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NSC

Weathering at Winchester

Nov/Dec 2013

Vol 21 No.6

Kelpies head regeneration

Steel spans Mansion House

Birmingham retail boost

Steel houses Stirling students

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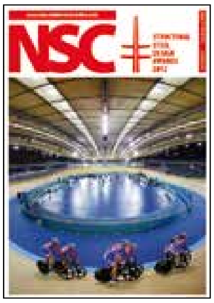

New Steel Construction keeps designers and contractors abreast of all major steel construction related developments and provides detailed technical information on key issues such as the introduction of the Eurocodes. NSC will be the first place most people hear about advances made by the extensive research and development efforts of the steel construction partners – Tata Steel, the British Constructional Steelwork Association, and the Steel Construction Institute, as well as other researchers.

Each issue of NSC is a blend of project reports and more in depth technical material. Taking up our free subscription offer is a guarantee that you will be alerted to significant developments in a sector that retains a commitment to continuous development in knowledge and techniques for timely delivery of cost effective, quality projects across all sectors of construction.

Each issue of NSC is typically 44 pages and contains four pages of news, developments related to Eurocodes, cutting edge project reports from site, and the latest technical updates from the Steel Construction Institute in its Advisory Desk Note series. One of the most popular features is 50 Years Ago, looking at key projects of the past by revisiting the pages of 'Building With Steel'.

NSC is available free of charge every two months to subscribers living in the UK or Ireland by contacting us by email at *admin@newsteelconstruction.com*, or filling in the form below and faxing it to 020 7747 8199.

You can fill out this form and fax it to **020 7747 8199**,
or scan and email it to **admin@newsteelconstruction.com**

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Cover Image
The Kelpies, Falkirk
Main client: Helix Trust (Falkirk Council, Scottish Canals)
Sculptor: Andy Scott
Steelwork and principal contractor: S H Structures
Steel tonnage: 300t

BCSA

TATA STEEL

SCI Steel Knowledge

NSC

November/December 2013 Vol 21 No 6

These and other steelwork articles can be downloaded from the New Steel Construction Website at *www.newsteelconstruction.com*

Cost guidance for steel construction

Nick Barrett - Editor

Economic recovery seems to be the dominant theme in the financial news pages these days, and survey after survey confirms that things are getting better in the construction industry. Margins remain tight and we are a long way off a return to pre-recession levels of demand, but the previously half empty glass definitely has a half full look about it.

Cost will always be a major factor influencing decisions on whether to invest, whatever stage of the business cycle we happen to be in, and it also swings decisions on what type of framing solution to use. Steel wins out on most occasions for multi storey buildings, for example, as a long history of market share surveys shows.

A careful approach to cost planning pays dividends, as a wrong decision based on inadequate understanding will be expensive to rectify. Having realistic cost information to hand is crucial, as is a well developed appreciation of what factors are important.

The steel sector is committed to helping designers and others involved in the cost process – the fuller the industry's understanding of the cost advantages of steel, the more steel will be appreciated. Regularly updated cost information is freely available on the steel construction website *www.steelconstruction.info* where a series of Steel Insight analyses from cost consultants Gardiner & Theobald are available that explore cost related topics like pricing structural steelwork and cost planning through the design stages, as well as comparative cost studies on a variety of building types including multi storey offices, schools and hospitals where steel has cost as well as other proven advantages.

With this issue of NSC you will find a new steel sector guidance document called Steel Construction: Cost which brings together a lot of this previously published material into one convenient source. It is also being distributed with a range of construction magazines and is available for free download at *www.steelconstruction.info.*

Examples of how steel construction provides cost effective solutions for the widest range of buildings is of course available with each issue of NSC, and this issue is no exception. Whether it involves creating space for a large retail development over a live main railway station, student accommodation, squeezing a modern commercial development into a tight City space, the first arena to earn a BREEAM rating or a waste to energy plant, steel is proving to be the cost effective option. The new guidance document will help to explain why.

NSC

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Rebuilding Britain campaign gathers pace after Northern Ireland infrastructure announcement

From April 2014 the Register of Qualified Steelwork Contractors Scheme for Bridgeworks (RQSC) will be a requirement for constructional steelwork on highways and bridges projects across Northern Ireland.

The announcement by the Northern Ireland Executive Minister for Regional Development was one of the first responses to The Rebuilding Britain campaign, which was launched in February 2013 by the British Constructional Steelwork Association (BCSA).

It aims to place UK-based manufacturing and construction businesses at the heart of the Government's National Infrastructure Plan and in turn ensure the economic benefits of the £100bn investment are felt in the UK. The campaign is calling for procurement guidelines to prioritise best value and recognise the economic, social and environmental quality benefits that UK firms can offer.

Sarah McCann-Bartlett, Director General of the BCSA, said: "Since the campaign was launched in February, we have held very positive meetings with key stakeholders across our industry, as well as in Westminster and with local and regional politicians. This, combined with the businesses who have pledged support through our website ***www.rebuildingbritain.com***, shows that there is real backing for the campaign. Now it is time for individuals and organisations to convert support into action."

One of the campaign's principal asks of government is that the constructional steelwork supply chain on all government funded, endorsed or PF2 infrastructure projects is procured using a BCSA quality assurance scheme, to ensure that UK companies can compete for this work.

Roofs depart and arrive at Manchester Victoria station

A £44M revamp of Manchester Victoria has kicked off with the dismantling of the station's wrought iron roof structure.

In order to bring the station up to 21st century standards and turn it into a major regional interchange for trains and trams, a new steel and ETFE roof will be erected.

Starting in January Severfield-Watson Structures will be erecting 15 curved fabricated box girders to form the new roof, the longest of which will be 96m-long.

"We will be bringing the girders to site in lengths of up to 24m, welding them up into the required spans before lifting them into place using a 750t capacity crawler crane," explains Gary Dooley, Severfield-Watson Structures Project Manager

At one end, the girders are each connected to an 18m high 660mm diameter CHS column via a pin detail. The girders then span over the station concourse and railway lines, and curve down to a concrete buttress foundation.

Other improvements to the station include a new footbridge, refurbishments to the Grade II listed Victorian buildings and a revamp of the existing retail outlets.

The overall project is due to be completed in late 2014.

Blue Book app and running

Tata Steel's app for steel section properties and member capacities for design to BS5950 or EC3 can be downloaded for free from the Apple App Store.

The app is an abridged version of the electronic Blue Book, giving users access to section property and member capacity information through iPhones, iPod and iPad.

Navigation is simple, as users can swipe seamlessly between properties and capacities. A simple tab at the bottom of the screen presents data to either BS5950 or EC3.

Steel leads the way for Crossrail developments

Three major office developments at Farringdon and Paddington Crossrail stations are set to be built with structural steelwork.

Plans have been submitted for a 15-storey 30,000m^2 office and retail development to be located at the junction of Bishop's Bridge Road and the Grand Union Canal, with direct access to Paddington Crossrail, National Rail and Underground stations. It is expected that the steel framed structure will get underway in 2016.

Two over site developments are planned for Farringdon Crossrail station's eastern and western entrances, both of which according to Crossrail will be steel framed.

Plans for the eastern entrance building are still to be finalised, while a six storey office block on the corner of Cowcross Street and Farringdon Crossrail western entrance has been approved.

By 2018 Farringdon will be one of the UK's busiest rail stations, linking Crossrail, Thameslink and London Underground services.

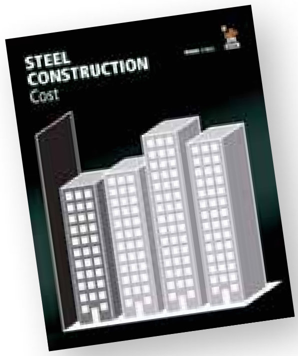
New guidance on cost

New guidance on how to cost steel frames has been published by Tata Steel and the British Constructional Steelwork Association, taking building professionals step by step through the stages of the cost planning process.

The guide – Steel Construction: Cost – is distributed with this issue of NSC and with a range of leading construction magazines, including Structural Engineer, Building, Construction News and Construction Manager. It is based on the quarterly Steel Insight series prepared by Gardiner & Theobald whose articles, as well as the new guidance document, can be downloaded free of charge from ***www.steelconstruction.info.***

Cost information used in the printed version of the new guidance is based on prices current in the fourth quarter of 2013. Regular updates on cost are made available at ***www.steelconstruction.info*** where the electronic version of the new guidance will always be kept up to date with the latest figures.

Gardiner & Theobald have so far produced nine articles in the Steel Insight series on topics including pricing



structural steelwork, cost planning through the design stages, a comparative cost study on multi storey offices, education buildings, multi storey commercial buildings and healthcare buildings. All are available for download at ***www.steelconstruction.info.***

Chinese to fund Crystal Palace rebuild

A £500M plan to rebuild the historic Crystal Palace and restore the surrounding parkland in south London has been announced.

Designed by Sir Joseph Paxton to house the 1851 Great Exhibition in Hyde Park, the palace was the largest iron and glass structure in the world. After the exhibition the entire building was dismantled and relocated to south London.

Chinese investor ZhongRong Group has appointed Arup to develop a concept for the ambitious project, which will recreate the Victorian structure (with steel and glass) on the exact spot it previously occupied until it burnt down in 1936.

The new Crystal Palace will be approximately 500m long and 50m tall, and include a hotel, conference facilities and commercial space.

"London is renowned across the world for its history and culture and the former Crystal Palace is celebrated in China as a magnificent achievement. This project is a once in a lifetime opportunity to bring its spirit back to life," said Ni Zhaoxing Chairman of the ZhongRong Group.

Tate Modern expands with steel extension

More than 5,500m^2 of exhibition and display space will be added to London's Tate Modern when its 10-storey high steel framed extension is completed.

Being built to the south of the former Bankside Power Station, the extension is being constructed on previously derelict industrial land once used to house the site's fuel tanks.

The new steel building will top out at 64.5m high and will be clad with a perforated brick façade. Two terraces will overlook the City and two new public squares will form part of a wider scheme to regenerate north Southwark.

Working on behalf of main contractor Mace, Severfield-Watson Structures is fabricating, supplying and erecting the project's steelwork.

NEWS IN BRIEF

The steel framed **Coop** headquarters in Manchester is said to be the UK's most environmentally friendly building after it was given a BREEAM score of 95.16%, the highest ever awarded.

A 30m tall man of steel sculpture is set to be installed on a hill overlooking both Sheffield and Rotherham. In recognition to the area's steelmaking heritage, the work of art is set for a public opening in 2015. Creator of the sculpture, **Steve Mehdi** said: "The figure represents mankind and despite its size it does not impose itself on people."

Newport Galvanizers (part of the Wedge Group) has provided hot dip galvanizing to 30t of structural steelwork for the Hanham Hall development in Gloucestershire. The project will include 185 homes and is set to become one of the preliminary zero carbon communities in the UK.

Tekla has launched BIMsight 1.8, the latest version of its free software tool for building information modelling project coordination. The company says the design tool concentrates on the three C's: combining models, checking for conflicts, and communicating.

Netherlands based manufacturer **Voortmann** has started production of its new V304 plate processing system. The machine is said to be ideal for repeat and simultaneous cutting jobs as well as layout marking. A maximum of six oxy-fuel torches, two plasma torches or a combination can be added to the steel gantry.

Kaltenbach has ceased representation of the German machinery manufacturer, Behringer. Customers of Kaltenbach that have purchased Behringer equipment will, however, be able to continue to receive technical support and after sales support services.

AROUND THE PRESS

New Civil Engineer
7 November 2013
Keeping Ireland green
[Wexford power plant] - "Steel has the ability to be quickly and economically erected with large spans which can absorb big loads. Steel frames are also versatile enough to be continually redesigned, even while the erection process is on going," said Santiago Paje, Initec Energia chief designer for civil engineering.

The Structural Engineer
October 2013
Design and construction of Milton Court
The concert hall and foyer structures are steel framed which provides slim but strong vertical structure and addressed some of the buildability issues associated with the [needed] 'box-in-box' approach used to meet acoustic performance criteria.

Construction News
20 September 2013
Steel brings new life to Longbridge
"I've been here for 14 years and nearly all the buildings are steel," says St Modwen construction manager Mark Batchelor. "We like it because of its speed of construction. You can still put it up in bad weather, it doesn't require much back propping and you span large distances and build in future flexibility."

Construction News
20 September 2013
Power plant walks with dinosaurs
[Ardley EfW plant] - Tata Steel Projects designed the complex curved steel superstructure with a high architectural specification, which needed to be integrated with the process steelwork.

Building Magazine
13 September 2013
One for heavy metal fans
[Leadenhall Building] – According to Steve Cork, Laing O'Rourke Director, 85% by value of the project has been prefabricated, which is unprecedented for a high rise City office building.

Contractor opens structures division

Mabey Bridge has expanded its operations by launching a new business venture known as Mabey Structures. Employing former directors, engineers and technical staff from Rowecord Engineering, the new operation has an initial focus on manufacturing for stadia, healthcare, and commercial sectors.

"This is a fantastic and exciting opportunity," said Jason Churcher, Sales Director of Mabey Structures. "The new business builds on Mabey Bridge's growing portfolio of business sectors that include; infrastructure for road and rail, wind turbines towers, and international bridging.

"The range and scale of the Mabey Bridge business is impressive and the advanced manufacturing facilities are outstanding. The team and I are very excited that we will be able to continue delivering iconic structures."

Commenting on the company's business expansion Chris Droogan, Managing Director at Mabey Bridge said: "Initial market reception to Mabey Structures has been extremely positive and we are confident that this new venture will add considerably to our overall business success."

Campus by the sea takes shape

The £450M Bay Campus development in Swansea is rapidly taking shape with the help of steel construction.

Developer St Modwen and Swansea University, along with their construction partners, Vinci Construction and Leadbitter, are constructing a new campus on the eastern approach to the city.

Located on a former BP Transit site, the campus will have the distinction of being one of the few universities with direct access onto a beach and its own seafront promenade.

The majority of the campus will comprise of steel framed buildings, with Caunton Engineering responsible for five structures.

The company will erect 1,600t of steel for an innovation hub and manufacturing block; a teaching block; a great hall student facility; a learning and resource centre; and a Swansea Materials and Research Testing (SMaRT) building which will be used for testing materials for the aerospace industry.

Thames crossing to be built with steel

A new pedestrian and cycle bridge spanning the River Thames at Reading, designed by architect Design Engine in collaboration with engineers Peter Brett Associates, has been awarded planning permission.

The steel bridge's deck will be supported by paired cables that reach up to the top of a single mast in a vertical fan formation.

"This will create an elegant and balanced solution," said Richard Jobson, Design Engine Director. "And by using a bespoke H-shaped connection at the top of the mast, the cables will be concealed, furthering our concept of an elegant mast."

Where the bridge connects to the south bank towpath, feature balustrading made from weathering steel to resemble reed beds, will conceal a ramp and staircase.

"Steel was chosen for its speed and strength qualities," added Mr Jobson.

Located to the east of Fry's Island, between the existing Caversham and Reading Bridges, the crossing will provide an important new link to the town's redeveloped railway station.

Antarctic station's steelwork passes the test

Weighing more than 500t, the British Antarctic Survey's Halley V research station, located on the Brunt Ice Shelf in the southern Weddell Sea, has been decommissioned and recycled with all the steel found to be in perfect condition.

Over a period of one month, the station, including its steel superstructure, was systematically unbolted, removed from the ice shelf and shipped to South Africa.

The original steel frame consisted of Grade 50E and Grade 50EE steel sections with a three degree tapered flange. In a modular construction programme the steel had been delivered to site in less than 6t loads. The frame was then bolted and held in place by Lindapter girder clamps.

Despite the structure having an intended lifespan of 20 years, the girder clamps withstood 28 years of extreme conditions and were also said to be in prime condition.

The station's steelwork had to endure the Antarctic weather, which is extreme. During the summer months the continent has 24 hours of sunlight a day, which warmed up the steelwork, while in the totally dark winter months the external frame cooled as low as minus 55 degrees.

