Structural Steelwork in action

Special Report 08|11|12 >>

New Civil Engineer in association with BCSA and Tata Steel

This supplement showcases the best uses of structural steel in building bridges and energy projects across the UK

Movement control

The Place

By Martin Cooper

How do you construct a modern office block in the midst of a busy station forecourt and with a myriad of subterranean services immediately beneath the site's footprint? Use structural steelwork was the answer.

Designed by renowned architect Renzo Piano, The Place is an innovative steel framed London headquarters building which will provide 40,000m² of efficient office space within a 17-storey structure. The building has plant levels on floors 18 and 19.

It forms part of the South Bank development known as the London Bridge Quarter (LBQ), which also incorporates The Shard, improvements to London Bridge railway and bus stations, and a new landscaped public realm developer. Located in the heart of the LBQ and spanning three lanes of the new bus station, The Place's structure has posed the construction team a number of unique challenges.

"Steelwork was the ideal material for constructing this project," says developer Sellar managing director Flan McNamara. "It has given us the required efficient structure with long cantilevers, erected on a constrained site with minimal disruption to pedestrians and traffic. Below ground steel plunge columns allowed us to conduct a top-down programme, while an on site archaeological dig was ongoing."

Below ground, the building's foundations are constrained by a host of London Underground assets. This has demanded some innovative engineering techniques as pile locations are limited.

PROJECT TEAM

Project: The Place, London
Main client: Sellar Property Group
Architect: Renzo Piano
Main contractor: Mace
Structural engineer: WSP
Steelwork contractor: Severfield-Reeve Structures
Steel tonnage: 6,700t

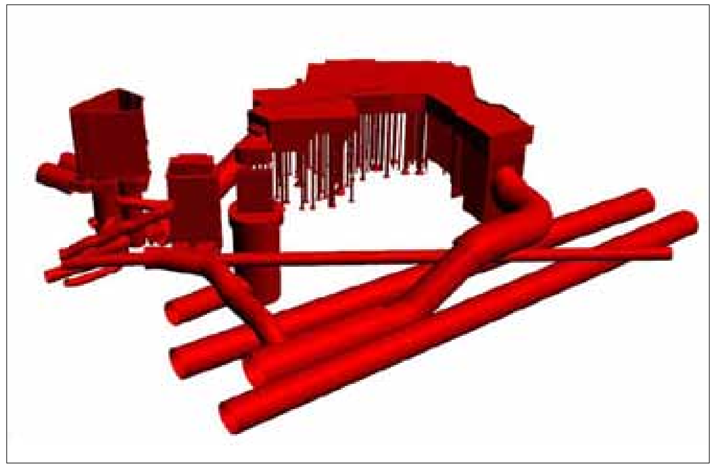
"Steelwork was the ideal material for constructing this project. It has given us the required efficient structure"
Flan McNamara, Sellar

Meanwhile above ground, the building's steel framed floorplates expand outwards at level 3, with the aid of cantilevering spans of up to 14m.

The spans are not regular, they are longer on the east elevation than on the west, and this means the building is out of balance. In the north south direction it is again out of balance, because of the limited columns. To stop the structure from tipping, the cores provide the lateral stability, taking the gravity loads imposed by the cantilevers.

This balancing act has been one of the biggest challenges.

Unusually for a structure of this height, the basement is no more than 50% of the overall footprint. This is because Northern and Jubilee Line running tunnels, escalators, vent shafts and escape stairs as well as the main London Bridge Underground ticket hall, are all within the building's footprint, sometimes only a matter of metres away from the basement walls.



Small footprint: The basement has to fight for space with the Underground

Steel solution: In many areas steelwork is hung from concrete cores

With so many subterranean obstructions, column and pile locations were extremely limited and had to be carefully planned.

"Where we couldn't pile we have installed non-load bearing columns, more architectural than structural to give the building a symmetrical look," says, Mace senior project manager Matt Massey. "In these areas the steelwork is all hung from the concrete cores."

During the early part of the programme the site was rather busy and congested. After the majority of the footprint was cleared and the basement was being excavated, a team of archaeologists from the Museum of London came on site.

