designed to be installed pre-finished."

meticulous planning to ensure the most efficient use of time and craneage, without bringing traffic in the area to a standstill. The ring beam was brought to site in 3.5 m-long sections, each weighing 3 tonnes.

"The use of steelwork has allowed the internal building arrangements to be transformed from a dark, cellular arrangement to the column-free space it now enjoys," Mr Pearce adds. In the finished building, there are two basement levels and, above ground, two levels of retail and seven storeys of offices.

SSDA judges commented that it showcases the role steelwork can play in the extension and re-purposing of historic buildings.

COMMENDATION Central Square, Leeds

Architect DLA Design

Structural Engineer WSP

Steelwork Contractor
Elland Steel Structures Ltd.

Main Contractor Wates Construction

Client M&G Real Estate

The longest structure of its kind in the UK and with look-out platforms designed to be lively, STIHL Treetop Walkway meanders through Silk Wood some 13 m above ground. This tree-hugger formed from steel and timber has been key to a rise in visitor numbers at the National Arboretum.

"We made a few tweaks to the design, such as changing the walkway support spine from timber to steel," says BuroHappold project engineer Joe Darcy.

"Steel was chosen as it is more durable and will give the walkway a longer lifespan, while we also needed a material to give us a stiffer deck to provide lateral stability," adds Westonbirt Arboretum project manager Sophie Nash.

"We have used two primary materials to construct the walkway, steel and timber," she adds. "Steel has been used to support the deck of the walkway, which enabled us to slim down its profile, reducing the visual impact on the landscape. Using steel also allowed us to create gentle, sweeping curves."

COMMENDATION STIHL Treetop Walkway, Westonbirt, the National Arboretum

Architect Glenn Howells Architects

Structural Engineer BuroHappold Engineering

Steelwork Contractor S H Structures Ltd.

Main Contractor Speller Metcalfe

Client Forestry Commission, Westonbirt, the National Arboretum

Show of support for Selfridges

Refurbishment of an iconic department store has begun with construction of a new services ramp for HGV lorries

RUBY KITCHING

Occupying an entire block on London's Oxford Street, Selfridges' original and flagship department store has a commanding presence. To keep it at the forefront of fashion and shopping trends, there are plans to revamp its accessories hall and create a new eastern entrance. But before this work can begin, the seemingly less glamorous job of sorting out how delivery lorries leave the building needed to be sorted out.

The existing HGV egress ramp from the basement loading area bisected the ground floor, so the first phase of Selfridges' masterplan involved building a new ramp to the rear of the building. Occupying the north-east corner of the site and tight against its perimeter, relocating the ramp would enable the ground floor to become a single uninterrupted retail space, which could be treated with one consistent style.

The new ramp's design was profoundly influenced by the fact that it needed to be built without disrupting normal store operations and, crucially, shoppers. (The existing ramp would remain in use until the new one was complete). The ramp takes the form of 50 m-long braced steel 'tube' structure weighing 165 tonnes.

Accommodating it required three existing columns on its path to be removed and the loads coming down them transferred to steel girders incorporated into the ramp's design. Existing 1920s steelwork supports the northern side of the ramp while two new columns had to be built to support the southern side. These new columns had to be threaded through lower floors and supported off newly constructed, hand dug, pad foundations.

"Parts of the existing structure were strengthened, which allowed the new vehicle ramp to take support from it. This greatly reduced the extent of new structure required," says Expedition Engineering Associate Alessandro Maccioni.

Where ground floor beams were removed to make way for the ramp, columns below had to be checked to make sure they could sustain a change in loading and restraint.

©Kevin Sansbury

AWARD HGV Egress Ramp, Selfridges, London

Architect Gensler

Structural Engineer Expedition Engineering

Steelwork Contractor William Hare

Main Contractor Blue Sky Building and SRM JV

Client Selfridges

With a lack of historical information and the project being fast-paced, construction methods had to be flexible to accommodate the unknown.

"Interfaces between the new and existing structure relied on a seamless process of opening up the structure, [carrying out a] detailed site survey, developing a connection design and finally execution of the detail on site," Mr Maccioni explains.

"In some instances we were uncovering services that were unknown to all parties, which resulted in us having to be flexible in our approach," adds Blue Sky Building SRM joint venture project manager Martin Ewing.

As the ramp was designed to support heavy vehicles, the steelwork itself was of considerable weight. For members to be craned into position, without undermining the structure below, the contractor developed a series of temporary works that spread the load of a spider crane across the existing suspended floor. Further propping was also required to support the new opening in the ground floor until the ramp structure was complete.

"Steel was the most appropriate material for the project as the structure could be broken down into element sizes that could be easily erected within the confines of the existing building," comments Mr Maccioni. "Steel was also compatible with the existing building material which was easily upgraded to the required standard by the addition of site-welded plates."

Judges commented: "The outstanding success of this complex project was achieved through very close collaboration between the whole design and construction team."

COMMENDATION Watermark Westquay Footbridge, Southampton

Architect ACME

Structural Engineer David Dexter Associates

Steelwork Contractor S H Structures Ltd.

