The talk of the town

Rafael Viñoly's Walkie-Talkie tower is now flaring out over the London skyline, thanks to 13,000 tonnes of structural steel and 37 unique floor plates

Text by Pamela Buxton

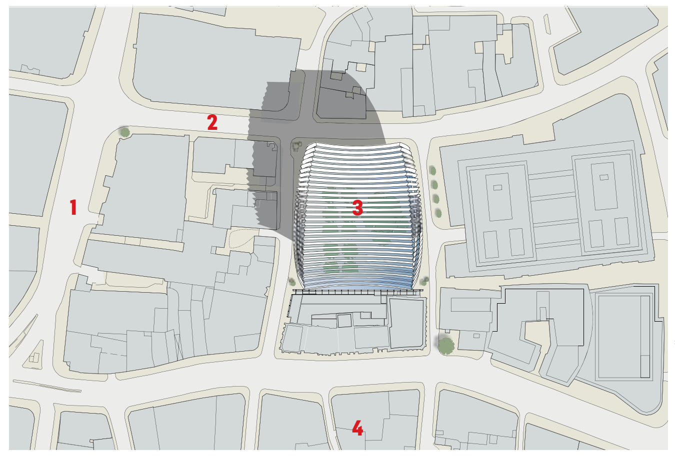


IMAGE: RAFAEL VIÑOLY ARCHITECTS

AERIAL PERSPECTIVE

1 Gracechurch Street 2 Fenchurch Street 3 20 Fenchurch Street 4 Eastcheap

Proclaimed on its hoarding as "the building with more up top", Rafael Viñoly's 177m-high tower 20 Fenchurch Street is rapidly taking shape on London's skyline. Now almost fully clad, the 64,140sq m tower is due for completion next year.

The skyscraper's controversial, distinctively flared shape — less like its nickname Walkie-Talkie and more like a pint glass — has been realised with the use of 13,000 tonnes of structural steel provided by steelwork contractor William Hare.

With such a distinctive form, this building will always divide opinion as it joins the growing number of unconventional towers now jostling for attention in the capital's financial heartland. Viñoly maintains that the design — criticised by some as overwhelming — respects the City's historic character by "following the contour of the river and the medieval streets".

Commercially, the swelling form makes sense, maximising the footprint by creating larger floor plates as the views get better. And at the very top, the joint developers Land Securities and Canary Wharf Group promise a publicly accessible sky garden with spectacular views over the City.

The tower's form presented a tough challenge for engineer Halcrow Yolles and contractor Canary Wharf Contractors since each floorplate was a unique shape and size due not only to the widening floor plates but also the concave curve on the north and south elevations and the convex curve on the east and west.

Creating and delivering the solution to a tight 38-month timetable was only possible, according to Canary Wharf Contractors associate director Charlie Paul, with the use of what he terms 4D BIM modelling — the fourth dimension being time. This gives complete coordination of all aspects of design and construction using software compatible with the Revit programme used by the design team, Sketchup Pro used by the contractor and Tekla used by the subcontractors.

This real-time model allowed the contractor to fully coordinate the design team and specialist contractors so that they could anticipate any clashes and hiccups within the various interfaces during the construction programme and act accordingly to eliminate them. In this way, it also enabled those tendering to give a more accurate price, according to Paul.

"We had very little argument and debate with William Hare. The modelling we did allowed us to have a much closer relationship," he adds.

Steel was the only viable choice for 20 Fenchurch Street's structure, lowering the weight of the building and allowing the engineers to use existing foundations on the site, according to Halcrow Yolles buildings team lead Jason Guneratne. It also met the requirement for long spans in order to maximise lettable office space.

The structure consists of 22 box columns arranged on a 9m grid around a central core. Columns were constructed from fabricated sections ranging from 525mm x 525mm square box sections with 100mm-thick plates to 525mm x 350mm I sections with 40mm-thick plates at higher levels.

