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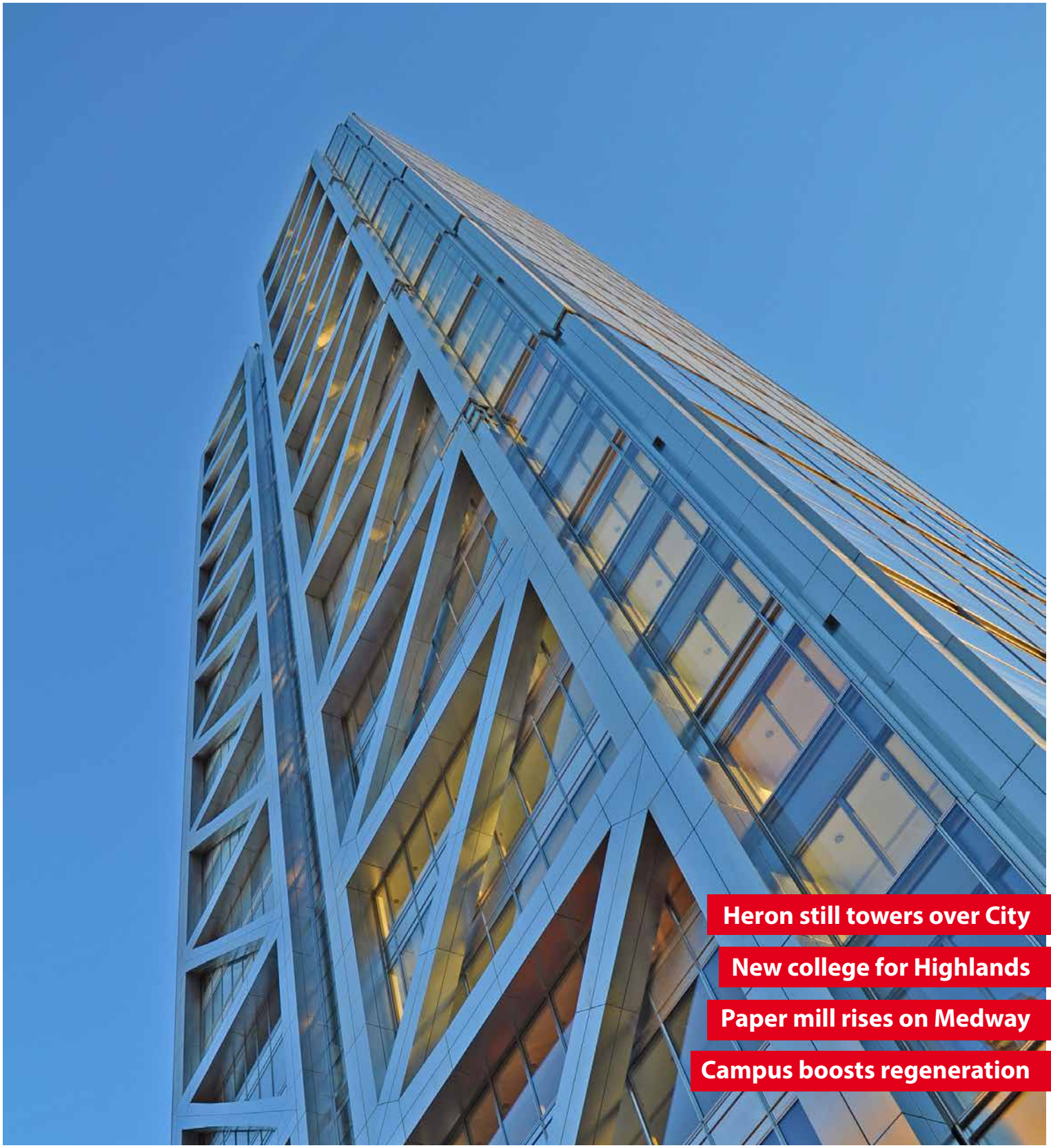
NSC

Steel takes Pancras podium

Mar/Apr 2014
Vol 22 No.2



Heron still towers over City

New college for Highlands

Paper mill rises on Medway

Campus boosts regeneration

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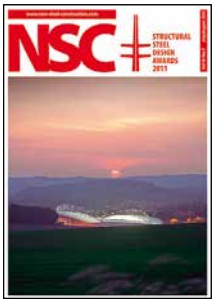










New Steel Construction keeps designers and contractors abreast of all major steel construction related developments and provides detailed technical information on key issues such as the introduction of the Eurocodes. NSC will be the first place most people hear about advances made by the extensive research 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.





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Position

Company

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Postcode

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Email

Cover Image
Heron Tower, London
©Harsil Shah
Main client: Heron
Architect: Kohn Pedersen Fox
Steelwork contractor:
Severfield-Watson Structures
Steel tonnage: 12,000t

NSC

March/April 2014 Vol 22 No 2

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

angle ring

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Steel Bending, Forming, Welding & Fabrication to Execution Class 4 – all under one roof !!

Angle Ring are proud to announce we are able to offer CE Marking to Execution Class 4 for fabricated / welded products and the full range of steel bending services.

Angle Ring have been accredited to ISO9001:2008 for some time and now also has a FPC system certified by the Steel Construction Certification Scheme (SCCS) to allow CE Marking in accordance with BS EN 1090 - up to Execution Class 4 for welding, fabrication and bending.

Angle Ring have been working with Tata Steel, BCSA, Sandberg, Swansea University, Peter Mould Associates and a number of BCSA fabricators to ensure that our approach to CE marking is understood and accepted by the whole market.

Angle Ring can therefore provide all the relevant information regarding essential characteristics on a DOP (Declaration of Performance) for the components or products supplied.

Having recently completed work for the stunning Kelpies project with S H Structures, The Dynamic Staircase, at the Wellcome Collection in London with Glazzard (Dudley) Ltd, and Reading station with Bourne Steel which featured 650x450x36mm curved RHS sections, Angle Ring are a clear choice for the entire range of curved steelwork, from a single bend to projects containing hundreds of unique pieces, all of which can now be offered with full confidence and in compliance with the CPR.

Kelpies photos courtesy of Tracey Fullerton

The Kelpies
Steel Bending - Angle Ring
Fabrication - S H Structures

Jeff Garner (IWE - Sandberg), David Springthorpe (Angle Ring), Denver Woodward (SCCS) , Peter Mould (PMA Associates)

Steel sector ready for recovery

Nick Barrett - Editor

By the time you read this the Chancellor will have finished his Budget speech, the small print will have been examined and the corporate world will have delivered its verdict on whether it was good for business.

Many businesses will have been waiting to hear the Chancellor's Budget speech before finalising their investment plans. Unlike a year ago however, when the Chancellor predicted a sluggish 0.6% growth in GNP for the year, there seems to be more than a fair wind behind the current economic recovery.

Growth over the year turned out to be almost three times the Chancellor's prediction, at almost 2%, and the Bank of England is now talking about 3% growth for this year – with many economists saying that this is still too pessimistic. BCSA President Ivor Roberts told the National Dinner that the light at the end of the tunnel was encouragingly bright, though he tempered that with warnings that margins remain tight and payment practices still need to be reformed.

The evidence mounts though that a broad based, increasingly strong economic recovery is under way. Recent evidence from Glenigans for example pointed to a 54% rise in starts on-site for office developments compared to a year ago, and a 16% growth in industrial projects. The hotel and leisure sector, another key market for steel construction, grew 21% although there was no sign of much improvement in retail – recent contracts awarded for some major retail led developments in the past month might change that picture soon.

Health projects were down over 40% as hospital building was cut back, but education spending on construction projects rose by 17%. Overall there was a 10% rise in project starts, led by the private sector. We are starting from a low base, but the direction of change is clearly positive.

Even more recently, there have been reports of a huge amount of international institutional investment funds looking for a home in infrastructure, with the UK a favoured destination. The pre financial crisis output peak for the economy overall is in sight; but despite all the good news it will probably be some time before the output of the construction industry catches up on that.

Already though we are hearing about shortages of some construction materials and of people with the skills to work with some of them. As Ivor Roberts said at the National Dinner, whatever pick up there is in the pace of demand the steel construction sector remains robust and ready to respond.

Some capacity has been trimmed during the recession, as would be expected, but the steel construction sector has continued to invest in skills and more efficient processes. It remains the world leader in providing cost-effective quality; and you can base your construction budget on that.

NSC

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 ISSN 0968-0098

Stockholders group to address industry concerns

The British Constructional Steelwork Association (BCSA) has reformed its Working Group for Steel Stockholders to address issues that have arisen since the introduction of the Construction Products Regulations (CPR) and the imminent CE Marking of fabricated steel.

"Our aim is to address the implications of the CPR for steel stockholders and the proposed changes to the manufacturing standard for steel sections EN 10025," said David Moore, BCSA Director of Engineering.

The CPR imposes legal obligations on stockholders and some BCSA members are unclear on the implications and actions that need to be taken.

A number of issues concerning CE Marking are also being looked into, such as the testing of upgraded steel and proposed changes to EN 10025-1.

The reformed Group met in January and further meetings are planned later this year. As well as raising the profile of BCSA member stockholders, the Group will produce an updated version of the Model Purchase Specification for Steel Sections.

BCSA members that attended the Group's first meeting were:

- ArcelorMittal Distribution Solutions UK
- ASD metal services
- Barrett Steel
- Billington Holdings
- CMC
- Duggan Steel Profiles & Steel Service Centre
- Murray Metals Group
- National Tube Stockholders
- ParkerSteel
- Rainham Steel Co
- SCCS
- Tata Steel

Landmark bowstring bridge lifted into place at Boston

Steelwork contractor S H Structures successfully lifted the new £750,000 St Botolph's bowstring footbridge across the River Witham at Boston, Lincolnshire into place on Saturday 22 February.

The bridge was assembled alongside the river and the majority of the finishes, such as handrails, were also installed prior to the lifting procedure.

The 65m long bridge weighed approximately 54t and was lifted into position by a 1,000t capacity mobile crane positioned on the riverbank adjacent to the assembly yard.

Main contractor for the project was Britcon. The bridge features a contemporary bowstring design that was chosen following extensive consultation with the public.

Andy Newell, Project Manager at Britcon, said, "We hosted a number of workshops to finalise the design details and resolve the many issues of building a bridge on such a confined site. The new structure is wider than the existing bridge and has an elliptical deck allowing people to admire the nearby Boston Stump without obstructing the crossing.

"Key features include a non-slip surface and improved access for pedestrians, wheelchair users, dismounted cyclists, pushchairs and mobility scooters. The bridge also colour matches the yellow lighting of the octagonal lantern in the church tower, which is believed to have been used as a marker to guide travellers on land and sea. There is also a tri floral motif installed into the parapet which will replicate the nearby Town Bridge."

Steel tackles phased rugby stadium build

The Ravenhill Rugby Ground in Belfast, which will be officially opened in May, has been redeveloped with the construction of three new stands, raising its capacity from 11,400 to 18,000.

Owned by the Irish Rugby Football Union, the stadium is the home of Ulster Rugby who were able to continually use the ground throughout a phased construction and demolition programme.

Working on behalf of main contractor Gilbert-Ash, Ballykine Structural Engineers erected 800t of steelwork for the Memorial and Aquinas Stands, as well as the new Main Stand.

No machinery was allowed to encroach onto the pitch during the construction, so cranes and MEWP's had to be positioned to the rear of each of the stands.

"This presented a major problem on the Aquinas Stand, as there was no access to the rear due to an adjacent school," said Ian Kerr, Ballykine Managing Director.

"We had to off load the 21m long steel rafters outside and bring them into the stadium using a side loader."

Recession a driver for change

Structural steelwork demand is expected to grow this year after hitting a nadir in 2013, BCSA President Ivor Roberts (above) told the association's National Dinner.

Mr Roberts said: "I have previously highlighted our ability as a sector to adapt and survive, and I'm pleased that we can finally say that there is light at the end of the tunnel.

"It's certainly been a long time coming, and there's no doubt that trading conditions are still mixed for many BCSA members.

"But after reaching a low point in 2013, the consumption of structural steelwork is forecast to increase in 2014."

Mr Roberts said the recent difficult years had brought out good qualities in many members, creating a driver for change and a search for new ways to do things better. The steel sector remained in good shape to respond to any increase in demand and members were investing in skills and improved systems.

"We need to harness our collective energy to drive change, and capitalise on the Government's realisation that economic recovery for the UK will be built on manufacturing, built on infrastructure and built on construction," he said.

Mr Roberts said more streamlined and effective procurement processes were needed. Filling out the same information in a multiplicity of prequalification forms was costing his business upwards of £20,000 a year. There was a danger of the burden becoming even more onerous as the industry moved towards introducing Building Information Modelling.

Mr Roberts said the introduction of Project Bank Accounts on government projects was proceeding faster than anticipated, helping industry cash flows. But the industry had to remain vigilant that the ground gained with PBA's and in other areas was not lost as main contractors argue against mandatory payment terms.

The steel sector had focussed on the regulatory, quality and skills requirements of CE Marking which is being introduced on 1 July. The efforts made had improved quality across the sector, he said.

BCSA's CRAFT certificate scheme had been developed to provide an alternative training route via an industry approved scheme. Steelwork contractors will be able to take on more trainees using on the job training as a result.

Vision of world class railway in sight

Guest speaker Crossrail Technical Director Chris Sexton (above) described the scale of the engineering success story currently being achieved under London's streets as the Crossrail project passed its half way stage.

Crossrail is the biggest infrastructure project under way in Europe, designed to carry 200 million passengers a year. It was on time for completion in 2018 and within its £14,800 million budget. The crucial tunnelling operations - 42 kilometres in total - will be completed this year: "We are on the cusp of finishing the main civil engineering works," he said.

The project had gone well and important lessons had been learned that could benefit other projects as well as the second half of Crossrail. Offsite manufacturing had been a 'massive help' towards improving safety and there had been programmes aimed at altering behaviour in safety related directions and much had been learned.

The importance of design and construction teams communicating better with each other was something that the industry has to recognise more fully and do something about. Simplifying processes like removal of spoil from tunnels was a good way to take risk out of the project.

Mr Sexton concluded: "The vision of a world class railway is in sight."

Eurocodes beam tool added to website

An easy to use software tool that carries out the design of simply supported composite beams to the Eurocodes is now available at *www.steelconstruction.info*

To use the tool steel sections may be selected from the range of universal beams (Advance ® UKB) in grade S355. The slab is constructed with metal deck, which may be selected from the ComFlor range, or specified for other metal decks.

Structural steel design is carried out to BS EN 1993-1-1, concrete design to BS EN 1992-1-1 and composite design to BS EN 1994-1-1. All standards are as implemented by the UK National Annexes.

ULS and SLS checks are carried out for the execution and normal stages. At the execution stage the secondary beam compression flange is assumed to be fully restrained by the metal deck, and the primary beam compression flange is assumed to be restrained at load application points.

NEWS IN BRIEF

The **Steel Construction Institute** (SCI) has signed an agreement with the Ukrainian Steel Construction Center (USCC) to establish a strategic partnership on issues related to the technical development of steel construction in Ukraine. One of the first projects of the partnership is the development and promotion of composite decking with fire ratings REI 45 and REI 60 according to the national standards.

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

The new HSFDB-C plate processor from **Peddinghaus** is said to offer the capability of drilling, scribing, countersinking, tapping, milling and oxy-fuel and plasma cutting. Other features include optional bevel cutting, hard stamping and a 12 station tool changer.