"We had to keep to some extremely tight tolerances, otherwise the cladding programme would have been affected"
Richard Tarren, Severfield-Reeve

The investigation unearthed a host of interesting finds including medieval remains and the walls of two Roman villas.

Construction work had to continue around the dig and the installation of a total of 56 prefabricated steel plunge columns allowed main contractor Mace to progress the project.

The slipforming of the two cores was completed on time and they are supported on forty of the plunge columns. A number of large diameter bored piles have also been installed, including what is believed to be the UK's biggest.

"This pile is up to 2.7m diameter and 58m long; it was installed during one 20 hour long operation," explains Massey. "It supports one of the main and most loaded columns in the building and it has to deal with loads of up to 32MN."

With the cores complete, steelwork erection was able to commence and one of the first tasks was to form the slab of level 0, which effectively made a bridge or crash deck above the archaeologists, allowing them to continue working safely while The Place's structure began to rise up in earnest.

Another early part of the steelwork programme was the erection of a temporary safety canopy around the elevations spanning the bus station. Safety is paramount, and this heavy duty system comprises of 61t of steel and could withstand drop loads of up to 8t.

A phased steel erection programme was used, due to the complexity and the long cantilevers.

Steelwork was initially erected up to level 3 using temporary props, as very few of the columns are load bearing. Above this, up to level 12 a temporary support system of Macalloy bars was used, holding the floors in place and allowing the props below level 3 to be removed.

The erection sequence involved Severfield-Reeve partially erecting the raking columns to level 8 and from these the Macalloy bars were suspended, holding each floor as it was completed.

"As each floor was completed we had to monitor and adjust the temporary Macalloy system," says Richard Tarren, Severfield-Reeve Project Manager. "We had to keep to some extremely tight tolerances, otherwise the cladding programme would have been affected."

The eastern side was initially erected to level 12 and then the western side followed. The remaining eight levels were then erected in a more traditional manner with the topping out taking place last June.

"Only when level 12 was complete with the permanent hangers in place, giving us the permanent load paths, could the temporary props be released," explains WSP technical director Jack Adams.

The loads from level 12 and from the permanent hangers are applied to the core through steel beams which are fixed to the core with embedment plates.

One of the final steel elements to be erected were winter gardens which stretch from level 3 to level 13 on the western elevation. These were simply bolted onto the already completed main frame in stages. The winter gardens are supported on one Y-shaped column, positioned at ground level and brought to site in three pieces.

The Place is scheduled for completion in mid 2013.

Organic household waste solution

Bolton IVC plant

By Martin Cooper

The Greater Manchester Waste PFI scheme is the largest of its kind in Europe and steel framed buildings are crucial to the programme.

Worth £3.8bn, the Greater Manchester Waste scheme includes the construction of 42 recycling plants for household and industrial waste in and around the UK's third largest conurbation.

The overall programme is the largest such PFI in Europe and part of it includes the building of four In Vessel Composting (IVC) plants, designed by TEG Environmental, a specialist technology provider that designs, builds and operates sites that treat organic waste.

Many local authorities are now investing in IVC plants as they offer an environmentally friendly solution for recycling food and green household waste.

This completely natural composting process generally takes approximately two weeks, with a further six to eight weeks for the product to stabilise before being dispatched as fertilizer.

The Bolton plant is the fourth IVC facility to be constructed by TEG in the PFI scheme, following on from similar builds in Rochdale, Bredbury and Trafford Park.

"Together the plants will recycle 179,000t of organic waste per annum, Bolton IVC will deliver 50,000t of this total," says TEG contract manager Nichola Rafferty.

All of the IVC facilities are housed within steel framed structures and Border Steelwork Structures has erected three of these projects on behalf of TEG.

"Cost, efficiency and the need for large clear spans were the main reasons why the IVC plants are all steel framed structures," explains Thomas Jagger, a director at project architect TD Jagger.

For the Bolton plant, Border has erected 340t of structural steelwork as part of its overall contract as envelope provider.

"We are responsible for all internal civil works," says Border Steelwork Structures senior contracts manager Stuart Airey. "As the steelwork fabricator, supplier and erector, it has been beneficial for us to also take responsibility for the civil and building elements as well as the cladding and roofing of the plant, as all of these trades revolve around the completion of the steel frame."

