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7. Expo '88 Shade Roofs and Feature, Brisbane (Australia)

Client/Owner:	*World Expo '88 Authority*
Architect:	*Bligh McCormick*
Structural Engineers/ Designers:	*Harald Muehlberger/ IPL, Radolfzell, FRG and Maunsell & Partners*
Fabricator:	*Carl Nolte GmbH, FRG*
Contractor:	*Thiess Contractors P/L*
Total Floor Area:	*30,000 m^2*
Maximum Height:	*50 m*
Diameter:	*120 m (individual structure)*
Construction Period:	*15 months*
Completion of work:	*September 1986*

World Expo of '88 in Brisbane will be among the highlights of Australia's 200th birthday celebrations. It will be staged from 30 April to 30 October 1988. The site is the south bank of the Brisbane River overlooking the city centre.

'Leisure in the Age of Technology' is the central theme of the Expo and will show achievements in technology, electronics and communication and leisure towards the year 2000. The architectural brief called for a unique striking 'roof' over the Expo site aimed at capitalising on the tropical environment of Brisbane while allowing a high degree of flexibility on the ground below the roof.

The very short design/construction schedule was of crucial importance as the huge shade structures had to be erected first, 16 months prior to the event, in order to allow sufficient time for construction of all pavillions and facilities underneath. Only 15 months were available for the contract with initially 5 months programmed for design which had to be extended to 7 months due to architectural modifications to the original site plan. Within only 8 months 45,000 m^2 of coated fabric was fabricated into the structures in the Federal Republic of Germany, shipped to Brisbane and erected on site.

Structural System and Constructional Design

The prestressed membrane structures consist of 7 semi circular tent like structures up to 120 metres in diameter and covering a total ground area of approximately 30,000 square metres (Figure 1).

The structures are supported on 5 masts (3 of which are inclined) 30 to 50 metres high. At the perimeter inclined tubular bi-pods, tri-pods and X-shaped pods support the membrane at a height of approximately 15 metres. From the mast heads steel cables, with sockets and fittings to accomodate for tolerances and stressing requirements, span to the perimeter supports. Tiedown cables with pulling points on the membrane are fixed to aerial points or to nodes close to the mast. The membrane consists of a PVC-coated polyester fabric Type IV Tensile strength 150 kN/metre in both directions.