Voortman Automatisering has changed its name to **Voortman Steel Machinery** as the new name is said to better define its core business activities. The company's contact details remain unchanged.

FICEP UK has been appointment as sole UK agent for the Ernst range of edge treatment machines for components produced from plate. The company is a leader in edge treatment technology for sheet metal deburring machines as well as for wood and lacquer sanding machines for the door and furniture industry.

The steel framed Cooperative Headquarters building in Manchester won the '**Your BREEAM Award**' at the annual BREEAM awards presentation. The award was decided by vote and the project was selected from a shortlist of sustainable structures.

AROUND THE PRESS

The Structural Engineer
March 2014
The Francis Crick Institute, London
From the fifth floor springs a vaulted steel roof enveloping the blocks and providing architectural continuity with the ground by forming four full height façades between the blocks.

Construction News
28 February 2014
Heli crash simulator in tight landing
[Offshore helicopter training facility, Tyneside] - The extension features 25 tonnes of steel portal frames with cladding rails and Kingspan micro-rib composite panels for the walls.

Building Magazine
21 February 2014
Heathrow Terminal 2
Whereas T5 features primarily column free spaces, T2 is a steel frame building more conventionally set out on a modular 9m x 9m grid on lower floors and opening out to an 18m x 18m grid on upper floors. The interior is thereby dotted with stainless steel columns, although the grid allows more spaciousness in the upper departure and arrivals lounges.

Building Design
14 February 2014
Rain pergola for Microsoft Italia HQ
The majority of the canopies, referred to by the architect as 'shade pergolas' provide shelter from the sun, while one, constructed of metal and glass and running at a lower height is referred to as a 'rain pergola'. The columns of the canopies are formed by tapering tubular steels that reduce to a diameter of 150mm at their tops.

The Structural Engineer
January 2014
Design of the new Crossrail station, Paddington, London
All columns are 550mm H-sections, with web and flange plate thicknesses varying from 25-40mm and 50-70mm respectively, dependent on column location. These steel columns approximately 23m long, are installed to a verticality tolerance of 1:400 and supported by 1800mm diameter piles.

Steel Essentials seminars go online

The Steel Essentials seminars that attracted a record number of attendees last year are now available as CPD's at *http://www.steelconstruction.info/Continuing_Professional_Development#Steel_Essentials_Seminars_2013*

Hosted by Tata Steel and the British Constructional Steelwork Association (BCSA), the Steel Essentials CPD's provide an opportunity for designers to keep up to date with the latest developments on important steel construction related topics.

Industry experts from Tata Steel and the BCSA speak on topics that include practical EC3 design that walks the designer through the design of restrained and unrestrained beams, and simple columns to the Eurocodes.

Other topics included in the CPD's are EC3 – the questions everyone is asking, steel specification and design that focuses on CE Marking and a presentation entitled steel grades that explains why steel subgrade selection is important and the procedures to follow in both BS5950 and EC3 to ensure the correct specification.

There is also a presentation on determining the fire resistance period for a structure, and how that requirement can be met using standard fire protection systems, and another discussing the sustainability of steel construction.

Also now available at *http://www.steelconstruction.info/Continuing_Professional_Development#Steel_Essentials_Seminars_2013* are the cost comparison webinars hosted by Tata Steel and the BSCA, and presented by Gardiner & Theobald with Peter Brett Associates and Mace.

Steel is appealing for banana facility

EvadX has fabricated, supplied and erected the steelwork for a bespoke banana ripening facility near Wigan.

The 5,600m^2 warehouse has a main span of 50m and a total of 12 × 8.5m wide bays. The height to the underside of the eaves is 10m and at each end of the structure there are two-storey office and administration areas.

Main contractor for the project is Pochin Construction and the client is Dole Fresh UK. The project forms part of a new major distribution park named M6 Epic, located close to junction 25 of the motorway in Lancashire.

Passing the test at Scottish academy

Work on the £36M Ellon Academy Community Campus in Aberdeenshire is progressing successfully; the steel erection programme has been completed and the project is on target for its 2015 opening.

Steelwork contractor BHC has fabricated, supplied and erected 1,400t of structural steelwork for the project.

The steel frame consists of a 1,200 capacity school accommodated within a three and four-storey building, a five-lane swimming pool as well as learning support and community facilities.

The new school is a replacement for the existing Ellon Academy and the project is part of Aberdeenshire Council's long term asset management strategy.

The main contractor for the job is FMP.

Steel construction leads the way in Formula E

A number of steel framed buildings have been erected at Donington Park as the headquarters for Formula E, the Federation Internationale de l'Automobile's new electrical racing series.

Steelwork contractor Caunton Engineering has fabricated, supplied and erected six single span portal frame structures measuring 42m × 15m. The buildings are to be divided in half with internal partitions to form workshops for the Formula E teams.

A further two similar sized steel structures have also been built, one to be divided into a workshop and offices for Formula E, the other to be used as an administrative headquarters by Donington Park Racing.

All of the facilities will meet the 'Very Good' BREEAM rating and in total 250t of steelwork was required.

Main contractor is Vinci Construction UK which is scheduled to complete the project by the end of April with the first teams moving in on 1 May.

Grade A office development on the mark

Steel construction is due to be completed in May at 70 Mark Lane, a 16-storey commercial development in the City of London.

Offering 15,700m^2 of Grade A office accommodation, the structure features a dramatic louvered sloping roof that provides protection to south facing terraced gardens located on the six uppermost floors.

Andrew Henstock, Severfield-Watson Structures Project Manager, said the roof steelwork is the most challenging aspect of the job. "It's a large architectural feature with many hidden connections that will require three weeks of on-site welding."

The building is aiming for a BREEAM 'Excellent' rating and the main contractor is Sir Robert McAlpine.

East Manchester regeneration scores twice

Much of the construction for the first phase of the East Manchester regeneration scheme is nearing full time as two steel framed facilities are due to be completed this summer.

Requiring 700t of structural steelwork, the Connell Sixth Form College and the Beswick Leisure Centre have both been erected by Elland Steel Structures, working on behalf of main contractor Laing O'Rourke.

The college will accommodate 600 students to meet a growing demand for places in this part of Manchester. It will open at the beginning of this year's autumn academic term.

Beswick Leisure Centre, which is also due to open in September, includes an eight lane swimming pool with a moveable floor, a gym and a dance studio.

Overall the project is a joint regeneration scheme between Manchester City Council and Manchester City Football Club. It will deliver new leisure, education and employment opportunities on a 16 acre adjacent to the football club's Etihad Campus.

Diary

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

Tuesday 1 April 2014
Steel Connection Design
This course is for designers and technicians wanting practical tuition in steel connection design.
(1 day course) Birmingham

Tuesday 29 April 2014
Member Design to BS 5950
An overview of frame stability, compression members, unrestrained beams and columns in simple construction, all to BS 5950
1 hour webinar

Tuesday 6 May2014
Steel Building Design to EC3
BS5950 has been withdrawn and designers are increasingly being asked to use the Eurocode suite for new works. The changes (and the number of documents) can initially appear overwhelming - until the Eurocode approach is explained and examples undertaken.
(1 day course) Leeds

Tuesday 20 May 2014
Multi-Storey building design with ease: Using on-line design tools Part 1
Why make life complicated? Design to the Eurocodes can be completed using free design tools from steelconstruction.info, and the Blue Book. This first session will cover practical design of composite and non-composite beams.
1 hour webinar

Tuesday 10 June 2014
Light Gauge Steel Design
This course introduces the uses and applications of light gauge steel in construction, before explaining in detail the methods employed by Eurocode 3 for designing light gauge steel members in bending and compression and calculation of section properties
(1 day course) Leicestershire

Tuesday 17 June 2014
Multi-Storey building design with ease: Using on-line design tools Part 2
Continuing the theme of practical design to EC3 using design tools, this session will cover struts, columns in simple construction and frame stability 1 hour webinar

The building is clad in terracotta and glass

Economic design drives commercial scheme

A new UK headquarters for a European banking organisation is quickly taking shape with the aid of a steel frame. Martin Cooper reports from Pancras Square.

FACT FILE
BNP Paribas Real Estate HQ, 6 Pancras Square, London
Main client: BNP Paribas Real Property Development UK
Architect: Jean-Michel Willmotte
Main contractor: Vinci Construction UK
Structural engineer: AKTII
Steelwork contractor: Severfield-Watson Structures
Steel tonnage: 2,950t

One of the largest regeneration schemes currently taking place in Europe is radically transforming the once rundown industrial zone north of King's Cross Station into a new and vibrant neighbourhood.

Described as a new piece of London with a brand new postcode, London N1C (as it will be known) will include 50 new buildings, 2,000 new homes, 20 new streets and 10 new public squares spread over 67 acres.

One of the initial phases of this huge and ambitious development is Pancras Square. Located between the busy rail terminals of King's Cross and St Pancras International, the scheme consists of seven retail and commercial buildings situated around a central public square.

This is a prestigious site with abundant nearby transportation links. Consequently a number of high profile companies are taking advantage and one of the first structures to be constructed is 6 Pancras Square, a new UK headquarters for Paris based BNP Paribas Real Estate.

An 11-storey steel framed structure, it will create 39,500m^2 of office space, with some ground floor retail, based around a large central atrium.

"A steel option was the only realistic choice for this project as the client wanted a City spec office building with long clear open spans," explains Steve Toon, AKTII Project Director.

Erected by Severfield-Watson Structures, the building is formed with a cellular steel composite frame which is both lightweight and economic.

The use of Fabsec cellular beams has allowed the project team to integrate all of the services within a constant and efficient structural zone created by the consistent depth of the beams.

The M&E contractor and Severfield-Watson shared the project's structural model

Podium offers access for all

Located in the middle of Pancras Square is a 4,000m^2 wedge shaped steel podium (see story in *NSC* Jan/Feb 2013). Completed last year by BAM and steelwork contractor Fisher Engineering, it creates a robust two level working surface for the overall project's many different contractors.

When the project is finished the podium will provide a shared delivery basement for all of the surrounding buildings, while the upper level will be landscaped and turned into a public realm.

The podium's usefulness during construction meant it was the catalyst for the entire scheme and so speed of construction was vital. The initial design envisaged a concrete podium but this was altered to a steel frame with precast floors, a decision that ensured the structure was completed on time and quickly,

"Having the completed podium has been extremely useful to our project as the adjacent Pancras Road is very busy and unsuitable for unloading materials," says Phil Willmott, Vinci Construction Project Director. "Deliveries such as steel are delivered directly to site and stored on top of the podium before being erected."

"A steel option was the only realistic choice for this project as the cient wanted a city spec office building with long clear open spans"

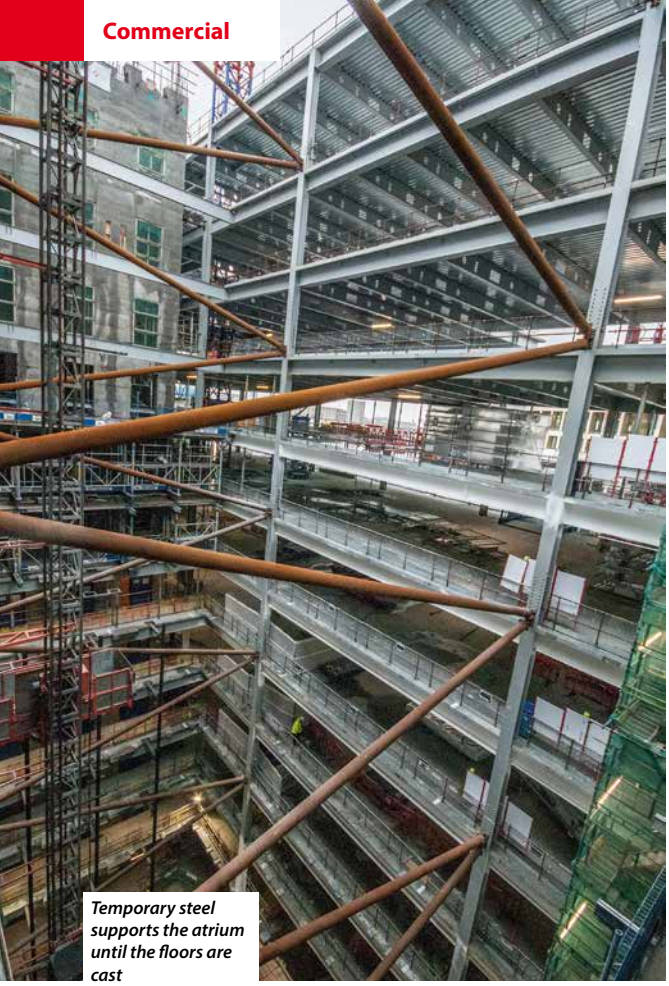
early in the design process and used Building Information Modelling (BIM) to ensure all of the cellular beams were fine tuned and arrived on-site with their openings in the correct position as well as the right shape and size.

Based around a large 15m × 9m grid pattern, the steel frame starts at level one - which links to the upper level of the project's shared podium (see box) – and extends upwards fairly uniformly to the rooftop.

"We came to site before our main programme started and erected level one steelwork which then allowed the concrete contractor to complete casting the remainder of this floor's slab," explains Richard Tarren, Severfield-Watson Structures Project Manager.

"We then returned to site a few weeks later and erected the rest of the frame during a three month programme."

Outdoor rooftop terraces take shape



Temporary steel supports the atrium until the floors are cast

Visualisation of the completed building

Below the steelwork there is an insitu basement zone which also incorporates a mezzanine level adjoining the street level along Pancras Road. The basement links into the lower level of the podium and is founded on more than 200 CFA piles.

The steel frame wraps around a centrally located atrium which is glazed at rooftop level, ensuring plenty of natural daylight will penetrate the building's inner office space. At either end of the large void there is a slip-formed core, each one containing three lifts.

Steelwork is connected to, and gets its stability from, the two cores. However a feature of the architectural design means the cores are very slim in order to maximise space. Separate steel framed service risers are attached to the outside of the main cores and the main steel frame could not encroach into these areas.

"We had to install a temporary CHS bracing system in these areas which was installed outside of the structural zone. After the floors were cast and stability achieved, the temporary steelwork was removed," says Mr Tarren.

The atrium also accommodates two pairs of scenic lifts, which have required approximately 50t of architectural steelwork. A series of spliced purpose made cruciform columns extend from ground floor entrance area all the way up to the eleventh floor, supporting and concealing the lift's guide rails.

In keeping with the rest of the Pancras Square development the building is subject to planning restrictions limiting its height. To conform, the structure is stepped, rising from south to north via two terraces on the eighth and eleventh floors.

The economic form and consistent floor depth of the steel frame is maintained even for the transfer structures that form the terraces. "Fabsec sections have been used here too, but have thicker plate for the extra loadings," says Mr Toon.

Affording views over the City of London to the south, the two outdoor areas will provide the building with pleasant breakout areas and function space.

The eleventh floor terrace is accessed from a large rooftop function room, or meeting area. The remainder of this uppermost level is given over to a plant deck which is shielded by a 3m high steel mesh fence.

The project is due for completion in October this year.

Pancras Square

Pancras Square will eventually consist of seven retail and commercial buildings arranged around the wedge shaped podium and public realm. As well as the BNP/Vinci project, BAM is nearing completion of two other commercial structures, while Kier is currently working on a office and leisure centre for Camden Council. Two more steel framed office blocks are planned to start later this year, occupying plots currently being used as contractors' compounds and offices. The square's seventh building is a restored Victorian tenement block being converted into shops.

