STEEL CONSTRUCTION
Commercial Buildings

Steel for Life and the British Constructional Steelwork Association (BCSA) are working closely together to promote the effective use of structural steelwork. This collaborative effort ensures that advances in the knowledge of the constructional use of steel are shared with construction professionals.

Steel is, by a considerable margin, the most popular framing material for multi-storey buildings in the UK and has a long track record of delivering high quality and cost-effective structures with proven sustainability benefits. Steel can be naturally recycled and re-used continuously, and offers a wide range of additional advantages such as health and safety benefits, speed of construction, quality, efficiency, innovation, offsite manufacture and service and support.

The steel sector is renowned for keeping specifiers abreast of the latest advances in areas such as fire protection of structural steelwork and achieving buildings with the highest sustainability ratings. Recent publications have provided detailed guidance on Fire Protection and CE Marking and what it means for the construction sector. Guidance is provided on all relevant technical developments as quickly as is possible.

The sector's go to resource website – *www.steelconstruction.info* – is a free online encyclopedia for UK construction that shares a wealth of up-to-date, reliable information with the construction industry in one easily accessible place.

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Introduction
by Sarah McCann-Bartlett, Director General,
British Constructional Steelwork Association

Steel a certainty

The commercial buildings market has been well served by steel construction for decades. It is hard to envisage what our cities' skylines would look like if it weren't for steel's ability to allow architects and engineers to fully exercise their vision and skills. It is also impossible to imagine our most iconic commercial buildings of the past 30 years or so without steel construction.

One of the certainties for those who would invest in buildings is that the UK will continue to be served by a world leading steel construction sector that has the capacity to respond to any likely increase in demand.

In this publication, readers will find many reasons why steel enjoys such a commanding position in the UK construction industry. For commercial buildings the obvious way to obtain the aesthetically pleasing, long span, column free, future-proofed, flexible spaces that the users of modern buildings expect is to use constructional steelwork. When some 70% of multi-storey buildings are constructed using steel frames year after year the clear message is that we are getting many things absolutely right.

That much is obvious, and the real challenge is not only to continue giving developers and designers compelling reasons to build in steel, but to maintain continuous improvement, and invest to ensure quality and productivity improvements that will make designing and building in steel even easier than before.

The structural steelwork sector looks forward to seeing, and to constructing, the iconic commercial buildings of the future.

October 2016

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The commercial buildings market stands ready for the future

Nick Barrett sees the steel construction sector's commercial building specialists ready to respond to the demands of the commercial buildings market.

After several years of strong growth in London, the commercial buildings market is strengthening in regional cities and towns. This is despite the short-term uncertainty that the Brexit vote created in the minds of some developers.

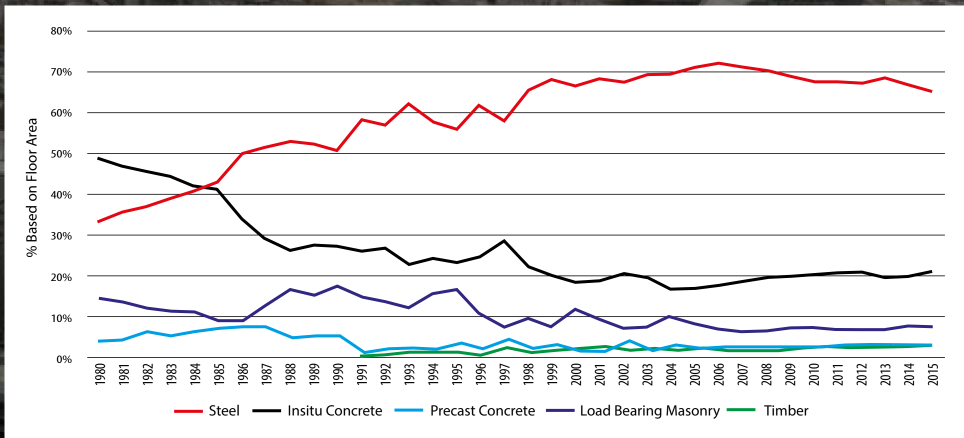
With 2016 expected to deliver the highest level of structural steel consumption in commercial buildings since 2009, the sector is maintaining its position as a key market well served by a steel construction industry that is at peak performance.

After some years of growth the size of the private commercial construction market, as it is called in government statistics, is now approaching £27,000 million per year in current prices. Surveys from independent researchers (see right) consistently show that this is a market that particularly values steel as a framing solution, with developers and designers of about two out of every three multi-storey buildings of all types opting for steel.

The reasons why can be seen in some detail throughout this publication – Steel Construction: Commercial Buildings. Cost, speed and ease of construction, offsite manufacture, sustainability, adaptability and flexibility are all highly valued by commercial developers.

While some forecasters are taking a slightly more cautious view of the London market in the short term, there is a planning pipeline of well over 100 multi storey buildings in London.

The underlying strength of the market for commercial buildings is underlined by a London Cranes Survey from Deloitte earlier this year, that is regarded as a useful market barometer for the multi-storey buildings market. This survey gave solid grounds for optimism, with 51 new schemes under way since the survey of a year previously. This was the highest number of project starts since the survey started 20 years



Construction Markets

Structural steelwork was confirmed as the preferred market choice as a framing solution for commercial buildings in the 2015 Market Share survey, which confirms the upward trend of demand for steel in several key markets.

The survey, the latest in a series carried out by independent researchers Construction Markets annually since 1980, is based on interviews with 750 architects, builders and designers, which makes it the biggest of its kind in the UK.

The total market for structural frames in 2015 was estimated to be 40.6 million square metres of floor area, up 7.2% from the previous year. Steel dominated the market for multi-storey office developments where it enjoyed a market share of 68%, up 1% from 2014.

The survey shows steel is the preferred choice of the construction market across all the building types analysed, with outstanding strength in the commercial sector.

ago, with the total volume of office space under construction up 28% in six months, the highest level since 2008.

Commercial building has always been a cyclical market.

The initial subdued responses to Brexit have given way to a more balanced outlook. Market sentiment moved from reports of a 'significant drop in sentiment' in the market immediately after the vote, to reports that the market was 'back to normal' by late September, while in between there were reports of foreign investors 'swarming' into the London commercial property market attracted by the weaker currency. Some overseas investors may remain on the sidelines until the dust settles on the UK's post EU environment. For other developers and potential occupiers of commercial buildings Brexit is not an important consideration.

The development market in the regions remains strong and less likely to be affected by the sentiment of foreign investors. There are still many projects going ahead across the UK, and Grade A office space remains in short supply in regional centres creating grounds for optimism.

Overall, there seem to be enough optimistic investors around to maintain a steady workload in the sector and there are good reasons to expect demand to remain solid over the next year or so before further growth kicks in.

Developers showed themselves capable of taking a long-term view a few years ago in the wake of the financial crisis when they decided to press on with major London schemes, especially in the City, in the hope that by the time construction was completed demand would have returned and offices in short supply; and so it came to pass. We have had a raft of iconic City buildings as a result, including the UK's tallest, The Shard. The post Brexit future will also belong to those with this kind of foresight.

Multiple reasons for cost-effectiveness

Steel has provided the market-preferred, most cost-effective framing solution for commercial buildings for almost 40 years. Whatever the state of the commercial buildings market, at all stages of the business cycle, steel provides the most cost-effective framing solution.

Projects such as 71 Queen Victoria Street, London relied on steel's long span attributes

Thanks to its low self-weight relative to concrete alternatives, a steel solution will always allow significant savings to be made in foundations costs. Other cost benefits arise from steel's inherent buildability and construction programme advantages.

The UK is the world leader for steel construction, which delivers cost benefits as the world's suppliers of steel and fabricating equipment prioritise the UK market, ensuring competitive prices all along the supply chain. The BCSA's membership ensures that a highly developed, healthily competitive constructional steelwork sector will always provide keen prices compared to alternatives along with their acknowledged technical sophistication.

Selecting steel also has many other cost saving benefits to construction programmes, which goes a long way to explaining why steel consistently commands a share of the multi-storey building market of around 70%.