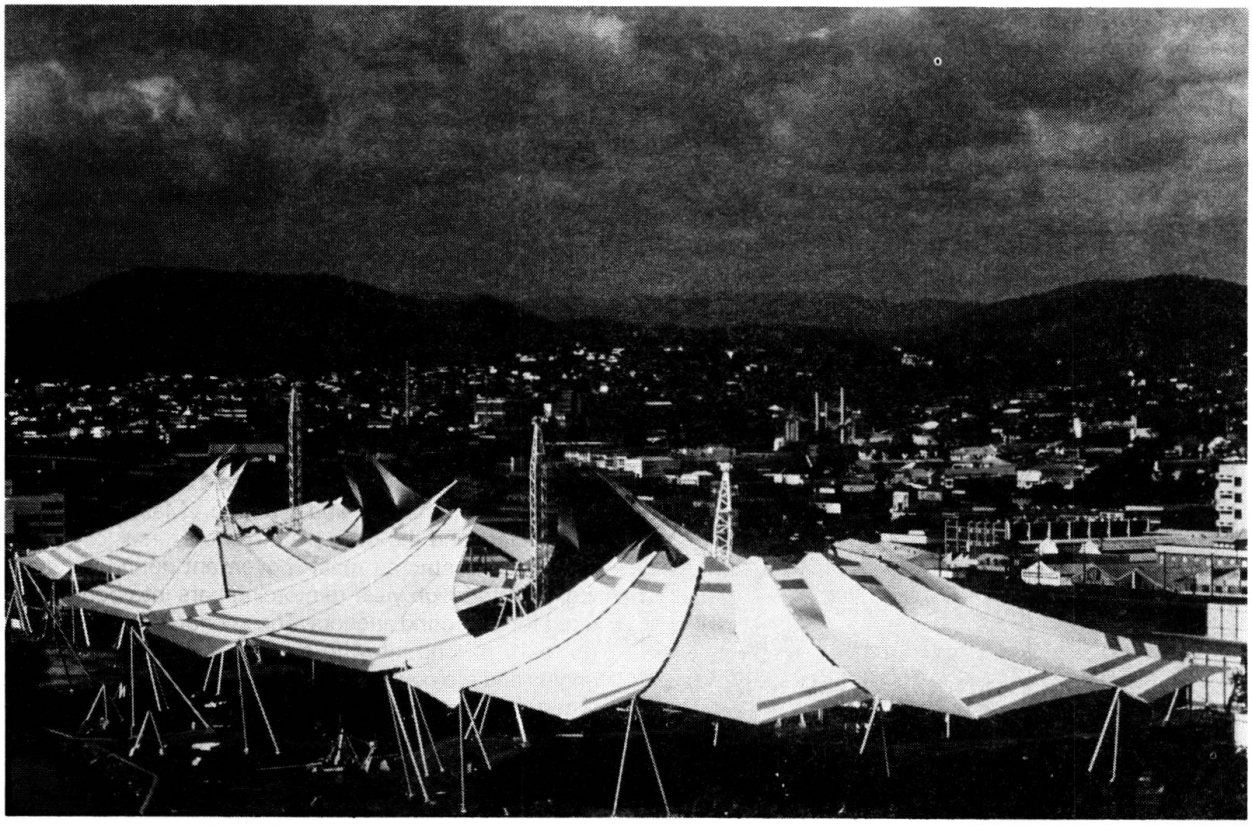

Fig. 1 Overall view of the shade structures

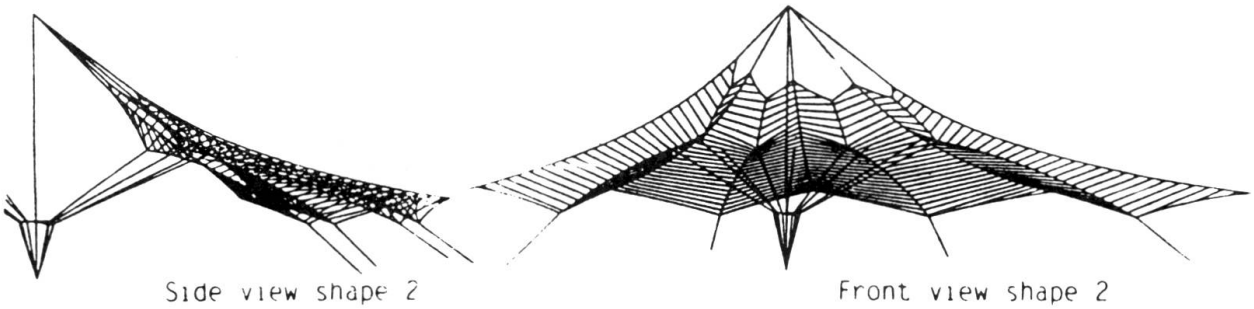

Fig. 2 Shape of one of the Structures

There are two characteristic types of shapes:

Shape 1: radial ridge- and tiedown cables supported from an inclined mast and leading to perimeter masts and valley points. The fabric panels are being prestressed between the ridge and boundary cables on one side and by the valley cable on the other side which drops to a low valley system point at the outer perimeter and to an aerial node below the central masthead system point and is tied back to the main anchoring point of the mast as well as to the mastbase.

Shape 2: also ridge and tiedown cables, however, the tiedown cables have an internal negative tie, which connects to the mastbase of the main centremast underneath the fabric (Figure 2).

All centre masts have systempoint heights between 30 and 50 m, with perimeter high points of 15 m height and low point system heights of approximately 11 m. The masts and the surrounding steel structures are supported by precast concrete foundations due to the poor substrata conditions on site. To resist the uplift forces piled foundations were driven into bedrock and stressed by rock anchors drilled 10 15 metres into the rock strata through a central void cast into the pile.

Due to the occurence of cyclonic winds, high windloads had to be catered for and windtunnel tests were conducted on rigid models. Computers were used extensively for the analysis, shapefinding and patterning.

Erection

Planning and execution of erection was the most crucial task of the project. To avoid damage to the membranes during erection, extensive weather investigation was required prior to erection. The erection was designed to allow for shortest possible overall risk in the sequence of erection. Therefore, the masthead design was changed to adopt a 2-parted design, a separate masthead detail with a welded on masthead detail which would connect in a drop-in-procedure with the separate masthead detail. The membranes and steel cables were erected in up to 11,000 m^2 sections and were lifted using 150 tonne and 90 tonne mobile cranes plus 25 tonne winches and truckmounted cherry pickers to the top of the central masts which had previously been guyed into position (Figure 3). The membranes were initially stressed by bringing the surrounding supporting steelwork slowly from an inwardly inclined to an outwardly inclined position.

The design and construction of prestressed membrane structures on this scale was new to Australia. The whole project cost was approximately A$ 6 million.

(Vinzenz Sedlak)

Fig. 3 Raising the membrane for one of the structures