Glen Eira Aquatic Centre Tensile Canopy – a case study of insulated tension structure

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This paper discusses the design and specification of insulated tensioned membranes. It will summarise the current options available and compare performance. The performance of other ''non-tensioned membrane'' options will also be presented to help illustrate not only the strengths and weaknesses of insulated tensioned membranes amongst themselves but also against other forms of cladding. This performance will then be related to some typical situations where insulated tensioned membranes are a good design selection. After this overview of insulated tensioned membranes, the roof structure at the Glen Eira Aquatic Centre will be presented as a completed insulated tensioned membrane. This project had 4 different insulated tensioned membrane solutions proposed along the way and so is a good example of comparing possible design solutions to achieve an optimal result across the multi-discipline design team.

Why insulate a tensioned membrane?

For that matter why choose a tensioned membrane at all?

- tensioned membranes provide an efficient method of spanning large distances with minimal materials.
- Many allow light to pass through them
- Free formed tensioned membranes can create curvaceous and striking envelops

Why not to choose a tensioned membrane

- very thin material has very little resistance to heat transfer
- surface temperatures of fabric reflect exterior conditions and condensation can be formed

Brief History of Insulated Tensioned Membranes

- Simplest form is to have a double layer structure with an air gap

- Many structures have tried to place insulation between an outer and inner layer
- Main issues – fungal growth, lack of light and movement of insulation material
- Projects like Hong Kong Airport overcame so of these issues by providing 3 separate layers.
- 3 layer ETFE pillows have been used for a number of projects
- More recently composite membranes have been used for example insulated truck curtains and Tensotherm

There are many parameters which each system can be measured against however to simplify U value and light transmission have been considered. These numbers are not exact as not all are measured to the same standard and it is difficult to allow for project specific framing and connections. Values also very a little for cold and warm roof applications and orientation however these numbers can be used as a basis for comparison. Resistance to moisture/fungal growth, appropriate fire characteristics, QUV weathering, have assumed to be appropriate. Along with material suitability for safe handling and fabrication. Heat gain can be considered approximately proportional to light transmission. Most systems can have solar gain reduced through the use of colors, low ''e'' coatings, frit patterns however are beyond the scope of this discussion. Acoustics has not been considered in this comparison.

Comparison of insulated tension membranes

System	**Single Layer PTFE**	**Double PTFE Skin 400mm air gap**	**InTeM™ by Oasis**	**Tensotherm™ by MakMax**
Overall Thickness (mm)	1	400	24	17
U value (W/m^2K)	5.6	3.5	1.1	1.1
Light transmission (% visable light 400-700nm)	10 to 15	3	0	2
	Multicell Polycarbonate eg dampolon	**Double glazed units**	**3 layer ETFE cushion**	
Overall Thickness (mm)	16	6 + 12 + 6.4 = 25mm	1 to 500	
U value (W/m^2K)	1.5	2 to 3	2	
Light transmission (% visable light 400-700nm)	20 to 50	0 to 75	0 to 90	

Essentially insulated tension membranes are have a lower U value than other forms of transparent cladding. The composite panels can be increased in thickness to improve U value even further however this reduces the amount of light transferred.

So when would an insulated tension membrane be a good idea;

- enclosed spaces – full or partial combined with other cladding products
- complex geometric building envelop

- skylights

Glen Eira Aquatic Centre

Client – City of Glen Eira

Design Team

Architect – Mantric Architecture

Structural Engineers – Cardno

Services Engineers – VOS Group

Tension Membrane Engineers – Tensys

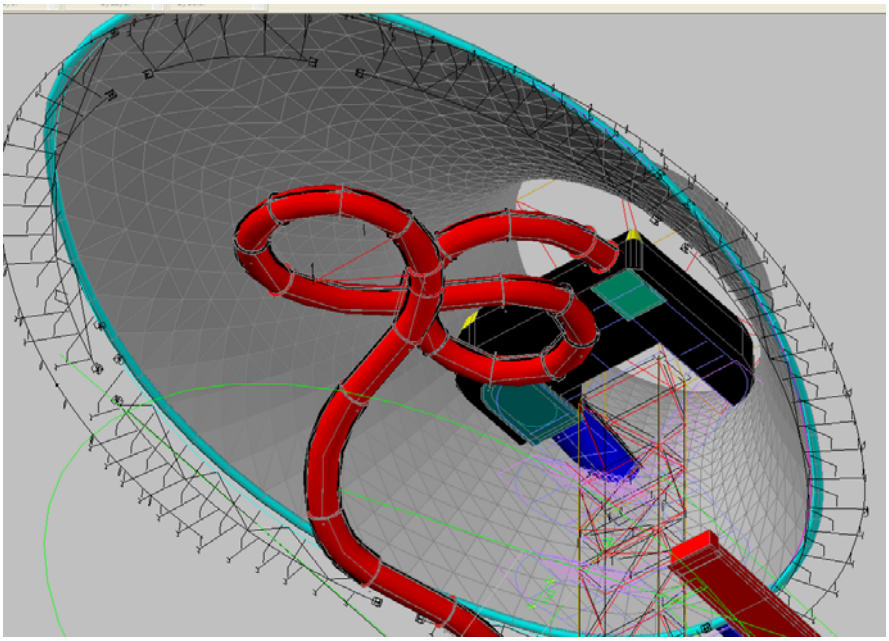
Construction

Main Contractor – Hansen Yuncken

Specialist Tensioned Membrane Sub-contractor – Oasis Tension Structures

Why tensioned membrane?

