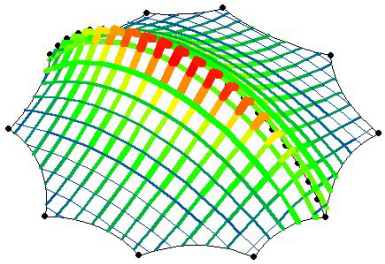

Textile Roofs 2016

May 2nd - 4th 2016

Prof. Dr.-Ing. Rosemarie Wagner

Dr.-Ing. Bernd Stary

Archenhold Observatory Berlin

Report

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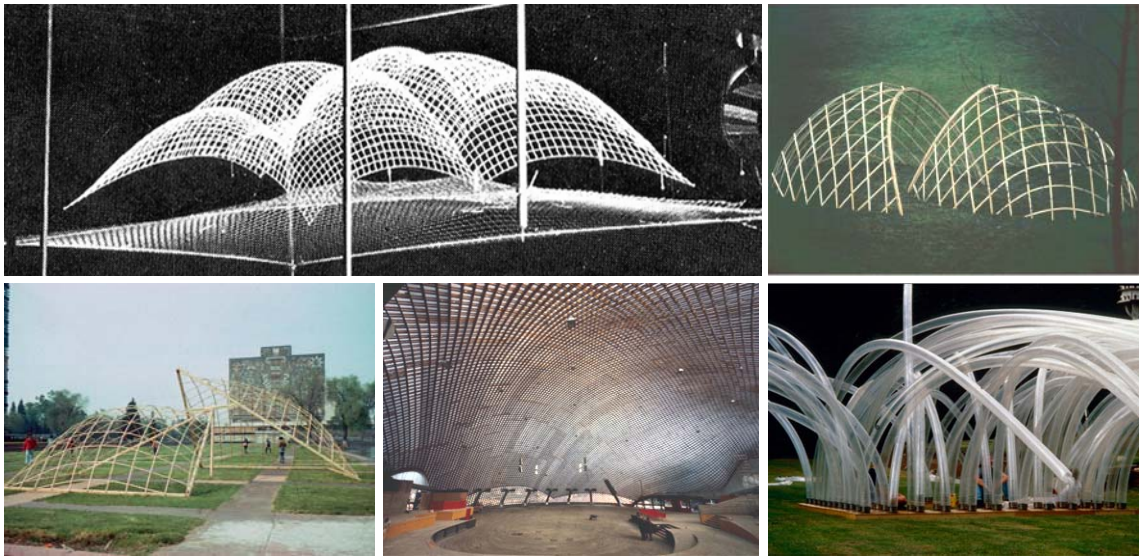
Building with positive and negative pressures - Universität Stuttgart - Studio ltd - FESTO

Introduction

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.



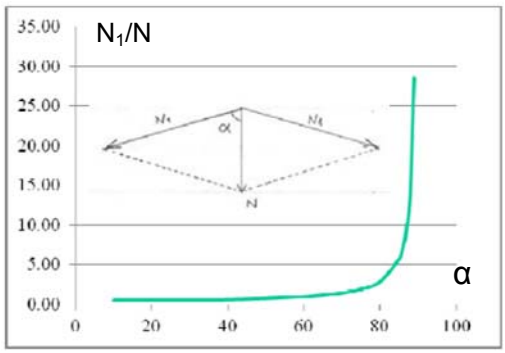
In conclusion, lightweight structures were considered as a way to build in accordance with the principles of stability, utility, beauty, and sustainability in order to shelter people, to recycle materials, and to compensate for 60% of the natural resources consumed for building construction.

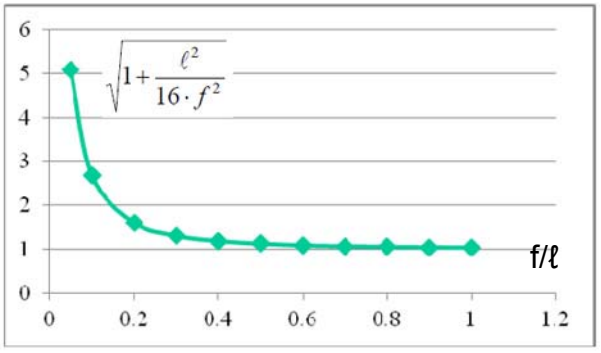
An impressive example of the application of these principles is the pneumatic gridshell "PlusMinus," made of inflated film tubes flexibly connected, and completed for stability and rigidity by two shell films vacuum sealed above and below the tube latticework. PlusMinus is a project initiated by students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

Pathology, Josep Llorens - School of Architecture, Barcelona.

