SOFTENING THE HABITATS
SUSTAINABLE INNOVATION IN MINIMAL MASS STRUCTURES AND LIGHTWEIGHT ARCHITECTURES

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Alessandra Zanelli, Carol Monticelli, Marijke Mollaert, Bernd Stimpfle (Eds.)

Softening the environments: Is there anything like an environmentally compatible membrane?

Katja BERNERT*

*Architect, Low & Bonar GmbH
Rheinstr. 11, 41836 Hueckelhoven, Germany
katja.bernert@lowandbonar.com

Abstract

Thoughts about environmentally friendly materials focus on recyclability if not compostability. Opinions about Polyvinylchloride as one of the main components of architectural membranes reflect the opposite of what is commonly described as environmentally friendly. It is the industry's responsibility to explain the compatibility of the composite membrane material and environmental concerns.

Most evident are of course the savings in tons of material - when it comes to a comparison between a fabric and a stone cover for example. Secondly there is the durability of today's membranes that is more and more competitive with other established materials. As these two aspects were previously discussed extensively, this paper will focus on the membranes' other environmentally compatible properties. There are two lines of argument: on the one hand membrane constructions as softening our built environment by their shape and by their soft skills. On the other hand there is the membranes' advantage of adaptivity.

Fabric façades for example are much more than just a textile wrap for a building. The soft forms of a membrane façade are acoustically effective in the cities' micro climate. Additionally they can easily adapt to the user's changing needs. The fabrics' adaptivity is facilitated if the textile has smart properties. Within tensile architecture smartness is only

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evolving now: at the end of this development the fabric mesh will be the matrix for all sorts of applications – ranging from leading electricity to supplying lighting as in a vast LED screen. Along with the fabric's inherent soft skills, its growing smartness will facilitate its role in softening our environment.

Keywords: softening, environment, vinyl coating, lightweight structures, sustainability, smartness, textile facades, adaptivity, compatibility

1. Introduction

The technical textiles industry has been repeating two answers when it came to the sustainability question: Yes, the products are environmentally compatible because they are fully recycable. And: Yes, using an extremely light material makes fabrics sustainable right from the start. The latter is old hat; the former is not true anymore for the European recycling site was closed in summer 2018 due to the lack of recycling orders.

In order to reassure the textile industry's sincerity of still be taking part in the sustainability debate, it has to find new lines of arguments. There is more to technical textiles than their lightness and (now mere theoretical) recyclability. The membrane's soft skills have to take over.

2. Sustainability thoughts up till now

Most likely most architects and planners are fed up with the sustainability debate by now. The longer it has been going on the more its actual content was depraved. Whereas certifications as BREEAM or LEED were initially meant to testify on the buildings green properties they are now more and more degraded to a mere financial issue – mislead by investment companies that focus on the value for money of environmentally compatible materials or ways of building. The same is true for the material suppliers. There are whole industries lobbying on materials like Polyvinylchloride, pushing forward its ecological value.

2.1. Material savings

"The best material is the one that you don't need to use." Knut Göppert's introductory words in his talk about material savings in membrane structures are of course still valid[1].

2.1.1. Reducing tons – reducing costs

It is obvious that fabrics are apt to wrap buildings at a fraction of the material need for other aesthetical enclosures as stone or aluminium façades. This applies to the sub construction, too, which is obviously even more important when it comes to roof structures. It is most evident that a spoked wheel construction for a stadium roof is so much lighter than a concrete cover.

The textile industry should not dwell on these evident facts. All players in the market should be striving for new lines of reasoning for the softening of our habitats.

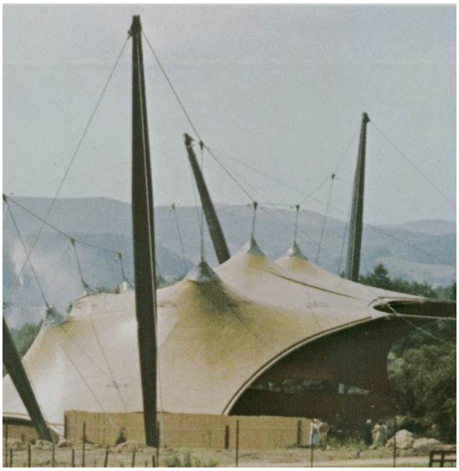
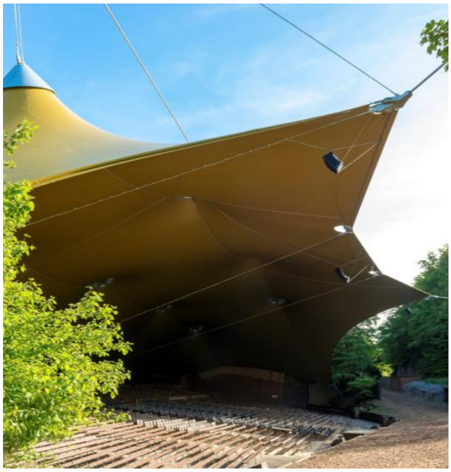
2.1.2. Reusing – recycling