A quality assured, offsite manufactured steel frame means cost savings from reduced on-site waste. Useable space is maximised thanks to the more elegant aesthetics of steel sections. The longer spans without intervening supports that steel makes possible also means more useable space is created. Construction programme benefits allow steel-framed buildings to be available for letting or sale sooner, a key consideration for developers.

Offsite production can make the difference between a project on a hard to access, possibly inner city site, being physically or financially possible or not. Visitor centres have been made possible in places like mountaintops – Snowdonia for example – only because relatively

Building 1

Building 1 is a typical out-of-town speculative three-storey business park office with a gross internal floor area of 3,200m² and rectangular open-plan floor space. Cost models were produced for four frame types developed by Peter Brett Associates to reflect the typical available framing options; steel composite, steel and precast concrete slab, reinforced concrete flat slab and post-tensioned concrete flat slab.

Building 2

Building 2 is an L-shaped eight-storey speculative city centre office building with a gross internal floor area of 16,500m² and a 7.5m x 15m grid. Cost models were developed for a steel cellular composite frame and post-tensioned concrete band beam and slab, being two frame and upper floor types that could economically achieve the required span and building form.

The latest cost data for both Building 1 and Building 2 from G&T for Q3 2016 is presented here.

Figure 1: Building 1 Cost Model (key costs per m² GIFA, Central London location)

	Steel composite	Steel and precast concrete slabs	Rein-forced concrete flat slab	Post-tensioned concrete flat slab
Substructure	£71	£75	£91	£85
Frame and Upper Floors	£177	£196	£173	£205
Total Building	£1,982	£2,099	£2,183	£2,165

Figure 2: Building 2 Cost Model (key costs per m² GIFA, Central London location)

	Steel cellular composite	Post-tensioned concrete band beam and slab
Substructure	£80	£86
Frame and Upper Floors	£244	£281
Total Building	£2,461	£2,565

As Figure 1 shows, the steel composite beam and slab option remains the most competitive for Building 1, with comparable frame and upper floors cost and the lowest total building cost.

For Building 2 (Figure 2), the cellular steel composite option has both a lower frame and floor cost and a lower total building cost than the post-tensioned concrete band beam option with lower substructure costs, lower roof costs and a lower floor-to-floor height resulting in lower external envelope costs.

The study also demonstrated that the steel-framed options had shorter construction programmes for both building types.

lightweight, offsite fabricated steel lends itself to easy transportation.

Steel's wider benefits include improved safety as fabricating and erecting a steel frame is inherently safer than alternatives that involve multi-trades and on-site congestion.

Fully costing the benefits of steel frames for buildings is difficult – what price do we put on the sustainability benefits of steel's future-proof flexibility, its ability to be infinitely recycled or re-used, or its lower levels of embodied carbon? Proper consideration of the life cycle costs of framing materials that takes a cradle-to-cradle approach is another calculation that will show cost advantages from using steel.

Costing buildings can be a complex process so the steel sector provides guidance on the costing process and up-to-date cost figures which are freely available on *www.steelconstruction.info*.

On costs alone, before factoring in any of its many other benefits, steel delivers the most cost-effective solutions for commercial buildings. This is demonstrated by an independent cost comparison study of two typical commercial buildings. Peter Brett Associates designed representative framing solutions for both buildings, Mace Group considered buildability, logistics and construction programme, and Gardiner & Theobald provided cost information for each frame option.

Principal Place in central London, like most commercial developments requires large column-free floorplates

Long span flexibility supports modern growth industries

Column-free, long span office spaces are one of the greatest advantages of steel frames, and for long the first choice for City developments. Nick Barrett reports that the many attractions of long spans have reached other areas.

Commercial building developers and designers are among the most enthusiastic fans of the long span capabilities of steel frames. When the financial services market started to grow after the City's 'Big Bang' in the late 1980's demand for large, column-free spaces for City trading departments famously took off, and steel-framed solutions now set the industry standard.

Many other industries have since been inspired to demand the same sort of modern, aesthetically pleasing, flexible, open spaces for their office environments, and architects increasingly valued the potential of allowing the building's structure to be expressed, leaving much of the steel frame exposed.

Modern growth industries are fast changing and that has brought demand for buildings able to be quickly and cost-effectively changed to meet new needs – perhaps frequently or at least several times over a building's life. Column-free, clear spans in steel-framed commercial buildings today are commonly up to 15 metres, compared to between six and nine metres 20 years ago.

Increasingly sophisticated mechanical engineering systems are needed to heat, cool and illuminate the modern multi-storey buildings typically used in commercial environments, and fortunately these services can be easily integrated within cellular beams that go hand in hand with long steel spans. Achieving BREEAM "Excellent" ratings for these buildings can be straightforward thanks to steel's excellent sustainability credentials, such as a favourable embodied carbon rating.

Longer spans mean beams have to be deeper to give them the required increased structural strength, which at first glance might look like a disadvantage. But in fact using cellular long span beams creates space that allows services to be carried through the beams, rather than below them, integrating them within the structural zone. Overall floor depth requirements are reduced, allowing more floors to be created for a building of a particular height. Alternatively, the same number of floors could be created within a shorter building, which means a reduction in cladding costs.

With fewer columns in a building using long spans, there are fewer foundations, already minimised because of the relatively low self-weight of any steel framed building. As well as saving on costs this reduces the building's carbon footprint as a significant proportion of a building's embodied carbon is in the foundations. Longer spans can also contribute to the vibration performance of a building as more mass

Steel's long span qualities are utilised in distribution warehouses

Car parks also need large column-free areas

will be mobilised in the floor system.

The appetite for column-free, fully flexible space appeals to both building owners and users. Tenants are finding that they can adapt long span areas easily as their needs evolve, and adaptability means new tenants can easily be provided with an internal layout that works for them.

The preference for column-free spaces might have evolved with City trading floor needs, but the trend towards open-plan working areas helped ensure its spread in popularity to other industries.

Developers report that tenants in key growth markets like technology and the creative industries in particular also demand high quality, long span, column-free spaces as they foster collaborative working and their aesthetic appeals to the highly skilled workers in those industries.

Ease of changing internal configurations means areas can be cordoned off if required, for traditional facilities like break out and meeting rooms, but also for the legendary 'play areas' that companies like Google and Apple provide for staff.

Long spans have always been popular in other sectors but the examples being seen in commercial buildings are what sparked a new interest in long spans and clear spaces for all building types. For example, all of the London 2012 Olympics stadia took advantage of the long spans that only steel can provide. High height clearances demanded by many sports are also efficiently provided in steel buildings.

Longer spans than the typical 15 metres that a City trading floor uses can be achieved with trusses and spans of 50 metres are not uncommon. Some industries are seeing value in capturing the flexibility advantages of long spans by using trusses in structures that look like conventional 'sheds', allowing them almost infinite reconfiguration possibilities.

Other sectors have been inspired by the pathbreaking example of large column-free spaces and the flexibility they provide in commercial buildings. The retail sector for example has eagerly bought into the potential, as long spans mean that shelf space can be maximised and internal layouts reconfigured in line with marketing demands. Steel-framed retail buildings can also be easily and quickly reconfigured to accommodate changing shopping habits or even a radical change in the type of product sold from a store.

School designers have also learned these lessons, and some school authorities have specified that buildings must be designed to accommodate changes in classroom sizes and teaching methods as well as possible changes to non academic use in future, which has meant long span steel solutions.

Car park operators see the value of steel in creating more aesthetically pleasing, and less intimidating structures, with long spans eliminating many columns so making it easier for vehicles to be manoeuvred and more parking spaces being made available.

Flexibility in the way it can be used is an obvious attribute to have designed into a building for an increasing range of developers, building owners and users. As the pace of change seems to pick up steadily in the modern world, we can expect modern buildings to increasingly have long spans created by steel.

The ultimate sustainable material choice

Steel is the ultimate sustainable construction material, supporting the environmental strategies of building owners and tenants of all types. Nick Barrett outlines the sustainability case for steel construction.

