

Structural Steelwork in Action

Showcasing innovative uses of steel, from education buildings to hospitals and office and retail buildings.

Special Report

05|11|15 >>

New Civil Engineer in association with BCSA and Tata Steel



TATA STEEL



Steel in the frame

Three Pancras Square, London

By Martin Cooper

The latest commercial office block at Pancras Square in central London is reliant on steel construction for an efficient and speedy completion.

Described as a new piece of London and boasting a brand new postcode, London N1C will eventually include 50 new buildings, 2,000 new homes, 20 new streets and 10 new public squares spread over 26.8ha.

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 will consist of seven retail and commercial buildings positioned around a wedge-shaped public square.

Pancras Square's central landscaped realm sits on a steel podium deck that accommodates an underground, shared delivery space for all of the buildings.

So far five of Pancras Square's

buildings have been completed, with the final two – both of which are steel-framed – currently at different stages of construction.

The more advanced of the two is Three Pancras Square, where the steel frame was topped out in August.

This 11-storey 15,230m² building will offer generous office floor plates of 1,700m² over the 10 upper levels, while the ground floor will house a double height reception area as well as retail units.

"This is a classic steel frame design, with a central stability concrete core and long clear spans radiating out on all four sides," says Bam Design principal structural engineer Naresh Tailor.

"In order to get an economic building with long spans, the structure has been designed with a steel frame utilising cellular beams for service integration on all floors."

According to Bam Construction, the choice of steel as the framing material suited the programme, particularly the



Structure: The steel frame choice gave flexibility to make design changes

"To get an economic building with long spans, the structure has been designed with a steel frame utilising cellular beams for service integration on all floors"
Naresh Tailor, Bam Design

installation of the exterior glazing.

Initially the structural design envisaged numerous tenants, possibly one on each floor, within the completed building.

Steelwork contractor Severfield's

PROJECT TEAM

Main client: Argent
Architect: Porphyrios Associates
Main contractor: Bam Construction
Structural engineer: Bam Design
Steelwork contractor: Severfield
Steel tonnage: 1,900t

design team spent a considerable amount of time early in the project coordinating design with Bam Design, in advance of its construction drawings being issued.

This proved to be beneficial even though things changed early in the programme when Havas, the international advertising and public relations company, secured the lease for the entire building for its new London headquarters.

"Havas wanted to change the design and add two atriums within the building to allow light to penetrate the inner office space and to allow the installation of a feature staircase leading up from the reception area to 10th floor level," explains Bam Construction project manager Geoff Hall.

Here again the choice of steel helped the project team, as design changes were easily absorbed into the structural design as steelwork contractor Severfield was still in the early stages of its fabrication programme.



Service driven: Cellular floor beams accommodate pipes and cables

Sitting atop a two-level reinforced concrete basement that connects into the shared podium, the building measures approximately 58m by 36m and it is 46m high to fit into the overall height scheme of the Square.

Steel starts at ground floor level and columns are generally spaced at 6m centres around the perimeter, with splices occurring on every second floor.

Fabsec cellular beams have been used throughout the project and these span up to 13.5m. This creates a near column-free internal space on every office floor. However as the main core is positioned slightly off centre, there is one row of internal columns parallel to the north elevation, as a single beam would have been too deep and heavy to span more than 20m.

The project's beams were also subject to a design change, albeit in the very early stages of the programme.

"We redesigned all of the cellular beams to our own Fabsec design as this offered the best and most economical solution," explains Severfield project

manager Glen McCleery.

As well as accommodating all of the building's services within their depth, some of the project's cellular beams have to double up as transfer structures.

On floors seven and nine, the building steps back to accommodate outdoor terraces, and so larger Fabsec beams were required on these levels.

"On floor seven some of the beams are supporting three floors to create the terraces and on floor nine they are holding up two," explains Tailor.

"For this reason in these areas the cellular beam sizes had to be increased

"None of the steel sections could be heavier than 14t in order to not exceed the tower crane's lifting capacity,"

Geoff Hall, Bam Construction

from 600mm deep sections – used throughout the building – to 750mm deep sections."

So as to keep the floor-to-ceiling heights the same on the floors with the deeper Fabsec sections, the slabs have been cast around the flange of the beams instead of on top of the steelwork.

Severfield fabricated these cellular beams with an internal shelf plate, stiffened at nominal centres to accept the metal decking within their depth.

The main concrete core, which accommodates lifts and stairs, is positioned off-centre so a steel-framed secondary core could be added to accommodate toilets. This secondary steel-framed core gets all of its stability from the attached concrete core.