The sustainability debate about fabrics has been mainly dominated by elaborate documentations about the possibility of recycling. It was shown and communicated again and again that principally the PVC-coating can be separated from the Polyester base fabric, that both materials can re-enter a new cycle similar to raw material. About ten years ago even the Glass/PTFE fabric industry showed scientific research programs that enabled the separation from the compound of glass fibres and PTFE coating. The latter never really left the laboratory stage. More frustrating is the outcome of the former: diverse prefixes like vinyl- or texy- were communicated for loop-programs meant to fill a factory in Ferrare, Italy, that was built only for the purpose to separate the two raw materials PES and PVC. Elaborate life cycle assessments made the fabric industry believe that it was worthwhile collecting the used material and bring it all the way to the factory. Unfortunately we now know that these loop-programs failed – at least on the European level[2].

This is obviously rubbing salt into the sustainability wound of the tensile architecture industry. On the one hand the reason for this failure might have been the business model of the factory itself, not being able to charge adequate prices for all players within the coating industry – no matter which prefix to the loop. On the other hand it very often was a customer decision. When for example fabrics were used as a replacement for older textile wraps, the thermal recycling was most often the customer's choice. The fact that there's a lot of energy in raw oil based material like PVC is only whitewashing the fact that the industry did not succeed in pushing the true recycling program forward.

2.2. Durability

The durability of PVC/Polyester fabrics – for example with Nano topping – now comes close to that of glass/PTFE membranes. Even in the 1970's – in the pre Nano age – the fabric was already extremely durable. This was shown for example in the Elspe paper that was presented at the Tensinet Symposium in Newcastle 2016[3].

Figures 1 and 2: Elspe, Grandstand Canopy, Figure 1 shows the original project from 1978 © Mehler Texnologies, figure 2 shows the replacement from 2015 © Koch Membranen

The grandstand canopy was originally covered in 1978 with a Type V Mehler membrane. It was thoroughly surveyed – mostly within the last 10 years of its design life. It turned out that the loss of tensile strength was only about 20%. Given these values and the ample safety factors used in tensile architecture, the structure was obviously not in danger of falling down. Nonetheless the client opted for a new roof with Mehler Type V fabric – new lacquer techniques now promise a similarly positive performance of the colour.

Table 1: material residual mechanical values compared with the initial properties

Year 1979 ►	198 kN/m = 9935N/5cm	Results extract of 30 years periodical tests on yearly base
Year 1989 ►	173 kN/m	
Year 2000 ►	168 kN/m	
Year 2005 ►	197 kN/m	
Year 2007 ►	184 kN/m = 9450 N/5cm	

In the past the PVC/PES players within the tensile architecture range tended to compare themselves with the still more durable glass/PTFE fabric version. Whereas the Vinyl-Industry has been struggling to improve their recipes – not only in terms of REACH compliance – but at the same time in terms of longer durabilities, the glass/PTFE coaters have been relaxing on their quality advantages. The gap within the main two options shrinks: that is to say new benchmarks turn up to be compared to.

2.2.1 Catching up with the big five

The textile industry is now more and more facing the comparison to the big five of building materials: bricks, steel, concrete, glass and timber which have been used for hundreds and thousands of years. The textile industry's narrative about ancient fabric structures like Bedouin tents or tipis belie the fact that the fabrics which used to be part of the Roman coliseum are no longer in place – as opposed to the stone bricks.

This is yet another reason to look for alternative membrane skills that are apt to show its environmental capability. There is definitely more to environmental compatibility than the hitherto discussed topics of recyclability and durability.

3. Environmental compatibility by soft skills

It is amazing what sorts of positive aspects are mounted when seen through the eyes of the PVC industry. Association like Plastics Europe or the German AGPU frequently publish news on the enormous environmental compatibility of vinyl floors, tubes etc.[4] Clear enough that political lobbying and re-labelling PVC as Vinyl is still not able to brainwash the architects' minds when it comes to the choice between a Polyvinylchloride coated Polyester Fabric and an organically degradable cotton cloth. Yet there are distinctively soft skills that need to be pushed forward – along with a continuous guidance about the positive properties of PVC et al. in membranes.

3.1. Softening the environment

Which material seems more appropriate to soften our habitats: concrete or fabrics?

Within the trend of parametric architecture buildings tend to be softer than in the technologically dominated style of the 1990s for example. Houses that react sensitively to their environment tend to be softer within their surroundings. Nonetheless we still see lots of glass and steel in these buildings. Whereas their forms pretend tenderness close to fabrics their conventional execution betrays their designer's parametric design approach.

