SHELL WEST GATE

– A NEW LAND MARK

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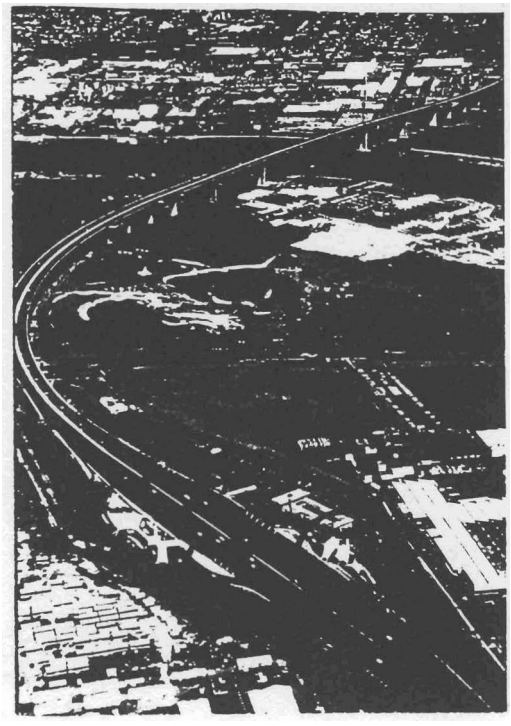
SYNOPSIS: The paper addresses specifically the pre–stressed membrane canopies of this project and is a collaborative statement of both project Architect and Engineer.



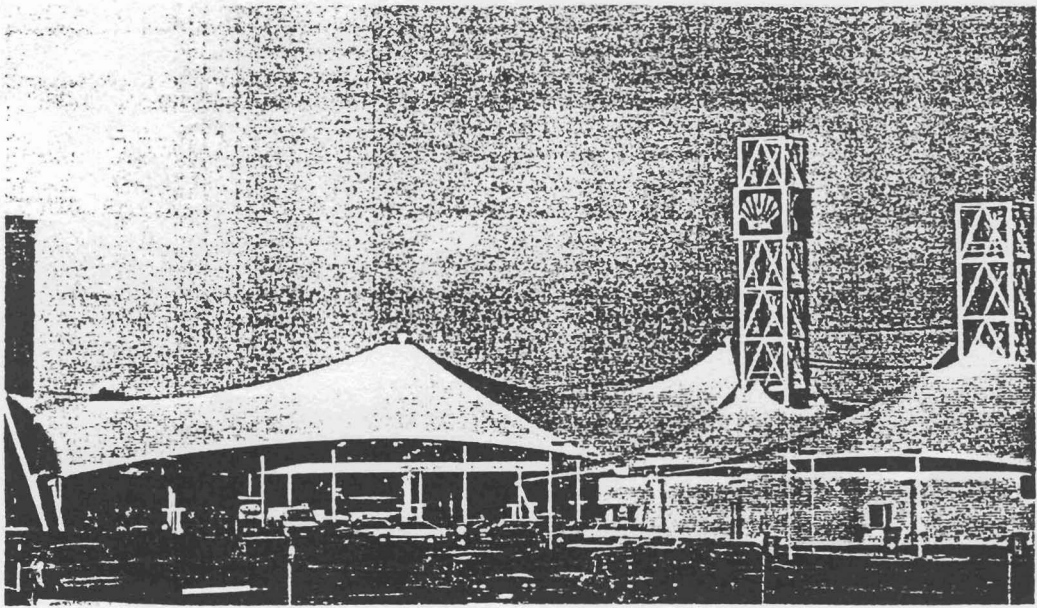
1. Introduction

Following a request from the Minister for Transport the Road Construction Authority determined a need to provide additional services to motorists using the West Gate Freeway.

Consequently the RCA identified areas of land adjacent to the freeway made surplus to road requirements by the removal of the toll plaza areas.

