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NSC

Manchester Airport transformed

March 2019 Vol 27 No 3

Truss support at City fringe

Hallé strikes harmony with steel

Maritime HQ launched at Lowestoft

Dublin bio-energy to feed grid

Cover Image
One Crown Place, London
Main client: AlloyMtd
Architect: Kohn Pedersen Fox
Main contractor: Mace
Structural engineer: AKT II
Steelwork contractor: Severfield
Steel tonnage: 2,600t

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5 **Editor's comment** Editor Nick Barrett reports that surveys show strong developer confidence, especially in the regions, despite Brexit induced uncertainty.

6 **News** A crane survey reports that construction is booming in UK regional cities, and the BCSA publishes a second edition of its welding publication.

10 **Transport** The centrepiece of the Manchester Airport Transformation Programme is a steel-framed extension of Terminal 2.

12 **Music** The renowned Hallé Orchestra is enlarging its rehearsal and recording facility with the construction of a steel-framed structure that features acoustically-isolated practice spaces.

14 **Headquarters** One of Lowestoft's main employers is developing a new sustainable and contemporary HQ that makes use of exposed steelwork throughout.

16 **Mixed-use** A series of 15 steel trusses support two residential towers and accommodate apartments within their depth at a prestigious central London scheme.

20 **Energy** Ireland's latest steel-framed renewable energy plant is taking shape at Huntstown near Dublin.

22 **Technical** Ricardo Pimentel of the SCI introduces the topics of buckling phenomenon, second order effects and the approximate methods to allow for those effects.

26 **Codes and Standards**

26 **50 Years Ago** Our look back through the pages of *Building with Steel* features an unusual television studio.

27 **Advisory Desk** AD 428 –Draft guidance: lateral and torsional vibration of half-through truss footbridges.

28 **BCSA Members**

30 **Register of Qualified Steelwork Contractors for Bridgeworks**

Healthy appetite for growth - and steel

Nick Barrett - Editor

Mixed messages can be found from recent surveys and forecasts about what the future holds for construction. As can be read in the President's Column in this issue of NSC, the outlook for structural steelwork in the latest Construction Markets forecast is for a fairly flat 2019, followed by 2.3% growth in 2020 before levelling off again in 2021.

That is not a bad outlook given the background noise being generated by Brexit, with fears of the unknown reportedly leading to investment decisions being delayed, which has a knock on effect on construction demand. Opinion seems to be growing, however, that these investment plans are only delayed, not cancelled. And it isn't all doom and gloom out there.

Barbour ABI, for example, report a near 10% rise in new orders in January compared to December, which was 7.6% ahead of November, with infrastructure contracts ahead by 18.5%. As the President points out in his column, infrastructure is a growth area in which demand for structural steelwork is rising.

As we report in News, the latest Deloitte Real Estate Crane Survey shows that confidence among developers is high despite the subdued economic backdrop. The survey shows either sustained or increased levels of construction activity in key regional centres like Manchester, Birmingham, Belfast and Leeds.

An earlier survey of the London market showed construction down by 13%, but this was due to completion of some very large schemes. The development pipeline remains above average, Deloitte noted, and almost half of space under construction is already pre-let. It doesn't take much for the London market to show a significant worsening of its outlook though - projects tend to be bigger than in the regions so a single delayed project can have a big impact.

Having said that, as Deloitte point out, activity at the reported levels given the market uncertainties is testament to a strong appetite for growth. Development activity in Manchester, for example, is at record levels with 78 sites under construction compared to only one crane observed in 2011.

Another confidence boost recently was the news that Citigroup is about to invest £1.2Bn to buy the 45-storey Canary Wharf building - 25 Canada Square - that currently houses its European HQ. This is being hailed as a clear sign that one of the world's largest banks expects London to remain a key global financial centre, a market that has shown an overwhelming preference for steel-framed solutions over many years.

Many, if not most, of these multi-storey developments in London and the regions will be steel-framed. The development market is fast-moving and tenant demand can change quickly, which brings steel's adaptability to the fore as steel-framed buildings can be relatively easily and quickly reconfigured for changed uses. A strong market in upgrading existing building stock looks likely to be a feature of demand in coming years as tenant needs change.

Demand growth is coming from technology, media and telecom companies ahead of traditional up-market tenants from the financial sector. Steel is recognised as providing the flexible, aesthetically pleasing modern buildings that these companies demand, partly to attract staff. The uncertainty around Brexit will be a distant memory one day, hopefully soon, but property investors will have cause to remember steel with gratitude for a very long time to come.

Survey shows construction growth in UK regional cities

Confidence among developers is exceptionally strong across the UK's regional cities according to the latest Deloitte Real Estate Crane Survey.

The survey monitored construction activity in Belfast, Birmingham, Leeds and Manchester during 2018. Each of these cities saw a sustained or increased level of development across a range of sectors including offices, residential, hotels, retail, education and student housing.

Commenting on the survey's findings, Partner and Regional Head at Deloitte Real Estate Simon Bedford said: "To have construction figures this healthy is somewhat of a surprise given a myriad of market uncertainties. Developer confidence is a key indicator for economic health and to have this many significant construction starts over the last 12 months, especially in speculative office schemes, is testament to the resilience of the regions and appetite for growth."

Top of the list for construction activity is Manchester, which has seen record levels of development activity.

The city's office sector has over 185,000m^2 of office space under construction across 13 schemes; a huge increase on the consistent levels of 140,000m^2 reported between 2015 and 2017.

Bedford commented: "If Manchester had featured in the recently published North American Crane Index, it would have ranked number two - behind Toronto but in front of Seattle, Los Angeles and Chicago. That might have seemed like a remarkable stat a few years ago given Manchester only had one crane in the sky in 2011, but today the figure is a massive 78 sites under construction."

100 Embankment: one of the many commercial schemes currently under way in Manchester

Across the Irish Sea, Belfast has 34 schemes under construction in the city centre – with 21 schemes completed in 2018 and nine set for completion this year.

Birmingham saw 23 new starts last year, with residential taking the lion's share. New office development is down from a peak of seven new starts in 2016, to just two new schemes today. However, total office volume under construction remains high at 130,000m^2 and 2019 is set to be a record-breaking year for office completions.

Leeds has recorded the highest level of construction in the city centre since the Leeds crane survey began in 2002, with 21 new construction starts in 2018. This includes seven new office schemes adding to the record 78,500m^2 office development currently in the pipeline.

Learning and teaching hub takes form in Glasgow

The multi-million pound University of Glasgow Campus Development is progressing with the steel frame for the Learning and Teaching Hub nearing completion.

Designed by HLM Architects, the Hub will be an inspirational and diverse learning space, allowing undergraduate and postgraduate students access to advanced and useful learning spaces.

Construction work on the £90.6M building started at the end of October 2017 and is due to be completed in the academic year in 2019/20.

Working on behalf of main contractor Multiplex, BHC will erect 950t of steel for the structure that forms the centrepiece of the development's phase one.

The eight-storey building comprises an in-situ concrete frame and a steel-framed structure within, forming the lecture theatres. Externally, it will be clad with curtain walling, precast panels and weathering steel.

When complete, the building will accommodate over 2,500 students, including a lecture theatre with capacity for 500 students. Interactive teaching spaces will range in capacity from 340 - 75 students, while the hub will also have a number of seminar/group study spaces. There will also be a café on the ground floor.

Three-legged bridge for canalside marina

Working on behalf of main contractor Land & Water, S H Structures has fabricated and supplied a 35m-long bridge for the Newlands Marina project near Milton Keynes.

Designed by Knight Architects and Cowi for Crest Nicholson Regeneration, the firm behind a mixed-use development beside the Grand Union Canal, the bridge crosses the waterway at right angles, aligned with the marina entrance, and over the last third of its length, the deck branches in two parts to form a Y-shape in plan.

The bridge is made out of weathering steel with a laser cut steel balustrade system, featuring panels cut to resemble riverside reeds and grasses.

BCSA updates welding publication

The British Constructional Steelwork Association (BCSA) has published a second edition of the *Typical Welding Procedure Specifications for Structural Steelwork*.

First published in 2009, it was prepared to simplify and standardise welding procedures for structural steelwork and to develop qualified Welding Procedure Specifications for use in fabrication workshops. Since then, the field of welding has seen several developments, changes in welding practice and more recently a drive towards the use of higher strength steels.

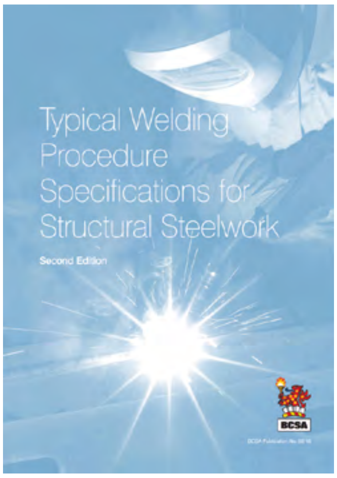
BCSA Manager Fabrication and Welding Tom Cosgrove said: "This second edition builds on the information provided in the original publication, introduces the use of higher strength steels, other welding processes and updates the previous content to reflect current standards and specifications."

Whereas the original document was based solely on the solid wire Metal-arc Active Gas shielded (MAG) process, this second edition also contains a small number of preliminary Welding Procedure Specifications (pWPS) and partially completed Welding Procedure Specifications (WPS), using MAG welding with flux cored electrode (FCAW) for high yield steel and Manual Metal Arc (MMA) for site welding.

In total, the publication contains 20 pWPS, to support the necessary welding procedure tests on the route to qualifying a typical WPS, and 49 partially completed WPS, which cover the majority of those required for typical buildings and bridges.

They cover weld types ranging from simple fillet welds to the more difficult butt welds made from one side without backing.

This second edition (BCSA Publication No 58/18) is available in PDF format only from the BCSA Publications and Online Shop: https://www.steelconstruction.org/shop/, with BCSA members receiving a 50% discount.



Steel complete at Warrington Time Square

More than 3,000t of structural steelwork, amounting to 6,500 individual pieces, has been erected by James Killelea at the Warrington Time Square project.

The mixed-use scheme is set to transform a large part of Warrington town centre when it opens in early 2020.

The project includes a 13-screen cinema complex with ground floor and mezzanine retail outlets, a new indoor market hall, a four-storey council office block and a further two-storey retail building.

The new buildings will all be set around a large public square, while along the adjacent Bridge Street, the scheme's Market Hall incorporates a Grade II listed former

Boots building façade.

Main contractor Vinci Construction started on site in September 2017, after a major demolition phase had been completed. The company remediated the entire site's footprint prior to the steelwork package starting.

According to Vinci, the project team chose a steel framing solution for the whole scheme because of the material's speed and ease of construction.

The cinema block has a complex design that incorporates two distinct grid patterns, one for the retail zones and the other for the cinema screens. A series of transfer structures, supporting the upper levels, allow the column positions to change.

Vinci says this structure could only have been built using steelwork, while the office block and market hall, both make use of long clear spans, which is another design aspect best suited to steel construction.

Frames up for major South West logistics park

Five steel industrial units have been erected by Billington Structures for the first phase of a multi-million pound business park in Avonmouth.

Located on a site known as More + Central Park, the project is a joint venture speculative development by Richardson Barberry, with Vinci as main contractor.

The five portal-framed structures vary in size, the largest measuring 76.5m-long × 64.2m-wide and formed by a series of 38.25m-long rafters arranged in pairs with a bolted splice connecting to a central ridge beam. The smallest is a 45m-long × 25m-wide single bay portal-framed structure.

All of the five units feature internal mezzanine floors and offices incorporated within their footprints. Billington has designed, fabricated and erected more than 580t of steel for the project.

Central Park already boasts several major occupiers including The Range, DHL, Amazon, Lidl, Farmfoods, Davies Turner and CHEP.

Barberry Development Director, Jonathan Robinson said: "This is a significant development of industrial/warehouse space that will create the size of warehouses and business units that local, regional and national occupiers have indicated are in short supply".

"It will also complement the larger buildings at Central Park. The scheme will bring around 700 new jobs to Bristol and provide a boost in jobs for the construction sector."

NEWS IN BRIEF

Forming an integral part of a road realignment scheme, **Nusteel Structures** has fabricated and delivered a 50m-long × 3m-wide cycle and pedestrian bridge that spans the A55 south of Chester.

Tata Steel's new RoofDek manual is said to be the most comprehensive structural roof decking document to date, containing a wealth of information to aid design. It is available for download at: *https://www.tatasteelconstruction.com/en_GB/OurBrands/building%E2%80%93systems/RoofDek-manual-now-available*

Plans have been approved for a multi-million pound industrial/warehouse scheme that is set to generate significant employment opportunities in the West Midlands. Commercial property developer, **Stoford Developments** and specialist sustainable and impact investor, **Bridges Fund Management**, will develop four Grade A industrial/warehouse units at Pantheon Park in Wolverhampton, after planning consent was granted by the City of Wolverhampton Council.

HS2 has named the construction teams that will be awarded contracts to deliver the project's London terminus and its west London super-hub at Old Oak Common in deals which could support up to 4,000 jobs across the UK. A joint venture between Mace and Dragados will build the new Euston terminus, while Balfour Beatty/Vinci joint venture will deliver Old Oak Common.

Developer Palace Capital has appointed **Caddick Construction** as its main contractor for the £35M Hudson Quarter mixed-use scheme in York city centre. The two-acre development on the site of the former Hudson House, opposite York railway station, will be transformed into a new community featuring 127 apartments, 3,200m² of Grade-A office space, 460m² of other commercial uses and car parking located in four buildings around a landscaped garden.

PRESIDENT'S COLUMN

With the 2019 Spring Statement due on 13 March, and the UK currently scheduled to exit the EU at the end of March, all eyes are on the UK economy this month. But what does this actually mean for the structural steelwork sector?

Every year, Construction Markets undertakes what is believed to be the largest survey of its kind, surveying specifiers and analysing the responses against government data in order to calculate the current and future consumption of structural steelwork in the UK, and the market share of the key framing materials.

The most recent data has just been released, including forecasts to 2021, and as most of us would have expected, in 2018 the consumption of structural steelwork in the UK remained fairly flat at 895,000 tonnes. Overall, Construction Markets is forecasting more of the same in 2019 (up 0.5%) and then stronger growth overall in 2020 (up 2.3%) before a levelling off again in 2021. By 2021, the UK's consumption of structural steelwork should have reached 920,000 tonnes.

