Produced in association with TATA STEEL BCSA

Tram plan calls for bridge variety

Nottingham's tram network is being extended with the aid of five new steel bridges, including one launched across the city's main railway station

PROJECT REPORT
RUBY KITCHING

A mass transit project is currently under construction to extend Nottingham's tram system, Nottingham Express Transit.

Phase one of the route opened in 2004 and currently operates between the city centre and suburbs to the north.

Phase two of the network has been on site since 2012 and will connect the city centre to those at its southern end.

The new route is made up of two new lines, both extending from the current tram terminus at the city's main railway station. One line will head south through the town of Clifton and the other south-west through Beeston.

Both lines will draw together key conurbations as well as the Nottingham University campus and Queen's Medical Centre.

Park and Ride facilities at extremities of the new lines will also encourage the public to leave their cars at free car parks and travel by tram into the city.

More than 17 km of tram line will be built as part of phase two to create a 21 km-long network. Client Nottingham City Council has appointed contractor Taylor Woodrow Alstom and consultant Mott MacDonald.

Project	Nottingham Express Transit (NET)
Client	Nottingham City Council
PFI concessionaire	Tramlink Nottingham
Main contractor	Taylor Woodrow Alstom
Structural engineer	Mott MacDonald
Steelwork contractor	Cleveland Bridge

Five steel bridges will allow the new lines to span Nottingham railway station, the A52 dual carriageway, the mainline railway at Lenton south and the River Trent (see box). The steelwork contractor on the scheme is Cleveland Bridge.

1,600
Weight in tonnes of the Queens Rd bridge

Historic path

The bridge that is being built over Nottingham's main rail station follows the line of a former railway bridge – which was demolished in 1983 – and is able to use some of its foundations.

The new 1,100 tonne, 104 m-long, two-span tubular steel warren truss bridge is similar in style to its predecessor, but with a neat modern twist: jumbo circular hollow sections up to 711 mm in diameter and 40 mm thick have been specified rather than rectangular sections, and the top chords are arched. The truss is deepest at its centre pier.

"Using a truss structure [and circular hollow sections] has meant that it is light enough to be supported by the previous bridge's substructure, and has made launching a more feasible form of erection," says Mott MacDonald senior bridge engineer Ray Sexton.

The bridge will feature a composite deck and was launched into its final position last month.

Flanking it are two further bridges which will take trams on the Beeston line south across Queens Road and down to street level and north across Station Street to the existing tram line.

The Queens Road bridge is a 1,600-tonne, two-span 70 m-long structure comprising twin steel trapezoidal box girders and a reinforced concrete deck, while the Station Street bridge is a 16 m-long pre-stressed precast beam structure.

In honour of Nottingham's twin city in Germany, which inspired the council to develop a tram system, the bridge will be known as the Karlsruhe Friendship Bridge.

Earlier this year, the first half of the Nottingham station bridge steelwork was erected in a compound adjacent to Queens Road and in line with its final location. A Liebherr LTM 1500 crane was used to erect 12 truss sections onto a series of high-level temporary trestles for final welding ahead of the structure being launched over Queens Road in February 2013.

With the first half of the bridge launched, there was then space for the second half of the structure to be erected.

This second launch followed the same procedure as the first, but this time with the full 1,100-tonne weight of the structure.

BRIDGE DESIGN LOOKS TO STEEL FOR AESTHETICS

"Our main challenge is that we are building in key urban areas, rather than in a green field," explains Nottingham City Council project director Chris Deas. Therefore construction methods have had to take into account much more than just the build itself.

The bridges have been designed, he continues, to enhance their environment. "We considered carefully the look and function of these structures as part of the design process and chose steel because we wanted to achieve something with a contemporary feel," Mr Deas says.

Describing the Karlsruhe and Clifton Boulevard bridges, he says, "These bridges will be the most obvious landmarks of the route – providing interest and excitement to change Nottingham for the better."

