# The Development of a Small Market

## A Fabricators View

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Structurflex grew from a division of a sailmaking company in 1980 to an independant and fully separate company located in a purpose built building in 1987. The division was originally a canvas shop doing jobbing work but an early decision to confine all work to P.V.C. and eliminate sewing set the future direction. The shareholders and directors of the company having a highly technical fabric background built up from the design and manufacture of yacht sails for America's Cup and Ocean racing were interesting in the more refined fields of P.V.C. fabrication. Tension membrane Structures were promoted on a broadcast basis and enquiries handled as they arrived.

Two things became clear the market had a limited concept of a tension membrane structure, secondly, the concept of a cheap, temporary structure was the norm. After fielding many enquiries and building a few low budget structures we felt New Zealand had readily accepted fabric structures after two significant structures were ordered in 1987.

Firstly the Massey Park Pool Dome. The Papakura City Council wished to build a removable coverover their Olympic sized pool but also to cover a learners pool within the same enclosure. The result was an 'L' shaped structure formed by pushing an 11m x 24m bubble against the main 56m x 24m structure. A valley cable relieves the fabric at the junction of the two domes. Connel Barrow and McCready Pty were the specialist consultants and we understand they found the form finding "interesting". The mechanicals were designed by Babbage & Partners retained directly by the City.

Construction and erection proceeded smoothly and the Structure has now been cycled three times.

Retrospective analysis:

The dome is performing all of the functions required of it, but it is a laborious job to erect and remove. I understand some of the new air houses have addressed this problem and have 'hold down and jointing' systems that are less labour intensive.

The dark colours, cream and green, make the dome quite hot on sunny days and we would suggest that future domes be predominatly white with coloured highlights only.

Noise reverberation is a problem when school sports events are held.

| Frequency | 125 | 250 | 500 | 1K | 2K |
|---|---|---|---|---|---|
| RT | 4.5 | 8.0 | 7.5 | 7.5 | 6.5 |

and although strong points were built into the dome to hang acoustic panels they have not yet been hung.

MASSEY PARK POOL DOME

WICKING INITIATING FROM SCRATCHES

The valley cable was determined to move away from the large dome over the surface of the small dome eventually peeling off its restraining cuff. At the first cycle the cable was restrained by a pocket opposing the direction of movement and no further problems have occurred.

Each cycle results in minor mechanical damage to the fabric, however there is now some evidence of water getting into the base fabric at these points (very minor at this point) however inevitably this will reduce the life of the structure. In an attempt to minimize damage we have spread clear silicon on areas of minor abrasion.

Where the base pipe pocket is welded to the canopy it is oversewn with two rows of stiching and again there is evidence of water penetration through the stitch holes. Any penetration of the P.V.C. coating must be sealed. Water penetration may not show up as quickly in Australia's drier climate but it is happening.

The second major project in 87 was the Sunhill Garden Centre.

The main structure has two pairs of masts of differing heights, 13 perimeter buttresses and a centre tie down in the form of a glazed barrel. The area covers about 950m². Cantilevered partitions enclose a sales and office area. A peaked 113m² shade house and a 16m² entry canopy complete the development.

Fabrication and erection of the two main structures were logically persued with no unexpected problems, however the entry canopy did not fit the frame. In the sailmaking business it is always the sailmaker that is initially blamed, never the mast maker or the boatbuilder. So it seems in the fabric structure business. Following a few "discussions" with the architect and owners we had the support structure surveyed, the results of which showed substantial errors in the positioning of frame anchor points. The support structure was modified and the canopy refitted.

The garden centre has been very successful and the structure has become a land mark in Eastern Auckland.

Retrospective Analysis:

The Entry Structure is not perfect, I believe caused by the use of a very stable fabric on a small and highly curved structure. We have subsequently come across this problem with other small structures. Surveying of and checking of fitting compatability of all attachment points before erection is absolutely essential.

A webb was sewn around the catenary and again there is evidence of water entering the fabric via the stitch holes. The webb gets damp and does not dry readily holding moisture in the area of the stitch holes. Aesthetically the webb tends to green with mildew although this is superficial only and can be brushed off.

The interface between the canopy and the partioning is a loose fabric skirt. This is unattractive and was added as an after though by the architect. This interface is not an uncommon problem and needs thought. One suggested solution is a fabric tube attached to the top of the partitioning and inflatable with a low pressure blower.

The site is next door to a Pizza Hut and after dinner revellers commonly climb onto the structure gaining ready access via the buttresses. Although they have not caused physical damage the trail of muddy skid marks are unsightly and have led the owners to add an electricfied wire to the catenary edge. This appears to have been effective.

McWilliams 6 Partners were the specialist consultants and the Architects were Murray North 6 Partners.