Integration of services

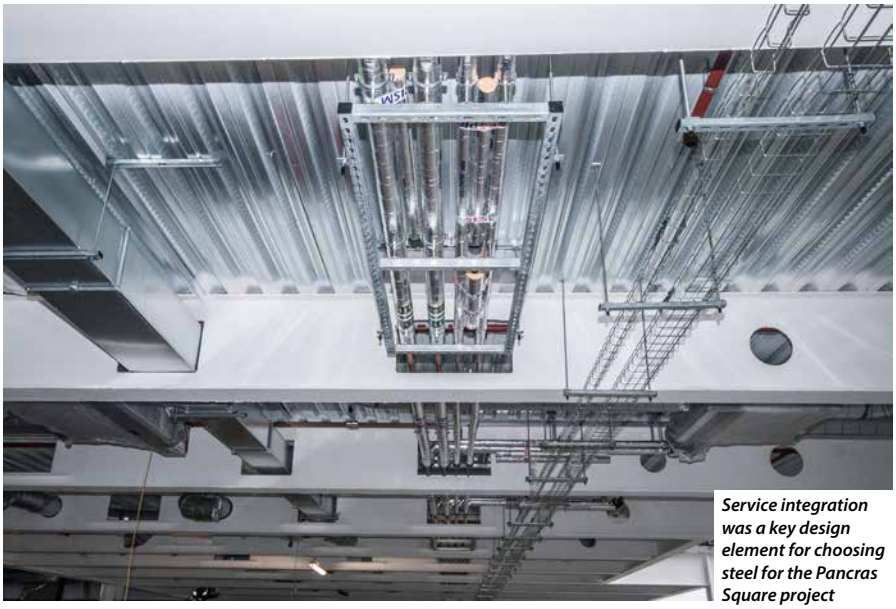
Dr Richard Henderson (SCI)

Dr Richard Henderson of the SCI considers the use of cellular beams for the integration of building services and structure.

The integration of building services with the structure is an important issue in the design of the floor beams. The zone which remains when the clear height of the usable space is deducted from the storey height serves multiple functions and must accommodate many different elements. These include some or all of floor finishes (usually a raised floor); horizontal structure (floor slab and beams); building services (lighting, small power, supply air ductwork or chilled water, fan-coil units or diffusers, exhaust air ductwork, perimeter heating pipework); ceiling. Arrangement of these elements of construction to take up the shallowest zone is desirable.

Various approaches to services integration have been tried including truss-beams, tapered sections to allow ducts under and castellated beams. The latest form of castellated beam is the cellular beam in which the characteristic hexagonal openings in the original beam are replaced by more visually appealing circular openings. Cellular beams are usually designed to act compositely with the concrete floor slab. The beams take up most of the ceiling void and all services have to pass through the openings in the beam web. Adjacent cells can be joined together to create elongated openings to accommodate rectangular ducts.

The depth of the "parent" beam is increased by 40% to 60% in forming the cellular openings. For an increase in depth of 50%, the plastic modulus of the cellular beam is increased by about 66% and the second moment of area is increased by about 270%. Examination of section tables for beams with equivalent properties shows that a cellular beam is approximately 66% of the weight of an equivalent strength beam with a solid web. In terms of stiffness, the equivalent percentage is about 60% These values correspond to weight savings of 25 to 35 kg/m depending on whether the choice of beam is strength or stiffness-governed. In a 15m × 9m bay, assuming secondary beams at 3m centres and 54 linear metres of beam per bay, this adds up to a potential weight reduction of 1350 to 1890 kg in an area of 135 m^2. Over a floor area of 39,500 m^2, this represents a weight reduction of 400 to 550 tonnes of steel.



Service integration was a key design element for choosing steel for the Pancras Square project

The use of cellular beams clearly results in a valuable saving of steel weight in floor beams. SCI publication P355: Design of composite beams with large web openings is a useful reference for the design of beams required to integrate with building services.

Paper making gets a boost

The entire project has been reliant on steel's speed of construction

One of Kent's oldest industries is expanding with the aid of a new steel framed manufacturing hall.

Kent's Medway Valley has a long tradition of paper making and today a number of mills are still in existence, supporting the local economy and producing a sought after and valuable commodity.

One of the oldest and largest mills is the Townsend Hook Paper Mill at Snodland near Maidstone. Owned by the Smurfit Kappa Group, the site has been manufacturing paper for more than 150 years and this tradition is set to continue as a £98M investment programme nears completion.

The installation and commissioning of a custom designed container board machine is due to be completed and operational by the end of this year. The machine will produce lightweight corrugated packing from recycled material and, once up and running, it will secure the supply of paper for all of Smurfit Kappa's packaging operations in the UK and the Republic of Ireland.

The new equipment will replace two existing container board machines, increasing the mill's capacity of recycled paper per annum by over 8% from 240,000 to 260,000 tonnes.

Chris Allen, CEO of Smurfit Kappa Paper UK, comments: "This investment in the current financial climate shows our commitment to the UK, Ireland and pan-European customers of our products.

"The design of the new machine means the mill will offer the most sustainable approach to packaging in the UK."

In order to accommodate the new machinery a large steel framed building along with a number of smaller ancillary steel structures are being constructed.

Atlas Ward Structures has been contracted directly by Smurfit Kappa to fabricate, supply and erect 2,200t of structural steelwork for the project. The contract also includes the installation of precast floors and walls, as well as supply and erection of 14 steel stairs and a further four steel stair towers.

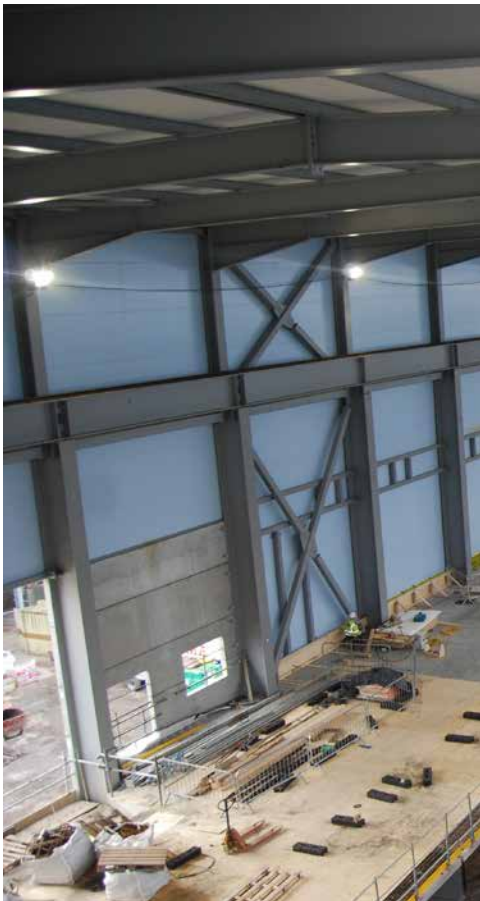
The largest part of the construction programme involves the new main paper mill building that is 162m long and has a span of 32.7m. This large portalised frame is formed with a series of 22m high 914 UKC sections spaced at 6m centres.

"Large column sections are needed in the design to support the main frame and internal crane beams," explains Neil Hall, Atlas Ward Structures Project Manager.

Two 50t capacity overhead gantry cranes will serve the entire length of the building. These will operate along rails supported on steel beams connected to the main columns 15m above ground level.

Internally the building also features an 8m wide mezzanine level that extends the full length of one elevation. On the opposite side of the building an 8m wide lean-to structure connects to the main frame and extends along this elevation for 25m. To be used as a plant zone, the lean-to has two levels and overlooks the main hall.

The lean-to and mezzanine create a large void in the centre of the building into which the majority of the new container board machinery will be installed.



FACT FILE
Townsend Hook Paper Mill, Snodland, Kent
Main client: Smurfit Kappa Group
Architect: AF Incepal
Principal contractor: Raymond Brown
Structural engineer: AF Incepal
Steelwork contractor: Atlas Ward Structures
Steel tonnage: 2,200t

Large crane beams span the hall

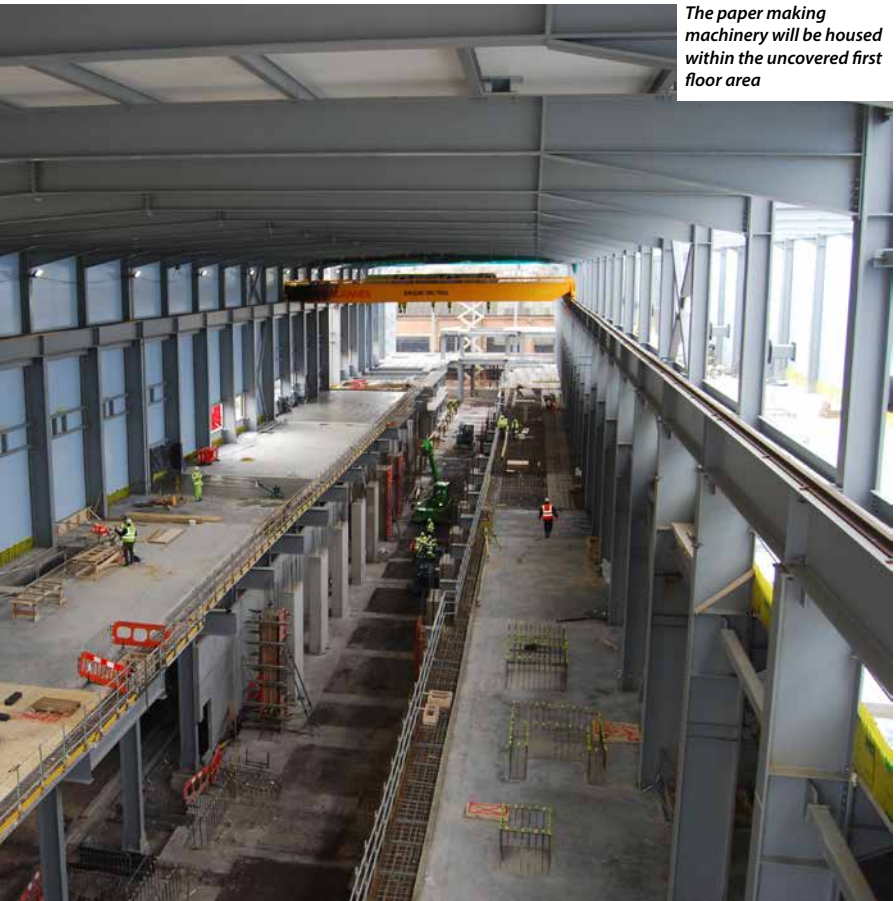
Plant equipment brackets are attached to the outside elevations

Because of potential vibration issues due to the amount of heavy machinery to be installed, the structure's floor slab, mezzanine floor and annex levels all have a floor thickness of up to 450mm. To support the heavy mezzanines, the same large 914 UKC's, as used for the building's perimeter, have been erected to support these floors.

"The connections are large and very complex due to the onerous loading from the paper machines and associated M&E services," says Mr Hall.

"To further mitigate against vibration all of the columns have been erected on fixed bases with up to 100mm thick base plates."

Using a 90t and a 50t capacity mobile crane, Atlas Ward erected the majority of the steelwork during a 15 week programme. The company also installed precast floor and wall units at the same time, minimising the overall erection period.



The paper making machinery will be housed within the uncovered first floor area

Prior to the steelwork programme beginning, the ground had been prepared by Keller and the principal contractor Raymond Brown, work that included the installation of 1,000 piles.

Atlas Ward constructed the building and lean-to simultaneously, working from one gable end to the other. Once each 6m wide bay was erected, the company then installed the precast floor units and walls.

Braced bays provide stability for the frame, although the initial gable end of the structure had to be propped during erection. This temporary support was then dismantled once a few bays had been completed which allowed the partially erected structure to be self-supporting.

The longest steel elements within the steel frame are the roof rafters for the main hall. At 32m long they are formed from two 16m long sections that were bolted together on-site and then lifted into place by Atlas Ward's 90t capacity mobile crane.

During February Atlas Ward revisited the site to erect the smaller buildings around the site including a stock prep unit, a control building and a conveyor belt link from the new paper mill building to the site's existing facility.

As the Chancellor of the Exchequer, George Osborne MP commented after meeting local MP, Tracey Crouch: "The investment in the mill is a vote of confidence in the UK economy and will maintain the historical link between Snodland and the paper making industry."

"Large column sections are needed in the design to support the main frame and internal crane beams."

Photo courtesy of Moray Council and Royal Haskoning DHV

A bridge to the future

Providing Elgin with an iconic steel structure, the new Pansport Bridge is also part of an important flood alleviation scheme.

FACT FILE
Pansport Bridge, Elgin
Main client: Moray Council
Main contractor: Morrison Construction
Structural engineer: Royal Haskoning
Steelwork contractor: Cleveland Bridge
Steel tonnage: 600t

The replacement Pansport Bridge in Elgin forms an important part of Scotland's largest ever flood alleviation scheme which is also Moray's biggest ever construction project.

Straddling the River Lossie, Elgin is one of Scotland's oldest towns and no stranger to flooding. Elgin's river defences have been catastrophically breached four times in the last 17 years and, in order to prevent this happening again, new embankments and river walls are being constructed.

The £86M scheme has been funded by Moray Council and the Scottish Government, and is part of a larger £150M investment in flood alleviation works across the area.

Main contractor Morrison Construction started on-site in April 2011 and is scheduled to complete the project in June 2015. One of the initial tasks was the demolition of the old Pansport Bridge and the installation of a temporary crossing that will remain in place until the new bridge is opened to traffic this summer.

"The new bridge is longer than the old one," explains Allan Russell, Construction Manager for Morrison Construction. "As well as the river, it also has to span an adjacent relief channel that we've excavated to help with the flood alleviation."

Cleveland Bridge began erecting the 75m long bridge last August, once the piling programme had been completed and the central pier and abutments installed.

The bridge is a two-span double arch structure with a suspended deck. The arches are constructed from fabricated plate trapezoidal boxes that provide support for the deck via 16 x 55mm diameter cable hangers. The main carriageway is located between the arches, with segregated pedestrian walkways outside of them.

Erection, which was reliant on a series of temporary trestles placed in the river and channel, began with the arches. Each of the double span arches was divided into five sections for installation.

"The 25t central nodes which connect the two spans of each arch to the central pier were the first pieces to be installed," says Dominic Charlton, Cleveland Bridge Project Manager.

The remaining four sections for each arch were then installed, with each section connected via a Cleveland Bridge designed landing bracket positioned inside of the box girder.

"Once each section of an arch was positioned on a bracket, only a minimal amount of welding was needed while the crane held it in place," says Mr Charlton. "This meant the erection was quicker and we needed less temporary works."

Preassembled cassettes, consisting of two crossbeams, connecting secondary beams and bracing were then lifted into place to form the bridge deck.

A slab was then cast on top of the steelwork and once this was completed the permanent cable hangers could be fully loaded to support the bridge deck allowing the trestles to be removed.

Cantilever sections are connected to the deck to provide support for the segregated pedestrian walkways.

To minimise the number of crane lifts, the walkways were fabricated and transported to site in modules measuring 4.8m wide with lengths varying from 15m to 21m.

"In order to lift the walkways, the heaviest of which was 52t, we used the largest cranes we could safely position on-site," sums up Mr Charlton.

A walkway module is lifted into position

Steelwork is nearing completion in readiness for the summer opening

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Steel heads campus examination

Fast lightweight construction is the order of the day for a new college project in the Highlands. Martin Cooper reports from the initial project for the ambitious Inverness Campus scheme.