Steel-framed solutions have proven to be the superior sustainability choice for commercial buildings of all types for many years, thanks partly to the inherent sustainability advantages of steel as a construction material, but also because of its flexibility which allows designers to generate new sustainability enhancing ideas.

Steel-framed commercial buildings routinely achieve the highest ratings after being assessed under BREEAM for how they perform on key environmental indicators. Low and zero carbon buildings are made possible with steel. Developers recognise the value of ratings like BREEAM's 'Excellent' and tenants are proud to occupy buildings that they are confident will support their own sustainability policies and reduce running costs.

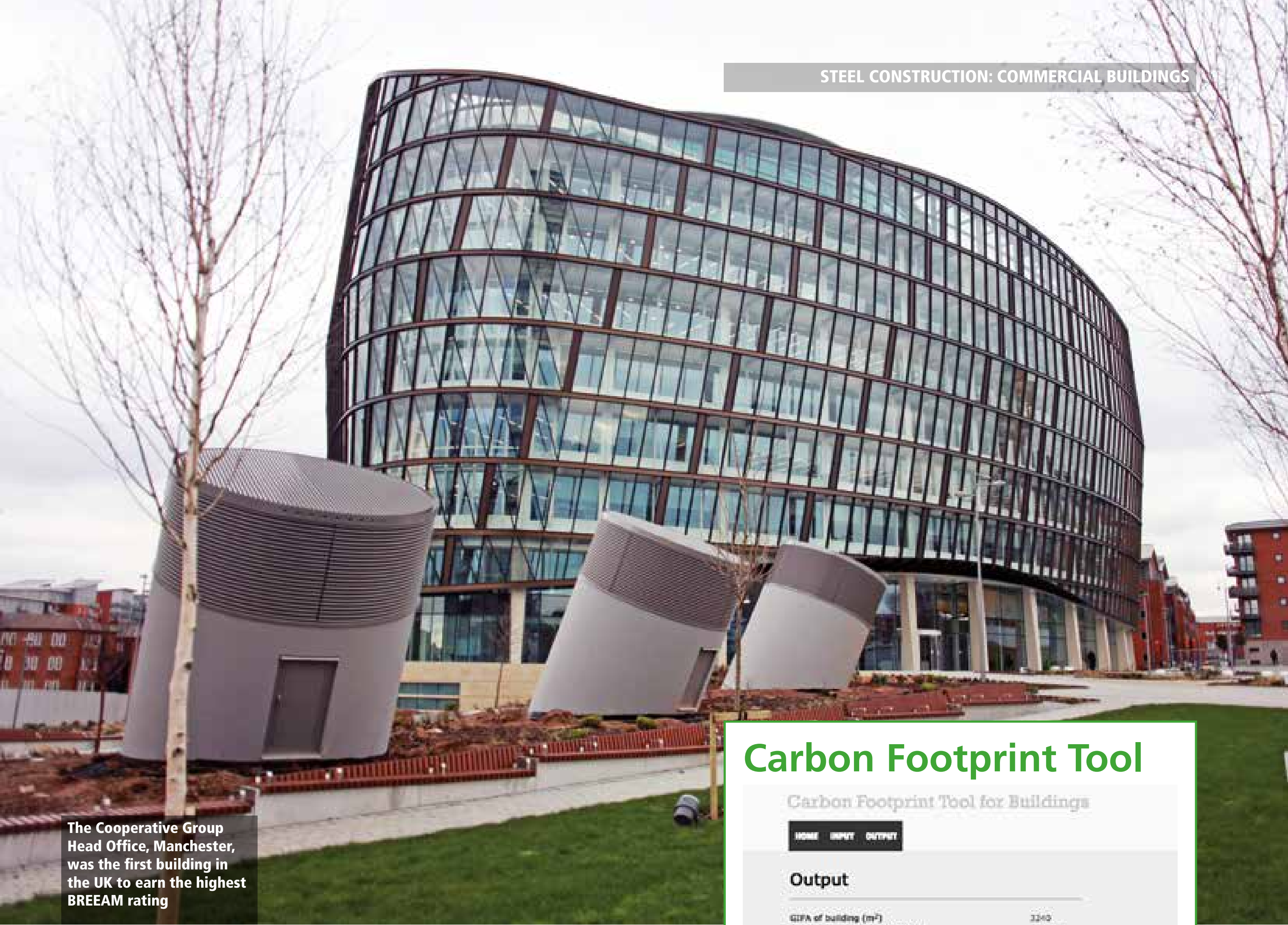
Steel has a host of sustainability advantages to take advantage of in the design and construction of buildings. Steel has a relatively low self-weight when compared to alternative framing materials which means foundations can be smaller – a significant percentage of a building's embodied carbon is in the foundations so steel will always score better than alternatives on that measure alone.

Steel is manufactured in plants that have improved their environmental performance dramatically over the years and the industry collaborates worldwide on energy and carbon emissions reducing projects.

In the UK structural steelwork is manufactured in factory environments where waste minimisation and high quality are key business objectives for the world's leading and most competitive steelwork contractor industry. Fabricating steelwork represents the sort of offsite manufacture that other parts of the construction supply chain can only envy. Many years of consistent investment in quality and productivity enhancing fabrication equipment lie behind the UK industry's acknowledged world leadership, all of which delivers sustainability advantages today.

Having its skilled workforce mainly in the workshop rather than travelling the country from site to site means steel construction scores highly on sustainability measures that focus on the quality and welfare of the workforce. Safety is enhanced by having most of the work carried out in easier to control factory type environments rather than on congested construction sites. Erection of steelwork on site is carried out by skilled specialists, also working in relatively safer conditions from Mobile Elevated Work Platforms.

Steelwork contractor members of the BCSA can sign up to a Sustainability Charter that commits them to an independently assessed set of



The Cooperative Group Head Office, Manchester, was the first building in the UK to earn the highest BREEAM rating

sustainability-related performance indicators. The contractors can demonstrate their own carbon footprints by a specially developed carbon footprint tool.

Steel can fully justify its claims to be the ultimate sustainable construction material. It's adaptability means that rather than being demolished to make way for a new building with changed use, a steel-framed building can often be reconfigured for a new use, and given a whole new look by changing its cladding. The long span capabilities of steel construction provides clear spaces that can be easily reconfigured, offering the prospect of extending a building's useful life.

At the end of a building's useful life its steel frame can be easily dismantled and elements of it either re-used or recycled; demountability can be designed into a steel building, allowing owners to plan for future use on another site. Steel used in construction will not go to landfill as even scrap steel has a value and is a vital element in the process of producing new steel. Steel can be recycled in this way infinitely as successive recyclings do nothing to reduce its qualities; it is not merely recycled, but multicycled.

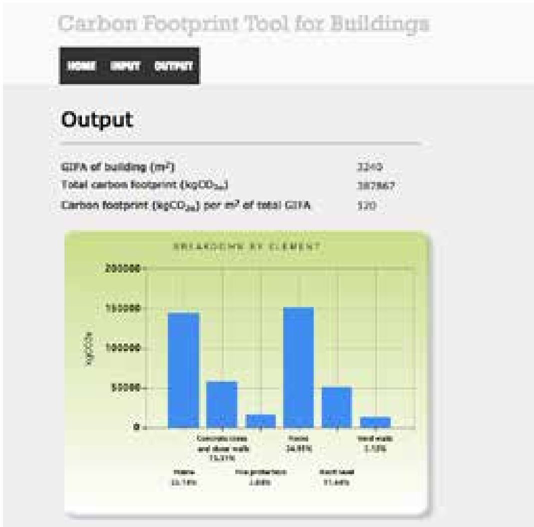
This whole life cycle value of steel has always existed and been taken advantage of - it predates today's sustainability concerns by generations - and the infrastructure to support re-use and recycling is highly developed. Some 99% of structural steelwork arising from demolition in the UK is recovered, and 96% on average of steel products of all types, a great example of the circular economy philosophy already in action.