"Because there were a lot of individual steel members in the core we split the erection between the two onsite tower cranes so we could erect the main frame at the same time," explains McCleery.

As the building takes up most of the

project's footprint there was no room for positioning mobile cranes, and so all of the steel erection was carried out via the two onsite tower cranes.

"None of the steel sections could be heavier than 14t in order to not exceed the tower crane's lifting capacity," says Hall. "Even the deeper Fabsec beams have been designed economically and only weigh 11.5t each."

Before steelwork erection began, the concrete basement, ground floor slab and core had all been completed. The cast slab gave the steelwork erectors a good working surface to put their mobile elevating work platforms on.

Severfield's steel erection sequence consisted of erecting the first three floors from the ground floor slab. From then on the company erected two floors at a time, using man-riders, working off of the previously installed metal decking surface.

Three Pancras Square is aiming to achieve a Breeam "Excellent" rating, and is scheduled for completion in July 2016.

Main frame delivery

Royal Liverpool University Hospital

By Martin Cooper

Going up: The steel frame of the CSSB was completed in September



A £335M Public Private Partnership at the Royal Liverpool University Hospital will completely transform the NHS site.

One of the largest hospitals in the north of England is under construction on Merseyside. The new Royal Liverpool University Hospital will have 646 beds all in single ensuite rooms, it will have 18 operating theatres, 23 wards and units, and one of the largest emergency departments in the North West.

Sited on land adjacent to the existing hospital, this multi-million pound project is vital to the regeneration and transformation of an area that acts as a gateway into Liverpool city centre.

Overall the project has been divided into three phases. The first and current phase includes a new Acute Hospital building; a separate Clinical Services Support Building (CSSB); and two link bridges, one spanning between the

PROJECT TEAM

Main client: Royal Liverpool and Broadgreen University Hospitals NHS Trust
Architect: NBBJ; HKS
Main contractor: Carillion
Structural engineer: TPS
Steelwork contractor: Elland Steel Structures
Steel tonnage: 1,770t

Acute Hospital and the CSSB and the other linking the CSSB to an existing multi-storey car park.

The new buildings are scheduled for

“After an appraisal, steel was opted for on the CSSB because of its speed and quality of construction”

Stuart Loftus, Carillion

LINK BRIDGES

Connecting the CSSB to the Acute Hospital is a 42.7m by 5.7m wide steel link bridge.

The structure is supported by a single 10m-high V-shaped column, positioned slightly off-centre due to a service road that runs beneath the bridge.

completion by early 2017.

Phase two will then kick off with the hospital decamping its services into the completed new structures, allowing demolition of the existing 1960s hospital to commence.

Once demolition is complete, phase three will begin. This involves constructing a large steel-framed public realm and car park (see box).

A hybrid design has been chosen for the first phase of the redevelopment. The new Acute Hospital building is being constructed with an insitu

The steelwork for this bridge was brought to site in individual sections, which were then assembled on site using temporary support frames to minimize crane requirements.