FACT FILE
Inverness College UHI
Main client: Miller Equitix Inverness
Architect: BDP
Main contractor: Miller Construction
Structural engineer: Struer
Steelwork contractor: BHC
Steel tonnage: 1,400t

One of the largest developments to take place in the north of Scotland for many years is under way in Inverness. Described by Highlands and Islands Enterprise (HIE) – the Government quango responsible for local commerce and development – as a once in a lifetime opportunity, the Inverness Campus could generate around £38M for the regional economy each year and provide work for more than 6,000 people.

Overall the scheme is split into three phases (see box top of p19), with the initial part of the work centred on a new home for Inverness College.

One of 13 colleges and research institutions that make up the University of the Highlands and Islands, the new premises will allow Inverness College UHI to vacate its old buildings and take possession of state-of-the-art facilities.

Located in the centre of the first phase, the new college building will act as a focal point for the entire Campus as it is by far the largest single structure in the development.

Spread over three-storeys, the completed building will offer more than 20,000m^2 of teaching and workshop space for some 6,500 students.

The largest project within the Inverness Campus takes shape

The building uses the diaphragm of the floor plate to transfer horizontal loading from the steel frame to the six braced steel cores. Where required, cross bracing has been provided within partition walls to give additional stability.

"The steelwork supports steel decking and we went for this composite design as it was considered to be the quickest and lightest solution," says David Trahar, Struer Project Director.

The weight of the structural frame was an important consideration, not just because it would be more cost-effective, but also because its lighter weight meant that pad foundations could be used and piling avoided.

A standard 6m grid pattern has been used throughout the structure with only a few areas needing to have a variation. The unorthodox shape of the building – it is roughly kidney-shaped with the addition of one long straight elevation – meant a lot of time was taken with the setting of column lines, particularly around the structure's corners.

"It is a difficult shape and we had to pass the structural model back and forth between ourselves and the engineer in a BIM (Building Information Modelling) exercise, in order to get it right," explains Stephen Kelly, BHC Drawing Office Manager.

Using BIM also made the steel frame's design cost-efficient as cellular beams have only been used where needed for service integration. The BIM model quickly showed where these areas were, an exercise that helped save money.

Craig Paterson, Miller Construction Project Director agrees: "The geometry is complex and using BIM ensured the steel frame was as flexible and as cost-effective as possible."

Three large rooftop pods will house the college's plant equipment

The project does have some long spans such as the main entrance and its adjoining full height atrium. Creating this large open area is a series of 21m long beams, spaced at 6m centres and supporting roof lights.

Another long span area is the first floor sports hall, where 17m long column free spans were needed to accommodate badminton and squash courts.

Maximising space as well as making sure the gym would be accommodated within the main structure led to the decision to put it at first floor level as opposed to the ground floor, allowing the area below the hall to be occupied by workshops.

An economic design has been achieved as the sports hall's 17m long beams only have to support the roof. If the facility had been located at ground floor level, a series of less economic transfer structures would have been required to support not only the roof but also a floor of workshops.

Befitting the centrepiece building of the Campus, it has a number of architectural features. Adorning the top of the building are three pods used as plant enclosures but initially designed purely as architectural highlights.

The pods are different sizes, but all elliptically shaped, with the biggest measuring 40m long and 9m high. Supported by the building's roof steelwork, the pods are formed with a series of curved hollow section rings that will be clad with a copper mesh.

The building's roof also overhangs the main elevation and this feature ends with a prow that covers the main thoroughfare into the entrance. A series of four 14.5m high V-shaped CHS columns support the overhang. A slightly larger 17m high V-shaped section stands guard in front of the entrance supporting the upturned prow.

Inverness College UHI is scheduled to open in September 2015.

The Inverness Campus

The scheme is being developed on a 215 acre site just off the A9 dual carriageway on the outskirts of the city. It is located adjacent to the Raigmore Hospital (the region's largest NHS infirmary) and Lifescan Scotland, a manufacturer of scanners and currently the biggest employer in Inverness.

The vision is for the Campus and its neighbours to forge an alliance and form a key research and education environment.

As well as the College **(A)** , phase one of the Campus project includes a four-star hotel **(B)**, student accommodation blocks **(C)**, offices and research space **(D)**. Designs are currently being finalised and the likelihood is that steel will play a role in most of these schemes when they get started later this year.

Two further phases are planned: phase two **(2)** will include leisure and sport facilities, and more office blocks, while phase three **(3)** will be residential.

Throughout the scheme, positive measures will be taken to be sympathetic towards the natural environment. "The Campus will have parkland, recreational space for people working and studying on-site as well as for the wider local community," says Ian Thorburn of the Highlands and Islands Enterprise. "Public art features will further develop the high quality landscape for all to enjoy."

Bridge to the Campus

Linking the Campus with Inverness city centre is an 84m long single span steel pedestrian and cycle bridge that crosses the A9.

This important link was fabricated and assembled by Cleveland Bridge. It is 9m wide, weighs 290t and was brought to site as six main girders, two measuring 36m long and four 24m sections.

"We assembled the bridge on 2m high stillages on an adjacent site," says Paul Walmsley, Cleveland Bridge Project Manager. "We welded the girders and crossbeams, as well as installed the metal deck."

Once the bridge was assembled and clad, Morgan Sindall (the main contractor for the Campus infrastructure works) and heavy lift specialist Mammoet, installed the bridge during a weekend road closure. The bridge structure was jacked up and transported from its assembly yard to its permanent position by self propelled mobile transporters, and then lowered onto its permanent bearings.

The bridge will be officially opened this April.

College qualifies with steel

As one of the town's initial regeneration phases, a new college campus is set to help reinvigorate Grays town centre.

FACT FILE
The new Thurrock Campus of South Essex College
Main client: South Essex College
Architect: KSS
Main contractor: Skanska
Structural engineer: Skanska Technical Services
Steelwork contractor: William Haley Engineering
Steel tonnage: 830t
Project value: £33M

Relocating businesses and shops out of town and into purpose built accommodation has become something of a trend throughout the UK in recent times. .

New premises do have many advantages, but so do buildings in town centres. In some instances things seem to have now come full circle as there is now a growing movement to reverse this trend and bring vibrancy and life back into many of our forgotten and underused town centres. It is gathering pace and a good example is taking place in Grays, Essex.

One of South Essex College's three campuses is currently located on the outskirts of this Thames side town, but from September a new facility will open right in the middle of Grays.

Known as the new Thurrock Campus of South Essex College, the facilities being built by Skanska are a key element of the local council's plans to re-invigorate the town centre. The new campus will also enable the college to decamp into bespoke buildings and leave behind tired 1960s premises.

Graham Farrant, Chief Executive of Thurrock Council says of the scheme: "The new college buildings will enable Grays to recapture the hustle and bustle of previous years and become a town that will attract exciting businesses and stores."

It is apt that the council offices are directly opposite the project, allowing it to literally oversee this town-changing development.

Located on a plot previously occupied by housing and a car park, the new college campus will be well served by local transport, as it is less than 150m from the train station, something which will be a real boon for students who may have to travel from other parts of Essex.

Skanska started on-site in January 2013 and had to undertake some demolition work – many of the buildings had already been cleared under a previous contract - prior to starting with groundworks and the installation of CFA piles.

The development comprises of two buildings: the West Building and the East Building. The former is a four-storey structure and will contain the main entrance, restaurants, a performance area, staff rooms, a library and classrooms for subjects such as hair and beauty, and catering.

The latter is a three-storey building containing workshops and studio spaces linked to applied science, technology, media and creative arts courses. There will also be facilities for art, design, logistics, engineering and IT.

Both structures are formed from steel frames that derive their primary stability from braced cores and cross bracing located in exterior walls.

"We've used a composite method of construction with the steelwork supporting steel decking and insitu flooring," says Steve Arthrell, Skanska Project Director. "Speed of construction was an important consideration and one of the reasons why we changed the design from the original plan that envisaged using a precast flooring system."

Hardip Bansal, Skanska Technical Services Project Engineer, continues: "Both buildings' geometry is quite complicated and steel fits well with these difficult shapes.

"Plus the site is tight and we wanted to

Steel erection underway

"Both buildings' geometry is quite complicated and steel fits well with these difficult shapes."

manufacture as much of the project off-site as possible. With steelwork, it comes to site and can be erected immediately without the need for any storage space."

Steelwork contractor William Haley Engineering started its erection programme with the smaller East Building. With a single core in the middle, the structure has two wings, both three storeys high.

"There were more groundworks to complete on the West Building as it has a basement level," explains Mr Arthrell. "Once the East Building was completed, the ground was ready for the West structure to be erected."

Creating the desired and varied classroom sizes, the East Building is based around two distinct column grid patterns (7.5m and 8.5m). Room sizes change on a regular basis depending on their future use, and this meant a slightly longer steel erection process as there were more sections to install.

Steelwork's flexibility is evident on the top floor where one workshop has been equipped with movable sliding partitions, allowing it to be subdivided into three separate rooms if required, something which would have been difficult with a concrete frame.

The larger West Building is the campus' main building, fronting the High Street. Structurally it is divided into three sectors; a central portion that is four-storeys high, containing the main entrance and featuring a triple height central atrium. Either side of this are two, slightly skewed in position, three-storey teaching wings, each containing one core.

"Because of the different angles of this structure and the varying room sizes the steelwork for this building is based around three grid patterns," says Mr Bansal.

"Consequently there are a number of transfer structures to support the frame."

The largest of these is an 11m long 1m deep beam that supports two-storeys of the building while creating a large open column free space on the ground floor.

This area will be the college's Multi Use Space, a performance room with terrace seating that will also have sliding doors allowing the space to combine – weather permitting - with an adjacent outdoor amphitheatre.

Steelwork was completed last year and the project is now racing towards its July completion date. Everything is on schedule and utilising a BIM programme during the design phase has been hugely beneficial.

"Although William Haley use Tekla design software for its steelwork model and we use Revit, they are both interchangeable and compatible and meant we were able to combine and export our models, which speeded up the process by highlighting any potential problems early on." says Mr Bansal.

The Thurrock Campus of South Essex College will be open for the coming autumn term, which is good news for Grays and its ongoing rejuvenation.

The three-storey high East Building was erected first

The West Building's four-storey sector contains the main entrance and a large atrium

Steel delivers parcel hub

One of the UK's fastest growing parcel firms is constructing a new £100M facility in the East Midlands.

FACT FILE
DPD UK parcel hub, Hinckley
Main client: DPD UK
Architect: Stephen George & Partners
Main contractor: Winvic Construction
Structural engineer: Cameron Darroch Associates
Steelwork contractor: Caunton Engineering
Steel tonnage: £2,300t

Due to ever increasing demand for its services, UK and International parcel delivery provider DPD UK is building its fourth and largest hub in the United Kingdom.

The company currently has three large main parcel sortation hubs at Smethwick and Oldbury in the West Midlands, locations that are conveniently located in the centre of the country with easy access to the M6 motorway.

The new facility at Hinckley also has good motorway access and should be fully operational by 2015. It will create up to 1,000 jobs, increasing DPD's overnight parcel sorting capacity by as much as 65%.

The structure is huge and measures 480m long × 40m wide. Internally it has a 30m wide clear span, formed by a series of tapered lattice trusses that have a maximum depth of 5m. The trusses are important, not just forming the roof, but also supporting a steel grillage that will in turn support the hub's conveyor system.

In most similar installations the conveyor would be supported off the ground floor slab by an extensive system of support frames provided by the conveyor supplier. This format significantly reduces the clear circulation routes and operating efficiency of a facility.

"To avoid this the client required us to design the building frame to support the conveyors without the need for internal supports. It is believed that the company's Hub 3 and this new Hub 4 are the only such facilities in Europe to be designed in this manner," says Neil Darroch, Cameron Darroch Associates Project Engineer.

"In effect the client has paid an initial premium for the building to maximise long term operational efficiencies. Steel was the only feasible option to allow us to meet the client's brief."

The structural steel frame of the hub is based around 72 × 6.35m wide bays, with each bay large enough to accommodate four loading doors – two on each side of the building. Stability is derived from the portal action within the trusses and bracing located in some bays.

The steel grillage hung from the trusses is not based on the standard grid pattern. These columns are mostly set off grid and were all designed with the conveyor system in mind.

"The steelwork can't interfere with the building's all important conveyors or any internal traffic movements," explains Mr Darroch. "Consequently the hanging columns are all set at various points so as not to clash with any of the sortation plant."

Aside from the main sorting area of the hub, the remainder of the structure's width is formed by a series of 10m long rafters that share a row of internal columns for support. The rafters support the roof over a two-storey office mezzanine that extends throughout the 305m long central portion of the hub, while either side of this shallower lattice girders support single-storey timber decked mezzanine floors required for the parcel in-feed areas.

The timber areas required steelwork contractor Caunton Engineering to erect a system of cold rolled C-sections, spanning between hot rolled primary beams suspended from lattice girders forming the roofs. The office mezzanine levels are constructed with a more traditional composite steel beam and steel flooring configuration.

"Because of the overall length, we divided the building into four phases for our erection programme," says Bob Aitman, Caunton's

The office mezzanine is formed with metal decking

Parcel delivery hub

The latest DPD UK hub at Hinckley forms part of a new business park being developed by Goodman. As well as the main building, the hub also consists of four other structures, all of which are formed with steelwork.

A four-storey gatehouse, with a footprint of 20m x 37m, is the largest of these structures. Constructed around a standard beam and column grid the building will accommodate three floors for security, offices, a canteen and staff welfare facilities, with the top level used for plant equipment.

The other on-site structures consist of a portal framed vehicle maintenance unit with attached offices, a garage/tyre store and salt barn building, and a vehicle jet washing facility.

Erection Manager. "Using two mobile cranes we erected two trusses and their columns, then in-filled the hanging steelwork and then installed the connecting rafters and mezzanine sections. We would then repeat this format until each phase was completed."

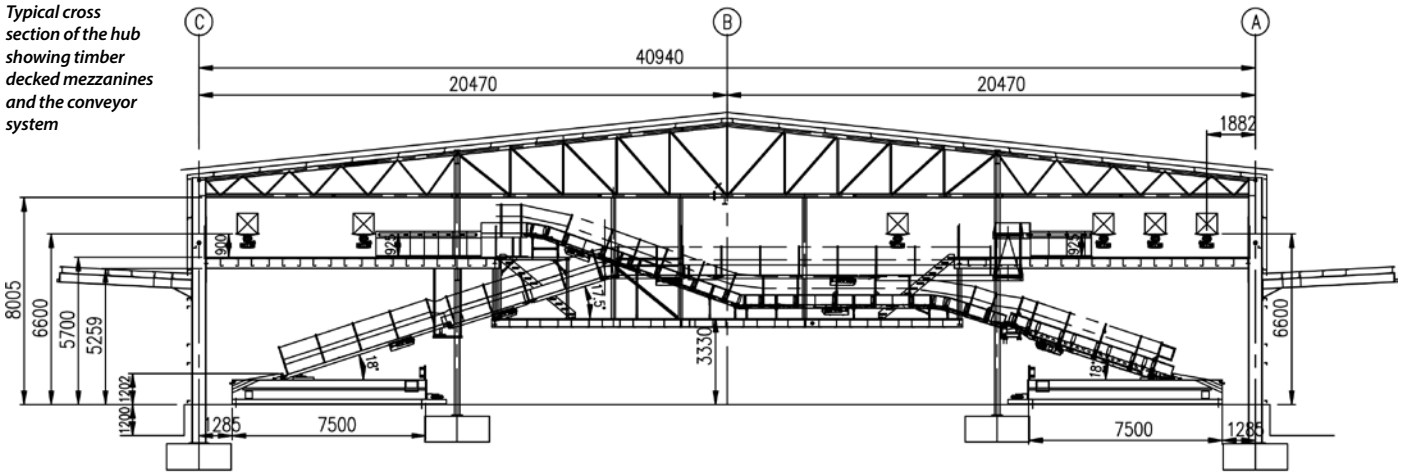
Apart from the trusses, which arrived on-site in two pieces, all of the steelwork for this project was immediately ready for erection once it was delivered.