But the interesting reading really comes when we delve into the details of some key sectors.

Thinking about government investment decisions over the last few years, nobody will be surprised that structural steelwork consumption in infrastructure has seen higher growth than buildings and has a more positive outlook. Steelwork consumption in power, bridges and other infrastructure grew 12% in 2018 and is projected to grow a further 16% in 2019 before the growth rate begins to ease. Having said that, in 2021 these sub-sectors combined will still only account for 23% of total UK structural steelwork consumption.

Structural steel has been able to take advantage in the growth of the industrial buildings market over the last 6 - 7 years because of its ability to create very large column-free spaces, its high strength-to-weight ratio and its future adaptability. And AECOM's cost studies demonstrate that for an identical building steel is the cheaper framing material. After seeing 3% growth in 2018, structural steelwork consumption in industrial buildings is forecast to increase slightly in 2019 and then by almost 2% in 2020. By 2021, consumption of structural steelwork in this sub-sector will be 432,000 tonnes, accounting for 48% of all UK structural steelwork consumption.

A couple of years ago, BCSA (along with others) predicted a cyclical slowdown in the London offices market. This has come to bear and as a result, the consumption of structural steelwork in the offices sub-sector fell 15% in 2018 to 104,000 tonnes. Construction Markets are forecasting more of the same in 2019 (down 15% again), with slow growth in 2020 and 2021. Within this much slower market, however, steel has increased its market share to over 70%.

Whatever the future brings for the UK's construction sector, having such a detailed insight into the structural steelwork market helps BCSA members understand future demand, plan their resourcing and ensure a sustainable business model.

Tim Outteridge
BCSA President & Sales Director Cleveland Bridge

SCCS gains SSIP accreditation

The Steel Construction Certification Scheme (SCCS) has become one of the first certification bodies to achieve SSIP Accreditation (Safety Schemes In Procurement) following a recent UKAS assessment.

SSIP aims to streamline prequalification by driving unnecessary cost and confusion out of supplier health and safety assessment. Its core philosophy is to enable effective cross-recognition between existing schemes.

The SSIP Core Criteria for assessments is aligned to the Government-backed construction prequalification document PAS 91, ensuring consistency within supply chain management.

Suppliers registered with a SSIP Member Scheme are listed on the SSIP web portal, which provides an easy way of finding out if a supplier holds valid certification with an SSIP member scheme and confirms compliance with the SSIP Core Criteria and UK Health & Safety legislation.

"This is a significant addition to the service that SCCS offers its clients and further develops our strategic objective of offering a one-stop shop for certification," said SCCS Director of Certification Stephen Blackman.

The SCCS is a wholly-owned subsidiary of the British Constructional Steelwork Association. It was established in the early 1980s to provide quality management certification for steelwork contracting organisations.

SCCS now offers a wide range of certification and monitoring services for the structural steelwork sector, including integrated or separate UKAS accredited Quality management systems, Environmental and Health & Safety management systems, Factory Production Control systems and selected National Highways Sector Schemes.

For more information about SCCS go to *www.steelcertification.co.uk*

Plans submitted for 31-storey London tower near the Shard

Developer Great Portland Estates has submitted plans for a new high-rise tower to be built in the shadow of the Shard at London Bridge.

A planning application has been submitted for the 31-storey office building at New City Court in Southwark. Designed by AHMM architects, the offices will rise to 139m offering 34,000m^2 of office and ground floor retail space.

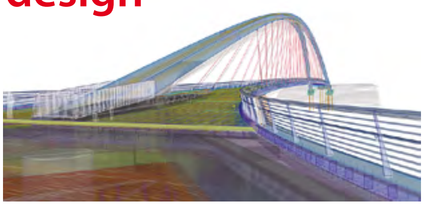
The project will require the demolition of existing buildings at 20 St Thomas Street and will also see the front elevation of existing Georgian buildings retained and Keat House reconstructed.

The tower will boast a 250-seat auditorium and terrace on the 21st and 22nd floors and an elevated double-height public garden within the building on the fifth and sixth floors.

Gardiner and Theobald has been appointed as construction manager and has drawn up the construction management plan.

Toby Courtauld, the company's Chief Executive, said the London Bridge project was one of the most exciting schemes in the firm's current portfolio.

Tekla bridge software extension spans complete design



Trimble has introduced Tekla Bridge Creator, a new extension for Tekla Structures Building Information Model (BIM) software that is said to integrate the complete workflow from design geometry to constructible modelling and detailing.

The new software extension for bridge designers is said to provide a solution to common problems: importing a road alignment directly from road design software; creating one or more key sections that define the bridge deck and abutments, and then modelling and detailing the reinforcing bars easily and efficiently.

As part of a user feedback program, WSP Finland participated in testing Bridge Creator. WSP Finland is part of WSP Group headquartered in Montreal, Canada and is a global engineering professional services consulting firm with more than 550 offices across 40 countries.

"Bridge Creator is intelligent and certainly the most efficient tool for the whole bridge design workflow, which no other software provider has to offer. It automatically imports the road alignment and helps create bridge geometry easily. Even when facing complex deck geometries, the extension creates the deck with impressive accuracy," said Hannu Suojanen, Project Engineer for Bridges, WSP Finland.

The Bridge Creator extension version 1.0 can be downloaded from the Tekla Warehouse.

Steel-framed parcel hub will create 750 jobs

Caunton Engineering has been awarded the steelwork package by main contractor Winvic Construction for a major DPD (Dynamic Parcel Delivery) parcel hub near Hinckley in Leicestershire.

The new facility will be DPD's fifth UK hub and will be located two miles from Hub 4, which Winvic and Caunton completed in 2015.

For the new hub, DPD will develop a 39-acre site within a new 82-acre employment park, close to junction 1 of the M69. The building will be 503m long and will be capable of handling 71,000 parcels an hour, increasing DPD's total overnight parcel sorting capacity by 60%. It is reported that the facility should be operational by October 2020.

DPD CEO Dwain McDonald said: "We have invested hugely in our infrastructure nationwide over the last six years, moving our older depots to brand new, larger and purpose-built facilities or upgrading them to state-of-the-art distribution centres.

"And by 2020 we will have built three of the largest overnight sorting hubs in Europe.

"We already know that the location works brilliantly for us and having the two hubs in such proximity will give us a huge amount of flexibility."

Plans revealed for joint rugby and football stadium in Workington

Ambitious plans for a new community stadium and sports development in Workington have been released by Allerdale Borough Council.

The planned 8,000-capacity stadium would be a new home for both Workington Town rugby league club and Workington football club. The development would also include a full-size synthetic pitch for community use.

According to the council, both the rugby and football club have been working with the local authority and jointly approached it to see if they could develop first-rate shared facilities, which would benefit the clubs, players, and supporters.

With shared costs and new, modern and more efficient facilities, the new steel-framed stadium would make the clubs more sustainable and encourage a bigger fanbase.

To meet the playing demands of both clubs, the pitch will exploit the latest hybrid technology using both plastic and real grass. Pitches like this are successfully in use in shared facilities elsewhere. Many of the premiership clubs use this pitch technology and it appeared at the recent World Cup in Russia.

The plans have been drawn up by architects Holmes Miller and the council is currently putting together a funding package which could include grants, sponsorship and money from partner organisations so that the impact on the council taxpayer can be kept to a minimum.

It is hoped that the stadium will be completed by Spring 2021, in time to host three games for that year's Rugby League World Cup.

Go-ahead for Farringdon landmark office scheme

Plans for a prestigious 13-storey office development, designed by tp Bennett are set to go ahead after the City of London gave it full approval.

Construction work is expected to begin in May and will include the demolition of two existing buildings – 81 Farringdon Street and 1 Stonecutter Court – to make way for 32,000m^2 of new office space.

The design of new build structure will also include six roof terraces, 1,200m^2 of retail space and 230m^2 of public realm improvements.

Adding some complexity to the scheme, the Hoop & Grapes, a grade II-listed pub dating from the 18th Century, will remain untouched as the development goes on around it.

Developer Greycoat, has appointed Hoare Lea as energy and BREAAM consultant, Pell Frischmann as structural engineer, Arup for security and GVA as project manager.

Diary

For SCI events contact Jane Burrell, tel: 01344 636500 email: *education@steel-sci.com* web: *www.steel-sci.com/courses*

Tuesday 5 March 2019
Steel Frames and Disproportionate Collapse Rules
This course provides a solid introduction into the design of steel-framed buildings to avoid disproportionate collapse.
London

Tuesday 12 March 2019
High Strength Steel Structures
This webinar will cover various aspects of high strength steel including; production and fabrication, its applications and when to use HSS and design to EC3.
Webinar

Tuesday 2 April 2019
Fabricated beams with corrugated webs
Although not common in the UK, these beams are regularly used in other parts of Europe and has its own dedicated part of the Eurocode. The corrugated web increases the resistance to shear, so much thinner webs may be used without stiffening. This SCI Member webinar will cover the design rules in BS EN 1993-1-5, which have been built into design software prepared by SCI.
Webinar

Thursday 4 April 2019
Steel Building Design to EC3
This course will introduce experienced steel designers to the Eurocode provisions for steel design, providing attendees with a sense of reassurance that design to EC3 is straightforward.
Bristol.

Thursday 9 May 2019
Steel Connection Design Course
The course concentrates on the design of nominally pinned connections, in accordance with BS EN 1993-1-8, considering vertical shear and tying.
Birmingham.

36m-long trusses span the departures hall

Airport transformation takes flight

A steel-framed terminal extension building, featuring internal spans of up to 36m, is the centrepiece of Manchester Airport's Transformation programme. Martin Cooper reports.

FACT FILE
Manchester Airport Transformation Programme
Client: Manchester Airports Group
Architect: Pascal and Watson
Main contractor: Laing O'Rourke
Structural engineer: BuroHappold
Steelwork contractor: William Hare
Steel tonnage: 11,300t

Ranked as the third busiest in the UK, Manchester Airport is currently in the midst of a large-scale expansion programme that will ensure it maintains a position at the heart of the North of England's transport network.

Known as the Manchester Airport Transformation Programme, the scheme, which began in July 2017, consists of an extension to the existing Terminal 2, the construction of a 3,800-bay multi-storey car park, a new baggage sortation hall and three new piers, one of which has a link bridge.

Structural steelwork is playing a crucial role in the programme as all of the new structures are steel-framed, aside from the concrete-framed car park. Working on behalf of main contractor Laing O'Rourke, William Hare is fabricating, supplying and erecting 11,300t of steel for the project.

Rob Stewart, Programme Delivery Director for the Manchester Airport Transformation Programme, says: "This is the largest infrastructure project in our history and one of the biggest seen in the North of England for the last decade.

"The airport is committed to the region benefitting through the scheme, so it's been great to have William Hare on-board, especially with the affinity it has to Terminal 2, having worked on the original in the late 1980s."

The Terminal 2 extension is the centrepiece of the project and is scheduled for completion in April 2020. The six-storey extension measures 160m-long, has a gross internal floor area of 86,500m² and will increase the terminal's overall size by 150%. The new structure has required just over 9,000t of steel, which equates to 9,000 individual pieces needing more than 130,000 bolts.

Founded on 1,345 CFA piles, the terminal's compositely designed steel frame is predominantly based around a regular 12m × 9m grid pattern. Three sway frames, which run the length of the extension provide the overall structural stability, while a movement joint cuts the building in half, alleviating any challenges associated with its length.

"It's a very complex steel frame and so the best design was to go with sway frames as opposed to stability-giving concrete cores," explains Laing O'Rourke Project Leader Tim Brown. "This method was also quicker as the steelwork was able to start being erected without us having to wait for any cores to be completed."

BuroHappold Director Julian Sheppard adds: "The client was keen for us to minimise the number of movement joints, because they create operational issues, but this created a massive structural analysis challenge for us – how to analyse the steelwork with significant gravity and lateral forces including blast as well as controlling the enormous build-up of thermal thrusts and stresses, caused by the lack of movement joints."

The solution was to adopt several analysis models for each primary load case, as these were more manageable. Then the team wrote computer programmes to pull the separate analysis models together to create a combined model.

"This meant we were able to alter variables as the design developed and have the software easily process large amounts of data very quickly. This data processing technique proved essential in delivering the steel design to the tight programme," says Mr Sheppard.

The design also allowed William Hare to erect the extension in three sway frame strips. Beginning with the central frame, which was erected to its full height, the two adjoining areas on either side were then completed using a similar method.

William Hare had up to 10 steel erection teams on site, each with their own dedicated crane. Having so many cranes on one site was logistically challenging, especially as they could not overslew the adjacent airfield or the operating Terminal 2 building.

The middle sway frame section of the extension accommodates three modular mega-risers, each measuring 8m × 11m and containing much of the building's services.

Each riser consists of eight fully-assembled modules, each weighing 8t. Once the central area's steelwork was completed, and before the side sway frames were erected, the modules were lifted into place through gaps left in the frame.

"We had to lift the modules into place in this way as a much larger crane would have been needed to lift the modules over and into the completed steel frame," says William Hare Project Manager Richard Branford.

"A lot of detailing had to be done on the steel modules and the bracketry they fit to inside the voids as there was only millimetres of clearance during the lifting process."

The overall layout of the structurally-independent extension mirrors the adjacent steel-framed terminal building. Once construction is complete, the two will be connected, as various breakout zones will be formed in the existing partition to allow a seamless transition between the two structures.

The ground and first floor of the extension accommodate arrivals, second floor is departures, third is the international departure lounge with retail units, the fourth mezzanine level has restaurants and VIP lounges, and the uppermost level is a plant zone.

While the lowest three floors occupy the extension's entire footprint, the upper floors are set-back and overlook the departures level.

Consequently, much of the departures zone is a triple-height 36m-wide column-free area. This is created by a series of 2.5m-deep trusses positioned at roof level. These large steel elements were brought to site in three pieces, assembled on the ground before being lifted into place as one 36m-long section.

The majority of the terminal extension steelwork was completed towards the end of 2018, but further steel construction is taking place at the front of the new building. The existing forecourt, which has an entrance on level 2, is being extended to include the extension and a new canopy, supported on CHS columns, is being erected.

The Terminal 2 extension is scheduled to open in April 2020.

Transforming an airport

As well as the Terminal 2 extension, structural steelwork has also played a leading role in a number of other parts of the Manchester Airport Transformation Programme.