Overall the road reservation is a Crown Grant in favour of the RCA zoned "main road" in the Melbourne Metropolitan Planning Scheme.

The sites are within the municipal boundaries of Port Melbourne.



Expressions of interest were invited in 1986 by the RCA from major oil companies and private developers to tender for the provision and operation of twin vehicular and motorist service facilities, one servicing the northern carriageway and one serving the southern carriageway. Six companies initially registered with five formally submitting tenders.

The successful tenderer would subsequently lease the sites from the RCA.

The Authority required three basic considerations in the tenders:

- a site "upfront premium" and annual rental;
- compatibility of design with the West Gate Bridge and environs;
- extent and scope of services offered.

The Architects Graeme Law & Associates Pty Ltd were approached by the Shell Company in 1986 to develop an architectural concept which married both the RCA brief and the requirements of the Shell Company of Australia Ltd. Together with Tract Consultants Australia Pty. Ltd. we developed a site concept which was subsequently submitted.

In September 1987 the Minister announced the acceptance of the Shell Company of Australia Limited submission A formal site lease was signed in December 1987 between the RCA and Shell for an initial lease of 10 years with 3 options for 5 year extensions.

The major architectural requirements of the RCA brief were that the development should:

- "achieve a standard of visual amenity commensurate with its proximity to the West Gate Bridge structure and the importance of the freeway as one of the major approach routes to Melbourne. The architectural style of the service buildings should consider the form and style of the adjacent bridge structure and should reflect in a general way such shape and form within the practical limits of the service functions that the centres are required to provide....."
- full fuelling facilities providing all liquid fuels including LPG;
- take–away food;
- free public conveniences;
- restaurant facility on the southern side;
- auto accessory lines;
- carparking and road transport vehicle parking.

The site originally comprised an old tip and swamp and is subject to relatively strong on–shore winds

Major architectural requirements of the Shell Company of Australia Ltd were that:

- "The site location represents a unique and exciting development opportunity for the construction of two "landmark" service centre facilities. The design ought be a thoughtful and innovative response unfettered by existing corporate design practices. It is our intention that this development proposal is not merely another service station . . . ."

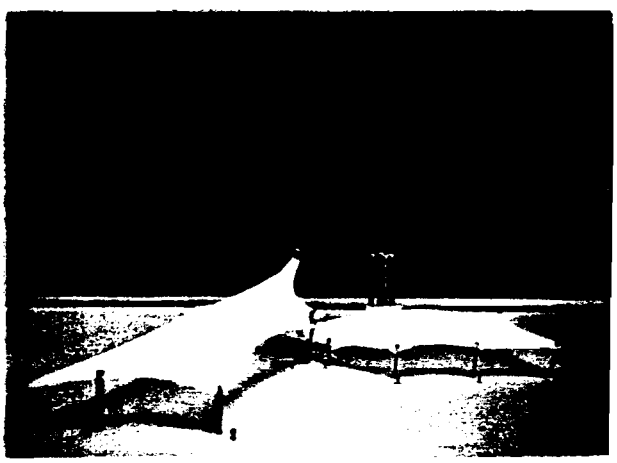
2. Architectural Approval

This paper primarily addresses and restricts itself to the canopy and canopy support structure of this Shell project

After an initial briefing from the client the architect visited the site to better appreciate the site conditions and environs.

It was during this visit and a drive across the West Gate Bridge that the concept of sail like canopies, tension wires and structural towers was formulated. The white sails of the craft on Hobson Bay and the cable stays to the bridge were accepted by the Architect as relevant statements that could be highlighted in this proposed new element in the landscape.