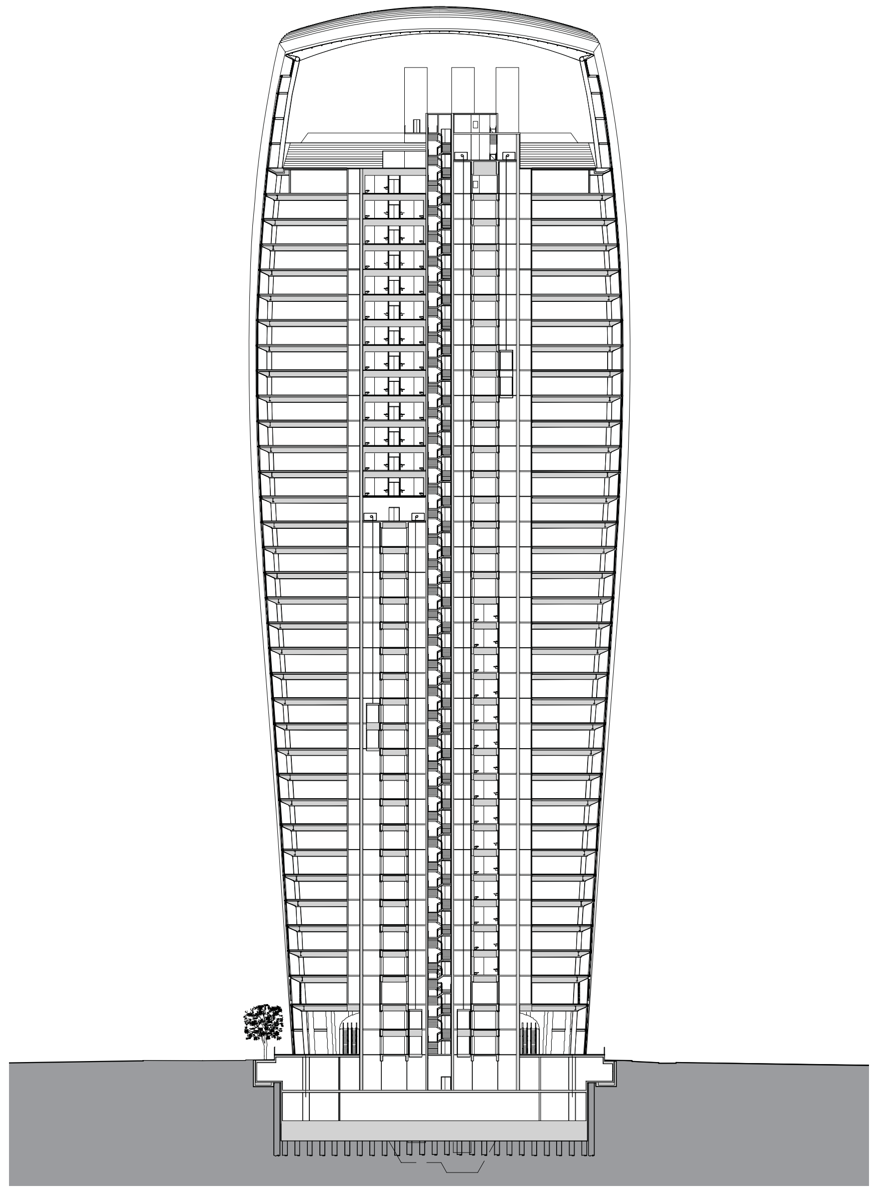
PHOTO: WILLIAM HARE

FACETED STRUCTURE

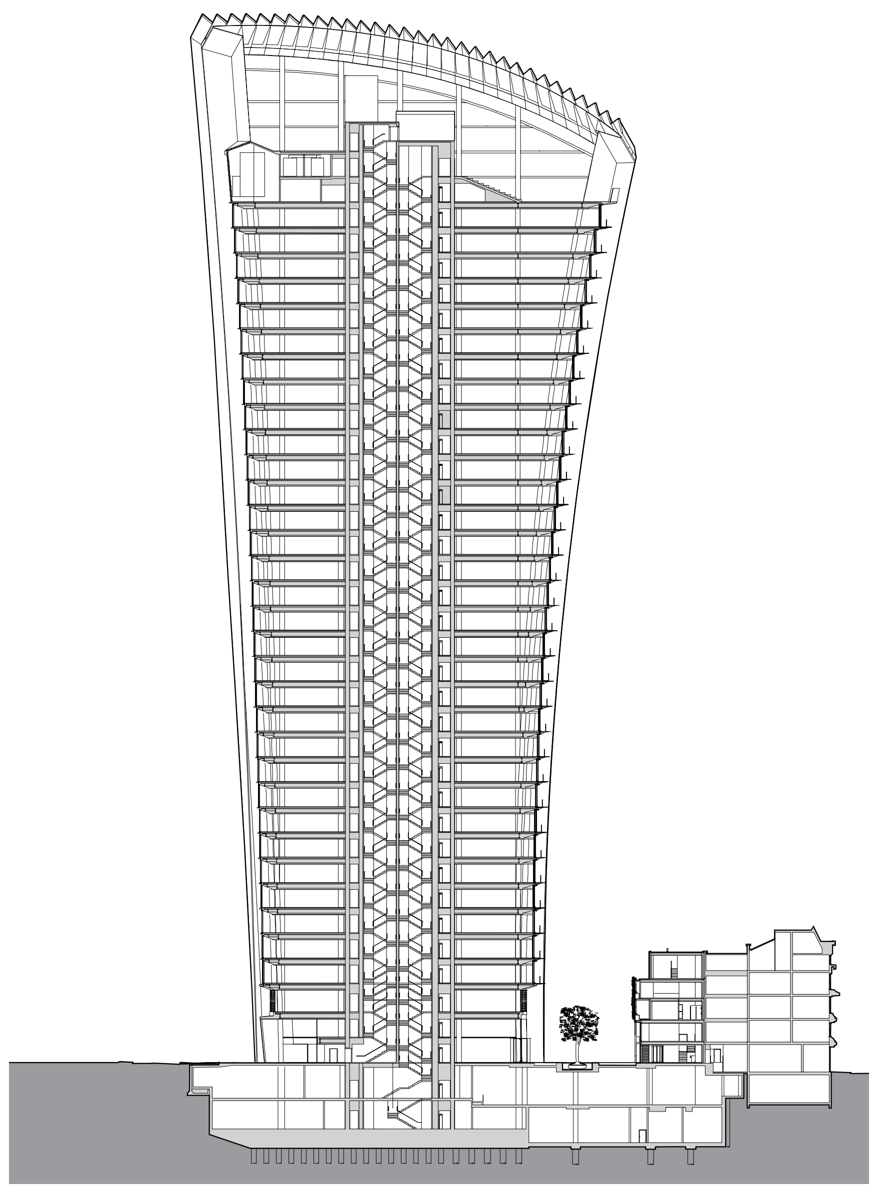
To create the flared shape the columns are faceted up to the 25th floor, after which the top of the flare is achieved with a cantilever, both of which simply delivered the desired profile. The angle of the columns is changed in a concealed, bespoke spigot connection welded to the top of each column during fabrication. This allowed the next column to be positioned at the correct angle to achieve the facet while avoiding the need for an external flange. The impact of the bolt head is minimised by the fire-protective covering. With such complex column geometry, the use of 3D project information was hugely important, according to steelwork contractor William Hare.