Border started on this former British Coal site, located on the outskirts of Bolton, last February. Previously Costain had completed a thorough ground improvement programme as a number of mine workings beneath the site needed to be drilled and grouted.

The ground was then stabilised, vibro stone columns installed and ground beams cast.

Following the completion of the foundation works, the steel erection programme started in May and this process was divided into three phases in order to complete the task as quickly as possible.

The overall footprint of the structure is 8,046m² and measures 96m by 84m. For operational purposes the building is split into three distinct parts to comply with industry regulations, which require designated "clean" and "dirty" areas of operation to avoid cross contamination between the waste and the finished product.

The first part houses the waste intake area with bunkers and shredding equipment; the second contains the composting technology and the third is the compost management building where compost is stored while it stabilises.

"The requirement for three distinct zones dictated the structural design of the plant," says Jagger. "We had to devise a way these could all be accommodated within a structure with no strange shapes; a steel portal design was the best option."

Long clear spans are important, as the waste intake area will have numerous vehicles manoeuvring. Internal columns, which could hinder vehicle movement, were out of the question, so a clear span 30m portal frame has been erected.

Interestingly, this part of the structure has been swivelled 90° from the rest of the steel frame in order to get the long clear spans.

The building is 48m wide in the opposite direction and this was deemed too long for a single span.

The zone directly behind the waste intake area, which houses the composting technology, is facing in the other direction and the 48m width is accommodated with a propped portal frame.

The three column bays measure 18m, 12m and 18m, and accommodate the three silo cage composting lines. "We erected the steelwork for the area to house the composting lines first, followed by the waste intake area, to enable TEG's specialist suppliers to proceed as quickly as possible," says Airey. "It was important to get the steelwork up to allow the job to progress steadily."

While steelwork erection was ongoing in one phase, bunkers and plinths for the silo cages were being cast simultaneously in adjacent zones. As Border was responsible for the entire package, it could organise all trades around one common roster.

Immediately after the steel frame was erected the cladding and roofing contractors followed on behind, ensuring the structure was watertight as quickly as possible.

For the steel erection programme, Border used a 50t capacity mobile crane, while a mobile tower crane was utilised to install the cladding.

The building's cladding consists of a traditional composite panel with a 200 micron thick external paint coating, which is applied internally as well as externally to protect it from the humid composting environment.

Construction of the Bolton IVC is due for completion in March 2013 and the plant will start receiving waste in April 2013. TEG will remain on site during the commissioning phase, to oversee the operation and train the Viridor staff, who will ultimately be running the site.

TEG site manager David Nicholson says: "The project is going well, the build is on programme and we expect to be commissioning the plant early next year."

PROJECT TEAM

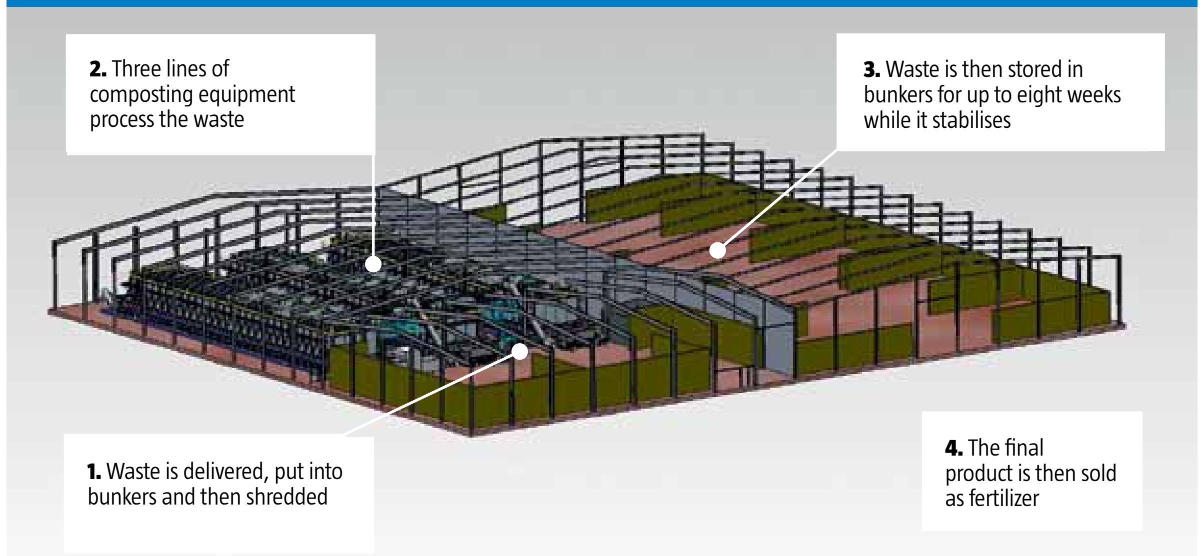
Project: Bolton IVC plant
Main client: Greater Manchester Waste Disposal Authority
Architect: TD Jagger
Principal contractor: Costain Construction
Structural engineer: AL Daines & Partners
Plant operator: Viridor
Technology provider: TEG Environmental
Steelwork contractor and envelope provider: Border Steelwork Structures
Steel tonnage: 340t

