Big West soon to welcome a very moving venue

Perth Arena

Structural steel smarts are enabling construction of Perth's world class indoor sports facility complete with a huge retractable roof and highly flexible stage and seating facilities.

Expected to be the 'jewel in the crown' of Perth's central entertainment precinct once complete, the new venue will be able to be configured from a more intimate, 3000-seat concert mode up to 12,000 seats for sporting events and 14,000 for concerts.

The Perth Arena project is an investment by the Government of Western Australia in new social infrastructure. The facility when complete in late 2011 will be owned by VenuesWest on behalf of the State Government. Project delivery is the responsibility of Strategic Projects, a business unit of the Western Australian Department of Treasury and Finance.

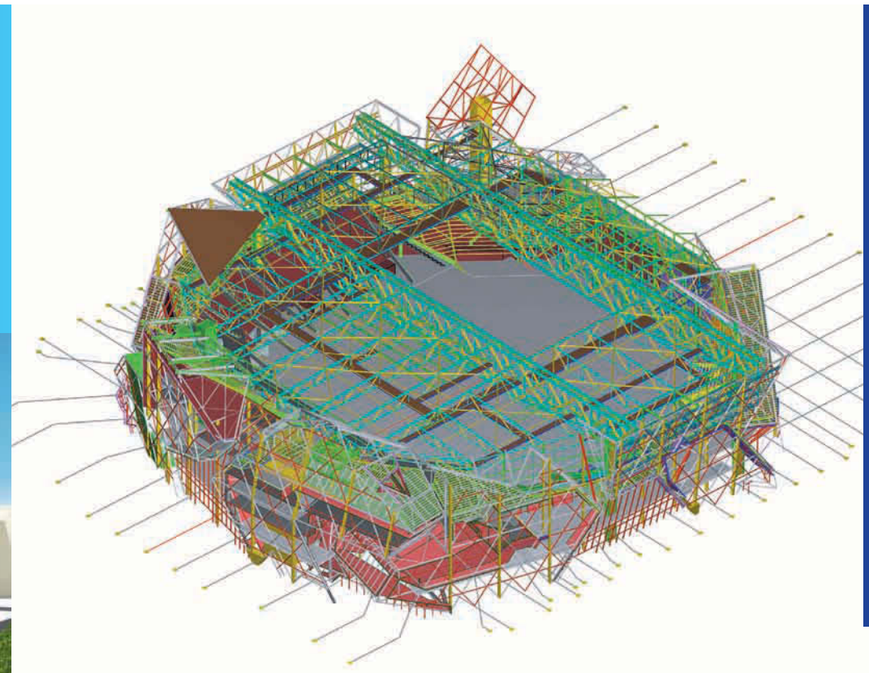
The building will comprise a basement level carpark, ground level plaza, a five-level superstructure housing tiered seating, hospitality and corporate suites. The northern elevation will house a demountable stage with retractable seating, and tiered seating on the east and west elevations. The roof will span over the bowl and include a massive retractable centre section.

The superstructure comprises a combination of precast concrete columns and walls, in-situ concrete and structural steel columns and structural steel floor beams with a metal decking infill slab. The tiered seating areas are supported off structural steel box beams which support precast seating plat units of various sizes and profiles.

According to **Howard Raggatt**, Design Director from Ashton Raggatt McDougall (ARM) that jointly designed the arena with architects Cameron Chisholm and Nicol, the initial spark came from the Round House in Fremantle (1831).

"A one-time prison but now iconic attraction, the 12-sided Round House reminded us of all the Ideal City diagrams of history, and then of the Eternity Puzzle as another amazing 12-sided icon," Mr Raggatt said

The arena roof structure is a matrix of complicated and unique truss systems comprising two mega trusses which span over the whole bowl area. The mega trusses are supported by four mega structural steel columns encased in concrete. The mega trusses support both fixed and moving portions of the roof over the bowl and the east and west tiered seats. They span 115 metres and are 132 metres long, 10 metres high and two metres wide.



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Lead Structural Engineer with Aurecon, **Nalean Lal** said that the mega trusses are a critical element of the design.

"They each weigh 2.6 tonnes per metre length and are required to support the moving roof panels as well as rigging loads from concerts and performances," he said.

"They are pre-cambered 300mm at mid-span. Standard pre-cambering techniques couldn't be used for such a large truss size so we specified the pre-cambers to be fabricated into the mega trusses. This involved the top chord being fabricated larger than the bottom chord, thus creating the curve of the pre-camber."

The striking and irregular façade forms come from the elements of the Eternity Puzzle. It is comprised of an aluminium composite panel cladding system over a triangular structural steel frame that is self-spanning and supported by precast concrete façade columns which have cast-in structural steel plates incorporated into the precast modules.

"The complex geometry of the structural steel superstructure, in particular the façade, posed unique challenges in the development, analysis, design, documentation, and shop detailing process," Mr Lal said.