Lindapter manufactured customised clamps for the project, using blackheart malleable iron to provide significant tolerance and strength to withstand thermal flexing.

"Conditions are extremely inhospitable at times," said Steve Canham, British Antarctic Survey Building Officer. "But it's a non-corrosive atmosphere, which explains the steelwork's condition, as we have high winds and snow, but no rain."

Situated on the same ice shelf, the British Antarctic Survey's latest steel framed research station, Halley VI, is now in use.

Malcolm Cooke (second from left), Welding Apprentice at South Durham Structures (SDS) collects his Apprentice of the Year Award, Craft Section from the Worshipful Company of Tin Plate Workers Alias Wire Workers. Mr Cooke was the first person from the structural steel sector to ever win the award which also included £2,000 in prize money. Also pictured are (from left to right) Dianne Gregory, SDS Human Resources Manager; Andrew Balcombe, Master of the Worshipful Company of Tin Plate Workers alias Wire Workers of the City of London; and Brian Hope, SDS Managing Director.

More exacting certification for Celsius® sections

Tata Steel Celsius® 355 hot finished hollow section is manufactured exclusively from normalised, fine grain steel. This enables the customer to benefit from many advantages – in both performance and processing.

Celsius® 355 is supplied with an inspection certificate type 3.1. This guarantees that the products comply with European Standard EN10210. Until now, however, the product certification has not fully reflected the quality and traceability inherent in Celsius® 355.

Tata Steel is now certifying the product to comply with the improved standard BS EN10210:S355NH ensuring customers can use the high performance and benefits.

Celsius® 355 product will be dual certified and fully meet the requirements for BS EN10210:S355NH & BS EN10210:S355J2H.

A six page flyer, detailing Tata Steel Celsius® 355 sections, is distributed with this issue of New Steel Construction. The flyer can be downloaded at ***http://www.tatasteeleurope.com/file_source/StaticFiles/Business_Units/Corus_Tubes/Tubes/TST52_Celsius_355_NH_explained.pdf***

Diary

For SCI events contact Jane Burrell, tel: 01344 636500 email: *education@steel-sci.com*
For Tata Steel/BCSA events register online at *www.steelconstruction.info/Steel_Essentials_2013*

Tuesday 26 November
Loading to BS EN 1990
1 hour webinar

Thursday 28 November
Steel Essentials Seminar
The George Hotel, Edinburgh

Tuesday 10 December
Frame Stability
1 hour webinar

Tuesday 14 January 2014
Compression Members
1 hour webinar

Thursday 30 January 2014
Steel Building Design to EC3
(1 day course) London

Tuesday 11 February 2014
Members in Bending
1 hour webinar

Tuesday 25 February 2014
Steel Frame Stability
(1 day course) Leeds

Wed12 & Thu 13 March 2014
Essential Steelwork Design
(2 day course) Sheffield

Retail is just the ticket for station upgrade

A number of unique challenges are being successfully overcome as a steel framed department store is built beside and over the UK's busiest rail interchange. Martin Cooper reports.

FACT FILE
Birmingham New Street Station redevelopment and Grand Central incorporating John Lewis Partnership department store
Main client: Network Rail
Architect: Haskolls
Main contractor: Mace
Structural engineer: Atkins
Steelwork contractor: Severfield-Watson Structures
Steel tonnage: £2,850t

Birmingham New Street is undergoing a major redevelopment that will transform what is universally recognised as a dark and unwelcoming station into a light filled modern facility fit for the 21st century.

The project is due to be fully completed in 2015 and includes a spacious concourse and retail area enclosed by a giant ETFE clad atrium, more accessible platforms served by new escalators and lifts, and a new station exterior.

The retail part of the scheme is important, as it will transform the station into a destination not only for rail passengers but also for city centre shoppers.

Situated above the concourse the retail zone is known as Grand Central and will be anchored by a four-storey 23,500m^2 John Lewis store.

This steel framed structure recently topped out and is one of the more advanced parts of the overall scheme.

Approximately half of the store's footprint sits on top of an existing station concrete structure and this necessitated a thorough review of both the existing frame and foundations which then resulted in a more complex design than would ordinarily be expected.

The John Lewis store was a late addition to the scheme and much of the design work for the station had already been completed prior to its inclusion.

"The demolition of Stephenson Tower created some space for the construction of the new John Lewis building, however a substantial part needed to be built over the existing station. To achieve this some of the existing heavy concrete frame needed to be demolished and replaced with a new lightweight steel frame in order to not overload the remaining foundation," explains Atkins Project Engineer Mike Stephens.

Information of the existing piled foundations revealed that a limited amount of additional load could be accommodated. This still meant the new frame needed to be as light as possible to achieve the desired four-storeys. Weight was one of the main reasons why steel was chosen as the framing material.

In some locations the new steel structure surrounds the existing reinforced concrete beams. To ensure loads are transferred through and not carried by the existing structure, an online monitoring system has been installed to the 18 new columns that sit on the concrete structure. This system consists of highly accurate level monitoring equipment, strain gauges and load cells.

Underneath the existing structure steel columns have been installed to add extra support. A system of flat jacks has been fitted to these columns which allows any settlement of the new foundations to be jacked out and the forces above the below the existing structure to remain in balance. The columns can also be monitored during the entire construction phase and the later fit-out programme, again ensuring the loads are not too high.

"This automated system allows us to check that we are minimising the weight in these areas," explains Steve Swift, Severfield-Watson Project Manager. "This has made the erection programme more complex and meant our steel team had to be educated about installing the monitoring system."

The frame has a number of transfer structures, some of which limit the amount of load being transferred to the existing station structure. Above platform 12 there is a series of large plate girders installed within the store's roof. Measuring up to 20m in length and weighing in excess of 15t each, they were all erected with temporary columns supporting the area directly above the station.

Once the building's floors have been cast, the temporary columns will be removed and the floors above will hang from the plate girders, to ensure that in these areas the loads are carried by new piled foundations.

The John Lewis store will feature the same metallic cladding as the rest of the station project

A large void penetrates the centre of the store

Plate girders form the large opening for the store's main entrance

Severfield-Watson has not only erected the project's steelwork, it has installed stairs and taken on much of the concreting works, such as slipforming the cores and installing the floors. To further save weight the floors are all of a composite design comprising metal decking and the thinnest possible topping.

"Much of the frame's stability is derived from the cores and we had control of their construction and the installation of the cast-in plates for our connections, all which are bespoke," says Mr Swift.

The majority of the steel frame has been erected around a regular grid pattern of 10.9m x 9.6m. Most of the steel sections are of a transportable size with the exception of two large plate girders that span over the new southern entrance.

Known as the Spanish Steps, this will be one of the main entrances into the redeveloped station. The plate girders, which support four levels of retail frame above and create a large column free area, are 33m long and had to be brought to site in three pieces.

Working on a major construction project in the middle of the UK's second largest city is in itself a tricky undertaking, this is compounded by keeping New Street fully operational throughout the scheme.

It is the busiest interchange in the UK, with a train leaving the station every 37 seconds and over 140,000 passengers using the station every day, all of which adds to the project's complexity.

"It's a live station environment operating for almost 24 hours each day, so we have limited windows of opportunity for large lifting operations and the movement of materials," explains Jeremy Haldane, Mace Associate Director.

"The site is also very confined and surrounded by busy city streets and all steel deliveries and lifts have had to be fully coordinated, all of which has been done very successfully through meticulous planning."

> *"Some of the existing heavy concrete frame needed to be demolished and replaced with a new lightweight steel frame in order to not overload the remaining foundation."*

A new station for Birmingham

As well as the John Lewis store, structural steelwork is playing a significant role in other areas of this major project. Severfield-Watson has erected approximately 2,000t to form the new station concourse and new platform entrances.

Under a separate contract structural steel has formed the new station exterior, a faceted curving façade, which incorporates the John Lewis store, onto which a stainless steel cladding is being installed.

Apart from the John Lewis store the most prominent feature of the project will be the atrium of the Grand Central shopping mall that will be formed by a series of 30m long arched steel box section trusses.

The John Lewis store takes shape while the steel trusses for the redeveloped station (right of picture) are assembled in readiness for erection

Load sharing between the existing and new structure at New Street

Dr Richard Henderson (SCI)

Construction of the new building over the existing New Street Station involves load sharing between the existing and the new structure. Monitoring and adjustment is required to ensure that the existing structure is not overloaded. Dr Richard Henderson of the SCI explains.

Existing concrete columns at New Street Station are capable of supporting only part of the load from the new structure. New steel columns and foundations have been installed to share the additional load and the compression carried by the existing columns is monitored and adjusted as the new structure is built. Load cells in the new steel columns immediately above and below the existing concrete column-head are used to determine the load carried by the existing structure. Load data is transferred in real time over an internet connection and can be monitored remotely. Hydraulic flat jacks are used to relieve the load in the existing concrete columns by jacking load into the new steel columns. (Figure 1)

The new columns support a series of transfer beams at roof level which act compositely with the concrete slab. In the permanent state, these transfer beams support three levels of steelwork which, during the erection phase, were supported from below. Following the casting and the development of sufficient strength in the concrete at roof level but before casting concrete on the floors below, the temporary supports were removed and the structure was lowered until it was hanging from the transfer beams. During this operation, additional load was transferred into the new columns via the transfer beams, requiring monitoring and control of the load in the existing concrete columns.

The magnitude of load carried by the existing columns was related to a traffic-light system, used to trigger alerts sent by text and subsequent actions. On amber, the erector was alerted to relieve the existing structure within an agreed timescale. On red, the erector was alerted to take immediate action and the engineer was alerted too. A red alert has not so far been triggered. Monitoring and adjustment will continue during casting concrete on the floors suspended from the transfer beams to ensure the existing columns are not overloaded.

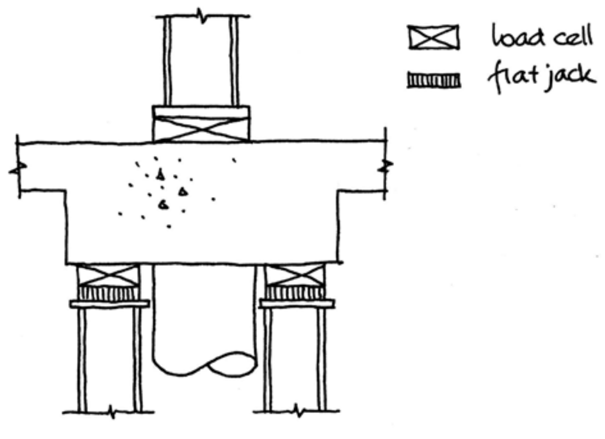


Figure 1 Indicative Arrangement

This complex project successfully demonstrates the real-time monitoring of load, and careful adjustment of jacking forces to maintain an allowable level of load carried by an existing structure. The sequencing of steel erection, casting concrete and load transfer was carefully planned, including the prediction of structural movements and the selection of connection details to allow the anticipated movement to occur.

The first building to be completed was Willow Court

Student accommodation graduates with steel

An ambitious student accommodation project is under way at the University of Stirling, a scheme that will ultimately provide 788 new bed spaces.

FACT FILE
University of Stirling residences
Main client:
University of Stirling
Architect:
Lewis and Hickey
Main contractor:
Graham Construction
Structural engineer:
Woolgar Hunter
Steelwork contractor:
Walter Watson
Steel tonnage: 920t

Established by Royal Charter in 1967 the University of Stirling had the distinction of being the first new university in Scotland for nearly 400 years. Since then it has earned a reputation for excellence in arts and science by attracting leading researchers and scholars from around the world.

The campus has been continually evolving and a new masterplan was completed in 2011.The redevelopment of some of its residential accommodation formed an integral part of this plan and highlighted the continuing evolution of the site.

Costing in the region of £38M and funded by the University, the project is due to be completed by 2015. It will replace 40% of the existing accommodation and is being delivered over three separate phases.

The first phase of the construction programme began in 2012 (see box) and was recently completed in time for the start of this year's autumn term. Main contractor Graham Construction is now well under way with the second phase.

This part of the project began with the demolition of the ageing concrete framed Murray Hall which is being replaced by a new 285 bedroom steel framed residence. This is scheduled for completion in time for the 2014 autumn term.

Walter Watson has been responsible for all of the steel packages and started erecting steel for this phase in late September. It consists of the three, four and five-storey residential blocks, all interlinked and set out in a U-shape configuration.

Built on top of a steep slope adjacent to the campus loch, the open part of the U-shape faces the water, affording many of the flats a scenic view.

The location has also thrown up one of the job's main challenges, namely access. During the steelwork erection programme

The choice is steel

Three framing options were initially considered for two main residential developments of phase one and two; a light steel framed modular system formed from profiled strip, a structural steel frame with concrete planks, and a concrete frame.

"The structural steel option was adopted to provide flexibility both in terms of design development and of procurement, as well as to provide a fast and buildable frame," says Fiona Harvey, Lewis and Hickey Associate.

She adds the lightweight solution was discounted due to potential restrictions in design and procurement, while concrete was disadvantaged in terms of cost and programme.

Malcolm Buchanan, Woolgar Hunter Project Director adds: "A detailed option appraisal was undertaken and a steel framed solution with asymmetric floor beams and precast floor units offered the best value."

Structural flexibility was a key requirement for the client and the University recognised that this framing solution would create buildings that could be adapted to changing student requirements over the potential 60 year lifespan.

"The current residences, including the recently demolished Murray Hall, are load bearing blockwork with precast slabs which has proven to be restrictive to future development," sums up Ms Harvey.

Phase one

Phase one of the project consists of a cluster of three townhouses known as Alexander Court (above) and a 128 bedroom residential block called Willow Court.

The four-storey Willow Court is a braced steel framed structure based around a regular grid pattern. Three stair and lift cores, at either end of the building and one centrally positioned, provide the structure with stability.

The ground floor of the building contains a launderette, cafe and offices. The upper four levels are all identical and consist of two rows of bedrooms separated by a central corridor. Midway along each floor level there are shared kitchen spaces that cantilever out by 2m from the rest of the structure.

The townhouses, will provide 128 beds within a number of two, three and nine bedroom flats housed in the three-level structures.

They have been formed with a ground floor steel portal that supports a timber frame for the two upper levels.

"Steel was introduced within the townhouses to provide open plan living accommodation at ground floor level,' explains Malcolm Buchanan, Woolgar Hunter Project Director.

Walter Watson quickly began to eat up any available space, except for the central and open sector of the U-shaped footprint.

"It's very difficult to gain access and bring deliveries to the site as it is surrounded by a steep slope on one side and existing buildings on another," says David Smith, Graham Construction Site Engineer. "The only practical route in is directly through one of the blocks."

Walter Watson has left out some floor beams from the middle bay of the central block creating an access tunnel with enough headroom for materials to be delivered into the site.

"We've added some temporary bracing to support the area and we will have to return to site to infill the bay later in the construction programme," explains Trevor Irvine, Walter Watson General Manager, Structural Division.

Woolgar Hunter did the project's steel design, while Walter Watson designed the frame's connections. These are generally within the width of the precast slabs as a flat soffit solution offers ease of services integration and a more economical reduced building height.

Each of the three residential blocks in phase two is a braced steel structure with extra stability derived from lift and stair cores. All of the floors, except the ground floor, feature a central corridor with bedrooms on either side.

"Lack of space meant we had to move our crane a few times to get the necessary reach and sequence the erection programme correctly," sums up Mr Irvine. "Bearing In mind there were only a few spots on the site flat enough to accommodate a 60t capacity crane."

All rooms could be reconfigured in the future

Murray Hall is a U-shaped residence positioned on a steep slope

Art signposts seat of learning

The centrepiece of a new steel framed university teaching block is a hanging artwork of Christian symbols.

FACT FILE
St. Alphege Learning and Teaching Building, University of Winchester
Main client: University of Winchester
Architect: Design Engine Architects
Main contractor: Geoffrey Osborne
Structural engineer: Heyne Tillett Steel
Steelwork contractor: Snashall Steel Fabrications
Steel tonnage: 130t

The latest instalment in the University of Winchester's redevelopment masterplan is the recently completed St. Alphege Learning and Teaching Building, a project that has made full use of steel construction's speed and flexibility.

