

PROJECTS

TENSILE STRUCTURES AS UNIFYING ELEMENT

6 BEVIS MARKS
HIGHEST ALL-WEATHER ROOF GARDEN

“THE KEY”
A BUILDING AS A LAB

REPORT

TEXTILE ROOFS 2016 **BERLIN**





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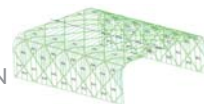
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TECHTEXTIL 9-12 MAI 2017

Edito
Dear Reader,

We are now only one month away from the next TensiNet Symposium, which will be held together with the Cost Action TU1303. The symposium will take place at Newcastle University, from the 26th till the 28th of October 2016, see also <http://conferences.ncl.ac.uk/tensinet2016>. The theme of the symposium is Novel Structural Skins, the same as the COST Action. More than 70 presentations cover a wide spectrum of the five main topics, and include also a good mix of interesting keynote speakers. On Wednesday 26th of October 2016 in the afternoon takes place the open session with the focus on built projects. We invite architects, engineers and professionals to learn more about structural skins and the recent development.

This issue of TensiNews contains, as a preview of the symposium, an article from Carl Maywald who is one of our keynote speakers, and an article about the project the Key in Newcastle, which can be visited during the symposium.

We present in this TensiNews another variety of new foil and membrane projects. An ETFE roof over an atrium in the Netherlands is presented, as well as the first stadium in the United States with ETFE, and an ETFE roof covering a courtyard in Germany. The environmental opportunities using membranes present articles about retractable shading screens in Singapore, a climatic envelope in Ecuador and the membrane roof for a day care centre in Germany. Still under construction, the new Trabzon stadium in Turkey is presented.

The 21st Textile Roofs workshop took place this May in Berlin. Many TensiNet members were present with their presentations. We are glad that Joseph Llorens was so kind to write again a summary of this event for us.

We look forward to seeing you all in Newcastle on our TensiNet / COST Action TU1303 symposium, and on other tensile structures related events this autumn. Please enjoy in the short meantime this issue of TensiNews.

Yours sincerely,
Bernd Stimpfle



TensiNet

Forthcoming Events

IASS 2016 *Spatial Structures in the 21st Century*
Tokyo, Japan • 26-30/09/2016
<http://iass2016.jp/>

3th Essener Membranbau Symposium 2016
University of Duisburg-Essen, Essen • 30/09/2016
<http://www.uni-due.de/iml/>

TENSINET - COST ACTION TU1303 SYMPOSIUM 2016
Novel structural skins
Newcastle, UK • 26-29/10/2016
<http://conferences.ncl.ac.uk/tensinet2016/>

10th Aachen-Dresden International Textile Conference 2015
Aachen, Germany • 24-25/11/2016
<http://www.aachen-dresden-denkenhof.de/en/itc/>

Techtextil 2017
Frankfurt am Main, Germany • 9-12/05/2017
<https://techtextil.messefrankfurt.com>
Textile Roofs 2017
Archenhold Observatory, Berlin, Germany 15-17/05/2017
www.textile-roofs.com

Forthcoming Meetings

Partner Meeting 2 and Annual General Meeting
Thursday 27 October, 18.45 - 19.45
Newcastle University, Great North Museum Hancock
<http://conferences.ncl.ac.uk/tensinet2016/>

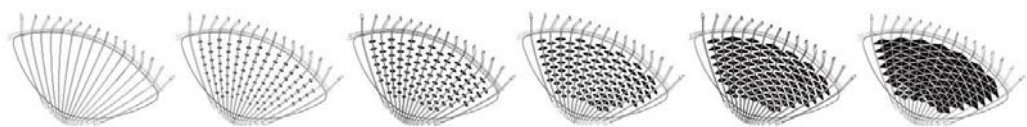
Multihalle Mannheim, Germany
FREI OTTO'S PIONEERING PIECE OF STRUCTURAL DESIGN NEEDS YOUR ATTENTION.
SAVE THIS UNIQUE AND LARGE GRID SHELL BUILDING!



© Hubert Berberich

The council of Mannheim decided last June to demolish this unique grid shell building unless, by the end of 2017, means of federal, state and private initiatives (crowdfunding, donations and grants) are found for the renovation. The Multihalle is a very important building in the history of lightweight structures and especially for so called grid shells. The city of Mannheim, heavily destroyed during WWII, started a slow post-war reconstruction phase. The Multihalle building, originally constructed as a pavilion in 1974 for the biennial horticulture show "Bundesgartenschau" was part of this larger redevelopment. The architects Carlfried Mutschler and Winfried Langner engaged Frei Otto as consulting engineer for the design of the roof. Frei Otto designed an extraordinary ingenious grid shell with a large span of 60x60m. To give this unusual sensitive form enough stiffness 4 layers of wooden laths were

placed one above the other to form a three-dimensional grid. Joining was complex as during the erection process the grid has to rotate into its final organic shape. Pinned connections were needed to enable this rotations. Once the final form was achieved the pin joints were bolted. Originally the pavilion was designed as a temporary construction, as often is the case for exhibition facilities. A first renovation took place beginning of the '80s when the PVC film was replaced. Meanwhile the membrane became porous and the timber construction damaged. In 2008 a large scaffold was constructed to stabilize the construction. Finally Multihalle was closed in 2011. The building is on the Heritage conservation list since 1998. Harald Voigt from Tentum GmbH brought under attention the fact that we should react to counter the demolition and find a way to preserve the building!



1

GARDENS BY THE BAY

Singapore

RETRACTABLE SHADING SCREENS FOR THE COOLED CONSERVATORY COMPLEX

Introduction

In 2006, Wilkinson Eyre architects were part of a British-led team that won the design competition for one of the most ambitious cultural projects of recent years – the masterplan for Singapore's Gardens by the Bay. The project, comprising three separate gardens covering a total of 101 hectares was central to the government's visionary plan to transform the city-state into a City-in-a-Garden. Wilkinson Eyre's brief was to design an architectural icon, a horticultural attraction and a showcase for sustainable technology at the heart of the Gardens at Bay South. Their response was the Cooled Conservatory Complex.

The two main conservatory structures are among the largest climate-controlled glasshouses in the world, covering an area in excess of 20.000m², and showcase the flora of those environments most likely to be affected by climate change:

- **Flower Dome:** which recreates the conditions in Mediterranean spring time (the cool-dry Mediterranean zone) with a surface of 1.2 hectare and a height of 38m);
- **Cloud Forest:** which emulates the conditions of tropical highlands (the cool-wet tropical montane) with a surface of 0.8 hectare and a height of 58m.)



3



4



5



6

The challenge of creating these conservatory environments under glass was a fundamental driver of the design, which was brought about through a uniquely collaborative relationship between Wilkinson Eyre and the other members of the multidisciplinary team: masterplanner Grant Associates, structural engineer, Atelier One and environmental specialists Atelier Ten. Each conservatory has a composite structure composed of a gridshell, which works in tandem with an external superstructure of radially arranged, arched steel ribs. These were introduced primarily to address the lateral loads to the gridshell, although they also give the conservatories their distinctive

organic identity. (information <http://www.wilkinsoneyre.com/projects/cooled-conservatories-gardens-by-the-bay>)

Gardens by the Bay is a project that has been awarded not only a Platinum rating in the Green Mark For Parks scheme (Singaporean equivalent of LEED), but also a World Building of the Year 2012 award at the World Architecture festival (WAF) and in 2013 the project received the prestigious RIBA Lubetkin Prize.

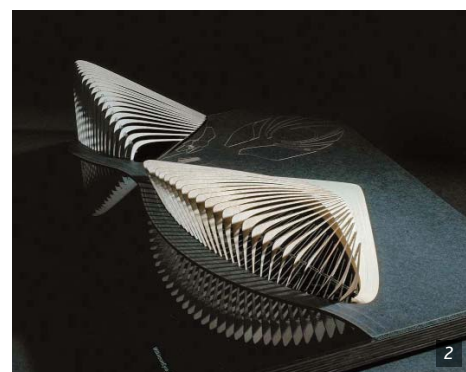
Soltis 92 screens

Screens made by Serge Ferrari were chosen to realise a retractable sun protection system. In total the conservatories Flower

Dome and Cloud Forest benefit from an external solar protection system that is every bit as exceptional with its 25.000m² of Soltis 92 screens.

The conservatories feature astonishing specific characteristics:

- Maintain the high light levels required by the plants within, while minimizing the associated solar heat gain inevitable in Singapore's tropical climate;
- Dynamic nature of the completed building, with shades opening and closing in response to the changing solar environment;
- Distinct curved forms of the biomes generated from the geometry of a hyperbolic curve and



2

Figure 1. Open versus closed configuration of the shading screens © Wilkinson Eyre architects

Figure 2. Model Cooled Conservatory Complex - Flower Dome and Cloud Forest © Wilkinson Eyre architects

Figures 3 to 6. Shading screens seen from above and beneath © Serge Ferrari

Name of the project:	retractable shading screens for the Gardens by the bay
Year of construction:	2012
Architect:	Wilkinson Eyre Architects
Local Implementing Architects:	CPG Consultants Pte Ltd
Structural Engineers:	Atelier One
Building Services Consulting Engineer:	Atelier Ten
Consulting Engineer:	Wade Consulting
General Contractor:	Woh Hup Pte Ltd
Manufacturer membrane:	Advance Canvas
Fabric - Serge Ferrari composite screens:	Soltis 92-2051
Screen area:	25.000m ²

• Lightweight structure to minimize shadows cast onto the planting below.