A third project fabricated during 87 was to be erected in Samoa at the Bank of Western Samoa.

This involved two tiers of perimeter awnings covering 240m² , an entrance canopy and a roof top shade structure.

A mock up was built in factory and after the first awning was fitted it became apparent that the high curvature would require more seams to achieve a fair curve. The pattern was amended and fabrication completed. Having had little involvement with the building industry and having emphasised the need for accuracy to the main contractor we arrived on site to find anchor points far from the designed position. The awning supports consisted of curved arches cantilevered from the building and the on site rectification of problem consisted of attaching a block and tackle to the tube and are bending them to the point the catenary wires could be attached.

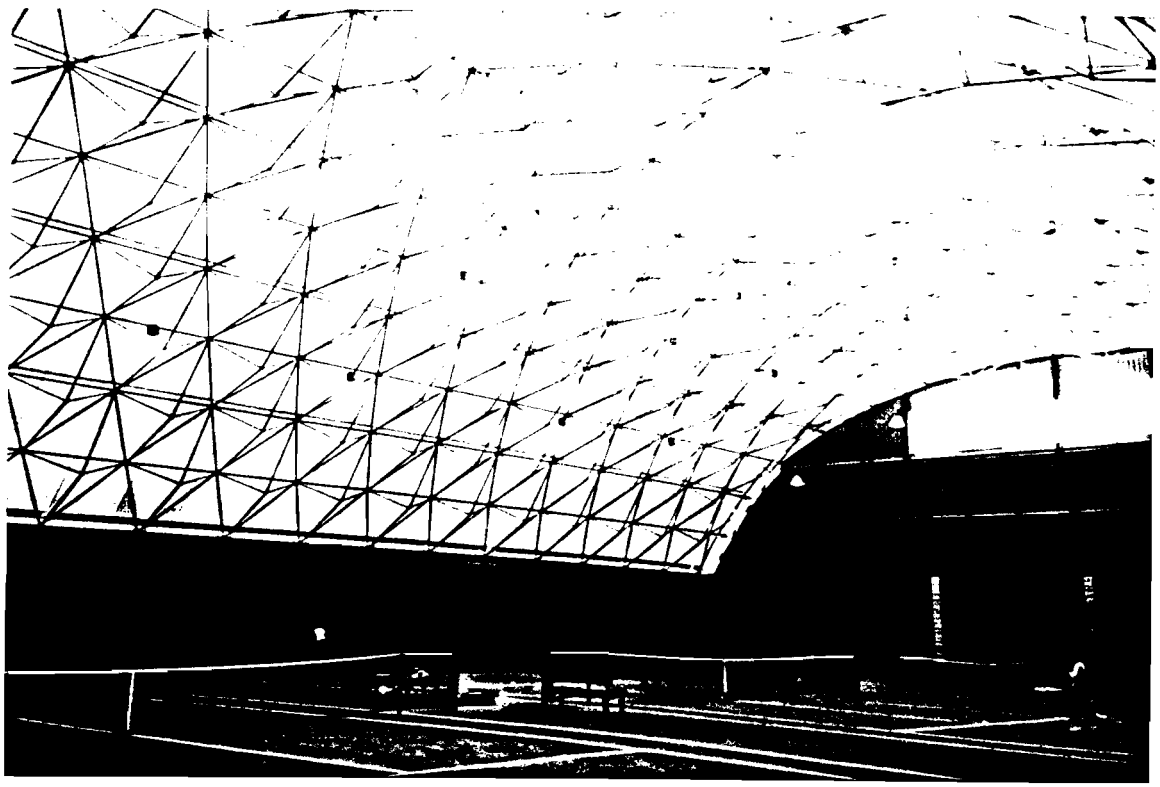
While the finished appearance is excellent we would never attempt a job on this basis again. There were no satisfactory methods available to tension the fabric and on site adaption was required.

Retrospective analysis:

A prior visit to the site should have been made and measurements taken. Rectification of anchor points positioning should have been insisted on before erection proceeded.

The design concept should have allowed for complete modules to which the fabric could have been fitted or at least partially fitted with the complete module then lifted and fitted to the building. Had this not been acceptable we should have satisfied ourselves as to the tensioning method to be used before undertaking the work.

**SUNHILL GARDEN CENTRE**



**50M X 40M VAULTED ROOF**

Having now completed three complex and varied structures and having documented and considered our mistakes we felt well equipped to tackle any job. Unfortunately it was now post share crash 1988. During this year 1.5 million dollars in quoted work crashed along with the entrepreneurs and developers. Interest in fabric membrane structures was high with architects and engineers who were drafting grand schemes often for no fee in the hope of generating work, few succeeded.