The first half of the Nottingham station bridge steelwork was erected earlier this year

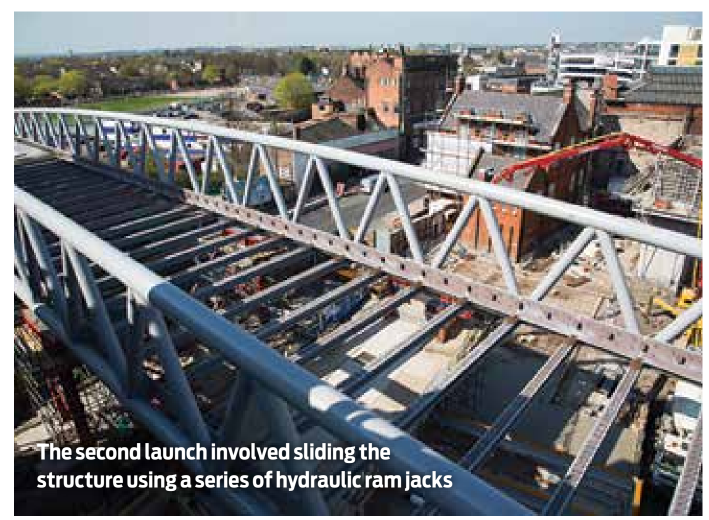
Night-time slide

Launching involved sliding the structure using a series of hydraulic ram jacks positioned on supporting temporary towers between 8pm and 6am over the course of a number of nights. A slide of up to 13 m was achieved in one night. "Launching the structure was preferred to craning sections into position, since the station would have had to close to allow cranes to operate," explains Mr Sexton. "Temporary supports would also be needed."

> "We chose steel because we wanted to achieve something with a contemporary feel"
>
> CHRIS DEAS, NOTTINGHAM CITY COUNCIL

One of the main construction constraints was that the slender bottom boom sections could not resist high levels of point stress between nodes.

In the bridge's finished state, this would not be a problem. But during launch, there was concern that roller or sliding bearings might overload the section, requiring extra plates to be welded to the section to provide temporary stiffness.



The second launch involved sliding the structure using a series of hydraulic ram jacks

The length between node points is 5.2 m, so the slide length adopted for the launch was designed to be 2.6 m, explains Taylor Woodrow Alstom section manager Paul Channon. "This ensured there would never be a concentrated load halfway between nodes," he says.

A sliding launch solution was also favoured over rollers for practical reasons: the weight of the structure on the rollers would scrape off the paint during the launch, eventually clogging up the rollers.

"If we'd used rollers, we would not have been able to paint the bottom boom until after the launch," explains Mr Channon, who adds that this would have affected the programme.

The sliding system, he says, also used hydraulic rams, which were simple to control.

Now the Nottingham station bridge has been launched, Station Street bridge and Queens Road bridge can be built, with the entire line due to open in December 2014.

> "A truss structure means it is light enough to be supported by the previous bridge's substructure"
>
> RAY SEXTON, MOTT MACDONALD

THREE MORE NEW BRIDGES ON THE TRAM NETWORK

Clifton Boulevard Bridge
A 61 m long, single span bow-string arch structure weighing 940 tonnes is due to be built across the A52 in September 2013, using self-propelled modular transporters during a night-time road closure (CGI, right).

The composite deck bridge has been designed with a steel box section for the arch and fabricated I-section girder along the deck.

Its end piers are currently being constructed and main steelwork is being fabricated offline at site.

Lenton South Junction Bridge
This 285-tonne, 45 m-long single-span steel structure comprises a series of steel crossbeams between two 2 m-deep plate girders (left).

Prior to being installed in February 2013, the plate girders were supported on temporary platforms and bearings while all steel erection and deck concreting took place. Self-propelled mobile transporters lifted the skewed structure perfectly into position on each abutment during a weekend rail possession.

The Wilford Toll bridge
This three-span structure over the River Trent (CGI, right) has been widened by retrofitting a line of 91 m-long plate girders. An underbridge unit was used to access all cross-bracing members and bolts.

Pier strengthening works and steel erection methods had to take into account wildlife in the river.

Twice as high for office replacement

Building a new office block on existing foundations in a restricted London site around the Olympics challenged conventional construction methods

PROJECT REPORT
RUBY KITCHING

The decision to reuse the foundations of the former eight-storey office block at 6 Bevis Marks in the City of London has had a profound impact on its new, larger replacement. Two lift cores for the new 16-storey building have had to go in similar locations as those of the former building and a lightweight frame solution was essential to ensure the existing foundations could be reused. The main steelwork frame, totalling 2,100 tonnes, has just been erected on the project by contractor William Hare.

