



## ■ Elegant curved steel arches roof of the Sydney Wildlife World

Located on the eastern side of Darling Harbour the recently opened Sydney Wildlife World adds an iconic landmark to the Darling Harbour foreshore. The urban zoo is an extension to the facilities at the Sydney Aquarium. The wildlife park has been created to accommodate Australian wildlife in as natural an environment as possible to give short stay Sydney visitors exposure to the unique Australian fauna and flora.

Designed by a joint venture partnership between Misho & Associates and Rihs Architects, the unusual building sits on an unusual site. It was designed as part of a detailed and lengthy competition between the joint venture and much larger practices. Misho's work on the Sydney International Airport Terminal had drawn both attention and acclaim and was a

factor in the client's selection of architect. "The design brief was to produce a building that would attract attention and excite the imagination, curiosity and emotion about what was inside, while complementing the Sydney Aquarium," Misho told steel Australia. "The site plan was incredibly difficult with half the building on land and half over water. What was needed was something that was organic, yet within a very tight budget."

First briefed seven years ago the original client was the Sydney Aquarium Corporation Limited which morphed into the Sydney Attractions Group. With a change of chief executive and chief financial officers, the organisation went through changes and growth, as did the design development for the building.

*The long, low, unobtrusive lines of the Sydney Wildlife World on the foreshore of Darling Harbour preserves the view for the hotels and businesses on the western side of Sydney's central business district.*

# The arches take shape



The original design presentation, to the Sydney Harbour Foreshore Authority, was made in May 1999, but approvals for the project took several years. Multiple government departments had to consider the sensitivity of the site and other issues before the project could be approved. The building contract was awarded in April 2005 with project completion in September 2006.

Constructed over two levels, the building is in two sections and flows back from its waterside location above Darling Harbour. The load is carried by the main concrete slabs which form the base of the structure. These had to be strong enough to not only support the roof but take into account the wet weight of the soil - 1000 millimetre depth of soil was needed for the large trees to take root

The iconic lines of the light weight steel arch are the visible part of the building above ground level. It is a curved light weight structural steel frame with 35 arches, constructed from tubular circular hollow sections (CHS), hot dip galvanised and coated, topped by an almost transparent fine stainless steel Zoomesh.

The design for the arches was flexible in width and height, varying in height from 10 to 20 metres to allow full size trees to be incorporated into the exhibition. The structure is evocative of the outside environment and has been designed to draw people in. Approximately 45 tonnes of steel went into the project.

The client's need for a light, unobtrusive structure presented a challenge. The inspiration for the roof structure was from an organic arch but the inspiration on how to achieve it was drawn from the skeletal frame of a python. During the design phase Misho saw the skeleton on a visit to Sydney's Taronga Zoo. Observing the python's skeleton, Misho reflected on the way the snake's frame was flexible enough to accommodate a swallowed kangaroo and, once devoured, return to its original size.

Misho said that: "The steelwork is based on a parabolic curve which is a self supporting structure. The idea was to keep the structure as thin and transparent as possible so that the emphasis is on the animals and the flora."

Universal Fabric Structures (UFS) was contracted in March 2004 to develop the design concept. Jethro Jones, UFS's Projects Director said that; "It was our job to take Misho's unique concept and make it work."

"We used an S<sup>2</sup> solution for the arches and they were responsible for engineering the steel frame. S<sup>2</sup> are experts in clear span structures and had to convert the concept into a practical building solution that was easy to fabricate and assemble while still achieving the architectural intent."

"S<sup>2</sup> designed a very efficient structure, the bulk of the arches being made up of 219 millimetres CHS. On the city side

where the structure spans in excess of 40 metres the arches had to be increased to 273 millimetre CHS," Jethro said.