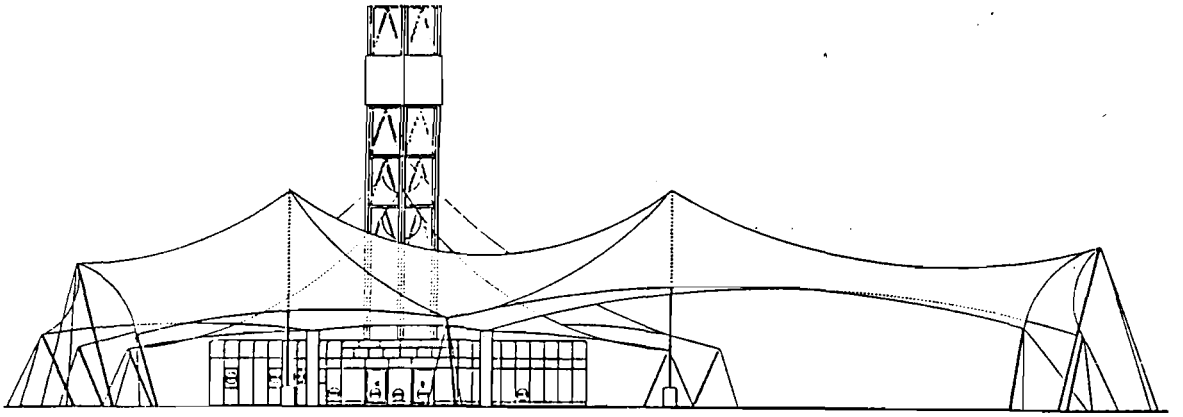
Early concepts were developed along these lines with preliminary architectural design sketches being extended into study models made from such basic materials as stocking and steel nails.



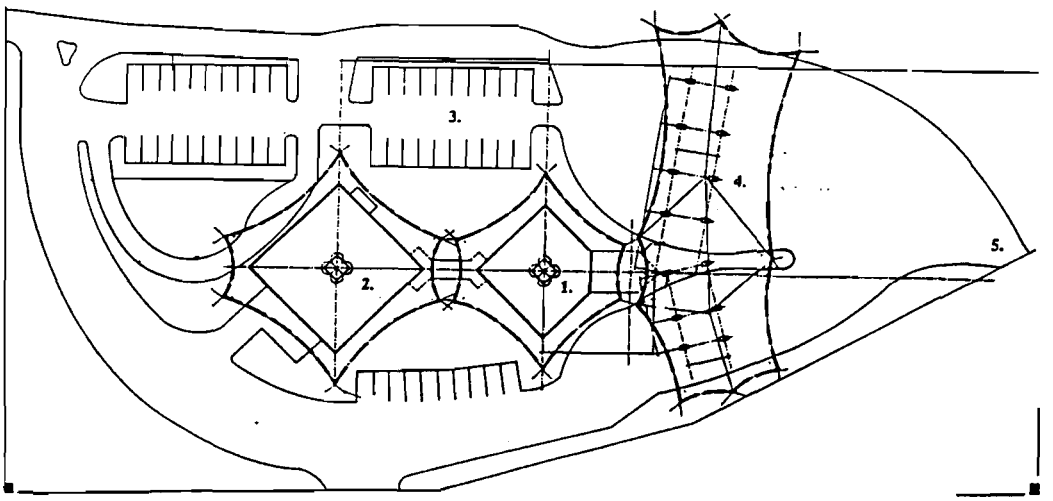
The site constraints and a number of issues within the brief impacted upon the shape and form of the canopies

e.g.
- The tapering site boundaries
- The traffic access/egress points
- Vehicular traffic patterns
- Visual sight lines from cashier to dispenser pumps
- Heights of articulated vehicles and 4.5 metre minimum head room aver roadways.
- Maximum roof coverage to the petrol bowser forecourt.
- Compatibility with buildings below.

Shell Australia supplied details of all their standard above ground facilities including their dispenser pump locations. From this information the extent of required weather shelter was able to be determined. All these issues created the need for a linear development with the form of the front canopy being cranked about the central axis to physically fit the development on the site.