"Cost, efficiency and the need for large clear spans were the main reasons why the IVC plants are all steel framed structures"
Thomas Jagger, TD Jagger architects


Bolton best: Border has erected 340t of structural steelwork


Column free: Long spans were important

IN VESSEL COMPOSTING PROCESS



Phoenix from the floods

Northside bridge

By Martin Cooper

Workington's Northside Bridge reopened last month, three years after the original structure collapsed. Steelwork played a pivotal role in re-spanning the River Derwent.

The devastating floods of 2009 will not be forgotten in the north west of England for a long while. Human casualties aside, the effects are only now being completely rectified and the opening of Workington's Northside Bridge represents the last major hurdle on the way to Cumbria's infrastructure recovery.

The original bridge collapsed and was swept away on 20 November 2009. Within weeks a temporary bridge was erected but last month, after three years, a new permanent crossing spanning the River Derwent and the A596 was opened.

The new 152m long, three span composite steel bridge has been erected in the same position as the former structure. It is supported on concrete piers with bored pile foundations and clad in sandstone some of which was recovered from the original bridge.

"Steel offered us a number of benefits, one of which was speed of construction," says Capita Symonds project manager Alan Webb.

Main contractor Birse Civils started on site during August 2011 and completed the programme in a little over 14 months, achieving one of the client's main objectives – namely having the new bridge open within three years of the old original structure's demise.

Early works for Birse included the removal of the original bridge's foundations and locating the service diversions. For the foundations a total of 72 bored piles were installed to a depth of 26m.

The structure's two piers are positioned on both river bank.

This negated a lot of potentially hazardous working over and in water and also resulted in a quicker construction programme.

> **" Steel offered us a number of benefits, one of which was speed of construction,"**
> Alan Webb, Capita Symonds

In place: A crane postioned on the river bank erected the bridge's steelwork, negating the need for any potentially dangerous work in or over the water

Complete: The finished structure also spans a busy road

New structure: The replacement bridge takes shape

Opens: Princess Anne inaugurates the new bridge

PROJECT TEAM

Project: Northside Bridge, Workington
Main client: Cumbria County Council
Main contractor: Birse Civils
Structural engineer: Capita Symonds
Steelwork contractor: Mabey Bridge
Steel tonnage: 980t
Project value: £11.7M

But it was not the only reason for this design as Cumbria County Council project manager Jason Dixey explains: "During public consultations about the construction of the bridge, local people made it clear they wanted something that looked robust, and bearing in mind what happened to the old bridge, piers in the river did not seem appealing."

Mabey Bridge fabricated, supplied and erected the steelwork package in three phases.

The structure was split into three segments for the construction programme.

The northern side of the bridge was erected over one weekend in February, followed a month later by the installation of the southern part.

The northern side of the bridge comprised of six pairs of braced girders, three 30m long pairs and three 23m long pairs all incorporating the bridge's haunch.

Spanning from river bank abutment, onto a pier and then over the river, temporary trestles supported the structure between the pier and the abutments during the erection process.

"Once all of the girders were installed and the cross beams had been welded into place the trestles were removed as the steelwork was then stable," says Birse Civils site manager Phil Dilworth.