The solar protection system in detail

The external solar protection system integrating 25.000m² of Soltis 92 screens was designed to ensure the comfort of visitors, limit solar energy contribution and reduce air-conditioning consumption. A total of 419 outdoor retractable blinds made of Soltis 92 screens are completely hidden beneath the building structural arches, when not in use. A cable system tensions the 8x12m triangular blinds (average dimensions). The automated, individual blind control system integrates an intelligent self-learning algorithm for adjusting the internal lighting level. The shading reduces solar heat gain by more than 30% when partially deployed and approximately 70% when fully deployed. They can be deployed in an emergency to reduce solar heat gain inside the building.

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The Soltis 92 advantages

1. Lightweight and flexible

No extra weight on building structure - Adapts to external envelope curved shapes

2. Structural strength

Resists pressures exerted by the wind

3. Long-term dimensional stability

Allows unusually shaped blinds that adapt to complex structural geometry

4. Heat shield

Prevents building overheating and reduces air-conditioning consumption

5. Light filter

Light conditions and dazzle control inside the domes, while conserving high luminosity for well-being of plants and vegetation

6. 100% recyclable through Texyloop

Environmental impact reduction A decisive criterion for obtaining Green Mark certification




CENO MEMBRANE TECHNOLOGY GMBH

TRANSFORMATION

Duiven, OF A BUSINESS PARK the Netherlands



Figure 1. The new "waving" roof connecting the 5 transformed buildings.
 Figure 2. The skylights made of 3-layered ETFE cushions seen from above.
 Figure 3. The waving roof with integrated ETFE cushions.
 Figure 4. The waving roof made of white opaque fabric panels.

 Anne Bosse
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 www.ceno-tec.de

ETFE-SKYLIGHTS OF CENO TEC PROVIDE A NEW ATRIUM WITH LIGHT AND ATMOSPHERE

Introduction

With the renovation of the business park of the energy operator company Alliander the seemingly outdated real estate was revived in a very innovative way. Several of the existing buildings were connected with one common waving roof into a closed complex of buildings creating both: extra indoor space as well as a "greenhouse", which allows the office to obtain a positive energy balance. The buildings are now interconnected by large walkways. Along these walkways a coffee bar, lounges and flexible workstations makes the open to the public atrium the ultimate place for (informal) meetings. This atrium forms the beating heart of the building.

Skylights made of 3-layered ETFE cushions

To create more natural light within the building, CENO produced and installed several skylights, made of ETFE-cushions. A total of 20 circular skylights with 6 different geometries were used. The sizes vary from 6.7m to 19.7m diameter. Overall, they provide a transparent area of 1.714m² at a total roofed atrium area of about 9.500m². The 3-layer cushions have two air chambers and the upper ETFE-layer is silver color printed to achieve the required G-value (Fig. 2 and 3).

The cantilever of the new atrium roof is encased with white opaque fabric panels made of PVC-coated polyester fabric with PVDF-coating (Fig. 4). The wave design of the roof sets a new landmark in the Netherlands.

Name of the project:	New atrium with ETFE-skylights
Location:	Duiven, the Netherlands
Owner:	Alliander
Client:	Boele & van Eesteren bv, Rijkswijk
Year of construction:	2014-2015
Architects:	Rau Architects
ETFE-Skylights and covering for outer roof ceiling:	CENO Membrane Technology GmbH
Material ETFE skylights:	thickness upper foil/middle foil/lower foil = 200/100/200µm
Covered area with ETFE	1.714m ²
Material cantilever:	PVC coated Polyester Fabric Type II with PVDF-lacquer (white opaque)
Covered area with PVC/PES	approx. 2.500m ²

"THE KEY"

Newcastle University, UK

The Key is a revolutionary 'building as a lab', and is the first fabric structure to be used as a heated work space in the UK. It is the university's first building on Science Central. Science Central is Newcastle's flagship project bringing together academia, the public sector, communities, business and industry. They aim to create a global centre for urban innovation in the heart of the city. The industrial site is transforming into an exemplar of urban sustainability, a 'living laboratory' where they will trial innovative urban technologies.

A building as a lab



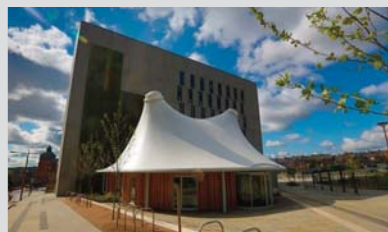
The Key is a large-scale research facility with detailed environmental and structural monitoring. It is the culmination of 15 years' world-leading research on fabric structures at Newcastle University. It has been designed in collaboration with Arup and _space Architects.

It links urban, sustainability and digital themes. This furthers the world-leading structural and materials engineering research,

strengthening existing collaborations and building new ones. As well as providing a unique venue for research, the building will also be used to showcase the Science Central vision.

The building has a sustainable structure with minimal use of materials and rapid construction/dismantling. The fabric and timber clad structure has been designed to have the smallest impact on the environment. This aligns with

the vision for the site to become an exemplar of sustainability. It has a high quality interior space with a curved ceiling reaching 18m. This makes it suited to open-plan collaborative working. It also provides an exciting space for evening events with projection on to the underside of the fabric roof. The insulated fabric roof aims to be the first to meet current UK building regulations for energy efficiency.



Rain Noise test apparatus and Sound insulation measurements for thin roofing elements at Textiles' Hub Laboratory in Milan

Starting from July 2016 the Interdepartmental Research Laboratory on Textile materials and Polymers at Polytechnic University of Milan has been performing the Rain Noise Tests and sound insulation measurements on films and membranes and every kind of thin roofing system.

The artificial drop apparatus, reproducing both Heavy and Intense Rain, is connected to a new acoustic room which was realized with the support of Knauf.

An inclined roof sample of at most 3,5m x 4,5m can be tested, according to the standards ISO 10140-1:2010/Amd2: 2014 (Annex K), ISO 10140-5:2010/Amd1:2014 (Annex H) and ISO 15186-1:2000.



For more info: <http://www.polimi.it/en/scientific-research/research-structures/interdepartmental-laboratories/textiles-hub-interdepartmental-textiles-and-polymers-research-laboratory/>

IMPROVING SUSTAINABILITY AND EFFICIENCY THROUGH NEW STRUCTURAL TEXTILE MATERIALS AND DESIGNS

Novel structural skins The urban built environment is being transformed by building skins derived from textile architecture. Working from a basis of tensioned membranes, these highly efficient structural forms are now being integrated with multi-disciplinary technologies to form new multi-functional systems that address the needs and global challenges of the urban built environment. The rapid emergence of lightweight building skins is in response to factors associated with climate change, energy, and workplace health and well-being, and is directly linked to advances in material development, analysis tools, and skills in design.

The three day symposium is divided into five main topics, to be introduced by keynote speakers:

- New applications of structural skins and new concepts
- Sustainability and Life Cycle Analysis of structural skins
- Building physics and energy performance of structural skins
- Materials and analysis
- From material to structure and limit states: codes and standardization

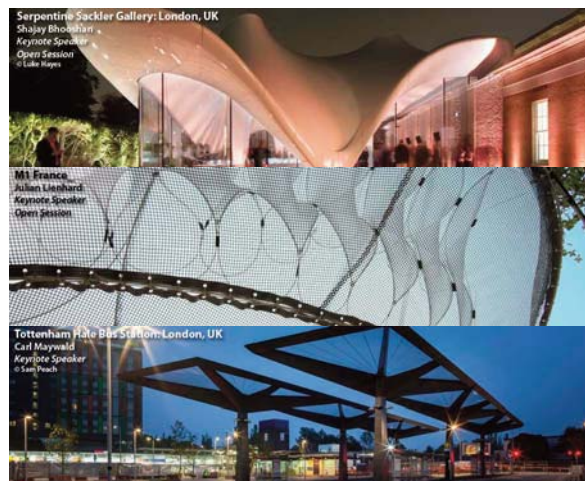
Jan Knippers: *Institut für Tragkonstruktionen und Konstruktives Entwerfen, University of Stuttgart*, Fibres Rethought – Towards Novel Constructional Articulation

Carl Maywald: *Vector Foiltec GmbH, Bremen* Sustainability – The Art of Modern Architecture

Raul Figueiro: *University of Minho*, **Martin Tamke:** *School of Architecture, Royal Danish Academy of Fine Art*, Bespoke Materials for Bespoke Textile Architecture

Gordon Mungall: *Arup, Newcastle upon Tyne* Unlocking the Potential of Insulated Fabric

Jürgen Wacker: *Wacker Ingenieure, Birkenfeld* Wind Impact on Textile Structures



An Open Session:

'Built Projects' is scheduled for the afternoon and evening of Wednesday 26 October 2016 when prominent experts in the membrane architecture and engineering world will present their inspiring built projects to demonstrate to a wider audience the potential of lightweight structures.