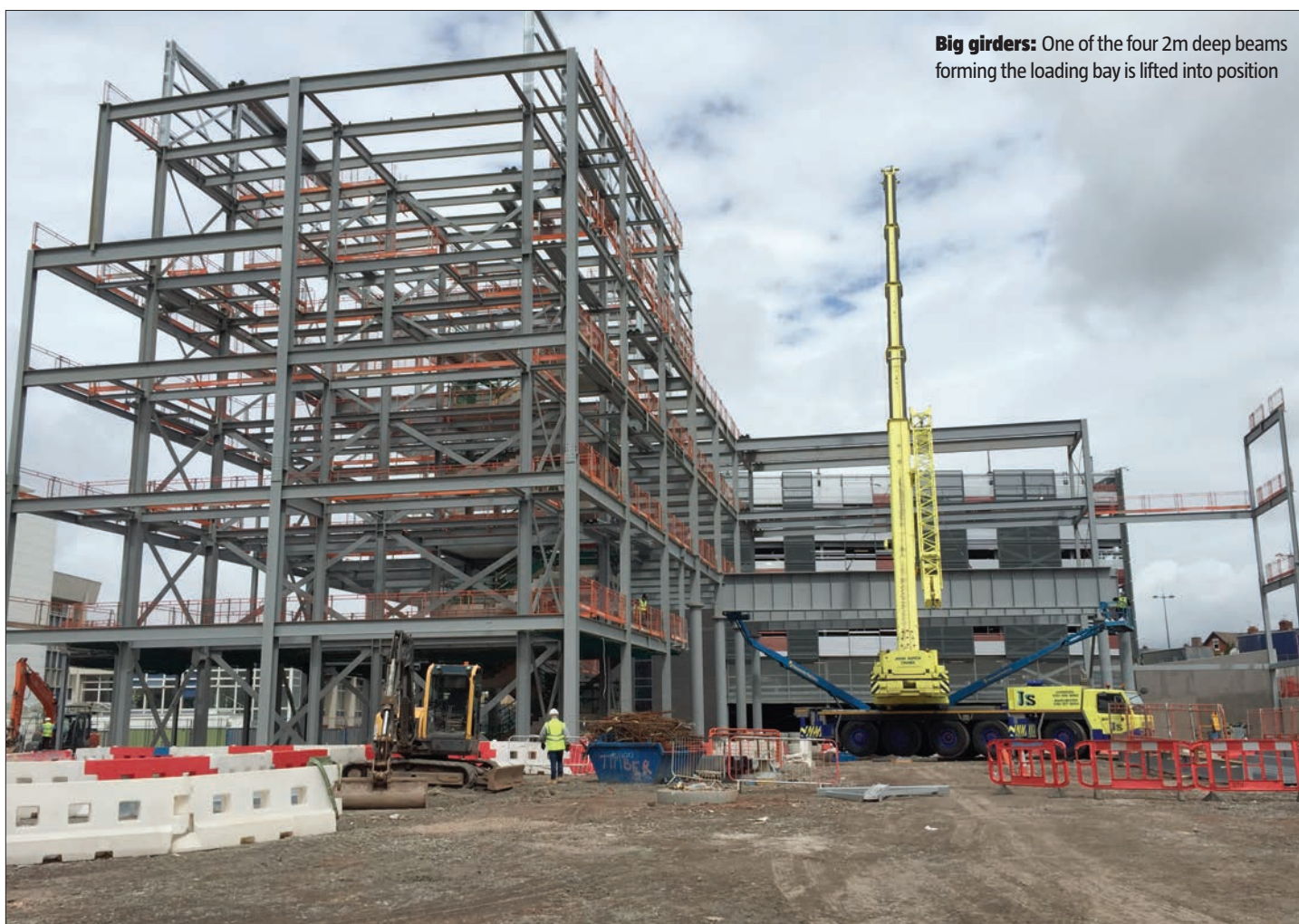
Also on level three, linking the CSSB to the adjacent multi-storey car park, is another 21m-long bridge.

concrete frame, although there are a number of internal steel elements within this 150m-long structure.

These include plant enclosures and screens and an internal atrium created using structural steelwork.

The largest steel element of phase one is the five-storey CSSB and its two link bridges, a contract that has required Elland Steel Structures to fabricate, supply and erect more than 900t of structural steelwork.

“Trust requirements had to be adhered to when choosing which mate-



Big girders: One of the four 2m deep beams forming the loading bay is lifted into position

rial to use, but after an appraisal, steel was opted for on the CSSB because of its speed and quality of construction," says Carillion project manager Stuart Loftus.

The CSSB will accommodate storage facilities for medical supplies, laboratories and offices. It is also the hub for many of the vital services that power the main hospital.

Many of the power duct routes from the onsite energy centre go into the CSSB's own substation and then onwards into the Acute Hospital building.

The CSSB has a footprint measuring 60m by 40m and the steelwork has been erected around a regular 9.9m by 6.6m grid pattern.

Two structural steel masonry lined cores provide most of the steelwork's stability, along with bracing. The main core was installed as part of the first steel erection phase, as this then provided the steel erectors with sufficient temporary stability from which all other areas of the structure could be erected. Five phases, working

PHASE THREE CAR PARK AND PUBLIC REALM

Once the existing hospital has been demolished, a steel-framed podium, accommodating a ground level car park with a public realm above will occupy the large cleared space.

Founded on pad foundations, the steel podium will measure 110m by 90m, with a series of 305 UC columns erected around a 7.5m by 7.8m grid pattern.

This column spacing, with a floor to ceiling height of 4.5m is considered to be ideal and the most efficient for the car park. Spanning the columns, a series of 610 UBs supporting precast planks will form the roof.

"The steelwork has been designed around the heavy loadings generated by the podium's deep landscaping build-up," explains TPS Structural Engi-

neer Duncan Gray.

to the full height of the building were needed to complete the structure.

A large part of the ground floor of the CSSB incorporates a double height

near Duncan Gray.

