THE PERFORMANCE OF YULARA AND OTHER FABRIC SHADE STRUCTURES ACROSS AUSTRALIA

It could be argued that Australian architecture is an architecture of roofs. With our warm and often wet climate, protection from the sun and the rain is a basic requirement. Insulation from the heat or the cold is generally not the basic requirement as in northern Europe, broad hipped roofs and deep verandahs are the traditional form, transplanted from India, and possibly influenced by traditional Aboriginal architecture.

Fascination with roof forms in this country has provided a fertile breeding ground for the use of fabric structure, particularly as shade and occasionally and most interestingly as roof.

Ayers Rock, literally in the centre of Australia, has become a focus for local and overseas tourists. In 1981 we commenced design of the Yulara Tourist Village. To serve in excess of 250,000 visitors per year to Uluru National Park a range of tourist accomodation was to be provided on a site amongst the sand dunes some 14km from Ayers Rock and just outside the park boundary. Our concept was to draw all the various components of the village into a single pedestrian spine, to minimize the impact on the fragile desert environment and to maximize the enjoyment of the visitor to this remote area by concentrating activity as much as possible.

Shade from the sun was a key requirement and the repetition of hypar structures has become central to the image of Yulara. The hypar shades are designed on a 10.8 x 10.8 metre grid. They are manufactured from PVC coated polyester with acrylic laquer on the top surface by the Swiss company Sarna and were fabricated and erected by Sarna in association with Humes. Yulara is a long way from Switzerland where the hypars were fabricated but generally there were few problems with the erection. The hypars had a cable roped edge connected to the steel support structure. We did experience some problems with the design of the steel connectors and some sails were actually blown away in a severe storm in 1986. The connectors were not adequate for movements experienced by the joint and have now had a component in the joint replaced. They have since performed quite satisfactorily.

It is clear that where the interface between the fabric and the support structure is minimal and particularly where the interface is flexible the problems are minimal. Each hypar has only four support points and each is adjusted to accommodate comfortably any misalignment between fabric and support structure. Design sizes may not match on site measurements.

The simple fabric shades over the main pedestrian spine, also of PVC coated polyester were designed with a high degree of tolerance at the interface with the steel support structure, with minimal problems during installation.

The roof over the public areas in the Sheraton Hotel is a series of fabric panel vaults. A PVC coated polyester fabric is fixed over a series of steel vault frames. The edges of the vaults are cable roped and pulled over steel plate flanges to drain into structural steel gutters. Here where there was much more interface between the fabric membrane and the steel support structure there was less margin for error.

The vaults arrived dimensioned to the retaxed size, not the final tensioned size indicated on the shop drawings and additional flanges were added to the gutter sides on site to accommodate the difference.

A weak spot where heat welded seams crossed also developed on site requiring the on site application of reinforcing strips.

Erection of these structures requires care and expertise, and some difficulties were experienced on site encouraging care by workmen in their treatment of the fabric during erection. Care is required in the tensioning process to avoid wrinkling and it is essential to be able to tension components individually.

The only criticism of the performance of the membrane structures at Yulara that we are aware of is that dust has accumulated on the surface of the fabric and is difficult to clean. This is really a misunderstanding about the performance of this material. It is actually designed to allow the accumulation of a patina of red dust over time. This in turn will assist with long term ultra violet light protection.

The membrane and its steel support structure, being subject to constant dynamic forces require regular checking of the tension in all bolts and connections.

Whilst there has been some public access on to the tops of the the hypars in the shopping centre at Yulara, there has been little vandalism and the structures have performed very well.

From the dead heart of Australia to the coastal environment of Sydney Harbour, the Sydney Aquarium. To reduce costs and reduce construction time the major exhibition tanks were designed to float in the water, moored in the basin next to the main aquarium exhibition building. Huges volumes of water, 40 x 15 x 2.5 metres deep, providing an excellent environment for fish and traversed by submerged viewing tubes so that the public literally move about the ocean floor, are housed in giant barges. Membrane roofs cover both the tank entrance areas and the fish tanks themselves.

The membranes are both PVC coated polyester, fabricated and erected by Chemfab. The membrane roof over the public entrances is a barrel vault similar to the shape used at Yulara. However, in this instance the vault roof was fabricated and erected in one piece, with minimal fixings, fixings being restricted to the barrel edges only. Welded joints and welding strips occur over the steel arches.