Its client is Bevis Marks Development, a joint venture between Axa and MGPA. The main contractor is Skanska and the structural engineer is Waterman Structures.

Project 6 Bevis Marks
Client Bevis Marks Development
Architect Fletcher Priest Architects
Main contractor Skanska
Development manager City Office Real Estate
Structural engineer Waterman Structures
Steelwork contractor (structural frame) William Hare

Lettable space

"An eight-storey concrete building was demolished and replaced with a 16-storey steel one using existing foundations," says Waterman Structures director Julian Traxler. "We couldn't have achieved that and the net lettable areas required by the client if we hadn't used a steel frame – it just wouldn't have been viable."

Thirty-seven new piles were installed around existing ones to account for different loading patterns, but the ethos of the project has been to keep the weight of the structure to a minimum by using elements as light as possible to achieve large useable floor areas.

"Floor beams are made up of fabricated plate girders that have the smallest possible top flanges [to keep the weight low] – just sufficient for the shear stud connection through the metal deck," adds Mr Traxler.

Beams span up to 13.5 m and are typically 600 mm deep and designed primarily for vibration and response. Openings in the beams for services keep the structure and services zone to a shallow 750mm. With floor plates up to 53m long, the span between columns has been dictated by the position of the two cores and the optimum column arrangement for open plan offices.

The L-shaped building sits between the 41-storey Gherkin building at 30 St Mary Axe and more modest seven-storey buildings on Bevis Marks. The new building at 6 Bevis Marks sympathetically steps down from 16 storeys to 11 storeys towards the shorter buildings.

Basement project

The new steel frame and composite floor structure occupies the same plan area as the former building since the existing single-storey basement walls are also being reused. A 1 m thick transfer slab forms the basement floor. Steel construction has proceeded up from the basement slab in an anti-clockwise direction from the south east corner of the site.

Columns are typically circular hollow sections in the centre of the building and rectangular hollow sections at the perimeter. These perimeter fabricated rectangular sections measure up to 550 mm by 350 mm with plate thickness varying between 12 mm and 19 mm. The columns are boarded rather than having intumescent coatings applied because, in the event of a fire, there was not enough room for the coating to expand. To accommodate the largest of these members at ground floor required some clever detailing and design.

16 Storeys in new office block at 6 Bevis Marks

Bolted splice connections would have taken up too much room, so columns had to be welded on site. "To save time and allow construction to proceed, temporary cleats join columns, with welders returning to grind off the cleat and make the permanent connection later," says Skanska project director Andy Hankin.

William Hare designed a bespoke cantilevered welded frame or "cradle", which was fixed to the column and floor to allow safe access to the column, that sits on the outside of the slab on three of its sides.

The cradle was developed specifically for this building to access all four sides of the column and was modelled into the 3D fabrication computer model to consider splice levels and edge conditions.

> **"It just wouldn't have been viable if we hadn't used a steel frame"**
> JULIAN TRAXLER, WATERMAN STRUCTURES

Cradle saving

Using a cradle meant that much less scaffolding was required on the project, saving time.

With the main steelwork now complete, work on site is focused on erecting the roof steelwork to support an ETFE roof. The £50m building, which has 22,000 sq m of office space, is due to be completed in November and is aiming for a BREEAM Excellent rating.

A lightweight steel framed solution allowed existing foundations to be reused

The mobile crane lifts a transfer beam with 10-tonne kentledge

BUILDING DURING THE OLYMPICS

Skanska received the site in January 2012. The streets around the site were buzzing with utilities contractors trying to complete work before the Games in August, when roadworks would not be allowed.

For 6 Bevis Marks' main contractor, Skanska, it meant that there were fewer slots available for road closures to allow large deliveries such as tower cranes onto site and closures had to be booked at least 12 weeks in advance.

"Our operations were restricted by having to keep a 3 m wide lane open on [the 6 m wide] Bevis Marks at all times," says Skanska project director Andy Hankin. Site cabins supported by gantries on the eastern edge of the site restricted access from Bury Street.

To overcome access restrictions, Skanska senior engineer Chris Field came up with the idea of building two 7 m tall platforms from basement level adjacent to Bevis Marks. This gave enough room for two outriggers on one side of a 500-tonne capacity Liebherr LTM mobile crane to position itself on the platforms with outriggers on the other side within the allowable zone on Bevis Marks. "As the crane lifted piling equipment, large transfer beams and tower crane parts on to the site, it was about 100 mm shy of the existing retaining wall," says Mr Field.