The public realm on top of the podium will be formed with 700mm fill within which there will be numerous plants and trees, many of which will be in large planters.

Paths, leading to and from the surrounding buildings, will crisscross the realm and public access will be via a flight of stairs. Because of the site's sloping topography, the CSSB will overlook the realm and will be linked to it via a ramp.

Gardens will provide solitude and a relaxing environment, while a café situated in the middle of the realm will offer drinks and snacks.

Elland Steel Structures will erect approximately 700t of galvanized steelwork for this phase, with work due to begin in 2019.

service yard. This part of the erection programme involved the project's heaviest steel members.

Elland Steel Structures used a variety

of different mobile cranes for the job. The biggest capacity crane was a 100t unit used to lift four 2m-deep girders, spanning 20m and each weighing 17t, to form the yard's open plan space.

A series of 10m high, 559mm diameter CHS sections, with 25mm thick walls, support the girders. Once each CHS section was installed, Carillion had to concrete fill each member to add to the overall robustness of the column supports.

Level two of the CSSB wraps around the loading yard, and so the first floorplate to cover the entire footprint is level three. This floor accommodates laboratories and the connections to the two link bridges (see box).

Level four is more or less identical to level three, while level five only occupies half of the CSSB's footprint.

"We've added some flexibility into the structure as extra steelwork could be added in the future to complete level five if the hospital wants to expand the building," says Loftus.

The entire project including phase three is due for completion by 2020.

Steel encyclopaedia

www.steelconstruction.info

By Chris Dolling

www.steelconstruction.info was launched in October 2012. It brought together for the first time all the sector's technical and cost information, which was only previously available from a variety of different sources.

Described as the free encyclopaedia for the UK steel construction sector, it was designed to be easy to use, as comprehensive as possible, and the one-stop-shop for technical guidance on steel construction.

"We were responding to the needs of designers with this new website," says British Constructional Steelwork Association technical development manager Chris Dolling.

"We set out to provide the best possible internet-based source for steel construction information and with almost identical functionality to Wikipedia. We feel this is exactly what we've achieved as all of the feedback has been very positive."

During the three years since it was

launched, the website has developed enormously with significant improvements in functionality, the addition of lots more content and regular updates to ensure the information provided remains current.

Here are some of the highlights:

Improvements

- The "Main page" has been redesigned with the addition of colour, images and new sections on "Featured Projects" and "Featured Articles".

- A new Google search facility has been installed to improve the number of search results found, the relevance and the prioritisation.

- All of the videos on the website have been reconfigured to play via a YouTube

"We were responding to the needs of designers with this new website"

Chris Dolling, BCSA

channel, so they will run on a wider range of browsers/devices.

- A "Sitemap" and "Index of main articles" has been added to aid navigation, and give users an appreciation of the broad range of content on the website.

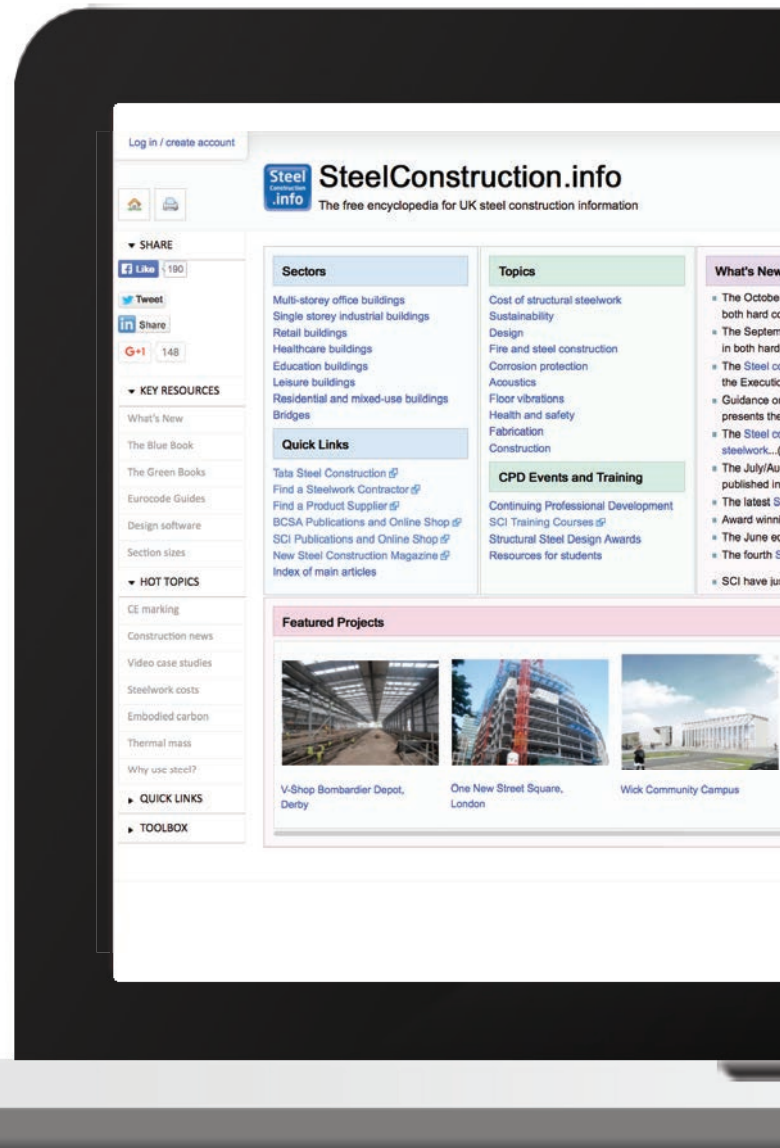
- All of the sector case studies have been converted from a PDF format to fully integrated/hyperlinked page content to aid browsing