During 1989 we completed a series of Teflon glass barrel vaults and two domes during the redevelopment of a shopping .centre. This work was done under a supply agreement with Chemfab P.T.Y. and is the first use of teflon glass in New Zealand. Unfortunately this structure has already been vandalised.

In early 89 we were asked to advise on the use of fabric structure to enhance the Commonwealth Games athletes village. The budget was extremely constrained but high impact was required. This resulted in the fabrication of thirty 6m x 6m hypars, ten 3m x 3m peaked canopies and two 12m x 12m peaked canopies in addition to converting 3300m2 of fabric as the membrane covering for a space framework to be used as the dining hall.

Two current contracts in New Zealand are a 900m$^2$ P.V.C. canopy over a plaza area and a teflon glass curved vault in the same development. Proposals for this development began in September 1988 and have survived the receivership of the developer and the builder to come in fruition.

This is the history of the permanent major tension structures in New Zealand. The awareness of architects and engineers is now high and fabric is considered on its merits and with understanding.

Cost Competitive Structures

In addition to the foregoing, we have converted 19937m$^2$ of fabric for architectural use in lightweight structures that have been specified on a cost competitive basis against conventional materials.

The majority of this work has been coverings for space frames in conjunction with Boral Acrow New Zealand. The advantages of natural light, fast erection time, clear spans and competitive prices commended these to Nissan New Zealand for a 40m x 50m parts warehouse, the Commonwealth Games Company for the 40m x 40m dining hall. the Auckland tennis centre for a 38m x 38m building housing two courts and a further 42m x 50m building covering three tennis courts.

The covers are welded up flat sheets with mitred corners mostly done in one piece. The final handling of up to 3400m$^2$ of fabric cover can be a real pantomime with 4 wheel drive vehicles and plenty of human labour used to fold and move the cover around the factory floor to the despatch point. The engineer for these works has been Dunning Moore 6 Associates who have developed an Italian design. The covers are primarily tensioned over the space frame by the use of steel tubes in fabric pockets built into the base of the structure and tensioned down by the use of bungy cord. Parallel rows of eyelet bands at 6 metre intervals laced to the frame with bungy cord provide secondary tensioning. The system sounds primitive but appears very effective.

While most of these structures have been four sided domes with the fabric reaching the ground the most recent is a 40m x 50m barrel vault. This gives a very interesting roof structure on a conventional looking building. Roof costs of space frame, cover and installation were $165m^2$.

To lift us from doom and gloom New Zealand is celebrating 150yrs in much the same way Australia held its Bi Centennary. A Road show was promoted and Structurflex was asked to suggest a method of housing the displays on their nine month thirty stop trip around the country. Approximately 2500$m^2$ of covered space was required and erection time needed to be less than twenty four hours.

We suggested an American system called the Clamshelter which offered some interesting features such as the ability to open the whole end of the building for vehicle access and the pneumatic post tensioning of the fabric panels that resulted in a quiet building. Our proposal was accepted and we supplied the components which are set up as a three building configuration as 50m x 20m entry hall depicting New Zealand history, a 20m x 17m theatre and a 50m x 20m hall showing the future.

The tour is now well underway and the system has lived up to expectation, however it appears that preliminary investigations of site conditions were not adequate and anchoring the structures has posed problems on some sites, further weather conditions and a very tight time frame have made life hard for the erection gangs. At an early site the the buildings were erected in winds gusting to 65 knots however the task was completed in 28 hours. High rainfall and muddy conditions have also hindered erection by filling bolt rope grooves and jamming zippers.

A very interesting application for an industrial fab'ric roof has arisen in the dairy industry. Rotating milking sheds have been around for some time however an enterprising inventor realised that by attaching the roof structure to an already strong rotating platform meant that the shed walls could be simplified and overall cost savings achieved.

Three sheds have been erected at the point of writing. A 2 cow platform of 10.4m diameter and a 36 cow platform of 15.2m diameter both being convex arched domes. A 44 cow platform will be doughnut shaped to reduce the fabric usage in the centre area where cover is not required.

Through evolution the tensioning and erection procedures have been refined to allow rapid installation by unskilled people.

Fabric offers the advantage of economic covering of a shape that is expensive to waterproof with conventional materials, a small compact package for transportation, and erection possible by remote instruction of unskilled labour. (We would like to be able to add that the diffuse light and delightful ambience encourages the cows to higher productivity but this may be a bit effusive.) The specialist engineer for these structures is Chapman Oulsman 6 Associates.

Fabric has a future in New Zealand as it has proved itself viable, aesthetic and functional. The climate of clear, high UV sunlight combined with high rainfall requires shelters in order that expensive spaces can be fully utilised and commercial and entertainment functions planned with certainty. It has been important for our companys survival and for the ongoing use of fabric membranes that all uses are considered from the mundane to the exalted.