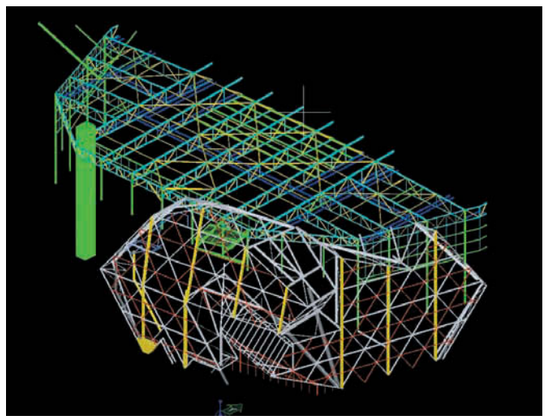
"Collaborative Building Information Modeling (BIM) using 3D software between the architect, structural engineer and steel shop detailer has been a key feature in effectively responding to the challenges.

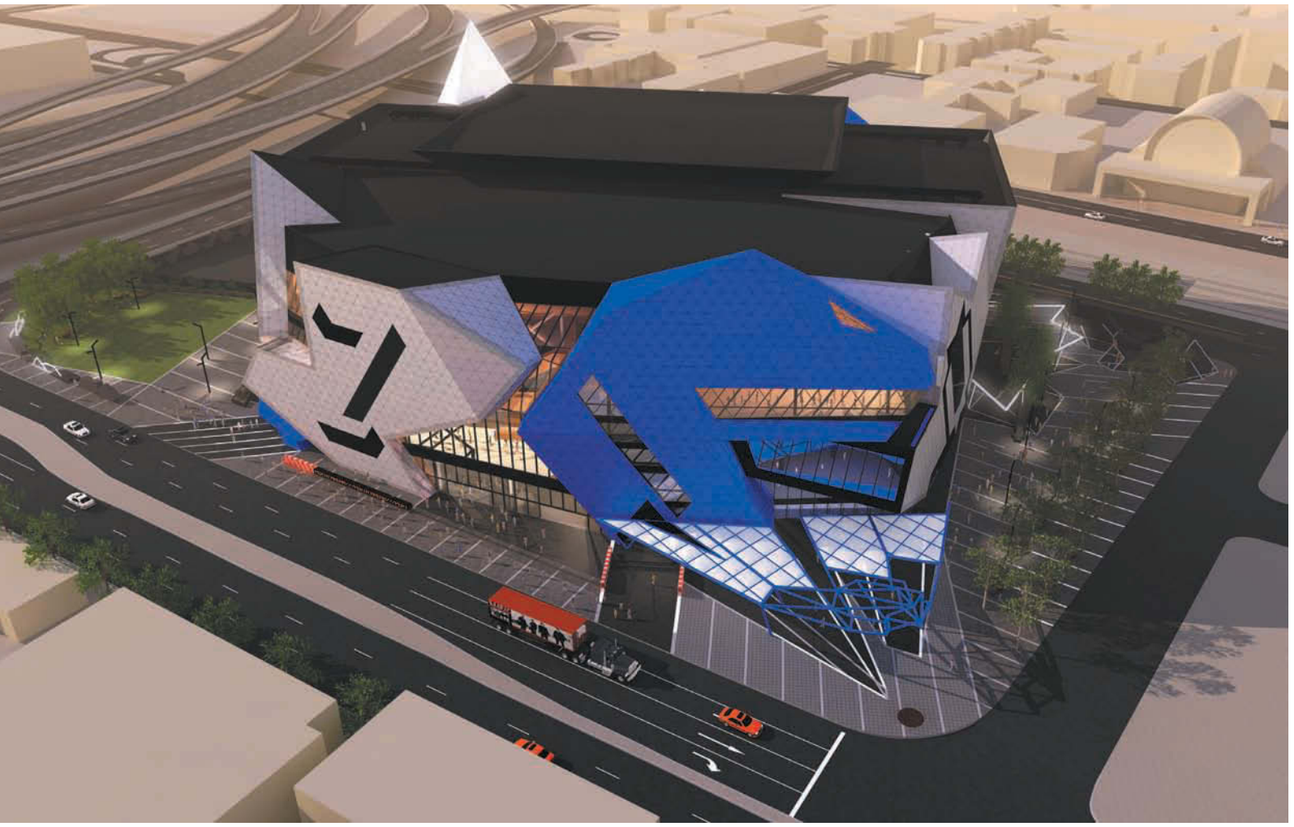
"We used various analysis programs including *Space Gass and Strand7*® and then used *ProSteel* to model and document the structural steelwork. This was overlaid with the architectural model that was prepared using *Rhinoceros*® 3D modeling software during the building form development process and later on for coordination of the structure and building envelope."

"Those models were then used as the base to assist in the shop detailing process. Subsequently, during the steelwork shop drawing review phase, CAD models provided as *Autodesk AutoCAD* and *Navisworks* files by the steel shop detailer have been overlaid with the architectural and structural models to review and coordinate the steelwork.