Steel even extends the life of other structures, frequently being used to provide a new structure behind a retained façade that allows survival of the appearance, and at least part of the structure, of historically important buildings.

Heating and cooling commercial buildings accounts for a significant part of their whole life running costs and carbon emissions, and a key way to control all of these is proper consideration of thermal mass at the design stage. Optimal thermal mass is easily achieved in typical steel-framed commercial buildings.

When proper 'cradle to cradle' costings are calculated, steel buildings easily produce the strongest sustainability case.

Carbon Footprint Tool



The steel sector has developed a web tool to enable designers of multi-storey buildings to easily estimate the superstructure's embodied carbon footprint. The tool is easy to use. In 'Auto generate' mode the basic building geometry, structural grid and chosen floor system are used to estimate structural material quantities using algorithms developed by the Steel Construction Institute (SCI) for common structural steel solutions.

The tool also provides a 'Manual input' mode that allows designers to enter the actual material quantities for their building.

Under either mode appropriate carbon emission factors are applied to the material quantities to estimate the overall carbon footprint of the building.

The results are presented as a single CO_{2e} figure for the building, a CO_{2e} figure per m^2 of floor area, and a bar chart illustrating the contributions to the total made by the various elements of the building, i.e. frame, concrete cores, floors, roof, fire protection, and void walls.

The tool is available at: *http://www.steelconstruction.info/Design_software_and_tools*

Regeneration on track

Two office blocks within a former railway station's retained façade are set to breathe new life into the area separating Manchester and Salford. Martin Cooper reports.

Set within a retained Grade II listed sandstone façade, and consisting of a nine and a 10-storey office block sat atop a three-level car park podium, the Embankment scheme forms an initial phase of a much larger regeneration project.

On the banks of the River Irwell, overlooking Manchester Cathedral, the project is situated on a plot once occupied by Exchange Station that closed down in 1969.

Opened in 1884, the bulk of this station was within the boundaries of Salford, although Europe's longest platform – built in 1929 – did provide a direct link to nearby Manchester Victoria Station.

Although the original buildings and platforms are long gone, the sandstone façade of the masonry podium that once supported the station has been retained and this forms the exterior for a three-storey car park on top of which, at podium level, the two office blocks will both sit.

The steel-framed car park infills most of the retained façade, except the rounded corner areas, creating 442 spaces.

The car park has been built around a variable grid pattern to meet parking requirements and the constraints of the existing retained façade, with stability-giving cross bracing positioned within internal bays and perimeter elevations.

As far as the steelwork is concerned, the car park and the first office structure [Building 101] are complete, with the second office structure (Building 100) due to begin early next year.

The roof of the car park or podium deck provided the design team with the project's biggest challenge as Ramboll Design Engineer Allan Wilson explains: "Both of the office buildings will have a similar design that includes main columns set at 7.5m centres, which doesn't match the car park grid below. This, combined with the larger column density in the core areas, led us to adopt transfer structures at this level to maximise parking spaces."

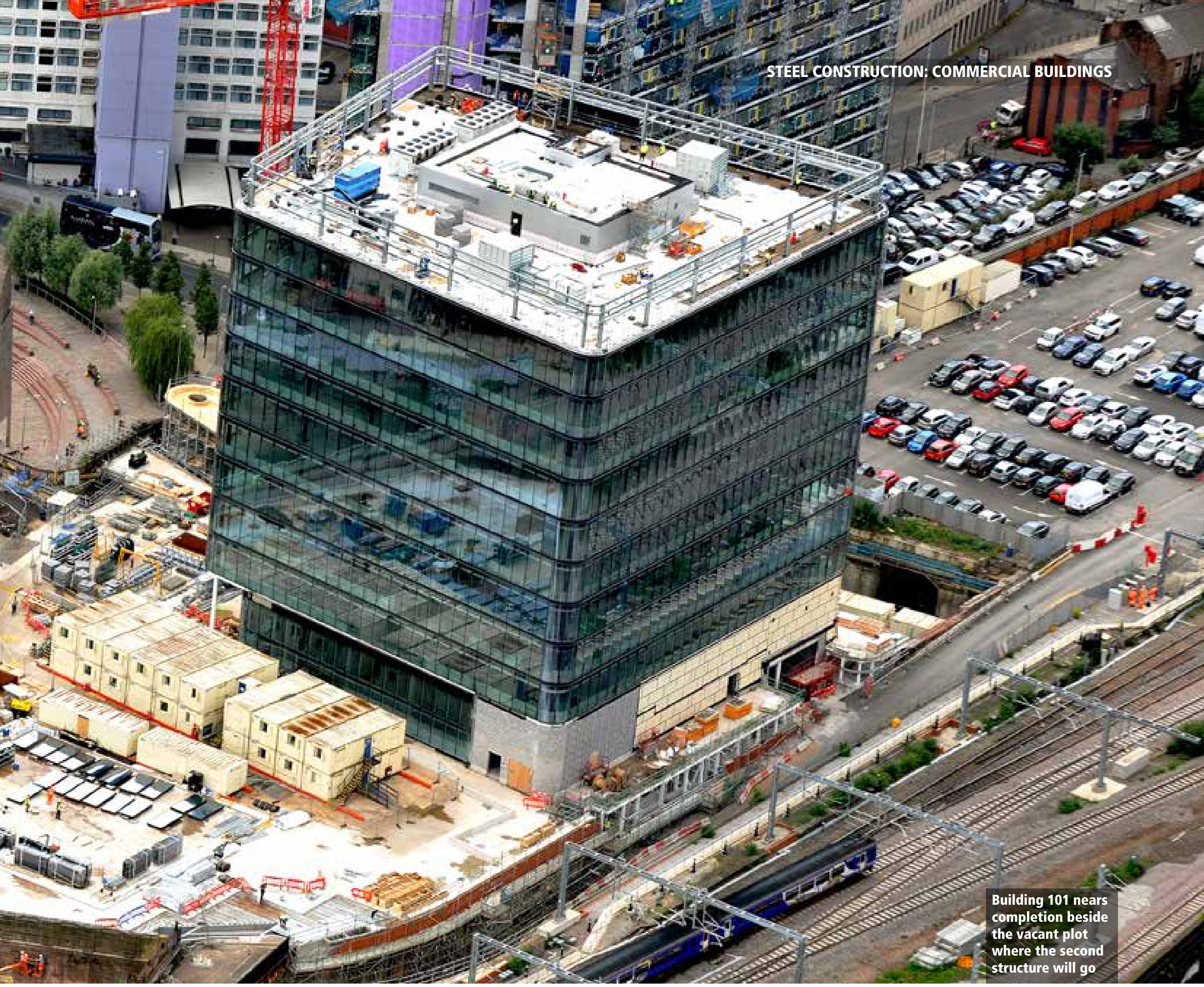
The client requirement to maximise the number of car parking spaces did not permit the building's cores to continue down through the podium structure. Therefore, steel-framed cores were adopted to minimise the loads onto the transfer structures, as they are significantly lighter than concrete cores.

Encompassing an area around each of the building's cores, which equates to approximately one third of their footprints, the two transfer slabs will employ an innovative design, with a 1,500mm thick slab built off a 130mm thick composite slab acting as permanent formwork.

The remainder of the podium slab is 170mm thick. In order to resolve complex punching shear issues, 914UB cruciform sections were cast within the depth of the transfer slabs.

"Many buildings of this size would have used a concrete core, but a steel core is quicker to erect," says Elland Steel Structures Commercial Director Jeremy Shorrocks. "In order to get the required stiffness the steel core is heavily braced and consists of a condensed configuration of beams and columns all supported by the transfer slab."

Steelwork for both transfer slabs was installed as part of the initial car park construction programme in preparation



Building 101 nears completion beside the vacant plot where the second structure will go

for the steel erection programme for Building 100 starting next year.

Building 101 is a 10-storey commercial block offering clear spans of up to 15.3m. Westok cellular beams, 680mm-deep with 475mm diameter holes, have been used throughout for service integration.

