

2012 Olympic Velodrome, London, UK

Expedition Engineering, London, UK



The Velodrome is a world-class venue which intelligently answers questions of function, beauty, sustainability, buildability and value. Inspired by the dynamism and geometry of the track and the engineering rigour of high performance bikes, the truly integrated design and construction team set out to design a building that makes no distinction between architecture and engineering.

The Velodrome has been very well received by the Client and also by the legacy operator and cyclists. With cycling at its core, the building is a combination of simple technologies which cumulatively have produced an exciting, elegant and innovative building.

It starts with the cycling...

The 6000 seat London 2012 Velodrome will serve as an Olympic and Paralympic stadium for track cycling during the Games. In legacy use, it will take its place as the centrepiece of the VeloPark, a unique community cycling venue that will provide pleasure and employment to generations of Londoners and visitors from all over the world.

Responding to the seating below, the roof is lifted gently over the seats and pulled down elsewhere, forming an elegant and ultra-efficient curved roof. Around the sides, the façades are pulled in around the seating bowl, creating a dynamic timber-clad façade. This ensemble appears to float over a glazed band splitting the upper and lower tiers - flooding the stadium with natural light and providing dramatic views inside and out.

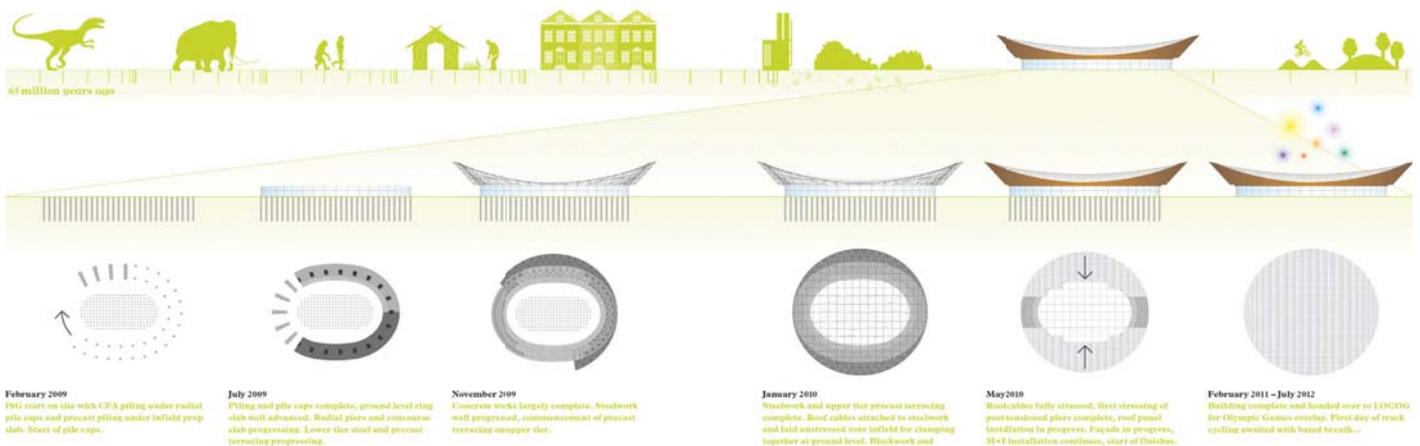
...and develops principled curves...

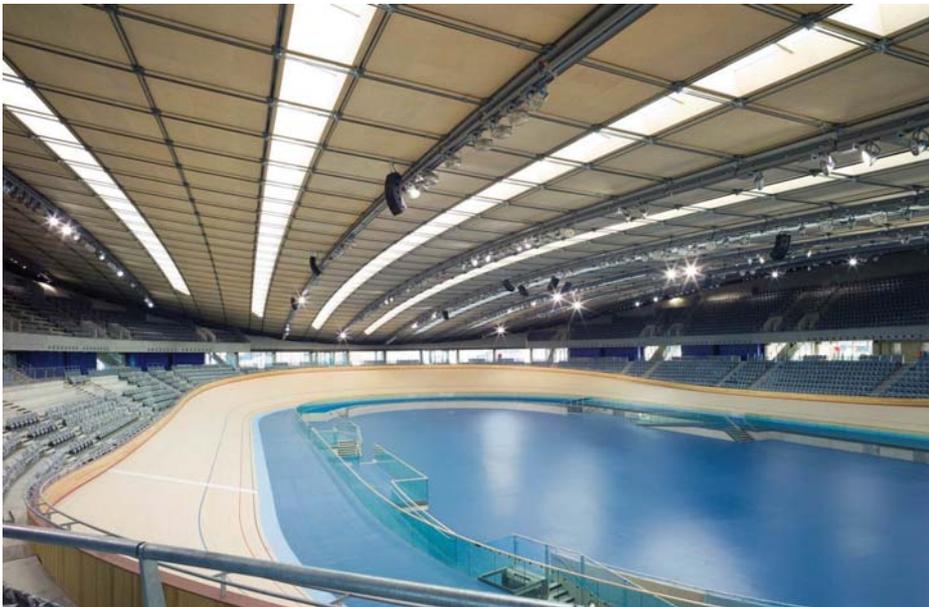
The 13,000m² roof is supported by a doubly curved cable net, formed from 36mm diameter cables stressed between a perimeter ring beam. Unusually for a cable roof, the perimeter ring beam is integral with the curved steel supporting 'bowl' in order to take advantage of the strength and stiffness of the whole structure: much of the cable forces are transferred around the bowl and down to a series of post-tensioned concrete piers, these resisted by the concourse ring slab, foundations and cross-propped through the infield slab.