Two mobile cranes were utilised for this operation, one 700t capacity unit to do the three girder lifts, and a smaller 60t crane to install the cross beams.

The northern section spans the A596 road, and, in order to install the steelwork, the project team had a weekend possession in place from a Friday night until the following Monday morning.

So successfully and quickly was the steelwork erected that the road was able to reopen on the Sunday lunchtime. – earlier than anticipated.

In a similar procedure the southern section, which is identical to the north, was then erected last April, leaving the middle 46m long mid span to be installed during May.

In order to avoid working in and over the river, the installation of the middle section was done slightly differently.

"We couldn't put temporary trestles in the river so we had to weld the six pairs of girders into three long sections and lift them into place with a much bigger crane," says Dilworth.

Mabey Bridge brought six pairs of small girder sections to the riverside site to make the 46m long centre span girders. Over a period of four weeks they were welded into the required longer lengths.

The cantilevering formwork – used to form the deck – was also installed on the steelwork before the lifting process, minimising even further the amount of work that would have had to be done over the river.

Birse provided an on site assembly yard adjacent to the southern abutment for this work.

Each of the three lifts needed to erect the bridge's mid span weighed 160t, 88t of steel and the remainder consisting of formwork.

To do this work a Demag cc2800-1 crawler crane was needed. This unit has a lifting capacity of 800t, a 60m long boom, a 180t counterweight and took two days to assemble on site.

"Installing the final sections of the bridge girders was a key moment in the delivery of the project.

"It was also significant in this case as it re-established the connection between the north and south banks of the River Derwent," says Dilworth.

> **" Local people made it clear that they wanted something that looked robust"**
> Jason Dixey, Cumbria County Council

Economy with thermal mass

Thermal mass

Utilising thermal mass within a steel frame can reduce a structure's CO_2 emissions while contributing to overall cost savings.

Many designers and engineers are looking to achieve the optimum thermal mass of a building to help minimise the energy required for cooling. This can ultimately save the client a lot of money otherwise spent on powering air conditioning units.

Rising energy costs and a possible increase in temperature over the next 100 years, due to climate change, have both prioritised the need to construct buildings in the most energy efficient way. Designers need to make use of thermal mass in buildings to address this issue.

Structural steelwork offers a number of benefits, such as cost efficiency and speed of construction, but using a structural steel frame can also offer the design team the perfect solution for an economic and cost effective method for achieving peak thermal mass.

It has been thought that large, heavy buildings can mobilise greater amounts of thermal mass than lightweight alternatives, sometimes resulting in specification of reinforced concrete frames. Thermal mass is, however, independent of frame material.

"It's a common misconception that a building needs to have large volumes of concrete to achieve thermal mass. In fact the first 50mm to 75mm of an exposed concrete soffit is the bit that does all the work – the thickness of material exceeding this is thermally neutral in its beneficial effects on the space below," explains Mott MacDonald technical director Edward Murphy.

> **"It's a common misconception that a building needs to have large volumes of concrete to achieve thermal mass"**
> Edward Murphy, Mott MacDonald

Thermal mass is the ability of a structure to absorb excess heat. The element with the most thermal mass is the concrete in the floor slab and for this to work efficiently it requires the floor soffit to be exposed.

During the day, solar gain, electrical equipment and human activity generate heat, which warms the air in a building. Most structures would use air conditioning to artificially cool the internal environment, but if the concrete slab is exposed it can absorb and store heat during times of peak temperature, then release it later as internal temperatures fall at night.

Designing to effectively use thermal mass can remove the need for air conditioning. As mechanical cooling is energy intensive, this can have a huge impact on running costs, and will significantly reduce CO_2 emissions.

CHESHIRE POLICE HQ

Mott MacDonald and Fairhurst were commissioned by Cheshire Police to design its new 2,800m² headquarters in Blacon, Cheshire. Sustainability and energy efficiency were key areas for this project along with cost and the need for a quick delivery.

The team opted for a steel framed solution, rather than concrete, due to the relative cost and time savings the material offered.

The steel framed building was designed to exploit thermal mass, providing "inertia" against temperature fluctuations.