The centrally-positioned braced steel core, that accommodates six lifts, provides the structure with its stability.

Offering some aesthetic appeal around the exterior, all of the perimeter columns are circular hollow sections that are set within a 900mm cantilever and will be left exposed in the building's completed form. These sections are 406.4mm diameter columns at the lower levels, decreasing to 323.9mm diameter columns for the upper two storeys.

Columns outside of the building core were generally co-ordinated with the car park layout, but where this was not possible, transfer beams were employed to take the loads into the podium columns.

There are 25 transfer beams in total with the largest measuring 1,400mm-deep and weighing close to 8t.

Building 100 will have a similar design to its neighbour, however it will have a larger floor area on plan, but one less storey (nine-storeys), so the net lettable area is approximately the same as Building 101.

This second building will include a column-free cantilever corner (6.5m projection) and it will also incorporate curves to follow the shape of the listed retained façade wall. A further 1,500t of structural steelwork will be fabricated, supplied and erected for this phase.

For the erection programme Elland Steel Structures began its work by firstly installing the car park steelwork directly below each of the transfer slabs.

In preparation for the next phase of the construction programme, all of the transfer beams for Building 100 were also installed in readiness.

While the transfer slab was being cast Elland completed the remainder of the car park steel erection.

"We then erected Building 101, using a sequence that required three levels of core to be erected, followed by three levels of main frame steelwork wrapping around the core structure in a clockwise manner," adds Mr Shorrocks.

"These floors were metal-decked while the next three levels of core were going up. This then gave us a surface on which to work off of for the next stage of the sequence."

The Embankment scheme will be connected to Manchester city centre via the old station's link bridge that spans the River Irwell. As part of the project the bridge is being renovated including the wrought ironwork railings.

A new public square, adjacent to the scheme, has also been constructed and many of the retained façade's arches will include shops and restaurants complimenting the realm.

Phase one of the Embankment is due to complete later this year.

The Embankment, Salford

Main Client: Ask Real Estate, Tristan Capital, Carillion JV

Architect: Flanagan Lawrence

Main contractor: Carillion

Structural engineer: Ramboll

Steelwork contractor: Elland Steel Structures

Steel tonnage: 2,700t

Growing Leeds' commercial landscape

6 Wellington Place, Leeds
Main Client: MEPC
Architect: CJCT
Main contractor: Wates Construction
Structural engineer: Arup
Steelwork contractor: Billington Structures
Steel tonnage: 700t

The completion of 6 Wellington Place was another step towards satisfying the city's heightened demand for prime office space.

Leeds city centre has seen a number of changes in recent years as new commercial and residential schemes alter the landscape of former industrial sites on either side of the River Aire.

One such commercial scheme, known as Wellington Place, is located five minutes walk west of the city centre. Here a number of medium-rise commercial, retail, leisure and residential blocks are planned for a site once occupied by Leeds Central Station.

The station closed in 1967 and all that remains of the site's transportation heritage is a wagon hoist tower, once used to lift goods, and the viaduct over the River Aire and Leeds Liverpool canal.

Developer MEPC envisages turning the site into a prestigious new multi-use quarter and so far it has completed three commercial blocks with another, 3 Wellington Place, due to start shortly.

All of the buildings have different designs and footprints but one thing they do have in common is that they all have steel frames.

6 Wellington Place was completed in April and is a six-storey (including ground floor) structure with a basement car park offering 9,600m² of grade A office and retail space.

The structure is wedge shaped in profile, with four elevations. From the widest south facing elevation the building tapers down to the narrowest northern façade.

The roof slopes down from the southern façade and conceals a plant deck, while the rooftop of the narrowest part of the wedge accommodates an outdoor terrace for the topmost offices.

Arup did the original concept design for No.6, and this was then value engineered by the Wates Construction-led project team to make it as efficient as possible (see box).

"By using cellular beams throughout the building we made the steel frame lighter and more cost-effective," says Wates Construction Project Manager Dan Miller. "A lighter frame requires shallower foundations which meant we had a quicker programme."

Prior to Billington Structures starting its steel erection programme Wates had completed the project's early works. These included digging out the basement car park, constructing the concrete retaining walls and installing CFA piled foundations.

Two main concrete slip-formed lifts cores, along with three smaller stair cores, provide the steel frame with its stability.

The steel columns begin at basement slab level and a regular grid pattern, based around columns spaced at 7.5m and 11.8m centres, extends upwards to roof level.

A slightly higher floor-to-ceiling height of 5.5m is accommodated within the ground floor, which houses the office entrance foyer and some retail units. Another prominent feature is the centrally-positioned full-height atrium that allows natural light to penetrate the building's inner zones.

The majority of the project's steelwork was erected using the on-site tower crane working in conjunction with two MEWPs each with a 40m-high maximum reach.

"The only exception was a 6.5t transfer beam at first floor level supporting two 24m high, five-storey columns across the 10m-wide opening required for the basement car park entrance," says Mr Miller.

This was the heaviest steel member erected for the job and it required steelwork contractor Billington Structures to bring a 60t-capacity mobile crane to site.

However this wasn't the largest piece of craneage needed for the steel programme. As the majority of the steel frame was erected from within the building's footprint, there came a point when the company had to complete the final grids from outside the footprint.

The MEWPs gained access onto the basement slab via a temporary ramp, but as the job progressed this had to be removed. This left the MEWPs, which weigh more than 20t each, with no way out other than being lifted.

"The MEWPs were very large and were chosen for their reach which proved to be invaluable during the erection programme, but to get them out of the basement we had to use a 220t-capacity mobile crane," says Mr Miller.

Summing up the project, Wates Construction Yorkshire and North East Business Unit Director Paul Dodsworth says: "As Leeds' commercial market continues to flourish, a strong business hub is emerging in the city, which is mirrored through our delivery of 6 Wellington Place."

Cellular solution

Kloeckner Metals UK Westok engineers worked closely with Wates Construction and Billington Structures to value engineer the frame.

The floor beam solution comprises 11.8m span Westok floor beams spaced at 3.75m centres. The architect had placed a 700mm depth limit on the beams, and so Westok provided a minimum 500mm diameter cell hole across the full width of each floor beam. This ensured the current service requirements were met, and also provided for maximum flexibility in future-proofing the service needs of the building.

Kloeckner Metals UK Westok Design Team Leader John Callanan comments: "This was a very good example of the return of the commercial office sector. As we move out of recession, we've noticed a significant upturn in steel-framed office developments."

The completed 6 Wellington Place (this photo) and the building after the steel programme was completed (opposite)

The full height atrium ensures daylight can penetrate central areas of the building

Midlands rejuvenation

The 1,000t steel frame was completed in 12 weeks

Coventry city centre's Friargate development has kicked off with the construction of an 11-storey commercial block. Martin Cooper reports.

Over the coming years a large 37-acre swathe of Coventry city centre will be transformed as the Friargate regeneration project progresses. The first building in this scheme – a new office for the local council – is under way, with a second office block due to start very soon (see box).

The Friargate vision is to deliver a high quality, low carbon development that generates jobs and attracts investment. Situated opposite Coventry railway station, the mixed-use office-led development will also encompass residential blocks and a hotel, creating a new city gateway.

Steelwork will play a significant part in the construction of Friargate, beginning with Building One, which is an 11-storey steel-framed office block to be occupied by Coventry City Council.

Prior to work starting on this initial structure, main contractor Bowmer & Kirkland spent nearly nine months on site demolishing existing buildings to make space for the new building, creating new footpaths and doing service diversions.

Known as Project Heron, Building One is constructed around a slightly offset slipformed concrete core, with the steel composite frame, supporting 150mm-thick decks, sitting atop a ground floor transfer slab that spans a two-level basement.

No internal bracing systems are necessary as all of the steel frame's stability is derived from the core.

Perimeter columns are spaced at 9m centres, while internal spans are up to 12m-long, creating a mostly column-free environment for the majority of the building's floorplate.