Shajay Bhooshan: *Zaha Hadid Office, London*, Formfinding and Tectonic Articulation – Making Performative Logics Speak

Julian Lienhard: *str.ucture GmbH, Stuttgart*, Pushing the Boundaries of Textiles in Architecture

Tim Lucas: *Price & Myers, London*, Full Metal Jacket

Al Fisher: *BuroHappold Engineering, London*, How to Build Lightweight – Advances in Computational Engineering

ATTENDEES WILL HAVE THE OPPORTUNITY TO VISIT THE UNIVERSITY'S BUILDING, KNOWN AS THE KEY, THE FIRST FABRIC STRUCTURE TO BE USED AS A HEATED WORK SPACE IN THE UK.

Full details at <http://conferences.ncl.ac.uk/tensinet2016/programme/> tensinet2016@ncl.ac.uk

RUBBER DESIGN 2016 COMPETITION

The Rubber Design Competition 2016 will be a contest of ideas, open to students, researchers and professionals from the world of architecture, design and engineering and aims to stimulate ideas for new applications of elastomers in different fields.

Specifically, The Competition aims to find the most impressive ideas relating to the range of products which can be feasibly made, in addition to proposals for optimising and improving current rubber-sheet production processes with a view to creating new lines of products.

The Competition is being promoted by *Tovo Gomma S.p.A.* together with support from the interdepartmental laboratory *TEXTILES HUB* at Politecnico di Milano.

The initiative is being sponsored by the European association for the development of membrane structures (*TensiNet*), the Italian Society of Architectural Technology (*SITdA*), the Industrial Association of Brescia (*AIB*) and the Building Technologists Italian Association (*ATE*).

The registration period for the Competition will close at 00:00 on 30 September 2016. For information please visit the website: <http://www.rubberdesigncompetition.com>



Day-care center

Burgthann, Germany

SUSTAINABILITY TO THE NEEDS OF CHILDREN

In addition to the comfort factor there must be achieved high demands on energy efficiency and ecology. By environmental and economic advantages of the material, the membrane therefore provides an optimal solution.

Context

Since 2006, the demand for places in day-care centers in the municipality Burgthann has risen continuously. To comply with this demand the number of nursery places was expanded through an outbuilding with about 260m² of space in three parts of the municipality: Unterferriden, Oberferriden, Ezelsdorf. The community thereby put main importance on following principle "with few resources and as much sustainability and effectivity as possible", exactly like the guidelines of the integrated rural development concept (ILEK) which faces the challenges of the future by these attachments. Sustainability and effectiveness are also very important in the fundamentals of K.T.A and so the architects Graf Architekten GmbH found a suitable planning office and specialist in lightweight structures and membrane construction with them.

Project

In the circular outbuilding, on an area of about 260m² in total, are located two children group rooms, a relaxation room, a kitchen, a therapy room, a waiting room for parents as well as areas for staff, sanitary, storage, technology and a cloakroom. The complex is covered with a high point membrane structure whereby the aesthetics looks like a circus tent. The supporting construction for the roof forms a circular tubular steel ring with a central support with high point ring. The outer ring is mounted on six fixed supports and six articulated connections to the building.

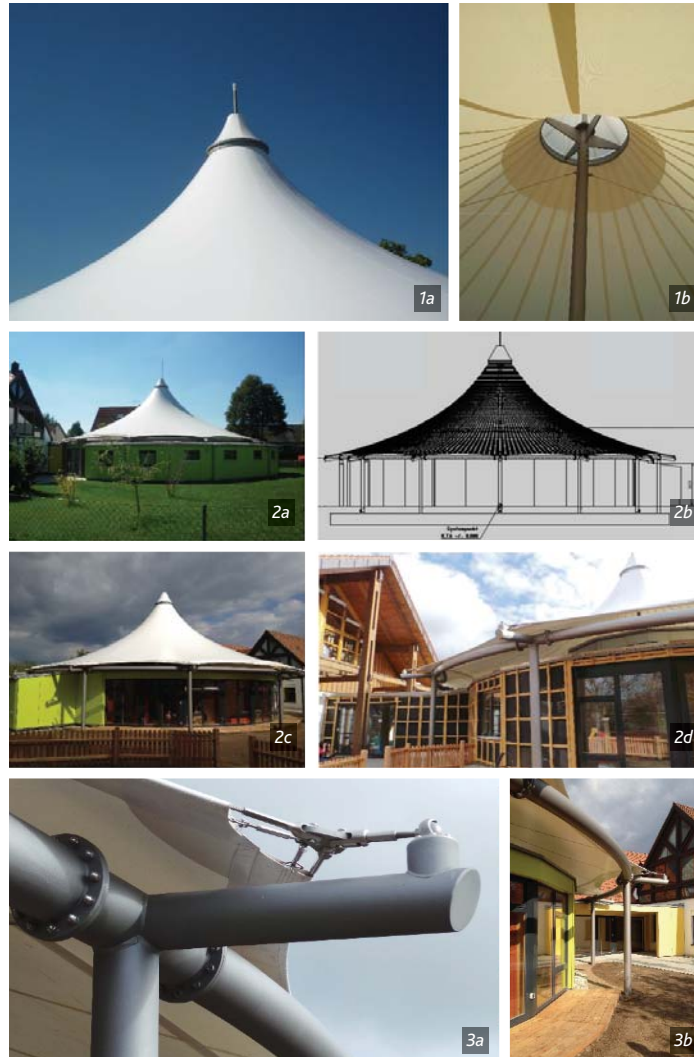


Figure 1. High point of the circus tent like day-care outbuilding.

Figure 2. Circular outbuildings: view and drawing.

Figure 3. Construction details: membrane connected to the steel frame.

On 12 projecting outward, radially arranged steel tubes, the membrane is punctually fastened. The centrally placed mainstay sits on the roof of the underlying building and is simply supported. To introduce the pre-stress, the membrane is stretched upwards at the high point ring, which is fixed on the main support. The "circus tent" has a diameter of about 20m. The highest point is located at a height of approximately 9m. Overall, 370m² of membrane material were needed for the roofing of the building complex. Above all, the most important indicator of the material membrane allowed the execution of the design - the low weight. The optimal tuning of the internal stress distribution and the external load conditions, allows to cover wide open, column-free spaces, such as here, without much effort. Through the interaction of form, strength and material properties of membrane structures we can achieve a high load carrying capacity, rigidity and stability of the supporting structure - and it creates the opportunity to play with a huge selection of great variety of shapes.

Name of the project:	Roofing for day-care center
Location address:	Mimberger Strasse 41, 90559 Burgthann, Germany
Client (investor):	Municipal Burgthann
Function of construction:	Roofing
Year of construction:	2015
Architect:	Graf Architekten GmbH
Main contractor:	A. Arnegger GmbH
Structural engineer:	Kiefer. Textile Architektur
Manufacturer of steel:	SB Metall- und Glasbau GmbH
Manufacturer of Membrane:	A. Arnegger GmbH
Cutting Pattern Membrane:	Kiefer. Textile Architektur
Installation:	A. Arnegger GmbH
Material:	Material Valmex FR 1400
Covered area:	ca. 370m ²

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Tensile structures as unifying element

CLIMATIC ENVELOPE FOR THE NEW HEAD
OFFICE AND LEISURE FACILITIES
Esmeraldas, Ecuador



Context

The city of Esmeraldas on the west coast of Ecuador is mostly known for its port and the head office of Flopec, the state oil transport company. Till now, the city's seaside was dominated by industrial sites. There was hardly any access to the sea for the population. That changed significantly this year. After Flopec decided to build a new head office building, the local municipalities succeeded in combining this with a development of urban landscaping. Finally Esmeralda's population gets back its beaches. In between the coastline and the city centre there is now not only the new office building but as well lots of recreation space, restaurants, little shops and an open air cinema. In order to give a unifying appearance to all these structures the designers used tensile structures as common element. There is the prominent wrap of the office building on the one hand (Fig. 1) and a prismatic roof above the restaurant and shop structures on the other hand (Fig. 2). In this there is a show case of tensile architecture on Ecuador's coastline.

Structure

The office building dominates the whole area. Seeing it on a two dimensional plan one could easily guess that it blocks important

views on the ocean. In reality the building is completely wrapped into Mehler's white mesh fabric. Therefore the façade smoothly integrates into the color of the sky. A huge gap in the building's ground floor plan serves like a frame for the views on the ocean. At the same time it is a doorway for the people to the beach huts which lay directly behind the paved area (Fig. 3). Structurally the architect Jose Saenz used a steel construction which was first filled with the primary façade. The opaque and glazing fillings are equally shared. In front of this climatic envelope lies the secondary façade: a TF 400 mesh, produced by Mehler Technologies in Germany and manufactured by Preysi in Quito, Ecuador. Preysi is an experienced façade developer on the one hand and an expert in tensile constructions on the other hand. This combination was the optimum choice for the 16.000m² wrap for Flopec.