Providing teaching spaces for 600 students, the new two-storey building has achieved a BREEAM 'Excellent' rating and is part of the University's aspiration to drive for higher standards for studying and learning.

The building has been constructed with a primary steel braced frame supporting block work walls, while an insulated rain screen cladding is fixed to the structure to form the finished envelope. One end of the building is completed with a 12m high portico housing a highly distinctive artwork of Christian symbols.

"A steel frame was chosen primarily for its speed of erection as we had a very tight programme," explains Richard Jobson, Design Engine Director. "From commission to completion we only had 18 months and by using the chosen materials the main contractor, Geoffrey Osborne, easily met the completion date."

Flexibility was another important design consideration that a steel frame was able to satisfy. None of the structure's internal walls are load bearing, meaning they could be removed in the future if the teaching spaces needed to be reconfigured.

Steel beams support exposed 12m span precast planks for all floors and the roof. The floors are water cooled as part of the overall heating and cooling strategy for the building. Pipework is linked directly to an air source heat pump and the building's management system.

"A steel frame and precast planks were used to achieve optimum thermal mass as the teaching rooms are fully occupied throughout the day resulting in significant heat build up from both students and computers," says Mr Jobson.

The St. Alphege Learning and Teaching Building is positioned on a steeply sloping site close to the campus entrance, a spot previously occupied by a 1930s Faculty of Arts building that was demolished to make way for the new building.

The new building is connected to the existing 1970s St. Edburga teaching block, which has undergone extensive refurbishment works as part of a second phase of the contract (see box).

Constructing a new two-storey block adjacent to an existing building posed a few challenges for the team, not least because St. Edburga had to remain partially operational during construction. Consequently, keeping noise to a minimum as well as inter-trade co-ordination were key issues.

St. Edburga refurbishment

A he second phase of the contract consisted of the complete refurbishment of the St. Edburga building with a new thermally efficient external cladding and a brand new rooftop teaching extension.

"In order not to overload the existing structure we needed a lightweight material for the new upper floor," explains Mr Jobson. "Steelwork connected to the existing concrete/masonry frame was the only viable solution."

However, erecting the extension's steel frame was not simple as Blair Thomas, Snashall Steel Fabrications Technical Director explains: "The old building was not entirely square so it was extremely challenging work getting the steel to match the existing grid."

The St. Edburga building is connected to the Learning and Teaching Building via a new steel framed glazed atrium. Together the two buildings combine to form a new landscaped piazza space fronting the campus entrance.

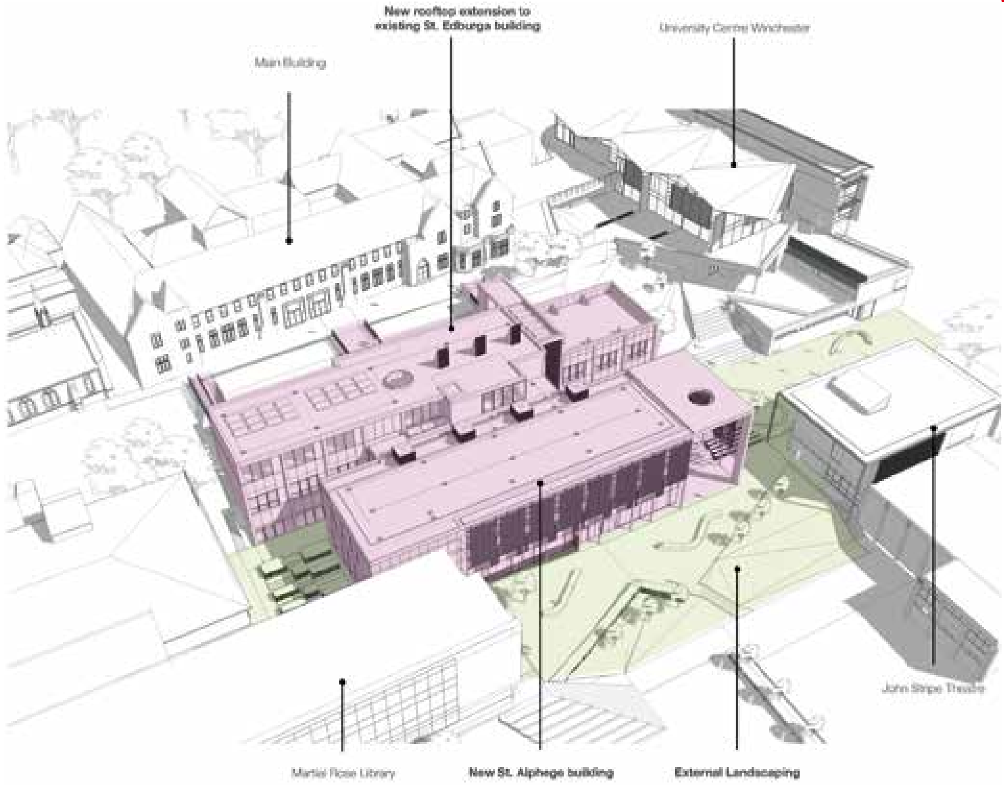
The twelve apostles are represented by hanging steel boxes

Another key factor concerning the St. Edburga building is that it has floor-to-ceiling heights of just 2.3m. The team wanted to have level floor plates to ease the transition between the two buildings and provide a degree of symmetry.

This was however problematic because of the desire to have higher teaching spaces in the new accommodation. Design Engine therefore opted to make the ground floor of the new teaching block double height so that the first floor could align with the new upper storey of St. Edburga.

Acknowledging the University's Christian links, the work represents Christ surrounded by the apostles, symbolised by suspended steel box sections, while a weathering steel element represents Judas. Thirty stainless steel rods, denoting the pieces of silver that Judas received for betraying Jesus, link all of the hanging elements.

The project's artwork highlight is accommodated within the galvanized steel portico, formed by two 850mm wide × 200mm thick steel ladders and supported off of one end of the main steel frame. The portico provides a frame for hanging artwork, designed by the architects in consultation with the University.



The side elevation is clad with brise soleil

The new block faces onto a landscaped piazza

Each head is formed from more than 13,000 invididual steel pieces

Key facts

1. More than 6km of Tata Steel Celsius® steel tube used to create the heads.
2. 10,000 bespoke fixings to secure the skin cladding to the steel.
3. The heads are approximately 30m high.
4. The ears are more than 5m high.
5. The base of each head is approximately 25m long and 10m wide.

The heads are located either side of a new canal lock

Kelpies give the nod to steel

Complex tubular steelwork has formed two 30m high equine heads that are an integral and highly visible signpost to a large Scottish regeneration scheme. Martin Cooper reports.

Regular road users of the M9 motorway will have noticed that two 30m high steel horse head sculptures have been taking shape over the last few months, close to junction 6 at Falkirk.

Not a regular occurrence by any stretch of the imagination, but these sculptures – called The Kelpies - are signposting one of Scotland's newest visitor attractions.

Known as the Helix project, a swathe of land between Falkirk and Grangemouth is being transformed into a vibrant park with its own lagoon, outdoor events space, and a new turning pool and lock for canal boats.

The Forth & Clyde canal joins the River Carron within the parkland but navigation is problematical due to a low bridge carrying the M9 motorway. A new lock and canal link, flanked and signposted by The Kelpies, will provide boats with an alternative route.

Construction work on Helix Park began in 2011 and much of it is now open to the public. The Kelpies project, which includes canal works and a visitor centre, is one of the final elements of the scheme.

Balfour Beatty Civil Engineering completed the foundations for The Kelpies earlier this year, allowing the steelwork programme to begin last July.

All of the steel fabrication and assembly was carried out at S H Structures' facility in North Yorkshire. Having sourced the necessary tubular steel from Tata Steel mills at Hartlepool and Corby, the sections were bent to the required shapes by Angle Ring before being shotblasted and coated with a four-coat protective coating system by Jack Tighe.

"We fabricated much of the steelwork offsite and brought it to Falkirk in the largest transportable sizes," explains Tim Burton, S H Structures Sales and Marketing Manager.

The internal structure has two elements, a primary main frame made up of tubular trusses and assembled frames that weigh up to 10t and have maximum measurements of 4.5m wide × 12m long. Outside of this there is a secondary steel structure that follows the profile of the internal surface and supports brackets to take the stainless steel cladding which forms the outer skin of the two heads.

As individual pieces were fabricated they were joined together to form larger sub-assemblies. It was impractical to trial erect both complete heads, but each interfacing frame was matched to ensure a first time fit could be achieved on site.

As the bulk of the fabricated steelwork had been stored close to the site the lifting of the first sections started immediately. Due to the detailed modelling process, accurate shop fabrication and trial assembly, the structure went up quickly.

The various elements were predominantly bolted together with some welding on site required, although the design process ensured this was kept to an absolute minimum. Primary trusses rapidly took shape and very soon the secondary steelwork was being added.

Some of the final items to be erected were the most complex, such as the ears, noses and jaws. They arrived on site fully

FACT FILE
The Kelpies, Falkirk
Main client: Helix Trust (Falkirk Council, Scottish Canals)
Sculptor: Andy Scott
Main contractor: Balfour Beatty Civil Engineering
Structural engineer: Atkins, SKM
Steelwork and principal contractor: S H Structures
Steel tonnage: 300t

Located within a parkland setting, the Kelpies are set to become a major tourist attraction

assembled and were clad before being lifted into place.

Using computer software, S H Structures was able to locate the optimum lifting points and determine the correct sling lengths for these complex shapes. This was invaluable to the site team as physically locating these points on site would have proven to be near impossible.

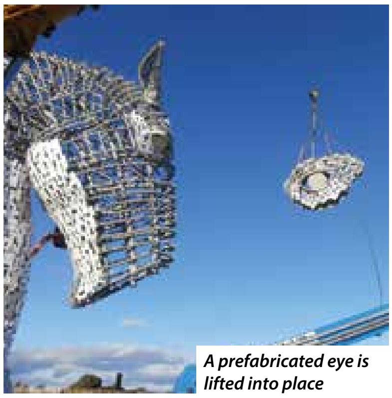
Early in the design process Andy Scott, Project Sculptor had produced a pair of tenth scale models to provide the team with something physical to work from. Once the steel frame had been modelled one of the biggest challenges was scaling up the method of creating the skin cladding.

Some of the final items to be erected were the most complex, such as the ears, nose and jaw. They arrived on site fully assembled and were clad before being lifted into place.

The skins of the models were created by carefully welding together hundreds of individual small plates. Creating something ten times this size needed a different approach. Structural engineer Atkins solution was to clad the heads with much larger 6mm thick panels that were then profiled by laser to appear like a number of smaller plates when viewed from a distance.

The Kelpies along with the associated landscaping and canal works are due to be officially opened in April 2014. As Mike King, Helix Trust Programme Director says: “The project will dramatically transform an area of under used land and will become a superb visitor attraction for the benefit of Scotland.”

Kelpies concept and modelling



A prefabricated eye is lifted into place

Sculptor Andy Scott was commissioned by the Helix Trust to design an artwork that would reflect the scale and scope of the project. His choice of two steel framed equine heads initially had mythical associations, Kelpies being supernatural water horses of Celtic folklore, but as the project developed his inspiration came from heavy working horses such as Clydesdales.

“These horses played a vital and significant role in Scotland’s industrial revolution, such as pulling barges along the Forth & Clyde canal, next to which they now stand,” says Andy Scott, Project Sculptor.

He has a long standing connection with steel and it is invariably his material of choice for artworks. Normally he undertakes the manufacture of his pieces himself, but producing two 30m high sculptures needed a more collaborative approach with the structural engineer and steelwork contractor.

SKM and S H Structures together value engineered the original design and came up with a revised concept that brought savings of around £750,000. The new design replaced horizontal plate members with tubular steelwork, meaning the entire internal primary frame is fabricated from 323 x10 CHS Celsius® tubes.

The project team produced a Kelpies BIM model that was used to exchange information between the consultants, the checking engineers, the cost consultants and Andy Scott.

“The ability to produce a snapshot of any given area of the structure enabled Andy Scott to see how his original concept was being developed,” says Tim Burton, S H Structures Sales and Marketing Manager.

Once the primary frame was modelled the secondary steelwork was added, which consists of smaller 139 × 5 CHS Celsius® tubes and supports the stainless steel skin cladding. After the model was completed nearly 2,000 individual fabrication drawings were produced.

A cantilevering feature entrance has been added

Additions enhance City office block

A former banking headquarters in the City of London is being converted into a new and spacious office development with additional new structural steel elements. Martin Cooper reports.

FACT FILE
71 Queen Victoria Street, London
Main client: QV Unit Trust
Architect: SPPARC
Main contractor: Bouygues
Structural engineer: Pell Frischmann
Steelwork contractor: Graham Wood Structural
Steel tonnage: 600t

The redevelopment of 71 Queen Victoria Street in the City of London is a prime example of how steel construction can help revamp a tired old office building and quickly and economically convert it into a modern commercial building.

Main contractor Bouygues is updating the concrete framed former London headquarters of the Royal Bank of Canada by demolishing large parts of the original structure and replacing it with steelwork, resulting in the floor area increasing from 13,000m^2 to more than 17,000m^2. The scheme will also result in the seven-storey structure gaining an extra eighth floor with the addition of a rooftop pavilion overlooking St Paul's Cathedral.

Work also includes a complete revamp of the main frontage of the building as well as further enhancements to the façades along Great Trinity Lane and Little Trinity Lane.

"The design of the building was bespoke and fine for a banking headquarters in the 1980s. However, the layout was unsuitable for a modern office building," explains Andrew Murray, Pell Frischmann Technical Director.

The existing building is founded on two separate foundation structures with the northern portion supported on deep Vierendeel trusses above Mansion House London Underground Station. Consequently the building's grid is defined by the spacing of the underground transfer structures resulting in a 6m grid in both directions.

The southern portion of the building is founded directly on piles, while a movement joint was provided across the floorplate effectively separating the two parts of the building. Pell Frischmann believes this was in order to allow the structure to accommodate potential differential vertical settlements between the two forms of foundation.

Working closely with Transport for London, the company says it was able to convince all parties that the movement joint was no longer needed since the old banking headquarters was constructed more than 30 years ago and differential settlement was no longer an issue. This meant new steelwork floors could be erected to join and knit the structure together and allow the new centrally positioned core to make the movement joint redundant.

Cost dictated that a complete demolition of the existing structure was not an option. Reusing as much of the original building was

Faceted members form the curving façade

The new building has an additional top floor pavilion

decided upon and this included the retention of the grid pattern.

"For convenience and ease of construction the new steelwork floors are based around the same grid, but by removing six old concrete cores we've de-cluttered each of the building's floors creating the desired modern increased office space," says Mr Murray.

The original structure was centred on two large atriums that have now been infilled with new steelwork floors. Additionally, a steel braced core has been erected in the middle of the building, accommodating six scenic lifts but more importantly providing the office block with much of its stability.

A cost-effective design option also extended to the building's substructure and the reuse of the existing foundations. The only area of the project that has needed new piles to be installed is the core.

Reusing old elements of the structure is a very economic and sustainable objective, but any new additions to the structure's frame needed to be as light as possible in order to avoid overloading the existing piles.

"This was why a steel composite design was chosen for the new parts of the building," says Jonathan Cassidy, Bouygues Project Director. "Steel offers a number of advantages but its lightweight construction was the main benefit. We've been able to add new floor space and cores without increasing the overall structural weight."

Gantry gets building watertight

Once the demolition programme had been completed, getting the remaining structure watertight as fast possible was a major necessity.