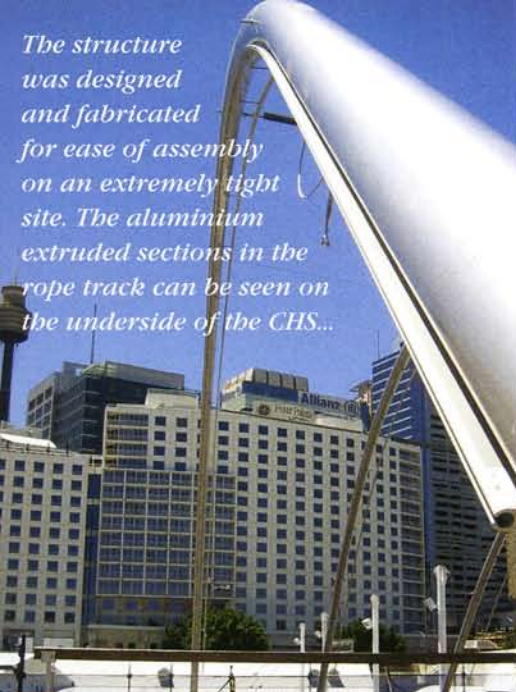
The lightweight steel beams fan out from a re-entrant corner on the south side of the main animal enclosure. Each arch has a different radius and is in sections of 219 and 293 millimetre CHS. The total combined length of all arches is 1280 metres. The structure has been engineered and patterned to ensure that the Zoomesh is in tension over every surface area of the structure.

"Each arch is unique. The steel geometry was carefully modelled and discussed in numerous design meetings. Some arches actually share the same radius but appear unique, achieved by varying the pitch and length of straight CHS at the beginning of each arch," Jethro said.

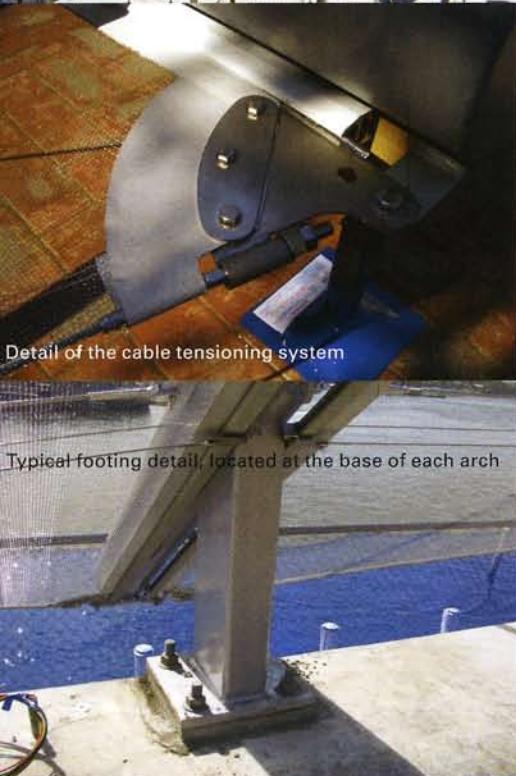
The final design, with its clear spans ranging from 27.8 up to 46.2 metres, evolved through a number of design phases. Dean Gavrilovic, Senior Consultant for project managers TSA Management said: "Once the client saw that the roof structure could be built with clear spans and no interruption to the viewing sight lines they were ecstatic."

UFS conducted extensive research and development on the Zoomesh, putting the mesh in a wind tunnel to determine the wind drag coefficients. UFS also completed detailed stretch testing to determine the required amount to compensate the mesh