The wider floor plates on upper storeys maximise lettable space with views over the city.

PHOTO: JON CARDWELL



North section: 20 Fenchurch Street's pint-glass profile is created as the floor plate flares and then tapers back on the upper storeys.



West section: The steel frame cantilevers after the 25th floor. The upper three storeys are taken up with the sky garden.

Each beam was kept to a 600mm depth whatever the span, except at the uppermost levels where they were increased to 1,150mm. All are fixed to the concrete core using embedment plates. Most are fabricated plate girders with web penetrations to accommodate services within the beam depth. Typical floor beam spans range from about 11m at level 2 to 18m on the upper levels.

According to Guneratne, the geometric changes were the crux of the structural design challenge. "Architectural aesthetics were the main driver. When the shape of the building changes, it fundamentally changes every beam a little bit. So we formulated an algorithm that automatically recalculated the positions of all the beams on every floor."

Bifurcating columns were initially considered in order to achieve the flaring shape but this would have taken up too much space within the plan. Instead, the solution was to facet the steel structure up to the 25th floor, with the facets occurring first every six floors, then every four and finally every two on areas of high curvature as the tower neared its widest "bulge" point on the 27th floor.

However, the maximum beam span that could be tolerated was 20m. So from level 25, the structure's flare was created using a cantilever to give the final 4m on the north and south faces beyond the column line. On the east and west sides, the columns remain in the facade, which is triple-glazed with panelised aluminium cladding and vertical louvres.

In order to avoid using the three tower cranes needed to erect the structure during the worst of the winter weather, Canary Wharf Contractors asked William Hare to deliver the steel installation in just 36 weeks from May 2012 to January 2013, rather than 41, by working on accelerated hours for 17 weeks. This included the installation of the approximately 8,500 major structural members that made up the steel frame.

Having installed the vertical cladding, the contractors are now building the sky garden. When complete in April 2014, the Breeam "Excellent" building will contain 61,000sq m of offices up to the 34th floor as well as 1,200sq m of ground floor retail, plus the sky garden, which is intended to be a public space with bars and restaurants served by its own dedicated lifts.

Development costs for 20 Fenchurch Street will total £239 million. So far, with completion still a year away, office accommodation is 56% pre-let.

PROJECT TEAM

Developers Land Securities, Canary Wharf Group
Architect
Rafael Viñoly Architects
Executive architect
Adamson Associates
Structural and facade engineer
Halcrow Yolles
Contractor
Canary Wharf Contractors
Steelwork contractor
William Hare

IMAGE: HALCROW YOLLES

The steel frame is made up of approximately 8,500 major structural members.

IMAGE: RAFAEL VIÑOLY ARCHITECTS

SKY GARDEN

The sky garden is a 50m x 60m, double-height glazed space at the top of the tower with clear spans and a giant full-height window on the north and south elevations.

The original intention had been to use a space-frame construction but this was changed to a more economical and faster-to-erect portal frame with 34 structural fins spanning east to west, including two central 20m sections 1,200mm deep. Each is fixed by William Hare into a base connection — a concealed steel "shoebox" typically 750mm x 400mm x 100mm deep. This takes the horizontal forces into the steel structure and accommodates the transition from the aluminium fins running up the side of the tower into the steel roof structure. Mitre connections on the four corner fins are also accommodated in more heavily loaded "shoeboxes".