Material

The chosen material is a bright white version of Mehler's façade mesh TF 400. The fabric serves as a sun screen and wind shield. Being so close to the equator, Esmeralda is facing an extremely bright sun light. In order to avoid mechanical, individual sun shading systems the architect chose a universal wrap

for the whole building. At the same time the mesh fabric reduces the wind loads significantly. Half of it is carried by the primary, the other by the secondary structure. In combining these two functions, the architect introduced a unique appearance to Esmeraldas' coastline which is unique in Ecuador at the same time: Preysi engineered and manufactured the biggest tensile façade in its country – maybe even in South America.

There is yet another side effect which comes on top of the functions mentioned above: during night time the TF400 façade serves as a cinema screen (Fig. 4). There are always lots of people gathering

on the beautifully landscaped areas around the building. Apart from the office building and the urban landscaping the architect Jose Saenz designed one little hut which serves as projection point. People can sit on stalls facing the cinema façade of Flopec's building. Buildings with an equal added value for a city's population outside and the office personnel inside are rare!

 **Katja Bernert**
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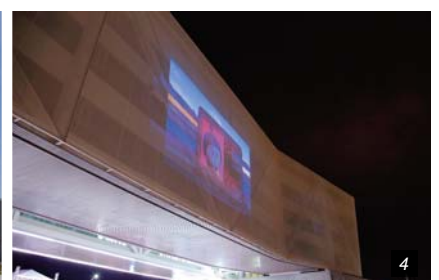
Name of the project:	Las Palmas, Esmeraldas
Location address:	Simon Plata Torres, Esmeraldas, Ecuador
Client (investor):	Flopec
Function of building:	office building and leisure
Type of application of the membrane:	mesh fabric
Year of construction:	2016
Architect:	Mr. Jose Saenz
Contractor for the membrane (Tensile membrane contractor):	Preysi, Quito
Supplier of the membrane material:	Mehler Technologies GmbH (now Low and Bonar)
Facade system:	Facid tension System
Manufacture and installation:	Preysi
Material:	TF 400
Covered surface (wrapped area):	16.000m ²

Figure 1. Aerial view of the Flopec new head office building in Esmeraldas © Preysi

Figure 2. Restaurant area covered by a Type III material of Mehler Technologies © Preysi

Figure 3. Flopec head office building, the large doorway leads to the beach © Preysi

Figure 4. Cinema projection on the Mehler's TF 400 screen © Preysi



The "Gherkin" has made architectural history and dominates London's skyline. A counterpoint to it is set by a directly neighbouring, much smaller 16 storey office building. London's highest all-weather garden with an area of about 400m² is located on the roof: visitors are protected against wind and weather by a baldachin engineered and installed by Vector Foiltec. The foils for transparent Texlon® cushions are extruded from the high performance material 3M Dyneon Fluoroplastic ETFE.



6 BEVIS MARKS

LONDON'S HIGHEST ALL-WEATHER ROOF GARDEN

London, UK

TRANSPARENT BALDACHIN MADE OF ETFE FILM CUSHIONS
LETS SMALL BUILDING STAND OUT

Introduction

The architects Fletcher Priest designed the new office building in the East End of London's City. It replaces an eight-storey building erected in the 1980s. The architects used 50% of the existing building fabric for the conversion, including the foundations. The eye catcher of the 21.370m² building, which is small in comparison with its neighbours, is the roof garden. Stretching over it is a baldachin made of Texlon® ETFE film cushions that is open on two sides. The support structure of the baldachin is continued as a diamond shaped network five floors below on the south side of the building, where it is easily visible from the street. Special attention has been paid to solar control for to provide maximum comfort even during hot summer days by applying a highly reflective Texlon® print pattern (DM 4:65 light) to the inner side of the outer layer.

Curved ETFE cushion structure

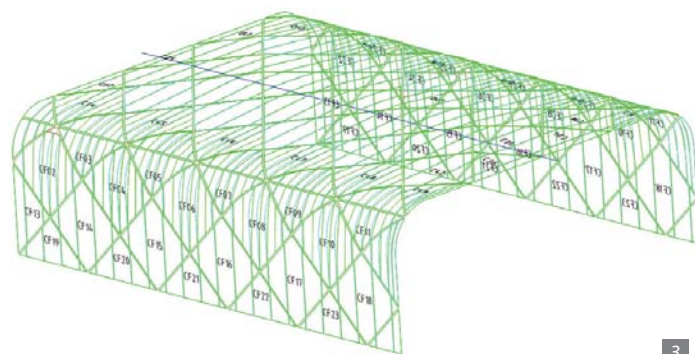
According to the design of the architects the cushion structure has to be two dimensionally curved. An enhanced number of welding seams for the cushions at the edges of the baldachin allowed for a smooth Texlon® ETFE cushion surfaces without any wrinkles. In order to achieve a smooth cushion surface avoiding any wrinkles. Figure 3 shows the seam design of

the cushions for both outer and inner cushion foils. The overall area covered by the Texlon® System is 1390m².

Water and snow loads

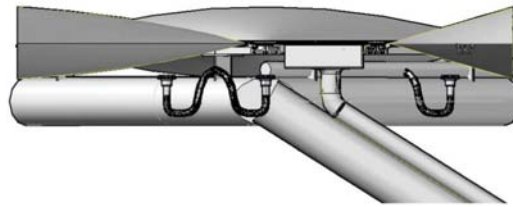
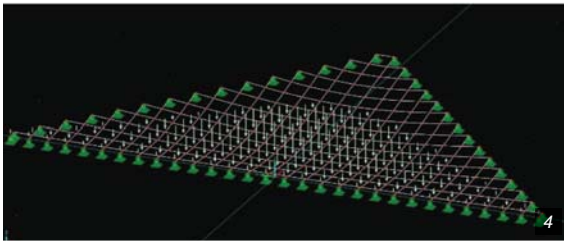
In order to not allow for water or snow ponding the load distribution has been carefully calculated for each cushion of the flat roof, whereas special attention has been paid to the central part as well as

to the curved cushions at the edge of the roof. Figure 4 shows the load distribution due to water for a curved edge cushion at the perimeter of the flat roof. For 90m² of the center cushions snow wires had to be installed. Figure 5 shows the central cushions as well as the moderate vertical exaggeration of the roof center which allowed for defined direction of water flow. For controlled drainage of the roof special rain water outlets have been designed and installed in certain areas, which is shown in figure 6 and 7.



Resistant to pigeon droppings and self-cleaning

Films for the air-supported cushions are made of the high-performance material Dyneon ETFE, from which Nowofol Kunststoffprodukte GmbH & Co. KG extruded NOWOFOL® ET 6235Z films. The Siegsdorf-based company's product range encompasses ETFE films in



6 Figure 1: Aerial views of the highest all-weather garden
© Edward Hill – Saentys

Figure 2: Amazing view taken from under the transparent baldachin
© Vector Foiltec

Figure 3: ETFE seam design
© Vector Foiltec

Figure 4: Load distribution for triangular cushion at the perimeter of the flat roof
© Vector Foiltec

Figure 5: Snow wires at the center cushions and 3D printed knots for the supporting structure
© Vector Foiltec

Figure 6: Sain water outlet and pipe
© Vector Foiltec

Figure 7: Rain water outlet
© Vector Foiltec

thicknesses from 12µm to 400µm in all RAL colours. The weight per unit area is just one twentieth of that of glass. Weight saving was an important criterion, since the foundations of the building - previously only half as tall - remained unchanged. The highly transparent films allow visible light and the UV-A radiation that is important for plant growth to pass through virtually without hindrance. The visitors can thus enjoy an unhampered view of London's City. ETFE has an almost

universal resistance to chemicals. It even resists, for example, the aggressive pigeon droppings that are omnipresent in London. The material is so smooth that a normal rain shower is sufficient for effective cleaning. That lowers the operating costs over the entire lifetime.

Components manufactured using 3D printing Skanska UK designed and manufactured the support structure. Measuring 33mx25m,

the U-shaped baldachin projects well beyond the floor area of the roof garden and thus effectively protects visitors to the garden from the rain. Figure 8 gives an impression of the supporting structure, consisting of eight hollow columns with a diameter of 355mm each. Up to seven support arms project from the columns and create a tree like look, which is shown for one column.

Components manufactured using 3D printing was used here for the first time in the construction industry. The components printed from architectural nylon cover the transitions from the columns to the support arms, creating a smooth transition. The 4x4m film cushions inserted in the steel structure were made up by Vector Foiltec GmbH - a pioneer

and world market leader in structural film construction. The Texlon® ETFE cushion system is designed to cope with high wind and snow loads. The tensile strength of films made of Dyneon ETFE can go up to 50N/mm² and the elongation at break is more than 300 percent. Over more than three decades, the material has proven to be extremely durable and resistant in all climatic zones.