Main Contractor Sir Robert McAlpine Ltd.

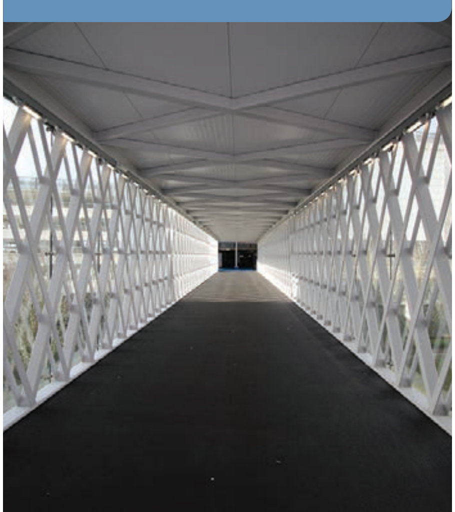
Client Hammerson plc

This footbridge in Southampton over Harbour Parade Road connects a new shopping centre with an existing car park. Made from a box truss structure, it spans 30 m between two vertical hoop frame supports and cantilevers a further 10 m at one end. A lattice arrangement of members on its side walls gives it a strong architectural identity. These members were carefully detailed to make walking along the bridge an uplifting experience.

This has been achieved by using Rectangular Hollow Sections (RHS) for diagonals in one direction (resisting compression forces) and a pair of steel plates in the opposite direction (resisting tension forces). Square Hollow Sections 200 mm deep form the upper and lower chords. The use of steel plate instead of RHSs and a philosophy of keeping outer dimensions slim and constant while increasing wall thickness or adding stiffeners, has created a minimal, uniform frame.

ACME project architect Mark Broom says, "The combination of box sections and plates to create the lattice provides striking layered visual effects and dynamic views as you move through the bridge."

The bridge was prefabricated in two sections and installed during a road closure using a 500-tonne capacity mobile crane. A temporary tower provided additional support.



Redevelopment of this shopping centre in Bolton involved adding a new nine-screen cinema at roof level and the remodelling of its central atrium.

Covering 2,782 sq m, the new roof-top extension neatly unifies three different parts of the existing development and required the existing steel-frame to be strengthened. The atrium is now topped with a new space frame roof and has been remodelled to include a feature lift, new link bridges and escalators. The centre remained open while this work took place.

"A steel frame solution was essential to the continued operation of the shopping centre and provided a 'slim-line' skeleton for the upper cinema extension. This maximised the internal auditoria and general amenity areas," says Shipley Structures director Glynn Shepperson.

MERIT Market Place Shopping Centre Redevelopment, Bolton

Architect Wren Architecture and Design

Structural Engineer Ramboll

Steelwork Contractor Shipley Structures Ltd.

Main Contractor McLaren Construction Ltd.

Client Moorgarth Properties Ltd.

MERIT Waterford Fire Station

Architect McCullough Mulvin Architects

Structural Engineer O'Connor Sutton Cronin

Steelwork Contractor Steel & Roofing Systems

Main Contractor Duggan Brothers Contractors Ltd

Client Waterford City & County Council

Organised around this fire station's drill yard, this steel-framed building spirals up from single storey parking units, workshops and dormitories to two-storey blocks containing offices, a canteen and leisure and study facilities before peaking at three storeys, where a lecture theatre occupies the highest level. Precast concrete planks are used for the floors in the building while the angled roof is zinc clad. Parts of the roof canopy are omitted to create open terraces.

"The angled views cutting across various spaces – from the canteen to the muster bay, from the gym down to the drill yard, from the break out spaces to the mountains – emphasise the three dimensionality of the building and make it extremely dynamic," says architect Valerie Mulvin. "Structural steel gave us the capability to deal with complex geometries on this project and delivered innovative forms and volumes within a speedy timeframe."

Heriot-Watt strikes gold w

Inspired by the curve of Brazilian footballer Roberto Carlos' free-kick in 1997, the roof of Oriam's football hall is also awe-inspiring

RUBY KITCHING

AWARD Oriam, Heriot-Watt University, Edinburgh
Architect Reiach and Hall Architects
Structural Engineer Engenuiti
Steelwork Contractor J & D Pierce (Contracts) Ltd.
Main Contractor Bowmer & Kirkland
Client Heriot-Watt University

©Reiach and Hall Architects

Located in Heriot-Watt University's leafy Edinburgh campus, Oriam is Scotland's national sports performance centre.

Used as Scottish Rugby Union and Scottish Football Association's training facility, it is made up of two main halls with additional fitness, training and administrative spaces. The larger of the two halls encloses a full-size 3G artificial football and rugby pitch, complete with 28 m maximum height clearance and seating for 500. It is an unheated, steel-framed space with tensioned PVC cladding. The smaller hall accommodates three basketball courts.

It is the larger hall with its asymmetric curved steel roof that is the star player in this game. "The architect worked hard to make it as inspirational as possible," says Oriam interim executive director Ross Campbell. This is reiterated in the name given to the facility where the Gaelic word for gold 'or' is combined with a self-affirming proclamation to assert, "I am gold".