Since the position of this crane was fixed, its reach was limited due to on-site construction, particularly the two stair cores. This meant that the crane could not lift from the centre of the load for the large transfer beams at first floor.

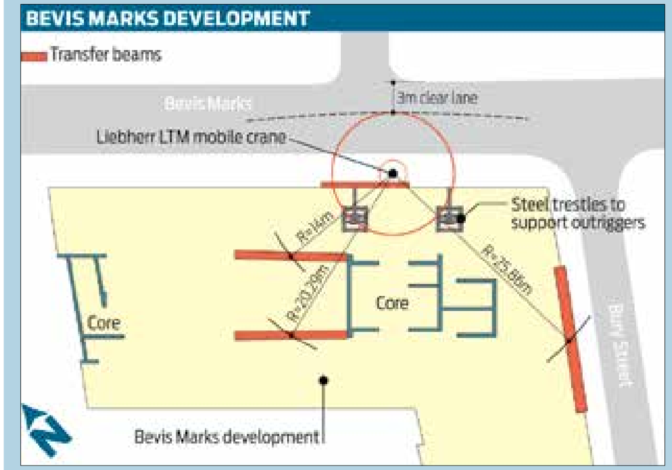
"To lift all transfer beams from the same mobile crane position, kentledge had to be fixed to one end of the beam to move its centre of gravity [to maintain balance during lifting]," recalls Mr Field.

The 12 m long transfer beam over the loading bay weighed 38 tonnes and comprised of a 1.5 m deep by 1 m wide I beam with 100 mm thick flanges and twin 50 mm thick webs. The centre of gravity of this beam was shifted 450 mm to avoid the core. This was achieved by the addition of kentledge made up of steel beam sections weighing 10 tonnes.

Two other smaller transfer beams had to be positioned using a similar method. The operation required careful planning and co-ordination with other contractors on site: first there had to be sufficient supporting structure to receive the beams, without obstructing for the crane's boom. The transfer beam on Bevis Marks could only be positioned using a smaller crane with the 500-tonne capacity Liebherr temporarily removed.

"The transfer beams were lifted in the two weeks between the Olympics and the Paralympics," says Skanska senior project planner David Abbott.

BEVIS MARKS DEVELOPMENT



CE marking: what you need to know

The legal requirement for CE-marking of construction products comes into force next month with fabricated steelwork to follow a year later. What does it mean for clients, consultants and contractors?

REGULATION
RUBY KITCHING

Starting from 1 July 2013, the Construction Products Directive will be replaced by the Construction Products Regulation.

This means it will be mandatory for all construction products covered by a harmonised standard or European technical assessment, such as a steel beam or column, to be CE-marked to demonstrate that it has been manufactured to a standard and set of procedures agreed by member states of the European Union and European Economic Area.

Essentially, this creates a common technical standard; a level playing field for safe, traceable and high-quality manufacture for all construction products used in EU countries.

Accordingly, if a product has been manufactured in Europe or outside of Europe, it will have to comply with the same harmonised standards before being CE-marked and placed on the European market.

For products manufactured outside of Europe, there are additional obligations such as sample testing.

A CE-marked product means:

- Systems are in place to assure the materials used for its manufacture are correct for purpose, have a traceable audit path and the product is compliant with its expected end-use.
- People involved with its manufacture are competent – the individuals have the knowledge and skills to do the job well.
- Equipment used in its manufacture is well maintained and calibrated (if necessary) with the required records in place.

"The good news is that manufacturers such as Tata Steel have been CE-marking their products for a number of years in anticipation of the regulations, so there won't be any shortage of supply for structural steelwork," says British Constructional Steelwork Association engineering director David Moore.

From 1 July 2014 all fabricated structural steelwork will also have to be CE-marked.

Part 1 of the CE-marking standard for fabricated structural steelwork, BS EN 1090, describes how components should meet the structural characteristics which make them fit for purpose.

Part 2 of the standard describes the fabrication requirements for these components to ensure adequate levels of mechanical resistance and stability, serviceability and durability.

Dr Moore says that 60 per cent of steelwork contractors, by tonnage, already have CE marking in place.