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★★★★★

BREEAM category "Excellent"

With regard to sustainability, 6 Bevis Marks achieves the category "Excellent" according to the widely used BREEAM certification method. The film cushion baldachin has also contributed to that, because the Texlon® System was certified with the world's first Environmental Product Declaration (EPD) for transparent building skins. Thanks to the low weight it was possible to give the support structure a much more slender and resource saving design than in the case of glazing. On top of that, Dyneon ETFE requires no softeners during production and is completely recyclable. During production of the ETFE cushions at Vector Foiltec 100% of the cut-off is recycled. The recycled material is reused to produce flexible pipes and valves for the Texlon® System, thus taking care for the environment by reducing the amount of raw material required.

Name of the project:	6 Bevis Marks
Location address:	Bury Court, London, UK
Client (investor):	AXA / BlackRock / CORE / Wells Fargo
Function of building:	baldachin for all-weather roof garden
Type of application of the membrane:	Texlon ETFE film cushions
Year of construction:	2014
Architects:	Fletcher Priest Architects
Structural engineers:	David Dexter
Consulting engineer for the membrane:	Vector Foiltec GmbH
Contractor for the membrane:	Vector Foiltec GmbH
Supplier of the membrane:	Nowofol Kunststoffprodukte GmbH & Co KG
Manufacture and installation:	Texlon® ETFE system by Vector Foiltec
Membrane material:	3M™Dyneon™ Fluoroplastic ET 6235Z
Overall covered area:	1390m²

TEXTILE ROOFS 2016 BERLIN

Textile Roofs 2016, the twenty-first International Workshop on the Design and Practical Realisation of Architectural Membranes, took place on 2–4 May, 2016 at the Archenhold Observatory Berlin, and was chaired by Prof. Dr.-Ing. Rosemarie Wagner (Karlsruhe Institute of Technology, KIT) and Dr.-Ing. Bernd Stary (Berlin Academy of Architectural Membrane Structures, AcaMem). It was attended by 77 participants from 19 countries covering four continents. Once again, the attendance demonstrated the success of the event, which has become firmly established since it was first held in 1995.

The lightweight design approach

Jürgen Hennicke, IL - University of Stuttgart & Vienna University of Technology.

Jürgen Hennicke addressed the lightweight design approach to design inspired by nature and by history, illustrated by his invaluable 100 slide collection. More than 50 ideas coming from the research conducted at the former IL Institute, Stuttgart were shown: tents, velaria, nets, spider webs, yurts, cantilevers, false arcs, arches, snails, radiolaria, grid shells, pneumatics, bubbles, hot air balloons, the Stonehenge's ring, trees, ramification, suspended chains, tubes, prestressed membranes, humps and funnels, among many others.

In conclusion, lightweight structures were considered as a way to build in accordance with the principles of stability, utility, beauty, and sustainability in order to shelter people, to recycle materials, and to compensate for 60% of the natural resources consumed for building construction.

An impressive example of the application of these principles is the pneumatic gridshell "PlusMinus," made of inflated film tubes flexibly connected, and completed for stability and rigidity by two shell films vacuum sealed above and below the tube latticework (Fig. 1). PlusMinus is a project initiated by students of the University of Stuttgart, Architecture Faculty, Institute for Lightweight Structures and Conceptual Design, in cooperation with the Bionic Learning Network of Festo.

Figure 1. "PlusMinus" inflated gridshell. University of Stuttgart, leichtbaukunst & FESTO.

Figure 2. The sag being equivalent to 30% of the span amplifies the load by 1,30. The sag being equivalent to 5% of the span amplifies the load by 5,10.

Figure 3. With Batyline Aw by Serge Ferrari, in the Vaujany ice skating the reverberation time has been reduced from 7,5 to 1,8s.



Pathology

Josep Llorens, School of Architecture, Barcelona.

Josep Llorens' presentation was based on the idea that failures are a source of knowledge that help to prevent future troubles. Failures in tensile structures can be due to:

- material failures, usually due to an inadequate resolution of requirements and properties.
 - the design is responsible for the resultant flatness (Fig. 2), lack of prestress, or an inadequate shape, resistance, or detailing.
 - the installation process involves stability issues, provisional situations, and the final shape.
 - final use does not always correspond to the design specifications. Maintenance is necessary in order to keep the structure clean and to preserve the effects of pre-tensioning.
- The responsibility of failure prevention lies with the owner, designer, manufacturer, builder, supplier, or users. All of the agents should be involved.

Innovative materials for tensile roofs and acoustic

Farid Sahnoune - Serge Ferrari
<http://en.sergeferrari.com/>

Farid Sahnoune began his speech by presenting the highly durable and recyclable new material "Précontraint TX30," the latest generation of flexible composites from Serge Ferrari, developed especially to guarantee a useful life of over 30 years for benchmark project roofing.

In contrast to conventional technologies, the material is "crosslinked," using a reticulated process which to date has been used exclusi-

vely to produce rigid materials. Its ability to withstand oxidation over the long term ensures that its structural and aesthetic properties remain unimpaired for decades.

The next point addressed was the Texyloop technology used to recycle polyester-PVC flexible composite materials that produces secondary raw materials of high intrinsic value, compatible with multiple processes. In recycling, the impact is reduced by 50% in comparison to incineration or landfilling.

In the last part of his presentation Farid Sahnoune referred to Batyline Aw, a varnished PVC-coated cloth for acoustic ceilings and walls. Its calibrated micro-texture ensures its sound absorption performance characteristics, resulting in a fine, lightweight, and compact material that achieves highly uniform acoustic behavior, ranging from treble to bass sounds. The material also achieves significant reduction in reverberation time, adapting to comfort requirements for buildings receiving the public (Fig. 3). It absorbs 65% of sound, transmits 41% of light, and protects from solar heat (-59%) and glare beneath a glass roof or facade.

Computational modelling of lightweight structures

Jürgen Holl, technet GmbH? <http://technet-gmbh.de/index.php?id=74&L=1>

"All models are wrong, some are useful" quoted Jürgen Holl in his introduction to the need for modelling. Models are abstractions or partial views of the reality that represent approximately the object's main features, including the connections among them, but he emphasized that they are not definitive. He mentioned physical and computer models, indicating that the latter allow for analysis that would be impossible to perform by other means, but they need to be sufficiently correct, precise, and complete. The modelling presentation was illustrated with hybrid systems, pneumatic structures, reinforced air halls, multi-chamber cushions, and textile halls.

Computational modelling has been recently refined with the introduction of shear and

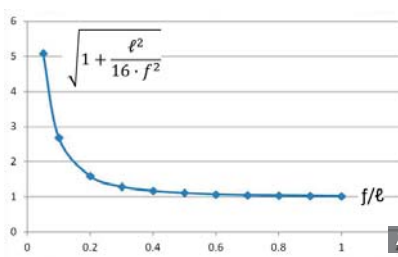




Figure 4. The umbrella of 53m in diameter is no longer a lightweight structure (Bodo Rasch).

Figure 5. Wacker Ingenieure wind tunnels.

Figure 6. A prototype of a modular canopy for parking lots developed at the Karlsruhe Institute of Technology.

crimp stiffness that steers the different behaviour under load with different material directions. Regarding the definition of the form, Jürgen Holl stressed once again that the form is not free because equilibrium depends on the prestressed state and the boundary conditions. The analytical form finding can be based on the force density method and the non-linear static analysis includes the membrane, cables, struts, and the bending of stiff elements. This inclusion of all elements involved has shown to yield favourable results because the changes in shape caused due to deformations generally result in smaller membrane stresses. The speaker also commented on the cutting pattern generation, its influential factors, compensation, verification, adjustments, cutting drawings, seam allowances, welding marks, visualisation, export to cutting machines and automatic patterning for cones, saddles, and air halls (see previous TR Reports at <http://www.textile-roofs.de>). He finally invited the audience to experience an "easy" modelling hands-on development of practical case studies in an informal tutorial workshop.

Light architecture

Mustafa Rasch, SL Rasch GmbH:
<http://www.sl-rasch.com/>

The special guest lecture was given by Mustafa Rasch. He reviewed the career of his father, who followed the path of his grandfather, and gave special mention to his collaboration with Frei Otto. Among the works presented, umbrellas were examples of the most representative and evolved. They started from the umbrellas of Kassel 1955, Pink Floyd 1977, the

solar powered umbrellas 1987, Madinah 1991 and 2011, Texas 2013, the U53 umbrella 2016, and the future project for the Schlossplatz in Stuttgart. He revealed that the biggest umbrellas don't fit into the stereotypical classification of lightweight structures (Fig. 4).

Wind loads on fabric structures and corresponding dynamic response

Martin Zschke, Wacker Ingenieure:
<http://www.wacker-ingenieure.de/>

Wacker Ingenieure is a spin-off company of the Karlsruhe Institute of Technology, specialised in wind load analysis of special construction not covered directly by building standards, such as high-rise buildings, stadium roofs, towers, photovoltaic panels, cathedral spires, and fabric roofs.