PHOTO: NICK KANE


PHOTO: NICK KANE

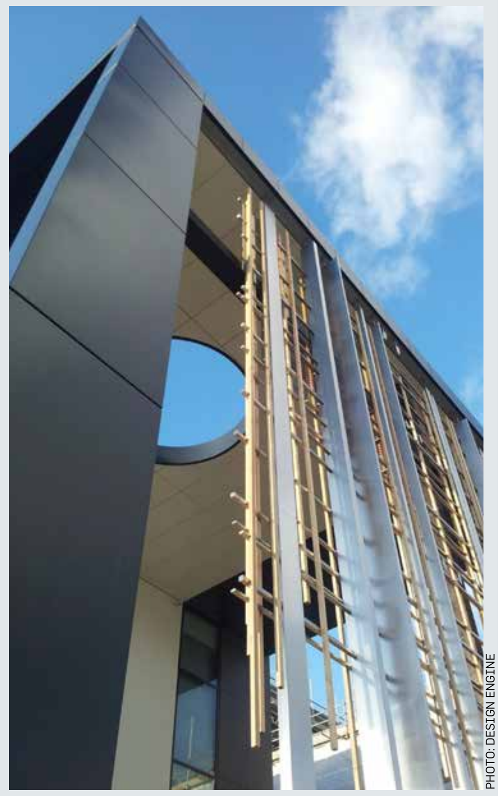


PHOTO: DESIGN ENGINE

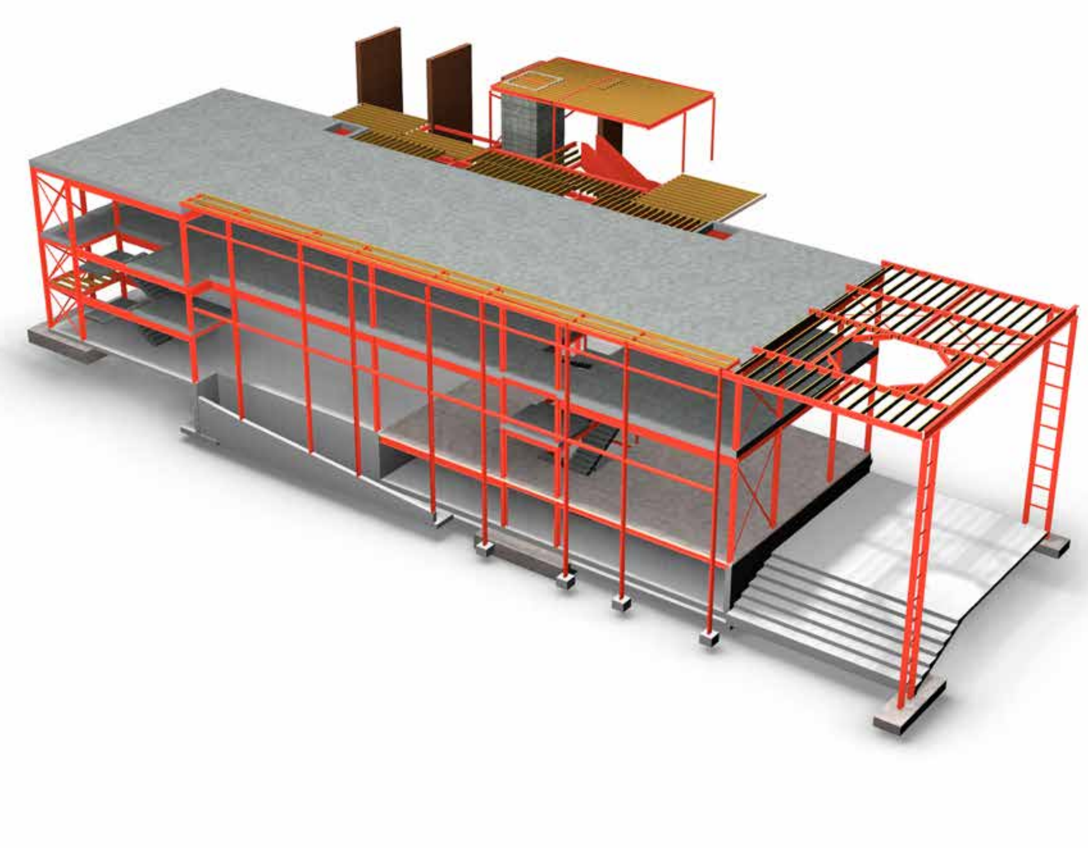


IMAGE: HEYNE TILLET STEEL

Thirty pieces of silver

Design Engine's new teaching block for the University of Winchester is dominated by a steel-and-timber portico inspired by Christian symbols

Text by Pamela Buxton

With its 12m-high steel portico and distinctive Christian-inspired artwork, there's no missing the University of Winchester's new Learning and Teaching Building.

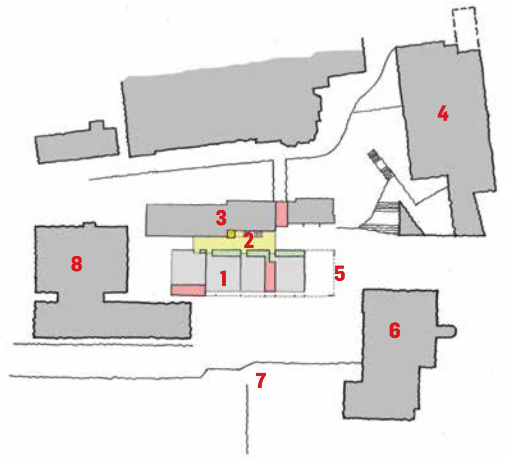
Designed by local practice Design Engine, the St Alphege building is the latest facility to be added to the former King Alfred teaching college's campus, following its reincarnation as first University College Winchester in 2004 and then the University of Winchester in 2005.

Design Engine has worked extensively on the campus, which occupies a steeply sloping site on the outskirts of the city. The St Alphege building, which was officially opened in January, helps to form a new public space bounded by the University Centre — completed by the practice in 2007 — and the theatre, which the practice refurbished in 2003.

Faced with an urgent need for improved and additional teaching space, the university decided to redevelop an inadequate 1920s arts block in front of the library to provide eight flexible teaching rooms for up to 600 students. Design Engine's eventual solution also creates a linking block to the adjacent 1970s St Edburga building, which has been reclad and given a lightweight, steel-framed rooftop extension containing two further teaching studios.