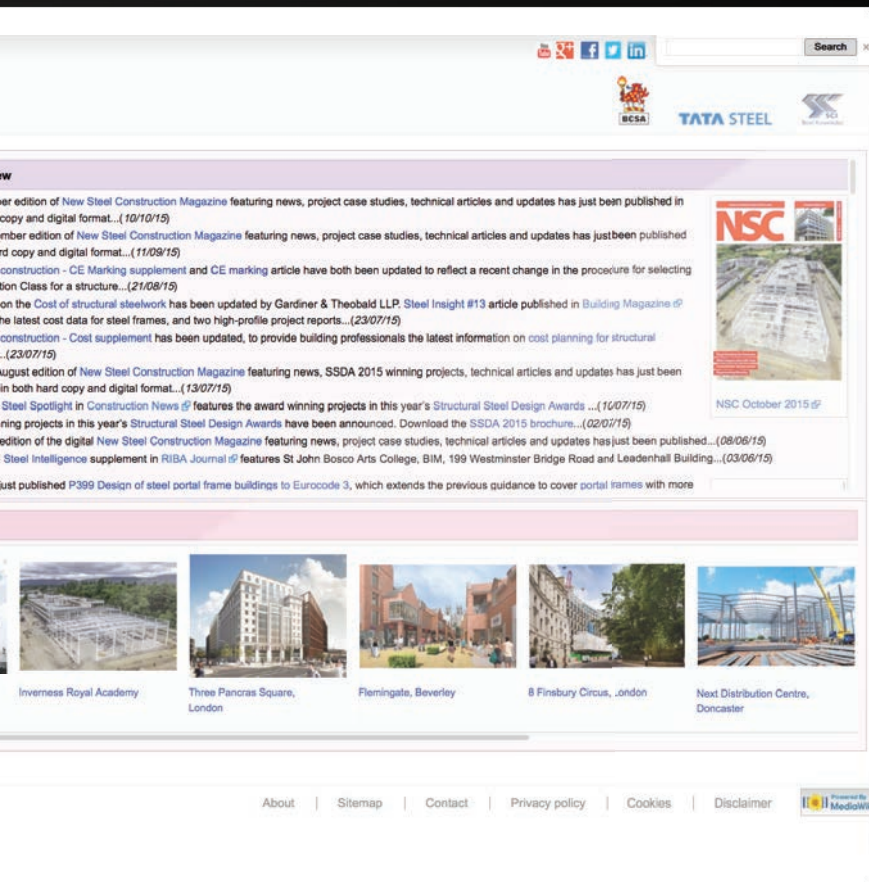
- A new magazine-style PDF reader has been installed to enhance the viewing of all the features on the "Steel Construction News" page.

- An embedded webinar facility has been added, and used to deliver training on a range of subjects including fire engineering, embodied carbon and thermal mass. These webinars are automatically recorded to YouTube and made available afterwards as online CPD with the usual testing and certification functionality.

New content

- **Steel construction news** contains all of the recent press features and steel supplements from a range of construction industry magazines.





“We set out to provide the best possible internet-based source for steel construction information,”

Chris Dolling, BCSA

REFERENCE MATERIAL

For those who are new to www.steelconstruction.info the site has well over 100 wikipedia style articles, written by the steel sector’s own experts as well as external consultants, and covering best practice in the use of steel across the construction sector, as well as topics such as fire engineering, costs, sustainability and health and safety.