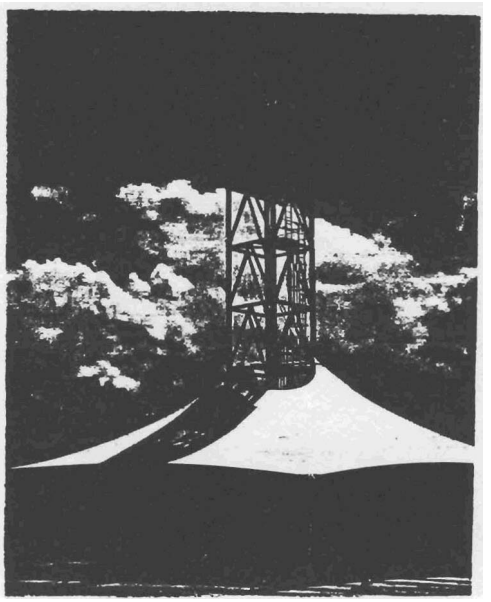


EAST



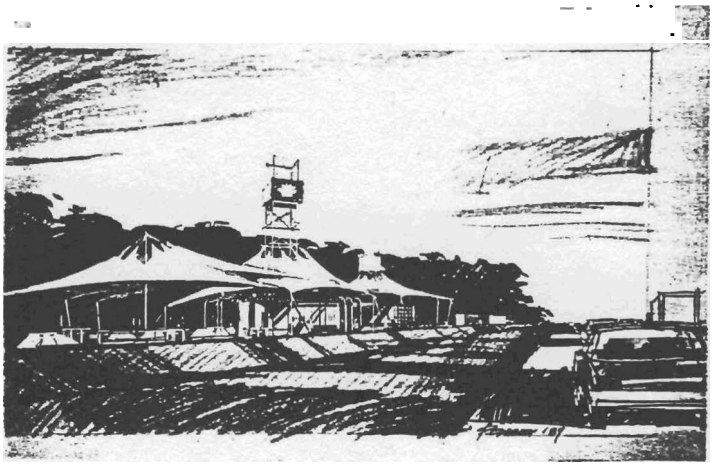
There is a strong planning connection with the built form ground elements and the overhead canopies. The shape and form of these canopies has been largely derived from the need to cover buildings of certain dimensions and weather protect pedestrians and vehicles as they pursued their needs external to the buildings.

The built elements below canopy level have been expressed as simplistic gift boxes which contain the goods being offered for sale. These under canopy capsules are physically isolated from the overhead canopy other than where they interlock at the major support towers. These towers penetrate the membrane through designed apertures and support the high points of the canopy.



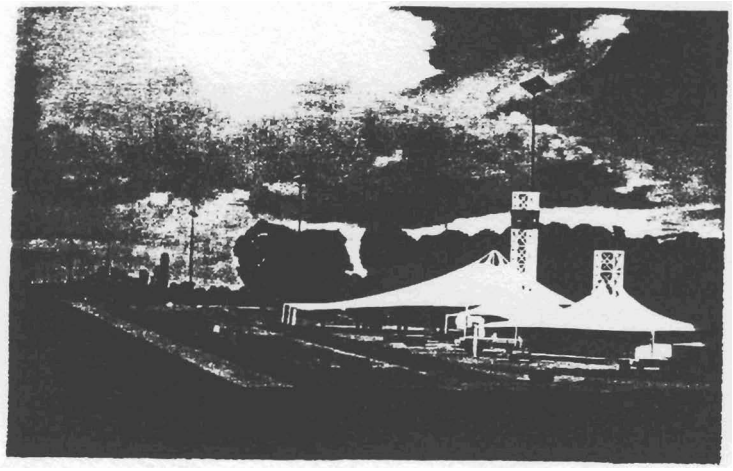
There was also a need to create a building form which highlighted the location of this facility to the passing motorist and create a strong focal point which seduced the motorist into interrupting his journey.

