

# Membrane Structures

Innovative Building with Film and Fabric

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**William Taylor  
Opting for Membrane Architecture**



Most people have childhood memories of being in a “tent”. It may have come from a trip to a circus, a family holiday or simply playing with friends in a sunny garden. For most of us, these memories are pleasant. “Tents” are fun – and people like them.

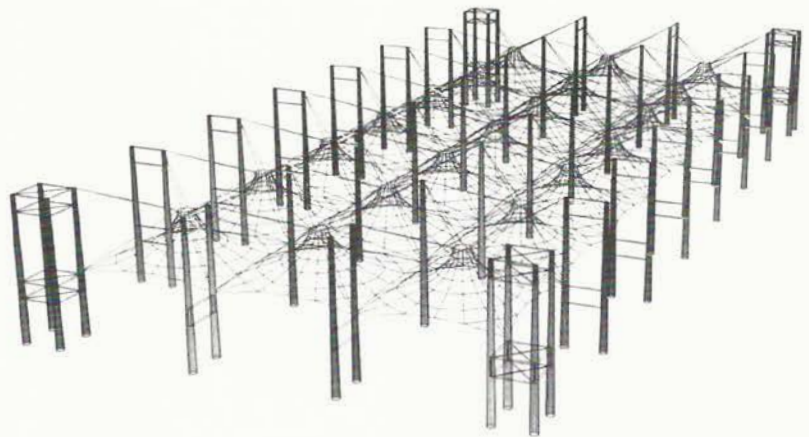
For me, the attractions of membrane structures lie as much in their visceral qualities as they do in their logical ones. A good tent just looks “right”. It possesses visual dynamism, lightness and openness, rhythm, harmony and elegance. The form requires no explanation, it simply “feels” appropriate and has the power to excite. Perhaps these feelings stem from these early connections.

This simplicity however belies the very high degree of sophistication that underpins these structures. Membrane architecture and its engineering is a serious business, designed and built to last a long time, and to carry substantial loads safely. Advanced fabrics together with high levels of analysis have empowered architecture to transcend the “circus marquee”. We have a new repertoire of forms and effects to play with, and what has emerged is a clearly identifiable architectural expression which continues to develop.

There is something very logical that draws me to using architectural membranes. Perhaps more so than in any other type of construction, the architectural solution derives directly from the structural performance and the use of the material itself. Membrane roofs are a pure expression of the inseparability of architectural form and structural function – the aesthetics are directly affected by the structural system. This gives a clear architectural generator for the entire scheme and a clear explanation of its meaning – a sort of “architectural onomatopoeia” – the dream of the modern architect.

I first became seriously interested in membrane architecture in my final years at Architecture School. Of course I pored over the books and articles about Frei Otto and the IL, but it was ultimately my final-year tutors, Ron Herron of Archigram and Cedric Price, and their exploratory work that really fired me up about membranes and their inherent possibilities. Here was an architecture that was both rooted in its time and ahead of it, using new materials and technology. In fact, here was a chance to create a new type of architectural expression with innovative social consequences and technical agendas to go with it.

One of the first pieces of technical literature I possessed was a brochure from Chemfab and Birdair that promoted their work at the then recently completed Haj Terminal in Jeddah (ills. 1, 2). For all of its constructional mastery, it was the scale of this “building” that was inspirational. Forty-metre-square repetitive structural bays provided cover for the pilgrims below and dwarfed the Boeing 747s parked alongside. Inside the brochure there was a photograph taken from above



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1, 2 Haj Terminal, King Abdul Aziz International Airport, Jeddah: isometric, and view of membrane roof structure, Architects and engineers: Skidmore, Owings & Merrill, Horst Berger, Schlaich Bergermann und Partner  
3 Schlumberger Research Centre, Cambridge, England, 1982–92, Architects: Michael Hopkins and Partners, Structural engineering: Arup; Wintergarden



the roof. The shot was of a vast white undulating membrane with a “dot” in the middle distance of a human figure standing alongside a four-wheel-drive vehicle. Such was the scale of this structure that the constructors had to drive across the roof to get to their place of work, and such was the strength of this fabric – itself no thicker than a tablecloth – that they could do so. Membranes can totally subvert normal expectations of form, structure and material.