The tank roofs are a different structure altogether to provide an economical roof over a large roof span. The membrane is supported on a system of PVC coated steel cable system suspended form steel masts located at each corner of the tank. The membrane is triple skin white, black and white, being opaque to eliminate daylight and inhibit algae growth inside the tank yet white to reflect light. Again the membrane roof was fabricated in one piece and no problems were experienced during erection with fabric damage or wrinkling.

The membrane material is an excellent performer in the highly corrosive environment of an aquarium. The use of coated cables and minimal steel minimizes the risk of corrosion in the supporting structure. Great care must be taken with coatings, fixings and finishes to prevent corrosion and by minimizing the number of fixing points and providing maximum flexibility at those points one can resolve any problems of tolerance between the accuracy of the fabric and the accuracy of the steel support structure.

Whilst much smaller in size the next case study, a footpath awning to an office building in North Sydney was a much more complex problem to resolve. The footpath to be protected has a sharp fall around a varying curve so that both the horizontal and vertical geometry of the awning was constantly changing. The structure is a series of cantilever circular hollow section frames forming a vault over the footpath and reflecting the geometry of the office building above.

The membrane is a PVC coated polyester supplied by Hammersteiner. The steel frame, with members at 3.6 metre centres, experiences high wind load, and thick wall sections were used to reduce the size of the members from an appearance point of view. The end frames only were braced to resist wind loading and stiffen the assembly.

The vaults were originally designed to be fabricated over several bays, but were finally designed as individual bays allowing progressive tensioning and very little consequent wrinkling in the fabric. Bays were designed to enable individual tensioning, not just as individual pieces. Cover pieces over and between bay membranes were the most difficult to tension wrinkle free. Each bay was folded over a 26mm CHS at the ends and bolted to a unistruct on top of the main frame. To ensure strength webbing was stitched at the edges and this collects dirt over a period of time. It would have been better to employ welded joints.

We had some difficulty providing a gutter on the leading edge because of the shape or profile, in fact we never did provide the gutter originally required by council and it is probably impossible to achieve.

Six months after installation a truck broke one of the panels, but it was easily and simply replaced.

Another fabric awning on an old building in the city of Sydney resolves the problem of roofwater drainage, with PVC coated polyester membrane stretched over a curved frame draining to a gutter at the street edge, with the frame struts acting as downpipe connections. The geometry of the membrane works in reverse to the vault at North Sydney, with the membrane stretched between wall and gutter and held down on the vault members. We are about to use the same system in another awning further along the same Sydney street. We have had no problems to date with this installation, now completed nearly four years.

Finally we move to Canberra, an outdoor auditorium, a covered stage, for the bicentenary. This is the largest single membrane roof structure we have designed.

The PVC coated polyester membrane supplied by Koitwerk Herbert Koch, is stretched over a large steel framed arch with steel cavle edges tied into the ground. The fabric was fabricated and erected in one piece by Spare Structures. Two steel props support the rear section of the roof.

The interface between the steel support structure and the membrane is again minimal to overcome where possible misalignment of steel and fabric. Some difficulty was experienced during erection, because of high winds and dragging the large membrane into position over the support structure. Calm weather, cranege of sufficient size and careful preplanning is required. However the result was acheived within an extremely short time frame.

One major unforeseen effect has been condensation on the underside of the membrane during winter. Despite the external nature of the structure there is considerable water drip from the roof onto the stage below. A double membrane, at considerably greater cost, could reduce condensation. The roof pitch increased to such an extent and low points eliminated to encourage moisture on the underside of the membrane to drain to the edges. Another alternative is to remove the roof each winter. This is an area requiring further research in our view.

In summary we have used membrane structures with success in a number of different ways. They are exciting, light, quick to erect, suitable for our climate. But there are a member of matters that require careful design.

1. The interface between the support structure and the membrane, particularly accumulated tolerances and misalignments.

2. Design for erection, avoidance of sharp edges, adjusted for tolerance.

3. Design where necessary for condensation.

4. Care with the design of fixings and fittings to avoid corrosion and dirt collection and to recognise the dynamic nature of these structures.

Finally it is important to explain precisely how the membrane will perform in the future to avoid client misunderstanding.

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