



TENTS, TECHNOLOGY AND TECTONICS

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Tents - **portable** shelter of skins,.....**supported** by one or **more poles**,..... and usually extended by **ropes** fastened to **pegs in the ground**.

Technology - the branch of **knowledge** that **deals** with science and engineering, or its practice, as applied to practice.

Tectonics - the science or art of assembling, shaping, or **ornamenting** materials in **construction**.

* Explanations of meanings **from** The Macquarie Dictionary.

In this paper I will outline the **development** of our thought **processes**, and trace the evolution of the design solution for the **Keysborough** Golf City project.

The **Keysborough** Golf City project was our firm's first experience in **designing** with membrane structures.

Completed in March this year, the project encompassed the design of a golf driving range located in an outer **southeastern** suburb of Melbourne.

A large dual **cone** membrane **roof** is utilised over **much** of the operational area of the facility, and **provides** for the user, both a stimulating internal space, and a strong external identity.

Our firm, Millar **Sainsbery** Mulcair were the Architects for this **project**, which was **project** managed by WBCM Consultants. WBCM consultants also **provided** general structural design expertise, whilst **Connell Barrow** McCready **provided** the specialist engineering design skills required for fabric structures. **Spacotech** were responsible for the fabrication and installation of the fabric roof.

The principles of lightweight membrane structures have been with us for many hundreds of **years**. Simple tent s t r u m , using relatively primitive materials, have **provided** an age old **system** of cover and **protection from** the elements. These structures have generally been temporary ones, capable of being packed up, **moved**, and reconstructed with relative ease, creating in our psyche a perception of such **structures** as temporal or transitory.

The **developments** in science and technology in the last century have been staggering by any **measure**. This is very much in **evidence** in relation to membrane structures.

Today's membrane structures are more than a **sophisticated** form of tent **structure**. They utilise advanced fabric materials that have **embraced** superior **technologies** in their **production** to **provide** levels of tensile **strength**, and **long term** durability, **previously unachievable**.



The problem facing designers, be they architects or engineers, in designing with membrane structures is then essentially a **tectonic** one. That is, the shaping and making of **forms which** whilst stretching the **inherent properties** of the material to its limits, **provide appropriate** and effective solutions to the problem of enclosing space and **creating** visually and physically stimulating **environments** for humans to inhabit.

The adoption of membrane structures by a designer, carries with it the need to **understand** the rules as it were, in utilising such structures, as well as a discipline involving the understanding of minimalist engineering detailing and fabrication principles.

The design of membrane **roof** structures involves a multi-disciplinary group of professionals and requires the **blurring**, or even abolition of **traditional** boundaries of professional **expertise**. For example, the architect is required to **know** and **understand** the **complexities** of detailing engineering edge support **conditions** as much as the engineer is **required** to **comprehend** the subtleties inherent in the form **making** aspirations of the project. In the **end** the design solution **comes from** the fusion of ideas generated by the **removal** of barriers, and the **allowance** of **inquiry** as a formal design **tool**.

In designing the **Keysborough** Golf City project we did not automatically decide to use a fabric m f . Rather the decision evolved as we explored the physical planning **requirements**, budgetary parameters, and imagery for the project.

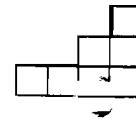
The client, **Keysborough** Golf Club came to us after they had undertaken **sane preliminary** research into other facilities of this type. This research had led them to Japan, the **home** of the **world's most** sophisticated driving ranges, as well as various facilities already operating throughout **Australia**.

Their **brief** was quite clear. They wanted to develop the best golf driving range in Australia, **utilising** within it, the **most** up to date golf range technology and systems available in **Australia**. The project was to **comprise** a range of practice facilities designed to cater for the specific practice **requirements** of golfers of various standards. **When completed**, it was to provide a level of amenity **unparalleled** in Australia.

The chosen site was located in the south western **corner** of their **Golf** Course on the corner of **Springvale** Road and **Hutton** Road, **Keysborough**. In terms of marketing potential, this site had obvious advantages, as **Springvale** Road, carrying up to 30,000 vehicles per day, is one of Melbourne's busiest roads.

The 5 Hectare site, however, possessed a number of inherent problems. It was a partially filled, low lying former **swamp** with **extremely poor** soil **conditions**. This was to create a number of problems in the design of the slab and below ground **structure**, as well as ongoing logistical problems during construction.

The detailed design brief called for a 2 storey 60 bay golf driving range, chipping, sand trap and practice putting areas as well as a **pro-shop**, creche, restaurant and bar facilities. Additionally a series of mini-golf, or putt-putt **courses** were planned to **attract** the less serious golfer and family groups.



It is an essential part of our firm's design philosophy to **approach** projects with a minimum of **pre-conceived** ideas, preferring rather to let the project brief, site, client interaction, and our detailed analysis of the **project** act as the **generator** of the design **solution**.