This integral approach generated savings of approximately 1,000 tonnes of steel worth some £4m and some 3,000 tonnes embodied CO₂.



Looking like a crisp, and as lean as Lycra, the Velodrome is the first finished London 2012 venue. It deserves a gold medal! - The Sunday Times





SEI Data Block

Owner:
Olympic Delivery Authority
Structural Design:
Expedition Engineering
Architect:
Hopkins Architects
Contractor:
ISG

Concrete(m³): 4500m³
Structural Steel(T): 800 Tonnes

Dates of design and construction:
Competition win 2007 – Completion February 2011

To achieve these savings, much more was required from the structural engineers. Being a fully integrated structure – from roof to foundations – the building is structurally indeterminate and so the interplay of stiffness was critical for example, in determining the roof shape and cable tensions. Many structural variables were carefully investigated, leading to an upper and lower bound stiffness analysis for the building. We were suitably humbled when the centre of the roof was surveyed as being within a few millimetres of our estimated position: pure luck obviously!

...created through innovation...

A number of innovations run through the design and many of these relate to the structure.

The Velodrome required a highly insulated roof leading to the need for rigid supporting roof panels. We developed a novel articulated roof cladding system based on prefabricated timber cassettes, ensuring that all 1,050 cassettes had appropriate tolerances to deal with the flexing of the roof under a wide range of loadings. Rationalising the individual panel shapes into 13 primary panel groups was one of many challenges along the way.

The phenomenon of crowd induced vibrations is well known and usual practice is to keep relevant frequencies above 3.5Hz. To comply would have required 400 tonnes of additional steelwork to raise the fundamental frequency from 2.3Hz. Instead, we were one of the first to use the IStructE's recently published guidance on human-structure interaction to justify the performance of the building: again showing that engineering innovation can save materials and cost.

...without excess baggage...

According to London 2012's "Learning Legacy", the Velodrome is an excellent example of a building that has optimised the use of materials, and minimised the environmental and social impact of the materials that were used.

The venue is recognised as being the most sustainable on the Olympic Park, and has been described by the ODA Head of Sustainability Dan Epstein as "the shining beacon of sustainability. It is incredibly resource and energy efficient".

...delivered safely by design...

Health and safety considerations were paramount during design and construction with buildability very much on the agenda during the design stage. All elements above the in-situ concrete floor slab were prefabricated to improve speed, cut down on waste, and improve quality.

The desire to reduce working at height was a significant reason for opting for a cable net roof. The cables were laid out at ground level, clamped together and safety netted. Only then were the cables jacked up into position: without any temporary works and completed in just three weeks.

The results of good design and a well-managed project have been recognised through several health and safety accolades and in achieving over 900,000 hours on site without a reportable accident.

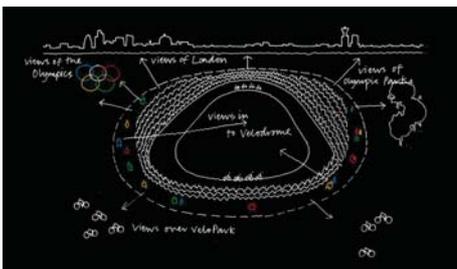
... And ends with the team

The Velodrome is testament to the success of Client, Design Team and Main Contractor collaboration and has been delivered on time and on budget. Hailed as an exemplary project with innovation at its core, the building is a combination of simple technologies and cutting-edge analysis which cumulatively have produced an exciting building with cycling at its centre.

Structurally, the key lesson the team has taken on board for subsequent projects is when working in the realm of innovation make use of testing, prototyping and specialist experts as appropriate to give confidence and reduce risk. This approach led us to consult with specialists in the fields of dynamics, cable net analysis and undertake hydraulic prototyping and testing. This contributed to producing a seamlessly integrated building, innovative in its structural and environmental performance.

In awarding the Velodrome the IStructE Supreme Award the judges commented that the Velodrome has "a sense of rightness that is a rare but undeniable quality. A gem that demonstrates outstanding creativity and uniqueness in its combination of the art and science of engineering".

Ultimately, the building would have been very different had it not been designed and built in a truly collaborative team with all designers and contractors providing suggestions and solutions to all hurdles. For the structure, the relationship between architect and engineer was never so strong or so excitingly blurred, a bit like Sir Chris Hoy on his final approach to the line in July 2012.



The Velodrome successfully hosted the Olympic test events in February 2012, with a series of new world records being set on the track. At the time Sir Chris Hoy commented that the Velodrome is "magnificent, better even than it looked on the drawing board"