To achieve the 15 m minimum height at the sidelines, rising to 28 m near the centre of the pitch, while still sailing over the much lower headroom required for other facilities, the architect looked to Roberto Carlos' successful free-kick in 1997 for inspiration. Taken 35 m from the goal, scientists discovered that the ball followed the trajectory taken by a sphere when it follows a spiraling path.

This curve accommodates the different height requirements of the building. However, such a curve is formed by a succession of curves of constantly changing radius. Fabricating a roof structure to follow this curve would be prohibitively complex and expensive. So, the shape was rationalized into just three curves formed by circles of fixed radius that could be joined tangentially.

The next aspect to consider was the form of arched roof member. The original design included 13, 1 m-deep trapezoidal section girders spaced at 7 m intervals. But prefabricating these heavy members and lifting them 28 m above ground would be costly and time-consuming, requiring temporary towers to be built to support each section of the roof until one entire arch was connected at height.

The towers would then need to be relocated to the next position where the operation would be repeated. And this would need to be done 13 times and with extensive temporary bracing until the whole roof was complete. Instead, the roof member was redesigned as an open truss where, ingeniously, each completed truss would act as the assembly jig for the next one. Installing the first truss arch required additional temporary members and kentledge to be applied to the gable steelwork to create a robust starting 'jig'.

With each truss arch made up of five sections, stubs on each section would be bolted onto a corresponding stub on the preceding completed 'jig'. When all five sections of the new arch had been positioned and connected to each other, pairs of stubs would be unbolted to allow the new arch to be lifted off the 'jig' by two mobile cranes to its final position.

The new arch would be held in this position while a third crane would be used to fit 6.6 m-long tie members between the 'jig' arch stub with the new arch stub to create the exact 7 m spacing required between the arches, as well as the necessary perpendicular restraint. Once connected up, the arch could be released from the cranes and the process repeated: this completed arch would be the next arch's assembly jig. Extra bracing was required in the first few trusses to add stiffness to the built structure until a sufficient number of arches had been connected. This erection method would not have been feasible for the heavier trapezoidal sections originally conceived for the roof.

Additional curved circular hollow section steel members support the large hall's tensioned PVC cladding to add another dimension to this structure. The fabric allows daylight to penetrate the hall to limit artificial lighting and is forgiving to structural movements and deflections.

Stiffeners had to be added to the truss arches because the membrane cladding would cause a lot of twist.

At ground level, the steel structure also has to accommodate a listed Victorian brick garden wall within its footprint, carefully avoiding its footing. The wall is the physical boundary between the two halls and part of a "street" circulation corridor.

The other side of this corridor is formed by a line of piers, which form the common support for both the sports hall and football hall roofs. (The sports hall roof structure is formed by beam sections rather than trusses). This colonnade had been designed in concrete, but due to time pressures, had to be redesigned in steel. Each pier weighs 17 tons. Outside these halls, cellular beams are used for floor construction to allow easier integration of services and structure.

SSDA judges commented that the steelwork was, "striking and effective."

ith Oriam

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MERIT Layered Gallery, London

Architect Gianni Botsford Architects

Structural Engineer Entuitive

Steelwork Contractor Trescher Fabrications Ltd.

Main Contractor Verona Construction

Layered Gallery is a building that stores a private collector's works of art.

It uses weathering steel for its structure, glazing supports and for the screens to display the artwork itself. The gallery name reflects the way the building is made up of different layers of weathering steel against the backdrop of a brick wall. The steel frame used in the glazing and structural layers echo the shapes created by hanging pictures for display in a gallery.

Architect Gianni Botsford says: "We made something interesting out of a very prosaic brief – initially the extension was to be purely storage space. We managed to get each element to work very hard to exist – an outer structural layer, the high performance glazing, protective blinds, sliding screens, a hidden folding toilet all fit within a depth of 1.2 m."

Entuitive principal Toby Maclean adds, "Layered Gallery is a perfect example of how close collaboration between disciplines can add something special to a project.

By aligning the architectural intent and the structural scheme, the structural elements and materials become a source of aesthetic quality in the project."

©Gianni Botsford Architects

MERIT Maxwell Centre, Cambridge

Architect BDP

Structural Engineer Ramboll

Steelwork Contractor The Wall Engineering Co Ltd.

Main Contractor SDC

Client University of Cambridge Estate

This four-storey research facility has been designed to be architecturally striking with internal and external spaces that can accommodate changes in future use.

The slim 350 mm-deep structural zone and need for 13 m spans led to a structural steel solution with precast plank floors. The shape of the doubly curved roof has been formed using curved steel beams.

The facility features columns rising up through the building so that they are external on some floors and internal on others.

"This required the introduction of joints with thermal breaks along their length to avoid cold bridging," says The Wall Engineering Co contracts director Ross McCulloch.

"These joints needed to be manufactured with a high degree of accuracy to ensure that the steelwork could be installed within erection and design tolerances."