"CE marking is good for the industry, as we now have a clear, identifiable set of standards for fabrication"

STUART WATT, WILLIAM HARE

FACT BOX

- CE marking for all construction products will become mandatory in all member states throughout the European Union and the European Economic Area from 1 July 2013, and 12 months later (1 July 2014) for fabricated structural steelwork.
- There will be no disruption to the regular supply of fabricated structural steelwork from accredited sources.

  Many steel products, such as open sections, hollow sections, plates and structural bolts have already been CE-marked well before the 1 July 2013 deadline.
- All BCSA steelwork contractor members will be compliant with CE marking after 1 July 2014 as part of their membership audit. Many are compliant already.
- For detailed information about CE marking in steel construction, visit www.steelconstruction.info/CE_marking

Natural progression

Stuart Watt, quality assurance manager for steelwork contractor William Hare, explains that the arrival of CE marking in structural steelwork products this July and fabricated structural steelwork products next year is a natural progression for the industry, which has been working hard to have high standards of safety and quality in place.

"CE marking is good for the steelwork industry because we now have a clear, identifiable set of standards for fabrication which ensures that only certified and reputable companies are carrying out steelwork production."

BCSA member William Hare spent the 12 months leading up to 2010 reviewing every procedure involved in steelwork manufacture.

It was the first steelwork contractor to obtain certification for its factory production control system certified via the Steel Construction Certification Scheme (SCCS), allowing it to CE-mark its products.

"Certification shows clients that we are annually audited for what we do and training has been undertaken to demonstrate our engineers are qualified for the job," Mr Watt says.

He adds that, on the whole, the systems required by the standards were already in place at William Hare, but CE marking has added a further level of assurance, ensuring traceability in all processes.

Dr Moore adds that engineers, contractors and steelwork contractors should already be amending their specifications for fabricated structural steelwork to ensure only CE-marked products are used on their projects (see boxes above).

60% Steel contractors that already have CE marking

CE marking represents a clear set of standards for fabrication

CE MARKS: KEY DATES

These structural steel products used in construction from 1 July 2013 must be CE-marked:

Open sections (BS EN 10025-1)
Hollow sections
- Hot-finished BS EN 10210-1
- Cold-formed welded (BS EN 10219-1)

Plates (BS EN 10025)
Structural bolts
- Non-preloaded structural bolting assemblies (BS EN 15048-1)
- High-strength structural bolting assemblies for preloading (BS EN 14399-1)

Fabricated structural steel products used in construction from 1 July 2014 must be CE-marked
Fabricated structural steelwork (BS EN 1090-1)

WHAT A CONSULTANT NEEDS TO DO

Specify CE marking
The National Structural Steelwork Specification (NSSS) for Building Construction 5th Edition-CE Marking Version and *Model Project Specification for the Execution of Steelwork in Bridge Structures (SCI Guide P382) revised January 2012* incorporate the obligations of BS EN 1090-1 and - 2 on the steelwork contractor.

Specify correct Execution Class
This is the required quality of fabrication for the whole structure, individual components and details for each component. Classes 1 to 4 are quoted depending on the safety-critical nature of the structure and the appropriate level of quality control required within the fabrication process.

Execution Class 2 will be the appropriate requirement for the majority of buildings constructed in the UK. For a detailed walkthrough of what execution class to specify visit www.steelconstruction.info/CE_marking

WHAT A CLIENT/MAIN CONTRACTOR NEEDS TO DO

- Specify that all construction products must be CE-marked where appropriate.
- Appoint a steelwork contractor with an 'Execution Class' that is equal to that which is required for the project.
- When buying a product, check that the product's "declaration of performance" means that it is fit for your purpose.
- If a main contractor buys steel from outside Europe, even if it is CE-marked, the contractor becomes an importer – so will be subject to further obligations.

Market confidence

"Specifiers and buyers can be confident that all BCSA steelwork contractors will have all the CE Standard systems in place by 1 July 2014," Dr Moore says.

As the BCSA has made CE marking compliance a condition of membership, he adds that: "Selecting a BCSA member company will guarantee that the steelwork contractor has the necessary certification to comply with the CPR requirements.

"Clients and main contractors can, therefore, be confident in the complete supply chain - from manufacture of the steel sections and other products such as structural bolts, welding consumables and proprietary products through distribution to fabrication and erection on site."

