Close work caps pro footy field with clever canopy

Melbourne Rectangular Stadium

The incorporation of a 'bioframe' roof to shelter most spectators within the soon-to-open $268 million, 31,000-capacity Rectangular Stadium is already turning heads in Melbourne.

The iconic new structure is Victoria's first purpose-built stadium for soccer and rugby league football games.

Arup Project Leader **Frank Gargano** said the 'bioframe' roof fulfils the client brief of providing rain protection over 80 percent of seating, whilst the structure's efficiency significantly reduces the embodied energy with the steel tonnage required about 50 percent less than a traditional cantilever roof.

"The design and construction team worked within a virtual 3D environment from early concept stage right through to construction which cut design process considerably and any redesign work could be rapidly turned around," he said.

"Structural design integrity was maintained by virtue of all parties using the same source information."

He said that many of the optimisation routines and structural analysis techniques were pioneered and refined on such projects as the 'Watercube' for the 2008 Olympics in China, and Heathrow Airport's 'T5', using parametric modeling to quickly generate complex geometry and compare different forms.

Arup worked with Cox Architects and Planners right from the competition phase to develop an iconic form. Sensitivity studies were undertaken to find a balance between structural requirements and aesthetics.

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"The 'bioframe' roof is very much an engineering solution that provides not only a highly efficient structure but one that is also visually exciting," Mr Gargano said.

"The unique 'bioframe' roof is a true three-dimensional structure supporting load using a combination of shell, arch and cantilever actions.

"No single shell is self-supporting and this allows many members to be engaged in sharing the load to achieve structural efficiency."

Nevertheless, that integrated approach made construction more complex. The principal contractor, Grocon managed the fabrication and construction.

As Executive Project Manager from Grocon, **Steve Richardson** explained, the construction phase of the project adhered to a number of guiding principles to simplify work onsite.

"It was most important to have safe and stable primary access platforms for all works including cladding, water proofing, drainage, lighting, maintenance access requirements and a number of other services that are required without using secondary steel propping system," he said.

"We also aimed the largest possible steel sections to be pre-fabricated off-site that could be delivered via road and employed bolted connections to limit onsite welding and painting."

The steel roof was fabricated at three different sites with a fourth fabricator supplying the terrace steel using a similar approach, and was brought to the site at night and craned into position.

An expectable tolerance was engineered at each connection in conjunction with the secondary support system that allowed for the flexibility to control the impact on the steel due to the temperature changes throughout the year.

"Another guiding principle was to pre-assemble sections together on the ground to maximise cranes and stem the need for a secondary support system from the primary access level when fitting up section to section."

Each 'shell' section of the gigantic canopy is connected to the concrete at only two locations.

"The design for the connection between the roof and concrete called for a construction tolerance in the range of plus or minus up to two millimeters," he said.

"Therefore we used our working platform to hang the roof form over the top and build the concrete up into the connection which is made up of reinforcement bars from 12mm to 40mm, plated steel beams, purpose-made Ancon couplers, steel billets, 60mm /110mm bearing plates and machine finish clamps to hold a 300mm diameter machined steel ball.

"The 300mm steel ball is connected into the primary roof steel and laterally supported by a 100mm diameter pin within the raker head of plated box beams that the precast seating plates sit on the terrace steel."

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The three-dimensional nature of the roof frame also presented challenges for the structural analysis as a full 3D model needed to be built in order to represent the structure true dynamics.

There are over 4000 primary structural members in the roof and Arup's in-house optimisation software was used to determine the minimum size required for each member and therefore reduce total tonnage of steel. Provisions were also made in the overall stadium and roof design to ensure sufficient air circulation will be achieved.

A number of studies were undertaken for the playing surface, such as sunlight modeling to ensure adequate light reaches the whole pitch.

As **Jonathan Gardiner** from Cox Architects explained, the stadium had a primary functional brief for the provision of facilities for hosting world class rectangular football codes, such as Rugby League, Rugby Union and World Football with spectator seating to be as close to the action as possible.

"Structural steel is integral to the design of the stadium and there is no other comparable material to steel for use in lightweight long span structures," Mr Gardiner said.

He said that the design process between the architects and engineers allowed for the curvature of the 'bioframes' shells themselves to provide the depth of structure.

"The finished roof uses a hybrid structure of shell, cantilever and arch support across the length of the building," he said.

Parametric modeling allowed the architect and engineer to refine the design to suit the architectural intent, structural requirements and optimisation of each member and connection.

"Each nodal point has been specifically designed for the load it carries," Mr Gardiner said. "The precision of the steel roof structure and connections to the concrete bowl required close coordination between all design, fabrication and assembly teams."

Currently the project is on time and on budget.

* Photographs 1 and 4 courtesy of Peter Glenane/Major Projects Victoria July 2009. Photographs 2, 3 and 5 courtesy of Marcina Productions/Grocon.

Project Team

Client: Major Projects Victoria

Architecture: Cox Architects and Planners

Structural Engineering: Arup

Consulting Engineers: Norman Disney & Young

Builder: Grocon Constructors

Steel Fabrication: GVP Fabrications, Haywards Steel Fabrication and Construction, Australian Iron, Eliott Engineering

Steel Detailing: PlanIT Design and Logistics, Bayside Drafting

Steel Supply: BlueScope Steel, OneSteel, Orrcon