Lakeside Joondalup Shopping Centre Great Space Roof Structure

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ABSTRACT

Lakeside Joondalup Shopping Centre is the major regional shopping centre servicing Joondalup City north of Perth. The centre is due for completion in October 1994.

The central feature of the centre is the 3500 sq.m. Great Space. The 5500 sq.m.Great Space roof overhangs the Great Space in plan and rises from a height of 9 metres at the edge to 27 metres at the central peaks to create a spectacular effect.

The roof comprises 32 PTFE Hypar fabric panels stretched between specially fabricated steelwork supported at the perimeter and on 4 internal columns.

The paper discusses the ways in which each of the different hypar shapes were created by cutting sections through one standard ”square” hypar, the extensive use of scale models as well as other design, fabrication and erection aspects of the project.

1. BACKGROUND

Joondalup City, located 20 km north of Perth, is one of the fastest growing regions in Australia. Lakeside Joondalup Shopping Centre, which is due to open in October 1994, and situated on a 22.47ha site, is an integral part of Joondalup City.

Stage One of the shopping centre comprises 2 supermarkets, a discount department store and in excess of 100 speciality shops with a gross area of approximately 46000 sq.m. and a net lettable area of 29,500 sq.m.

The focus of the centre is the ”Great Space” which is essentially ”triangular” in plan. The great space roof structure has a base measuring approximately 150m x 70m and rises from 9m to 27m in two 9–metre lifts. Elevations of the centre taken 6 months prior to completion are shown in Slides 1 and 2.

2. ARCHITECTURAL CONCEPT

The Joondalup Shopping Centre Master Plan was originally developed in 1989 and has always included a large fabric roof. Several schemes were investigated at the conceptual design stage and included tent structures, flying mast structures and dome arrangements. However after producing scale models of the ”better” schemes the multiple hypar concept was decided upon. The final form was determined with the assistance of a full 1:200 scale model of the full roof structure.

One significant factor influencing the choice of a multiple hypar system as opposed to a large tent structure was the perception that in the event of significant fabric damage, repairs could be effected with the removal of one ”small” panel that would not excessively impact on the centre’s ability to trade.

The roof is shown schematically in Figure 1 and comprises 32 individual fabric hypars supported by a series of straight steel edge beams. The hypars involve four basic shapes:

(e) ”Square Panel”: this panel is square in plan and has 3 ”low” corners and 1 ”high” corner. The panel has a plan area of approximately 200 sq.m. and rises approximately 9 metres.

(f) ”Triangular Edge Panel”: this panel is triangular in plan and is formed by cutting a diagonal section through the ”square panel”. Curvature in the panel is maintained by providing steel fabricated to arch along the diagonal.

(g) ”Saddle Panel”: this panel is square in plan with 2 ”low” corners and 2 ”high” corners and is formed by placing two ”triangular edge panels” together.

(h) ”Mall Entry Panel”: this panel occurs at each of the 4 Mall entries and is a variation on the ”Triangular Edge Panel” and is formed by taking an off–centre diagonal section through a square panel.

The concept of cutting sections through the standard ”square” panel has allowed the Architect to achieve all the shapes required for the building from one form. The different fabric shapes are shown in Slide 3.

This also achieved economies in the patterning and fabrication processes.

3. FABRIC DESIGN

Due to the client requirement to tender the project without nominated subcontractors, initial designs to check the fabric profiles and determine the loads applied to the steel supporting structure where conducted by Connell Wagner.

For the large area of fabric involved, there was an opportunity to achieve substantial economies by deriving the design wind pressures from a wind tunnel test rather than using the wind code directly.

A wind tunnel test was therefore commissioned and carried out by Dr Bill Melbourne at the Monash University wind tunnel. The fabric geometry was generated using the TENSYL computer program and the generated co–ordinates used to build the plastic pressure tap model.

The results from the wind tunnel test were approximately 30% lower than using code derived pressures.

Consequently the computer fabric reactions applied to the edge beams were reduced considerably with corresponding savings in the steel weight. The structure performed well in a recent major storm in Perth with wind speeds measured at other locations as high as 40 m/s.

The design work pointed to the need for sufficient rise in the standard ”square panel” and adequate tension in the fabric to ensure adequate slope at the ”low” corner. It should be noted that in the limit the slope in the low corner tends to zero.

Supporting fabric roofs by fixed edge boundaries requires special attention to the fabric beam connection details to provide adequate tolerance allowance. This is required to accommodate the beam out of straightness, fabric stretch etc.

The design therefore proposed 3–D adjustable cleat plate details along each edge beam.

The final design and patterning was undertaken by the winning tenderer Permafab Pty Ltd on the basis of a performance specifications. Permafab elected to use a fixed connection detail by site measuring the erected steelwork and patterning the fabric to suit.

4. STEEL DESIGN

A large number of aspects had a considerable influence on the steel section design. These included:

- the low level of allowable deflection even under asymmetrical fabric loads and the corresponding structural requirements for high vertical, horizontal and torsional stiffness.
- the need for ”clean” member connections
- cost
- the need to incorporate gutters into the system
- buildability

Initial concepts revolved around members consisting of triangular space trusses however, when it was recognised that some joints would involve as many as six elements each with 3 members intersecting in the same space, it was felt that this could not be resolved from an architectural as well as structured view. Further work led to the use of folded plate elements. The elements are fabricated from folded 10mm plate, are triangular in section and incorporate gutters.

Space frame techniques on a large scale were used in the design with the separation of the structure into node and member elements. With members of common length being connected to fabricated nodes via a concealed bolting arrangement. Slide 4 shows the Great Space steelwork in its final form.