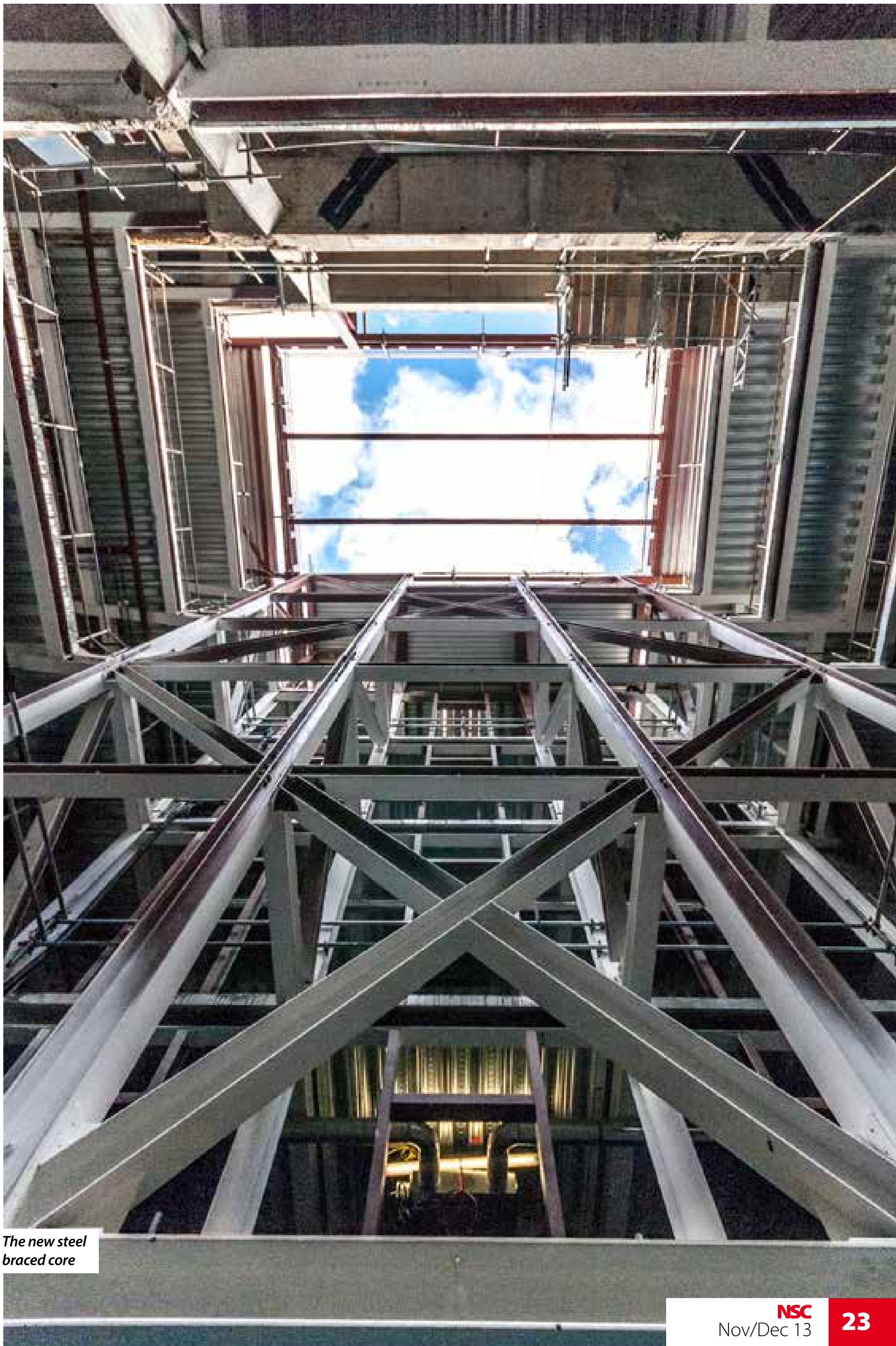
Bouygues decided to install a gantry crane, straddling the central void, a machine that was then covered by a scaffold to create a temporary roof.

"This has proven to be a very cost-effective way of achieving both a watertight project and having a piece of equipment which could erect the new steelwork," says Jonathan Cassidy, Bouygues Project Director.

"There is very little room around the site for a mobile crane and installing a tower crane would have left us with a large void in the centre of the structure which would have let in rainwater."

All of the steelwork, forming the smaller central atriums, the associated floor plates, the rooftop pavilion as well as the new lift core have successfully erected by the 3.5t capacity gantry crane.

Steelwork contractor Graham Wood Structural delivered all of its steelwork to site on a just in time basis as there is no room for storage. The steel members never exceeded the gantry crane's capacity and once on site beams and columns were immediately lifted into place.



The new steel braced core

The former banking headquarters is converted into a desirable commercial development

From the outside the most noticeable alteration to the structure is the new main entrance. Two 18m-long parallel two-storey Vierendeel trusses have formed a 6m cantilevering 'bullnose' feature.

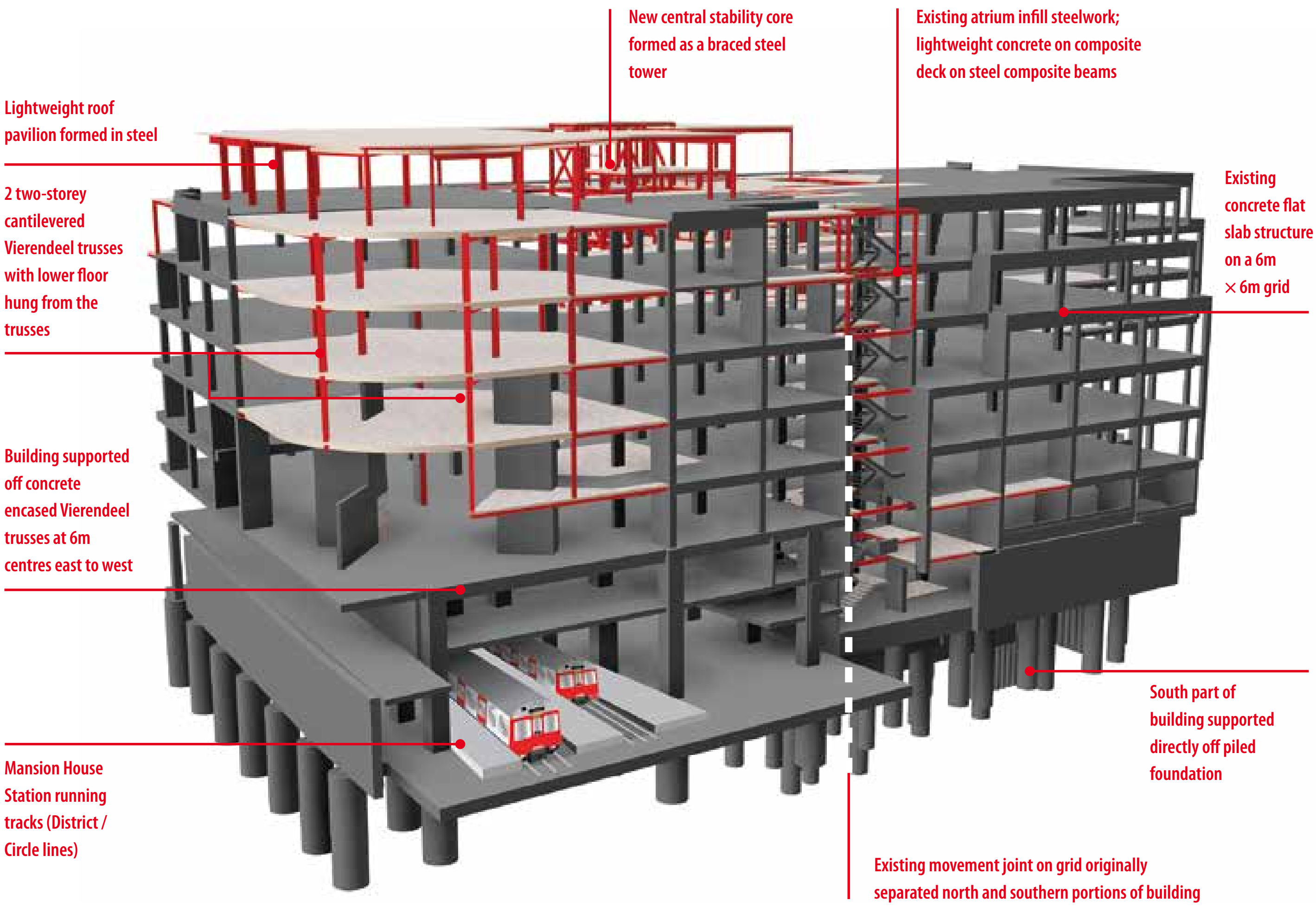
The trusses were brought to site in four one-storey high sections, per level. They were assembled on the ground into two larger elements, before being lifted into position by a 70t capacity mobile crane.

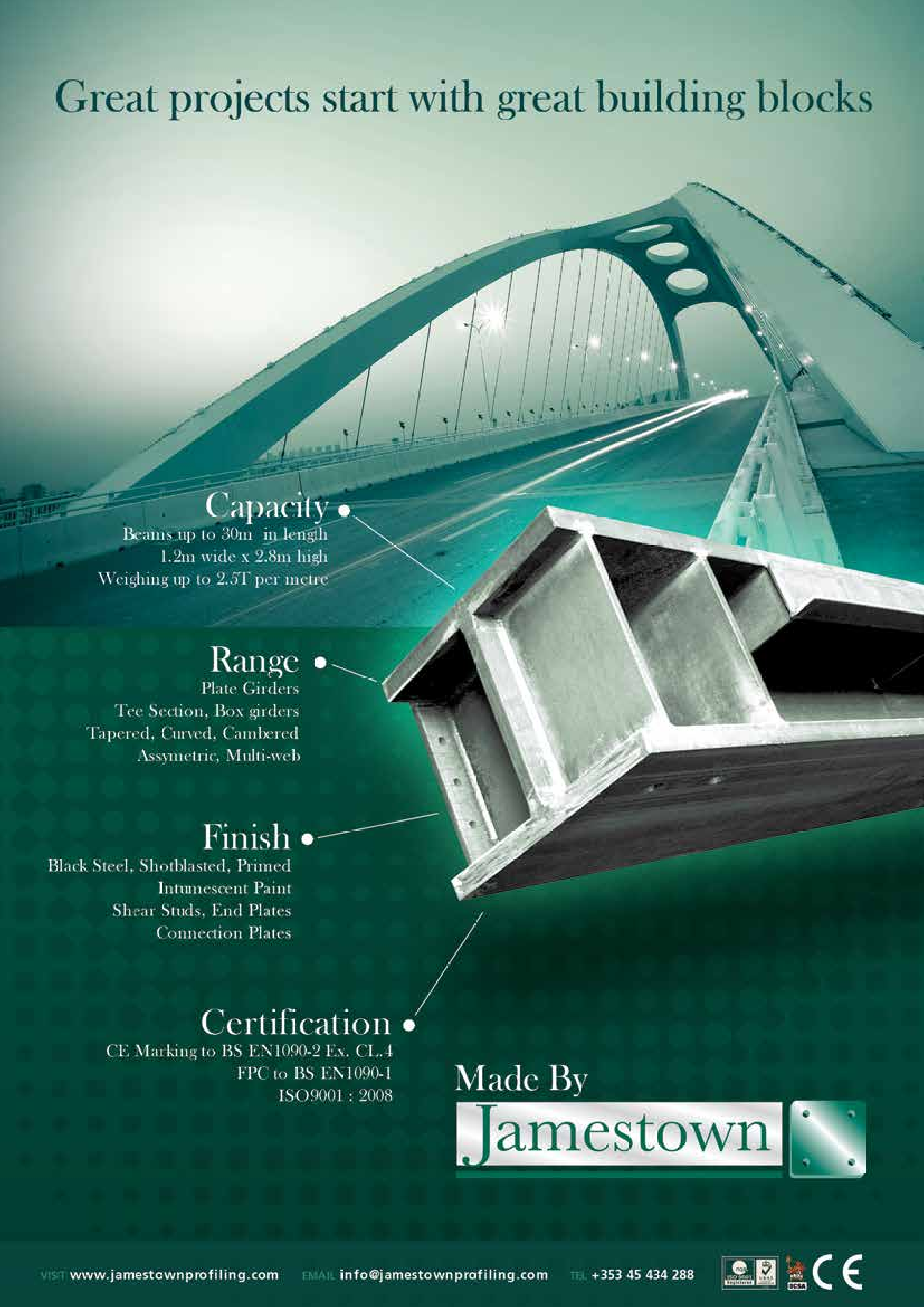
"This was the only part of the steel erection programme which was erected by mobile crane," explains Martin Campbell, Graham Wood Structural Project Manager. "The site doesn't have a tower crane (box p23) and space was tight all around the site with no room to park a mobile crane.

"However, for this part of our erection programme we were able to position the mobile just inside the site's entrance and partially in the adjoining street for a weekend lifting programme."

Bucking the trend of the small 6m × 6m grid pattern is the new eighth floor pavilion. A lightweight steel portalised 12m × 12m frame has been erected, delivering the new building a scenic top floor with views over the City and St Paul's Cathedral.

"Rights to light issues prevented this new floor covering the entire footprint, but a steel frame added little extra weight to the entire scheme," sums up Mr Murray.




Great projects start with great building blocks
Capacity
Beams up to 30m in length
1.2m wide x 2.8m high
Weighing up to 2.5T per metre
Range
Plate Girders
Tee Section, Box girders
Tapered, Curved, Cambered
Assymetric, Multi-web
Finish
Black Steel, Shotblasted, Primed
Intumescent Paint
Shear Studs, End Plates
Connection Plates
Certification
CE Marking to BS EN1090-2 Ex. CL.4
FPC to BS EN1090-1
ISO9001 : 2008
Made By
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Steel takes centre stage in Liverpool

Steelwork played a starring role in the construction of one of Europe's greenest venues and the first to earn a BREEAM rating. In the latest of our Project Revisited series, Martin Cooper takes his seat at the Arena and Convention Centre Liverpool.

Liverpool's latest visitor attraction by night

FACT FILE
Arena and Convention Centre Liverpool (home to BT Convention Centre and Echo Arena)
Main client: ACC Liverpool
Architect: Wilkinson Eyre
Main contractor: Bovis Lend Lease
Structural engineer: Buro Happold
Steelwork contractor: Severfield-Watson Structures
Steel tonnage: 6,000t

Who's there

Photo: David Munn

When I visited the ACC Liverpool earlier this year I was fortunate enough to also take in a live performance by The Who performing their seminal 1973 album Quadrophenia in its entirety.

OK, the group now only comprises of two original members, but nonetheless Roger Daltrey and Pete Townsend, together with their latest band mates, still managed to extract what sounded like an exact representation of the renowned album.

Acoustically the Echo Arena is first rate with the sound missing the fuzzy distortion many venues' PA systems are prone to.

We were sat on the middle tier, close to the stage, and the view was completely unobstructed. Sight lines are also excellent, as the Arena is column free and the banks of terraces afford everyone a good clear view.

Access into and out of the venue is quick and easy, while the high number of concession outlets meant that getting food and drink is devoid of lengthy queues.

Opened in January 2008 as an integral part of the city's European Capital of Culture Year, the Arena and Convention Centre (ACC) Liverpool has quickly established itself as one of the leading venues in the north of England.

Situated on the banks of the River Mersey alongside the Albert Dock complex and within walking distance of a host of city centre amenities, the venue is a symbol of the city's regeneration and is said to have contributed £620M in economic impact since opening.

ACC Liverpool comprises the 11,000 capacity Echo Arena and the BT Convention Centre which consists of a 1,350 seat auditorium, a multi purpose hall and 18 meeting rooms. It is one of the greenest venues in Europe, specifically designed with the most energy efficient, environmentally friendly green criteria in mind.

It has been designed to produce half the CO_2 emissions expected from a building of this size while using 20% less electricity – lighting, for instance, is high efficiency and controlled by motion detection.

Outside, rainwater is collected on the roof which is then used to flush toilets, accounting for about 40% of the water used in the venue's lavatories, while five 20m high low noise wind turbines on the riverside contribute to the electricity supply.