By working its way systematically down the structure, Caunton was able to leave a completed frame ready for follow-on trades to get started as quickly as possible.

Caunton has also installed six external staircases

Steel erection under way

Typical cross section of the hub showing timber decked mezzanines and the conveyor system



Reach for the sky

Heron Tower, the City of London's tallest building has been widely praised for its emphasis on quality and sustainability. Martin Cooper revisits another high rise steel-framed success story.

Completed in March 2011 Heron Tower has quickly become one of London's landmark structures, joining an elite group of steel framed signature buildings that dominate the capital's skyline.

The 46-storey steel and glass tower is 202m tall, with a mast adding a further 28m to its overall height, making it the highest building in the City.

Sustainability lies at the heart of the structure's design, highlighted by the award of a BREEAM 'Excellent' rating. The building is working well, fulfilling high expectations, while tenants enjoy the ambient and light filled office spaces.

More than 3,000m^2 of photovoltaic cells on the south elevation generate renewable energy and create a solar shield. The use of clear glass maximises daylight to the office floors, reducing the need for artificial lighting and importantly saving on energy consumption.

A unique and flexible architectural vision has come to fruition within Heron Tower whereby the building is based around a series of three-storey office villages, at the heart of which is a triple height atrium and entrance foyer.

On entering Heron Tower one of the first impressions is of the size and grandeur of the entrance foyer and of course the large aquarium that is 12m wide and 2m deep.

With a capacity of 70,000 litres and weighing more than 100t when full, this is the largest privately owned fish tank in Europe with 1,200 fish of 67 different species ranging from Green Chromis (60mm when fully grown) to Bamboo Sharks (which grow to a maximum size of 1.2m). The tank is cared for by two full time attendants and divers are needed to clean the rocks and windows twice a week.

Central to Heron Tower's structural design are the three-storey office villages or atria that begin above the building's entrance lobby and extend up to the 36th floor. Below the lobby there are three basement levels, adding to the structure's three-floor symmetry.

More offices are located on level 37, while floors 38, 39 and 40 accommodate Sushisamba and the Duck & Waffle restaurants. The former establishment has the highest outdoor dining terrace in Europe, while the latter, situated on level 40, is officially the highest restaurant in the UK. Above this, the tower's six topmost floors accommodate plant areas.

In contrast to a typical monolithic appearance with a centre core, Heron Tower has an offset core along its southern elevation that creates a structure with clear and open floor plates.

By positioning the service core along the entire south face of the tower it also shields the offices from unwanted solar gain. In contrast, the village atria are lit by triple height windows along the Bishopsgate elevation allowing northern light to penetrate the workspaces.

Much of Heron Tower's structural frame was prefabricated by Severfield-Watson at its Yorkshire facility and brought to site in erectable sections. Stability frame sections, weighing 18t each, were delivered to site on bespoke trailers fitted out specially to carry this unique steelwork. The single storey

A City landmark steel framed building

The Sushisamba restaurant occupies levels 38 and 39 and has the UK's highest outdoor terrace

The Duck & Waffle is the UK's highest eatery

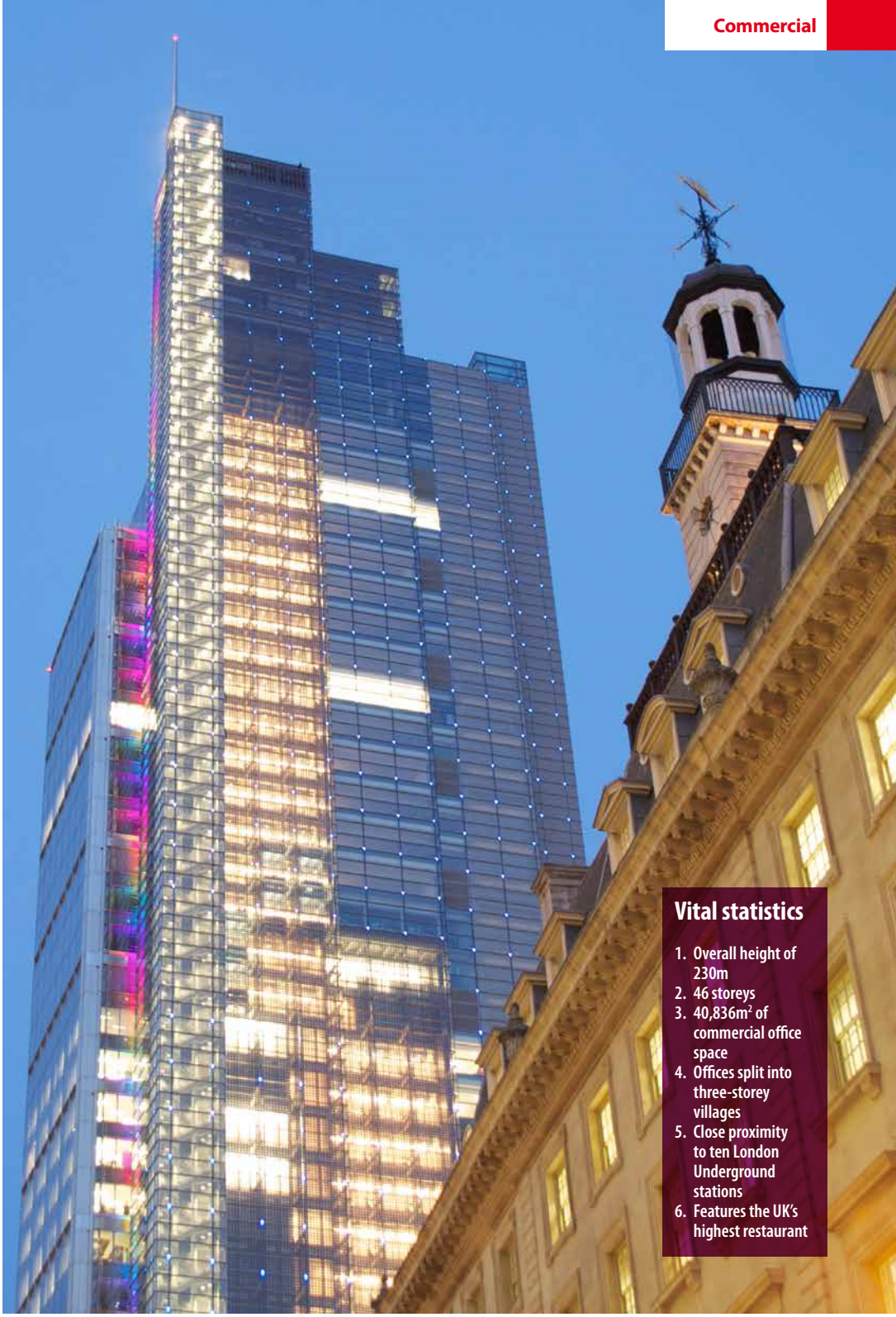
frame sections comprising of two columns and one 12m-long beam along the top, all fully welded, which form the perimeter for one and half structural bays. These sections arrived at site and were lifted straight off the trailers by tower crane and erected immediately.

"There was no site welding necessary and we reduced the amount of bolted connections, which meant a faster erection process," explains Richard Tarren, Severfield-Watson Contracts Manager.

The tower's steel framed offset core was erected with prefabricated sections. The core was formed with a number of fully welded T-shaped sections, each one floor high and weighing 16t. Again, with less on-site bolting and less steel members the core's erection was easily able to keep pace with the rest of the structure.

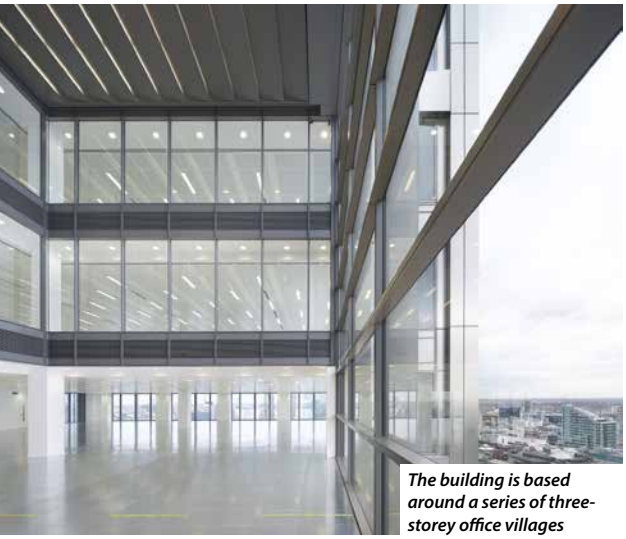
"Prefabrication played a significant role in the construction programme," sums up Skanska Project Manager Jonathan Inman. "We had a 189 week programme and the speed of the steel frame construction was vital. The decision to bring less steelwork pieces to site for erection by the utilisation of large prefabricated sections made the process quicker and significantly reduced our programme risk."

Summing up, Peter Ferrari, Managing Director of Heron International says: "From the building's exceptional location at the heart of the City, to the emphasis on quality and design, right through to the unique features such as the aquarium in the lobby and the high speed, fully glazed, double deck lift, Heron Tower is a truly special building."



Vital statistics

1. Overall height of 230m
2. 46 storeys
3. 40,836m² of commercial office space
4. Offices split into three-storey villages
5. Close proximity to ten London Underground stations
6. Features the UK's highest restaurant



The building is based around a series of three-storey office villages

FACT FILE

Heron Tower, London

Main client: Heron

Architect: Kohn Pedersen Fox

Main contractor: Skanska

Structural engineer: Arup

Steelwork contractor: Severfield-Watson Structures

Steel tonnage: 12,000t

One of the UK's largest aquariums dominates the main entrance

A lattice screen will help shield the residences from the busy A13

Retail buys into rooftop garden

A mixed use regeneration scheme in east London features a rooftop private garden that sits above a supermarket.

FACT FILE
Hallsville Quarter Phase 1, Canning Town, London
Main client: Bouygues Development
Owner: London Borough of Newham
Architect: Haworth Tomkins Associates
Main contractor: Bouygues UK
Structural engineer: MLM
Steelwork contractor: S H Structures
Steel tonnage: 1,000t
Project value: £54M

London's skyline is continually changing and if you blink you are likely to have missed a new building going up or an old one coming down.

Nowhere is this more so than in east London, where the continuing expansion of the Docklands development, the Olympic Park and a number of other schemes have culminated in regenerating large swathes of this previously forgotten part of the capital.

Forming part of the £3.7 billion Canning Town and Custom House Regeneration Programme, Hallsville Quarter as it has now been named will act as the catalyst for the transformation of the wider area, helping to form a new, thriving and prosperous district centre for this emerging area of east London.

Bouygues Development will deliver in Phase One 179 new homes (of which 108 flats are marked for sale, 20 shared equity and 51 affordable rented) arranged around a shared garden at podium level; a Morrisons food store and secure underground car parking at ground floor level. An energy centre capable of serving the requirements of the entire development will also be provided.

Overall the scheme's design has taken on a hybrid approach with structural steelwork also being used for the long span areas such as the supermarket. This frame also acts as a podium to support the garden and townhouses above.

"Steel is ideal for these areas as it is quick to erect and the supermarket required long open spans which is best done with steel," says Rory O'Sullivan, Bouygues UK Senior Engineer.

The supermarket incorporates a 2.8m high concrete formed basement, while the store's floor consists of a 250mm solid composite floor formed with a 100mm precast slab.

Founded on baseplates bolted to the slab, the steel frame for the supermarket is a 9m high double height space that consists of a series of 1.2m deep plate girders, each weighing up to 12t each. These large sections span the 16m × 16m grid to form the roof, while a series of 1m deep secondary beams give the structure added support.

"We've had to use such large steel sections as the supermarket roof will support 1m depth of soil and semi-mature trees up to 6m tall," explains Mr O'Sullivan. "Consequently the steel frame has been designed to absorb loadings of up to 3t per m^2."

Adjacent to the supermarket the steel

Base plates were installed with the main frame in readiness for the screen

The project forms part of a much larger regeneration scheme for east London

frame also includes a service yard and warehouse. These areas are based around 8m and 10m wide grids respectively and are formed with a series of 1m deep beams.

"This part of the steel frame will support the townhouses which are built with a lightweight steel framing material," says Philip Bell, MLM Project Engineer. "The beams didn't need to be as large as the supermarket roof due to the shorter spans."

Three seven-storey blocks and a row of 14 four-storey townhouses that sit in a horseshoe shape arrangement around the central green space form the residences.

Shielding the townhouses and providing a feature element along the A13 facing elevation is one of the project's main and most visible steel elements. Architect Haworth Tomkins Associates has designed an 110m long steel screen that S H Structures is fabricating from 168mm diameter circular hollow sections.

Arranged into a lattice truss the screen bolts to the project's podium steel frame at first floor level and is due to be erected in September.

A series of square eight bolt base plates has been installed to which the screen will be connected. These connections are designed to resist a large overturning force at the base of the screen, while further up there will be a second pin connection point.

In cross section, the screen is hockey stick shaped with the long handle making the 7m height and the short leg creating an overhang at the top. A stainless steel mesh curtain will be suspended from the inside overhang to provide support for climbing plants.

After fabrication the screen will be trial-assembled in SH Structures' factory in Sherburn-in-Elmet, North Yorkshire, and brought to site in sections.

"Using a series of jigs we'll build it in full height panels in our factory and then split it horizontally for delivery because a complete panel will be too wide for road transport," says Tim Burton S H Structures Sales and Marketing Manager.

Locating brackets pre-welded onto the truss will ensure the two halves of each panel align exactly before being welded on-site.