The main support tower masts were derived from communications network symbols evoking images of this Shell project communicating and interconnecting with the Shell infrastructure located throughout the nation. Signage was located on these to appropriately highlight the Company image.



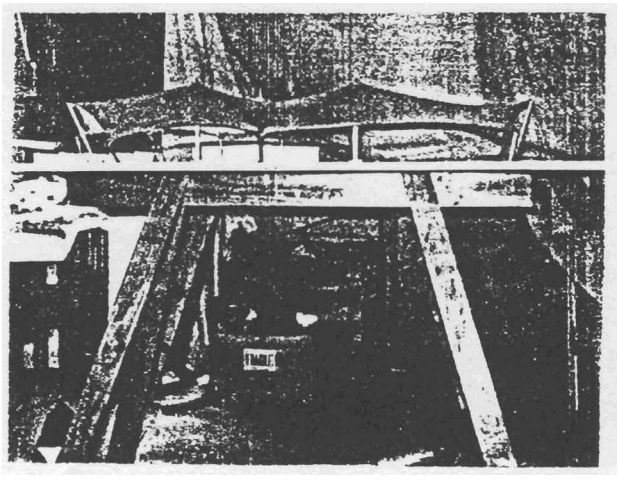
3. Design Development Stage

Having arrived at an acceptable preliminary designed form the next step was to carry out an analysis of membrane fabric types, availability, cost of supply, erection techniques, credentials of supply and erect companies, examples of other similar structures in existence.



A range of fabric materials and companies were researched with approximate costs per square metre, their durability qualities and potential guarantees. These were presented to the Shell Company Australia Ltd to allow them to determine the fabric most suited to their purpose and budget. The Shell Company Australia Ltd finally chose a PVC coated polyester fabric trademarked Polymar, acrylic lacquered both sides.

During design development a great deal of communication occurred between architects, the structural engineer, and the fabric designers engineers Connell Barrow McCready Pty. Ltd. Preliminary stocking models developed by the architects and used as a communication tool to the client and consultant group were expanded upon by the fabric engineers with new 1:50 scale models based on developing engineering data.



As with many projects the "stocking model" stage was crucial to the development of satisfactory fabric forms which met the aesthetic, functional, structural and erectability requirements. For reasons of fabrication economy and erection procedure it was decided to sub–divide the canopies into five separate membranes, two covering the north service station and three covering the south service station plus restaurant.

There needed to be considerable give and take between architects and engineers during this phase. With reference to the bowser fabric structure for example, the height of the main and perimeter masts required adjustment to obtain necessary curvatures to stabilise the structure sufficiently. If the original proposal by the Architect of a single mast was to be maintained it would have needed to be raised a further 5 metres higher. This extra height would have created planning authority problems as well as sight lines to the Shell sign beyond.

It was therefore concluded that a two mast system be utilised which reduced the height and created a more useful catenary at the perimeter cable for appropriate ground cover to vehicles. This also provided better stability in terms of deflections eliminating large oscillations in the front line which may have caused clashes with vehicle travel etc.

Due to the planning restraints only two out of the proposed five canopy structures could be identical and unfortunately some possible economics due to repetition were not available.

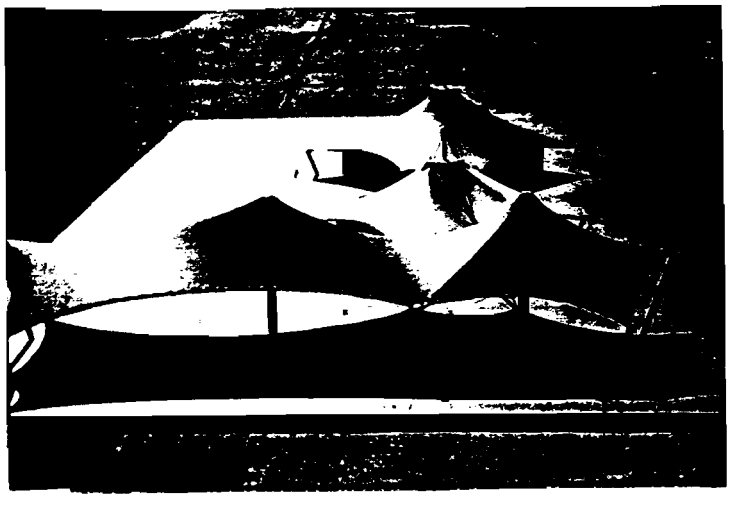
Extremely important was the fabricationlerection input supplied by Spacetech Pty. Ltd. at this early stage of the design process and there is no doubt that this greatly assisted the successful implementation of the project