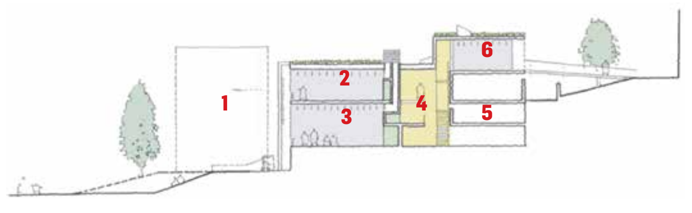
As well as providing the accommodation the university required, the architects were keen for the building to create a suitably impressive presence on the new piazza, which has become an important outside social space on the campus.

"My worry was that a teaching building wouldn't have a frontage with some element of closure to what would be an important public space," says Design Engine director Richard Jobson. "So we developed the idea of a large oversailing roof with an opportunity for an artwork." The grandiose steel atrium also facilitates pedestrian flow through to the green space alongside, known as the Dytch, Jobson adds.



SITE PLAN

1 St Alphege building
2 Link building
3 St Edburga building
4 University Centre
5 Piazza
6 Theatre
7 Dytch
8 Library



SITE SECTION

1 Library
2 St Alphege building
3 Double-height first floor
4 Link building
5 St Edburga building
6 Rooftop extension

Another important factor was the nature of the adjacent St Edburga building, which has floor-to-ceiling heights of just 2.3m. Ideally, the architects would have wanted to provide level floor plates to ease the transition between the two buildings, but this was problematic because of the desire to provide higher teaching spaces in the new accommodation. The practice therefore opted to make the ground floor of teaching studios double height (4.5m) so that the first floor could align with the new upper storey of St Edburga.

Steel was the only viable option for the primary structure, according to engineer Heyne Tillett Steel, because of the intense time pressure to complete the St Alphege building before the 2012 autumn term (the St Edburga phase completed early this year). As a result, the programme was accelerated, with the design detailed and procured at speed in order to finish in time. In total, steelwork contractor Snashall Steel Fabrications Co supplied 300 tonnes of steel.

The building is constructed with a steel superstructure with composite beams, highly insulated rainscreen cladding and blockwork walls. The 12m-span precast concrete planks provide thermal mass and use integral water pipes as part of an active cooling and heating strategy.

On the south side of the building, the recessed elevation is overhung by a 1.5m-wide colonnade of large brise-soleil blades. The colonnade's eight steel columns are syncopated with alternate wide and narrow gaps; these are balanced with a pattern of timber slats that the architects derived from an overlapping "golden rectangle" proportioning system. Rather than running continuously, says Jobson, the pattern is broken so that students don't feel as if they are imprisoned inside. "It's a repetitive pattern that you break with an alternative pattern that also repeats. It has a rigour but also a certain account of freedom," he adds.

'My worry was that a teaching building wouldn't have a frontage with some element of closure to what would be an important public space'

The glazed link between the St Alphege and St Edburga buildings contains the main entrance and is dominated by a purple "scissor" steel staircase which leads to teaching floors, as well as a mezzanine with computer and desk space.

The staircase is cantilevered 5m from the edge beams on each landing, with hollow section stringers further stiffened by a welded steel plate balustrade. This solution avoids the intrusion of support structure into the circulation space. Instead, each half landing is supported only by the staircases going up and down from it. The curved staircase has a randomised pattern of circles cut into the plate balustrade.

But it's the portico that steals the show. This provides a frame for the artwork, designed by the architects in consultation with vice-chancellor Professor Joy Carter. She wanted a piece that would reinforce the relationship of the university with its Christian heritage. The work represents Christ surrounded by the apostles, denoted by suspended steel boxes, with the exception of a rusting weathering steel element that represents Judas. These are linked by 30 polished rods in reference to the 30 pieces of silver that was the price of Judas' betrayal. Two Douglas fir timbers form a cross. Other elements include thin vertical strips of larch, which symbolise the population of the college.

The architects have made the most of views through the building, with a full-height window opening onto the portico from the lower teaching level, and visual connections through the linking building to a new rear courtyard.

The new building is designed to achieve a Breeam rating of "Excellent". The entire project, including the adjacent building's steel-framed upper floor, cost a total of just £3.8 million at a rate of £2,150 per sq m. "There's a lot of building, and a lot of complexity," says Jobson.

PROJECT TEAM

Client University of Winchester
Architect Design Engine
Main contractor
Geoffrey Osborne
Structural engineer
Heyne Tillett Steel
Steelwork contractor
Snashall Steel Fabrications Co

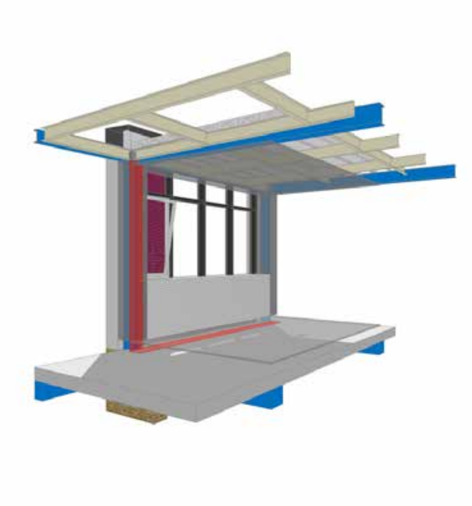
Clockwise from main image: The portico artwork uses suspended steel boxes to represent the apostles; Two layers of larch brise-soleil help to animate the side elevation; Structural steel model.