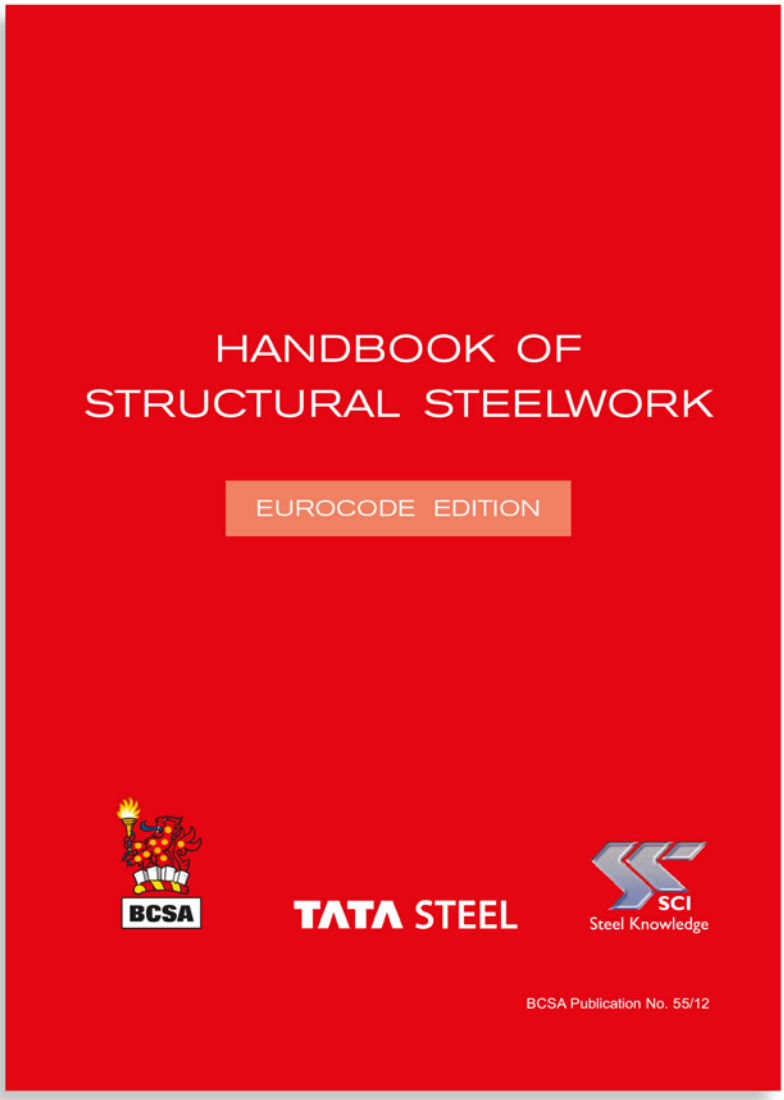
> *"We've had to use such large steel sections as the supermarket roof will support 1m depth of soil and semi mature trees of up to 6m tall"*

Bouygues UK will complete phase one in early 2015, by which time the adjacent phase two (mostly residential) will have started. Once all five phases are completed in 2024 the development will be at the heart of the wider Canning Town and Custom House Regeneration Project, a £3.7bn scheme which aims to transform a large part of the London Borough of Newham.

The ground floor supermarket forms the podium for the garden and residences

Red book for steel industry

A Eurocode edition of the Handbook of Structural Steelwork is now available.



Published jointly by the British Constructional Steelwork Association (BCSA), Tata Steel and the Steel Construction Institute (SCI), a Eurocode edition of the *Handbook of Structural Steelwork*, commonly referred to as the Red Book, has been published.

"The book introduces Eurocodes via simplified procedures which since 2010 has been an established method for structural steel design," said David Moore, BCSA Director of Engineering.

The publication is split into three principal sections - general guidance, general design data and design tables.

The guidance and design tables are all in accordance with BS EN 1993-1-1:2005 Eurocode 3: *Design of steel structures - Part 1.1: General rules and rules for buildings*, its UK National Annex and other relevant Eurocodes.

General guidance includes a chapter on limit state design, actions (loads) and an introduction to Eurocode 3. Further chapters in this section inform the reader about resistance of cross-section, buckling resistance of beams, members in tension, members in compression and trusses.

The section on general design data includes bending moment diagrams, shear force diagrams and expressions for deflection calculation.

A variety of beams and cantilevers with different loading and support conditions are covered. Expressions for properties of geometrical figures are also given, together with useful mathematical solutions.

The design tables include section property, member resistance and ultimate load tables calculated according to BS EN 1993-1-1:2005 and its associated National Annex for all common structural steelwork profiles used in the UK.

Following the same format as previous publications, readers will find the layout and design familiar. "Worked examples are also similar allowing readers to compare between the previous National Standards and the latest Eurocode examples," said Dr Moore.

Copies of the Eurocode edition of the *Handbook of Structural Steelwork* are available from the BCSA at £40 per copy to non members and £30 per copy to members.

Related Publications

Joints in Steel Construction - Moment-Resisting joints to Eurocode 3

Joints in Steel Construction - Simple Joints to Eurocode 3

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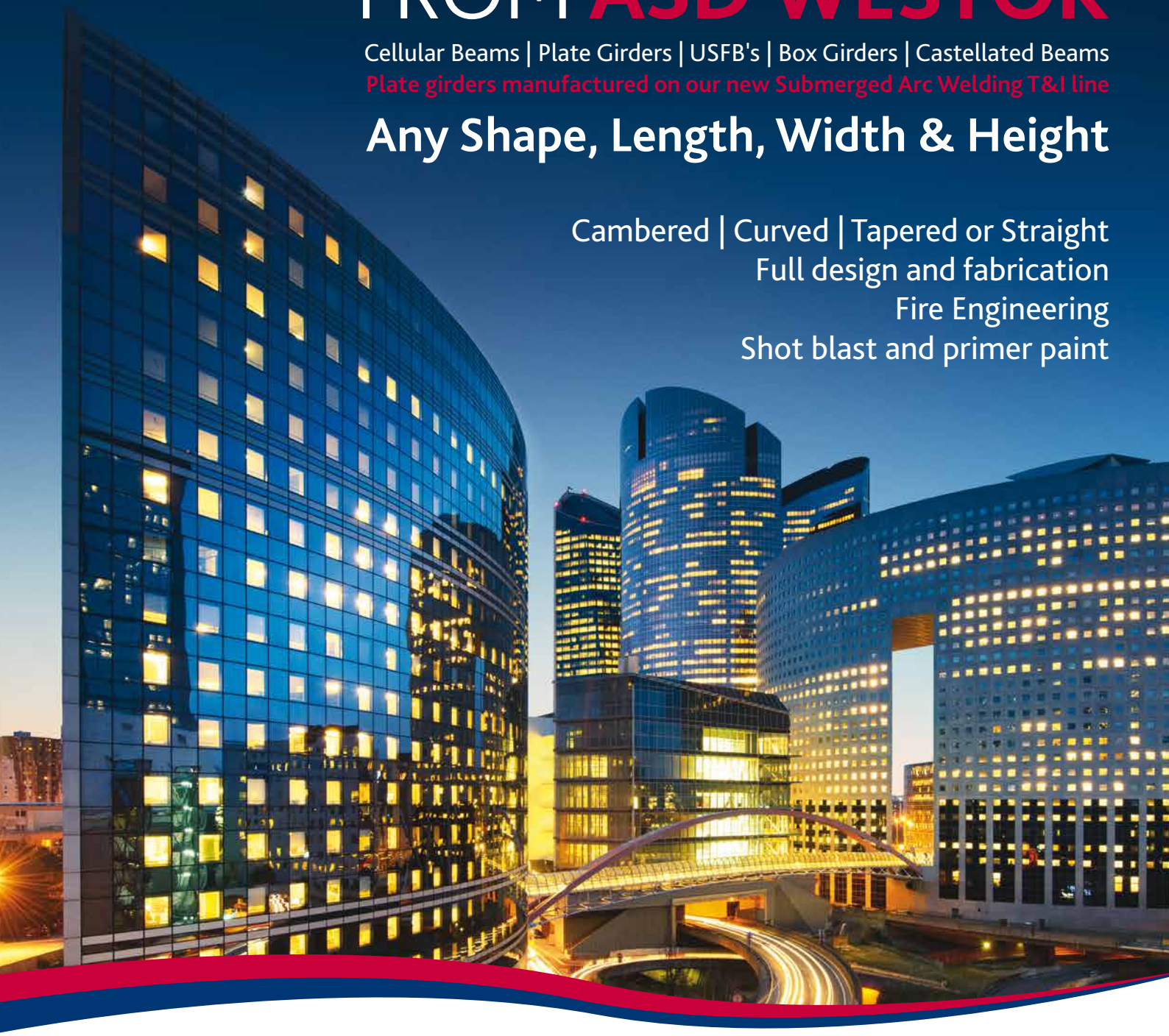

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Design of lapped gusset plate connections

Rules governing the design of single lapped gusset plate connections have not been updated for a number of years. Phil Francis, Senior Engineer at the Steel Construction Institute, describes a large Finite Element study that was undertaken to investigate the behaviour of these connections.

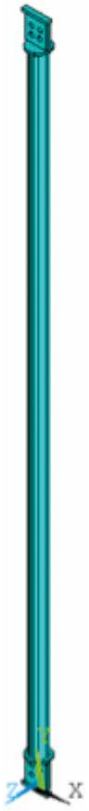

Figure 1: FE model of a typical system, showing that the model includes the member and a connection at either end

Introduction

Lapped gusset plate connections are a typical connection detail used in both single storey and multi-storey construction, mostly for connection of bracing members to the main frame.

Having considered guidance from a number of other countries [1, 2, 3, 4], the SCI has undertaken a review of existing design rules, using Finite Element (*FE*) analysis.

Finite element analysis

Examination of the potential modes of failure indicated that a model that included the full length of the bracing member with a connection at either end was necessary, as allowance could then be made for global movement of the member. Non-linear geometry options were activated, allowing for P-δ effects. Figure 1 shows this arrangement for a typical system. CHS were selected as typical bracing members.

All models were created using a combination of SOLID185 elements for connection components and SHELL181 elements for the CHS section. The use of shell elements for the CHS dramatically reduced the computation time, with no discernible loss of accuracy. The two elements were joined together using multi-point constraints. Figure 2 shows a typical arrangement of a connection; SOLID185 elements are shown in green, while SHELL181 elements are shown in purple. The bolts were modelled using a relatively simple continuous material approach, since this dramatically reduced the computation time. Comparisons with the physical tests described below show this is acceptable, since the resistance of the connection is mostly determined by the behaviour of the plates.

Figure 2: Connection arrangements in the FE model

Further allowance was made for bow imperfection of the member and non-linear material properties.

Comparisons with physical tests

A literature search identified a paper by Khoo *et al* [5] as an appropriate source of data. The paper describes testing on 12 full scale specimens.

Two parameters were investigated in Khoo *et al*; the length of the connection and the length of the member. All other parameters, including plate thickness, bolt size, bolt spacing and gusset plate width were kept constant.

Table 1 shows a comparison between the resistances obtained by testing and the resistances obtained from the SCI *FE* model.

Case	Connection Length (mm)	Member length (m)	Measured Resistance (kN)	SCI *FE* Model Resistance (kN)	Measured Resistance / *FE* Resistance (%)
A1	170	3	158.5	161.0	98.4%
A2	170	3	186.1	161.0	115.6%
A3	170	3	159.9	161.0	99.3%
B1	170	4	175.1	164.5	106.4%
B2	220	4	155.4	136.0	114.3%
B3	270	4	131.4	111.0	118.4%
C1	170	5	165.3	158.5	104.3%
C2	220	5	153.3	136.0	112.7%
C3	270	5	115.5	112.5	102.7%
D1*	170	6.5	141.0	137.5	102.5%
D2*	170	6.5	131.0	137.5	95.3%
D3*	170	6.5	140.0	137.5	101.8%
* Member failure				Average	105.0%

The comparisons show that the model is an accurate predictor of the connection resistance. The model captured both the connection resistance and the failure modes seen in testing. The majority of the predictions are on the safe side.

Figure 3 shows a comparison between photographic evidence from the tests and an equivalent image from the *FE* model.

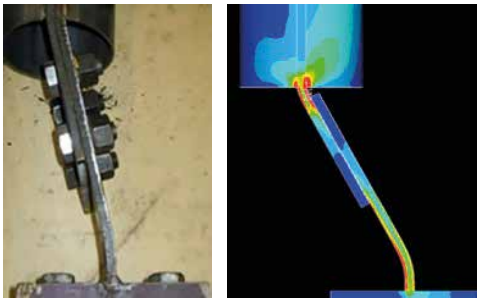

Figure 3: Predicted deformation of the connection compared to photographic evidence from tests for case B-3

▸ 30

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Figure 3 shows that the behaviour of the connection is accurately represented. A 'sway' mechanism has formed, with the eccentricity of the plates giving rise to a moment at either end of the connection. This behaviour is not prevented by the member, since it is free to translate globally.

Further parametric study

Once it was clear the *FE* model was a good predictor of the true resistance of the connection its use was extended for a full parametric study.

240 connection designs were investigated as part of the parametric study. Such a large number of cases was required to ensure that the study represented a comprehensive range of designs that are used in industry. Parameters that were varied in the study included:

- Connection length
- Connection width
- Member length / Imperfection
- Member angle
- Bolt arrangement

Gusset plate supported on one edge

Gusset plates supported on a single edge perform similarly to those tested by Khoo *et al*, with formation of a sway mechanism as a result of the formation of two plastic hinges always governing resistance.

Figure 4 shows images obtained for a compact angled design.

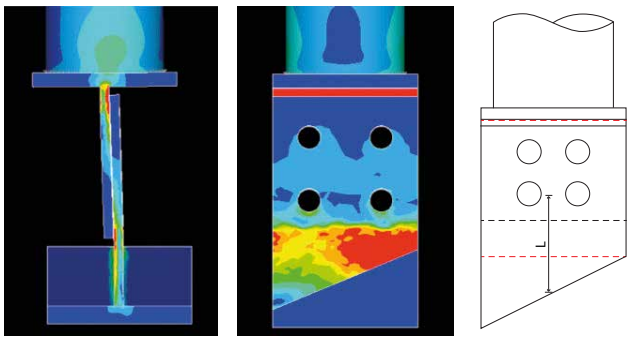

Figure 4: Formation of a yield line for an angled gusset plate supported on a single edge

The images show the two characteristic hinges; one at the top of the tab plate, and one in line with the 'point of nearest support'.

Gusset plate supported on two edges

The characteristic two-hinge mechanism still forms, even when the gusset plate is supported on two edges. However, further effort is required to understand the formation of the hinge in the gusset plate, since the support conditions to this design necessitate a more involved yield line analysis.

The yield line pattern can be characterised according to one of three possible scenarios.

Scenario 1

The 'point of nearest support' on both sides of the plate is 'in front of' the line of the last bolts (i.e. towards the member). Angled yield lines form between the bolts and the points of nearest support. This is shown in Figure 5.

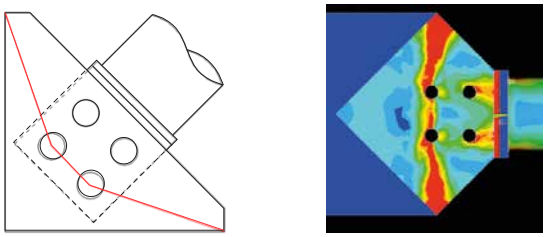

Figure 5: Scenario 1

Scenario 2

The 'point of nearest support' on one side of the plate is 'in front of' the line of the last bolts and one is behind. An angled yield line forms between the bolt and the points of nearest support. The yield line on the other side forms parallel with the line of the last bolt row. This is shown in Figure 6.

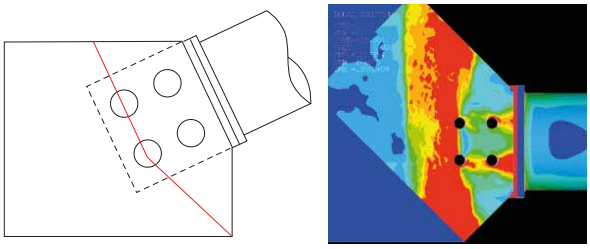

Figure 6: Scenario 2

Scenario 3

In Scenario 3 both of the 'points of nearest support' are behind the line. The line therefore forms parallel with whichever point of support is nearest. This is shown in Figure 7.