Of the project's three planned piers, the first one (pictured above) and its connecting 250m-long link was handed over in January.

William Hare erected 1,650t of steel for the pier and link, completing the work just as the main terminal steel programme was kicking off.

The pier has 11 gates and measures 216m in length. It was erected around a standard 9m grid pattern and its roof is a portal frame creating a 20m clear span.

The link connects the pier directly into the new terminal extension. However, as the pier will open earlier than the extension, a two-level (arrivals and departures) temporary link has been installed within the construction site to allow passengers to transit through the construction site from the existing terminal building.

A steel-framed baggage sortation facility is being constructed adjacent to the existing terminal. Measuring 220m-long × 14m-high, this 33m-wide single span portal frame required approximately 500t of steelwork.

Connecting the terminal extension to the new multi-storey car park, is a recently installed 45m-long steel bridge. Weighing close to 100t, the structure was fully assembled offsite in order to minimise disruption. It was then transported to its final position using self-propelled modular transporters (SPMTs) and then lifted into place by one 750t-capacity mobile crane.

Steelwork contractor William Hare also worked on the original terminal building

All of the terminal's floors are compositely designed

One feature lattice column is located on the main façade

Steel hits the right note

Manchester's Hallé Orchestra is enlarging its St Peter's rehearsal and recording facility with the construction of a steel-framed extension that will include acoustically-isolated practice spaces.

Located in Ancoats, a Manchester inner city district that was once the beating heart of the area's cotton industry, the Hallé Orchestra's principal rehearsal and recording space is undergoing a significant transformation.

A new three-level steel-framed extension, to be known as The Oglesby Centre at Hallé St Peter's will provide a brand-new façade to the existing facilities, which are housed in a former church, and front onto the adjacent open plaza of Cutting Room Square.

"The extension is conceived as a classically proportioned modernist metaphor of the existing grade II listed building," says Stephenson Studio Associate Project Architect Stuart Hollings.

"It will provide additional rehearsal facilities, practice rooms, café function space and an exciting entrance atrium offering direct views up towards the existing church campanile tower."

The current work is phase two of Hallé's overall vision, with the first phase being the restoration of St Peter's church which was completed in 2013 (see box).

Main contractor H.H Smith & Sons began on site for phase two in mid-2018 and initially excavated the extension's basement. This lowest level is where the steelwork starts, and it will house offices, a kitchen, piano storage and other back of house facilities.

The steel frame's columns at ground floor level terminate either at the perimeter capping beam or extend into the basement using a fairly regular grid pattern. The frame is primarily stabilised by two lift cores, one of which accommodates a piano elevator to transport the large instrument between the basement, the first-floor rehearsal space and into the existing building.

Along the façade that abuts the existing building, the steel frame is also sympathetically attached to the church at certain points, giving the steel frame some more stability along with perimeter vertical bracing.

The ground floor accommodates the entrance and café areas and the required long span column-free spaces have been created by using a series of 12m-long cellular beams. These pre-cambered members each weigh 1.5t, have a depth of 750mm and incorporate 350mm-diameter holes.

The first floor (third-storey), has an 8m floor-to-ceiling height, much higher than the other floors as it accommodates the main rehearsal room, along with some smaller practice spaces. A large front elevation vertical truss, measuring 12m-wide by 7m-deep, creates the open-plan area for the rehearsal room while also allowing a column-free zone below for a large glazed frontage.

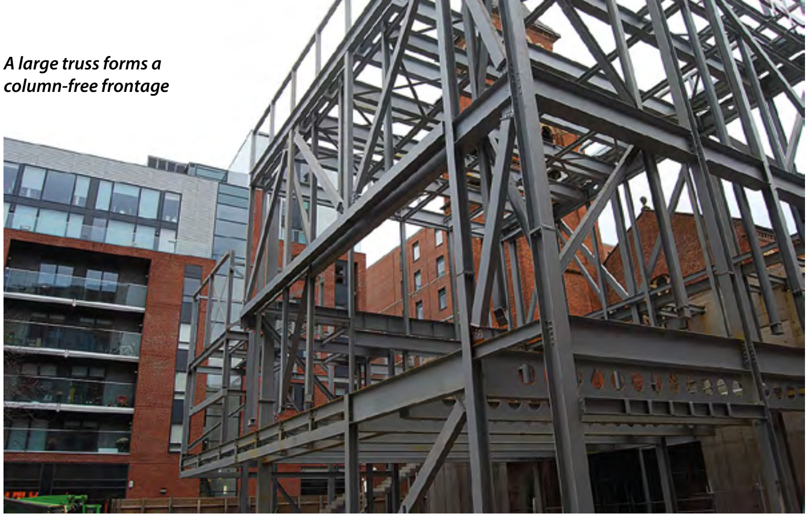
The truss was fabricated from 533UB top and bottom booms and 250mm × 150mm RHS internals. It was also designed to be transported and installed piece small, which was an important consideration, not just for this truss, but the entire steel package, due to the confined site conditions.

"There was only one location where our mobile crane could be sited to service the whole of the steel erection and this was quite close to the structure. Meticulous planning of deliveries and where erection could be completed was needed to ensure no area was left inaccessible," explains BD Structures Director Chris Heys.

Being able to deliver steel to site in small

FACT FILE
Hallé St Peter's, Manchester
Main Client:
Hallé Concerts Society
Architect:
Stephenson Studio
Main contractor:
H.H Smith & Sons
Structural engineer:
Booth King Partnership
Steelwork contractor:
BD Structures
Steel tonnage: 120t

The new extension will provide Ancoats with a landmark building

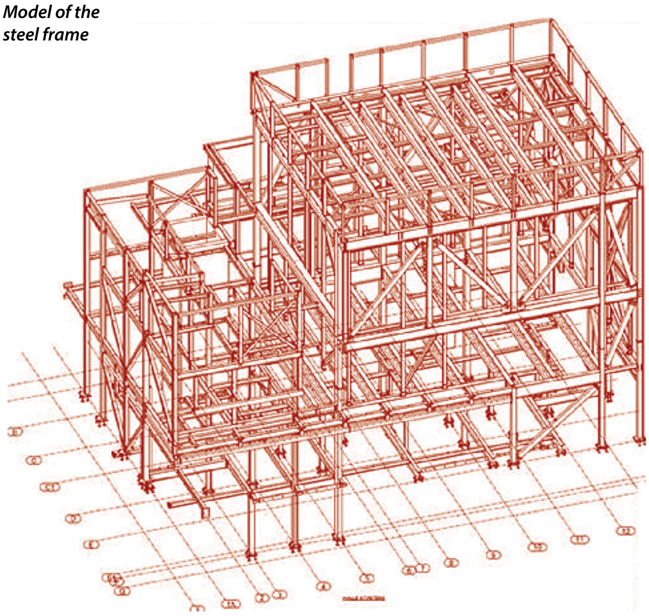


A large truss forms a column-free frontage

Cellular beams create the first-floor spaces

The steel frame connects to the existing church building

Model of the steel frame



manageable pieces was an important consideration when choosing a framing solution. However, the selection of steel for the primary structure was primarily driven by the need for large uninterrupted spans in the rehearsal, atrium and café space.

"The steel solution was also more economic, reduced the construction programme, offered a more sensitive connection to the existing listed campanile tower, and can ultimately be recycled should the building ever be dismantled," explains Mr Hollings.

The form of the extension is said to be expressed as a robust brickwork plinth at street level that cradles the first-floor main rehearsal space. Most of the upper floor is clad with weathering steel fins, allowing light to enter the rehearsal area, while making an exterior reference to the industrial heritage of the local environment.

The extension's upper floor rehearsal room and two adjacent practice rooms are floating box-in-box spaces, which are acoustically-isolated from the primary structural frame and slab. This is to prevent sound transfer and ensure the highest level of acoustic performance in these key spaces.

The boxes have their own compositely formed slabs, which are sat on acoustic pads and allow the spaces to be separated from the main first floor by a dividing and insulated void of 20mm.

Installing the steelwork for these isolated boxes was one of the trickiest parts of the erection programme.

"As the boxes' steelwork is not connected to the main frame, they were initially hung from roof level temporary supports, which had to stay in position until the slabs were poured and the boxes were supported," explains H.H Smith & Sons Project Manager Mark Taylor.

The rehearsal space box is formed with a traditional beam and column framework and measures approximately 20m-long × 12m-deep and 9m-high, while the two smaller practice rooms are constructed from light gauge steel framing system (SFS).

The Hallé St Peter's extension is due for completion in the final quarter of this year.

Phase one; church restoration

Built in 1859, St Peter's was the first protestant church to be built in Ancoats, which at the time was a predominantly catholic area, as a large proportion of the population was made up of mill workers from Ireland and Italy.

The church's iconic semi-circular apse was built to ensure the building's prominence against the surrounding angular cotton mill factories. Internally, the structure is notable for being one of the city's first to use cast iron columns.

As the cotton industry declined and the local population decreased, the church closed in 1960. After a period of being left empty, in 2013 the Hallé raised funding to complete a restoration project and convert the church for use by the orchestra and associated ensembles.

Interestingly, the Hallé, which is considered to be among the UK's top symphony orchestras, was founded just one year before the church was built.

Exposed frame creates sustainable HQ

A steel-framed solution has created the desired contemporary and cost-efficient headquarters building a leading Lowestoft employer wanted.

FACT FILE
Centre for Environment, Fisheries and Aquaculture Science (Cefas), Lowestoft
Main client: Department for Environment, Food & Rural Affairs (Defra)
Architect: AWW
Main contractor: Morgan Sindall Construction & Infrastructure
Structural engineer: MLM Group
Steelwork contractor: H Young Structures
Steel tonnage: 117t

Based in the Suffolk coastal town of Lowestoft since 1902, the UK marine science agency Cefas (The Centre for Environment, Fisheries and Aquaculture Science) is constructing a new £18.3M contemporary headquarters building.

This sustainable – it will have a green roof with in-built photovoltaics - steel-framed landmark HQ forms a central element of a much larger scheme that also includes the phased floor-by-floor refurbishment of an existing 1980s laboratory building.

Facilities currently housed in the former Grand Hotel and Experimental Block will be rehoused in the new build, allowing these two old buildings, which are deemed inefficient, to be demolished, thereby freeing up a large part of this seafront site for extensive landscaping and car parking.

According to Cefas, the new facilities will create greater opportunities for collaboration and innovation among the organisation's employees, local marine and research networks and the international scientific community.

The new building will house offices and meeting rooms, arranged either side of a spacious double-height glazed atrium and main entrance. On plan, the structure is a skewed H-shape, with a two-storey part arranged along one side and a two and three-storey element on the other.

The central atrium will house the building's communal facilities such as toilets and kitchens, vertical circulation as well as providing breakout spaces, informal meeting and relaxation areas.

Work commenced on site early last year and initially involved the demolition of the former hotel's Palais Block (dance hall), which then created a space for the new HQ.

"The site has had a number of uses over the years and consists of a lot of made-ground, which is quite poor," explains Morgan Sindall Contracts Manager Derek Foster. "Consequently, we had to install 2m-deep pad and strip foundations to support the steel frame."

The poor ground conditions also impacted on the steel erection programme, as Morgan Sindall Senior Site Manager Ken Bassett explains: "A crawler crane was deemed the best possible machine to use in such terrain due to the significantly lower ground pressure imposed by its tracks, compared to the outriggers on a mobile crane."

Steelwork contractor H Young Structures erected the main steel frame in a six-week programme and will return later in the year to add a link bridge and staircase, which will provide access between the existing facility and the new building.

"Although the overall tonnage is a modest 117t, the piece-count of individual steel members is quite high as the building is skewed and requires numerous small sections to infill the shape. This meant the number of individual crane lifts was also high," says H Young Structures Director Ian Peachment.

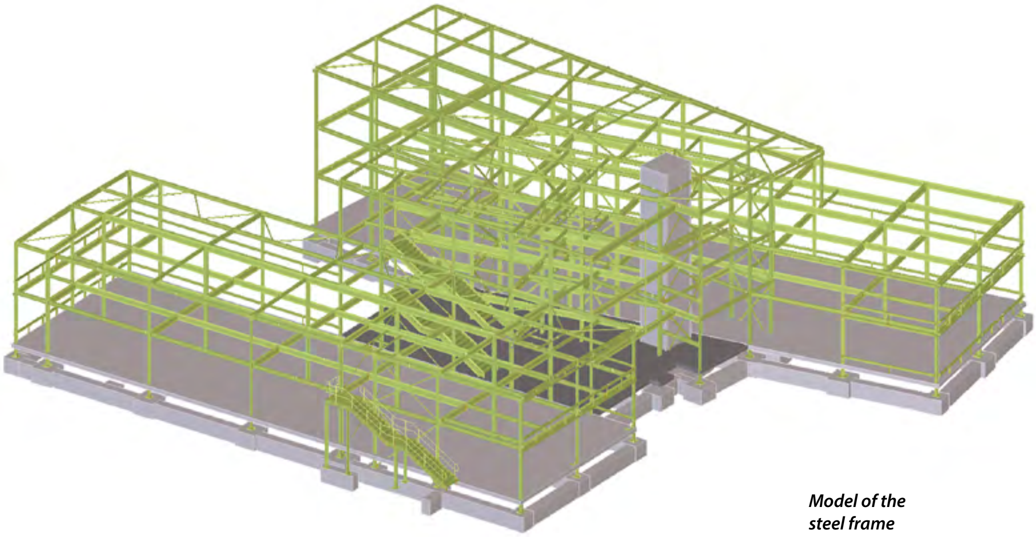
The building has a composite design with steelwork supporting metal decking and a concrete topping.

"After a value engineering exercise the design was changed from a precast floor design to metal decking as it was more practical and easier to install due to the skewed nature of the structure," says Mr Bassett.

Working on behalf of H Young Structures, Composite Profiles will ultimately supply and install 1,850m² of Tata Steel ComFlor 80 metal decking for the structure, along with 1,040m² of Tata Steel D137 RoofDek, 520m of edge shutter and 5,000 shear studs.

Most of the steel frame is based around a regular 6m column spacing, with internal spans of up to 12m. This was deemed sufficient to provide the new building with

How the new contemporary HQ will look



Model of the steel frame

All of the steelwork will be left exposed within the new building

Once the new build is complete the adjacent Grand Hotel and Experimental Block will be demolished

modern open-plan office and meeting room spaces.

