Evolution and Advantages of Membrane Structures in Architecture

> “Materials have always played a critical role in our architecture. We pursue an idea that one might call ‘truth to materials’ where the structure is both appropriate and evident, the details are self-explanatory, and the primary constructed surfaces remain visible in the finished building. Increasingly we are exploring highly efficient, multi-functional elements, where structural performance, enclosure, light and thermal transmittance are combined in a single element.
>
> In all of this we seek an architecture that is of our time and that fits our spirits.
>
> These are the reasons we use membrane structures in some of your buildings. Standing beneath the undulating and taut canopies high overhead, one is aware of the perfect diagram of forces, the precision of a handcrafted object and a sense of light that is perhaps this century’s response to the grace of the Gothic cathedral and the bravura of the Crystal Palace.”
> Sir Michael Hopkins, 2002

Figure 1. Covering of an inner court, Antwerp, © The Nomad Concept

The use of mobile circus tents, known for their efficiency, has stood the test of time.

About 60 years ago, textile architecture emerged, inspired from these circus tents, and gained popularity. This technology combines a primary structural framework with a thin curved skin. Unlike conventional structures, membrane structures constructed from flexible cables, fabric, or foil, exhibit remarkable deformability, attributed to their inherent flexibility. The necessary stiffness of these structures is achieved by prestressing.

In the 1970s, architects and engineers explored possible shapes, assembly methods, tensioning techniques, and the use of innovative textiles. The resulting membrane

structures often have organic forms that blur the traditional delineation between landscape and construction.

One prominent advantage of these structures lies in their exceptional lightweight properties, which offer significant benefits in terms of ease of construction, transportation, and overall sustainability.

These structures can be used to create retractable roofs and roof coverings with large spans. Moreover, integrating tensioned structures into traditional buildings is relatively easy.

In the past, designers mainly focused on form finding to determine the curved shape, establish an effective support system, determine prestressing, evaluate surface deformability, and develop specialized components for prestress installation and adjustment.

However, contemporary considerations extend beyond initial construction. Factors such as operational costs, maintenance demands and end-of-life disposal must be included in the design phase. For example, the membrane's ability to reflect and transmit solar radiation and light can significantly impact shading and daylighting effectiveness, thus affecting operational costs. In general, membrane structures can be easily dismantled, facilitating reuse or recycling strategies.

Werner Sobek once compared the applications of textile architecture to an iceberg, much of whose potential remains unseen. An increase and diversification of applications was anticipated. But what has become of the attraction of textile architecture? Is this metaphorical iceberg also melting?

Despite advances, the production and assembly of membrane structures still rely heavily on manual labour and specialised expertise, so it remains a niche within the industry. Nevertheless, this lightweight construction method has numerous advantages. With reuse and recycling emerging as the only viable end-of-life options, it is necessary to rise to the challenge and fully support relevant research efforts.

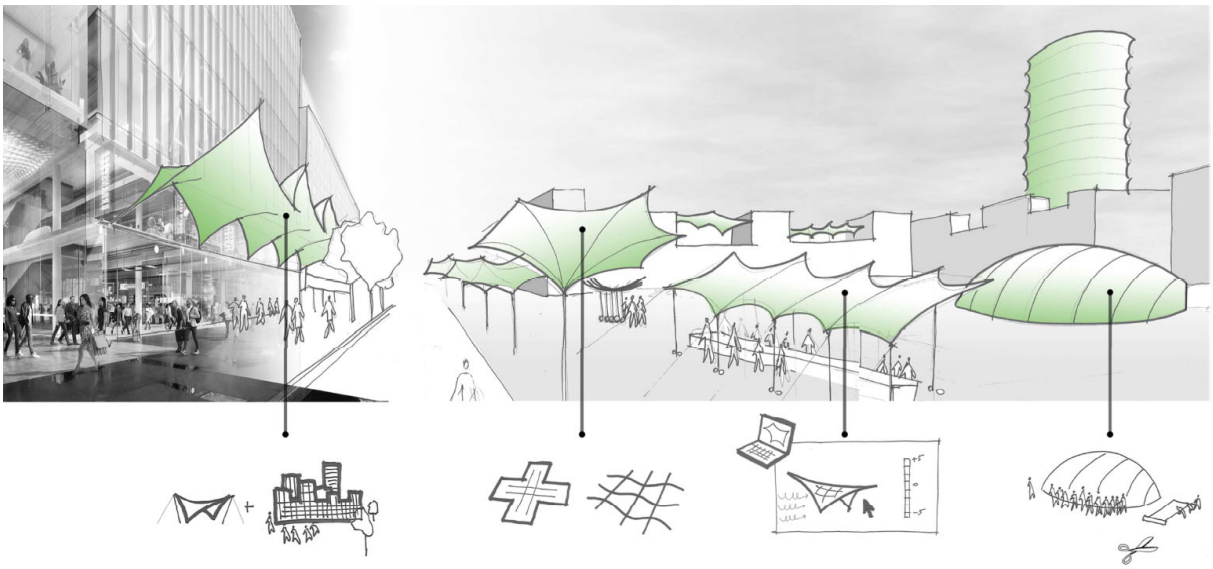

Figure 2. Textile architecture in the built environment, © Lars De Laet

April 2024, Marijke Mollaert