These core articles act as a roadmap to each topic using links to more detailed information from the sector and other external sources. A number of online continuous professional development presentations are also included. These enable the user to take a test and download a certificate for their records.

There is also a host of links where users can go directly to web-based steel design software and tools, while the news section allows access to a number BCSA and Tata Steel supplements that have appeared in the construction and architectural press, including NCE’s own “Structural Steelwork in Action” reports.

The steel sector has an on-going pipeline of research and development work, and continuously updates its guidance in line with changes in legislation, standards and industry practice.

Consequently, the website is also updated on a regular basis, and registered users (this can be done on the site) get quarterly email alerts highlighting all of the site’s new features, updates and additional information.

- **Design software and tools** brings together an increasing number of free software packages and spreadsheet tools from the steel construction industry intended to aid designers.
- Articles on **cost planning** for industrial buildings, education buildings and healthcare buildings offer guidance on current cost ranges and the key cost drivers for steel-framed buildings in those sectors.
- **Video case studies** has interviews with the participants interspersed with footage of the structure, and are used to describe recent projects, and the challenges faced during construction.
- **Steel section sizes** is a key resource providing users with swift access to steel section sizes and property data for

hot rolled sections from Tata Steel.

- **CE marking** highlights how the steel construction sector has been working behind the scenes; what it will mean for the sector and what needs to be done to comply with the Construction Products Regulation.
- **Resources for students** contains articles on the design and construction of steel framed buildings aimed specifically at engineering and architectural students.
- New videos on **Eurocodes, CE marking, sustainability and how to use the Blue and Green Books** have been uploaded.
- **End of life LCA and embodied carbon data for common framing materials** contains a complete

cradle-to-cradle dataset for embodied carbon.

Updates

The cost table, cost comparison figures, and BIS location factors are updated throughout the cost articles every quarter to suit the latest data from Gardiner & Theobald, and a formal maintenance regime ensures that every article is reviewed on a rolling two-year cycle.

The SSDA article is updated every year to feature the initial short-listed projects and then the winners as soon as they are announced. Fully hyperlinked case studies for each winning project are created and added to the ever-growing bank of project data.

An education in steel

Sunderland College, Holmside Vocational Campus
By Martin Cooper

A multi-million pound steel-framed vocational campus is being built in the heart of Sunderland to accommodate up to 2,000 students and more than 120 staff.

Covering 12,500m², the state-of-the-art Holmside Campus will house vocational courses, transferred from the nearby Hylton Campus, including advanced engineering, manufacturing, construction trades, automotive trades, travel and tourism, plus catering and hospitality.

The Campus will also feature hair, beauty and barbering facilities; a spa; a bakery; a travel agency; restaurant and a car repair service, all of which will be accessible to the public.

"The Campus has been designed to combine industry-standard facilities and outstanding teaching

for our vocational and apprenticeship students, and will equip them with the skills and practical experience they need for their future careers," says Sunderland College principal Anne Isherwood.

"As well as providing a wide range of professional and technical courses, it will also be home to the college's commercial ventures and we are looking forward to welcoming members of the public to these facilities.

"We are confident that our flagship campus will enhance the vibrancy of the city centre and will

"Many of the classrooms and workshops are heavily serviced and these require extensive ductwork to specialist equipment"

Andrew Cornwall,
WSP Parsons Brinckerhoff

PROJECT TEAM

Main client: Sunderland College

Architect: Red Box Design

Main contractor: Bam Construction

Structural engineer: WSP Parsons Brinckerhoff

Steelwork contractor: Harry Marsh (Engineers)

Steel tonnage: 900t

be of benefit to Sunderland for many years to come."

To achieve these aims, the Campus building's design had to stand out within its urban surroundings and maximise the space within its confined plot.

Stone walls, polished blockwork and metal cladding will give the Campus a modern exterior, while to best utilise the plot a steel-framed structure incorporating a 120m-long retaining wall was selected as the best design choice.

The retaining wall allows the steel-framed structure to adapt to

the site's tricky topography and include a basement level along the entire south facing classroom block.

"A steel-framed solution was chosen for a number of reasons, such as programme and cost," explains WSP Parsons Brinckerhoff project engineer Andrew Cornwall.

"However the main driver was the flexibility that this provided for services distribution and for modification in the future.

Many of the classrooms and workshops are heavily serviced and these require extensive ductwork to specialist equipment.