Bowmer & Kirkland Project Manager Paul Kelly says: "The design for this building is steel-framed as it is a quicker, and a more efficient method of creating the required long spans."

Capita Project Engineer Dave Middleton agrees and says: "Early in the design phase we undertook a comparative study which looked at a number of framing options. The optimum solution, which met the both the architectural and services requirements in the most cost-effective manner, was found to be a steel frame with cellular beams'.

Working on behalf of main contractor Bowmer & Kirkland, Hambleton Steel has erected approximately 1,000t of structural steelwork for the project, a total that includes 400t of Westok cellular beams.

"We worked in conjunction with Hambleton Steel to develop the most cost-effective cellular beam solution for the building," says Kloeckner Westok's Design Team Leader John Callanan.

"This is another example of the type and scale of modern Grade A office development we continue to see across the UK and Ireland, where the structure

Friargate Building One, Coventry
Main Client: Friargate Coventry
Architect: Allies and Morrison
Main contractor: Bowmer & Kirkland
Structural engineer: Capita
Steelwork contractor: Hambleton Steel
Steel tonnage: 1,000t

Friargate masterplan

According to project architect Allies and Morrison, the masterplan for Coventry Friargate will re-establish a straightforward and direct connection between the railway station and the city centre.

A new public square will be created in front of the Grade II listed station and Warwick Road will be transformed into a tree-lined boulevard with a public transport interchange close to the station.

The mixed-use scheme will provide high quality office buildings, with restaurants and shops at ground level. Hotels, leisure and community uses are also planned, with housing located in the quieter areas to the east and west of the central quarter.

Visualisation of the completed Building One

and service solution work hand-in-hand to deliver a flexible and cost-effective floorplate.

"Clients demand open, flexible, clear span office structures which are speedy to erect, and cellular steelwork hits the mark by integrating the service requirements of today, while at the same time providing the requisite future-proofing needed to safeguard against late design changes and differing future tenant service requirements.

A continuous string of cells within the beam is the most cost-effective means to achieve this. We worked closely with Hambleton Steel to value engineer the floorplate and discrete 400m × 700mm elongated cells were provided in the Westok floor beams to allow large rectangular ducts to pass where needed. These compliment the string of 400mm diameter cells provided in each beam."

Steelwork was completed during a 12-week programme with Hambleton initially using two mobile cranes and MEWPs, positioned on the ground floor slab, to erect up to level six.

Once the steel metal decking had begun to be installed, the upper floors were then erected using the site's two tower cranes supplemented by deck rider access equipment positioned on the decked levels.

Offering a spacious entrance lobby and areas for possible retail units, the building features a double-height ground floor area. This is formed with 356UC perimeter columns that then decrease in size as the building rises.

"Large section sizes were required as the steel frame is working hard supporting the cladding which is a panelised brickwork system with panels weighing up to 12t each," says Mr Kelly.

Offering breakout space for the office workers, the uppermost level of the building steps back on all sides to form a terrace.

Ready for occupation next year, the building will accommodate many of the Council's office-based staff. Summing up, Ann Lucas of Coventry City Council says: "This first building sets the standard, and as we want to be a top ten city again, developments like this will help us get there."

Second steel-framed office to start soon

Coventry City Council has recently approved the second building in the Friargate development. Sitting alongside Building One it has a similar steel-framed design.

The 14-storey office will have a double-height ground floor that will provide leisure space for a restaurant or café, and a seventh floor terrace.

Stephen Reynolds of Friargate Coventry said: "We are pleased to have secured consent for the second building having worked closely with the Council throughout the planning process. The masterplan is now beginning to redefine the urban landscape linking the station with the city centre."

Cellular beams, for services integration, have been used throughout the project

Cantilevering wall

Steel transfer structures supporting cantilevers and terraces abound on this prestigious City of London commercial development.

London Wall Place, London
Main Client: Brookfield, Oxford Properties
Architect: Make
Main contractor: Multiplex
Structural engineer: WSP Parsons Brinckerhoff
Steelwork contractor: William Hare
Steel tonnage: 8,500t

London Wall Place will be a new destination in the City of London, offering an acre of landscaped public realm set between two landmark office buildings with more than 46,000m² of Grade A office space. The realm features remains from the Roman City Wall and a Saxon church, surrounded by gardens, water features and suspended walkways.

Overall the project covers an area of more than 15,000m², on a plot previously occupied by numerous buildings including the 1960s built 20-storey high St Alphage House.

Work started on site in 2013 with main contractor Multiplex demolishing all of the existing buildings, while protecting the historic structures, and then enlarging the site's existing basement to create a two-level deep zone.

A portion of the high-level pedestrian walkways, known as the Barbican and City Highwalks, originally crossed the site and were removed as part of the demolition programme. These will be reinstated with a series of new weathering steel bridge-like walkways as part of the overall scheme (see box).

Both buildings, to be called 1 and 2 London Wall Place are steel-framed structures rising to 12 and 16 storeys respectively. Structurally independent they will however be linked by one of the weathering steel walkways that will eventually span the centrally positioned pubic realm.

The steelwork starts at ground floor level atop the concrete ground floor slab. Both buildings comprise a steel frame with composite concrete floors stabilised by concrete cores that incorporate the stairs and lift shafts.

"A number of alternate structural systems were considered during the design phase," says Multiplex Project Director Phil Clarke. "But it had to be a steel solution to meet the structural demands of the cantilevers."

Providing more than 27,000m² of floorspace, the 12-storey 1 London Wall Place is the largest, in terms of volume, of the two structures.

The final shape of the external envelope has been driven by the rights to light afforded to the adjacent Barbican and St Paul's Cathedral viewing corridor. Consequently the structure sets back at a number of areas to create terraces at the upper levels in order to reflect the planning requirements.

"To maximise floor space this building cantilevers out over adjacent roads on two of its main elevations," explains WSP Parson Brinckerhoff Senior Technical Director Stephen Jackson.

1 London Wall Place cantilevers by up to 8m along the London Wall elevation

1 London Wall Place cantilevers over the adjacent road by up to 8m

High-level walkways

A unique feature of the London Wall Place project will be the reinstated walkway structures, or Highwalks, that will cross the site to re-establish links to other parts of the City's high-level walkways.

Seven walkway structures fabricated from weathering steel are being installed as part of William Hare's steel package.

Three of the structures are reinstated bridges, one crossing London Wall and the other two spanning Fore Street, while a fourth will create a new high-level pedestrian bridge across Wood Street. The other structures crisscross the site below and around the new buildings linking all of the bridges together.

and by up to 3.5m along Fore Street.

Deep fabricated beams up to 1.95m in depth have been incorporated into the level 2 transfer structure to achieve the longest cantilevers. Other local transfers are also incorporated within the building at every floor to achieve changes in column grid as the envelope sets back floors and terraces.

Overall this structure's floor framing typically consists of primary beams spanning 9m with secondary beams, spaced at 3m centres, spanning up to 16.5m and in some locations up to 18m.

Steelwork contractor William Hare has installed numerous fabricated sections to act as transfer structures as standard rolled sections do not provide the required capacity.

"The heaviest fabricated beam we have installed is 70t and like many of these large beams it had to be lifted into place by a 160t-capacity crawler crane we had on site for the early part of the steel programme," says William Hare London Operations Director Curzon Graham.

Having such as large crawler crane on-site was a challenge in itself. Because the basement extends below most of the site's footprint and the slab would not ordinarily be able to support such a large crane, more than 300 temporary props were used to support the slab while the crane was on-site.

On the adjacent 16-storey 2 London Wall Place, the floor framing, from level two upwards, typically consists of primary beams spanning 7.5m and secondary beams provided at 3.75m centres with spans of up to 13.5m and in some locations up to 15m.

This structure also features cantilevers, which have again been introduced to maximise the floor area, although on this building the cantilevers are approximately 11m beyond the nearest internal column.

Along the south east corner of 2 London Wall Place the building cantilevers out over the main thoroughfare of London Wall, creating one of the project's main features and something of a structural steel highlight.