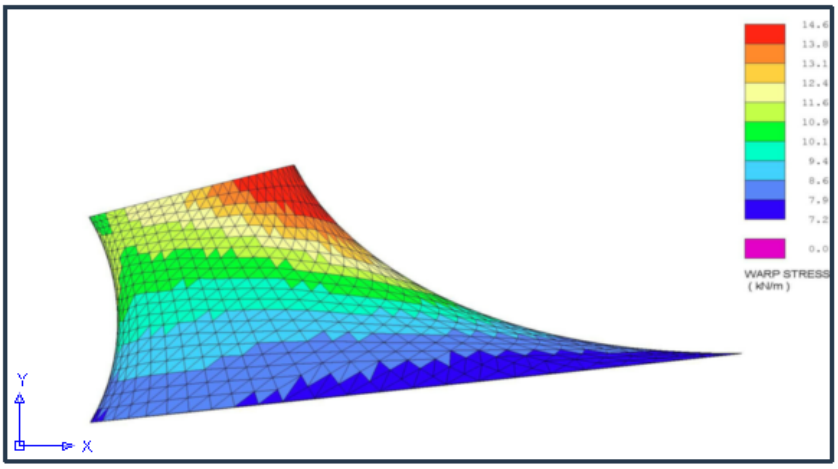
This solution was proposed by the structural engineer to address the geometric constraints of the roof efficiency while achieving the architectural image. The roof structure had to enclose the stair tower and two water slides as well as allow one water slide to pass through it. These restrictions resulted in a very asymmetrical conic form with highly varying prestress. Ties to the back of the head ring were required to balance the prestress forces. These were designed for temporary compression loads during erection.

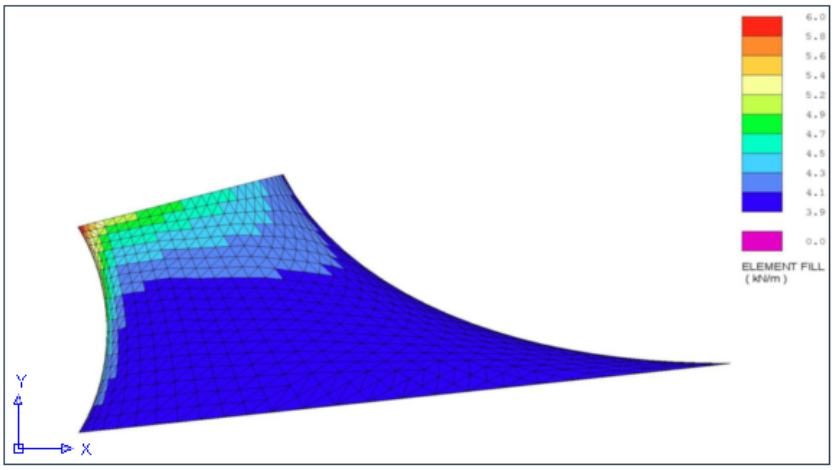


Why insulated tensioned membrane?

- enclosed building
- pool environment – moisture - high humidity
- Melbourne climate, cool winters, heating required in building
- VOS calculated an U value of around 1 would reduce condensation to suitable level
- Tender design was based on two alternative systems
    - 17mm tensotherm
    - Double layer with air gap and increased mechanical air handling capacity

These two options were fully designed and co-ordinated prior to tender. Tensys and Cardno worked closely to ensure accurate modeling of stair tower supporting to minimize steel tonnage. Tensys analysed the primary stair tower steelwork within the fabric model to given realistic deflections and resultant forces to Cardno. The fabric form was incorporated in the Architect's Rivot 3D model to ensure fit between stair tower, slides and handrails. These tender drawings included a proposed erection methodology.





During tender, an additional two systems were proposed;

4 layer ETFE cushions

Insulated composite fabric membrane (based on insulated truck curtain insulation)

So all four systems were evaluated base on performance and cost. Oasis' InTeM proposal was selected as natural light transparency was not a significant design consideration.

Conclusion

Will insulated fabric structures change the built environment as we know it? No, but in a world more conscience of building envelop performance, complex geometry and desire for varying cladding materials I can see opportunities for insulated tension membranes to become a bigger part of enclosed buildings.

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