Compliance requires that a steelwork contractor has been assessed by a notified body such as the SCCS and certified that it meets the required standard for factory production and welding.

Only then can the steelwork contractor CE-mark its products.

Dr Moore stresses, however, that while the CE mark ensures manufacturing quality and fitness for purpose, "you still need to check that the product is fit for your purpose".

"Specifiers and buyers can be confident that all steel contractors will have all the CE standard systems by 1 July 2014"

DAVID MOORE, BRITISH CONSTRUCTIONAL STEELWORK ASSOCIATION

www.steelconstruction.info_CEmarking

Mansfield's ride to regeneration

Mansfield bus station's striking design will not only improve public transport links, it will also set the benchmark for high-quality regeneration

PROJECT REPORT
RUBY KITCHING

Project	Mansfield bus station
Client	Nottinghamshire County Council
Architect	Nottinghamshire County Council
Main contractor	Kier Construction
Structural engineer	Nottinghamshire County Council/ William Saunders Partnership
Steelwork contractor	Caunton Engineering

When Nottinghamshire County Council began reviewing its bus stations in 2004, Mansfield bus station was quickly identified as one which needed modernising. The existing station, built in 1977, was looking tired and did not provide the facilities and access requirements that a busy transport interchange should offer in the 21st century.

"It was a product of its age," says Nottinghamshire County Council lead officer for the scheme Paul Horn. "With numerous steps, insufficient seating and cover, the bus station was fast becoming out of date."

But the bus station was attached to a car park and was also some distance from the town's railway station, so it offered very little in the way of integrating public transport in the area.

The council decided to step in, offering the bus station's existing location for retail development and shifting it towards the railway station to create a transport interchange, as well as a much-needed link between the railway station and town.

The new site is a former car park previously owned by Mansfield District Council. Connection to the higher level railway station is via a pedestrian link bridge (see box below).

The bus station scheme began in 2011 by redesigning the road junction to enable buses to turn. This work was designed and constructed by NCC Highways Department. Work on the main structure began in January 2012.

"We looked at designing the structure using timber, but the steel option came in cheaper. At a public exhibition, the steel design was also slightly more popular"

Quality ambition

At design stage, the council's aim was to create a safe, comfortable environment to stimulate more bus travel and create a benchmark for high-quality design in the area.

"We were looking for an airport-style building – something which felt light and airy and with clear sight lines to information desks and high-level screens," says Mr Horn.

With a nod to nearby Sherwood Forest, the structure comprises a system of tree-like steel support structures where the trunk-like columns are clad with stone from the Peak District, echoing the material used in an adjacent railway viaduct.

40
Column heads in the structure

SPECIAL BRANCHES

Each steel perimeter column ('tree trunk') of the building is a vertical cantilever with a set of stainless steel pinned connections at their tip to receive six 'branch members'.

These branches splay out from the column head at different angles and are also different lengths.

Pinned connections connect the ends of the branches to rafters in the undulating roof. Column lengths vary (the tallest being 8 m) due to the undulating roof design. In all, no two steel members on the 220-tonne project are identical.

"Modelling the roof was by far the most challenging part of this project," says NCC structural engineer Mike Wright. "The roof falls in three different directions and getting it to work was what you woke up in the morning worrying about."

Initially, a faceted perimeter roof beam was designed, he explains, but this did not give the sweeping curves that the architect envisaged, so curved beams had to be specified.

Erection involved building pairs of columns either side of the bus station first. Since the columns are fixed to ground beams, they could be freestanding, while temporary props were installed from column head to cross beams in the roof.

Three pairs of frames were built at a time to create two bays of the structure, starting from the two-storey end of the building.

When all six branches had been connected between column head and rafter on the first frame and steelwork on the subsequent two frames had been erected, props in the first bay could be removed and reused further along the length of the building.

Steelwork contractor Caunton Engineering had to design and fabricate bespoke connection details to locate and fix these members. "There are six pinned supports to each of the 40 column heads in the structure," says Caunton contract manager Adrian Downing.

"Each stainless steel connection is exposed and fits to lugs on a cranked cap plate [on each column]. Due to the roof geometry, no two supports are the same."

DELICATE OPERATION

The 73 m-long footbridge slopes down from a ramp in the train station to the bus station's second floor level, 3.15 m below. It is 3 m wide by 3 m tall and made up of twin vierendeel trusses consisting of circular hollow and square hollow section members.