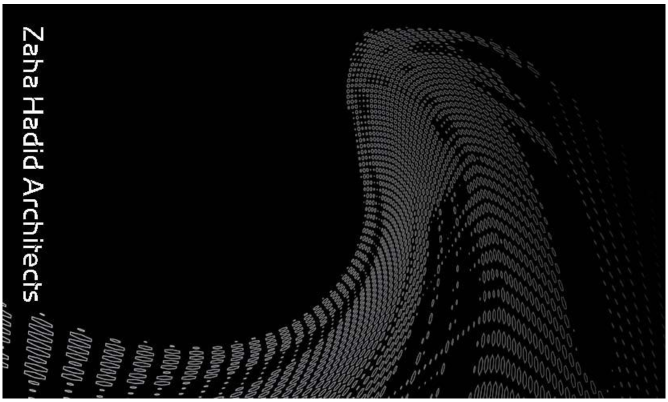


Figure 3: Exhibition poster on Zaha Hadid and Patrick Schuhmacher's parametric design

The list of the membrane's soft skills can be easily prolonged: a tensile wrap softens the impact of wind for example. With a fabric mesh in front of the glass façade the people in the office spaces are still able to open their windows individually. Another example is the radiation of the sun. Giving shade is a commonly used soft skill of fabrics.

Figure 4: office building in Ecuador with a textile wrap, TF 400

The constant sun shading by the fabric façade is obviously beneficial for the Indoor Environmental Quality (IEQ)[5]. As these softening effects are widely known and often applied the following two examples will put the light on functionalities which are less obvious.

3.1.1. Filtering effects

The membrane's ability to enhance the air's quality is often described as the autocatalytic effect. Indeed special coatings can filter and capture the dirt within the polluted air. With the help of the sun's radiation there is an improvement of the air quality in the textile structure's direct environment. Naturally this effect is biggest near to the fabric. It cannot solve the pollution problems of a whole city. Nonetheless this technique makes sense for example near transportation hubs where pollution caused by vehicles is particularly high. A team of the university in Aachen came forward with proposals in that direction for the local bus station. The situation of that building has been discussed within the city for a long time already. The team of the department of building technology at the architecture faculty developed a scheme to soften the station's environment: covering the run down façade with a fabric mesh that is not only delivering optical improvements but has the ability to improve the air quality with a special coating[6].

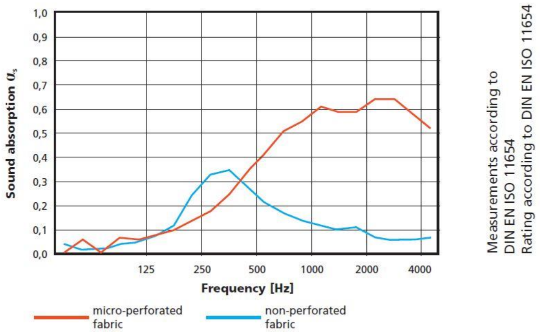
Figures 5 and 6: The main bus terminal in Aachen, as it is (on the left) and as a soft skin could alter it (on the right), computer simulation by Aachen university

There still needs to be more research and development in this direction. Of course it is difficult to measure the actual improvement of air quality. If there were decent numbers and figures that would help enormously to strengthen the fabric's image within the city councils. Just comparing the fabrics' function with the service of a number of trees won't convince decision takers – let alone the investors who need to put these vague numbers into a Green Building certification for example.

3.1.2. Acoustical effects

The transportation hub clad by fabric meshes is exemplary for another of the fabric's soft skills. It is more than obvious that textiles help a lot in the general acoustical comfort. Our comfort zones at home for example are full of textiles. Moreover office spaces can't provide for workable desk zones without implementing perforated textiles for acoustical absorption.

Table 2: exemplary acoustical absorption by a perforated PVC/Polyester membrane



Measured sound absorption (α_s) in reverberation room. The perforated material achieves a α_w rating of 0,40 (H), which results in sound absorption class D.

There has been elaborate testing as to the acoustical effects of textiles in inner spaces. Acoustical comfort in the outside environment gets more and more importatnt, too. Here, the absorption effects which have been tested for stadia spaces can be transferred to urban environments. At the moment there is a lot of steel and glass in our city's central business districts. The future is bright – and much more silent! – if these hard surfaces were more and more covered by acoustically effective fabrics or textile meshes. Replacing Diesel motors by electrical cars will add to this positive effect of silence in our cities

3.2. Smart skins

Up till now fabric façades play a minor role in urban street views. Their functionality is hence limited to providing for a cover of other –probably less presentable- building skins. The building's climatic wrap is conventionally done with the five main building materials: bricks, concrete, glass, wood or metal. The fabrics' part in actually shaping the city is still very small.