Wind effects are often decisive and unique for membrane roof design, with wind tunnel testing being the most exact and affordable tool to gather raw data with subsequent dynamic and statistical computations, used to obtain optimized and safe load distributions for the structural engineer (Fig. 5). When performing wind load analyses, the task of Wacker Ingenieure consists of analysing the effects of the wind to consider whether the deformations are significant and that they require feedback (a common situation with flexible structures). The final aim is to provide design-relevant peak values of target variables, e.g., maximum uplift or maximum internal stress. Martin Zschke ended his lecture stating that the sooner the wind engineer is involved in the structural planning in an early stage, the greater the optimization potential is.

Development of transparent textile structures for applications in architecture

Rosemarie Wagner,
Karlsruhe Institute of Technology.

Rosemarie Wagner presented a research concerning "ETTLIN black," a fabric for exterior use which is UV-resistant and fade-resistant. The research was conducted at the Karlsruhe Institute of Technology. (<http://www.ettlin-textiles.de/produkte/qewebe/ettlin-black>). Objectives of the research and development were the applications of double-curved membranes in architecture, the optimization of material choices and functional properties of the product, its mechanical behaviour, and detailing. The investigation was completed with the design of a prototype of a modular canopy for parking lots (Fig. 6).

Tensioned fabric structures design guide ASCE/SEI 2913

Maqsood Ahmed, Specialty Structures, Amherst:
<http://www.specialtystructuresusa.com/contact.html>

Maqsood Ahmed began summarizing the guide edited by C. G. Huntington and published by ASCE: "Tensile fabric structures. Design, analysis and construction." He emphasized that certain recommendations and rules are needed to prevent the loss of faith in the fabric industry, and consequent revenues, because low performers face the risk of failures, litigation in courts, and bankruptcy, resulting in the disappointment of building authorities and clients. He proclaimed the following verdict: "Not everyone who can afford a welding machine can become a fabric specialty contractor." The guide covers the history and development of fabric structures, the design process, characteristics of fabrics and foils, loads, form finding, structural analysis, detailing, non-structural performance, manufacture (including patterning), and installation. It is completed by a glossary of terms, a reference to wind tunnel tests, and bibliography.

He dedicated the second part of the lecture to special structures that combine fabric with other materials. "When a costumer asks for an apple, you can offer a fruit salad," was his philosophy. His firm "Specialty Structures USA" aims to bridge the gap between architects and engineers, connecting creative designs with specialty contractors across the world, helping



creative ideas get built, and making innovations affordable. In summary, they turn ideas into reality, blending art with structural design. His bold ideas were profusely illustrated with examples that partially met the expectations generated by the presentation (Fig. 7).

Details in membrane architecture. "My way to enthusiasm."

Horst Dürr, Tensile Evolution
www.tensileevolution.com/html/about.html

With a series of questions, Horst Dürr caught the interest of the audience in detailing textile roofs. His aim was to awake the interest in what has transpired so far and what is expected in the future. He emulated Albert Einstein with his assertion "*the important thing is to not stop questioning*," particularly the six key words: who? what? where? when? how? and why?, which he reminded were the six honest manservants who taught Rudyard Kipling all he knew. He considered the need for viewing things in new ways or from different perspectives in order to be creative, and to generate new possibilities and alternatives. Detailing is a part of the design process where certain problems are solved. The process starts by clarifying the problems, which evolve by means of ideas, opinions, beliefs, plans, or mental pictures that have to be evaluated and finally realized. The result is a complex whole, whose components are arranged according to

their requirements. As an illustration of his enthusiastic and creative method, Horst Dürr presented the design of a corner, combining membranes, reinforcements, pockets, belts, turnbuckles, seams, Keder, and cables (Fig. 8). The total cost was also estimated starting from the detailed list of quantities of all parts involved, and multiplying them by their unit costs. The speaker finally invited the audience to provide some ideas about their interests and to participate in the Seminar: "Idea-sketch-model-ff-presentation model" this coming October 2016: horst@tensileevolution.at.

New structures

Gregor Grunwald, Pfeifer Systems
<http://www.pfeifer.de>

Pfeifer Systems is specialised in movable, retractable, convertible building systems, offering innovative solutions for the development, design, and construction of special drive technology and transport solutions. Primary functions are the development, design, and construction of these drive and control systems of large-scale shelters, based on in-house FEM calculations. The company expanded with the incorporation of Covertex, in July 2015. Gregor Grunwald showed some remarkable works: the Msheireb retractable roof in the heart of Doha, Qatar (TensiNews 29, p.14), the Rosa Parks Transit Center in Detroit (<http://www.archdaily.com/30880/rosa-parks->

transit-center-ftl-design-engineering-studio) and the ASU Skysong Innovation Center, Scottsdale, Arizona (<http://www.fabritecstructures.com/portfolio-asu-skysong-innovation-center-scottsdale-az>)

Imagine tomorrow. Replacement and renovation of textile structures

Alexander Rütter, CENO Membrane Technology GmbH: www.ceno-tec.de.

The presentation of Dipl.-Ing. Alexander Rütter was truly instructive. His main theme was "Imagine Tomorrow." When designing and building textile projects, various construction materials with different life spans are used in one single project. This causes the need for replacement of at least the fabric parts in many projects. Apart from the lifespan of the different materials, other factors that cause the need for replacement include improper design or handling, and even vandalism. Several examples were shown including the Munich Airport Center, a PTFE-coated glass-fibre fabric where 5 of 7 existing panels were replaced while the airport was in full service (Fig. 9).

Conclusions were twofold:

- 1) the life span of PTFE-coated glass-fibre fabric is longer in principle, but glass fibres are very sensitive to handling and transportation.
- 2) "Think about tomorrow": consider the requirement of future replacements in the design.

Technical membranes market in Portugal.

Antonio Galhardo, APG Coberturas
www.apgcoberturas.com

APG started its activity in the production of tarpaulins and covers for trucks in 1958 under the hand of its founder, Mr. Abel Pereira Gonçalves. The company grew considerably, becoming the market leader from 1973 onwards. Referrals of their products created the need to expand the range into areas that until then were unexplored. They asserted the ability to implement any project in the area of textile architecture using recyclable materials that have high aesthetic beauty, longevity, efficiency, and low costs.

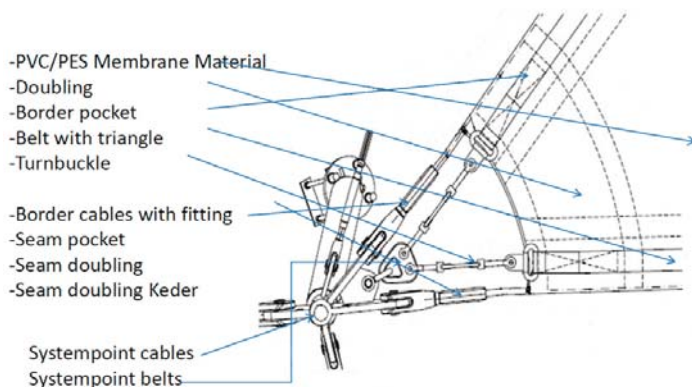


Figure 7. Sharafi PHB Architects: Shading elements. City hospital, Dubai.

Figure 8. Corner detail. Horst Dürr.

Figure 9. Replacement of the PTFE coated glass fibre fabric of the Munich Airport Centre.

Figure 10. ETFE cushions of the "Dolce Vita Tejo" shopping mall in Lisboa replaced by PVC coated polyester fabric.

Their best credentials are the works they've done in textile architecture, tents, covers, façades, ceilings, advertising, and transport. The most surprising work that Antonio Galhardo presented was the replacement of ETFE by PVC-coated polyester for the 10x10m cushions of the "Dolce Vita Tejo" shopping mall in Lisbon (Fig. 10). Could the replacement of ETFE cushions be considered a new market potential for PVC-coated polyester?

Report on current gmp Architekten projects

Martin Glass, gmp Architekten.
<http://www.gmp-architekten.de>.

Martin Glass began his talk by pointing out that despite what the title says, he could not show ongoing projects due to a lack of permission. Nevertheless, he showed once again a wealth of past projects, summarizing their main characteristics, available at the website.



The Twenty-second International Workshop on the Design and Practical Realisation of Architectural Membrane Structures will be held on 15-17 May 2017. Its format will be similar to that of TR 2016, with seminar-style lectures and hands-on activities. It will be preceded by the student seminar and sponsored by Serge Ferrari, Pfeifer and technet, and supported by TensiNet, KIT and gmp. <http://www.textile-roofs.de>.

The art and the material

Benoit Legall, BHD Group
<http://www.bhd.fr/>

Benoit Legall presented his company BHD, a leading industrial group in the transformation of technical textiles for the protection of people and goods. BHD is a group of 26 subsidiaries, each of which has specialist expertise in one or more sectors. Given the wide range of skills of its subsidiaries, the BHD group offers unique and dependable specialists in Europe. Its areas of expertise and business sectors are: textile architecture, signage, advertising and construction, industry, transport, aviation, civil, environment, agriculture, sport, outdoor, and event protections. He highlighted two recent works: the Nice and Lyon stadiums (Figs. 11 and 12).