PORTICO

A 12m-high galvanised-steel frame creates a suitably impressive portico. Steelwork contractor Snashall Steel created two 850mm-wide and 200mm-thick corner fins using steel "ladders" clad in powder-coated aluminium panels. These are of different heights to accommodate the sloping site.

"The architect wanted to see fins, so we used a double column arrangement to support the weight of the artwork structure," says Heyne Tillett Steel project engineer Andrew Blasdale. "The ladder arrangement gives fixing positions to the cladding and provides nominal interconnecting restraint to the two columns in their weaker direction."

The frame contains an oculus — originally intended to be positioned above a reflecting pool — which throws a circle of light onto the ground and backlights the artwork. Due to the cost and programme constraints on the project, Snashall Steel decided to use four corner beams at 45 degrees to provide an octagon. This was then finished off with plywood to create the curve.



ROOFTOP EXTENSION

One of the trickiest aspects of the project was creating the lightweight steel-framed storey on top of the St Edburga building. Although the skeleton portal frame was fairly standard, the challenge was getting the setting out right because the base building wasn't quite square, according to Snashall Steel technical director Blair Thomas. "The whole thing sat on top of the existing structure and fixed into the masonry," he says, adding that this was achieved using chemical anchors.

The existing roof finishes and toppings were removed and the original brick piers were tied into the new steel columns.

Putting frames on a firm footing

Accurate costing from the outset is essential to choosing the right structural frame

Text by Pamela Buxton Illustration by Nick Lowndes

In a recent industry survey two thirds of architects identified cost as the main driver in the choice of structural framing material, with under a quarter feeling that steel frames were expensive.

But as steel frames have accounted for 70% of all non-domestic framed multi-storey buildings over the last 10 years, this perception of steel is not borne out in reality. So what can be done to ensure that costing is accurate both at the early stages of the design process when the frame is chosen, and during detailed design stages?

According to Gardiner & Theobald (G&T), which is carrying out ongoing research into constructional steelwork prices, accurate costing can be challenging to achieve unless project-specific cost drivers are understood.

"Decisions on frame material choice and configuration are often made early in the design process without the benefit of fully developed information," says G&T associate Rachel Oldham. "Nonetheless, it is important to review alternative solutions and the implications of project and site-specific factors on the design of the frame and associated elements, since it can be costly and difficult to change the frame choice at a later date.

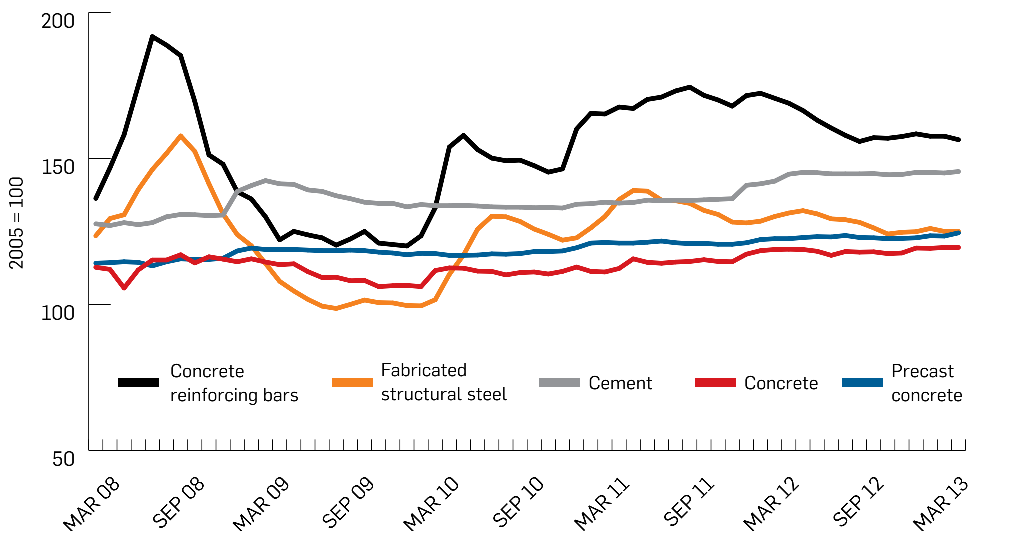
"Otherwise, it may lead to a project proceeding with a design solution that is not optimised."

Recent cost trends

According to the Department for Business, Innovation and Skills (BIS), prices for both structural steel and steel reinforcement (and therefore concrete frame) fell steeply from the second half of 2008 due to over capacity after the fall in demand caused by the economic crisis. They then continued to fall during 2009 before generally stabilising from the end of that year until the present (see chart below). Output fell by almost 35% by early 2010 compared with March 2008.