As the design **process** for this project evolved, we **determined** a series of design **tactics** aimed at addressing the inherent restrictions of the site, whilst exploring the architectural form of the **building**, and its relevance to the **functions contained** therein.

These tactics were to:

- i) develop a **strong** verticality in the **primary** building form to **ensure** the building was clearly visible from **Springvale Road**.
- ii) **develop** a dynamic building form reflective of the **nature** of the **game** of golf itself.
- iii) ensure that the building form **was** visually **dominant**, with a **strong** architectural **presence** separating it from *other* **buildings** in the vicinity, and other related uses.
- iv) **ensure** the building possessed an identifiable and marketable **imagery**.
- v) develop an efficient and repetitive structural **system** that could be **utilised** in all **circumstances**.

Whilst these **tactics** were **somewhat illusory**, they **provided us** with a **framework** within which to develop and test the evolving design for the **building**.

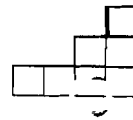
The **Driving Range** is a new type of **building** in Australia. As a result our design did **not have to be constrained** by an **established** language of **elements** or **forms**, such as when designing an office, or a **shopping** centre, **whereby** enough elements must read as **being** descriptive of the **buildings** function for it to be **recognisable**.

Our design problem, in effect **was** to create an image that would become **synonymous** with the building and its function. We were also aware that in doing so, we may also be **creating** the **image** for an **emerging building type**.

As we **embarked upon** the detailed site **planning**, a number of constraints were **identified**. These included the **locations** of a series of existing and filled **dams**, the height of the **tree line** along the **Springvale Road** frontage and the restricted public access available to the site.

With no **real** established design standards for **Golf Driving Ranges** available to us, **prior to commencing** the **functional planning** of the facility, we developed a series of spatial and functional models that were tested, refined and ultimately adopted in the **planning** of the facility. These included **areas such as driving bay sizes**, and ball delivery and return systems, as well as the **spatial relationships** between the **individual areas** called up in the brief.

Our early **building** form studies **investigated** roof forms that were **simple**, **constructed** in **conventional** materials and supported on a **regular grided** steel structure.



This early work, whilst confirming the **appropriateness** of our approach to the siting and **internal** planning of the facility, failed to resolve **satisfactorily**, the architectural place making, or **formal expression** of the building in a manner that was **appropriate**.

While the **solutions** that were developing reflected many of our aims, we felt this **was** in a static way **only**, and that **they** failed to **provide** the strong dynamic form we were seeking.

We then quite **consciously sought** to **explore** in the design, a form that referred more directly to the **fluid** nature of golf.

It was at this point that we first began investigating **membrane structures**.

Our initial **proposals incorporating** a **membrane** roof explored the roof as a series of tent like **forms**, or skins, held from above in tension by a series of cables **connected** to rigid steel frames or **poles**. They were then pegged at their **bases** to a rigid steel **frame**.

Although **comparatively** raw and tent-like, this idea had **considerable** merit we believed, and it was decided to undertake a period of research and **consultation** with various people **experienced** in the design and erection of **membrane structures**.

We were aware of the many **applications** of **membrane** structures **throughout** the east coast and central desert parts of Australia. We observed however, that many of these **structures** were designed to cover, screen, or protect external spaces. Few grappled with the problem of enclosing **internal** spaces below a **membrane** roof enclosed on its sides with rigid **external** walls. Those that did, often resolved the problem of differential **movement between** the flexible roof **membrane** and the static walls by the placement of a flexible **diaphragm** at the junction **point** to **control** all movement.

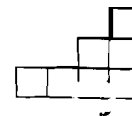
In deciding to **utilise** a **membrane** roof, we wanted to create below it a **stimulating** interior space, **full** of light and movement, that was integrated with the overall building form, not separate **from** it.

At this **time** we **met** with Bob Barrow of **Cornell Barrow McCready** and Spacotech. Our early **discussions** with him and subsequent visits to look at **existing** **membrane** structures confirmed some of the **complications** that were inherent in our **current** design solution.

This then led to a period of **reassessment** of our design approach to date. Rather than roof the entire **building** with a **membrane** roof, we **determined** to enclose the pro-shop, **restaurant** and bar facilities below a **membrane** roof **structure** which would **abut** and join the more **conventionally constructed** steel and glass structure of the **driving** range itself.

Given the relative **complications** of **joining** a **membrane** roof to an articulated **building form**, our initial analysis with **Bob Barrow** focused on shaping and **tensioning** the **membrane** to **ensure** it would maintain its shape free from flat areas, **wrinkles**, and the possibility of **long** term sagging.

The solution **developed** was to create a major roof **with dual peaks** enclosing the **internal space**, and a **somewhat smaller** roof with a single peak over the **external** point of **entry**.



The major roof would be strung between two steel columns and a rigid steel ring beam, which would be incorporated into, or attached to the external walling.

A smaller roof over the main entry, whilst similiarly attached to a ring beam around its perimeter was to be supported at its peak by a flying stub column supported on steel cables tied back to the ring beam.