Mott MacDonald technical director Edward Murphy, says: "Thermal mass can, if designed correctly, be just as effective within an exposed hollow floor deck steel frame building as it can within a concrete frame.

"In this instance we chose to use steel with hollow floor deck because of the cost and time efficiencies that it offered."

As a result of using a steel frame, approximately 5% was saved on the cost of the frame and the job was completed four weeks earlier than would otherwise have been expected.

ST JOHNS SQUARE

St Johns Square is a multi-use, four-storey council office block that formed part of a £19M redevelopment of Seaham town centre. The building houses a public library and cafe as well as offices for Durham County Council and Seaham Town Council.

The project team's aim from the outset was to reduce running costs and strengthen the scheme's sustainable credentials. The building needed to be kept cool in summer and warm in winter, sustainably.

A steel framed solution, comprising steel decking and composite concrete floor slabs was decided on as the best solution, to incorporate natural ventilation and thermal mass to control building temperatures.

Durham County Council design engineer Alasdair Cameron, says: "We wanted a naturally ventilated building with a design that would help cut down running costs and lower emissions. We also wanted to increase the thermal mass by exposing the floors to allow them to absorb heat during the day and dissipate it at night."

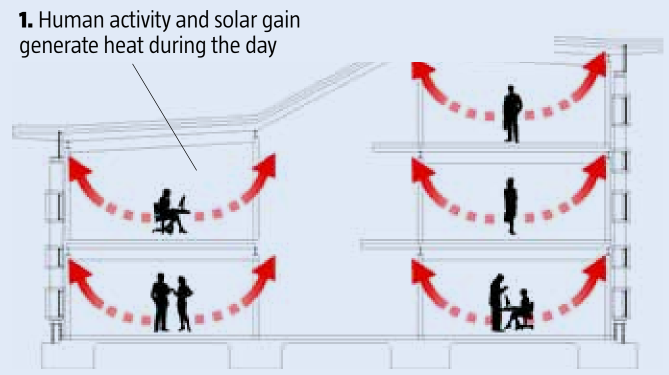
The building has achieved a BREEAM "Very good" rating.

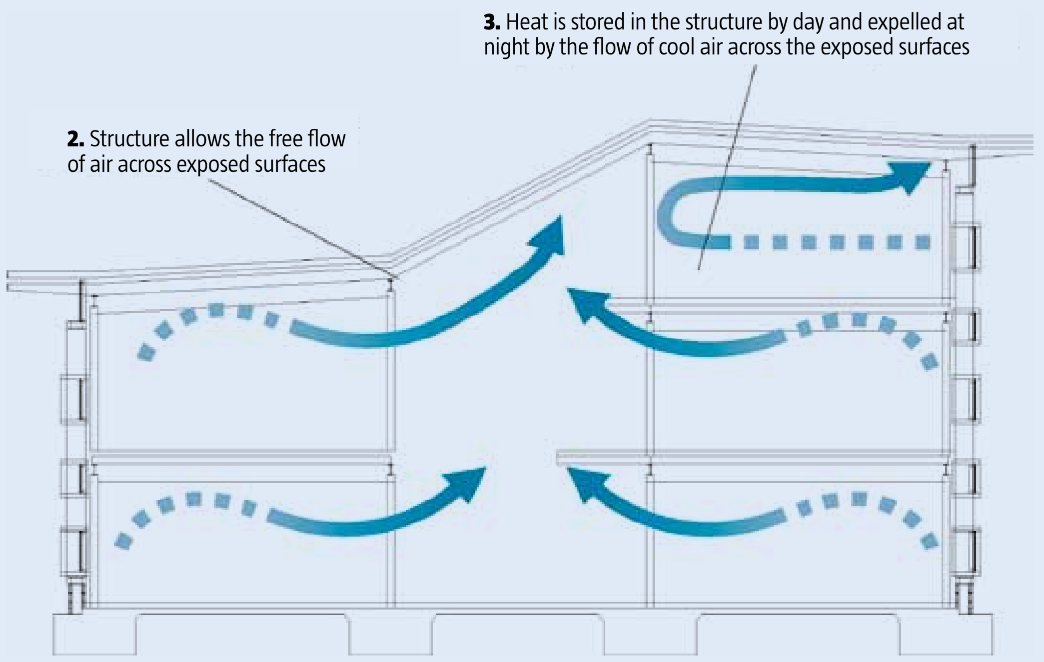
Very good: The St Johns Square steel framed building has achieved a high BREEAM rating

HOW THERMAL MASS WORKS

During the day, solar gain, equipment use and human activity generate heat, which warms the air in a building. The warmed air rises, flows across exposed surfaces and is absorbed into the building's floor slab.