The office space has been designed to be as open as possible to enable flexible working arrangements that can change over the years as employment patterns and technology evolves.

"All of the internal columns and beams will be left exposed, while the underside of the metal decking flooring will also be visible. It's very much a function over form design, but it does give the entire building the desired modern industrial feel," says MLM Group Project Engineer Steve Dillon.

Stability for the steel frame is provided by cross bracing, positioned along internal partitions and elevations where there are no windows. The one exception is the north-east corner of the new build – the area closest to the existing building and close to where the link bridge will be positioned. Here a moment frame has been inserted as the window positions meant bracing could not be installed.

Summing up, Cefas Chief Executive Tom Karsten says: "Since 1902, Cefas has been providing UK Government with scientific evidence and advice to support the fishing industry and to ensure the sustainable use of the marine environment.

"This project represents a vital step in realising our vision for Cefas; to deliver world-class science for the marine and freshwater environment."

The Cefas project is expected to be complete by May 2020.

Trusses provide towering support

One of the 15 trusses during the erection programme

The centrepiece of a central London mixed-use development is two residential towers supported on a series of 15 steel trusses.

A prestigious mixed-use scheme is set to invigorate a central London district with its blend of 246 residential apartments, 15,500m² of Grade A office space, and a boutique hotel and restaurant.

Known as One Crown Place, the scheme is close to both Liverpool Street and Moorgate stations, only metres outside of the City of London boundary and situated in the Borough of Hackney.

Its position on the fringes of both the square mile and the thriving Shoreditch district means the development will offer numerous amenities for office workers and residents alike.

Bounded on three sides by roads and the pedestrianised Crown Place on the fourth, the development occupies most of an island site, with the only exceptions being a retained chapel and pub, both of which have remained open throughout the works.

Along the site's southern Sun Street boundary, a previously dilapidated Georgian terrace has been retained and is being converted into the development's boutique hotel.

Emphasing the fact that the scheme is truly mixed-use in both use and architectural design, along the northern Earl Street elevation, a further Victorian façade is retained to be incorporated into the new build office scheme, while next to this a 1980s-office block, currently serving as a marketing suite and site offices, will be refurbished into a new stand-alone office block once the main project has completed.

Alongside these disparate elements, the main part of the development is positioned at the eastern end of the site where a six-storey podium supports two apartment towers, that will reach heights of 33 and 29 levels respectively.

This part is reliant on structural steelwork as the podium is a steel-framed structure topped by a series of 15 trusses. These steel trusses have three functions. Firstly they help to create the clear column-free internal office spans of up to 12m for the floors up to level six.

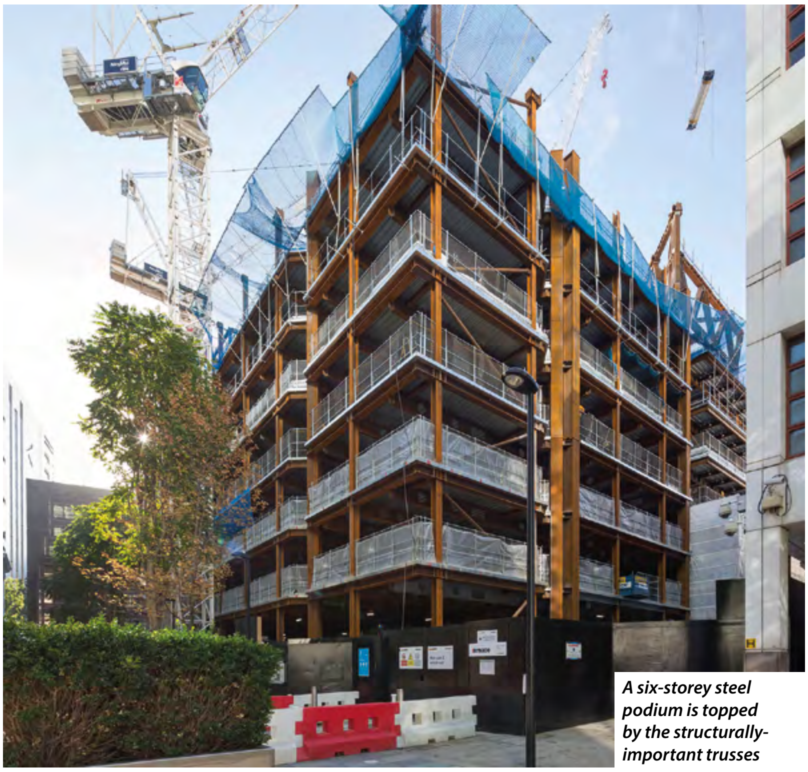
Secondly, levels seven and eight are accommodated within their depth, where the truss elements will be left exposed as architectural highlights.

Level 7 will accommodate a gym, a work hub, private screening room, meeting space and other exclusive amenities for the residents, while level 8 is given over to apartments.

And thirdly, and possibly most importantly, the trusses support the two-reinforced concrete (RC) residential towers that begin at level 9.

The change in construction materials at level 9 presented a challenge of transferring

The trusses will form an architectural feature in the completed scheme



A six-storey steel podium is topped by the structurally-important trusses

FACT FILE
One Crown Place, London
Main client: AlloyMtd
Architect: Kohn Pedersen Fox
Main contractor: Mace
Structural engineer: AKT II
Steelwork contractor: Severfield
Steel tonnage: 2,600t

the smaller RC column grid of the towers to the larger steel structural grid below. This was resolved by using the trusses to support the change in the column grid pattern.

This is the transition zone between the steel and concrete parts of the scheme and it required a lot of coordination during the design phase between steelwork contractor Severfield and the reinforced concrete contractor.

"There are a lot of steel to concrete interfaces, particularly along the top of the trusses where the tower's columns will be sat. Here we've had to install stiffeners for the rebar, while on the underside of the trusses, at these column locations, we've added stiffened nodes, some of which are up to 150mm thick," says Severfield Project Manager Richard Grey. "

There are 15 trusses in total of varying length, with the longest being 25m. There are eight double-height trusses, that accommodate two floor levels, and seven single level trusses.

Some of the single trusses are located where there is a set-back in the building accommodating a terrace, or in areas that will not need to absorb such heavy loadings as other zones. Above these slimmer trusses, a series of stub columns bring the steelwork up to level nine.

A variety of UC section sizes are used for the trusses with a number of them being 356 × 406 × 634 UC's. In some areas, the diagonal bracing elements have been pulled apart (un-noded) to provide sufficient space for doorways.

"The result of this un-noding has resulted in a huge local shear load - V=10,620kN, equivalent to 84 double decker busses - in the top boom," explains Mace Senior Project Manager Thomas Kercel.

"In these locations, in order to provide a member with adequate capacity the standard rolled UC has been replaced with a fabricated plate section. The webs of these fabricated sections are up to 150mm in thickness in order to provide the required shear capacity," he adds.

The trusses are supported at either end by a series of 600mm squared and double-webbed mega-columns, each fabricated from four plate sections.

All of the podium's columns are founded at ground level above a three-level deep basement. The subterranean level is predominantly formed with concrete, although some columns are steel members encased in reinforced concrete.

Based around a centrally positioned core, Fabsec cellular beams, accommodating all of the services, span outwards to the perimeter to form the desired column-free office spans.

The mega-sections account for approximately 50% of the podium's columns and are spliced at every second floor. Like all of the project's steelwork, the mega-columns had to be restricted to 9t sections so that each piece would fall within the lifting capacity of the site's tower cranes.

"It's a very confined project with no room for a mobile crane on site or on any of the surrounding streets, so everything has to be lifted by one of our three tower cranes," explains Mr Kercel.

▶18

The overall project includes a number of retained elements including a pub and a Georgian façade (under wraps)

▶17

Keeping the trusses to manageable pieces meant each one was delivered to site in at least 11 sections. The erection process had to be carefully planned with close tower crane co-ordination required to erect the trusses. Individual elements were held in place with one tower crane, while another section was craned in and connected before each truss was stable.

To reduce crane lifts and the risk of additional bolting at height, the flange splice plates were profiled with rounded ends and bolted on prior to transit. This allowed them to be swung round to complete the splice connection at high level. The web splice plates were then bolted on to alternate sides to complete the jigsaw.

Prior to delivery, each of the trusses was trial erected at Severfield's fabrication yard to ensure they could be fully assembled on site.

"This process also gave the client the opportunity to see the completed trusses," says Mr Kercel. "It was also interesting for them to observe the assembled steelwork and the large splices as some will be left exposed in the completed scheme."

One Crown Place is due to complete in February 2021.

Non-slip splice joints

David Brown of the SCI comments on the trusses' design

Substantial forces in the steel trusses at One Crown Place demand commensurate design and detailing of the splice connections – many of which can be seen in the accompanying photographs. The splices have been detailed with preloaded assemblies to ensure that the joints do not slip – essential in trusses of this nature where there are many splices and slip would have led to significantly increased deflection.

The splices are detailed with cover plates on the inside and outside of the flanges to accommodate the large forces (and bending moments, since the truss was analysed with continuity at the nodes). A common assumption is to distribute axial force in proportion to the cross section of the member, so a UC flange typically carries around 40% of the axial force.

The splices at One Crown Place were designed as bearing splices – direct transfer of compressive forces between the members. BS EN 1993-1-8 specifies minimum requirements for the splice components in clause 6.2.7.1 (13) and (14) – the choice for a bearing splice is highly recommended. The same clause specifies that the web connection must carry a proportion of the bending moment, even if it had been assumed that moment was carried entirely by the flanges. This requirement tends to lead to larger web connections than previous UK practice.

When multiple bolts are required in the direction of the force, clause 3.8 requires a reduction factor to be applied reflecting the non-uniform distribution of force between bolts. A joint is described as 'long' if the distance between end fasteners exceeds 15*d* (bolt diameter). This should be checked each side of a splice joint.

As can be seen in the photographs, the mating surfaces (called 'faying' surfaces) of the splices were left unpainted – vital if a reasonable coefficient of friction is to be achieved. Good practice is to agree the value of the slip coefficient to be assumed before starting connection design, and secondly to agree if the connection is category B or C – non-slip at SLS or ULS respectively. If category B connections are designed, the slip resistance is verified at SLS, but the bolt shear and bolt bearing are both verified at ULS to ensure that resistance at ULS is sufficient. Category B is a reasonable design choice as the applied loads should never exceed SLS – something has gone badly wrong if this happens.

At One Crown Place, HRC bolts (commonly known as 'tension control bolts') were used. Preload in the bolt is achieved when the splined end of the bolt shank shears off as the nut is tightened. Tightening torque is applied by contra-rotating sockets within the electric shear wrench. This type of preloaded assembly is widely used in the UK.

Power boost from bio-energy

Ireland's investment in green energy and waste solutions continues with the construction of a renewable bio-energy plant near Dublin.

FACT FILE
Huntstown Renewable Bio-Energy Plant, Dublin
Main client: Viridian
Main contractor: Priority Construction & Jones Engineering jv
Structural engineer: DBFL Consulting Engineers
Steelwork contractor: Fox Bros. Engineering
Steel tonnage: 200t

Creating greener sources of energy as well as finding alternative and more environmentally-friendly methods for waste disposal are challenges facing all countries across the globe.

The traditional reliance on fossil fuels is lessening, as green energy sources are now being increasingly harnessed. However, many experts state that the world still has a long way to go in order to meet targets set out at the Paris Climate Agreement.

The problem of waste is equally as challenging, because even with increased recycling, civilisation will always create some sort of waste that will need to be disposed of.

One solution to both of these challenges is anaerobic digestion (AD), which is recognised by the UK and Irish governments, Defra, the Welsh Assembly, the Scottish Parliament, Friends of the Earth and the National Farmers Union as one of the best methods for food waste recycling and dealing with farm waste and sewage sludge.

AD processes plant materials (biomass) using bacteria, which digest biomass and produce biogas as a by-product.

Biomass includes anything that is plant-derived; municipal solid waste, manure, crop residues, compost, food waste, paper and waste water.

The biogas can then be used as a fuel in a CHP (combined heat and power) unit to generate renewable energy, such as electricity.

Interestingly the use of biogas is not new. It has been used in the UK since 1895, when gas from sewage was used in street lamps across the city of Exeter.

Another benefit of AD is that whatever is left over from the process is a nutrient rich bio-fertiliser which can be pasteurised to kill any pathogens and then stored in large covered tanks ready to be applied twice a year on farmland in place of fossil fuel derived fertilisers.

It has been estimated that every tonne of food waste recycled by anaerobic digestion as an alternative to landfill prevents between 0.5t and 1t of CO_2 entering the atmosphere.

There are currently more than 100 AD plants in the UK at present and more than 14 in the Republic of Ireland. The number is expected to grow in the coming years and one that is due to come into operation next year is at Huntstown on the outskirts of Dublin.

A steel-framed solution is a proven method for AD facilities

The structure is a propped portal frame

Various forms of stability are used including the structural walls

This plant is located adjacent to the Huntstown Power Station and, once operational, it will generate up to 3.8MW of electricity to supply 7,500 homes from 90,000t of food waste per annum.

The main processing area for any AD facility is usually housed within one large structure and at Huntstown this structure measures 90m-long × 43m-wide.

This steel-framed building will house the waste disposal/reception area and pre-treatment zones, where the product is sorted prior to being pumped into the facility's six primary digestion tanks where the bio-fuel is created.

"We've been involved in a number of AD plants and they've all had a steel-framed pre-processing treatment building," says DBFL Director Colm Doyle.

"Steel is the ideal material to form these structures as they are always long span structures."

DBFL are the project's structural engineer and worked on the initial design for the main building. County Wexford-based steelwork contractor Fox Bros. Engineering were then subsequently contracted to the scheme on a design and build basis.

"This is the third AD plant we have done and they are all similar open-plan structures," explains Fox Bros. Director John O'Hara. "Once we were brought on board we value engineered the steel frame to make it as cost-efficient as possible."

Supported on pad foundations, the Huntstown facility's building is an asymmetric propped portal frame, with its centre line of columns located slightly off centre, in order to accommodate the internal equipment layout.

As well as having portalised bays for stability, the frame also makes use of bracing located in the gable ends. In these areas, the steel frame is founded on concrete walls, and uses their rigidity to add further stability to the overall frame.