5. FABRICATION, ERECTION AND CONSTRUCTION

Scale models of the structure showing every element as well as models of each of the critical nodes proved invaluable to steel fabricators and shop detailers with the shop detailing and fabrication of the nodes proving to be a major exercise.

Fabrication of the folded plate member elements was very successful with high tolerance being achieved.

The steel structure was erected in its final location with the nodes being supported on temporary structures and the member being supported between them. Maintaining tolerance during the erection process was perhaps the most difficult aspect of the procedure and some problems were experienced with a tendency for minor errors to accumulate. The overall error of approximately span on 2500 is not visually perceptible.

Tolerances between steel and fabric were allowed for at the design phase by providing an adjustable fabric cleat detail. In the final event, it was decided by the contractor to site measure each fabric panel.

The multiple hypar design of the fabric roof system has already proved its worth with a number of fabric panels being damaged for various reasons. The panels have been taken down and sections replaced.

6. CONCLUSION

The Lakeside Joondalup Shopping Centre Great Space Roof structure has combined similar PTFE fabric hypars and specially fabricated steel supports to create a visually spectacular effect.

PROJECT TEAM

Client	:	Armstrong Jones Funds Management and Landcorp
Project Manager	:	Armstrong Jones Property management
Architects	:	CCN Architects and Hames Sharley Australia
Structural Engineer	:	Connell Wagner (WA) Pty Ltd
Builder	:	Consolidated Construction
Fabric Subcontractor	:	Permafab Pty Ltd
Steelwork Subcontractor	:	Saipem Australia Pty Ltd

Slide 1 – Lakeside Joondalup Shopping Centre – Front Elevation

Slide 2 – Lakeside Joondalup Shopping Centre – Rear Elevation

Slide 3 – Fabric Roof Shapes

Slide 4 – Great Space Structure

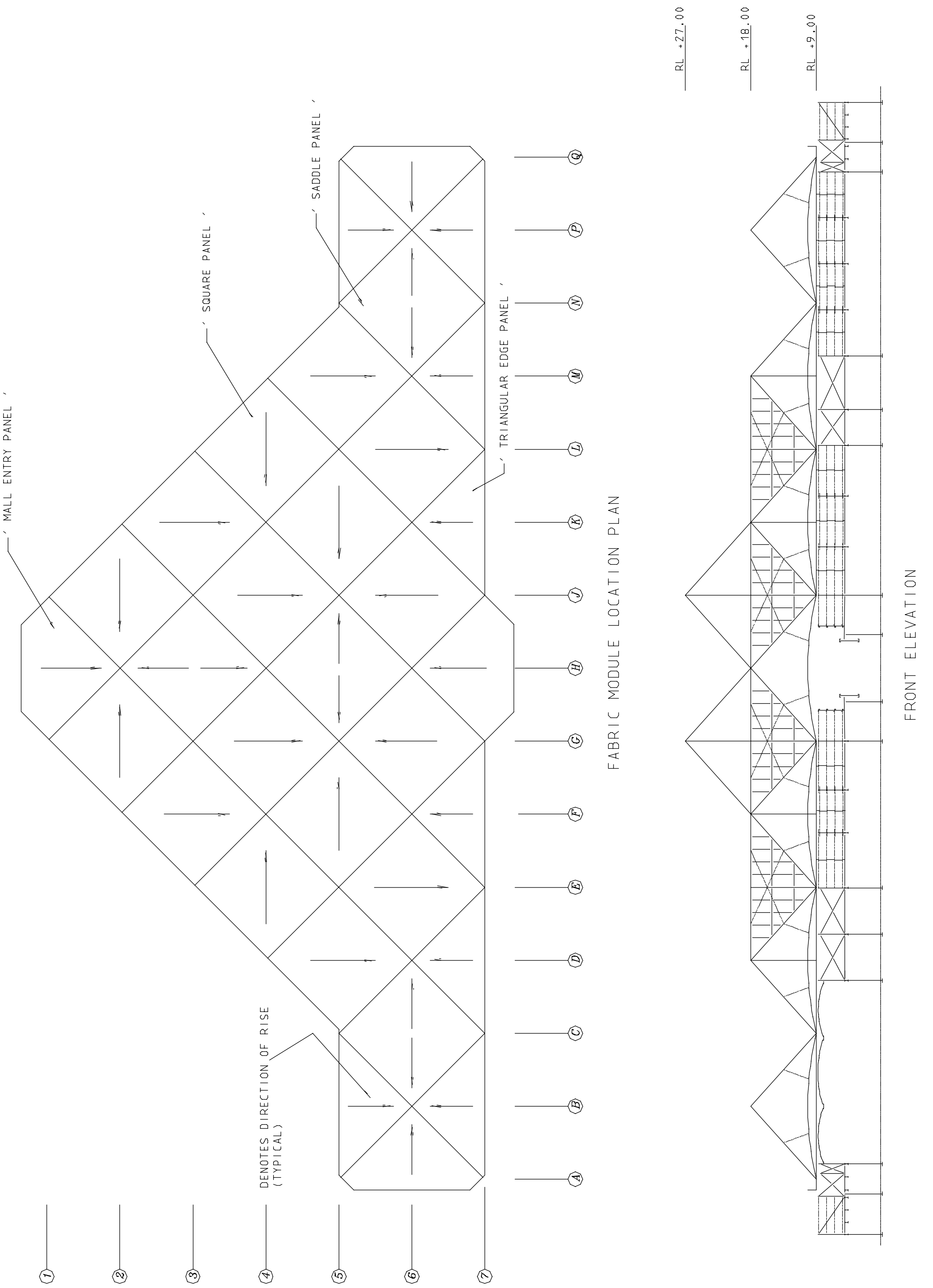

Figure 1 Lakeside Joondalup Shopping Centre Great Space Roof Structure