

TATA STEEL



Structural Case Study

BMX Stadium, Manchester

Product: Celsius® 355 Hollow Section

Client: New East Manchester Ltd
on behalf of Manchester City Council

Architect: Ellis Williams Architects

Structural Consultant: Doyle Consulting
Engineers Ltd

Main Contractor: Sir Robert McAlpine Ltd

Steel Fabricator: SH Structures

The Manchester BMX Stadium was built alongside the Manchester Velodrome and provides a major contribution to the city's successful National Cycling Centre. The striking BMX Stadium design incorporates an asymmetrically curved roof with an 80 metre clear span. The roof primary structure comprises an intricate series of 3.75 metre deep steel lattices. Tata Steel Celsius® 355 Hollow Section is used in the roof structure and in other new infrastructure at the site.





The new BMX Stadium and associated development represent a high-profile asset to the local Manchester community and the wider public. The covered stadium provides national competition standard facilities for use by the general public and elite sports competitors. It also incorporates facilities designed to maintain Manchester's place as Headquarters of British Cycling – helping to strengthen their aims to inspire cycling for sport, recreation and sustainable transport use.

The design of the stadium, with its landmark roof, meets all the criteria for a world-class indoor BMX track. The suspended roof provides safe headroom for BMX riders and ensures that the layout of the track can be re-configured if required. The immensely strong and stable steel roof trusses accommodate service walkways to a vast lighting system for television broadcasting.

The success of the stadium design is the outcome of close liaison between the design team, headed by Ellis Williams Architects (EWA). The team included Doyle Consulting Engineers Limited. Structural engineer, Chris Doyle, says the project presented "exciting structural design challenges".

Design requirements

A primary requirement for the new BMX Stadium was flexibility for the routing of the BMX track. The EWA-led design team developed a clear span roof solution – with no need for fixed, mid-span columns - to achieve full flexibility of future BMX route re-alignment. The BMX track is primarily of earth-bunded formation on a hardcore base and can be reconfigured easily. The initial configuration of the track was a replica of the London 2012 BMX track. Soon after its completion in 2011 the Manchester BMX stadium was used for training by the British Cycling BMX team in advance of the Olympics.

The stadium's asymmetrically curved roof is 100 metres long and has an 80 metre clear span east to west over the BMX track and

public viewing gallery. It extends as far as seven metres beyond supporting columns at west and east elevations. The roof height varies from 20 metres at the west elevation to 13 metres at the east. The height is dictated by the viewing gallery headroom requirement at the western edge of the stadium. To the east, the height reflects the requirement to reduce visual impact on nearby Bank Street housing whilst maintaining the minimum clear BMX performance headroom.

Strength and stiffness

The roof primary structure comprises a series of 3.75 metre deep, curved profile, triangular-section steel lattice trusses at 8.5 metre centres. Tata Steel Celsius® 355 Hollow Section is used in the lattice structure and in a building constructed to link the BMX Stadium with the adjacent Manchester Velodrome. Celsius® 355 Hollow Sections are supplied with a minimum yield strength of 355N/mm² and comply fully with the European Standard for hot finished structural hollow sections, EN10210:S355: J2H.

The lattice roof trusses have twin 219mm x 12.5mm circular hollow section (CHS) top compression booms and a single 273mm x 14.2mm CHS bottom boom with 139.7mm x 8.00mm webs. The strength and stiffness of the primary lattice trusses is augmented by a pre-stressed suspension cable system.

Chris Doyle says: "The triangular lattice form was adopted for its good inherent lateral stability. It has the additional major advantage that it readily accommodates a system of service walkways giving access to the high-intensity lighting system demanded by HD television broadcasting requirements. Each 80 metre-span lattice truss supports approximately 1.5 tonnes of lighting equipment in addition to normal dead, imposed and service loading.

"The lattice top booms directly support the Tata Steel 'Kalzip' roof cladding. A further advantage of the triangular lattice form was that we were able to reduce the decking span



to 5.5 metres due to the three metre separation of top boom members in the 8.5 metre lattice truss centres."

The suspension system comprises three pairs of cable assemblies supported by masts that are 35 metres high. The cable back-stays are anchored using 200 tonne capacity, pre-tensioned rock anchors at a depth of 50 metres. The suspension cables develop an axial load of some 500 tonnes in each supporting mast. The mast leg configuration, in conjunction with the mast profile, provides the required strength and stability whilst maintaining a slender elevational profile.

"The BMX Stadium, associated link building and the various external works structures presented exciting structural design challenges. Success of this project is very much attributed to the very close and long-standing working relationship between all principal design team members. Doyle Consulting Engineers is proud to have been a team member in this process and to have contributed to this successful and iconic development."

Chris Doyle, Doyle Consulting Engineers Ltd.

Celsius® 355 Circular Hollow Section contributes to a successful design



Steel fabrication

The 80 metre long, triangular section roof trusses were fabricated in four sections by steelwork contractor, SH Structures. The intricate and attractive form of the roof structure has a major visual impact on stadium users and immense care was taken with fabrication and erection.

"We used a company called Angle Ring to bend the roof structure tubes into their curved shapes as they are a market leader in this sort of work," says Barry Peel of SH Structures. He adds: "We carried out a full trial erection of the roof trusses at our workshop in Leeds before the four sections were transported to Manchester."

The sections are pin-jointed together for aesthetic reasons and to aid speed of assembly on site. The decision by SH Structures to make all connections 'in the air', using carefully-planned crane sequencing, enabled rapid erection and minimised site obstruction.

Says Barry Peel: "The external masts at the stadium were erected prior to the roof structure, with all pinned joints locked temporarily for the construction phase prior to cable tensioning. The roof structure was self-supporting during installation so was not reliant on the external masts and cables for support."

"The steel roof sections were lifted into position using four mobile cranes. Lifting points were located by calculation of the centre of gravity to ensure that each section was lifted into position in the correct orientation. Following erection, the external cables were attached to the masts and roof trusses and tensioned in a pre-determined way to ensure that the masts and roof achieved the correct line and level."

Superstructure modelling

The complete stadium superstructure was modelled for structural design and analysis purposes using non-linear, finite element analysis software. Apart from analysis of the final 'in service' conditions, this modelling facilitated staged analysis of the complex and changing structural form during the various erection and suspension cable stressing stages.

The completed BMX Stadium is visually striking – both inside and out – in addition to providing top-class facilities for BMX riders and the viewing public. Along with the Manchester Velodrome, built previously as part of Manchester's bid to hold the Olympic Games, it provides an outstanding home for British cycling in the 21st century.

"It's very gratifying to know that our steel has played an important role in the creation of such an exciting building. I was lucky enough to tour the BMX Stadium shortly after its completion. The complex, steel lattice form of the roof is extremely impressive. The excellent aesthetics, proven quality and versatility of Celsius® 355 Hollow Section have contributed to this successful design."

Peter Stokoe, Tata Steel Technical Advisory Engineer.

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