Considerable debate and discussion occurred between consultants during this model phase and the computer engineering design phase covering such items as:

- height at edge of canopy for weather protection
- structure shape and stability
- cost penalties incurred by non symmetrical form
- safety aspects of the masts, ie the vulnerability in collision
- deflections in wind and necessary tolerances from canopies to fixtures below
- tie down points to all masts established in relationship to other fixtures, pedestrian and vehicle travel at site boundaries
- connections to masts to allow for possible movement during erection and the facility for post tensioning the fabric

- Town Planning Authority approved earlier design form and therefore any major changes impacted on the programme if major revisions were to occur
- gas flues, kitchen exhausts etc located relevant to towers and canopy openings

The final resultant stocking model was shown to the client group and approval given to proceed.



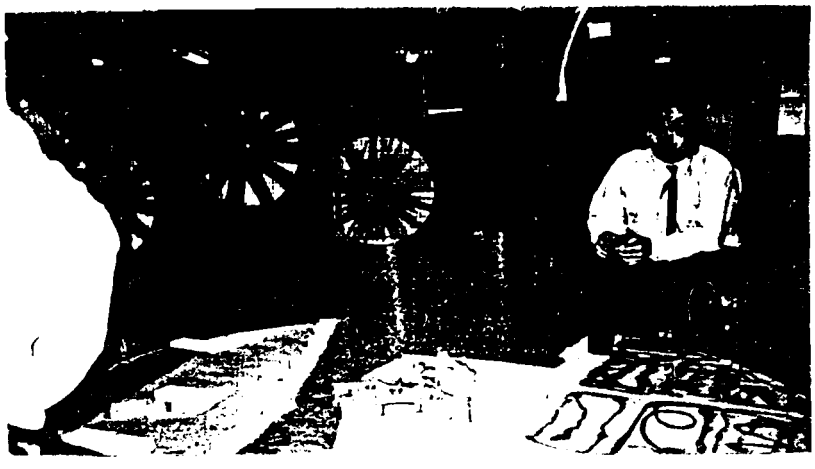
4. Wind Tunnel Testing

The site conditions necessitated the use of piled foundations which resulted in a significant structural cost premium. The number of piles was directly related to the fabric structure anchorage forces due to prestress and wind loading.

Connell Wagner's experience with previous projects indicated that the wind pressures obtained from wind tunnel testing could be substantially lower than the values obtained from the wind code AS 1170. Part 2. Firstly the code deals mainly with planar surfaces as opposed to curved forms and secondly wind directionality is not fully accounted for. The latter aspect is particularly important when there is upstream shielding by other buildings in the maximum wind speed direction.

A wind tunnel test was therefore commissioned and carried out by Vipac Pty. Ltd. 1:150 scale fibreglass models were produced from moulds which had been developed from accurate lycra ("stocking") models. The model geometry was also checked against the "TENSYL" computer generated model. This model making process significantly reduces the costs of wind tunnel testing and is recommended by the writers. Caution is required however, with highly curved surfaces with unequal warp and weft stresses because the accuracy of the stocking model geometry is reduced.

With reference to the photograph of the wind tunnel test the surrounding terrain and buildings were accurately modelled to correctly incorporate the shielding.