The Haj Project possessed another important characteristic. It did not follow the free form or organic shapes generated and favoured by other early membrane designers. It was disciplined by an overriding architectural system.

For me, membrane roofs and enclosures need to be controlled, and they need to have a logic that is rooted in a wider architectural concept. They are not merely technical responses to a given structural challenge, they have the potential to realise latent possibilities for the user and to provide the architect with a unifying architectural rationale for his or her work.

The options are almost endless, and it is the role of the architect to limit these by design, from setting the initial design agenda through to directing and controlling the final built details. As this applies to every architectural project, designing a membrane building does not call for some unique sensibility. So, what makes us select a membrane solution when not all of our buildings are membrane structures?

We choose architectural membranes where it is sensible and appropriate, where the qualities of a membrane structure are well suited to the issues at hand, and where there are innate opportunities within the clients' brief to do so. Normally, at least for us, the genesis of membrane buildings is not primarily technical, but rather it comes out of the possibility to create “new” or unforeseen types of space – for example, ones which may not need full environmental control, or ones that can create and promote social interaction which may even not have formed part of the clients' original brief. We see them as an imaginative tool whose specific characteristics can make them ideal for particular functions.

For the users of the building the attractions are obvious. We can provide shelter, a modified environment where they can linger and be sociable, a new type of space with natural light and contact with the outside world – all leading to an increased sense of well-being, of belonging, and of a great “place” to be.

These spaces can be memorable, even iconic, as can be said, for example, of the Schlumberger building in Cambridge, where the membrane-covered spaces immediately became both the external “image” and the internal “identity” for this organisation (ills. 3, 4).

Moreover, the building itself can quite literally project an image. The characteristics of a membrane



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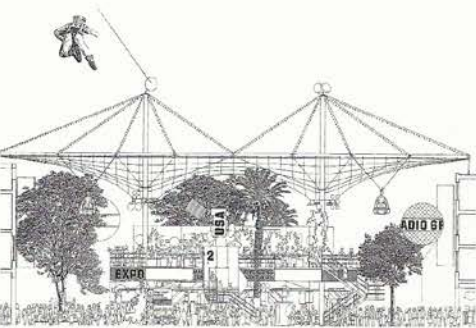




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by day are completely transformed when it comes to night-time. The building becomes animated in a completely different manner, and at its extreme, the membrane presents a large “light” canvas for projection and animation (ill. 9).

It is an interesting and valuable characteristic that the inherent architectural language of membranes is invariably morphologically independent of the historical, geographical, architectural or social context into which they are introduced. In this respect they can represent a neutral intervention whilst still possessing their own strong architectural identity. To us, this is one of their most appealing aspects (ill. 8).

The designer will inevitably be required to demonstrate the reasoning behind the choice of a membrane solution above the alternatives, and these may indeed be almost entirely technical – membrane structures can be overwhelmingly efficient. The potential of spanning relatively large distances with minimal materials and of allowing daylight and air into large volumes have set free a whole new set of possibilities for architects and engineers. A single membrane sheet can enclose a volume that would have been impossible or uneconomic to cover with traditional materials and it uses only a fraction of the built resource previously necessary.

For northern Europe's inhabitants, this type of structure provides shelter and protection, modifying the environment by reducing heat loss, allowing the penetration of natural light into the heart of buildings and utilising passive solar gains for the benefit of the occupants of spaces. In southern climates, they act as buffer zones too; they provide valuable shade and their form can induce beneficial ventilation-patterns.

Our practice learned very early on that the success of using membrane roofs relies heavily upon the controlled use of daylight and, in particular, on the combination of direct and indirect light through clear glazing and diffuse membranes respectively to provide a “modelled” and lively internal environment.