Prior to this structure being erected, the bus station structure had to be built as well as two piers for support. One pier is located on the embankment of the adjacent railway and another on level ground.

To ensure the neighbouring railway's retaining wall was not undermined and to reduce plant loads on the embankment, a steel pile and steel column encased in concrete solution was chosen for the pier on sloping ground, while a concrete pier and foundation solution was adopted for the pier on level ground.

The bridge was fabricated in four sections and bolted together on site to create two 30-tonne sections, so that each could be lifted in turn by a single mobile crane.

Kier senior project manager Paul Williamson says that there was very little tolerance at either end of the bridge, making the lift operation that bit more nail-biting.

Nottinghamshire County Council principal project engineer (bridges) Mike Hawkings adds that since the bridge was designed to have three spans, but had to be fabricated in four sections and lifted as two pieces, extra checks had to be carried out To keep the weight of the bridge low during lifting, deck concreting was carried out after erection.

"We were looking for an airport-style building – something that felt light and airy and with clear sight lines to information desks and high-level screens"

"We looked at designing the structure using timber, but the steel option came in slightly cheaper," recalls Mr Horn. "At a public exhibition, the steel design was also slightly more popular."

Since the railway station is at a level 9.45 m above the ground level of the bus station, the 73 m-long link-bridge slopes down and connects to the bus station at second floor level, and at a height that allows buses to pass under it.

Station shelter

The bus station roof accommodates the change in height from single-storey shelter to two-storey building (with offices on the upper levels) via an undulating copper coloured, aluminium roof. It has meant that the branches of the tree supports are of varying lengths (see box above).

3 m
Width of footbridge

The bus station has still had to include a few steps and ramps to accommodate the change in ground level on the sloping site.

Mansfield bus station is the county's busiest bus station after Nottingham and sees more than 5 million passenger journeys per year. The bus station, which opened in March this year, will also house a café, toilets and retail units as well as room for 16 bus bays and six bays for parked buses.

Stonehenge gets more welcoming

The last piece of steelwork has been installed on the roof of Stonehenge's new visitor centre, and indicates how it sits in the Wiltshire landscape

PROJECT REPORT
RUBY KITCHING

Dignified, discreet and easily dismantled – these are the main themes of Stonehenge's new visitor's centre, located 2.4 km west of the ancient stone circle. The new, more spacious building replaces the current facility, which, English Heritage admits, is a "cluster of old and cramped visitor buildings".

Construction of the new building is part of a wider £27m scheme to create a more serene atmosphere around the site by relocating the existing visitor centre, parking and roads close to the monument.

"Construction of the visitor building is just one aspect in transforming what is widely agreed to be an unsatisfactory tourist and cultural experience," says Stonehenge director for English Heritage Loraine Knowles. "It is [now] fantastic to see the building taking shape and to see how well it sits in the landscape."

Designed by architect Denton Corker Marshall, the building is made up of a pair of 35 m x 35 m single-storey steel framed pods that sit beneath a gently undulating steel and timber roof clad with perforated zinc sheeting. A seemingly random arrangement of steel columns span between the ground and pod roof and canopy.

Project Stonehenge Visitor Centre
Client English Heritage
Architect Denton Corker Marshall
Main contractor Vinci Construction
Structural engineer Sinclair Knight Merz (SKM)
Steelwork contractor S H Structures

Gentle curves

"The roof gently curves responding to the gentle curves of the Salisbury Plains. Walking through the columns will be like walking through a series of trees, again referencing the surrounding landscape," says Denton Corker Marshall project architect Angela Dapper.

One pod is clad in glass and the other in sweet chestnut timber. The glass pod will house the café, shop and learning zones and the timber clad pod, which also uses structural insulated panels will house a 17.5 m long exhibition space, and toilets.

As early as March 2012, steelwork contractor S H Structures used information provided by structural engineer SKM and Denton Corker Marshall to develop a 3D computer model of the project. The model formed the basis of all subsequent drawing, detailing, material procurement, manufacturing and site installation. Digital information was exchanged between parties as the scheme design developed until the final model was signed off for construction.

Main contractor Vinci began work on the site for the visitor centre in July 2012.