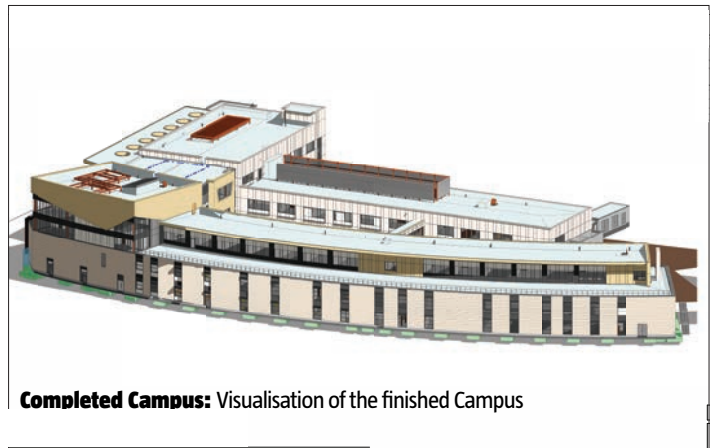
If the location of these changed in the future, openings in floors and walls could be accommodated more easily with a steel-frame than a concrete structure."

The steel-framed Campus comprises two teaching wings. Along the southern elevation there is a three and two-storey high classroom block, while to the north there is a two-storey Learning Resources Centre (LRC). Both of

Curved wall: The building matches the alignment of a neighbouring railway line



City changer: The Campus will help revitalise Sunderland city centre



Completed Campus: Visualisation of the finished Campus

“The terrace has been designed so in the future, if the college needs more teaching space, it could be roofed over and converted into classrooms”

Jason Kelly,
Bam Construction

these wings are joined at the western end by a three-storey entrance building that also incorporates an atrium.

Because the Campus is essentially one large braced steel-framed building, a movement joint has been placed along the line where the LRC meets the entrance wing.

Bracing, located in stairwells, along with the diaphragm action of the composite floor slabs, give the steel frame its stability.

The steel frame has been predominantly erected around a

COMPLEX LOGISTICS

Railway lines along one elevation and a city centre pedestrianised zone along another mean there is only one access route into the site for all materials.

On a tight and confined site such as this, well planned logistics are a key success factor and Sunderland College is no exception.

“Ideally we would have started the steel erection at the farthest end from the site’s entry point, which is the entrance block, and worked our way out,” says Bam Construction project manager Jason Kelly.

standard grid that incorporates perimeter columns spaced at centres ranging from 6.5m to 7.5m. Internal spans vary depending on the classroom or workshop’s ultimate use, with the longest span measuring 10m.

The classroom block is the largest section of the Campus. Filling up the southern portion of the plot, it

“However, due to some design changes, we’ve had to sequence the erection programme and erect the furthest point of the structure last.

“We then bring our cranes out via the central courtyard before finally erecting a footbridge that links to the two teaching wings.”

With little or no room for materials to be stored on site, especially towards the end of the steel erection programme, steelwork contractor Harry Marsh (Engineers) has delivered steel to site in 20t loads, which were generally erected in one day.

curves – via a faceted steel frame – along the site’s boundary, adjacent to railway lines.

This wing incorporates workshops and classrooms spread over basement, ground, first, and second floor levels.

A 5m-high retaining wall wraps along the wing’s north elevation, incorporating the site’s slope.

Because of this, the basement level workshops are at ground level along the south elevation and have windows overlooking the railway lines.

Flexibility is at the forefront of the first floor design, as it is split lengthwise between classrooms on one side and an outdoor terraced green roof on the other side.

“The terrace has been designed so in the future, if the college needs more teaching space, it could be roofed over and converted into classrooms,” says Bam Construction project manager Jason Kelly.

During the design stage, the foundations and the columns in this part of the structure were future-proofed by being designed to accept the extra loadings additional columns and a roof would exert.

As well as constructing the Campus, Bam Construction is responsible for the fit-out, which will be completed by the end of next summer, in time to open in September 2016.

Retail regeneration

The Crescent, Hinckley
By Martin Cooper

The Leicestershire town of Hinckley is being transformed as a multi-million pound mixed-use steel-framed development nears completion.

Known as The Crescent, the project occupies a large swathe of the town centre and will ultimately deliver a large 6,500m² Sainsbury's superstore, more than 25 smaller retail outlets, a five-screen Cineworld complex, a revamped bus station and a 550-space undercroft car park. This project represents a significant investment in Hinckley and will bring a great deal of new employment and prosperity to the town.

Work commenced during the summer of 2014, when main contractor Bowmer & Kirkland began a phased demolition and groundworks programme.