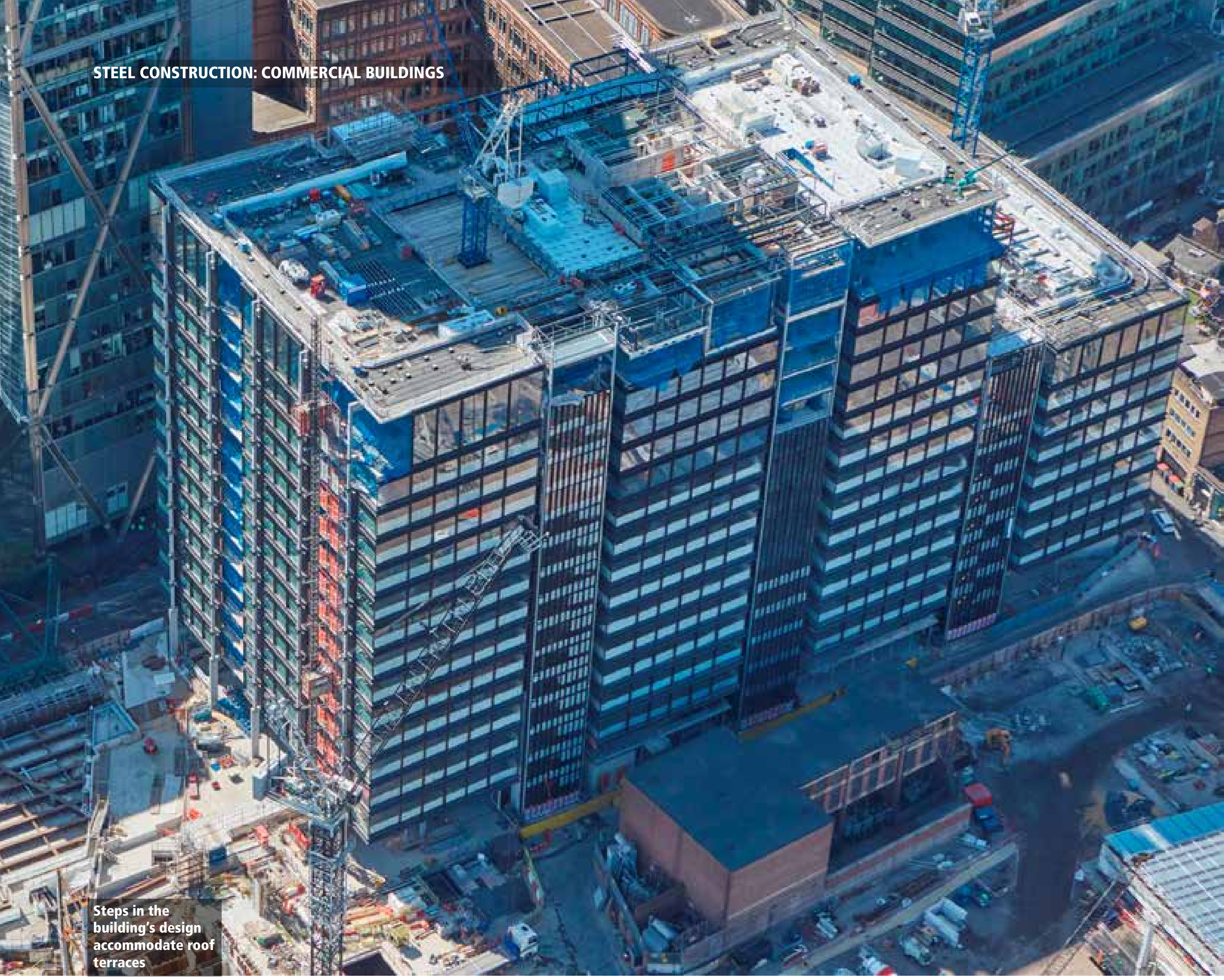
A series of single storey high trusses have been installed to form these long cantilevers and to help limit the potential for high deflections.

The chord members of the truss are 640mm deep fabricated sections that form part of the main floor framing. The diagonal bracing elements are universal column sections enhanced with plates welded across the flanges to provide the necessary strength and stiffness.

Supporting fifteen floors of the building, the truss members and their supporting columns are heavy and large. They were brought to site in two or three sections to make them transportable by trailer. Once on-site they were bolted together and then lifted into place by a 500t capacity mobile crane again sited on the ground floor slab with extensive back propping through the deep basement.

London Wall Place is due to complete in 2017

View of the project and its London Wall elevation



Steps in the building's design accommodate roof terraces

Principal Place Commercial, London
Main Client: Brookfield Property Partners
Architect: Foster + Partners
Main contractor: Multiplex
Structural engineer: WSP Parsons Brinckerhoff
Steelwork contractor: Severfield
Steel tonnage: 8,000t

A tower of principal

Located on a prime central London plot, the 15-storey Principal Place Commercial is a landmark mixed-use development utilising steel construction's flexibility. Martin Cooper reports.

Located just to the north of the City of London boundary, Shoreditch has in recent times transformed itself from a run-down former manufacturing district into a trendy and fashionable area that now seamlessly merges with the nearby business-dominated streets.

Taking advantage of Shoreditch's proximity to the Square Mile, a number of commercial developments have sprung up, including Principal Place Commercial, a 15-storey development being built by Multiplex.

Designed by Foster + Partners the 79,000m² scheme offers efficient and high density Grade A space with typical floors of 4,100m². The building will also offer retail space within its ground floor area.

The steel-framed building will also feature a 1,400m² reception area and a significant public realm, as well as two roof terraces exclusively for tenant use. All of these attributes, and with the City of London literally next-door, have persuaded Amazon, the global on-line retailer to pre-let 40,000m² of space at Principal Place.

A project on this site had been mooted for a number of years and a previous developer did begin preliminary works and installed a significant quantity of steel to form a bridge over the railway lines into Liverpool Street Station.

This ground level grillage of steel beams has now been incorporated into the Principal Place job, as it will form the entrance to the new building and a support for the public realm.

Brookfield Property Partners acquired the site in 2012 and immediately reviewed and improved the overall design with significant changes to the façade and interior of the scheme.

"Principal Place was always going to be a steel-framed building, but our design changes have enhanced the building and its cost-effectiveness," explains Multiplex Project Director David Jordan.

City of London viewing corridors required a lower western portion of the building

Prior to the construction programme starting, sports pitches most recently occupied the plot, although in the past it had been the site of a railway yard and one of Europe's first gasworks in the early 19th Century.

"The industrial past of the site meant we had to remediate parts of the site before we could start on the building's substructure," adds Mr Jordan.

The site's history went back further than Georgian times as Mr Jordan adds. "As with many central London projects, an archaeological dig was also undertaken and quite a few medieval and Roman artifacts were recovered."

Steelwork for the superstructure begins at basement level, so once this had been dug out and the slab cast, Severfield was able to begin its steel erection programme.

The centrally-positioned concrete core, that provides the steel frame with its stability, was more than 60 percent complete when the steelwork package started. To allow both of the site's tower cranes to be used for the steel erection, a third crane was temporarily installed by Multiplex to serve the core construction.

"One of the main challenges for us was the installation of the basement to first floor columns," says Severfield Associate Project Director Steve Dobbs. "They were erected and left free-standing while the reinforced ground floor slab was cast around them, as erecting them after the slab was cast would have been very difficult."