All of these features have contributed to ACC Liverpool being the only venue in the UK to be BREEAM accredited - it received a "Very Good' rating.

From the outset the project team's aim was to construct an iconic structure utilising steelwork's long span attributes. The Convention Centre portion of the building is a completely steel framed structure while the adjoining Arena is a steel frame sitting atop a concrete bowl.

Alex Harper, Severfield-Watson Structures (formerly Watson Steel Structures) Project Manager said when NSC initially visited the project (NSC October 2006): "The Arena has a typical football stadium design with steel columns and beams supporting rakers, which in turn support the terraces."

The two level Convention Centre was formed primarily with large trusses to get the open column free space. The lower level required Severfield-Watson to install three pairs of perpendicular trusses which measured 50m in length × 4.5m deep and accounted for the project's heaviest crane lifts.

Above this large open space and supported by the trusses is the second level auditorium and meeting areas.

Angus Palmer, Buro Happold Director says the entire Convention Centre is column free. "As the lower level doesn't have columns it didn't make sense to have any on the second floor either, and anyway the auditorium also needed an open plan design."

Flexibility was also a key requirement as the venue can cater for events of differing sizes. The Convention Centre and the Arena can be used separately or as a large combined space.

The Arena's floor links directly via the Galleria – a steel framed structure that joins both of the separate areas – to the lower level of the Convention Centre creating more than 7,000m^2 of column free exhibition space.

Covering both the Arena and Convention Centre are two highly architectural curved cantilevered steel framed roofs.

"Steel was used to create the seamless architectural curves," says Mr Palmer. "There is some complicated geometry involved and only steel could achieve this."

The Convention Centre roof is made up of primary trusses at 10m centres supporting 406 UKB roof beams spanning 6m. There are also secondary trusses which are at 6m centres. The primary trusses are 6m deep and the secondary trusses 3m deep. All of this steelwork was needed to create the large spans over the auditorium and meeting rooms.

Both the Conference Centre and Arena roofs are made of two layers, with the lower section forming an acoustic barrier while the upper section provides protection from the elements, as well as some additional acoustic properties. Between the two layers a 900mm void consists of an insulation layer and an air gap.

The Arena roof steelwork consists of some

"There is some complicated geometry invoved and only steel could achieve this."

very long trusses, the longest of which are 80m-long and weighing close to 100t. These members were lifted into position in two separate 40m lengths. To give the Arena roof its curved effect the trusses vary in length and depth, from 6.5m to a minimum depth of 4m.

Each of the two curved roofs have deep grooves running along their length, and these areas contain plant rooms. The roof structures are also clad with bespoke sound proofing panels.

'Having recently visited the project I can vouch for the fact that the venue has exceeded all expectations. Its flexibility and huge spans could only have been achieved using structural steelwork, while as a whole, the ACC Liverpool has been a catalyst for the wider regeneration of the Mersey waterfront," sums up Mr Palmer.

Key facts

- The Echo Arena has a BREEAM 'Very Good' rating and the only venue to be so highly rated in Europe.
- The Echo Arena has a maximum capacity of 11,000
- BT Convention Centre has 1,350 seats and 18 meeting rooms
- It has more than 7,125m^2 of exhibition space when the Arena and Convention Centre are combined
- The venue has hosted more than 1,200 events
- So far there have been three million visitors to the Echo Arena and more than 400,000 delegates to the BT Convention Centre

The venue features wide light filled concourses

Flexibility means a number of events can take place at once

The ACC is now the centrepiece of Liverpool's reborn riverfront

The A14 viaduct spans Brampton Road and the East Coast Main Line near Huntingdon Station

Safeguarding road and rail with steel

The installation of new steel beams will enhance the safeguarding of a viaduct that carries a busy trunk road over the East Coast Main Line railway.

FACT FILE
A14 Huntingdon Railway Viaduct safeguarding works
Main client: Highways Agency
Main Contractor: Costain
Structural Engineer: URS
Scheme Manager: CarillionWSP
Steelwork Contractor: Cleveland Bridge
Steel tonnage: 500t

Built in 1975 the Huntingdon Railway Viaduct carries the busy A14 dual carriageway over the East Coast Main Line railway adjacent to the market town's train station.

Traffic volume along this important highway – which connects the port of Felixstowe with the Midlands - is increasing year on year. Coupled with ongoing deterioration of the parent structure, this has necessitated some innovative steel construction to safeguard the structure.

The viaduct is a pre-stressed concrete six span structure with an overall length of 225.8m. The central span crosses the railway and carries the A14 over another bridge for Brampton Road; a busy route into Huntingdon town centre. Within this central span a pair of concrete half-joints support a suspended span directly above the railway.

"This is a vitally important viaduct and one which has been modified with steel before this current project," explains Mark Hatcher, URS Project Manager. "Back in 2003 the viaduct had interim strengthening measures applied consisting of a series of new steel beams beneath the central spans, to provide an alternative load path to the deteriorating concrete half-joints. In the event of a half-joint suddenly failing, the steel beams would 'catch' the suspended span and prevent it from falling onto the railway. "

This work only had a design life of 12 years as it was anticipated the structure would be decommissioned or subject to modifications as a consequence of detrunking this part of the A14. At that stage the depth of the steel beams had to be limited to 0.8 m in order to avoid imposing a headroom restriction on Brampton Road.

Alterations to this part of the A14 have recently been out for consultation, but the works being undertaken will restore the original 120 year lifespan of the central part of the structure. This will safeguard the viaduct for the foreseeable future whatever the outcome of the consultation process.

"As well as the lifespan of the previous works coming to an end, a review had concluded that increased traffic loading, combined with the ongoing deterioration of the half-joints, would increase the likelihood of the half-joints failing," says Paul Sinfield, Highways Agency Project Sponsor. "If this was to happen the viaduct could not be repaired without lane closures and major disruption on the A14. It was therefore necessary to develop a more resilient solution."

The new scheme will provide a stiffer and longer lasting structure with a series of replacement steel beams located in the same position as the steelwork installed in 2003.

"The new beams are sufficiently stiff that, following some initial jacking in of load, they will radically reduce the risk of half-joint failure as they provide an alternative load path of greater strength and stiffness," explains Mr Hatcher. "In the event of a half-joint failure, the replacement beams are stiff enough to limit deflection and keep the viaduct serviceable while it's in operation.

Furthermore, by coupling detailed studies into the vehicular use of Brampton Road with structural analysis techniques, we have been able to achieve this with only a marginal headroom restriction; keeping the route open to all scheduled double-decker buses."

The new steel consists of 38 steel I-beams 1.75m deep and arranged in a grillage formation with 19 members on each side of the viaduct. These deeper I-beams are more durable and inherently stiffer than the original box sections, and are able to provide the viaduct with a sufficiently stiff alternative load path to the half-joints without any significant increase in overall weight.

Main contractor Costain and Steelwork contractor Cleveland Bridge divided the steel installation into two distinct programmes (see box). For the north side of the structure Self Propelled Modular Transporters (SPMTs) were employed to lift and dismantle pairs of steel beams, while on the south side of the viaduct, a large capacity forklift was used as access for the SPMTs was restricted by the rail lines and associated overhead electricity cables.

Apart from a handful of overnight disruptive rail possessions, the work on Huntingdon Viaduct has caused minimal disruption to rail passengers on the East Coast Main Line. The project has also been completed with no disruption to motorists using the A14 as Costain and URS were able to mitigate the need for any traffic management on this key strategic route early in the project.

Steelwork has been beneficial to the project as it is partially assembled offsite to facilitate quicker installation. Cleveland Bridge estimates the average time taken to dismantle one pair of beams and install two new ones was about five hours.

"This is a technically challenging project, however we continue to deliver it safely having not had a lost time accident and expect to deliver it ahead of the contract completion date and within the Client's budget" says Sean Ellison, Costain Senior Site Agent.

Work on the viaduct is scheduled to be completed later this month (November).

Steel erection programmes

The 38 new I-beams were all installed in braced pairs, with each pair weighing up to 25t.

"As we were reusing most of the existing Macalloys we unbolted and dismantled a pair of box sections at a time, and in the same shift replaced these with a pair of I-beams," says Ben Binden, Cleveland Bridge Project Manager.

Because some of the beams span live railway lines or a busy road, all of the beam replacement works were done overnight; with many of the lifts requiring railway possessions, with the railway shut to all rail traffic for a maximum of six hours.

For the 19 beams on the north side of the viaduct, Cleveland Bridge assembled and braced each pair at a nearby assembly point.

They were lifted onto a large capacity scissor platform attached to an SPMT (above) which was then driven into place under the viaduct. Once the SPMT was in the correct location the beams were then lifted up 5m by the scissor platform and erectors working from adjacent mobile elevating work platforms were able to install them on the Macalloy bars.

However, for the south side of the viaduct, SPMTs could not access the site due to the railway and the maximum lift height increasing to 11m. A large 37t capacity forklift fitted with a 5m high frame was used to lift these beams.

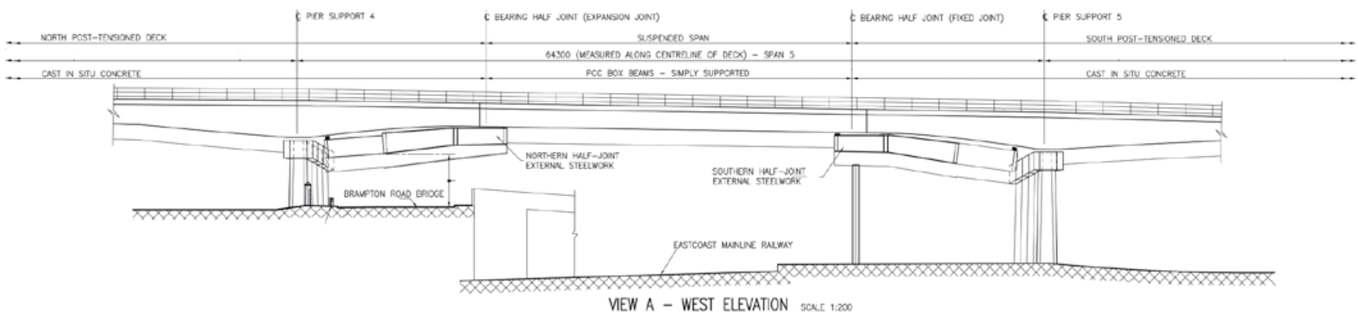
Steelwork strengthening in 2003

Work undertaken in 2003 to the original concrete structure comprised the installation of steel beams inter connected into a grillage attached below the bridge soffits of the two central spans at the half joints.

The steelwork consisted of box sections 800mm deep, 450mm wide and up to 15m long.

The grillages were supported via Macalloy bar hangers, connected to the hollow concrete bridge deck by large diameter pins and internal transfer steelwork.

The new steelwork has also been installed in a grillage formation, matching the steel from 2003 and reusing many of the supporting Macolloy bars. "When the new scheme was being devised all of the bars were discovered to be in good condition and consequently we optimised the design to re-use the existing bars wherever possible," says Mark Hatcher.



Portal frames waste treatment

Three large portal frames will house the main processing plant

An environmentally friendly waste treatment facility in Essex, housed within a number of large steel structures, has required some thoughtful design work.

FACT FILE
Essex Mechanical Biological Treatment Facility, Basildon
Main client: Essex County Council
Main contractor: UBB (Urbaser and Balfour Beatty joint venture)
Structural engineer: Atkins
Steelwork contractor: Fisher Engineering
Steel tonnage: 4,500t

Essex County Council has taken steps to divert most of its household waste away from landfill by granting planning permission for the construction of a Mechanical Biological Treatment (MBT) facility at Basildon.

Once operational the plant will treat up to 417,000t of waste each year that will be sorted into recyclable products, organic material and non-recyclable materials.

This processing will help increase the county's recycling by recovering metals, plastics and other salvageable materials left in bin bags that would otherwise end up in landfill.

Work on site began in March this year and is scheduled to be completed next July. This will be followed by a 12 month commissioning period after which main contractor UBB, a joint venture between Spanish based Urbaser and Balfour Beatty Construction, will operate the plant for 25 years.

The MBT consists of a waste reception hall, a pre-processing hall for the separation of recyclable materials, three bio stabilisation halls for the composting of waste, a product refining and storage unit, a three-storey visitor and education centre, and a vehicle maintenance unit.

All of these buildings are steel framed, predominantly structurally independent, and mostly linked by either walkways or processing conveyors.

"We have spans of up to 40m on some of the buildings and so the choice of materials was quite limited," explains Adam Miller, Atkins Project Engineer. "It's cost effective to construct long span buildings with steel and the material was also chosen for its speed of construction."

Four and a half thousand tonnes of steel will be needed for this project. Steelwork contractor Fisher Engineering began its contract during the summer and is expected to complete the work by the end of the year.

The site is a former storm water retention pond that had been demolished and backfilled. The backfill was unsuitable for foundations so the majority of the steelwork is founded on 15m deep precast piles, installed by UBB during its preliminary groundworks programme.

Following on behind the project's groundwork's team, Fisher is erecting the steel frames in a sequential manner. The first structure to be completed was the pre-processing hall, a large four span portal framed structure measuring 68m x 120m. The building features bracing located around each of the elevations helping to produce a more efficient structural frame.

Adjacent to this structure will be the waste reception hall, the first port of call for all material arriving at the site. A rather lengthier groundworks programme, including the excavation of two refuse pits,

Two of the three halls share a common internal column line

The facility is being built on a former waste water retention pond

has been required for this building meaning it will be erected towards the end of the steel programme, along with the visitor centre and storage unit.

The waste reception hall is also a four span portal framed structure measuring 120m x 47m. One of the structure's 30m wide spans houses two overhead cranes, which will sort incoming waste on a 24/7 basis.

"Larger columns have been designed into this sector of the frame to absorb the substantial loads from the moving cranes," says Mr Miller.

From the waste reception hall, material goes into the pre-processing building. This building will act a conduit in the waste process, as it is where the materials are sorted into recyclable and non-recyclable elements, with the latter being transferred to the bio-stabilisation halls.

Interestingly, UBB estimates that recyclable material taken out of the process at this stage could be as much as 14% of the overall quantity delivered to the site.

The three bio-stabilisation halls represent the largest part of the steel programme, as each structure required close to 800t and is 194m long x 42m wide.

The halls sit adjacent to one another and two share a common line of internal columns. Structurally this means two halls form one large double span portal frame. The third hall is a standalone structure separated from the other halls by a 2m wide covered fire and maintenance roadway.

Using an 80t and a 70t capacity mobile crane a series of tandem lifts were required to install the hall's roof rafters. They arrived on site as two 21m long sections that were then lifted up and bolted together in the air before being installed into their final position.

The rafters are supported on a series of 838 UKB sections. These columns are slightly larger than would normally be designed into an industrial building of this size, but the recycling process generates an aggressive and corrosive environment, as well as heat.

"Larger steel columns were specified for their resistance against expansion due to the heat which could be a high as 70 degrees," explains Mr Miller.

A total of 68,000m^2 of double sided Colorcoat HPS 200 Ultra® as well as RoofDek D60 profile from Tata Steel was used on the project for the roof and walls.

"It's cost effective to construct long span buildings with steel and the material was also chosen for its speed of construction."

Each of the bio stabilisation halls will store and process non recyclable waste in a seven day process which produces in an inert and safe material.

A bucket wheel moves up and down the halls, processing the waste. These large moving items of equipment are supported on crane beams which run the length of the three halls.

The crane beams are 914 UKB sections, chosen for their size and ability to absorb the substantial loads from the continuously moving bucket wheels.

Summing up, Luis Perez Firmat, Urbaser Project Director says: "Most of the waste projects we have built around the world have been steel framed because speed of construction is always vital."

Calculating the C_1 factor for lateral torsional buckling

David Brown of the SCI proposes expressions for C_1 for use with linear and non-linear bending moment diagrams

Background

When calculating the lateral torsional buckling resistance of an unrestrained member, the shape of the bending moment diagram is important. A uniform bending moment diagram is the most onerous, and non-uniform bending moment diagrams less onerous.