This work continued into the New Year as approximately one third of the site could only be handed over to the project team in January.

The topography presented another challenge.

The site incorporates a steep slope and so a large retaining wall has had to be constructed across its mid-point. This allows the ground floor level to stretch seamlessly across the entire site, with only a few minor pedestrian steps, while



Cinema steel: Erected by mobile crane

within the retaining wall, the project has a basement level accommodating the car park.

"When the steel erection commenced it had to be phased around the groundworks, especially the construction of the retaining

"When the steel erection commenced it had to be phased around the groundworks, especially the construction of the retaining wall"

Guy Laughton
Bowmer & Kirkland

Transport zone: The curved facade of the bus station takes shape



wall," explains Bowmer & Kirkland senior site manager Guy Laughton.

Steelwork contractor for the project is Billington Structures, and it was awarded a design and build contract for all of the Crescent's structural frames.

The initial steelwork phase involved Billington Structures erecting the 6,500m² Sainsbury's store (Block E) on top of an undercroft car park.

Steelwork was designed and erected on a large 7.5m by 16m grid, which is ideal for the car park and the superstore above.

A series of 16m long cellular beams forming the car park roof were chosen for their efficiency and for the fact the beam's openings

PROJECT TEAM

Main client: The Tin Hat Regeneration Partnership
Architect: TP Bennett
Main contractor: Bowmer & Kirkland
Structural engineer: Clark Bond
Steelwork contractor: Billington Structures
Steel tonnage: 2,000t

allow extra light into the undercroft car park. The beams support a 150mm thick diaphragm deck, which is the floor of the superstore.

Structurally, the Sainsbury's store and car park are contained within one large braced frame that incorporates a first floor service yard



in one corner. Because of the extra loadings from trucks using the yard, 10t, 16m long plate girders have been used in this part of the frame instead of cellular beams.

Block E is structurally independent from the adjacent retail Block A, although once clad the two will look like one continuous building.

Because of its length, the braced frame of Block A is split in half by a row of double columns forming a movement joint.

Sitting opposite and forming the other side of a pedestrian street, Block B is also split in half by a movement joint for the same reason. Steel erection for Block A had to be phased around the construction of the retaining wall.

Three of Block A's retail units closest to the Sainsbury's were erected along with Block E, with the rest of the retail units put up later in the schedule once the wall was completed and backfilled.

ASD Westok value engineered the steel frame on Blocks A and E, alongside Billington Structures, and supplied the cellular beams. This maximised design economy in the structural steelwork solution.

"There were a number of design constraints to understand," says ASD Westok design team leader John Callanan.

"This complex job involved strict beam depth restrictions arising from the site topography and load-transfer arrangements with columns

sitting on secondary and primary beams in Block A.

"Along with this, there is a raft of varying loading conditions to design for, including retail, back of house, service yard, roof and rooftop plant loading areas," he adds.

"Structurally optimised asymmetric cellular beams were ideally suited to the long-span grids. Plated transfer beams were designed for the transfer sections."

The next substantial part of the steel package to be erected was the cinema complex on the opposite side of the site from the Sainsbury's.

Some other smaller retail units, between the Sainsbury's and the cinema had been erected; most notably parts of Block B that forms

"Structurally optimised asymmetric cellular beams were ideally suited to the long-span grids. Plated transfer beams were designed for the transfer sections"

John Callanan
ASD Westok

the "Crescent" – an area around which the new bus station will be located. Otherwise much of the steelwork in the middle of the site was erected in May and June, phased around the remaining piling and groundworks programme.

The cinema forms Block C and is another stand-alone steel braced structure. It contains retail units on the ground floor and five cinema auditoriums above.

As the retail units and the auditoriums are different sizes, the grid pattern for this structure is very complex and changeable.

A single mobile crane erected the cinema steelwork, with the programme beginning in January and finishing in March. The work also included the installation of precast stairs as well as the auditorium seat terracing.

The steel erectors had to leave sections of the roof out to allow the stairs and terracing units to be lifted in. It was complicated by the fact that the terraces had to go in last as they are supported on rakers that in turn are supported by columns that support the entire structure.

Included in Billington Structures' design and build contract was the design of a bespoke terracing system for the cinema auditoriums.

The design for the seating had to be steel and each of the terrace banks is curved in plan.

Billington's solution was to form each step with curved plated sections, which were brought to site in two pieces and bolted together during installation. The plated sections in turn support metal decking and a thin concrete topping to complete the terracing.

The Crescent is scheduled to open in time for Christmas.