5. Structural Analysis and Design

The fabric structures were each formfound/analysed and patterned using the non-linear finite element computer program 'TENSYL', which is described in reference 1. The mathematical models included a number of basic fabrication/erection related decisions including:-

(a) The warp and weft directions were aligned to follow the main stress directions.

(b) Ridge line cable elements were included to model the splice lines of the bowser. Besides facilitating the erection sequence. These cables provided extra redundancy of the structure in the event of a major tear in one of the fabric panels.

Due to the planning and architectural constraints, the bowser canopies curvatures were relatively flat and hence deflection under wind loading was a major design criteria An earlier scheme involving a 55m spanning edge cable was rejected because of excessive movements under wind.

Consideration of vehicular impact was an important aspect Whilst it would have been uneconomic to provide an impact resistant structure measures were taken to minimise this possibility. Columns were therefore supported on concrete pedestals to minimise the risk of a vehicular collision and in addition each of the perimeter masts has two tieback anchorage(s) to provide a certain degree of structural redundancy. Furthermore crash bamers were installed around these perimeter structures.

A second design aspect raised by the Melbourne Ewe Brigade (MFB) was the consideration of fire. Data was submitted to demonstrate the zero "spread of flame" characteristic of the fabric but more important from the M.F.B.'s viewpoint, test information showing that fabric droplets showering down onto motorists below would not occur.

6. Construction Phase

The fabric structures were tendered as a Performance Specification but with substantial documentation specifying the structural component sizes and also the required form of connection detailing. This was considered necessary by the client to ensure a minimum quality of detailing and workmanship necessary for such a prestigious project.

The erection sequence of the fabric structures was a major task firstly due to the scale of the structures (surface area of Bowser canopy exceeded 1400 square metres) and secondly because the kiosk buildings were already constructed and the canopies had to be "threaded" over them into position. Thirdly the area is relatively exposed to onshore winds.

A number of erection sequences were considered by the successful tenderer Spacetech Pty. Ltd. to best fit in with the site constraints and overall construction program.

For the Bowser Canopies the four masts along the ridge line were stepped by means of mobile cranes with the fabric attached. The edge cables were then connected to the perimeter masts and the canopy prestressed.

A novel approach was adopted for the kiosk canopies, whereby the fabric was attached to a ring beam which was then threaded over the central mast prior to the fabric edges being pulled out into position.

To overcome the danger of wind, the site assemblies started at 1 a m in the morning and the canopies literally grew overnight much to the disbelief of early morning motorists!

7. Conclusion

The concept of a futuristic latest technology, fabric structure appealed immediately to the Shell Company marketing executives It was gratifying as an Architect to have reinforced the power of an "idea" and have a client group willing to embrace this "idea" and allow the structural analysis to follow.

This paper has outlined the design process from concept stage to fabrication of the Shell Westgate fabric structures. We have tried to demonstrate the need for design involvement by all sections of the industry to ensure a top quality product. Of major importance in our view is the use of large scale stocking models to clearly demonstrate the proposal to the client to resolve the various design constraints.

In summary the project has been most successful in that it has become a well known 'landmark and is seen as a fitting contribution to the Western Gateway to Melbourne. The Shell Company of Australia Limited have expressed their delight with the end product as has the Minister who instigated the site use proposal.

Proprietor	Shell Company Australia Ltd.
Project Manager	Mr Stephen Snow, Shell Company Australia Ltd
Consultants	
Architects	Graeme Law & Associates Pty Ltd
Structural Engineers	Connell Wagner
Fabric Designers	Connell Barrow McCready
Planners & Landscape Architects	Tract Consultants Australia Pty Ltd
Fabricators/Contractor	Spacetech Pty. Ltd.

Reference 1.

"Computer Modelling – the key to successful Fabric Structures" by B. K. Dean
M.S.A.A. Conference '89.