G&T's analysis of steel frame tender prices over the last five years shows an initial fall in rates in 2008 and 2009, with stability returning by the end of 2011 and continuing through to 2013. However, in the six months after July 2012, the material price of fabricated structural steel fell by about 1.2%. While steel prices in December 2012 were 2.7% lower than December 2011, this was generally not reflected in tender prices for fabricated structural steel. With small rises in the cost of raw materials in 2013, some firming of the price of fabricated structural steel is also expected in the second half of the year.

PRICES OF COMMON STRUCTURAL MATERIALS 2008-13



Getting the price right

To get an accurate picture of current pricing, G&T advises that those doing the costing should speak to the supply chain to find out the reality of current steel costs. When given a typical cost range for different frame types, G&T suggests that, rather than using the highest rate of a range, it is best to instead interrogate and understand what those rates buy, and also how the standard rates can be adapted to suit project-specific needs.

Those analysing costs need to consider the key cost drivers that impact on structural steel frames:

■ **Function, sector and building height** Average steel frame weights will vary considerably between different building types. An industrial building, for example, could have a frame weight of 40kg/m² GIFA (gross internal floor area) compared with 90kg/m² GIFA for a long-spanning city-centre office building due to the shed supporting a much lower load compared to the office frame. Variations in floor-to-floor height also need to be accommodated in a cost matrix. Discussion of design principles with the engineer and architect is essential to clarify this.

■ **Form, site conditions and complexity of structure** Complex structural solutions, irregular grids and the inclusion of non-standard sections will increase overall frame rates due to higher fabrication costs and more complex connection details.

■ **Location, logistics and access** Costs should be adjusted according to geographic location. Indices from building cost information provider BCIS currently show City of London at 120 with Belfast the lowest at 66 (see below).

■ **Site-specific factors** are also important — for example, city-centre sites can be restricted in terms of working hours and deliveries, which can affect programme costs.

■ **Programme, risk, and procurement route** Single-stage procurement routes are increasingly common compared to the previously dominant two-stage approach. This generally leads to more competitive tender prices.

BCIS LOCATION FACTORS*

Location	BCIS index	Location	BCIS index
City of London	120	Leeds	93
Nottingham	93	Newcastle	89
Birmingham	100	Glasgow	108
Manchester	96	Belfast	66
Liverpool	92	Cardiff	98

* As at 13 June 2013

Current costs

G&T has compiled current costs for two key building types:

■ **Low-rise and short-span buildings,** typically two to four storeys with a regular structural grid of 6-9m for largely column-free space and floor-to-floor heights of 3.75-4m. Average steel frame weight is about 50-60kg/m² including fittings. Due to the low-rise nature of the building, fire protection of 30-60 minutes would be considered standard.

INDICATIVE COST RANGES

TYPE	GIFA rate (£) BCIS index 100	GIFA rate (£) City of London
Frame: low-rise, short spans, repetitive grid/sections, easy access (see Building 1)	75-100/m²	90-120/m²
Frame: high-rise, long spans, easy access, repetitive grid (see Building 2)	125-150/m²	140-170/m²
Frame: high-rise, long spans, complex access, irregular grid, complex elements	145-170/m²	165-190/m²
Floor: metal decking and lightweight concrete topping	40-58/m²	45-65/m²
Floor: precast concrete composite floor and topping	45-60/m²	50-70/m²
Fire protection (60-minute resistance)	7-14/m²	8-16/m²
Portal frames: low eaves (6-8m)	45-65/m²	55-75/m²
Portal frames: high eaves (10-13m)	55-75/m²	65-90/m²

■ **High-rise and longer span buildings, typically 10-15 storeys plus basements.** These often require longer structural grid spans, increasing frame weight, and may require cellular beams for the distribution of services. Use of regular column grids may be hampered by irregular city-centre sites or the requirements of mixed-use schemes. This contributes to higher average weights of steel frames of 65-85kg/m² including fittings. Buildings over 15 storeys are likely to have a higher proportion of complex elements and non-standard sections, and the rate range can be 15-20% higher than the top of the standard range.

Costs include allowances for concrete costs and have been developed from cost models of the building types. For both, the average weight of the structural frame is given. Within this range, it is important to confirm anticipated frame weights, variables and fire protection with the design team, and also each key cost driver in turn.

To use the table above, choose the frame type that most closely relates to the project, add the floor type and fire protection required and adjust the total GIFA rate using the BCIS index. These rates can be considered suitable for cost planning of projects where the structural works would have commenced in the first quarter of 2013. After this point, there should be allowance for inflation.

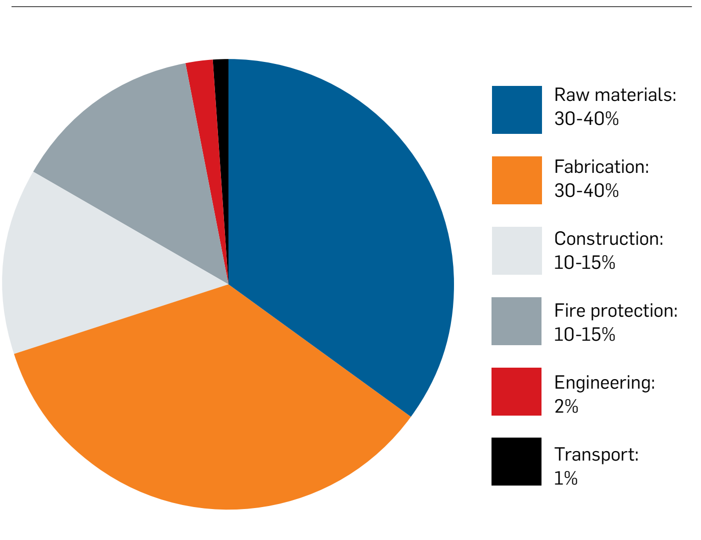
During detailed design

As the design develops, a more detailed costing of the structural steel frame on a per tonne basis can be made. This requires drawings from the structural engineer on frame configuration, cores and shear walls, columns and beams, section sizes and types, floor construction details and the strategy or integration of mechanical and electrical services.