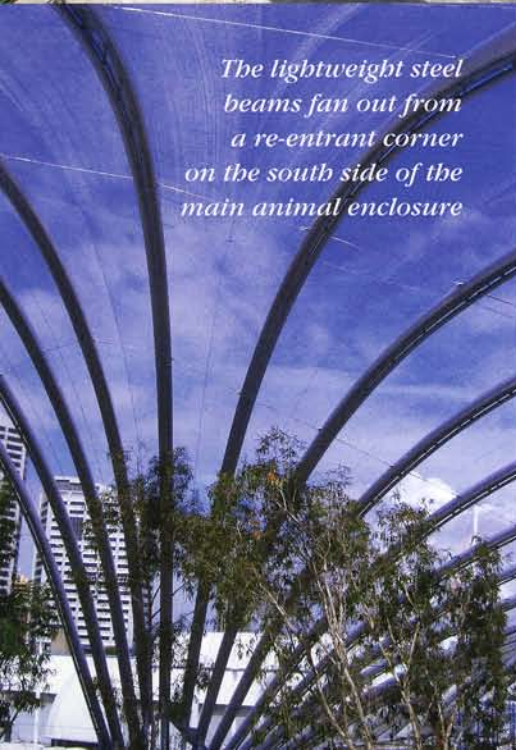


*The structure was designed and fabricated for ease of assembly on an extremely tight site. The aluminium extruded sections in the rope track can be seen on the underside of the CHS...*

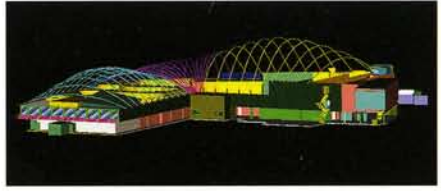


Detail of the cable tensioning system

Typical footing detail, located at the base of each arch



*The lightweight steel beams fan out from a re-entrant corner on the south side of the main animal enclosure*



when patterning. At this point UFS built a prototype of the structure before the designs were detailed and fabricated. Wade Consulting detailed the structural steelwork in AutoCad, creating a 3D model from which all the parties could work.

Jethro said: "We imposed very stringent quality control measures during the steel fabrication process, our steel fabricator, Steel Structures Australia, did an amazing job delivering perfect curved geometry in accordance with the shop drawings. We completed the steel installation with our own riggers along with sub-contracted riggers from DMG Engineering. We supervised and managed the entire installation of the steel and Zoomesh in-house . We applied Tensile Fabric Structure technology to the mesh, fixing it to the underside of CHS at 1 metre centres using our own custom aluminium extrusion."

Misho said that the UFS people were fantastic. "They understood the simplicity of the structure and the parabolic curve, which needed to be braced naturally. Jethro Jones and his team were key to realising the simplicity of the structure."

The structure was designed and fabricated for ease of assembly on an extremely tight site. Access to the site was complicated by its location close to Darling Harbour pedestrian walkways, local business, hotels and restaurants.

Once the roof arches were up and the Zoomesh stretched and fixed, crane access into the site would no longer be possible, so the construction sequence was more than usually important on this project. The site has to be built up with soils two metres deep to take the large native trees which form the animal habitat. The soil was pumped in and the tree installed by cranes. Most of the trees average two to eight tonnes with a maximum height of 10 metres.

Despite the congested and restricted site and coordination challenges, erection went according to plan. Dean Gavrilovic

said he was impressed by the way the steelworkers went about the work with an almost perfect installation process. The steelwork has been designed to take extra loads to support workers for repairs and maintenance.

Nine ecosystems are simulated within the facility. These range from semi arid grassland to a lush rainforest. There is a butterfly sanctuary and invertebrate exhibition space through to a wallaby escarpment and an aviary.

The enclosed walkways are ramped and extend for a kilometre, giving visitors viewed access to the exhibits through glass. The experience has been designed to simulate total immersion in nature without disturbing the animals.

The Sydney Attractions Group has invested around \$45 million in the project which was opened by the New South Wales Premier, Maurice lemma, in September.

**Project Team**

**Client:** Sydney Attractions Group  
**Developer:** Sydney Attractions Group  
**Project Manager:** TSA Management

**Architects:**  
Misho & Associates in association with Rihs Architects

**Engineers:**  
Robert Bird - Structural  
S<sup>2</sup> corporation - Steel frame

**Builders:**  
Lucas Stewart

**Roof Design and Construct Contractor:**  
Universal Fabric Structures

**Steel Fabricator:**  
Steel Structures Australia

**Steel frame and Zoomesh detailers:**  
Wade Consulting

**Design Consultants and Zoomesh fabrication:**  
Fabric Shelter Systems - New Zealand

**Protective Coating:**  
Industrial Galvanisers - Brisbane  
IMP Coatings - Sydney  
Wattyl - polyu 400 Metallic