Our presentation of concept drawings of the membrane roof to our client at this stage met with strong approval, notwithstanding that it would add significantly to their budget. They felt strongly however, that the image such a roof would create, would, over time offset any additional costs.

It is worth noting that the form of the roof has subsequently been adopted as the corporate and marketing image for the facility.

Now having confirmed the inclusion of a membrane roof, the detailed design analysis commenced, and the fax machine between our office and Spacetech was, to say the least, kept busy.

As already noted, we were aware that in dealing with relatively minimalist structures such as these, a close working relationship between architect and engineer was essential. All details, be they fabric joints, or steel plate fixings to edge beams, would ultimately be exposed. Thus their careful detailing, to suit both the architectural and structural agendas, would need to be undertaken in close association with the engineers.

Our design however, still had a number of complexities which required analysis and careful resolution. The two long sides of the roofed area for example were not parallel, in fact as well as curving in plan form against each other - like back to back boomerangs - they were located at different heights vertically.

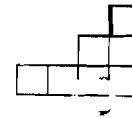
This created a series of difficulties in shaping and cutting the roof, as well as making it difficult to maintain all sections of the roof in tension.

The initial shaping of the roof was also somewhat flat, raising the potential for water ponding, and still lacking the dynamic form we had been seeking.

In consultation with Bob Barrow and Peter Lim of Spacetech, it was decided to raise the height of the peaks to 14 metres, tilt the major support columns outwards and slightly forward, whilst bringing the two long sides of the building into parallel.

A series of wire mesh form finding shape perspectives were generated by Spacetech for further analysis, and following some minor adjustments, the final shape was confirmed and the design detailing completed.

The membrane utilised is a woven PVC mated polyester fabric with tedlar laminations on the top. It was selected for its durability with respect to its resistance to ultra violet degradation, and its inherent self cleaning properties.



The edge support for the **membrane** roof **comprises** a steel ring beam turned at 90° through its XY axis to **provide** stiffness in the horizontal plane, and is fixed to fabricated steel trussed columns designed to act as vertical cantilevers to resist the inward pull of the **tensioned** roof. These trusses are identical to but **somewhat smaller** than, the trussed columns **supporting** the roof and first floor level of the driving bay itself.

The fine tolerances in the **fabrication** and **erection** of the **membrane** required that, once the ring beam at **the** base of the **membrane** was securely fixed in position on site, a licensed surveyor be engaged to plot **all** as **constructed** steel locations prior to **final** fabric cutting patterns being created.

The steel ring beam, also acts as a gutter and provides the head **support** for **both** the **external** walling and glazing.

The design of both the mechanical and electrical **services** also required careful integration, as both would be largely visible, and had to **contend** with providing an effective level of **amenity** to an unusually **shaped space**.

The fabric roof material has a **poor** thermal resistance for **transmission** and also allows a **proportion** of solar radiation to penetrate directly into the space. This resulted in significantly larger **heating/cooling** capacities for the air **conditioning apparatus**.

A **system** of split reverse cycle air **conditioning** was provided to the **main** area with the fan coil section **mounted** above the amenities **area** and the **condensing** unit **on** a plinth outside.

Because of the large **volume** of space at high level, jet diffusers **were provided** to ensure mixing of the air **conditioned** air **with** the **room** air over the full width of the room at low height. Exhaust fans are also placed at high level to exhaust the **build** up of hot air **under** the roof in **summer**, caused by the penetration of solar **radiation** through the **membrane** roof.

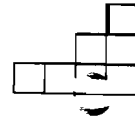
The effective **lighting** of a shape and material such as this requires the creative and adaptive use of light fittings.

To achieve an even lighting **distribution** **throughout** the main space, a system of uplighting was utilised. Because of the **limited** support locations within the fabric roof, all discharge **uplighting** had to be located on the **support** masts, or ring beam.

This lighting is a **combination** of 150w metal halide uplighters and 150w metal halide spotlights.

The light **coloured** fabric provides good reflection for the internal lighting and the fact that the material is partially translucent, allows the structure to be extremely well illuminated at night. **This** characteristic was **exploited** to ensure that the building became highly visible at night **across** the relatively flat adjacent landscape.

The **construction** of the overall facility took 18 months, mainly due to the difficult **site conditions**, with the **onsite installation** of the **membrane** roof **taking** 6 days.



The roof has already achieved popular appeal and ready identification amongst both users and the general public.

The client is satisfied it has realised a building that provides a clear sense of identity for itself, functioning both as a strong corporate image and a stimulating interior space. Its commercial success as golf driving range has been well founded.

Membrane structures provide the designer with enormous opportunity in form making and shaping, but their adoption requires that one develops an understanding of the basic nature of the material, its rules, and its restrictions.

The commitment, interaction and mutual respect between all members of the consulting team is a vital part of achieving a successful project, certainly more so than in a conventionally constructed building where the majority if not all the structure and connections are concealed.

A visionary client is also a must.