In BS 5950, the influence of the shape of the bending moment diagram is allowed for using the equivalent uniform moment factor, m_{LT}. In BS EN 1993-1-1, the shape of the bending moment diagram influences the calculation of the elastic critical buckling moment, M_{cr}, which is a step on the way to calculate the slenderness of the member.

Calculation of M_{cr}

The elastic critical buckling moment, M_{cr} may be calculated using software (notably *LTBeam*[1] and, shortly, a tool to be released on *Steelconstruction.info*) or by an expression. Within the software, the shape of the bending moment diagram follows from the loading which is input. If using software, it is educational to change all the loads by the same proportion and see that the value of M_{cr} does not change; the shape of the bending moment diagram is important, not the size, in determining M_{cr}.

If calculating M_{cr} using an equation, the equation is of the form $M_{cr} = C_1 \times$ (expression), where C_1 depends on the shape of the bending moment diagram. C_1 may be obtained from sources of non-contradictory complementary information (NCCI), such as the *Concise Guide*[2], or found on *Steelbiz*.

General expressions for C_1

Designers frequently request a general expression for C_1, so that it can be calculated automatically, (for example in software, or a spread sheet) rather than referring to tabular NCCI. Expressions for C_1 certainly exist from various sources, but are inconsistent, especially for non-linear bending moment diagrams. This article sets out the expressions that SCI generally uses, though others certainly could be used.

When assessing the accuracy of general expressions for C_1, the UK National Annex defines C_1 in clause NA.2.18 as:

$$C_1 = \frac{M_{cr} \text{ for the actual bending moment diagram}}{M_{cr} \text{ for a uniform bending moment diagram}}$$

Of course, to use this expression in the first instance, M_{cr} needs to be known, which depends on C_1, so in any comparisons made, SCI have tended to use software to calculate M_{cr}, to then compute C_1 for given shapes of bending moment diagram.

Linear bending moment diagrams

Although different expressions can be found, SCI generally uses the expression:

$$C_1 = 1.77 - 0.88\psi + 0.11\psi^2$$

Where ψ is the ratio of end moments.

This expression follows from the UK National annex where

$$k_c = \frac{1}{\sqrt{C_1}}$$

The NA is anticipating that k_c will be calculated based on C_1, but if the logic is reversed (a potential source of error), C_1 may be calculated for given values of k_c. Table 6.6 of BS EN 1993-1-1 has an expression for k_c for linear bending moment diagrams:

$$k_c = \frac{1}{1.33 - 0.33\psi}$$

Substituting and rearranging leads to the above expression for C_1.

A common expression found in several other sources, notably ECCS guides[3], is

$$C_1 = 1.77 - 1.04\psi + 0.27\psi^2, \text{ but } \leq 2.6$$

There is little difference in the outcome. Figure 1 compares the "SCI curve" against the above expression (described as the "ECCS curve"); the difference is only a few per cent. *LTBeam* can also be used to determine the value of C_1. The comparison is also shown in Figure 1.

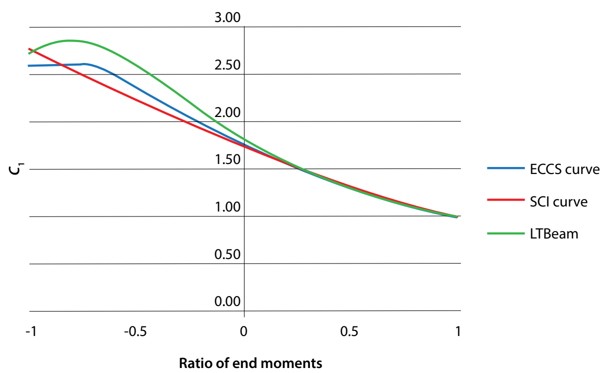


Figure 1: Comparison of C_1 curves

For positive ratios of end moments, the three curves are almost superimposed. For negative ratios, (a reversing bending moment diagram) the difference is more pronounced. Although the curve preferred by the SCI is slightly conservative, it does have the merit of having some provenance from the Eurocode itself.

Non-linear bending moment diagrams

There are many expressions proposed for C_1 for a non-linear bending moment diagram, in various research papers, but a general expression that shows good correspondence across all shapes of bending moment diagram remains elusive. In 2011, SCI reviewed the published expressions and tentatively suggested that the expression proposed by Serna et al[4] had a reasonable balance of accuracy and useability. For the common case of fork end supports (both lateral bending and warping free), the proposed expression for C_1 becomes

$$C_1 = \sqrt{\frac{35M_{max}^2}{M_{max}^2 + 9M_2^2 + 16M_3^2 + 9M_4^2}}$$

Where the values of M are shown in Figure 2. Readers will appreciate the conceptual similarity with the general expression for m_{LT} in Table 18 of BS 5950.

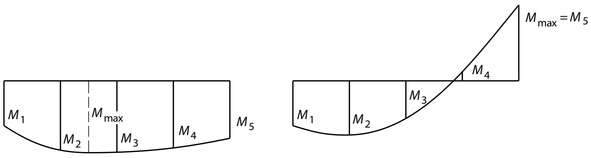


Figure 2: Values of M

Example 1

6m beam with 40 kN/m, and end moments of -50 and 200 kNm

The resulting bending moment diagram is shown in Figure 3

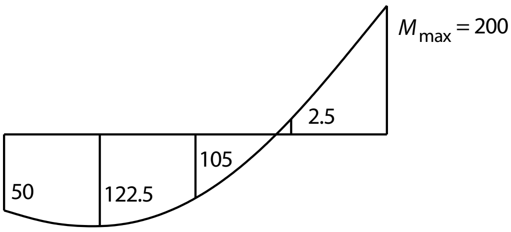


Figure 3: Bending moment diagram for Example 1 (kNm)

$$C_1 = \sqrt{\frac{35 \times 200^2}{200^2 + 9\times122.5^2 + 16\times105^2 + 9\times2.5^2}} = 2.0$$

Using *LTBeam* the value of C_1 is computed as 2.03

Example 2

6m beam with 40 kN/m, and end moments of -150 and 50 kNm

The resulting bending moment diagram is shown in Figure 4

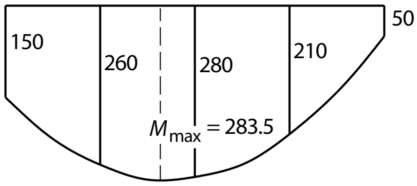


Figure 4: Bending moment diagram for Example 2 (kNm)

$$C_1 = \sqrt{\frac{35 \times 283.5^2}{283.5^2 + 9\times260^2 + 16\times280^2 + 9\times210^2}} = 1.1$$

Using *LTBeam* the value of C_1 is computed as 1.1

Conclusions

Closed expressions are available as an alternative to using software to determine C_1 and are reasonably accurate for standard (simple) end conditions. With other end conditions, software is the best approach.

[1] LTBeam
Available from *http://www.cticm.com/*

[2] Brettle, M.E; Brown, D. G
Steel Building Design; Concise Eurocodes (P362)
SCI, 2009

[3] Boissonnade, N; Greiner, R; Jaspart, J. P; Lindner, J.
Rules for Member Stability on EN 1993-1-1
Background documentation and design guidelines
ECCS guide No. 119
ECCS, 2006

[4] Serna, M. A; Lopez, A; Puente, I; Yong, D
Equivalent uniform moment factors for lateral-torsional buckling of steel members
Journal of Constructional Steel Research, Volume 62, 2006
Elsevier, 2006

New and revised codes & standards

From BSI Updates October 2013

CORRIGENDA TO BRITISH STANDARDS

BS EN 1998-3:2005
Eurocode 8. Design of structures for earthquake resistance. Assessment and retrofitting of buildings
CORRIGENDUM 2

UPDATED BRITISH STANDARDS

BS 5502-22:2003+A1:2013
Buildings and structures for agriculture. Code of practice for design, construction and loading

NEW WORK STARTED

ISO 148-1
Metallic materials. Charpy pendulum impact test. Test method
Will supersede BS EN ISO 148-1:2010

ISO 148-2
Metallic materials. Charpy pendulum impact test. Verification of testing machines
Will supersede BS EN ISO 148-2:2008

ISO 148-3
Metallic materials. Charpy pendulum impact test. Preparation and characterization of Charpy V-notch test pieces for indirect verification of pendulum impact machines
Will supersede BS EN ISO 148-3:2008

DRAFT FOR PUBLIC COMMENT

13/30265064 DC
BS ISO 630-5 Structural steels. Technical delivery conditions for structural steels with improved atmospheric corrosion resistance

13/30265067 DC
BS ISO 630/6 Structural steels. Technical delivery conditions for seismic improved structural steels for building

CEN EUROPEAN STANDARDS

EN 1998-3:-
Eurocode 8. Design of structures for earthquake resistance. Assessment and retrofitting of buildings
CORRIGENDUM 2: August 2013 to EN 1998-3:2005

AD 378

Web resistance to transverse loads according to BS EN 1993-1-5

Web resistance (which used to be described as web bearing and web buckling) is covered by Section 6 of BS EN 1993-1-5[1]. Although this Eurocode covers plated elements, the resistance checks of Section 6 apply to the webs of both rolled beams and plated elements. Designers will generally use these checks to decide if stiffeners are required under concentrated loads.

The design resistance of the web, F_{Rd} depends on the effective length, L_{eff}, which in turn depends on the effective loaded length, l_y. The effective loaded length depends on the stiff bearing length s_s and modification parameters m_1 and m_2. The purpose of this Advisory Desk is to explain the selection and use of the m_2 parameter.

Under an applied load, force in the web increases as the flange deforms. The resistance expressions assume that four hinges form in the flange, as shown in Figure 1. The influence of the flange width and web thickness is seen in the m_1 parameter.

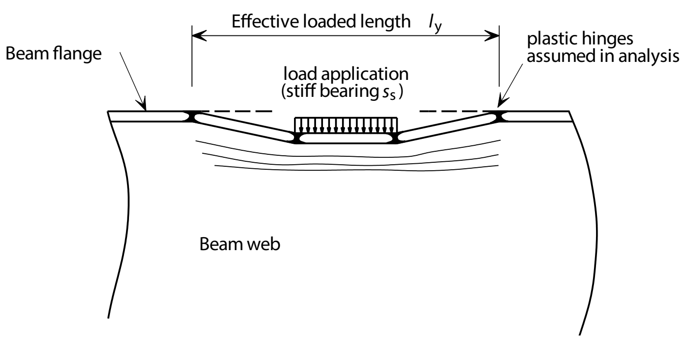


Figure 1: Deformation of the beam flange

In some circumstances (members with slender webs) physical tests showed an increased resistance. In these circumstances the design model assumes that part of the web acts with the flange as a tee section, thus increasing the bending resistance of the flange. This effect is introduced via the m_2 parameter.

m_2 depends on the slenderness of the web, but the web slenderness is only determined later in the calculation process. Thus an assumption needs to be made and subsequently verified. This is seen in expression 6.9 of BS EN 1993-1-5, where the value of m_2 depends on the web slenderness, $\overline{\lambda}_F$.

In some circumstances, two valid solutions may be found, when either assumption (a stocky web or a slender web) can be demonstrated to satisfy the requirements. In turn, this leads to two possible values for the resistance of the web.

A discussion on the subject is presented in *Designers' Guide to EN 1993-2*[2]. If two valid solutions are possible, the higher resistance may be taken.

Implications in practice

The effect of the discontinuity in the calculation process is that for a limited number of rolled sections, a step can be observed in the web resistance as presented in the Blue Book[3].

Figure 2 shows the results for a 1016 × 305 × 393 UKB in S355, with the web resistance calculated away from the end of the member (c = 1000 mm). For this beam, two valid solutions are possible over the range of stiff bearing lengths between 50 mm and 145 mm. This arises because if a stocky web is assumed, $\overline{\lambda}_F < 0.5$, which is satisfactory, and if a slender web is assumed, $\overline{\lambda}_F > 0.5$, which is also satisfactory. Following the guidance to take the higher value, the Blue Book resistances are shown in Figure 3, reflecting the jump in resistance at 50 mm.

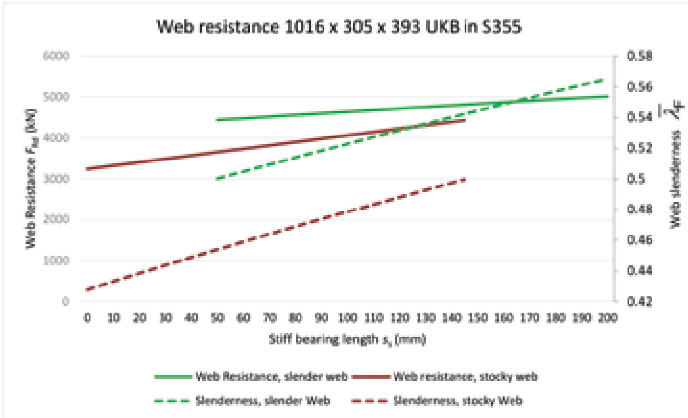


Figure 2: Web resistance and slenderness, c = 1000 mm

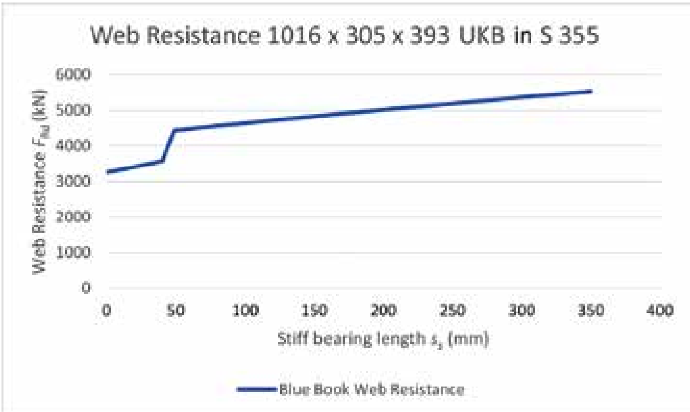


Figure 3: Web resistance from the Blue Book, $c > c_{lim}$

The Eurocode rules are attempting to reflect a complex problem, so perhaps it is not surprising that some discontinuities can be observed. The guidance in this Advisory Desk is that if two solutions are valid, the higher resistance may be taken.

