AUSTRALIAN EQUINE + LIVESTOCK CENTRE

ARCHITECTURAL STEEL DESIGN AWARD 2010 (NSW + ACT)

- HIGHLY COMMENDED

s² Corporation, Healey Castle + Associates, Timothy Court + Company

Architectural merit

The Australian Equine and Livestock Events Centre (AELEC) utilises energy reducing clear span solutions through the innovative use of a long span steel truss system. This $30m project included a Main Arena to ultimately seat 5000, stables for up to 700 horses, and a covered Stud Selling Centre with seating for 660 which also doubles as a horse warm-up area on event days, as well as truck and camping facilities for at least 195 vehicles.

The sweeping curved forms of the complex are coupled with streamlined structural members to create sleek, elegant forms with large column-free spaces.

s² were responsible for the steel design, engineering and construction methodology for the Main Arena (60m span), the Stud Selling Centre (42m span dome structure) and six stable buildings (25m span each). s² devised and supervised the various erection procedures utilised on site for each of the three main elements of the project, and also provided stressing and grouting services to ensure correct implementation of the technology.

The project represents new steps in the innovative use of steel in delivering outcomes right through the project lifecycle that would not be achievable with other materials.

Structural design concept

The design for all three main elements of AELEC incorporates sound engineering principles of the past with new tools available to engineers today. The structural design of the dome was determined using a "string line" model to simulate the self-weight of the dome, in much the same way as domed structures were designed in the early 18th century. The form of the string in tension was mapped and inverted and this was the shape to which the dome was built. The tension in the string line was then measured in order to establish the thickness of the dome.

The three main AELEC structural elements incorporate a similar design process, using the string line to size members in structural steel and to determine the amount of force with which to pre-load the structure. These members and the string line were then modelled using sophisticated software to calculate the loads in the members and the deflections of the structure. In practice, the string line physically exists as a post-tensioned cable system and is loaded to the calculated forces by hydraulic stressing. This pre-loads energy into the structure before the application of external forces. Key reasoning behind this design concept was to deliver unique architecture to the entire precinct, with uniform arch and dome geometry defining the visual landscape as well as enhancing operational elements within the structures.

Efficient use of steel products

AELEC's unique post-tensioned truss system is detailed using simple joint plates, "half moons" and end plate connections. All lengths are simple curves or straight members, easily bolted together on site. This means that while large truss elements were produced, all members are easily transported and erected using relatively light lifting equipment. Simple extrusions allowed for rapid installation of the 3 main structural elements, as well as delivering numerous downstream advantages such as reduced in-ground works and reduced assembly area requirements.

Practicality in Fabrication and Erection

In creating a vast, column free work environment on time and on budget, s² developed a highly efficient construction methodology. As it was essential that earthworks and concreting works for the seating bowls and pedestrian areas were completed as early as possible, s² designed the 60m main arena roof trusses to be assembled in pairs adjacent to the main site, fitted with purlins and stressed before being rolled down the completed pedestrian areas on a purpose built 'roller' skates and finally lifted into position by crane. This procedure delivered significant programme advantages as assembly works and concreting could take place simultaneously. Truss members were designed to be prefabricated in 12m lengths which could be easily transported and assembled on site. Truss sections were bolted together and erected on temporary props. There was no onsite welding required.

Once in assembled position on the ground, stressing strand was fed through the bottom chord of each main truss and stressed to precise loads. Stressing ensures the structure remains "active" for its lifecycle without the traditional "dead weight" structure controlling the building's force and deflection. Similar ground based assembly methodology was employed on the dome selling centre and stable buildings, bringing construction efficiency right through the project lifecycle. This methodology resulted in significant cost and time savings, keeping the project in line with budget and an extremely tight construction programme.

Innovation in the use of steel

s² believes that the post-tensioned solution for AELEC is the first of its kind in equine events space in the world. Longer spans create a suite of unique and significant deflection control issues to overcome, both real and perceived. Through its innovative use of post-tensioning, s² was able to 'tune' AELEC such that its deflection control exceeds Australian Codes. A further, unique feature of this genre of structure is the ability to confirm its computed structural performance from analysis in the field, through load measurements on the hydraulic jacks. This can be predetermined to be the largest load the structure will undergo. The structure is therefore actually proof tested during the construction process.

The post-tensioned solution and its resulting reduction in weights of steel, combined with a unique work methodology had a significant impact on the overall cost of the project. s² believes this to be a unique contribution to the quality of the work through the procedures used and compliments quality assurance programmes and documented procedures. The solution outlined is unique in its philosophy to store energy in the structure.

Design Efficiency

The concept of stored energy resulted in a significant reduction in the tonnage of structural steel required for the AELEC project due to the degree of deflection control provided by the stressed composite structural form.

The post-tensioned steel solution resulted in an approximate saving of up to 40% in overall steel weight when compared to a conventional design of the same span, a critical issue impacting on both fabrication and the assembly process.

The entire project – over 22,000m² of covered space – used only 430 tonnes of steel. This represents an average steel weight of under 20 kg/m²; a remarkable result considering the spans and performance criteria.

Specifically, the largest member sizes (generally Grade 450) were column legs at 200x200x8.0 SHS, while the majority of the project's 60m main arena roof truss top and bottom chords were made up of 150x150x6.0 SHS and 125x125x4.0 SHS respectively. The 42m dome selling centre comprised majority top chord members of 125x125x4.0 SHS and bottom chord 100x100x3.0 SHS, and the 6 x stable buildings majority top chords 125x125x5.0 SHS and bottoms 100x100x6.0 SHS.

Corrosion protection

The main structural element of the roof sections on all three elements is the post-tensioned cable system, encased within square hollow sections and grouted. This ensures long term internal corrosion protection as well as fire protection. A cost effective paint system appropriate to the local environment was developed to protect all exposed steel.

Summary

Through the reinterpretation of a classic structural modelling technique combined with cutting edge 3D visualisation software, s² have created a streamlined, economical structure utilising slender structural steel elements. The structures of the three pavilions have been designed to reflect the individual requirements of each space, testing the boundaries of elegant long span design.

Project team

Architect:	Timothy Court + Company
Structural Engineer:	s² corporation
Detail Engineer:	Healey Castle + Associates
Head building contractor:	National Build Plan
Steel distributor:	Australian Tube Mills
Steel fabricator:	Belmore Engineering
Steel detailer:	3D Specialists
	SD Drafting
Coatings:	Akzo Nobel