The nature of the main members, secondary members, fittings and connections should all be considered. Each structural product, whether rolled I-section, structural hollow sections, fabricated plate girders or trusses will have its own costs depending on the differing fabrication and erection requirements. As popular sections may be manufactured up to four times more often than less common sections, it may be less costly to use heavier options that are more readily available.

To calculate the costs of the structural frames, each of the different components will have a rate per tonne applied and then totalled. This will include all elements of the cost of the profile from raw material to erection.

BREAKDOWN OF FRAME COSTS



Separate cost allowances are made for preparation and coating works, fittings and fire protection.

As the pie chart above shows, raw materials make up only 30-40% of total frame costs, with fabrication the same again, followed by construction, fire protection, engineering and transport. As a rule, 20 hours of fabrication time is roughly equivalent in cost to 1 tonne of raw material.

With construction typically accounting for 10-15%, it is worth considering the extent of repetition and connection type as these can significantly impact on frame costs.

Case studies

The costs for the two typical office buildings below were developed by G&T, Peter Brett Associates and Mace Group and updated quarterly. Embodied carbon was discussed in the last Steel Focus (3 May 2013).

For further information go to www.steelconstruction.info/Cost_comparison_study

CASE STUDY 1: BUSINESS PARK OFFICE BUILDING

This is a low-rise building in an out-of-town location, with a GIFA of about 3,200m². It has an 18m-wide, rectangular floor plate and a floor-to-ceiling height of 2.8m. There is one central core and two lifts. The envelope has a brick outer skin and the window allowance is 35% of the facade. Ventilation is mixed mode.

Peter Brett Associates set a structural grid of 7.5m x 9m for four frame types: steel composite beams and composite slab; steel frame and precast concrete slabs; reinforced concrete flat slab; and in-situ concrete frame with post-tensioned slab.

For all options, the foundations are unreinforced mass concrete pads. Core construction is steel cross-braced framing with blockwork infill for the steel options, and concrete shear walls for the concrete. For the roof, the steel frames have a lightweight steel deck and the concrete structures continue the concrete slab construction of the lower floors. Floor-to-floor heights for steel options include an 80mm service zone below the metal deck and a 600mm service zone beneath the concrete slab.

Costs are at Q2 2013 prices based on the City of London, and exclude fees, VAT, project contingency and fixtures.

The steel composite option has the lowest cost in terms of frame and upper floors, and in total. The reinforced concrete option has the highest frame, upper floor and overall costs, with the frame and floors over 10% higher than the steel composite option, and total building costs about 6% higher. The post-tensioned option has a slightly lower frame and floor cost than the steel and precast option, but the latter costs less overall due to lower roof costs and a shorter programme. On average, both steel options can be built 5% faster than the concrete alternatives.

BUILDING 1 COST MODEL (PER M^2 GIFA)

TYPE	Steel composite	Steel and precast concrete slabs	Reinforced concrete flat slab	Post-tensioned concrete flat slab
Substructure	£52	£55	£67	£62
Frame and upper floors	£140	£151	£153	£150
Total building	£1,535	£1,561	£1,628	£1,610

CASE STUDY 2: CITY-CENTRE OFFICE BUILDING

IMAGE: MAKE ARCHITECTS

This is an eight-storey city-centre office with a GIFA of about 16,500m². The design is L-shaped with a central core, internal secondary escape stair and double-height reception. The clear floor-to-ceiling height is 3m, with a structural grid of 7.5m x 15m. Curtain walling is in 1.5m-wide, storey-height panels with solar control fins. Solid areas are lined with cold-rolled metal studwork, insulation and plasterboard. There is four-pipe fan-coil air-conditioning and no natural ventilation.

The study compares two structural systems: a steel frame with cellular composite beams and composite slab and 60-minute fire resistance; and a concrete option using post-tensioned band beams and slab with in-situ columns. The overall floor-to-floor height for the steel option is 4.18m, and 4.375m for the concrete option. All costs are at Q2 2013 prices, based on the City of London.

The steel composite option costs more than 3% less than the concrete option on a whole building basis and more than 8% less in terms of frame and floor. The steel option's lower floor-to-floor height reduces the envelope cost by about 5%. Substructure costs are also less, due to a lighter frame weight and a lower roof cost.

Mace estimates that both options would require 20 weeks for substructure and ground slab construction. For the frame and floor, the steel option would take 16 weeks, and the concrete 28.

BUILDING 2 COST MODEL (PER M^2 GIFA)

TYPE	Steel cellular composite	Post-tensioned concrete band beam and slab
Substructure	£56	£60
Frame and upper floors	£194	£210
Total building	£1,861	£1,922