Fascination for textiles and light! Structure and sculpture

Laars Meeb-Olsohn, leichtbaukunst
<http://leichtbaukunst.de/>

Laars Meeb-Olsohn presented an overview of his projects that show striking temporary installations for tradeshow and events, combining light and membranes (Fig. 13). The Riverside Lounge of Light was a light installation for the light art festival LUMINALE 2016, Frankfurt, between 13 and 18 March, 2016. Square and diamond-shaped screens were combined. The LOOPS pavilion, BAU 2011 Munich, introduced innovative products and services around the light and membrane construction.

Figure 11. Nice Stadium. End customer: City of Nice. General contractor: VINCI. Architect: Willemotte, Paris. Material: 20.000m², 1002 Fluotop T2. Fabrication time: 7.000 hours. Installation time: 5 months (8 people).

Figure 12. Lyon Stadium. End customer: Olympique Lyonnais. General contractor: VINCI. Architect: Populous, London. Material: 20.000m² 1202 TX 30. Fabrication time: 15.000 hours. Installation time: 7 months (15 people).

Figure 13. Psychedelic stage by "leichtbaukunst".

Figure 14. Palma Aquarium (www.iaso.es)

Figures 15 to 18. Installation of the four-point sail at the Archenhold Observatory garden.



Architectural design of lightweight membrane structures

Robert Roithmayr, formfinder
<http://www.formfinder.at>

Robert Roithmayr introduced his "formfinder" software. He started mentioning the artistic and architectural concepts hidden behind sketched ideas or fillings. In fact, "formfinder" starts from a hand-drawn sketch that was examined in terms of its physical, geometrical, and architectural characteristics. The design is compared with projects, materials, and details that have been implemented as a database. As an example of application, Robert Roithmayr showed the Palma Aquarium canopy to guide people into the building (Fig. 14). He considered it as something new that could not have been constructed with concrete.

Joint participant project

Stev Bringmann, 3dtext GmbH.

Starting from the design, the entire manufacturing and installation process of a four-point sail was carried out during the TR 2016 Workshop (Figs. 15 to 18). Phases involved were: "easy" modelling (form finding, structural analysis, and patterning), manufacture, foundations, assembly (masts, edge cables, corner plates, erection, and tensioning), and discussion (general design aspects, form, patterning, and detailing).

The **Student's project week** was led by Prof Dr.-Ing. **Rosemarie Wagner** between May 2nd and May 4th 2016 in parallel to the main event of Textile Roofs Workshop. The topic this year was an outdoor, self-transportable shade/resting place. It is discussed in another article of TensiNews.

Josep Llorens
 ETSAB/UPC
ignasi.llorens@upc.edu

3. essener membranbau. symposium

Essener Membranbau Symposium 2016 September 30th 2016

The Institute for Metal and Lightweight Structures of the University of Duisburg-Essen organizes the Essener Membranbau Symposium for the third time this year.

The objective of the symposium is the exchange between membrane experts in the fields of research, design and execution. The presentations consider up-to-date topics of particular interest:

Overview over the state of the art in the standardization work, design oriented determination of stiffness parameters for fabrics, convertible structures, relation between location and membrane structure, analogies to cable structures, specifics about building supervisory procedures for approval in Germany as well as an outlook on the future of membrane structures.

University of Duisburg-Essen Glaspavillon Campus Essen

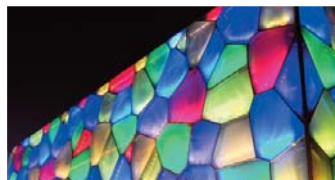
Faculty of Engineering - Department of Civil Engineering, Universitätsstraße 12 - 45141 Essen

Information and registration:

 www.uni-due.de/iml/

 stefanie.schuelpen@uni-due.de

FabriTec Structures and Guard-All Building Solutions partner with PFEIFER's business unit, Cable Structures



PFEIFER Seil- und Hebetechnik GmbH (Germany), with its business unit, Cable Structures, the world leader in the design, manufacturing and construction of architectural cable structures has acquired an ownership interest in the Dallas, Texas based FabriTec Structures and Guard-All Building Solutions. Last year, German-based PFEIFER acquired the Shanghai-based Covertex, an industry leader in PTFE, PVC and ETFE membrane manufacturing and in March 2016 acquired Austrian-based Erneuer-Plus (now PFEIFER Systems), a specialist in retractable and movable structures.

By combining these new acquisitions, PFEIFER, with its rich history and enduring 400-year-long reputation, is creating a global organization with unparalleled technical and

commercial experience and manufacturing resources. These new alliances will further enhance PFEIFER Group's capabilities to undertake large iconic projects around the world. "With this acquisition we are now the only specialty construction company in the world with the capabilities and experience to manufacture cables, stainless steel hardware, structural steel as well as membrane fabrication on a very large scale and a team to design, supply and install retractable and movable systems. By combining our resources, together with our technical, commercial, manufacturing and installation capabilities, we have the ability to execute a wide range of projects from small and simple to very large and complex effectively." said Mr. Gerhard Pfeifer, President of the PFEIFER Group. "This

new strategic alliance with PFEIFER will allow FabriTec to achieve its long term goal... to become the preferred vendor on major iconic stadium projects throughout North and South America, as well as providing PFEIFER with additional resources for its other global pursuits." said Mr. Basil Haymann, Chairman of FabriTec Structures.

 PFEIFER Seil- und Hebetechnik
www.pfeifer.info

FabriTec Structures, LLC
www.fabritecstructures.com

Guard-All Building Solutions
www.guard-all.com

PFEIFER Covertex
www.covertex.com.cn

PFEIFER Systems
www.pfeifer-systems.at

FIRST SPORTS STADIUM IN THE USA WITH LIGHTWEIGHT ETFE FILM ROOF



Context

The U.S. Bank Stadium in Minneapolis, Minnesota is the first sports stadium in the USA featuring a transparent roof construction with high-performance films extruded from 3M Dyneon Fluoroplastic ETFE. Outside temperatures of minus 30 degrees are usual during the American Football season from September to the beginning of February. Therefore, only closed stadiums are the only choice in the north of the USA. In order to create a genuine open-air atmosphere at least in summer, architects have often made use of movable, but expensive roofs in the past. The ETFE film cushion technology, which is already widespread in Europe and Asia, was used for the first time in the US by the HKS Architects for the construction of the new multi-purpose stadium in Minneapolis, thus lowering the construction costs by around USD 100 million as compared to a retractable roof.

Insulating air cushions lower operating costs

Round about 75 three-layer ETFE film cushions cover the total roof and facade area of 22.000m². Some of the individually air filled cushions are more than 110m long and around 3m wide. The top film is printed with a geometric pattern, which scatters the sunlight and prevents a greenhouse effect in summer. In winter, the film roof protects the interior from the cold outside temperatures.

The film cushions manufactured from 3M Dyneon ETFE allow 95 percent of the daylight to pass through, but their weight is only about five percent that of glass. As a result, the supporting steel structure can be particularly light and slender and offers all spectators an optimum view of the playing field.

Durable and flame resistant

The entrance consists of five giant glass doors, which are over 30m in height and remain open in summer. Vector Foiltec built the film construction that joins onto them. With 14 offices worldwide, Vector Foiltec covers the entire spectrum from the conception to the support structure planning and from the manufacturing of the cushions to their installation. The films are extruded from 3M Dyneon ETFE by Nowofol Kunststoffprodukte GmbH & Co. KG, NOWOFOLON® ET 6235Z films are available in thicknesses from 80 to 400 microns. Nowofol produces the films in a wide range of RAL colours as well as in transparent and, completely new, in an infrared absorbing variant. The films conform to fire protection class B1 (according to DIN 4102), which is an important criterion – not just in the USA.








TRANSPARENT ROOF FOR THE MINNESOTA VIKINGS Minnesota, USA

Designed for high snow loads

The architects and the roof planners paid particular attention to the load bearing capability under high snow loads, because the roof of the Metrodome, the predecessor building that was only half as large, collapsed in December 2010 under the heavy load of more than half a meter of snow. ETFE films feature very good values for tear strength, resistance to tear propagation and puncture resistance which let the air filled cushions easily cope with highly concentrated impact loads like hail. Their use in northern Europe and the Alps proves their winter compatibility, even in areas with heavy snowfall. The asymmetric roof is inclined more towards the north in order to fend the snow off. Due to their anti-adhesive surface, the films are so smooth that snow can hardly get a grip at all and slides off - in an almost controlled manner. A heavy rain shower is enough to clean it.

3M is Scientific Partner of the Vikings

In May 2016, 3M has been named the official scientific partner of the Minnesota Vikings. More than 50 innovative 3M products were used in the construction of the stadium. For instance, numerous fire protection solutions come from 3M, as does the equipment for the first-aid stations.

