

THE SUSTAINABILITY OF TENSILE SURFACE STRUCTURES

For every project, the designer must think about the efficiency of production and use phase, and about the valorisation at the end of life of components and materials. These concerns should be considered from the very start of the design. Tensile surface structures are considered temporary, as the life expectancy of coated fabrics is 20 to 40 years, for ETFE foils it is more (100 years).

When reusable and/or recyclable materials are chosen, a building's environmental performance improves. But, to what extent is this applicable for membrane structures?

Analysing 4 case studies

By means of analysing case studies, 'circularity' in use and current options at the end-of-life phase have been evaluated. Three case studies were made from PVC-coated polyester fabric, one used an ETFE-cushion system (Fig. 1). Environmental Product Declarations are used to estimate environmental data like the Global Warming Potential (GWP) and the Primary Energy Demand (PED) (Table 1).

From the 15th till the 21st of August 2005, the World Youth Day event took place in Cologne. **Wolke Marienfeld** (Fig. 1) was a pneumatic structure that served as the Pope's stage roof. At the end of the event, after only a few days, the construction was dismantled. The modular truss components were reused, while the membrane fabric was unfortunately thrown away (landfill). The client did not want that this iconic construction should be reused for another purpose.

The **Finmeccanica Pavilion** (Fig. 2) was built in 2006 for the International Air Show (Farnborough, UK). After four weeks, the construction was dismantled and stored. The pavilion was reused in 2008, in 2010, and in a different set-up in 2013 in Le Bourget (Paris, FR). The steel frame could be reused. What happened afterwards with the membrane and foils is unknown.

The **Elspe Grandstand cover** (Fig. 3) is an open canopy, hanging on 2 main cables. The structure was built in 1978 and the membrane replaced in 2014. The primary structure was reused, without major modifications, and supports the new roof for another 40 years. The old membrane was thrown away.

At the **Vodafone project** (Fig. 4) the ETFE cushions in the roof, installed in 2001, have been replaced in 2020, with the primary structure being reused (Newbury, UK). Vector Foiltec takes back all old material to recycle it, and purchases flexible pipes and valves made from recycled ETFE.

Generally spoken, the self-weight of all these structures, considering skin and supporting structure, is low, especially for the ETFE-cushion system (4,59 kg/m²).

The PVC-coated polyester fabric was in all cases either landfilled or incinerated, which is not at all an eco-friendly option. Only the ETFE foils were cleanly dismantled and down-cycled. The GWP as well as the PED for the structures covered with PVC-coated polyester fabric is low compared to the ETFE-cushion system, as in the cushion system the aluminium frame is included.

Sustainable approach

Membrane structures are conceived to be temporary: they appear and disappear depending on their function. It is hard to find data about their environmental impact, or to draw general conclusions. More research effort is needed.

Although it is perceived that worn-out membranes have no value, their production represents a large part in the environmental indicators. Hence, it is important to find alternatives for the landfill and incineration, currently applied after a mostly short lifespan. The technology and knowledge to recycle exist, the whole membrane structures industry must take its responsibility.

REFERENCES

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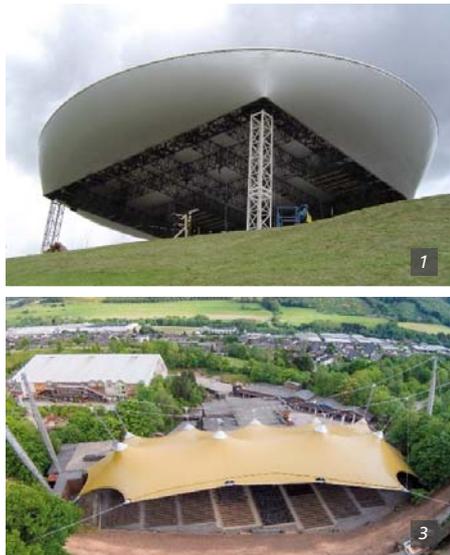


Figure 1. Wolke Marienfeld, © form TL

Figure 2. The Finmeccanica Pavilion, © Canobbio

Figure 3. The new Elspe Grandstand Roof, © Koch Membranen

Figure 4. Dismantling the ETFE-cushions, Vodafone project, © Vector Foiltec

Table 1. Case studies:

General information and end-of-life	Elspe Grandstand canopy (3)	Wolke Marienfeld (1)	Finmeccanica Pavilion (2)	Vodafone Project (4)
Year of construction	1978	2005	2006	2001
Covered Area	2600 m ²	960 m ²	1695 m ²	278 m ²
Material	PES-PVC	PES-PVC	PES-PVC	ETFE-cushion 8system
Self-weight membrane	1600 g/m ²	900 g/m ²	750-900 g/m ²	1000 g/m ²
Overall weight	13,5 kg/m ²	260,5 kg/m ²	50 kg/m ²	4,59 kg/m²
Use	37 years	2 weeks	every 2 years 4 w	20 years
Year of dismantling/renovation	Membrane replaced in 2015	Dismantled in 2005	Reused in 2008, 2010, 2013	Dismantled in 2020
End of life	couldn't be recycled/reused	landfill	stored, Incinerated?	downcycled
GWP per m ²	9.8 kg CO2-eqv	4.54 kg CO2-eqv	5.55 kg CO2-eqv	58.2 kg CO2-eqv
PED per m ²	135 MJ	142 MJ	78.1 MJ	747 MJ