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1. BS EN 1993-1-5:2006 (incorporating corrigenda April 2009)
Eurocode 3 – Design of steel structures –
Part 1-5: Plated structural elements
2. Hendry, C. R. and Murphy, C, J.
Designers' Guide to EN 1993-2. Eurocode 3:Design of Steel structure. Part 2: Steel Bridges
Thomas Telford, 2007
3. Steel Building Design: Design Data (updated 2013) P363
SCI and BCSA, 2013


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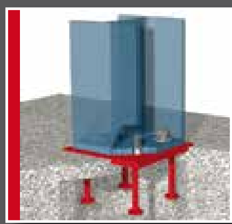
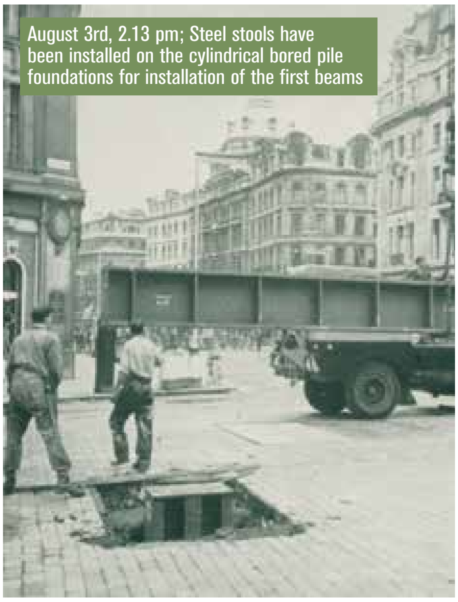
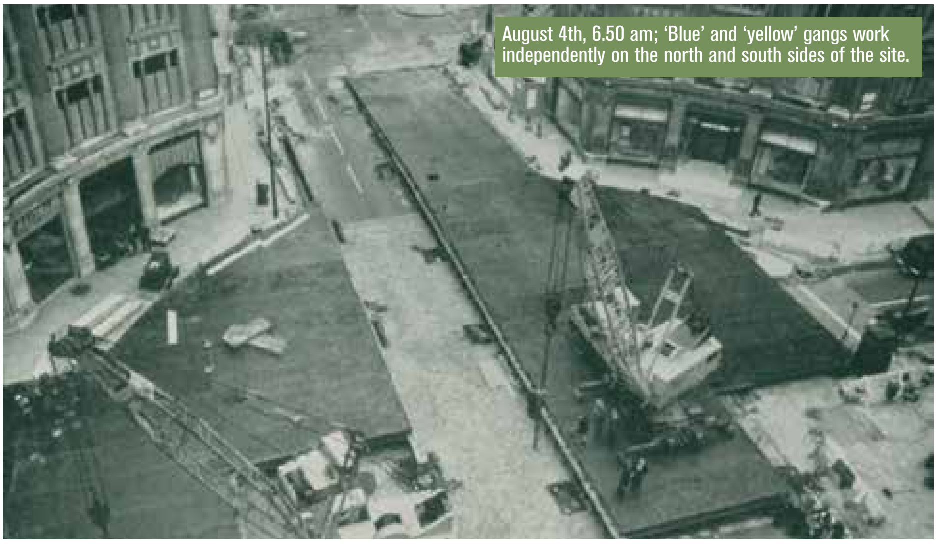


An umbrella for Oxford Circus

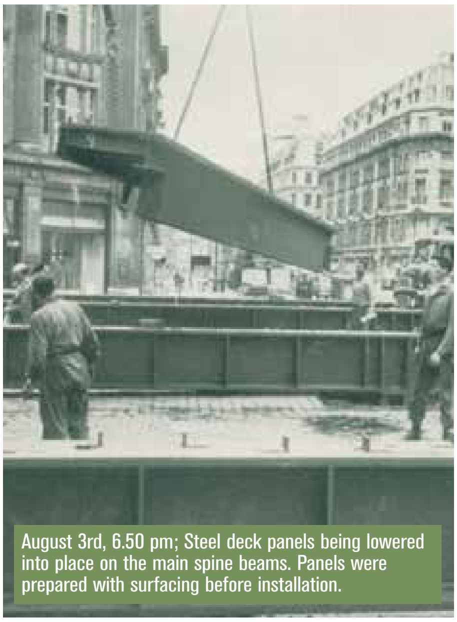
FROM BUILDING WITH STEEL NOVEMBER 1963



August 3rd, 2.13 pm; Steel stools have been installed on the cylindrical bored pile foundations for installation of the first beams



August 4th, 6.50 am; 'Blue' and 'yellow' gangs work independently on the north and south sides of the site.



August 3rd, 6.50 pm; Steel deck panels being lowered into place on the main spine beams. Panels were prepared with surfacing before installation.

August 3rd, midnight; Gangs on round-the-clock 12-hour shifts erect 600 tons of steel in 46½ hours.

At 1.30 pm on Saturday August 3rd 1963, Oxford Circus and the surrounding streets were closed to all road traffic and non-residents. They were not opened again until 6.30 am on August 6th. During this brief respite from holiday traffic, 65 hours in all, London Transport Engineers and contractors built an 'umbrella' bridge, weighing 850 tons and covering an area of 2,300 square yards. To disrupt West End traffic as little as possible, work had gone on round the clock to a minute-by-minute schedule. The bridge will carry traffic four ways over the Circus while a new upper concourse for Oxford Circus station, part of an extensive programme for the new Victoria Line, is being built beneath it.

The plan for the new Oxford Circus tube station has a large sub-surface ticket hall with a pavement stairwell entrance at the four quadrant. It was decided, therefore to build a steel 'umbrella' over the whole of the Circus while work was being carried out and it is expected that this will be a feature of the London scene for the next three years.

On September 20th, 1962, the first step to implement the decision to build the umbrella was taken and the digging of exploratory pits and headings started a night to discover the exact whereabouts of the pipes and cables carrying the various services beneath the crossroads. This enable accurate positioning of the 24 concrete cylinder foundations auger-bored at 3 ft diameter to carry the bridge. The headings were driven at night after heavy traffic had ceased and the pits were covered in time for the busy morning traffic. Eventually the sewers, main pipes and cables were all surveyed so that the foundations could be sunk to a depth of 54 ft.

The steelwork for the bridge is designed to MOT standard loading, type HA, with some modifications. It consists of 27 main welded girders up to 35 ft in length and 24 tapering lattice truss girders to take the bridge from its full height down to the ramp end panels, bringing the bridge back to normal road level. There are also 197 structural steel panels of battle-deck construction, generally 25 ft by 6 ft and weighing up to 5 tons each. These panels are laid with 1½ in of skid resistant material with half-inch chippings at 1 ton per 100 square yards to form the roadway itself.

In all there were 245 pieces of prefabricated steelwork to be fitted into place and these were bought to London and stacked at the south end of Cavendish Square. During the week-end the sections were brought on site by a shuttle service of low-loader lorries. The timing of the operation was such that the pieces were set in position at the rate of five an hour.

The various sections were coded either yellow or blue and numbered so that they could be handled in the correct order. The work was split into six 12-hour shifts, each shift having about 70 men. The shifts were divided into a north gang and a south gang and to ensure that each gang had a particular responsibility – the north gang handled only yellow sections and the south gang only blue sections.

In readiness for the week-ends work, the cylinder foundations were capped and fitted with holding down bolts and base plates. Foundations were prepared for the ramp truss girders and for the ramp end panels. Hoardings were erected and identity documents prepared to ensure that the police would allow only engineers and workmen into the closed area.

On the night of Friday, August 2nd, part of the hoarding in Cavendish Square was taken down in readiness for the moving of the steelwork. By 1.30pm on Saturday all the diversion notices had been posted and the Circus was deserted except for the workmen. The granite kerbs were removed from the Circus and stacked in Regent Street, and the prepared foundations cleaned out. Steel stools were erected on top of the cylinder foundations and the two erector gangs,

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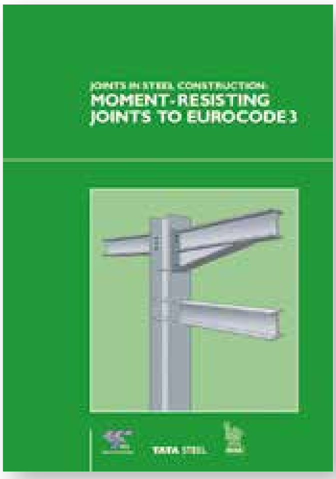
UKAS

Joints in steel construction: Moment-Resisting joints to Eurocode 3 (P398)



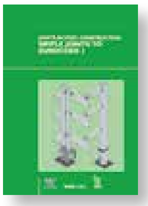
This publication covers the design of moment-resisting joints in accordance with Eurocode 3. Moment-resisting joints are typically found in portal frames and in continuous construction. This publication is the successor to Joints in steel construction – Moment connections (P207/95), which covers connections designed in accordance with BS 5950.

The major changes in scope compared to P207/95 are:

- The adoption of the published design rules in BS EN 1993-1-8 and its UK National Annex. Although most checks are almost identical to those in the earlier publication, some differences will be observed, such as the modest revisions to the yield line patterns and the allowance for the effect of shear in the column web panel.
- Indicative resistances of connections are given, instead of comprehensive standardised details, recognising that software is most often used for the design of moment-resisting joints.
- The 'hybrid' connections, comprising welded parts and parts connected using pre-tensioned bolts have been omitted, since they have little application in the UK.

This new publication will cover;

- Bolted end plate connections between beams and columns in multi-storey frames and portal frames (full depth, extended and plate and haunched connections)
- Welded beam to column connections.
- Moment-resisting splices.
- Moment-resisting column bases.



Design procedures are included for all the components in the above types of connection. Worked examples illustrating the design procedures are included for all the above types of moment- resisting joints.

A complementary publication covering nominally pinned connections (P358, Joints in steel construction: Simple joints to Eurocode 3) is also available.

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Publications are available to purchase through SCI's shop at http://shop.steel-sci.com

Or telephone +44 (0) 1344 636505 or through BCSA +44 (0) 207 839 8566

An umbrella for Oxford Circus

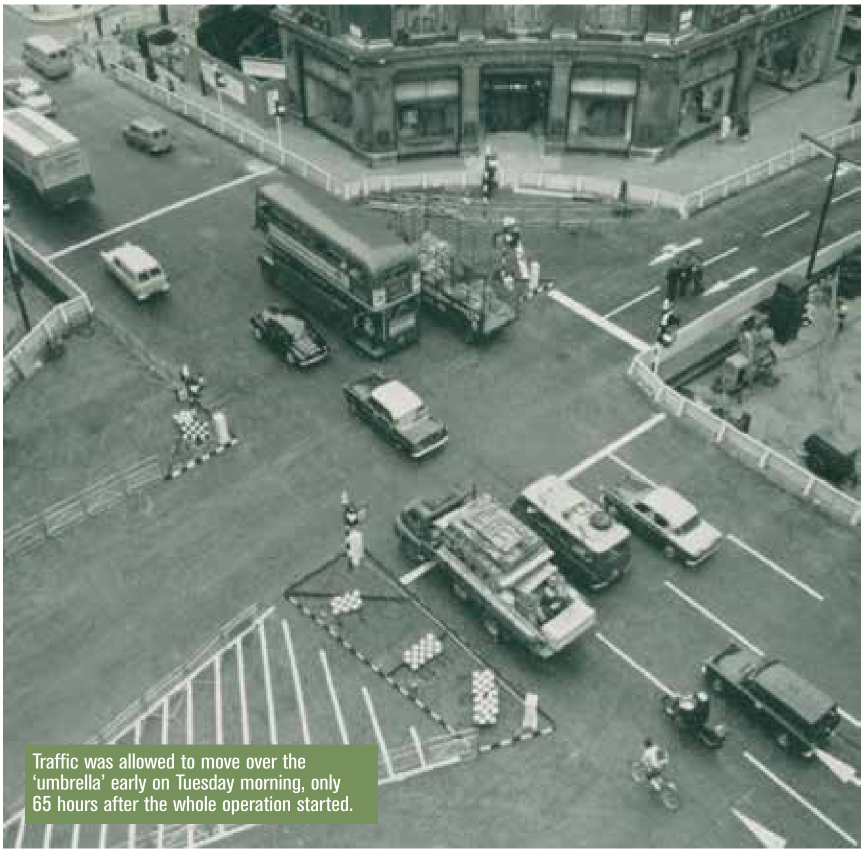
CONTINUED FROM P36

north and south, began to erect the steelwork in the prearranged colour and number order. Beams, trusses, panels and ramp units followed one another to the site and were lifted by road mobile cranes and lowered into place.

The bridge was due for completion by noon on Monday, August 5th and was actually completed by 12.15pm. By the late afternoon, traffic lights were being fixed on the 'umbrella' deck, traffic stop lines were being marked and the granite kerbs previously removed were being replaced, this time on the 'umbrella' deck. By 6.30pm on Tuesday the timber pavement decking on the south end of the hoarding at Regent Street (north) was completed, barriers had been moved and the police allowed the early morning traffic to move into Office Circus and over the bridge.

The bridge gives a full width road from Regent Street (south) and from Oxford Street (east to west). The ramp from the north of Regent Street is to the west only, the east side being closed. This will be used as the working site for the new station.

The bridge was designed under the direction of London Transport with Sir William Halcrow and Partners as consulting engineers.



Traffic was allowed to move over the 'umbrella' early on Tuesday morning, only 65 hours after the whole operation started.

Steelwork contractors for buildings

Membership of BCSA is open to any Steelwork Contractor who has a fabrication facility within the United Kingdom or Republic of Ireland. Details of BCSA membership and services can be obtained from

Gillian Mitchell MBE, Deputy Director General, BCSA, 4 Whitehall Court, London SW1A 2ES
Tel: 020 7747 8121 Email: *gillian.mitchell@steelconstruction.org*

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

- **C** Heavy industrial platework for plant structures, bunkers, hoppers, silos etc
- **D** High rise buildings (offices etc over 15 storeys)
- **E** Large span portals (over 30m)
- **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)
- **J** Tubular steelwork where tubular construction forms a major part of the structure
- **K** Towers and masts
- **L** Architectural steelwork for staircases, balconies, canopies etc
- **M** Frames for machinery, supports for plant and conveyors
- **N** Large grandstands and stadia (over 5000 persons)
- **Q** Specialist fabrication services (eg bending, cellular/castellated beams, plate girders)
- **R** Refurbishment
- **S** Lighter fabrications including fire escapes, ladders and catwalks
- **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
- **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	SCM	Guide Contract Value (1)
A C Bacon Engineering Ltd	01953 850611			●	●		●										2		Up to £2,000,000
A J Stead Ltd	01653 693742			●	●					●	●			●	●				Up to £100,000
Adey Steel Ltd	01509 556677				●	●	●	●		●	●			●	●	✔		Silver	Up to £2,000,000
Adstone Construction Ltd	01905 794561			●	●	●	●									✔	2	Silver	Up to £3,000,000
Advanced Fabrications Poyle Ltd	01753 653617				●	●	●	●	●	●	●				●				Up to £800,000
AJ Engineering & Construction Services Ltd	01309 671919			●	●					●	●			●	●	✔			Up to £1,400,000
Angle Ring Company Ltd	0121 557 7241												●			✔			Up to £1,400,000
Apex Steel Structures Ltd	01268 660828			●	●	●	●			●	●			●					Up to £1,400,000
Arminhall Engineering Ltd	01799 524510	●			●					●	●			●	●				Up to £200,000
Arromax Structures Ltd	01623 747466	●		●	●	●	●	●	●	●	●	●		●	●		2		Up to £800,000
ASA Steel Structures Ltd	01782 566366			●	●	●	●			●	●			●	●				Up to £800,000*
ASD Westok Ltd	0113 205 5270												●			✔	2		Up to £6,000,000
ASME Engineering Ltd	020 8966 7150				●					●	●			●	●			Member	Up to £800,000*
Atlas Ward Structures Ltd	01944 710421		●	●	●	●	●	●	●	●	●	●		●	●	✔	4	Gold	Above £6,000,000
Atlasco Constructional Engineers Ltd	01782 564711			●	●	●	●				●			●	●				Up to £1,400,000
Austin-Divall Fabrications Ltd	01903 721950			●	●		●	●		●	●			●	●				Up to £800,000
B D Structures Ltd	01942 817770			●	●	●	●				●	●		●					Up to £400,000
Ballykine Structural Engineers Ltd	028 9756 2560			●	●	●	●	●				●				✔			Up to £1,400,000
Barnshaw Section Benders Ltd	01902 880848												●			✔	4		Up to £800,000
BHC Ltd	01555 840006	●	●	●	●	●	●	●			●	●		●	●	✔	2		Above £6,000,000
Billington Structures Ltd	01226 340666		●	●	●	●	●	●	●	●	●	●		●		✔	4	Gold	Above £6,000,000
Border Steelwork Structures Ltd	01228 548744			●	●	●	●			●	●				●				Up to £3,000,000
Bourne Construction Engineering Ltd	01202 746666		●	●	●	●	●	●	●	●	●	●	●	●	●	✔	4	Gold	Above £6,000,000
Briton Fabricators Ltd	0115 963 2901	●		●	●	●	●	●	●	●	●			●	●	✔	4		Up to £3,000,000
Builders Beams Ltd	01227 863770				●					●				●	●	✔			Up to £400,000
Cairnhill Structures Ltd	01236 449393	●			●	●	●	●	●	●				●	●	✔	4	Gold	Up to £3,000,000
Caunton Engineering Ltd	01773 531111	●	●	●	●	●	●	●		●	●	●		●	●	✔	4	Gold	Up to £6,000,000
Cleveland Bridge UK Ltd	01325 381188	●	●	●	●	●	●	●	●	●	●	●		●		✔	4	Silver	Above £6,000,000*
CMF Ltd	020 8844 0940				●		●	●		●	●				●	✔			Up to £6,000,000
Cook Fabrications Ltd	01303 890040				●					●	●			●	●				Up to £800,000
Cordell Group Ltd	01642 452406	●			●	●	●	●	●	●	●					✔			Up to £3,000,000
Coventry Construction Ltd	024 7646 4484			●	●	●	●	●	●	●	●			●	●				Up to £800,000
D H Structures Ltd	01785 246269			●	●		●				●			●					Up to £100,000
DGT Structures Ltd	01603 308200			●	●	●	●					●		●		✔	2		Up to £2,000,000
Discain Project Services Ltd	01604 787276				●					●	●				●	✔			Up to £1,400,000
Duggan Steel Ltd	00 353 29 70072		●	●	●	●	●	●			●								Up to £4,000,000
ECS Engineering Services Ltd	01773 860001	●		●	●	●	●	●	●	●	●			●	●	✔	3		Up to £2,000,000
Elland Steel Structures Ltd	01422 380262		●	●	●	●	●	●	●	●	●	●		●		✔	4	Gold	Up to £6,000,000
EvadX Ltd	01745 336413			●	●	●	●	●	●	●	●	●				✔		Gold	Up to £3,000,000
Fisher Engineering Ltd	028 6638 8521		●	●	●	●	●	●	●	●	●	●				✔	4	Gold	Above £6,000,000
Fourbay Structures Ltd	01603 758141			●	●					●	●			●	●				Up to £1,400,000
Fox Bros Engineering Ltd	00 353 53 942 1677			●	●	●	●	●			●								Up to £3,000,000
Gorge Fabrications Ltd	0121 522 5770				●	●	●	●		●				●					Up to £800,000
Graham Wood Structural Ltd	01903 755991		●	●	●	●	●	●	●	●	●	●		●		✔		Silver	Up to £6,000,000
Grays Engineering (Contracts) Ltd	01375 372411	●			●					●	●			●	●				Up to £100,000
Gregg & Patterson (Engineers) Ltd	028 9061 8131			●	●	●	●	●				●		●		✔			Up to £3,000,000