"This approach provided significant benefits to the project, both in terms of time and the quality of information being provided for fabrication and construction of the structure."

The floors consist of steel beams with concrete slab-on-metal decking. Composite action is utilised to control the dynamics of the floor.





BGC Construction commenced work on the project in June 2007 on the site framed on three sides by major roads and Perth's rail network at the rear.

Site Manager, **Ray Daly** of BGC Construction said that in order to save time during construction, major roof elements were identified as a key area where off-site production could reduce erection timeframes on site.

"The bowl roof is designed as a combination of mega trusses which support two fixed roof structures and two moving roof structures," he said.

"The engineers identified areas along the truss where splice connections could be located. This allowed each truss to be broken down into segments which could be pieced together onsite.

"These segments were further broken down into bottom chord, mid chord and top chord sections."

He said that the east and west fixed roof areas have been designed with primary and secondary truss sections with round hollow section braces and universal beam sections spanning between the trusses.

"The moving roof sections have adopted the same design philosophy as the fixed roof, except the primary trusses are bolted to bogies which are mounted onto rails on the top cord of the mega trusses," Mr Daly said.

Every truss section on the roof was detailed in order that sections of the truss were pre-fabricated off-site. Delivery of the individual truss sections was coordinated to arrive on site and assembled on the ground prior to being lifted into position.

The incorporation of an operable roof into the design of the roof structure is a first in Western Australia for an events facility and presented many challenges to the design team.

"One of the fundamental criteria for an events facility of this nature is to ensure visitors to the Arena experience the same visual experience no matter where they are seated within the venue," he said. "That means clear sightlines from every aspect which transforms into big spans and no vertical support within the bowl area."

BGC Construction decided to build the roof structure on the ground and then jack the roof into position in order to save time on the construction process. A total of 2200 tonnes of steelwork was lifted into its final position.

"This in itself is not a unique idea except for the massive size of the roof structure and employing this construction methodology has taken months off the construction program," Mr Daly said.

The roof elements were broken down into segments, pre-fabricated and stored off-site whilst the basement was still under construction. Building the roof off the ground floor suspended slab reduced erection and rigging times in terms of access to the structure and temporary propping of elements off the ground floor slab.

Time is also saved as the roof structure is able to be built in parallel with the southern superstructure and the northern elevation of the building. Once the roof is jacked into position the truss sections from the southern fixed roof brace the mega truss sections against lateral movement and create the clear open space below in the bowl.

The movement of the cranes required to erect the huge structural members were carefully planned to ensure it did not overload the ground floor slab. Temporary propping designs where established for various size cranes so the entire slab area was propped to take the loading from an 80-tonne mobile crane and the ground slab area contained within the bowl had propping designed to take the loading from a 200-tonne crawler crane.

All the hydraulics for the jacks were synchronised and the data from each jack fed back to a central computer.

In order to prevent the mega trusses from buckling, the moving roof sections have to be placed in their half open/closed position, thus restrained along bracing lines.

The structural steel package was assigned in three components. The first was contracted to Cays Engineering responsible for fabricating the main building structure including the superstructure floor steel, the southern fixed roof and all the catwalks. The second was contracted to Park Engineering for the structural steel associated with the bowl roof structure, the mega truss, the fixed and moving portion of the roof and the box beams to the bowl. The final component was awarded to Scenna Constructions who handled coordination of the overall structural steel package as well as fabrication of the traveling equipment and the façade structural steel.

Coordination of the shop detailing and fabrication drawings by Steelplan enabled all three fabrication yards to make the structural members required for different areas of the building at the same time.

Mr Daly said the decision to use structural steel as the primary building material for the superstructure has benefited the project in many ways.

"Building in the traditional method of in-situ concrete would prove both costly in terms of time and money as all the complex geometry associated with the design would mean that hundreds of 'one-off' moulds would have to be manufactured in order to achieve the unique shapes incorporated into the design and the sheer mass of the concrete units would have created logistical challenges for delivery and craneage onsite," he said.

"Designing the fabrication of trusses into manageable segments has lead to increased productivity onsite through shorter assembly timeframes and reduced costs in terms of plant and equipment.

"The other bonus is that we do not have endless tonnes of individual structural steel members lying around the site. The structural steel members are easily transported and handled onsite and there is very little propping required because of its material characteristics.

"This all results in clear open areas which allow other contractors access to their area of work and earlier roughing in of services."

Project Team

Owner: Government of Western Australia

Operating/Client Agency: VenuesWest

Project Delivery: WA Department of Treasury and Finance (Strategic Projects and Building Management and Works)

Architects: Ashton Raggatt McDougall and Cameron Chisholm & Nicol, with RTKL

Structural Engineers: Aurecon

Project Management and Contract Administration: Appian Group

Builder: BGC Construction

Onsite Erection: Perth Rigging

Steel Detailing: Steelplan

Steel Fabrication: Cays Engineering, Park Engineering and Scenna Constructions

Protective coatings: International Paint