Five hectare roof beats weather, open below

Livestock Centre, Muchea WA

A canny structural steel approach to a huge open canopy structure without sidewalls has created the largest dual species stock handling facility in Australia.

The new facility at Muchea 50km north of Perth replaced the historic Midland saleyard after 100 years of operation.

It comprises 86,300sqm of hardstand area for loading and unloading of stock trucks and parking and a 52,000sqm steel framed undercover livestock facility with supporting infrastructure. The centre has a servicing capacity for 120,000 cattle, 1.5 million sheep and up to 20,000 calves per annum.

The main structure consists of a 260m long by 200m wide lightweight roof covering the entire saleyard complex. Columns were required to be as small as possible to minimise impact on pens and gates and to avoid bruising of livestock.

Arthur Psaltis, Managing Director of Pritchard Francis, the project's civil and structural engineers said that a number of roof profiles were investigated.

"A sawtooth roof varying in height from five to seven meters with a five degree pitch was determined to be most efficient in covering such a large area and most appropriate to accommodate functional requirements of the facility," he said.

"The sawtooth roof design produced a number of benefits including the effective use of natural sunlight to lower power consumption and much better air circulation for more effective noise attenuation, animal odour control and heat dissipation."

The 5.2 hectare roof structure was completely constructed from structural steel due to its high strength and stiffness and relatively light weight as well as its versatility of construction and suitability to the sawtooth profile.

"The sawtooth arrangement allowed the roof structure to be divided into nine segments and a steel post and beam frame was determined to be the most simple and efficient support system," Mr Psaltis said.

"Pen layouts were typically based on a three metre square grid and therefore dictated locations of structural roof columns. A number of column arrangements were considered to find the optimum frame design solution."

Each sawtooth canopy structure comprises two 12m bay spans with an intermediate column. Frames were typically spaced at 9m centres.

Lateral stability in the north-south direction is provided via a sway frame through interaction between columns and beams.

Stability in the east-west direction was analysed by initially considering columns cantilevering from their base.

"However the columns were found to have insufficient bending capacity to resist the ultimate lateral wind loading condition. Vertical bracing to ground was problematic as it would interfere with pen layouts and be obstructive to saleyard operations," he said.

Stability in the east-west direction was ultimately achieved by utilising the 2.0m deep steps in the roof which was selectively braced via rod cross bracing in some areas. This solution created a 'portalising' effect enabling the required lateral capacity to be achieved without increasing column sizes or impeding saleyard operations.

This solution allowed for repetition and standardisation of connections to be adopted into the design to achieve maximum economies in fabrication. Simple connection details were generally used and those in rafters were located at points of minimum bending moments to simplify connection detailing.

Careful consideration was given to steelwork detailing to ensure compatibility with standard transport and handling requirements with simple onsite bolted connections typically used to facilitate the onsite handling and erection process.

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Z450 grade purlins were sourced from the eastern states with the entire amount of coil required to ensure commitment to the tight construction program.

Pritchard Francis engaged the University of Western Australia to build a roof model and undertake wind tunnel testing. A 1:100 scale model of the saleyard roof structure was built using profiled cardboard and tested in the UWA Boundary Layer Wind Tunnel.

"Experimental results compared well with the more realistic combination of peak plus mean addition of friction and pressure from the requisite Wind Code, AS1170.2 with a variance of 14 percent. The total horizontal wind force obtained from testing was 51 percent less than that calculated by adding peak uplift and peak drag pressures in accordance with the Code," Mr Psaltis said.

Results from wind tunnel testing led to the dead plus live load combination becoming the governing design load condition. Bending moments for this condition were carefully assessed with the provision of deeper structural steel sections over internal columns to cater for higher bending moments. Within the span, bending moments were much less and a smaller section size suitable to resist these moments was provided.

The open and organic nature of the structure's function required special consideration of protection systems to be applied to the steelwork.

Structural steelwork was hot dip galvanised with a coating mass of 600g/sqm to cater for potential corrosion from animal activity and also abrasion due to potential rubbing and knocking of steel columns by them. The base of steel columns was painted with two coats of high build epoxy and concrete encased to avoid direct contact with moist woodchips, animal urine and faeces.

Due to infrequent wash down of purlins, a more durable coating was provided by specifying a Z450 coating class to all external purlins, specified with a down turn purlin lip to reduce retention of general detritus material and moisture condensation on the bottom flange.

Structural steelwork enclosed and not exposed to the weather reverted to traditional protection incorporating a Class 1 sandblast with one coat of Red Oxide Zinc Phosphate.

The steel intensity for the saleyard structure, including steel columns and roof sheeting was approximately 10.5kg/sqm. The refined design that resulted from wind tunnel testing produced a cost saving to the client of approximately $750,000.

Project Team

Architect: Ferguson Architects
Structural Engineer: Pritchard Francis
Head Building Contractor: Cooper and Oxley Builders
ASI Manufacturer: OneSteel
Steel Fabricator: Metrol Lintels Steel
Steel Detailer: Metrol Lintels Steel