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

Company name	Tel	C	D	E	F	G	H	J	K	L	M	N	Q	R	S	QM	FPC	SCM	Guide Contract Value (1)
H Young Structures Ltd	01953 601881			●	●	●	●	●			●			●	●	✔	2	●	Up to £2,000,000
Had Fab Ltd	01875 611711				●				●	●	●				●	✔			Up to £2,000,000
Hambleton Steel Ltd	01748 810598		●	●	●	●	●	●				●		●		✔		●	Up to £1,400,000
Harry Marsh (Engineers) Ltd	0191 510 9797			●	●	●	●				●	●			●	✔			Up to £1,400,000
Henry Smith (Constructional Engineers) Ltd	01606 592121			●	●	●	●	●											Up to £2,000,000
Hescott Engineering Company Ltd	01324 556610			●	●	●	●			●				●	●				Up to £3,000,000
Hills of Shoeburyness Ltd	01702 296321									●				●	●				Up to £800,000
J & A Plant Ltd	01942 713511				●	●									●				Up to £200,000
J Robertson & Co Ltd	01255 672855									●	●				●				Up to £200,000
James Killelea & Co Ltd	01706 229411		●	●	●	●	●					●		●			4		Up to £6,000,000*
John Reid & Sons (Strucsteel) Ltd	01202 483333		●	●	●	●	●	●	●	●	●	●		●					Up to £6,000,000
Kiernan Structural Steel Ltd	00 353 43 334 1445			●	●	●	●	●	●	●	●	●		●	●	✔		●	Up to £2,000,000
Leach Structural Steelwork Ltd	01995 640133			●	●	●	●	●			●					✔	2	●	Up to £2,000,000
Legge Steel (Fabrications) Ltd	01592 205320			●	●		●		●	●	●			●	●				Up to £400,000
Luxtrade Ltd	01902 353182									●	●				●	✔			Up to £800,000
M Hasson & Sons Ltd	028 2957 1281			●	●	●	●	●	●	●	●				●	✔	2		Up to £3,000,000
M J Patch Structures Ltd	01275 333431				●					●	●			●		✔			Up to £800,000
M&S Engineering Ltd	01461 40111				●				●	●	●			●	●				Up to £1,400,000
Mabey Bridge Ltd	01291 623801	●	●	●	●	●	●	●	●	●	●	●	●	●		✔	4	●	Above £6,000,000
Mackay Steelwork & Cladding Ltd	01862 843910			●	●		●			●	●			●	●	✔	4		Up to £800,000
Maldon Marine Ltd	01621 859000				●	●		●	●	●					●				Up to £1,400,000
Mifflin Construction Ltd	01568 613311		●	●	●	●	●				●								Up to £3,000,000
Newbridge Engineering Ltd	01429 866722			●	●	●	●								●	✔			Up to £1,400,000
Nusteel Structures Ltd	01303 268112						●	●	●	●						✔	4		Up to £4,000,000
On Site Services (Gravesend) Ltd	01474 321552				●		●	●		●	●				●				Up to £100,000
Overdale Construction Services Ltd	01656 729229			●	●		●	●			●				●				Up to £400,000
Painter Brothers Ltd	01432 374400								●		●				●	✔		●	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									●					●	✔			Up to £800,000
PMS Fabrications Ltd	01228 599090			●	●	●	●		●	●	●			●	●	✔	2		Up to £1,400,000
Remnant Plant Ltd	01594 841160				●		●	●	●	●	●				●	✔			Up to £400,000
Rippin Ltd	01383 518610			●	●	●	●	●						●	●				Up to £1,400,000
S H Structures Ltd	01977 681931						●	●	●	●		●				✔	4	●	Up to £3,000,000
SDM Fabrication Ltd	01354 660895			●	●	●	●				●			●	●	✔	4		Up to £800,000
Severfield-Watson Structures Ltd	01845 577896	●	●	●	●	●	●	●	●	●	●	●	●	●	●	✔	4	●	Above £6,000,000
Shaun Hodgson Engineering Ltd	01553 766499	●			●		●			●	●			●	●				Up to £800,000
Shipley Fabrications Ltd	01400 251480			●	●	●	●		●	●	●			●	●				Up to £1,400,000
SIAC Tetbury Steel Ltd	01666 502792			●	●	●	●		●		●	●		●					Up to £400,000*
Snashall Steel Fabrications Ltd	01300 345588			●	●	●	●	●			●				●				Up to £1,400,000
South Durham Structures Ltd	01388 777350			●	●	●				●	●	●			●				Up to £800,000
Southern Fabrications (Sussex) Ltd	01243 649000				●					●	●			●	●				Up to £800,000
Temple Mill Fabrications Ltd	01623 741720			●	●	●	●				●			●	●	✔	2		Up to £200,000
Traditional Structures Ltd	01922 414172		●	●	●	●	●	●	●		●	●		●	●	✔		●	Up to £2,000,000
TSI Structures Ltd	01603 720031			●	●	●	●												Up to £1,400,000
Tubecon	01226 345261						●	●	●	●				●	●	✔	4	●	Above £6,000,000*
W & H Steel & Roofing Systems Ltd	00 353 56 444 1855			●	●	●	●	●						●	●				Up to £3,000,000
W I G Engineering Ltd	01869 320515				●					●					●				Up to £200,000
Walter Watson Ltd	028 4377 8711			●	●	●	●	●				●				✔	2		Up to £6,000,000
Westbury Park Engineering Ltd	01373 825500	●			●		●	●	●	●	●				●	✔			Up to £800,000
William Haley Engineering Ltd	01278 760591			●	●	●			●	●	●					✔	2	●	Up to £2,000,000
William Hare Ltd	0161 609 0000	●	●	●	●	●	●	●	●	●	●	●		●		✔	4	●	Above £6,000,000
Company name	Tel	C	D	E	F	G	H	J	K	L	M	N	Q	R	S	QM	FPC	SCM	Guide Contract Value (1)

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	Company name	Tel
Balfour Beatty Utility Solutions Ltd	01332 661491	PTS (TQM) Ltd	01785 250706
Griffiths & Armour	0151 236 5656	Roger Pope Associates	01752 263636
Highways Agency	08457 504030	Sandberg LLP	020 7565 7000
Kier Construction Ltd	01767 640111	SUM Ltd	0113 242 7390

Associate Members

Associate Members are those principal companies involved in the direct supply to all or some Members of components, materials or products. Associate 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
AceCad Software Ltd	01332 545800		●								N/A	
Albion Sections Ltd	0121 553 1877	●									M	
Andrews Fasteners Ltd	0113 246 9992									●	M	
Arcelor Mittal Distribution – Birkenhead	0151 647 4221								●		D/I	
Arcelor Mittal Distribution - Scunthorpe	01724 810810								●		D/I	
Arcelor Mittal Distribution – South Wales	01633 627890								●		D/I	
ASD metal services	0113 254 0711								●		D/I	
Ayrshire Metal Products (Daventry) Ltd	01327 300990	●									M	

Company name	Tel	1	2	3	4	5	6	7	8	9	CE	SCM
BAPP Group Ltd	01226 383824									●	M	
Barnshaw Plate Bending Centre Ltd	0161 320 9696	●									N/A	
Barrett Steel Ltd	01274 682281								●		D/I	
BW Industries Ltd	01262 400088	●									M	
Cellbeam Ltd	01937 840600	●									M	
Cellshield Ltd	01937 840600							●			N/A	
CMC (UK) Ltd	029 2089 5260								●		D/I	
Composite Profiles UK Ltd	01202 659237	●									D/I	

Steelwork contractors for bridgeworks

RQSC The Register of Qualified Steelwork Contractors Scheme

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:

FG Footbridge and 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
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	FG	PG	TW	BA	CM	MB	RF	AS	QM	FPC	NHSS 19A	NHSS 20	SCM	Guide Contract Value [1]
Access Design & Engineering	01952 685162	●						●	●	✓					Up to £3,000,000
Briton Fabricators Ltd	0115 963 2901	●	●	●	●	●	●	●	●	✓	4		✓		Up to £3,000,000
Cairnhill Structures Ltd	01236 449393	●	●	●	●			●	●	✓	4			Gold	Up to £3,000,000
Cleveland Bridge UK Ltd	01325 381188	●	●	●	●	●	●	●	●	✓	4	✓	✓	Silver	Above £6,000,000*
Four-Tees Engineers Ltd	01489 885899	●	●	●	●		●	●	●	✓	3		✓	Member	Up to £2,000,000
Kiernan Structural Steel Ltd	00 353 43 334 1445	●	●	●	●			●	●	✓				Gold	Up to £2,000,000
Mabey Bridge Ltd	01291 623801	●	●	●	●	●	●	●	●	✓	4	✓	✓	Gold	Above £6,000,000
Millar Callaghan Engineering Services Ltd	01294 217711	●						●	●	✓					Up to £800,000
Nusteel Structures Ltd	01303 268112	●	●	●	●	●	●	●	●	✓	4	✓	✓		Up to £4,000,000
Painter Brothers Ltd	01432 374400	●		●					●	✓				Gold	Up to £6,000,000
Remnant Plant Ltd	01594 841160	●	●	●					●	✓					Up to £400,000
S H Structures Ltd	01977 681931	●		●	●	●			●	✓	4		✓	Silver	Up to £3,000,000
Severfield-Watson Structures Ltd	01204 699999	●	●	●	●	●	●	●	●	✓	4		✓	Gold	Above £6,000,000
Non-BCSA member															
Allerton Steel Ltd	01609 774471	●	●	●	●	●	●	●	●	✓					Up to £1,400,000
Cimolai SpA	01223 350876	●	●	●	●	●	●	●	●	✓					Above £6,000,000
Concrete & Timber Services Ltd	01484 606416	●	●	●	●	●	●		●	✓				Member	Up to £800,000
Donyal Engineering Ltd	01207 270909	●						●	●	✓			✓	Member	Up to £1,400,000
Francis & Lewis International Ltd	01452 722200							●	●	✓	2			Gold	Up to £2,000,000
Harland & Wolff Heavy Industries Ltd	028 9045 8456	●	●	●	●	●		●	●	✓					Up to £2,000,000
Hollandia BV	00 31 180 540540	●	●	●	●	●	●	●	●	✓					Above £6,000,000
IHC Engineering (UK) Ltd	01773 861734	●							●	✓			✓		Up to £400,000
Interserve Construction Ltd	0121 344 4888							●	●	✓					Above £6,000,000*
Interserve Construction Ltd	020 8311 5500	●	●	●	●		●	●	●	✓					Above £6,000,000*
Lanarkshire Welding Company Ltd	01698 264271	●	●	●	●	●	●	●	●	✓	4			Member	Up to £2,000,000
P C Richardson & Co (Middlesbrough) Ltd	01642 714791	●						●	●	✓					Up to £3,000,000
Varley & Gulliver Ltd	0121 773 2441	●						●	●	✓			✓		Up to £3,000,000

Company name	Tel	1	2	3	4	5	6	7	8	9	CE	SCM
Cooper & Turner Ltd	0114 256 0057									●	M	
CSC (UK) Ltd	0113 239 3000		●								N/A	
Cutmaster Machines (UK) Ltd	01226 707865					●					N/A	
Daver Steels Ltd	0114 261 1999	●									M	
Duggan Profiles & Steel Service Centre Ltd	00 353 56 7722485	●									M	
easi-edge Ltd	01777 870901							●			N/A	●
Fabsec Ltd	0845 094 2530	●									N/A	
FabTrol Systems UK Ltd	01274 590865		●								N/A	
Ficep (UK) Ltd	01942 223530					●					N/A	
FLI Structures	01452 722200	●									M	●
Forward Protective Coatings Ltd	01623 748323						●				N/A	
Goodwin Steel Castings Ltd	01782 220000	●									N/A	
Graitec UK Ltd	0844 543 8888		●								N/A	
Hadley Group Ltd	0121 555 1342	●									M	●
Hempel UK Ltd	01633 874024						●				N/A	
Highland Metals Ltd	01343 548855						●				N/A	
Hilti (GB) Ltd	0800 886100									●	M	
Hi-Span Ltd	01953 603081	●									M	●
International Paint Ltd	0191 469 6111						●				N/A	●
Jack Tighe Ltd	01302 880360						●				N/A	
Jamestown Cladding & Profiling Ltd	00 353 45 434288	●									M	
John Parker & Sons Ltd	01227 783200								●	●	D/I	
Jotun Paints (Europe) Ltd	01724 400000						●				N/A	

Company name	Tel	1	2	3	4	5	6	7	8	9	CE	SCM
Kaltenbach Ltd	01234 213201					●					N/A	
Kingspan Structural Products	01944 712000	●									M	●
Lindapter International	01274 521444									●	M	
Metsec Plc	0121 601 6000	●									M	●
MSW Structural Floor Systems	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 Performance Coatings UK Ltd	01773 814520						●				N/A	
Prodeck-Fixing Ltd	01278 780586	●									D/I	
Rainham Steel Co Ltd	01708 522311								●		D/I	
Sherwin-Williams Protective & Marine Coatings	01204 521771						●				M	●
Sika Ltd	01707 384444						●				M	
Structural Metal Decks Ltd	01202 718898	●									M	●
Tata Steel	01724 404040				●						M	
Tata Steel Distribution UK & Ireland	01902 484000								●		D/I	
Tata Steel Ireland Service Centre	028 9266 0747								●		D/I	
Tata Steel Service Centre Dublin	00 353 1 405 0300								●		D/I	
Tata Steel Tubes	01536 402121				●						M	
Tata Steel UK Panels & Profiles	0845 3088330	●									M	
Tekla (UK) Ltd	0113 307 1200		●								N/A	
Tension Control Bolts Ltd	01948 667700						●			●	M	
Wedge Group Galvanizing Ltd	01909 486384						●				N/A	