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Name of the project:	U.S. Bank Stadium
Location address:	Minneapolis, USA
Client (investor):	Minnesota Sports Facilities Authority
Function of building:	multi-purpose stadium
Type of application of the membrane:	ETFE cushions
Year of construction:	2015
Architects:	HKS Architects
Structural engineers:	Thornton Tomasetti
Contractor for the membrane:	Vector Foiltec GmbH
Supplier of the membrane:	Nowofol Kunststoffprodukte GmbH & Co. KG
Manufacture and installation:	Texlon® ETFE system by Vector Foiltec
Membrane material:	3M™Dyneon™ Fluoroplastic ET 6235Z
Overall area:	22.000m ²

Thannhausen, Germany

Context

After the topping-out ceremony in January 2015 for the redesign of the building complex of the Fleischwerke Zimmermann GmbH & Co.KG, a medium size company in Thannhausen (Bayern, Germany), construction already was completed in spite of the specific needs and requirements because of preservation order in December 2015. "With 'much empathy' architect Egon Kunz managed to realize a modern structure, although the old buildings was demolished but reconstructed historically" writes the Augsburgener Allgemeine.

A roof for the courtyard

The courtyard of the building complex was covered with an approximately 10x30m cushion foil construction. The primary supporting structure are 13 parallel, with a distance of about 2,5m each, arranged steel arches. These are connected with steel pipes at the longitudinal sides to a frame. Every second steel arch is placed on two approx. 7 to 8,2m high steel columns (Fig 1). The height differs because the columns are adapted to the slope of the courtyard. On the long sides additional cross braces are needed. These are designed as trusses of steel tubes with a smaller diameter (Fig. 2).

The entire steel structure acts straight, slim and well thought out. The ratio of steel to foil is optimal, so that neither of the two materials will disappear in the shadow of the other. Also the consideration of the complete structure, means the combination of steel and foil forms a pleasant contrast to the existing buildings, but nevertheless creates a harmonious transition from "old" to "modern".

The foil cushions are fixed with a revolving, double-sided clamping



INNER COURTYARD ROOFING

OF THE FLEISCHWERKE ZIMMERMANN GMBH & CO.KG

Custom-fit sits the cushion foil roof in the courtyard surrounded of monumental existing buildings.



profile and then biased pneumatically. In total, the construction consists of 12 foil cushions (Figs. 3 and 4). Each cushion has a supply air and exhaust air valve and is powered by a single, higher-level air supply

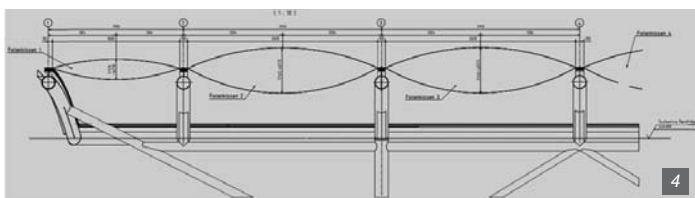
Choosing the appropriate material

ETFE foil, as material that was chosen for the courtyard roofing, is a relatively young, ambitious building material, which could

make career as a transparent technology for roofs and facades. Above all, the low weight, the high surface tension or the harnessing of roof and facade surfaces for lighting, solar cells or promotional offers tremendous advantages over other materials.

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Figure 1. Inner court roofing / Figure 2. Side view / Figure 3. Framework and membrane.
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Figure 4. Construction detail – cushions and their connection to the structure.



Name of the project:	Roofing inner courtyard
Location address:	E.-Zimmermann-Strasse 29, 86470 Thannhausen, Germany
Client (investor):	Zimmermann E. GmbH & Co.KG
Function of construction:	Roofing
Year of construction:	2015
Architect:	Egon Kunz Architekten
Main contractor:	CENO Membrane Technology GmbH
Structural engineer:	Kiefer. Textile Architektur
Manufacturer of steel:	Windhorst Stahl- und Metallbau GmbH
Manufacturer of ETFE:	CENO Membrane Technology GmbH
Cutting Pattern ETFE:	Kiefer. Textile Architektur
Installation:	Montageservice LB GmbH
Material:	ETFE-foil 250µm
Covered area:	ca. 310m ²

TEXTILE ROOF AND FACADE FOR THE Trabzon Akyazi Stadium

Trabzon, Turkey

Introduction

The Akyazi Stadium will be built on a piece of artificially created land of almost 800.000m² on the shore of the Black Sea in the Akyazi area, located on the west side of the city of Trabzon. The stadium will be a part of a large complex of sports and leisure facilities. The Akyazi Stadium, which will be the future heart of the Trabzon complex, will have a capacity of 42.000 seats, including 3.000 VIP seats and 122 sky boxes.

Design


The design of Akyazi Stadium was made by Adnan Aksu Architecture. The architects designed an elegant and modular stadium with spacious interiors. The dynamic external form catches the eye. The stadium will be covered with membranes which will be tensioned over steel frames to create a unique, angular form. At the same time the enclosed form gives the supporters a shelter against sun, rain and strong winds from the sea as the stadium will be built just a few meters away from the Black Sea coast. Tensaform was involved in the implementation of the textile roof and facade for the Akyazi Stadium.

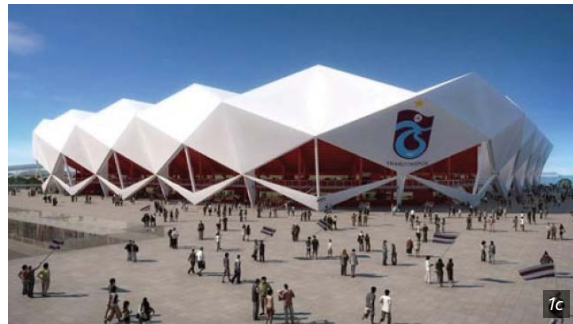
Membrane

For the realisation of the membrane surface of approximately 46.600m² (roof and facade) Tensaform has chosen the membrane Sheerfill PTFE II, manufactured by Saint Gobain.

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HOME OF THE TURKISH SUPER LEAGUE CLUB OF TRABZONSPOR

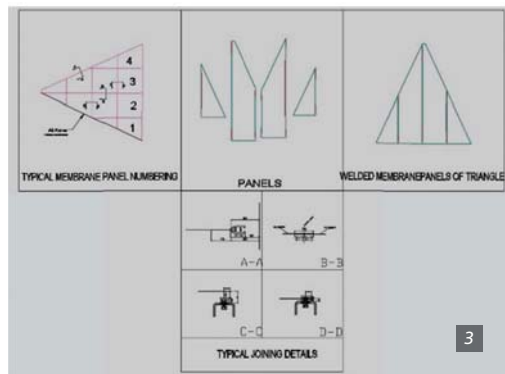
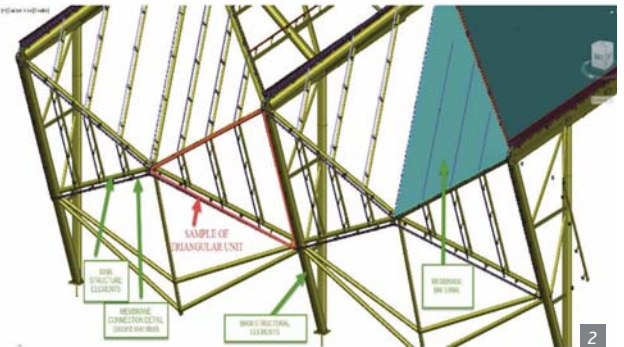
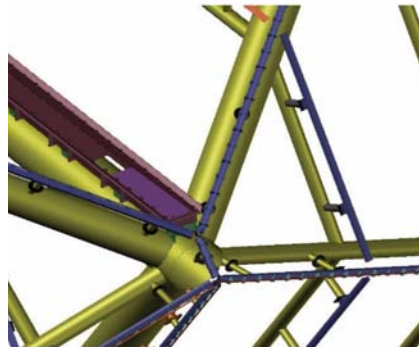


Figure 1. a-d Visualisations of the Akyazi stadium

Figure 2. Technical details: Triangular membrane units connected to substructure.

Figure 3. Technical details: Membrane panels: cutting and welding

Name of the project:	TRABZON AKYAZI STADIUM
Location address:	TRABZON/TURKEY
Client (investor):	HOUSING DEVELOPMENT ADMINISTRATION OF TURKEY (TOKİ)
Function of building:	SPORT COMPLEX
Year of construction:	2015
Architects:	ADNAN AKSU
Multi-disciplinary engineering:	ERDUMAN ENGINEERING OFFICE
Structural engineers:	ERDUMAN ENGINEERING OFFICE
Consulting engineer for the membrane:	TENSAFORM MEMBRANE STRUCTURES INDUSTRY & TRADE INC.

Engineering of the controlling mechanism:	HOUSING DEVELOPMENT ADMINISTRATION OF TURKEY (TOKİ)
Main contractor:	SARIDAĞLAR- STY- YETAŞ CONSORTIUM
Contractor for the membrane (Tensile membrane contractor):	TENSAFORM MEMBRANE STRUCTURES INDUSTRY & TRADE INC.
Supplier of the membrane material:	SAINT GOBAIN
Manufacture and installation:	TENSAFORM MEMBRANE STRUCTURES INDUSTRY & TRADE INC.
Material:	SAINT GOBAIN SHERFILL II
Covered surface (roofed area):	Apprx. 46.600m ²



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