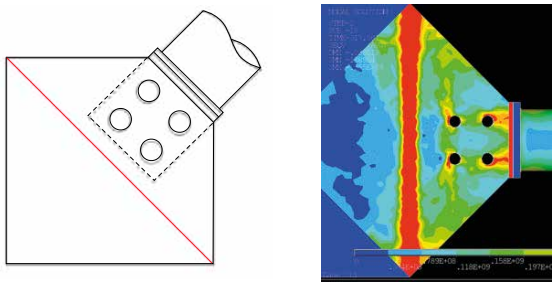

Figure 7: Scenario 3

An analytical model has been developed for establishing the yield line pattern, using trigonometry. The length of the yield line may be established by calculation, or measured using a CAD software package.

New rules

Existing design rules based on buckling curves correlate poorly with the resistance obtained from the *FE* modelling. New rules have therefore been developed that account for the behaviour observed during the modelling. These rules have been verified against each of the 240 test cases.

This behaviour of the gusset plates seen in the *FE* study can be reproduced analytically by considering an equivalent 'frame'. This is shown in Figure 8.

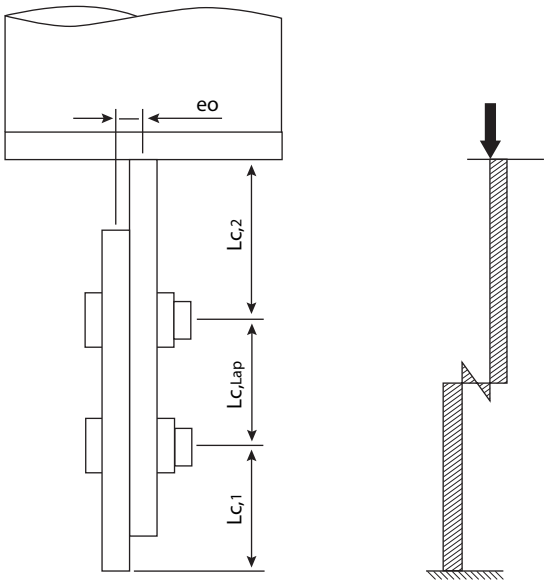

Figure 8: Equivalent 'frame' for analysis using the new method, and the bending moment diagram arising

As a result of the force applied, moments arise in the gusset and tab plates. The relative magnitude of these moments depend on the stiffness of each plate.

Once the bending moment distribution has been established, a combined axial force and moment interaction check in both the gusset plate and the tab plate can be carried out. The connection resistance is taken as the lowest value from each. The two equations are shown below.

$$N_{Rd,tab} = \frac{w_{tab} f_{y,tab} t_{tab}^2}{\left[5 \times k_{amp} \times 0.5 \left(t_{guss} + t_{tab}\right) \mu_{tab} + t_{tab}\right]}$$

$$N_{Rd,guss} = \frac{w_{guss} f_{y,guss} t_{guss}^2}{\left[5 \times k_{amp} \times 0.5 \left(t_{guss} + t_{tab}\right) \mu_{guss} + t_{guss}\right]}$$

Where:

t_{guss} and t_{tab} are the thicknesses of the gusset and tab plates respectively.

w_{guss} and w_{tab} are the lengths of the yield lines in each of the plates. For gusset plates supported on one edge these widths are easily calculated, but a more complex analysis is required for gusset plates supported on two edges. A limiting width of 20t is needed, except for gusset plates supported on two edges, where w_{guss} can be up to 50t. Designers will find these widths exceed the traditional 'Whitmore' width for the majority of conventional designs.

k_{amp} is an amplification factor that accounts for the second-order increase in eccentricity as a result of bending of the plates. In nearly all cases a 20% increase on the initial eccentricity can be safely assumed.

μ_{tab} and μ_{guss} are moment distribution factors. These reflect the allocation of moment to the gusset and the tab plate, based on their relative stiffnesses.

The factor 5 is a stress distribution factor, which allows stresses arising to the applied moment to be more than elastic (a stress factor of 6), but not plastic (a stress factor of 4). Fully plastic hinges cannot be realised, since to do so would imply unlimited rotation, leading to unlimited second-order eccentricity.

Comparisons between new design model, test results and *FE* results

Figure 9 shows the comparison between the test results from Khoo *et al* and the new design model:

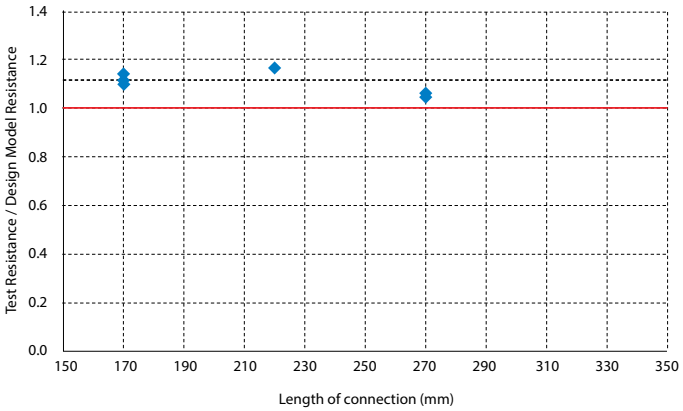

Figure 9: Comparison between resistance obtained by test results and the resistance predicted by the new design model

It can be seen that model is accurate for all of the connections in the study. All resistances calculated using the model are within 10-20% of the resistance from the tests.

Figure 10 (over page) shows the comparison between the *FE* results and the new design model.

It can be seen that the new design model predicts conservative ▸ 34

AD 380
What height of shear stud should be used in Eurocode 4?

The answer to this question is not as obvious as it may sound. BS EN1994 1 1[1] is not itself consistent, because in the list of notation it defines h_{sc} as the 'overall nominal height' of a stud connector, but elsewhere the same variable is defined as simply 'the overall height'. Moreover, a stud that is for example 105 mm long when manufactured would typically have "length after welding" (LAW) of 100 mm when welded directly to a beam flange, or 95 mm when welded through decking. It would generally be described as a nominal 100 mm stud.

This advisory desk note provides guidance on the height/length to be used in design calculations, noting that this is interim advice and may change after a program of tests/analysis has been completed.

BS EN1994 1 1, clause 6.6.5.8(1) which deals with detailing clearly states that the 'nominal height' of a connector should extend not less than 2*d* (where *d* is the stud diameter) above the top of the decking. Only one variable is used to define decking height, and it may be assumed to be the height to the top of the shoulder in this case, i.e. excluding any small stiffening ribs in the crest of the decking. A nominal 100 mm stud, of 19 mm diameter, may therefore be used with 60 mm decking (this is a combination that has been shown through many push tests and frequent practice to 'work'). Note that if LAW of 95 mm was to be applied, this detailing check would fail. The code correctly clarifies that the "nominal length" should be used because a pass/fail detailing check should not rely on dimensions that may vary slightly on-site.

Stud resistance values are also a function of h_{sc}, in terms of the solid slab resistance P_{Rd} (clause 6.6.3.1(1)) and the reduction factors k_l (clause 6.6.4.1(2)) and k_t (clause 6.6.4.2(1)) used to allow for the presence of decking. SCI's current advice is that LAW should be used, because although the code itself is not clear, in the ICE Designers' Guide to Eurocode 4[2], Prof. Roger Johnson uses the LAW in his examples. This is authoritative guidance.

However, the correct answer as to whether "nominal" or LAW should be used in the various formulae affecting stud resistance depends on what was used by the researchers/code writers when deriving the various empirical formulae. If a designer uses the same value he is simply reversing the analysis that was used to derive the equation so should get the right answer. SCI is currently carrying out testing and analysis that should lead to revised resistances, and for ease of use by designers we will consider using the "nominal height" for all checks.

One final point for designers to be aware of is that studs come in standard lengths (of which 100 and 125 mm are the most common). A designer may consider increasing the length of a stud to (potentially) increase resistance, but only standard lengths should be specified.

Contact: **Dr Graham Couchman**
Tel: **01344 636525**
Email: **advisory@steel-sci.com**

1. BS EN 1994-1-1:2004 (Incorporating corrigendum April 2009)
Eurocode 4: Design of composite steel and concrete structures
Part 1-1: General rules and rules for buildings
2. Designers Guide to Eurocode 4: Design of Composite Steel and Concrete Structures, EN 1994-1-1, Second edition, Roger P Johnson, Published, 2012

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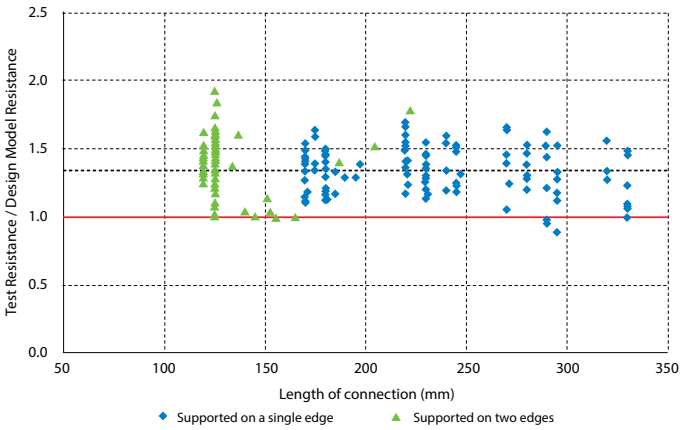


Figure 10: Comparison between resistance obtained by FE analysis and the resistance predicted by the new design model

resistances for nearly all of the connection designs included in the study.

Typical connections are conservative by a factor of 20-30%. A number of cases are considerably more conservative, but these tend to be 'edge cases', such as extremely wide connections with thin plates, where the widths of the yield lines are limited.

Conclusion

A large study has been undertaken to investigate the behaviour of lapped gusset plate connections, using Finite Element analysis. The modelling has shown that the eccentricity of the two plates does generate a moment that must be accounted for in design.

New rules have been developed that allow design of a wide range of different connection designs. These rules are described in the revised BCSA/SCI Green Book [6], to be published imminently.

1 Design of structural steel hollow section connections;
Volume 1: Design Models
Australian Institute of Steel Construction, 1996

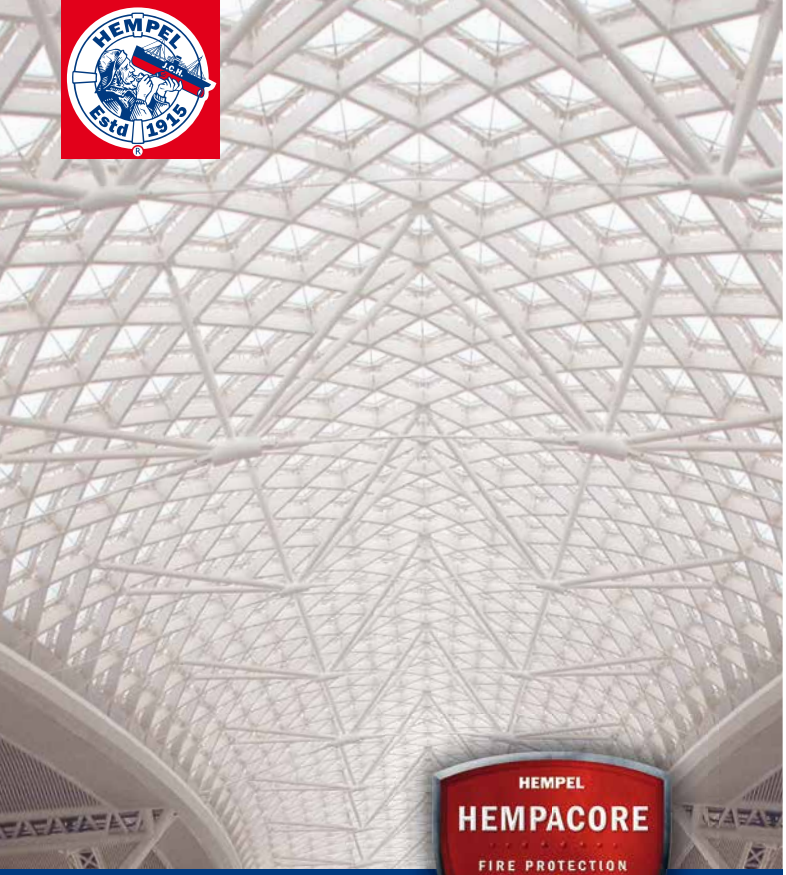
2 Hollow structural sections connections manual
American Institute of Steel Construction, 2010

3 CISC Technical Memorandum No 5 Ultimate compressive capacity of a L brace connection detail
CISC, 2002

4 Eccentric cleats in compression and columns in moment-resisting connections.
Heavy Engineering Research Association Report R4-142:2009
HERA, 2009

5 Khoo, X. E, Perera, M, Albermani, F.
Design of eccentrically connected cleat plates in connections
International Journal of Advanced Steel Construction, Volume 6, Issue 2
The Hong Kong Institute of Steel Construction, 2010

6 Joints in steel construction: Simple joints to Eurocode 3 (P358)
SCI and BCSA, 2014



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New and revised codes & standards

From BSI Updates February 2014

BRITISH STANDARDS WITHDRAWN

BS EN 1403:1998
Corrosion protection of metals. Electrodeposited coatings. Method of specifying general requirements
Superseded by BS EN ISO 27830:2013

BRITISH STANDARDS UNDER REVIEW

BS EN 1011-8:2004
Welding. Recommendations for welding of metallic materials. Welding of cast irons

BS EN 10349:2009
Steel castings. Austenitic manganese steel castings

NEW WORK STARTED

EN ISO 1421
Determination of tensile strength and elongation at break
Will supersede BS EN ISO 1421:1998

EN 1993-1-4:2006/A1
Eurocode 3. Design of steel structures. General rules. Supplementary rules for stainless steels

EN 1993-1-6:2007/A1
Eurocode 3. Design of steel structures. Strength and stability of shell structures

EN 1993-4-1:2007/A1
Eurocode 3. Design of steel structures. Silos

EN 1994-4-2:2007/A1
Eurocode 3. Design of steel structures. Tanks

ISO PUBLICATIONS

ISO 4355:2013
Bases for design of structures. Determination of snow loads on roofs
Will not be implemented as a British Standard

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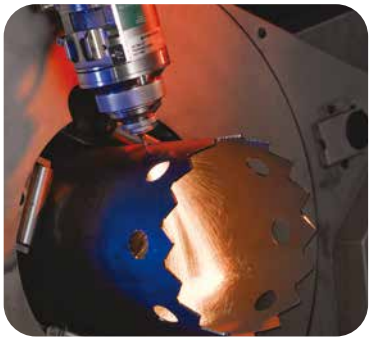

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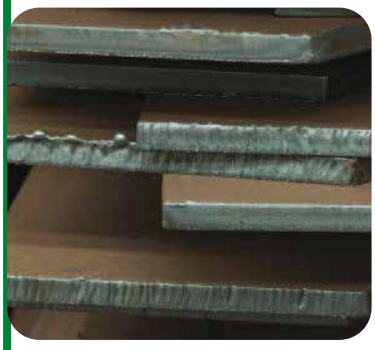
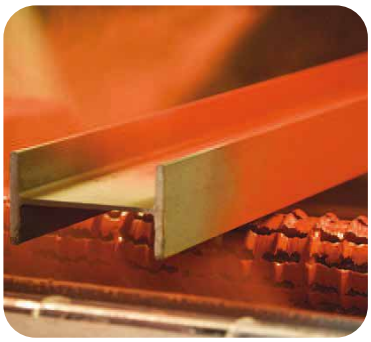


Plate stocks up to 200mm Various grades



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Steel for New Guinness Nigerian Brewery

FROM BUILDING WITH STEEL NOVEMBER 1963

The largest brewery that has ever been built abroad by a British firm is the new Ikeja brewery of Guinness (Nigeria) Ltd. This is the third Guinness brewery to be built during the 200 year history of the company, the others being in Dublin and London. The Dublin Brewery is in fact the largest single exporter of beer, ale and stout in the world with an overseas sale of over 2 million half-pint glasses per day. Exports have risen from well over £1 million in 1951 to nearly £5 million today and Guinness is sold in 125 different countries.