Slender steel columns support the new visitor centre canopy

300
Slender columns that support the canopy

Sharp edge

"Steel was the obvious choice to minimise the thin depth of the canopy and achieve a sharp edge," says SKM project director Matt McNab. "The relative ease of bending steelwork also lent itself to the organic curved shape of the canopy."

He adds that the lightweight steel structure fulfilled the design brief that required that the building be easy to deconstruct as well as construct.

The choice of steel, says Mr McNab, "stemmed not only from a client's desire for a sustainable building but also for a building that could be removed leaving minimal impact on the landscape."

Raking 100 mm wide square hollow section columns provide vertical supports to the canopy. Their slenderness makes them much less visually obtrusive than larger sections, despite there being more than 300 supporting the canopy.

The main challenge for SKM was to solve the problem of lateral thrust in the structure from these raking columns. Stability was achieved using a variety of means without compromising the building's architecture and included using the moment capacity of fixed columns between pod roof and canopy.

The glazed pods gain structural stability from cross bracing, while the timber/SIPS pods require no extra bracing because the SIPS provide lateral stability. Other pod walls have cross bracing built into the wall thickness.

The lightweight roof canopy also required firm anchoring in the ground, explains Mr McNab. "The ground floor slab had been designed as a raft to minimise foundation excavations in the archaeologically sensitive ground. This provides the weight to resist the considerable uplifts generated by the canopy, which acts as a huge wing in the reasonably strong winds over Salisbury Plain."

Raking columns

The 35 m wide x 80 m long steel gridshell canopy comprises curved and straight 200 mm x 100 mm box sections and incorporates site-welded connections. Raking columns support the canopy and generally follow a 7.5 m by 5.5 m grid and mark out circulation routes around each pod.

S H Structures started on site in March. Erecting this vast canopy roof has been challenging – partly because of its size, but also because it required temporary support until the last piece of roof and column steelwork was installed. The canopy was erected using a full birdcage scaffold designed with strategically placed screw heads. These were surveyed and set out to achieve the required three-dimensional tolerances.

The roof erection sequence involved installing one complete gridline of raking columns, followed by propping each one individually and then lifting the roof members into place. Steelwork for the canopy roof arrived on site in 17.5 m long ladder truss sections. These curved sections were adjusted to meet the exact requirements of the roof geometry while temporarily supported.

Once this shape was achieved, the splices in the ladder trusses were welded together to create the canopy's undulating form. In-filling between ladder sections was completed by welding small secondary steel pieces into place.

"There are some 725 site welds within the structure joining the sections of primary truss and the steel grillage system within the roof," says S H Structures project manager Dave Poole.

Coordination between architectural and structural details has led to a much simplified set of rules for canopy erection; all the inclined columns have been located and pitched to penetrate the canopy soffit at either the corner of the cladding panel or the centre of the edges between panels.

With the building now topped out, fitting out has begun in earnest. The new visitor centre is due to open this December, after which existing facilities will be dismantled and the landscape restored around the stone circle. The transformation will be complete in summer 2014.

> **"The relative ease of bending steelwork lent itself to the curved shape of the canopy"**
> MATT McNAB, SKM

LOW-IMPACT DESIGN

Currently, the A344 runs uncomfortably close to the stone circle, so English Heritage's £27m Stonehenge Environmental Improvement Project also includes closing this route to the public from the end of June.

Parking areas will also be relocated near the new visitor centre 2.4 km west of the stones. The stone circle will be accessed via a shuttle service, which follows the existing route of the A344.

Currently, the A344 runs close to the stones and severs the ancient processional route to the monument

The project will remove the A344 and move the visitor centre and car parks 2.4 km away

IMAGES: ENGLISH HERITAGE

INSIDE STONEHENGE

Stonehenge in Wiltshire is one of the most important and popular ancient monuments in the world, attracting more than a million visitors every year. The site is a place of worship and celebration during the Summer Solstice each June.

Stonehenge started life as a simple earthwork enclosure and developed in several stages until the Neolithic period around 2,500 BC when the lintelled stone circle was erected. The tallest stone is 7.3 m high and weighs over 45 tonnes. The stone circle originally comprised 30 uprights, each weighing about 25 tonnes, capped by horizontal lintels weighing about 7 tonnes.

The 'Bluestones', weighing up to 4 tonnes each, came from the Preseli Hills in Wales, 240 km away. The site's interest lies in its many mysteries of how the stones came to be positioned and how it was used.