Opting for membrane architecture is not a decision for the architect or the engineer alone. Although the use of PTFE- and PVC-coated fabrics and ETFE foils has now become a more established form of construction, membrane buildings are still relatively unusual, and it has never been easy to persuade a client that they should commit to this form of construction. The growing body of work exemplified by this book is a credit not just to the technical teams who drove the projects forward, but also to the clients whose confidence has been amply rewarded.

We are now moving forward with a new generation of materials and new levels of sophistication. Foils, films and new composite materials will continue to extend the vocabulary and possibilities, giving us improved thermal performance, higher structural

4 Schlumberger Research Centre, Cambridge, 1982–92

5 Glyndebourne Opera, Glyndebourne, England, 1989–94, foyer, Architects: Michael Hopkins and Partners, Structural engineering: Arup

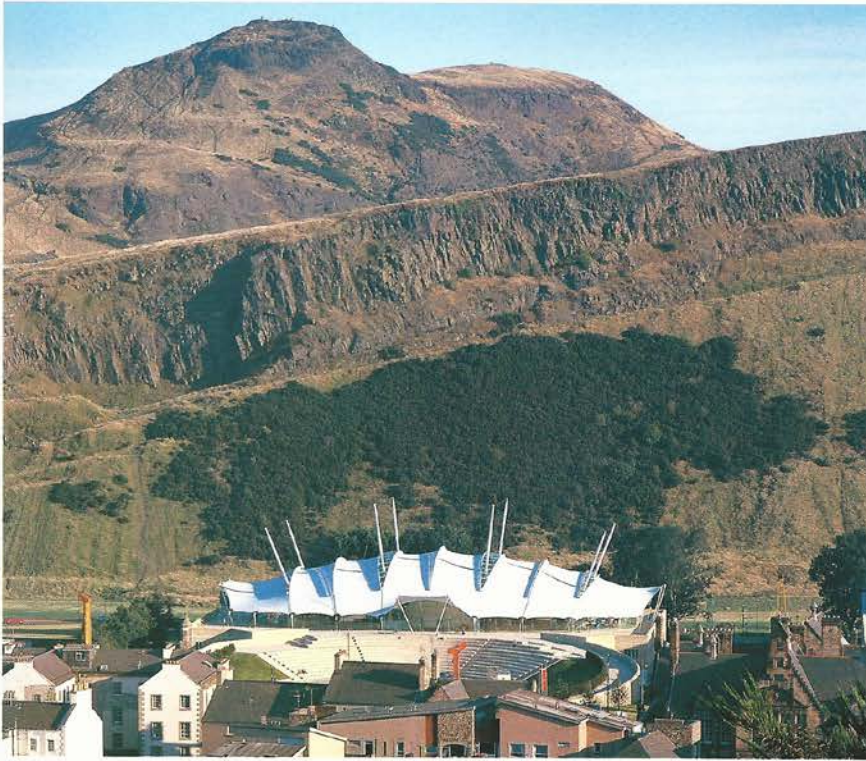
6, 7 Basildon Town Centre, project, 1981–84, Architects: Michael Hopkins & Partners

8 Dynamic Earth Centre, Edinburgh, Scotland, 1990–99, flamboyant landmark in the daytime, Architects: Michael Hopkins & Partners, Structural engineering: Arup

9 Dynamic Earth Centre, night view

10 Saga Amenity Building 1996–98: view from inside over the surroundings and the ocean, Architects: Michael Hopkins and Partners, Structural engineering: Arup





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efficiency and better value for money. The architectural consequences are there to be explored and the future remains exciting. As these developments increase the range of applications where membranes are appropriate, we could see the emergence of a new architectural language, where the relationship between form, space, material, light and texture differs from any previous one. In one sense, it will be abstract and mathematical, but in another, it could allow architects to evolve entirely new configurations between form and people.



9