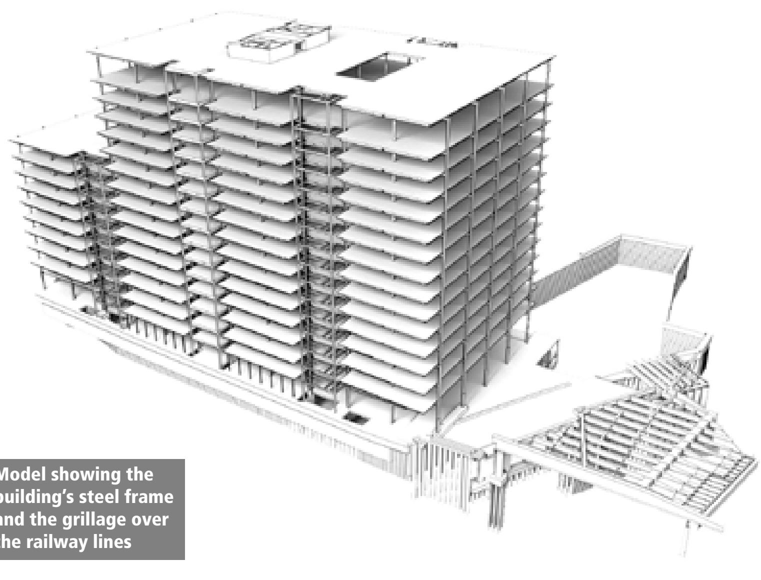
To allow the columns to free-stand, a series of large base plates was initially installed, these each measured 1.5m × 1m and weighed close to 1.5t. Once the base plates were in place the columns were then attached via a welded connection.

Within the double-height basement a steel-framed mezzanine deck was also installed along with the main columns. This extra level will primarily support cycle storage facilities and plant areas.

The steel frame has been erected around a 10.5m × 10.5m grid, offering quite a lot of repetition as the steel frame went up. Two of the main features are the double-height entrance foyer that incorporates a first floor that is setback to overlook the main doors, and large 4.5m deep cantilevers that run along both of the building's main elevations.

One of the enhancements to the original design was the addition of these two cantilevers. The columns have been set back to form these overhangs and increase the floorplates above. An added benefit has been the creation of a sheltered pedestrian walkway along the Worship Street elevation.

"A lot of work and coordination was required so we could agree the cantilever deflection criteria with the cladding contractor," says WSP Parsons Brinckerhoff Project Engineer Andrew Woodward.



Model showing the building's steel frame and the grillage over the railway lines

The building has a step at level 10 that creates one of its roof terraces on this western portion – the other terrace sits atop level 15 on the eastern side. As well as forming an interesting design feature, viewing corridor regulations also stipulated a lower part of the structure at the western side.

During the initial steel erection programme both of the site's tower cranes were positioned within the structure's two atriums. However, once the steelwork had progressed past level 10, Multiplex decided to reposition the crane on the western side in order to help speed up the cladding installation within the atrium.

In order to support the tower crane on the steel frame at level 10, Severfield designed, fabricated and installed a bespoke steel grillage.

Also at level 10 the main core decreases in size, as there are less services to accommodate for the upper floors.

"This means the steel piece count actually increases for the upper levels as more steel components were required to infill the area above the core," adds Mr Woodward.

"Plus the roof has a significant amount of steel to form plant enclosures and a Building Maintenance Unit (BMU) support system."

Principal Place is targeting a BREEAM 'Excellent' rating and is scheduled for completion by the end of the year.

INEOS Headquarters, Grangemouth, Stirlingshire
Main Client: INEOS UK
Architect: Michael Laird Architects
Main contractor: BAM Construction
Structural engineer: Woolgar Hunter
Steelwork contractor: BHC
Steel tonnage: 950t

Steelwork ensures a safe design

INEOS Olefins & Polymers UK, the country's largest privately-owned company and one of the world's largest chemical businesses has a new, state-of-the-art and blast resistant steel-framed headquarters.

Constructing a new office block within a large petrochemical works brings with it a host of unique challenges, the most important of which is to be blast resistant.

In the event of an accident involving combustive materials, the new building must be able to withstand any possible resultant blast, all of which requires a number of considerations to be implemented during the design stage.

This was precisely the challenge set for the team that constructed the £20M steel-framed headquarters building for INEOS at its Grangemouth facility in Stirlingshire.

"Because of the location, the design stage for this project was more onerous than would be expected for a job of this size," explains BAM Construction Project Manager Gary Brown. "Because the building is located within a major petrochemical complex the office HQ had to be designed to take this into account and so we employed a specialist blast engineer who had to review all of the initial designs, including the steel frame, secondary steel and cladding, to ensure everything was blast resistant."

Woolgar Hunter Senior Engineer Kenneth Irvine adds: "We worked closely with Michael Laird Architects to develop a solution for the steel frame and cladding, which addresses the loading issue but still provides an

The completed blast resistant HQ building elegant and economic building.

"The structural design had to take into account potential blast loadings and so the steel frame has to be flexible." The requirement for the steel frame to be ductile in the event of a blast led the design team to choose steel-framed cores for the building instead of the more rigid concrete versions.

All of the cross bracing comprises 250mm × 12mm flat sections, which were chosen as this steelwork offers optimum flexibility. The only areas where flexibility is not required are the connections between the cross bracing and the main frame's columns. Here large stiffened connections have been designed to hold firm against blast loads.

The 6,500m² steel-framed building now provides high-quality open-plan office space over four floors and includes meeting rooms, conference facilities and kitchens located on the ground floor. Main contractor BAM Construction started work on the site in August 2015. The plot had already been cleared of its previous buildings, and so one of the initial tasks was to install a series of precast plies to a depth of between 35 and 40m.

The completion of the piling works then allowed steelwork contractor BHC to begin its steel erection programme. The steelwork forms a braced frame that is based around a regular grid pattern of 7.5m × 18m. A series of 18m-long × 750mm-deep Westok cellular beams has been used throughout the structure, not only to create the desired open-plan space but also to efficiently accommodate all of the services within the structural void.

"We erected the entire steel frame using two 80t-capacity mobile cranes," says BHC Project Manager Bobby McCormick. "The 18m-long cellular beams, which each weigh 5.5t, were the heaviest and longest steel sections on the job."

BHC began by erecting the central area of the building, which contains the main core. Once this area was up and stable, the erection team was divided in two to work outwards in both directions simultaneously.

Although the structure is based around a large column-free design, there are a few internal columns and these are located around the centrally-positioned atrium and its adjacent core.

As well as the steelwork fabrication, supply and erection, BHC was also responsible for the installation of metal decking and precast stairs.

As well as in the central core, precast staircases are positioned at either end of the building in secondary steel-framed cores.

All intumescent painting was carried out by BHC offsite at its fabrication yard. Again for blast resistance, the paint specified for this building is of a higher specification than usually applied to commercial structures.

The INEOS HQ building was completed in August.

Creating a manufacturing hub

INEOS operates 65 petrochemical plants worldwide and Grangemouth is its largest facility. The new building forms part of INEOS' grand vision for the site as it plans to turn it into a manufacturing hub for the whole of the Central Belt of Scotland.

The company says the new building is just one part of the innovative redevelopment plans for Grangemouth. Old manufacturing plants and vacant buildings will make way for brownfield plots that will be made available to new businesses attracting investment into the area. These businesses will be able to benefit from the raw materials, existing power stream, logistics and other services provided by INEOS.

INEOS Olefins & Polymers CEO at Grangemouth John McNally says: "The site is undergoing a radical transformation with significant investment that will herald a new era in petrochemical manufacturing at Grangemouth."

"For the first time in many years, the business at Grangemouth will be able to bring its employees together in a way that suits the new business operation. It will improve productivity and collaboration with a single office building."

Model highlighting the 950t structural steel frame

Steel for Life

Steel for Life is a wholly owned subsidiary of BCSA, created in 2016, with funding provided by sponsors from the whole steel supply chain. The main purpose of Steel for Life is to communicate the advantages that steel offers to the construction sector. By working together as an integrated supply chain for the delivery of steel-framed solutions, the constructional steelwork sector will continue to innovate, educate specifiers and clients on the efficient use of steel, and market the significant benefits of steel in construction.

British Constructional Steelwork Association

BCSA is the national organisation for the steel construction industry: its Member companies undertake the design, fabrication and erection of steelwork for all forms of construction in building and civil engineering. Industry Members are those principal companies involved in the direct supply to all or some Members of components, materials or products. Corporate Members are clients, professional offices, educational establishments etc which support the development of national specifications, quality, fabrication and erection techniques, overall industry efficiency and good practice.

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