The majority of the central spine columns are arranged in a hit and miss configuration, whereby only every other bay features a column. Consequently, some roof rafters span the entire 43m width unsupported, while others span 18m and 25m, either side of the off centre spine column.

Fox Bros. had to bring the roof rafters to site in three pieces, which were then assembled on site before being lifted into place in one piece.

All of the project's steelwork has been galvanized to protect it against the highly-corrosive atmosphere that arises inside an AD facility. No steel member on this project is longer than 16m, because the beams and columns all needed to fit into the galvanizing contractor's tank.

The structure also incorporates an internal two-storey office which is situated along one main elevation. Measuring approximately 50m-long × 18m-wide, its internal partition, separating it from the reception part, is formed by the off centre spine columns.

The Huntstown AD facility is due to be operational by late 2019.

Stability and second order effects on steel structures: Part 1: fundamental behaviour

Ricardo Pimentel of the SCI introduces the topics of buckling phenomenon, second order effects and the approximate methods to allow for those effects. In part 2, the various methods will be compared to the results from a rigorous numerical analysis.

When a structure is loaded, deformation occurs, and the internal forces within the structure are modified. If at some point an increase of load (and deflection) does not modify the internal forces, the structure became unstable (only considering elastic buckling). In a perfect structure, a theoretical sudden instability exists when the applied loads reach a critical load. However, because real structures are always imperfect, the so-called sudden instability does not exist – an initial bow imperfection in a strut will increase as the applied load increases. When the applied load becomes closer to the theoretical critical value, the deformation increases rapidly. This leads to the following conclusions: (i) when loaded, a strut tends to diverge from its initial position "guided" by the initial bow imperfection; (ii) the magnitude of the initial bow imperfection will have influence in the critical load of the strut; (iii) the applied load will have impact on the deformed shape, which in turn will influence the buckling resistance of the member.

From the concepts explained above, the assessment of instability problems must consider the effects of the deformations due to the applied loads. Even for the theoretically perfect structures, the prediction of the load that leads to sudden instability requires the assumption of a deformed shape of the system. To address the problem, taking the frame in Figure 1 as example, two types of effects are important:

(i) *P-δ* effects, which are related to deformations within the length of members, and

(ii) *P-Δ* effects, which are related to movement of nodes.

The impact of the *P-δ* and *P-Δ* effects is to change the forces and deflections within the structure. These are second order effects, not accounted for in a usual first order analysis. Second order effects may be accounted for by a geometric non-linear analysis or by approximate modifications of a first order analysis.

A second order analysis can be done through a series of first order analyses, applying the load in small increments, but for each increment, the deformed shape of the structure is considered.

For an idealized "perfect" pin-ended strut (Figure 2), the theoretical critical load that leads to a sudden instability of the system can be obtained by solving a second order differential equation[1]. In the process, the displacement "y" along "z" is established using a sinusoidal function, which later leads to the following definition:

$$P = \frac{n^2\pi^2 EI}{l^2} \quad \text{where } n=1,2,3\ldots$$

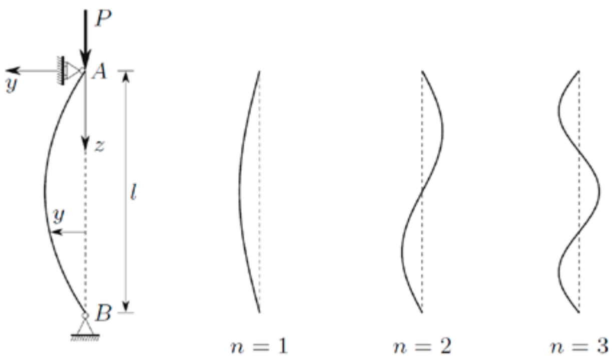


Figure 2 – Buckling modes for a pin-ended strut[2].

The load *P* is the Euler buckling load. It is clear that there are many possible values for *P* with different value of "*n*" leading to different buckling mode shapes. These modes are usually called

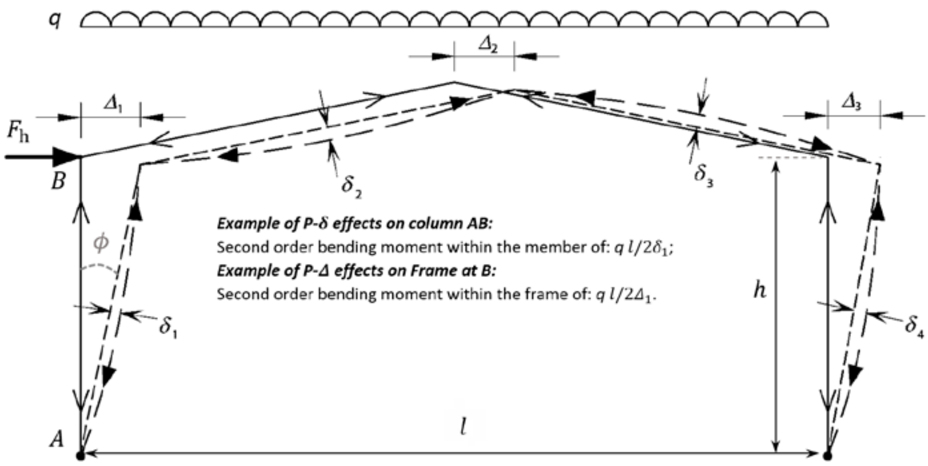


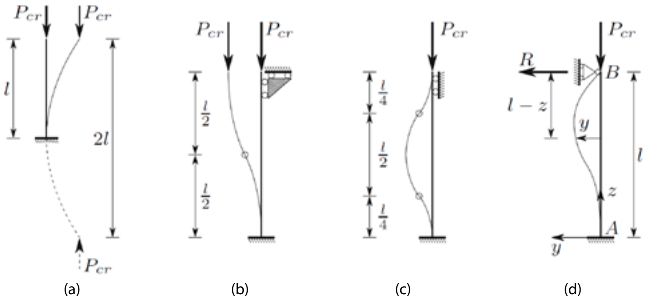
Figure 1 – Local (δ) and global (Δ) displacements which produce second order effects P-δ and P-Δ.

eigenvalues. The minimum value of P (n=1), represents the critical load of the strut (P_{cr}), which means that the first eigenvalue of the system will represent the critical buckling mode shape.

The governing equation can be re-arranged for different boundary conditions as presented in Figure 3. For some configurations (such as "a", "b" or "c"), with geometric/symmetric considerations a solution is possible without solving the differential equation. For example "a", it is clear that the critical configuration has the same shape of a pin-ended member with an equivalent length of $2l$. The corresponding critical load for case "a" is presented in the expression below ($P_{cr,a}$). The term l_{eff} is the so-called effective length, which may be defined as the length that a pin-ended strut with the same cross-section that has the same Euler load as the member under consideration.

$$P_{cr,a} = \frac{n^2\pi^2 EI}{2l^2} \text{ or } = \frac{n^2\pi^2 EI}{l_{eff}^{\ 2}} \text{ ,therefore } l_{eff}=2l$$

The behaviour presented above represents a "perfect" strut. However, imperfections will always exist, creating additional flexure in the element. This will limit the resistance to loads lower than the Euler load (line HJ in Figure 4). The residual stresses due to manufacture processes will also contribute to a lower resistance. Eurocode 3 deals with initial imperfections by specifying an equivalent bow imperfection which allows for all these effects. The behaviour of a real strut can be represented by line OCFD in Figure 4, where it is clear that the maximum axial



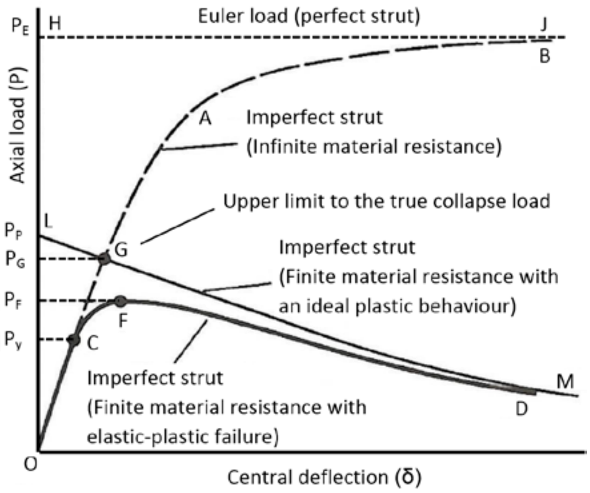
$l_{eff,a} = 2l$
$l_{eff,b} = l$
$l_{eff,c} = 0.5l$
$l_{eff,d} \approx 0.7l$

***Figure 3 – Effective length for struts with different boundary conditions*[2].**

resistance is between the elastic (Point C) and the plastic resistance of the cross section (Point G). As the resistance of Point F is difficult to determine, the calculated resistance is conservatively taken as Point C. According to clause NA.2.11 of the UK NA to EN 1993-1-1[3], to obtain the initial bow imperfection, the designer should complete a back-calculation using the buckling design procedure according to EN 1993-1-1[4] section 6.3. For the reasons explained, the elastic section modulus should be used in the process.

Figure 5 shows the Euler buckling curve (presented as stresses) which is an upper limit to the resistance. AB represents the plateau where according to theory, there is no buckling. At slenderness λ, Point G would represent the theoretical resistance, but this is reduced to Point H, due to the effect of local imperfections.

▶24



Notes: for an imperfect strut with finite material resistance (curve OCFD), after reaching yield (Point C), there is a clear decrease of stiffness due to plasticity, making the behaviour diverge from the elastic response (line OCG).

P – Axial Load;
P_E – Euler Load;
P_y – Load to elastic resistance;
P_F – Load in failure with elastic-plastic behaviour;
P_P – Load to ideal plastic resistance (squash load);
P_G – Load in failure with a perfect plastic hinge;
σ_y – Yield strength of the material.

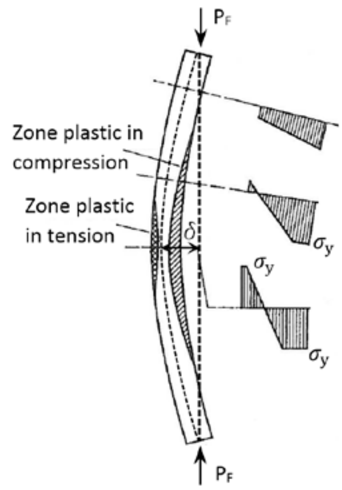
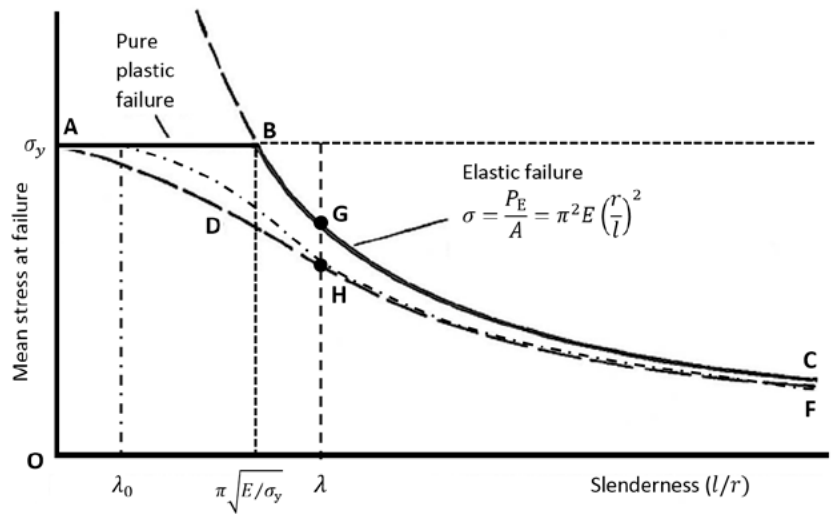


***Figure 4 – Response of a strut under axial load*[5,6]**



P_E – Euler Load;
σ_y – Yield strength of the material.
σ – Allowable stress;
l – Strut length;
r – Radius of gyration;
λ – Slenderness;
E – Young modulus;
A – Section Area.

***Figure 5 – Response of a real strut under axial load*[5]**

▶23 The Eurocode introduces an initial plateau (limited by λ_0 in Figure 5) for the design of imperfect struts. According to clause 6.3.1.3 of EN 1993-1-1, the plateau is determined by $\bar{\lambda} = 0.20$, where $\bar{\lambda} = \sqrt{A\sigma_y / P_{cr}}$ (the Eurocode terms are $\bar{\lambda} = \sqrt{Af_y / N_{cr}}$). This plateau makes an allowance for strain hardening in short columns[6]. For values above the specified slenderness for the plateau, second-order P-δ effects are always relevant for members.

The differential equation for the "perfect" struts in Figure 2 can be adapted to consider an initial bow imperfection. If the formulation for a "perfect" problem is rather complex, including an initial imperfection would certainly be more so. However, to demonstrate the concept of the effects of an initial bow imperfection, a simplified model can be adopted, where the system from Figure 2 is replaced by an idealized problem having a joint with a spring stiffness as shown in Figure 6 [2,6].

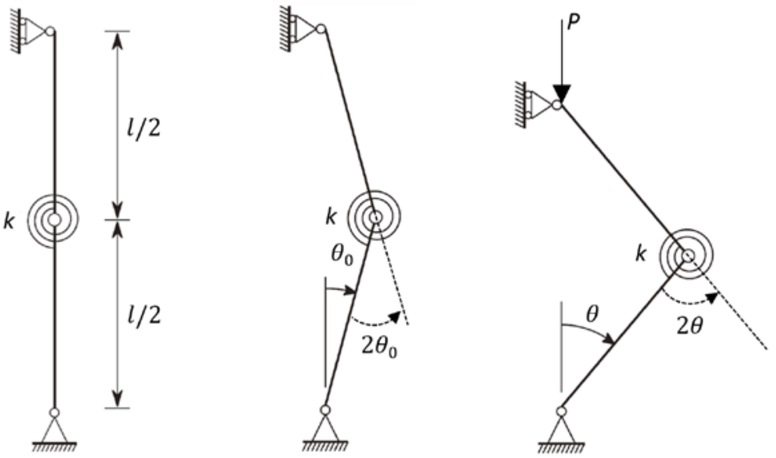


Figure 6 – Idealized system with a joint with a spring stiffness [2].