At night, cool air is allowed into the building and flows across surfaces which have been used to absorb heat during the day. These surfaces are then ready to absorb heat again the following day.





At your fingertips

Website
www.steelconstruction.info

The steel sector's new website – www.steelconstruction.info – has been hailed as one of the most significant developments in making steel related advice available to engineers and architects since the internet started, and is already proving popular since its launch on 1 October.

The new site brings together for the first time all the technical and cost information previously available across a variety of steel sector sources into one place. It is a Wikipedia based site that has been described as the free encyclopaedia for UK steel construction, designed to be as easy to use and as comprehensive as possible - a first stop for technical guidance on steel construction.

The site is the result of a two-year development programme by Tata Steel, the British Constructional Steelwork Association and the Steel Construction Institute. Chris Dolling, BCSA Manager, Technical Development, said: "A survey confirmed that the internet has become the first port of call for architects and engineers looking for design guidance and other information, so the steel sector decided to provide a class-leading internet based source for steel construction. It has already proven to be a great success with designers, which is no surprise as all the guidance they need can be found there and it couldn't be more straightforward and simple to use."

At the heart of the site is a series of over 100 interlinked technical articles written by steel sector experts and external consultants covering best practice in the use of steel. Topics covered include fire engineering, costs, sustainability and health and safety. These are all downloadable as pdfs and contain multiple links to other information sources. These core articles act as a roadmap to each topic, using links to more detailed information available from the sector and other external sources.

A number of online CPD presentations are also included, which enable users to take tests and download certificates for their records.

The steel sector has an ongoing pipeline of research and development, continuously updating its guidance in line with changes in legislation, standards and industry practice, and the already comprehensive site will be continuously updated as new information and guidance becomes available.

> "It is a Wikipedia based site that has been described as the free encyclopaedia for UK steel construction, designed to be as easy to use and as comprehensive as possible"

1 SECTORS

Here you will find links to other parts of the site for information relating to various building types such as multi-storey offices, single storey industrial buildings, education and healthcare buildings as well as bridges. Links to external sources of information are also provided.

2 KEY RESOURCES

This section leads you to all the steel sector produced basic resources such as the Blue and Green books, Eurocode design guides, Target Zero (the steel sector low carbon buildings research initiative), design software and tools and online Continuous Professional Development presentations.

3 TOPICS

A vast amount of detailed advice produced after extensive research by the steel sector in areas like the costs of structural steelwork, sustainability, design, fire engineering, acoustics, floor vibrations is linked from here, including links to external sources. The cost of structural steelwork link, for example, leads to the results of a relatively new steel sector initiative to explain the key cost drivers for steel frames for different types of buildings, written by Gardiner & Theobald.

4 HOT TOPICS

Advice on life cycle assessment and embodied carbon can be located from here, as can the various sources of news provided by the sector like "New Steel Construction" magazine and regular steel special sections produced with magazines such as "New Civil Engineer". From here can be found a section devoted to explaining what the site is all about, how it works and an overview of what it contains.

5 CPD EVENTS AND TRAINING

All training courses and Continuous Professional Development initiatives provided by the steel sector can be learned about here, as well as information on the Structural Steel Design Awards, the Tata Steel/BCSA Student Awards and SCI Training Courses.

The section provides access to free technical seminars on a number of topics, including Portal Frames, Acoustics, Introduction to EC3, that can be provided online or in house in the UK by Tata Steel's team of Regional Technical Managers.

6 QUICK LINKS

From here you can quickly access the Tata Steel construction website, information about finding and selecting a steelwork contractor (for which there is now a free searchable app listing BCSA members available for smartphones), the BCSA and SCI online shops where their publications are listed. "New Steel Construction" magazine, to which free subscriptions are available, can be accessed from here.