Made to measure for big moments, and modify after

London 2012 Olympic Stadium

The Stadium that recently hosted key sporting events and the opening and closing ceremonies for the London 2012 Olympic Games was developed via a bespoke design approach around an innovative use of permanent and temporary structures designed to accommodate up to 80,000 spectator seating capacity during, and 28,000 after the Games.

For the designers this was a real challenge as the first time the conversion of a stadium on this scale had never been attempted. It meant ensuring materials and components are relocatable, reusable and recyclable wherever possible.

The seating bowl section largely houses the 25,000 permanent seats in the lower tier with a temporary section for 55,000 in the upper tier. The single most important design decision was to remove the majority of spectator facilities from within the stadium and relocate them in self-contained pods around it.

Pulling the facilities out of the main body of the stadium enabled the scale and mass of the stadium building to be dramatically reduced and lower the embodied energy of construction, whilst enabling all to fit the island site with sufficient circulation throughout, whereas a conventional Olympic-sized stadium would not.

The engineers closely interrogated the serviceability requirements for the seating structure and a design was created with a natural frequency below default values recommended by standard industry guidance enabling significant carbon savings. The result is a project with only about an eighth the carbon intensity of Beijing's Olympic stadium.

Light and limber design

The project called for the structures above podium level to be demountable and the design became a lightweight steel solution with bolted connections. An arrangement of trussed rakers was conceived by the engineers to address the loading and spatial aspects of the architecture.

The influence of the steel fabricators was important in refining the setting out to its absolute maximum for best repetition of components for fabrication and erection. The value engineering aspect of the geometric optimisation needed to be introduced into the design process early as changing the setting out any later would have meant a lot more redrawing.

The overall geometry of the structural frame was delivered by the designers to the fabricator by 3D models without the need for detailed dimensional drawings. Assembly was carried out in fabrication yard jigs.

The overall concept allowed the number of concourses to be reduced from the North, South and East stands for a simple 'raw' building surrounded by lightweight pods on the podium. By contrast, the West stand needed to house a number of coordinated spaces and intermediate floors and was conceptualised as a simple kit of beams and columns with stability provided by the main stadium steelwork.

The cantilevers of the leading edges of all upper tier stands were around six metres. At the West stand the leading edge cantilever

supported a composite floor above the middle tier terracing. A series of vomitory stairs from the podium slab to the upper levels was formed of conventional steel sections and precast steppings.

A 'twisted wrap' of 25-metre wide and high fabric panels spans the stadium building's outer perimeter. The engineering solution was conceived for the fabric to span horizontally onto vertically inclined stressed cables, fixed at their bases at podium level and attached to the steelwork of the upper tier at their top ends.

The roof was designed with the minimal optimised number of elements by employing straight cables with 112 flat PVC panels. A major loading consideration was for the roof structure to support the massive sports arrays required to illuminate the field sufficiently for high definition TV and photographic coverage. The A-framed 12-metre high cage-like structures containing the lights each sit on 30-metre high columns that in turn sit on the main tension ring of the cable net.

The sports lights, access stairs, landings and walkways, power supplies, cabling and lighting were designed, detailed, integrated and built into the structural assembly on the ground with a single lift for each intact tower structure and services.

Global stability of the lighting towers is provided by two sets of cables; circumferential cables around the stadium which restrain the towers toward the playing field, and radial cables attached to the perimeter compression truss restraining the towers the other way.

The lighting towers were engineered to each support one of the lighting rigs and additional simple A-frame steelwork was designed to be connected to the compression ring to provide a set of supports for a second independent rigging system for conducting ceremonies. The upper structure connections are all bolted to allow for demountability. The truss lacer connections were formed of simple bolted joints with bolting positions carefully arranged.

Precision fabrication

The necessary accuracy of construction required that the designers discussed the needs of the connections with the fabricators and tight tolerances were specified for the length of individual members and the angle of the end plates.

Crucial were the fit of each element of the segments, the fit of each segment to another and fit of the final segment of the 'whole ring'. The fabricator proposed and developed a methodology with the chord members fabricated in a continuous run in the workshop with each segment being fabricated slightly oversize and the 'pipe flange' bearing connections machined to fit with the previous segment following a survey of the previous end plate.

The first fabricated segment was kept in the factory and used for the fabrication of the last segment to ensure correct fit up of all pieces. The jig was reproduced in the centre of the site so that the pieces could be reassembled to their desired geometry and checked again onsite before lifting.

PROJECT TEAM

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London 2012 Olympic Delivery Authority

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Steelwork Contractor:
Watson Steel Limited

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