Assuming that the upper and lower bars have an initial rotation "θ_0", with zero rotation of the spring, and an axial load is applied, the rotation increases to θ, and the moment on the spring becomes $M_{spring} = k{\cdot}2(\theta - \theta_0)$, where k is the (elastic) spring stiffness. The equilibrium in the deformed shape leads to the following expression: $P\theta\, l/2 = M_{spring}$. From the two previous expressions, it can be shown that $P = \frac{4k}{l}\left(\frac{\theta - \theta_0}{\theta}\right)$. The critical buckling load P_{cr} is for a perfectly straight member, i.e. $\theta_0 = 0$. In this case, $P_{cr} = 4k/l$. Therefore, $P = P_{cr}\left(\frac{\theta - \theta_0}{\theta}\right)$. If $\theta_0 \neq 0$, θ would need to be infinite for P to be equal to P_{cr}. This means that the imperfect column will never reach the Euler load (this is consistent with the line OCGAB from Figure 4). The equation can be re-written as $\theta = \left(\frac{1}{1-\mu}\right)\theta_0$, where $\mu = P_{cr}/P$. This is the so-called amplification factor. This factor allows the consideration of second order effects by amplifying the first order effects. EN 1993-1-1 section 5.2.2 introduces this factor for frame stability in the form of $\frac{1}{1-1/\alpha_{cr}}$ which leads to $\alpha_{cr} = P_{cr}/P$, where P is the applied load and P_{cr} is the elastic critical load (for a strut, this will be Euler load). From a rigorous calculation, it can be justified that the simplified formulation provides reasonable results for $P \leq 0.5P_{cr}$ ($\alpha_{cr} \geq 2$)[7]. EN 1993-1-1 clause 5.2.2 limits the method for frame applications where $\alpha_{cr} \geq 3$.

The global P-Δ effects, according to clause 5.2.1 of EN 1993-1-1 need to be considered for the cases where the value of $\alpha_{cr} \leq 10$ for an elastic global analysis, and $\alpha_{cr} \leq 15$ for a plastic global analysis. Global imperfections for frames are defined according to EN 1993-1-1 section 5.3.2. Basically, an initial frame rotation $\phi = h/200$ (where h is the height of the frame/structure) is recommended (Figure 1), although the value can be reduced based on the number of columns and height of the frame. If the applied horizontal loads in the frame are more than 15% of the vertical loads, clause 5.3.2 of EN 1993-1-1 allows the global imperfections to be neglected. In this circumstance, the effects of global imperfections are small compared to that of the applied horizontal loads.

To assess global instability in a structure, the problem is often addressed using the Finite Element Method. In simple terms, the stiffness of a beam element is reduced based on the level of axial force. The method leads to a stiffness matrix $[K^t]$ for the total structure, where the critical factor α_{cr} is obtained by solving the determinant $|K^t| = 0$. Different buckling modes can be found (eigenvalues). For global stability, local modes (related to individual members) are ignored. The exact answer for the problem is complex, leading to the implementation of simplified approaches. The exact answer for a simple beam with no axial or shear deformation is presented in Figure 7. The terms in the matrix depend on the stability functions ϕ_i. By necessity, simplification generally involves making approximation to the highly non-linear ϕ_i functions (see Figure 8), which in turn leads to recommendations regarding modelling.

At large values of N/P_{cr}, the difference between precise and approximate values for ϕ_i is significant. It is therefore recommended that individual members are modelled by at least 3 finite elements, which reduces the N/P_{cr} ratio by a factor of 9, and consequently reduces the error in taking approximated values for ϕ_i. The maximum value of N/P_{cr} is 4 (when $l_{eff} = 0.5l$), so modelling the member with 3 finite elements reduces the ratio to 0.44. As can be seen from Figure 8, the error between the approximate and precise values of ϕ_i functions for $N/P_{cr} = 0.44$ is insignificant.

$$[K^t_{ij}] = \frac{EI}{l}\begin{bmatrix} 4\phi_3 & \frac{6\phi_2}{l} & 2\phi_4 & \frac{-6\phi_2}{l} \\ \frac{6\phi_2}{l} & \frac{12\phi_1}{l^2} & \frac{6\phi_2}{l} & \frac{-12\phi_1}{l^2} \\ 2\phi_4 & \frac{6\phi_2}{l} & 4\phi_3 & \frac{-6\phi_2}{l} \\ \frac{-6\phi_2}{l} & \frac{-12\phi_1}{l^2} & \frac{-6\phi_2}{l} & \frac{12\phi_1}{l^2} \end{bmatrix}$$

$$\phi_1 = \beta\phi_2 cotg(\beta)$$
$$\phi_2 = \frac{\beta^2}{3[1 - \beta cotg(\beta)]}$$
$$\phi_3 = \frac{3}{4}\phi_2 + \frac{1}{4}\beta cotg(\beta)$$
$$\phi_4 = \frac{3}{2}\phi_2 + \frac{1}{2}\beta cotg(\beta)$$
$$\beta = \frac{\pi}{2}\sqrt{\frac{N}{P_{cr}}}$$

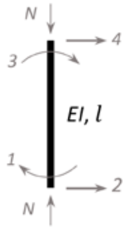


Figure 7 – Formulation for the exact stiffness matrix [8,9].

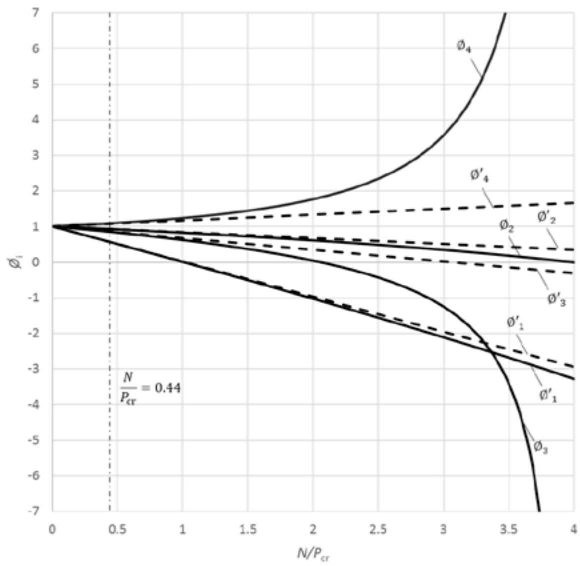


Figure 8 – Stability functions for exact (ϕ_i solid lines) and for approximate (ϕ'_i – dashed lines) stiffness matrix stiffness (ϕ'_i) [8,9].

Conclusions

1 Buckling problems demand the consideration of the deformed shape of the system;
2 The concept of an effective length is used to adapt the Euler buckling load to different boundary conditions;
3 An imperfect strut buckles before the plastic section capacity is reached;
4 Elastic section modulus must be used to back-calculate the initial imperfection;
5 Second order effects can be allowed for by using an amplification factor;
6 Approximate methods for stability functions ϕ_i are generally used in assessing frame stability;
7 Modelling with at least three finite elements per member reduces the error in using approximate stability functions.

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New and revised codes & standards

From BSI Updates February 2019

BS EN PUBLICATIONS

BS EN 1011-6:2018
Welding. Recommendation for welding of metallic materials. Laser beam welding
Supersedes BS EN 1011-6:2005

BS EN 1090-4:2018
Execution of steel structures and aluminium structures. Technical requirements for cold-formed structural steel elements and cold-formed structures for roof, ceiling, floor and wall applications
No current standard is superseded

BS EN 1708-2:2018
Welding. Basic weld joint details in steel. Non internal pressurized components
Supersedes BS EN 1708-2:2000

BS EN ISO 8504-3:2018
Preparation of steel substrates before application of paints and related products. Surface preparation methods. Hand- and power-tool cleaning
Supersedes BS EN ISO 8504-3:2001

BS IMPLEMENTATIONS

BS ISO 5952:2019
Steel sheet, hot rolled, of structural quality with improved atmospheric corrosion resistance
Supersedes BS ISO 5952:2011

CORRIGENDA TO BRITISH STANDARDS

BS EN ISO 11124-2:2018
Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. Chilled-iron grit
To be completed

BS EN ISO 15612:2018
Specification and qualification of welding procedures for metallic materials. Qualification by adoption of a standard welding procedure specification
To be completed

BRITISH STANDARDS WITHDRAWN

BS EN 1011-6:2005
Welding. Recommendations for welding of metallic materials. Laser beam welding
Superseded by BS EN 1011-6:2018

BS EN 1708-2:2000
Welding. Basic weld joint details in steel. Non-internal pressurized components
Superseded by BS EN 1708-2:2018

BS EN ISO 8504-3:2001 (BS 7079-D3:1993)
Preparation of steel substrates before application of paints and related products. Surface preparation methods. Hand- and power-tool cleaning
Also numbered BS 7079-D3:1993. Superseded by BS EN ISO 8504-3:2018

BS ISO 5952:2011
Continuously hot-rolled steel sheet of structural quality with improved atmospheric corrosion resistance
Superseded by BS ISO 5952:2019

BRITISH STANDARDS UNDER REVIEW

BS 3692:2014
ISO metric precision hexagon bolts, screws and nuts. Specification

BS 4190:2014
ISO metric black hexagon bolts, screws and nuts. Specification

PD 6513:1985
Magnetic particle flaw detection. A guide to the principles and practice of applying magnetic particle flaw detection in accordance with BS 6072

PD 6688-1-7:2009+A1:2014
Recommendations for the design of structures to BS EN 1991-1-7

PD 6695-1-9:2008
Recommendations for the design of structures to BS EN 1993-1-9

PD 6695-1-10:2009
Recommendations for the design of structures to BS EN 1993-1-10

DRAFT BRITISH STANDARDS FOR PUBLIC COMMENT - ADOPTIONS

19/30374057 DC
BS EN ISO 8504-2 Preparation of steel substrates before application of paints and related products. Surface preparation methods. Abrasive blast-cleaning
Comments for the above document were required by 9 February, 2019

CEN EUROPEAN STANDARDS

EN ISO 22825:2017
Non-destructive testing of welds. Ultrasonic testing. Testing of welds in austenitic steels and nickel-based alloys

BUILDING WITH STEEL

Reprinted from Volume 5 No. 3
November 1968

UNUSUAL TELEVISION STUDIO

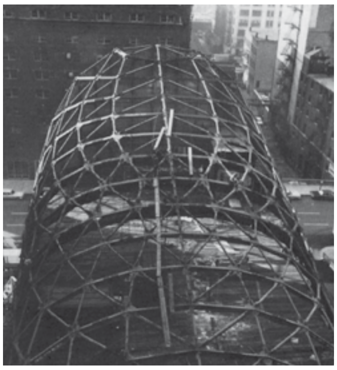
The building illustrated is clad with 85 tons of sheet lead – chosen for its sound insulating qualities – coloured a soft grey. The cantilever doubly curved roof is a steel space truss: three arches

in high tensile steel span the building between two concrete piers. The arches have tapered wide flange cross sections which have a maximum depth of 27 in at the apexes.

The steel space truss resists the roof deadload of a 4 in thick lightweight concrete slab: this is cast on steel mesh and finishes flush with the top surface.

Under live load the concrete roof and supporting space trusses act compositely.

Steel tubes – maximum diameter 8 in – for extra heavy cross sections form the longitudinal, diagonal and edge members of the cantilever spans. Gusset plates at the connections of the tube resist shear stresses between truss



and concrete deck, so ensuring composite action. The building is in Marina City, Chicago and was designed by Bernard Goldberg Associates, architect-engineers of that city. The unusual roof was designed by Hannskarl Bandel, Severud Associates, New York.

AD 428:
Draft guidance: lateral and torsional vibration of half-through truss footbridges

Purpose of this guidance
This note alerts designers to the potential susceptibility of narrow half-through footbridges to excitation by pedestrians in a lateral-torsional mode. Eurocodes and UK National Annexes do not currently fully address this mode of vibration, so there is a danger it may be discounted without proper consideration. This gap in the standards has led to the need to retrofit dampers and/or provide additional stiffening to some recently constructed footbridges where excitation occurred due to pedestrians walking eccentric to the deck centreline and, more significantly, from deliberate shaking of the deck.

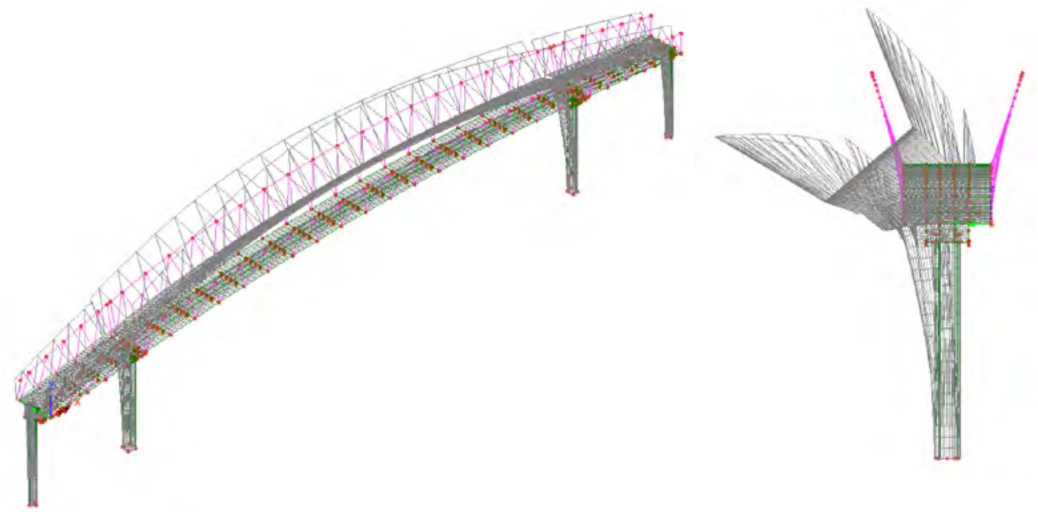


Figure 1 – Lateral and torsional mode of vibration

Affected mode of vibration
Half-through footbridges, without plan bracing to the top chord, often have as their lowest natural mode of vibration a lateral-torsional mode. A typical example is shown in Figure 1. The mode occurs because the open bridge cross-section has a low torsional stiffness with a shear centre below the deck level about which axis the rotation occurs.