As smartness and adaptivity are now becoming more and more important for building wraps textiles will eventually play their joker: as opposed to brittle building materials fabric façades have the enormous advantage of being perfectly equipped for adopting this challenge. Developments in this direction are done on a push and pull basis. On the one hand it is the input of architects and designers that strive for innovative solutions for their building skins and hence pull the industry. On the other hand it is the industry itself which pushes the material development forward in order to provide for solutions that are easily applicable by the market.

3.2.1 Smartness by technical features

Smart phones are omnipresent in today's life. According to the phone analogy smart is everything that facilitates processes. Our smart phones enable actions that used to take a lot of time – only a couple of years ago. Taken into the material world, smartness hence means that a smart material is able to solve complex specifications at one glance and in one form. That is to say that smartness in material science has a spatial and a temporal notion.

We already live in smart homes that link all our smart devices with the smart materials – enabled by our smart ideas. Following this line, smartness in material science means providing for multifunctionality. Smart wraps are hence building skins that are not mere climatic façades but provide for many other functions at the same time.

One step in the direction of including various technical features within a membrane is the pocket membrane Valmex Systems. On a still analogue level it is meant to give an answer to the users' different needs for including for example lighting or heating elements. The fabric provides for linear pockets in warp or weft direction which can be filled with all sorts of technical features. In this way it is the analogue matrix which is the first step in providing for a digital net that makes the filling process obsolete. The fabric itself would be the matrix, including all technical features in its structure – like the circuit board of a computer.


a)


b)


c)


d)


e)


f)

Fig. 7 a), b), c), d), e) and f) pictures of possible technical features within a membrane

3.2.2. Smartness by adaptivity

Along with the technical features that today's materials have to provide for there is an additional need for adaptivity. We want to have the above described smartness by technology. Because the users will change along with the building, along with the climatic conditions, along with environmental inputs, these technological features have to be adaptable - making it fit for the contemporary occupant. Almost all building types need to provide for a maximum of adaptivity when it comes to their ground floor flexibility. Hence they need to be wrapped into a façade with a maximum of adaptivity – reflecting on the inner flexibility.

The easiest way of adapting to a user's new needs is still by replacing one building by the other. This is of course the most extreme adoption – more often it seems to be enough to replace one cover by another. When it comes to replacing building wraps or wrapping-up a building that did not have but the mere thermal skin, textile facades can play their soft card easily. It might be said that on optical change is more an eye catching gimmick than a serious skill. When seen in the context of fast fashion and fast food it is just another fast adopting aspects of a trend which affects the whole society. It is the industry's responsibility to explain that the membrane's skill of quickly adopting to new needs is still compatible with environmental concerns. Smartness in this context is the membrane's skill to adapt easily to new needs.

Figure 8: textile mesh façade for a one family house , printed TF400

About 15 years ago, distinction in textile façades meant for example XXL prints. This was the easiest means to adapt to the user's individual needs and tastes. Obviously that was to do with extravagance rather than adaptivity. Actual smartness by adaptability is only evolving now: at the end of this development the fabric mesh will be the fast adapting matrix for all sorts of applications – ranging from leading electricity through its veins to supplying lighting as in a vast LED screen.

4. Conclusion: environmental compatibility

Whereas the sustainability discourse was dominated by thoughts on material savings and the durability of the material there is now a need to broaden the view on other aspects. There are many more properties in fabrics which are apt to soften the environment. One of them lies in the fabric's flexibility itself. Soft shapes will alter our cities' environment. Up till now technological leadership was primarily expressed by high-tech steel and glass façades. Soft skins will be part of a new corporate identity that focusses on the soft skills of its inner parts.

Another of the membranes' soft skills is its adaptability. A fabric skin is able to adapt to the changing needs of altering users. We see various approaches of adaptable fabrics. The analogous matrix called "Valmex Systems" for example is a first step towards smart adaptivity. Future fabrics must be open for all sorts of applications, not limited in flexibility nor properties.

The necessary invention work will be done by experts in all different fields. It will often be triggered by a project-wise approach. At the same time, there will be scientific research programs. At best these two strands will join-up within the development process.

Cooperation between the above described parties and the ones interested in innovative materials – that is to say architects and designers, respectively their customers - will be vital for bringing the idea of sustainability in fabrics forward.

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Figures and Tables

Figures 1 and 2: Elspe, Grandstand Canopy, Figure 1 shows the original project from 1978 © Mehler Texnologies, figure 2 © Koch Membranen

Table 1: Elspe Grand Stand Canopy, Tensinet Symposium 2016, Dipl.-Ing. Katja Bernert
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