Located on a 14-acre site, some 12 miles from Lagos, the Nigerian brewery was built at a cost of well over £2 million and is designed to produce 150,000 barrels or 75 million bottle of Foreign Extra Stout per year.

Most of the brewery and bottling buildings are of simple rolled-steel section and tubular-frame construction roofed with corrugated aluminium sheeting. The bottling hall is a triple-span structure, two spans of 50 ft. and a third of 66 ft. 8 in., with an overall length of 333 ft., and a height of 20 ft. 6 in. It is designed to allow future extensions and will cover a floor area of 55,550 sq. ft.

The brewery building is a double-span structure, with spans of 66 ft. 8 in. and an overall length of 500 ft. One span, the services building, rises to a height of 32 ft; this span incorporates the tower. The fermenting section and brewing tower is a purpose built unit to accommodate the particular Guinness brewing vessels. The brewery building has a total floor area of 62,000 sq. ft. Steel roofs covering some 5,000 sq. ft. are also used for the locker rooms and canteen.

Materials and equipment used included 5,000 cu. yds. of concrete, 200 tons of mild steel reinforcement, 880 tons of structural steelwork, 19,000 sq. yds. of flooring and 1,000 tons of mechanical plant and tanks.

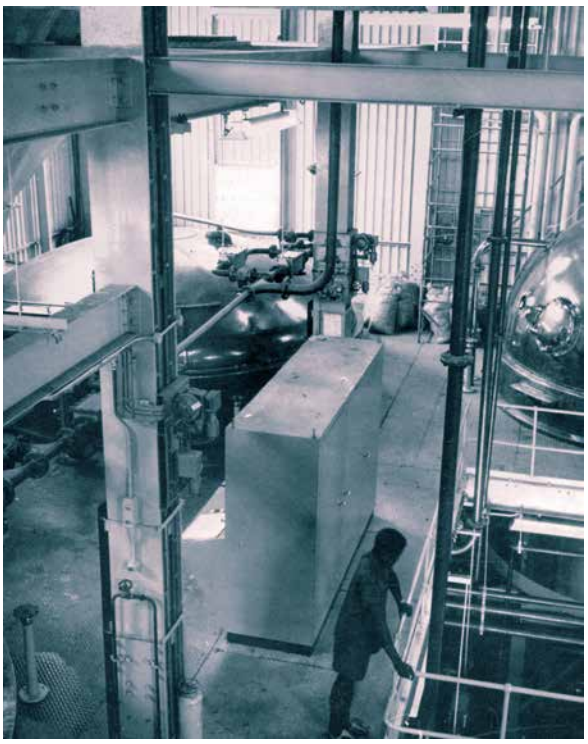
All the brewing and fermentation vessels necessary to produce Guinness, such as mash tuns, coppers and skimming and liquor vessels, were manufactured at Burton-on-Trent and Tournai in Belgium. The plant also incorporates the most up-to-date automatic equipment.

The bottling plant includes two bottling lines, which together handle up to 30,000 bottles per hour. The installation of these lines is the largest of its kind in West Africa.

Six ammonia refrigerating units have been installed, each rated at 1 million B.t.u.'s per hour when producing chilled alcohol water at 40°F. Provision has been made to increase the capacity to meet expansion of the brewery.

The main supply of electricity enters the brewery at 11,000 volts where it is transformed through the brewery's own three 1,000 kva transformers to a 440 volt 3-phase distribution system. During the initial stages of operation the electrical maximum demand will be about 1,200 kva. To ensure uninterrupted supply to the essential processes, when the main supply fails, a 300 kva auxiliary generator has been installed and coupled to a 'maintained services' panel.

The water consumption is approximately 250,000 gallons per day which will be supplied by the local authority, and to have uninterrupted supply of this external resource a large reservoir has been constructed to hold one day's requirements. In addition a borehole pumping installation has been installed, the borehole having a yield of 10,000 gallons per hour.

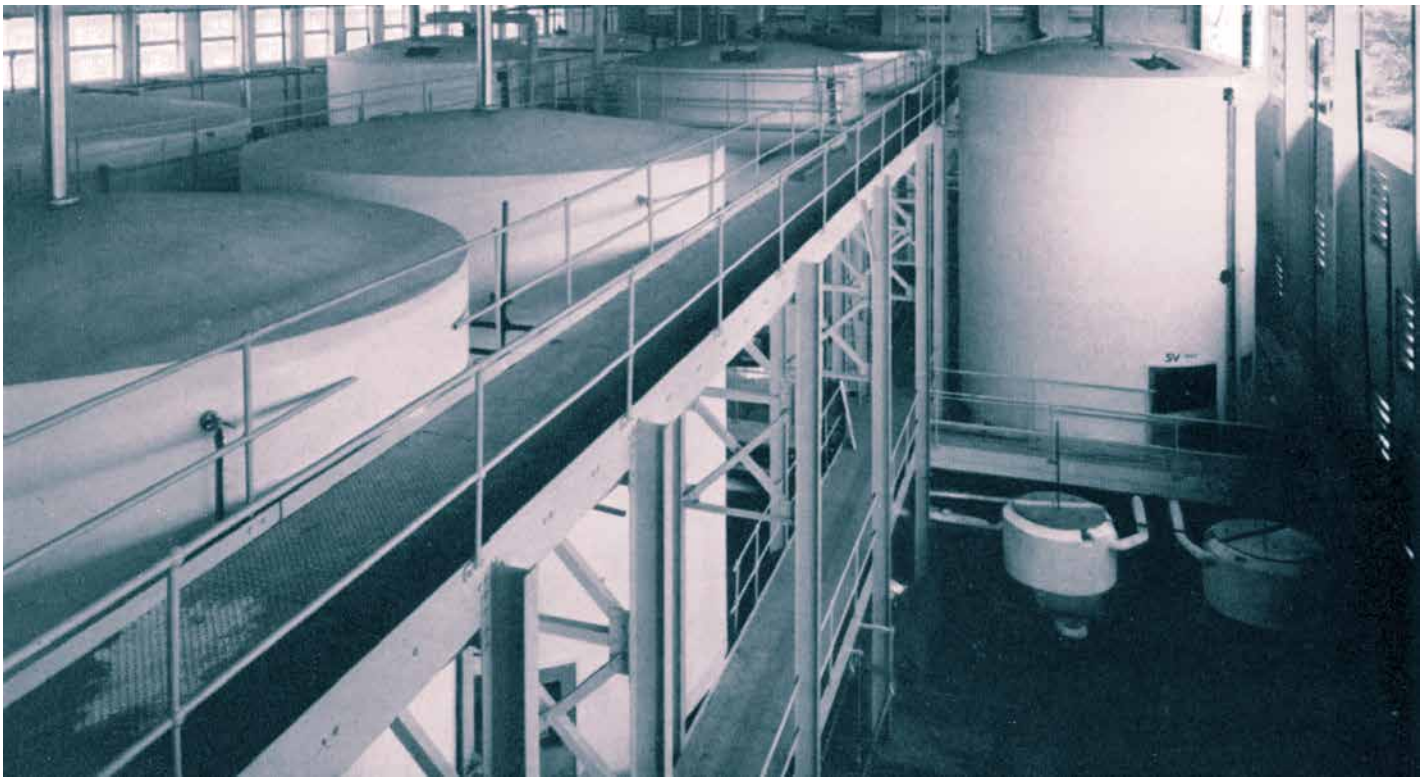


Above Left: General view of the new Guinness Brewery at Ikeja, Nigeria, 14 miles from Lagos. Most buildings are of simple rolled steel and tubular framed construction except for a purpose-built brewing tower.

Above: General view of the mash tun stage. Steelwork is extensively used to support the special brewing equipment.

Left: Light steel roof trusses support the brewery's corrugated aluminium roofing; the plant incorporates the most modern brewery controls.

Below: Racking and storage vessels. The brewery is designed for the production of 15,000 barrels of stout per year.



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				●	●	●	●		●	●			●	●	✔		●	Up to £2,000,000
Adstone Construction Ltd	01905 794561			●	●	●	●									✔	2	●	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
AKD Contracts Ltd	01322 312203				●					●	●			●	●		2		Up to £100,000
Angle Ring Company Ltd	0121 557 7241												●			✔	4		Up to £1,400,000
Apex Steel Structures Ltd	01268 660828			●	●	●	●			●	●			●					Up to £1,400,000
Arminhall Engineering Ltd	01799 524510	●			●					●	●			●	●	✔			Up to £400,000
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				●	●				●	●			●	●	✔		●	Up to £800,000
Atlas Ward Structures Ltd	01944 710421		●	●	●	●	●	●	●	●	●	●		●	●	✔	4	●	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			●	●	●	●	●				●				✔	4		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	●	Above £6,000,000
Border Steelwork Structures Ltd	01228 548744			●	●	●	●			●	●				●				Up to £3,000,000
Bourne Construction Engineering Ltd	01202 746666		●	●	●	●	●	●	●	●	●	●	●	●	●	✔	4	●	Above £6,000,000
Briton Fabricators Ltd	0115 963 2901	●		●	●	●	●	●	●	●	●			●	●	✔	4		Up to £3,000,000
Builders Beams Ltd	01227 863770				●					●				●	●	✔	2		Up to £400,000
Cairnhill Structures Ltd	01236 449393	●			●	●	●	●	●	●				●	●	✔	4	●	Up to £3,000,000
Caunton Engineering Ltd	01773 531111	●	●	●	●	●	●	●		●	●	●		●	●	✔	4	●	Up to £6,000,000
Cleveland Bridge UK Ltd	01325 381188	●	●	●	●	●	●	●	●	●	●	●		●		✔	4	●	Above £6,000,000*
CMF Ltd	020 8844 0940				●		●	●		●	●				●	✔			Up to £6,000,000
Cook Fabrications Ltd	01303 890040				●					●	●			●	●				Up to £800,000
Coventry Construction Ltd	024 7646 4484			●	●	●	●	●	●	●	●			●	●				Up to £800,000
D H Structures Ltd	01785 246269			●	●		●				●			●					Up to £100,000
Discain Project Services Ltd	01604 787276				●					●	●				●	✔			Up to £1,400,000
Duggan Steel Ltd	00 353 29 70072		●	●	●	●	●	●			●					✔	4		Up to £4,000,000
ECS Engineering Services Ltd	01773 860001	●		●	●	●	●	●	●	●	●			●	●	✔	3		Up to £2,000,000
Elland Steel Structures Ltd	01422 380262		●	●	●	●	●	●	●	●	●	●		●		✔	4	●	Up to £6,000,000
EvadX Ltd	01745 336413			●	●	●	●	●	●	●	●	●				✔		●	Up to £3,000,000
Fisher Engineering Ltd	028 6638 8521		●	●	●	●	●	●	●	●	●	●				✔	4	●	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
Grays Engineering (Contracts) Ltd	01375 372411	●			●					●	●			●	●				Up to £100,000
Gregg & Patterson (Engineers) Ltd	028 9061 8131			●	●	●	●	●				●		●		✔			Up to £2,000,000
H Young Structures Ltd	01953 601881			●	●	●	●	●			●			●	●	✔	2	●	Up to £2,000,000
Had Fab Ltd	01875 611711				●				●	●	●				●	✔			Up to £2,000,000
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)
Hambleton Steel Ltd	01748 810598		●	●	●	●	●	●				●		●		✔	4		Up to £1,400,000
Harry Marsh (Engineers) Ltd	0191 510 9797			●	●	●	●				●	●			●	✔	2		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 £2,000,000
Hills of Shoeburyness Ltd	01702 296321									●				●	●				Up to £800,000
Intersteels Ltd	01322 337766				●	●	●	●					●			✔			Up to £2,000,000
J & A Plant Ltd	01942 713511				●	●									●				Up to £200,000
James Killelea & Co Ltd	01706 229411		●	●	●	●	●					●		●			4		Up to £6,000,000*
John Reid & Sons (Strucsteel) Ltd	01202 483333		●	●	●	●	●	●	●	●	●	●		●	●	✔	4		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 £4,000,000
Legge Steel (Fabrications) Ltd	01592 205320			●	●		●		●	●	●			●	●				Up to £400,000
Luxtrade Ltd	01902 353182									●	●				●	✔	2		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
Murphy International Ltd	00 353 45 431384	●			●		●								●	✔			Up to £1,400,000
Newbridge Engineering Ltd	01429 866722			●	●	●	●								●	✔			Up to £1,400,000
Nusteel Structures Ltd	01303 268112						●	●	●	●						✔	4		Up to £4,000,000
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
R S Engineering SW Ltd	01579 383131				●					●	●			●	●				Up to £100,000
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 Structures Ltd	01400 251480			●	●	●	●		●	●	●			●	●				Up to £1,400,000
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		●	●	●	●	●	●	●		●	●		●	●	✔	2		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 £2,000,000
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	●			●		●	●	●	●	●				●	✔	4		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)

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Company name	Tel
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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 - Scunthorpe	01724 810810								●		D/I	
ASD metal services	0113 254 0711								●		D/I	
Ayrshire Metal Products (Daventry) Ltd	01327 300990	●									M	
BAPP Group Ltd	01226 383824									●	M	
Barrett Steel Ltd	01274 682281								●		D/I	

Company name	Tel	1	2	3	4	5	6	7	8	9	CE	SCM
Behringer Ltd	01296 668259					●						
BW Industries Ltd	01262 400088	●									M	
Cellbeam Ltd	01937 840600	●									M	
Cellshield Ltd	01937 840600							●			N/A	
Cleveland Steel & Tubes Ltd	01845 577789								●		M	
CMC (UK) Ltd	029 2089 5260								●		D/I	
Composite Profiles UK Ltd	01202 659237	●									D/I	
Cooper & Turner Ltd	0114 256 0057									●	M	

Steelwork contractors for bridgeworks

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

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

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			●	Up to £3,000,000
Cleveland Bridge UK Ltd	01325 381188	●	●	●	●	●	●	●	●	✓	4	✓	✓	●	Above £6,000,000*
Four-Tees Engineers Ltd	01489 885899	●	●	●	●		●	●	●	✓	3		✓	●	Up to £2,000,000
Kiernan Structural Steel Ltd	00 353 43 334 1445	●	●	●	●			●	●	✓				●	Up to £2,000,000
Mabey Bridge Ltd	01291 623801	●	●	●	●	●	●	●	●	✓	4	✓	✓	●	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	●		●					●	✓				●	Up to £6,000,000
Remnant Plant Ltd	01594 841160	●	●	●					●	✓					Up to £400,000
S H Structures Ltd	01977 681931	●		●	●	●	●		●	✓	4		✓	●	Up to £3,000,000
Severfield-Watson Structures Ltd	01204 699999	●	●	●	●	●	●	●	●	✓	4		✓	●	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	●	●	●	●	●	●		●	✓				●	Up to £800,000
Donyal Engineering Ltd	01207 270909	●						●	●	✓			✓	●	Up to £1,400,000
Francis & Lewis International Ltd	01452 722200							●	●	✓	2		✓	●	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			●	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
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	
Kaltenbach Ltd	01234 213201					●					N/A	

Company name	Tel	1	2	3	4	5	6	7	8	9	CE	SCM
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	

ANY QUESTIONS?

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