Current UK design criteria and their interpretation
The criteria for assessing the dynamic behaviour of footbridges are outlined in the following Eurocodes (BS EN) and BSI Published Documents (PD):

- BS EN 1990:2002+A1:2005 as modified by UK National Annex
- BS EN 1991-2:2003 as modified by UK National Annex
- PD 6688-2: 2011

They contain the following requirements:

- Eurocode BS EN 1990 clause A2.4.3.2(2) requires comfort to be verified if the natural frequency is lower than 2.5 Hz for lateral and torsional modes;
- BS EN 1990 clause A2.4.3.2(1) states that comfort criteria should be defined in terms of maximum acceptable acceleration and proposes a horizontal limit for lateral and torsional vibrations of 0.2 ms^{-2} under normal use and 0.4 ms^{-2} for exceptional conditions, but makes these values nationally determined parameters;
- Clause NA.2.3.10 of the UK National Annex to BS EN 1990 states that the pedestrian comfort criteria should be as given in NA.2.44 of the UK National Annex to BS EN 1991-2. However, this clause does not specify a maximum acceptable acceleration for horizontal movement under normal use – it (and PD 6688-2) only address synchronous lateral vibration caused by lateral forces from footfall and does not address lateral and torsional modes excited by vertical loading.

None of the documents provide limiting horizontal accelerations for deliberate lateral shaking of the bridge.

A literal reading of all the applicable clauses therefore leads to the conclusion that a lateral-torsional mode with frequency less than 2.5 Hz should be verified for horizontal acceleration as BS EN 1990 clause A2.4.3.2 (2) still applies. However, no acceleration limit is provided as BS EN 1990 clause A2.4.3.2(1) is modified by the UK NA to BS EN 1991-2 which, itself, does not provide a limit.

Interim recommendations
Work is under way to update the relevant Eurocodes via BSI and CEN. However, the following interim recommendations are made until such time as the suite of codes above are made consistent.

i. The design should conform to the requirements of BS EN 1990 clause A2.4.3.2(2) i.e. a verification of the comfort criteria should be performed if the fundamental frequency of the deck is less than 5 Hz for vertical vibrations, and 2.5 Hz for horizontal (lateral) and torsional vibrations.
ii. In the absence of a maximum acceptable acceleration for horizontal movement under normal use being specified by NA.2.44 of the UK National Annex to BS EN 1991-2, the recommended value given in BS EN 1990 clause A2.4.3.2(1) should be used (i.e. 0.2 ms^{-2}), measured at the level of the deck. The acceleration should be calculated under the vertical load models of NA.2.44 considering walking paths offset from the bridge centreline as necessary.
iii. Where the fundamental frequency of the bridge is less than 3 Hz for horizontal (lateral) and torsional vibrations, consideration should be given to making provision in the design, in discussion with the client, for possible installation of dampers to the bridge after its completion. (This recommendation makes some allowance for uncertainty in the value of damping and other parameters used in the calculations and also provides some potential remedy for unacceptable horizontal accelerations from deliberate shaking should they occur).
iv. Any further limiting criteria for pedestrian comfort, such as under deliberate shaking, should be determined on a project-by-project basis and agreed with the client.
v. The potential for unstable lateral responses (synchronous lateral vibration) should still also be checked using NA.2.44.7 of the UK National Annex to BS EN 1991-2.

Chris Hendy, Atkins SNC-Lavalin
Chair of SCI's Steel Bridge Group

Contact: **Richard Henderson**
Tel: **01344 636555**
Email: **advisory@steel-sci.com**

Steelwork contractors for buildings

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- **F** Medium/small span portals (up to 30m) and low rise buildings (up to 4 storeys)
- **G** Medium rise buildings (from 5 to 15 storeys)
- **H** Large span trusswork (over 20m)
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  3 – Execution Class 3, 4 – Execution Class 4
- **BIM** BIM Level 2 assessed
- **QM** Quality management certification to ISO 9001
- **SCM** Steel Construction Sustainability Charter (● = Gold, ● = Silver, ● = Member)

Notes

(1) Contracts which are primarily steelwork but which may include associated works. The steelwork contract value for which a company is pre-qualified under the Scheme is intended to give guidance on the size of steelwork contract that can be undertaken; where a project lasts longer than a year, the value is the proportion of the steelwork contract to be undertaken within a 12 month period.

Where an asterisk (*) appears against any company's classification number, this indicates that the assets required for this classification level are those of the parent company.

Company name	Tel	C	D	E	F	G	H	J	K	L	M	N	Q	R	S	QM	FPC	BIM	SCM	Guide Contract Value (1)
A & J Stead Ltd	01653 693742			●	●					●	●			●	●		3			Up to £400,000
A C Bacon Engineering Ltd	01953 850611			●	●	●	●				●			●			2			Up to £3,000,000
A&J Fabtech Ltd	01924 439614	●					●		●	●	●		●	●		✔	3			Up to £400,000
Access Design & Engineering	01642 245151					●				●	●			●	●	✔	4			Up to £4,000,000
Adey Steel Ltd	01509 556677	●		●	●	●	●	●	●	●	●			●	●	✔	3	✔	Silver	Up to £4,000,000
Adstone Construction Ltd	01905 794561			●	●	●	●									✔	2	✔	Gold	Up to £3,000,000
Advanced Fabrications Poyle Ltd	01753 653617				●	●	●	●		●	●			●	●	✔	2			Up to £800,000
AJ Engineering & Construction Services Ltd	01309 671919			●	●		●		●	●	●			●	●	✔	4		Silver	Up to £3,000,000
Angle Ring Company Ltd	0121 557 7241												●			✔	4			Up to £1,400,000*
Apex Steel Structures Ltd	01268 660828					●	●			●	●			●	●		2			Up to £3,000,000
Arminhall Engineering Ltd	01799 524510	●			●	●		●		●	●			●	●	✔	2			Up to £800,000
Arromax Structures Ltd	01623 747466	●		●	●	●	●	●	●	●	●	●		●	●		2			Up to £800,000
ASA Steel Structures Ltd	01782 566366			●	●	●	●			●	●			●	●	✔	4			Up to £800,000
ASME Engineering Ltd	020 8966 7150				●	●	●	●		●	●			●	●	✔	4		Gold	Up to £4,000,000
Atlasco Constructional Engineers Ltd	01782 564711			●	●	●	●			●	●			●	●	✔	2			Up to £1,400,000
Austin-Divall Fabrications Ltd	01903 721950				●	●	●	●		●	●			●	●	✔	2			Up to £1,400,000
B D Structures Ltd	01942 817770			●	●	●	●				●	●		●	●	✔	2	✔	Silver	Up to £1,400,000
Ballykine Structural Engineers Ltd	028 9756 2560			●	●	●	●	●				●				✔	4			Up to £1,400,000
Barnshaw Section Benders Ltd	0121 557 8261												●			✔	4			Up to £1,400,000
BHC Ltd	01555 840006	●	●	●	●	●	●	●			●	●		●	●	✔	4	✔	Silver	Above £6,000,000
Billington Structures Ltd	01226 340666		●	●	●	●	●	●	●	●	●	●	●	●	●	✔	4	✔	Gold	Above £6,000,000
Border Steelwork Structures Ltd	01228 548744			●	●	●	●			●	●				●		4			Up to £3,000,000
Bourne Group Ltd	01202 746666		●	●	●	●	●	●	●	●	●	●	●	●	●	✔	4	✔	Gold	Above £6,000,000
Briton Fabricators Ltd	0115 963 2901	●		●	●	●	●	●	●	●	●		●	●	●	✔	4			Up to £6,000,000
Builders Beams Ltd	01227 863770			●	●	●	●			●	●			●	●	✔	2	✔		Up to £3,000,000*
Cairnhill Structures Ltd	01236 449393	●			●	●	●	●	●	●				●	●	✔	4		Silver	Up to £4,000,000
Caunton Engineering Ltd	01773 531111	●	●	●	●	●	●	●		●	●	●		●	●	✔	4	✔	Gold	Above £6,000,000
Cementation Fabrications	0300 105 0135	●			●		●	●			●		●		●	✔	3		Gold	Up to £6,000,000
Cleveland Bridge UK Ltd	01325 381188	●	●	●	●	●	●	●	●		●	●	●			✔	4		Gold	Above £6,000,000
CMF Ltd	020 8844 0940				●		●	●		●	●				●	✔	4			Up to £6,000,000
Cook Fabrications Ltd	01303 893011			●	●		●			●	●			●	●		2			Up to £1,400,000
Coventry Construction Ltd	024 7646 4484			●	●	●	●		●	●	●			●	●	✔	4			Up to £1,400,000
D H Structures Ltd	01785 246269			●	●		●				●						2			Up to £40,000
D Hughes Welding & Fabrication Ltd	01248 421104				●	●	●	●		●	●		●	●	●	✔	4			Up to £800,000
Duggan Steel	00 353 29 70072		●	●	●	●	●	●	●		●	●			●	✔	4			Up to £6,000,000
ECS Engineering Services Ltd	01773 860001	●		●	●	●	●	●	●	●	●			●	●	✔	3			Up to £3,000,000
Elland Steel Structures Ltd	01422 380262		●	●	●	●	●	●	●	●	●	●		●		✔	4	✔	Gold	Up to £6,000,000
ESL (GB) Ltd	01482 787986	●					●	●	●	●	●	●	●	●	●	✔	4			Up to £400,000
EvadX Ltd	01745 336413			●	●	●	●	●	●	●	●	●			●	✔	3		Gold	Up to £3,000,000
Four Bay Structures Ltd	01603 758141			●	●	●	●	●		●	●			●	●		2			Up to £1,400,000
Four-Tees Engineers Ltd	01489 885899	●			●		●	●	●	●	●		●	●	●	✔	3		Member	Up to £2,000,000
Company name	Tel	C	D	E	F	G	H	J	K	L	M	N	Q	R	S	QM	FPC	BIM	SCM	Guide Contract Value (1)

Company name	Tel	C	D	E	F	G	H	J	K	L	M	N	Q	R	S	QM	FPC	BIM	SCM	Guide Contract Value (1)
Fox Bros Engineering Ltd	00 353 53 942 1677			●	●	●	●	●		●	●				●		2			Up to £2,000,000
Gorge Fabrications Ltd	0121 522 5770				●	●	●	●		●				●	●	✔	2			Up to £1,400,000
Gregg & Patterson (Engineers) Ltd	028 9061 8131			●	●	●	●	●				●		●		✔	3			Up to £3,000,000
H Young Structures Ltd	01953 601881			●	●	●	●	●		●	●			●	●	✔	2		● (green)	Up to £2,000,000
Had Fab Ltd	01875 611711				●				●	●	●				●	✔	4			Up to £3,000,000
Hambleton Steel Ltd	01748 810598		●	●	●	●	●	●				●		●		✔	4		● (grey)	Up to £6,000,000
Harry Marsh (Engineers) Ltd	0191 510 9797			●	●	●	●			●	●				●	✔	2			Up to £1,400,000
Hescott Engineering Company Ltd	01324 556610			●	●	●	●			●				●	●	✔	2			Up to £3,000,000
Intersteels Ltd	01322 337766	●			●	●	●	●		●				●	●	✔	3			Up to £2,000,000
J & A Plant Ltd	01942 713511				●	●									●		4			Up to £40,000
James Killelea & Co Ltd	01706 229411		●	●	●	●	●				●	●		●			4			Up to £6,000,000*
Kiernan Structural Steel Ltd	00 353 43 334 1445	●		●	●	●	●	●	●	●	●	●	●	●	●	✔	4		● (orange)	Up to £6,000,000
Kloeckner Metals UK Westok	0113 205 5270												●			✔	4			Up to £6,000,000
Leach Structural Steelwork Ltd	01995 640133			●	●	●	●	●			●					✔	2		● (grey)	Up to £6,000,000
Legge Steel (Fabrications) Ltd	01592 205320			●	●		●		●	●	●			●	●		3			Up to £800,000
Luxtrade Ltd	01902 353182									●	●			●	●	✔	2			Up to £800,000
M Hasson & Sons Ltd	028 2957 1281			●	●	●	●	●	●	●	●				●	✔	4		● (green)	Up to £2,000,000
M J Patch Structures Ltd	01275 333431				●					●	●				●	✔	3			Up to £1,400,000
M&S Engineering Ltd	01461 40111				●				●	●	●			●	●		3			Up to £2,000,000
Mackay Steelwork & Cladding Ltd	01862 843910			●	●		●			●	●			●	●	✔	4			Up to £1,400,000
Maldon Marine Ltd	01621 859000				●	●		●	●	●	●			●	●	✔	3			Up to £1,400,000
Mifflin Construction Ltd	01568 613311			●	●	●	●				●						3			Up to £3,000,000
Millar Callaghan Engineering Services Ltd	01294 217711									●				●	●	✔	4			Up to £1,400,000
Murphy International Ltd	00 353 45 431384	●			●		●	●	●		●				●	✔	4			Up to £1,400,000
Newbridge Engineering Ltd	01429 866722	●	●	●	●	●	●	●	●		●	●		●	●	✔	4		● (grey)	Up to £2,000,000
Nusteel Structures Ltd	01303 268112						●	●	●	●				●		✔	4		● (orange)	Up to £4,000,000
Overdale Construction Services Ltd	01656 729229			●	●		●	●							●		2			Up to £400,000
Painter Brothers Ltd	01432 374400	●			●				●	●	●				●	✔	3			Up to £6,000,000*
Pencro Structural Engineering Ltd	028 9335 2886			●	●	●	●	●	●		●			●	●	✔	2			Up to £2,000,000
Peter Marshall (Steel Stairs) Ltd	0113 307 6730									●					●	✔	2			Up to £800,000*
PMS Fabrications Ltd	01228 599090			●	●	●	●		●	●	●			●	●		3			Up to £1,400,000
Robinson Structures Ltd	01332 574711			●	●	●	●				●			●	●	✔	3			Up to £6,000,000
S H Structures Ltd	01977 681931	●			●		●	●	●	●	●	●			●	✔	4	✔	● (orange)	Up to £2,000,000
SAH Engineering Ltd	01582 584220			●	●	●				●	●			●	●		2			Up to £800,000
SDM Fabrication Ltd	01354 660895	●	●	●	●	●	●				●			●	●	✔	4			Up to £2,000,000
Severfield plc	01845 577896	●	●	●	●	●	●	●	●	●	●	●	●	●	●	✔	4	✔	● (orange)	Above £6,000,000
SGC Steel Fabrication	01704 531286				●					●				●	●	✔	2			Up to £200,000
Shaun Hodgson Engineering Ltd	01553 766499	●		●	●		●			●	●			●	●	✔	3			Up to £800,000
Shipley Structures Ltd	01400 251480			●	●	●	●		●	●	●			●	●		2			Up to £3,000,000
Snashall Steel Fabrications Co Ltd	01300 345588			●	●	●	●	●			●				●		2	✔		Up to £1,400,000
South Durham Structures Ltd	01388 777350			●	●	●				●	●	●			●		2			Up to £1,400,000
Southern Fabrications (Sussex) Ltd	01243 649000				●	●				●	●			●	●	✔	2			Up to £1,400,000
Steel & Roofing Systems	00 353 56 444 1855			●	●	●	●				●	●		●	●	✔	4			Up to £3,000,000
Structural Fabrications Ltd	01332 747400	●							●	●						✔	3		● (grey)	Up to £1,400,000
Taunton Fabrications Ltd	01823 324266				●					●				●	●	✔	2		● (grey)	Up to £2,000,000
Taziker Industrial Ltd	01204 468080	●		●	●		●			●	●		●	●	●	✔	3			Above £6,000,000
Temple Mill Fabrications Ltd	01623 741720			●	●	●	●			●	●			●	●	✔	2			Up to £400,000
Traditional Structures Ltd	01922 414172			●	●	●	●	●	●		●			●	●	✔	3	✔	● (grey)	Up to £2,000,000
TSI Structures Ltd	01603 720031			●	●	●	●	●			●			●			2	✔		Up to £2,000,000
Underhill Engineering Ltd	01752 752483				●		●	●	●	●	●			●	●	✔	4	✔		Up to £3,000,000
W I G Engineering Ltd	01869 320515				●					●					●	✔	2			Up to £400,000
Walter Watson Ltd	028 4377 8711			●	●	●	●	●				●				✔	4			Above £6,000,000
Westbury Park Engineering Ltd	01373 825500	●		●	●	●	●	●	●	●	●				●	✔	4		● (green)	Up to £800,000
William Haley Engineering Ltd	01278 760591				●	●	●									✔	4		● (orange)	Up to £4,000,000
William Hare Ltd	0161 609 0000	●	●	●	●	●	●	●	●	●	●	●	●	●	●	✔	4	✔	● (orange)	Above £6,000,000
WT Fabrications (NE) Ltd	01642 691191			●	●	●	●				●			●	●	✔	4			Up to £40,000

Company name | Tel | C | D | E | F | G | H | J | K | L | M | N | Q | R | S | QM | FPC | BIM | SCM | Guide Contract Value (1)

Steelwork contractors for bridgeworks

The Register of Qualified Steelwork Contractors Scheme for Bridgeworks (RQSC) is open to any Steelwork Contractor who has a fabrication facility within the European Union.

Applicants may be registered in one or more category to undertake the fabrication and the responsibility for any design and erection of:

FB Footbridges
CF Complex footbridges
SG Sign gantries
PG Bridges made principally from plate girders
TW Bridges made principally from trusswork
BA Bridges with stiffened complex platework (eg in decks, box girders or arch boxes)
CM Cable-supported bridges (eg cable-stayed or suspension) and other major structures (eg 100 metre span)
MB Moving bridges
RF Bridge refurbishment
AS Ancilliary structures in steel associated with bridges, footbridges or sign gantries (eg grillages, purpose-made temporary works)
QM Quality management certification to ISO 9001
FPC Factory Production Control certification to BS EN 1090-1
1 – Execution Class 1 2 – Execution Class 2
3 – Execution Class 3 4 – Execution Class 4
BIM BIM Level 2 compliant
SCM Steel Construction Sustainability Charter
(● = Gold, ● = Silver, ● = Member)

Notes

(1) Contracts which are primarily steelwork but which may include associated works. The steelwork contract value for which a company is pre-qualified under the Scheme is intended to give guidance on the size of steelwork contract that can be undertaken; where a project lasts longer than a year, the value is the proportion of the steelwork contract to be undertaken within a 12 month period.

Where an asterisk (*) appears against any company's classification number, this indicates that the assets required for this classification level are those of the parent company.

BCSA steelwork contractor member	Tel	FB	CF	SG	PG	TW	BA	CM	MB	RF	AS	QM	FPC	BIM	NHSS 19A	NHSS 20	SCM	Guide Contract Value [1]
A&J Fabtech Ltd	01924 439614										●	✓	3					Up to £400,000
AJ Engineering & Construction Services Ltd	01309 671919	●			●	●	●	●	●	●	●	✓	4				Silver	Up to £3,000,000
Bourne Group Ltd	01202 746666	●			●	●				●	●	✓	4	✓		✓	Gold	Above £6,000,000
Briton Fabricators Ltd	0115 963 2901	●	●	●	●	●	●	●	●	●	●	✓	4			✓		Up to £6,000,000
Cairnhill Structures Ltd	01236 449393	●	●	●	●	●	●	●		●	●	✓	4			✓	Silver	Up to £4,000,000
Cementation Fabrications	0300 105 0135	●		●	●	●	●				●	✓	3			✓	Gold	Up to £6,000,000
Cleveland Bridge UK Ltd	01325 381188	●	●	●	●	●	●	●	●	●	●	✓	4		✓	✓	Gold	Above £6,000,000
D Hughes Welding & Fabrication Ltd	01248 421104	●		●		●			●	●	●	✓	4			✓		Up to £800,000
Donyal Engineering Ltd	01207 270909	●		●						●	●	✓	3			✓	Silver	Up to £1,400,000
ECS Engineering Services Ltd	01773 860001	●			●	●	●		●		●	✓	3					Up to £3,000,000
ESL (GB) Ltd	01428 787986									●	●	✓	4			✓		Up to £400,000
Four-Tees Engineers Ltd	01489 885899	●			●	●	●		●	●		✓	3			✓	Member	Up to £2,000,000
Kiernan Structural Steel Ltd	00 353 43 334 1445	●				●				●	●	✓	4			✓	Gold	Up to £6,000,000
M Hasson & Sons Ltd	028 2957 1281	●	●	●	●	●	●	●	●	●	●	✓	4			✓	Member	Up to £2,000,000
Millar Callaghan Engineering Services Ltd	01294 217711	●						●		●	●	✓	4			✓		Up to £1,400,000
Murphy International Ltd	00 353 45 431384	●	●	●	●	●	●				●	✓	4			✓		Up to £1,400,000
Nusteel Structures Ltd	01303 268112	●	●	●	●	●	●	●	●	●	●	✓	4		✓	✓	Gold	Up to £4,000,000
S H Structures Ltd	01977 681931	●	●	●	●	●	●	●	●	●	●	✓	4	✓		✓	Gold	Up to £2,000,000
Severfield (UK) Ltd	01204 699999	●	●	●	●	●	●	●	●	●	●	✓	4	✓	✓	✓	Gold	Above £6,000,000
Shaun Hodgson Engineering Ltd	01553 766499									●	●	✓	3			✓		Up to £800,000
Structural Fabrications Ltd	01332 747400	●		●	●	●	●			●	●	✓	3				Silver	Up to £1,400,000
Taziker Industrial Ltd	01204 468080	●		●	●	●	●	●	●	●	●	✓	3		✓	✓		Above £6,000,000
Underhill Engineering Ltd	01752 752483	●	●	●	●	●				●	●	✓	4	✓		✓		Up to £3,000,000
William Hare Ltd	0161 609 0000	●	●	●	●	●	●	●	●	●	●	✓	4	✓	✓	✓	Gold	Above £6,000,000
Non-BCSA member																		
Allerton Steel Ltd	01609 774471	●	●	●	●	●	●	●		●	●	✓	4			✓	Silver	Up to £4,000,000
Centregreat Engineering Ltd	029 2046 5683	●		●	●	●	●	●	●	●	●	✓	4					Up to £2,000,000
Cimolai SpA	01223 836299	●	●	●	●	●	●	●	●	●	●	✓	4		✓	✓		Above £6,000,000
CTS Bridges Ltd	01484 606416	●	●	●	●	●	●	●	●	●	●	✓	4			✓	Member	Up to £1,400,000
Ekspan Ltd	0114 261 1126	●				●			●	●	●	✓	2					Up to £400,000
Francis & Lewis International Ltd	01452 722200									●	●	✓	4			✓	Gold	Up to £2,000,000
Harrisons Engineering (Lancashire) Ltd	01254 823993	●		●	●	●	●	●	●	●	●	✓	3		✓			Up to £1,400,000
Hollandia Infra BV	00 31 180 540 540	●	●	●	●	●	●	●	●	●	●	✓	4					Above £6,000,000*
HS Carlsteel Engineering Ltd	020 8312 1879									●	●	✓	3			✓		Up to £200,000
IHC Engineering (UK) Ltd	01773 861734	●									●	✓	3			✓		Up to £400,000
In-Spec Manufacturing Ltd	01642 210716									●	●	✓	4			✓		Up to £400,000
Lanarkshire Welding Company Ltd	01698 264271	●		●	●	●	●	●	●	●	●	✓	4		✓	✓	Gold	Up to £2,000,000
Total Steelwork & Fabrication Ltd	01925 234320	●		●		●				●	●	✓	3			✓		Up to £3,000,000
Victor Buyck Steel Construction	00 32 9 376 2211	●	●	●	●	●	●	●	●	●	●	✓	4		✓	✓	Silver	Above £6,000,000

Corporate Members

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.

Company name	Tel
Control Energy Costs Ltd	01737 556631
Gene Mathers	0115 974 7831
Griffiths & Armour	0151 236 5656
Highways England Company Ltd	08457 504030
Inspire Insurance Services	02476 998924
Kier Construction Ltd	01767 640111
McGee Group (Holdings) Ltd	020 8998 1101
Sandberg LLP	020 7565 7000
Structural & Weld Testing Services Ltd	01795 420264
SUM Ltd	0113 242 7390

Industry Members

Industry Members are those principal companies involved in the direct supply to all or some Steelwork Contractor Members of components, materials or products. Industry member companies must have a registered office within the United Kingdom or Republic of Ireland.

1 Structural components
2 Computer software
3 Design services
4 Steel producers
5 Manufacturing equipment
6 Protective systems
7 Safety systems
8 Steel stockholders
9 Structural fasteners

CE
CE Marking compliant, where relevant:
M manufacturer (products CE Marked)
D/I distributor/importer (systems comply with the CPR)
N/A CPR not applicable

SCM
Steel Construction Sustainability Charter
● = Gold,
● = Silver,
● = Member

Company name	Tel	1	2	3	4	5	6	7	8	9	CE	SCM	BIM
AJN Steelstock Ltd	01638 555500								●		M		
Albion Sections Ltd	0121 553 1877	●									M		
Arcelor Mittal Distribution - Scunthorpe	01724 810810								●		D/I		
Ayrshire Metals Ltd	01327 300990	●									M		✓
BAPP Group Ltd	01226 383824									●	M		
Barrett Steel Services Limited	01274 682281								●		M		
Behringer Ltd	01296 668259					●					N/A		
British Steel Ltd	01724 404040				●						M		
British Steel Distribution	01642 405040								●		D/I		
BW Industries Ltd	01262 400088	●									M		
Cellbeam Ltd	01937 840600	●									M		
Cleveland Steel & Tubes Ltd	01845 577789								●		M		
Composite Metal Flooring Ltd	01495 761080	●									M		
Composite Profiles UK Ltd	01202 659237	●									D/I		
Cooper & Turner Ltd	0114 256 0057									●	M		
Cutmaster Machines (UK) Ltd	01226 707865					●					N/A		
Daver Steels Ltd	0114 261 1999	●									M		
Daver Steels (Bar & Cable Systems) Ltd	01709 880550	●									M		
Dent Steel Services (Yorkshire) Ltd	01274 607070								●		M		
Duggan Profiles & Steel Service Centre Ltd	00 353 56 7722485	●							●		M		
easi-edge Ltd	01777 870901							●			N/A	Gold	
Fabsec Ltd	01937 840641	●									N/A		
Ficep (UK) Ltd	01924 223530					●					N/A		
FLI Structures	01452 722200	●									M	Gold	
Forward Protective Coatings Ltd	01623 748323						●				N/A		
Hadley Industries Plc	0121 555 1342	●									M	Silver	
Hempel UK Ltd	01633 874024						●				N/A		
Highland Metals Ltd	01343 548855						●				N/A		
Hi-Span Ltd	01953 603081	●									M	Member	
International Paint Ltd	0191 469 6111						●				N/A	Gold	
Jack Tighe Ltd	01302 880360						●				N/A		
Jamestown Manufacturing Ltd	00 353 45 434288	●									M		
John Parker & Son Ltd	01227 783200								●	●	D/I		
Joseph Ash Galvanizing	01246 854650						●				N/A		
Jotun Paints (Europe) Ltd	01724 400000						●				N/A		
Kaltenbach Ltd	01234 213201					●					N/A		
Kingspan Structural Products	01944 712000	●									M	Gold	
Kloeckner Metals UK	0113 254 0711								●		D/I		
Lincoln Electric (UK) Ltd	0114 287 2401					●					N/A		
Lindapter International	01274 521444									●	M		
MSW UK Ltd	0115 946 2316	●									D/I		
Murray Plate Group Ltd	0161 866 0266								●		D/I		
National Tube Stockholders Ltd	01845 577440								●		D/I		
Peddinghaus Corporation UK Ltd	01952 200377					●					N/A		
PPG Architectural Coatings UK & Ireland	01924 354233						●				N/A		
Prodeck-Fixing Ltd	01278 780586	●									D/I		
Rainham Steel Co Ltd	01708 522311								●		D/I		
SDS/2 Ltd	07734 293573		●								N/A		
Sherwin-Williams Protective & Marine Coatings	01204 521771						●				N/A	Silver	
Structural Metal Decks Ltd	01202 718898	●									M		
StruMIS Ltd	01332 545800		●								N/A		
Stud-Deck Services Ltd	01335 390069	●									D/I		
Tata Steel – Tubes	01536 402121				●						M		
Tata Steel – ComFlor	01244 892199	●									M		
Tension Control Bolts Ltd	01978 661122						●			●	M		
Trimble Solutions (UK) Ltd	0113 887 9790		●								N/A		
voestalpine Metsec plc	0121 601 6000	●									M	Gold	
Wedge Group Galvanizing Ltd	01909 486384						●				N/A		
Wightman Stewart (WJ) Ltd	01422 823801					●					N/A		