J. 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.





Left: The angle multiplying effect: three or more forces come into play at a corner. Equilibrium requires that each force be the resultant of the others. The best way to save energy and material is by directly following the path of the loads. When derivations are needed, the influence of angles is significant. Being able to divide a force into two components is highly dependent upon the angle of projection.

Right: 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.

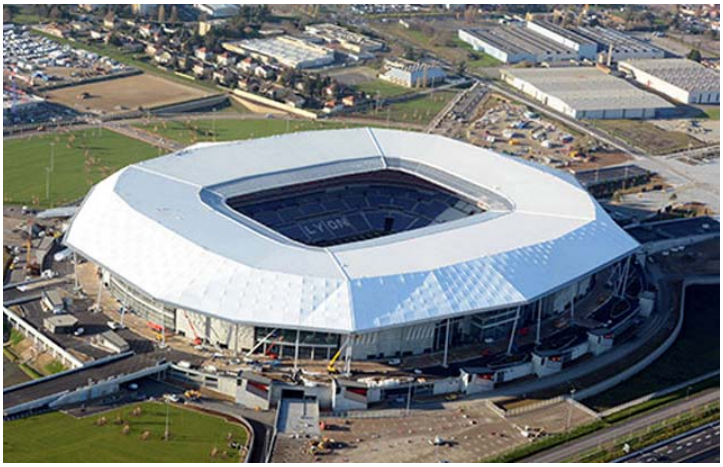
- the design is responsible for the resultant flatness, lack of prestress, or an inadequate shape, resistance, or detailing.
- the installation process involves stability issues, provisional situations, and the final shape.
- final use does not always correspond to the design specifications. Maintenance 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 exclusively to produce rigid materials. Its ability to withstand oxidation over the long term ensures that its structural and aesthetic properties remain unimpaired for decades.



Over 30 000 m^2 of Précontraint TX 30 form the flexible roofing on the Stade des Lumières, Lyon.

Recycled polyester fibres and PVC granules from PVC coated polyester

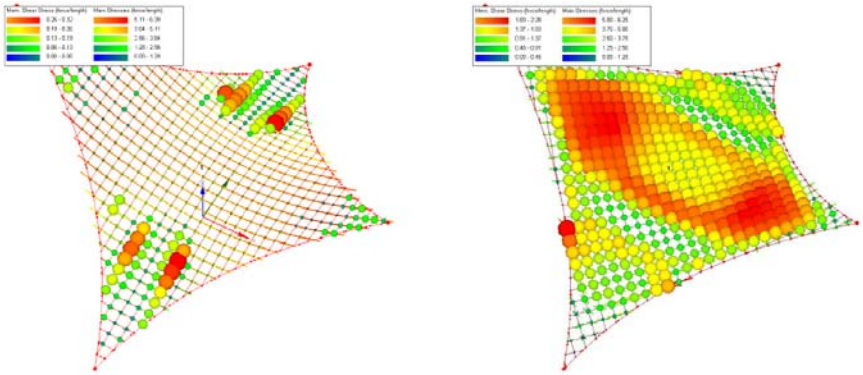
The next point addressed was the Texyloop technology used to recycle polyester-PVC flexible composite materials that produces secondary raw materials of high intrinsic value, compatible with multiple processes. In recycling, the impact is reduced by 50% in comparison to incineration or landfilling.

Left: in the Netball centre, Auckland, the reverberation time has been reduced from 6,95 s to 2,5 s and in the Vaujany ice skating ring (right) the reverberation time has been reduced from 7,7 s to 1,8 s.

In the last part of his presentation F. 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. It absorbs 65% of sound, transmits 41% of light, and protects from solar heat (-59%) and glare beneath a glass roof or facade.

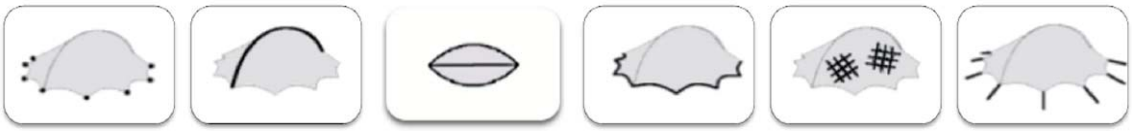
Computational modelling of lightweight structures, Jürgen Holl, technet GmbH: *http://technet-gmbh.de/index.php?id=74&L=1*

"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.



Left: material direction parallel to main curvature → small shear-stresses under snow-loading.
Right: material direction under 45° to main curvature → big shear-stresses under snow-loading.

Computational modelling has been recently refined with the introduction of shear and crimp stiffness that steers the different behaviour under load with different material directions.



The form is defined by the boundaries, supports, orientation of warp and weft and prestress.

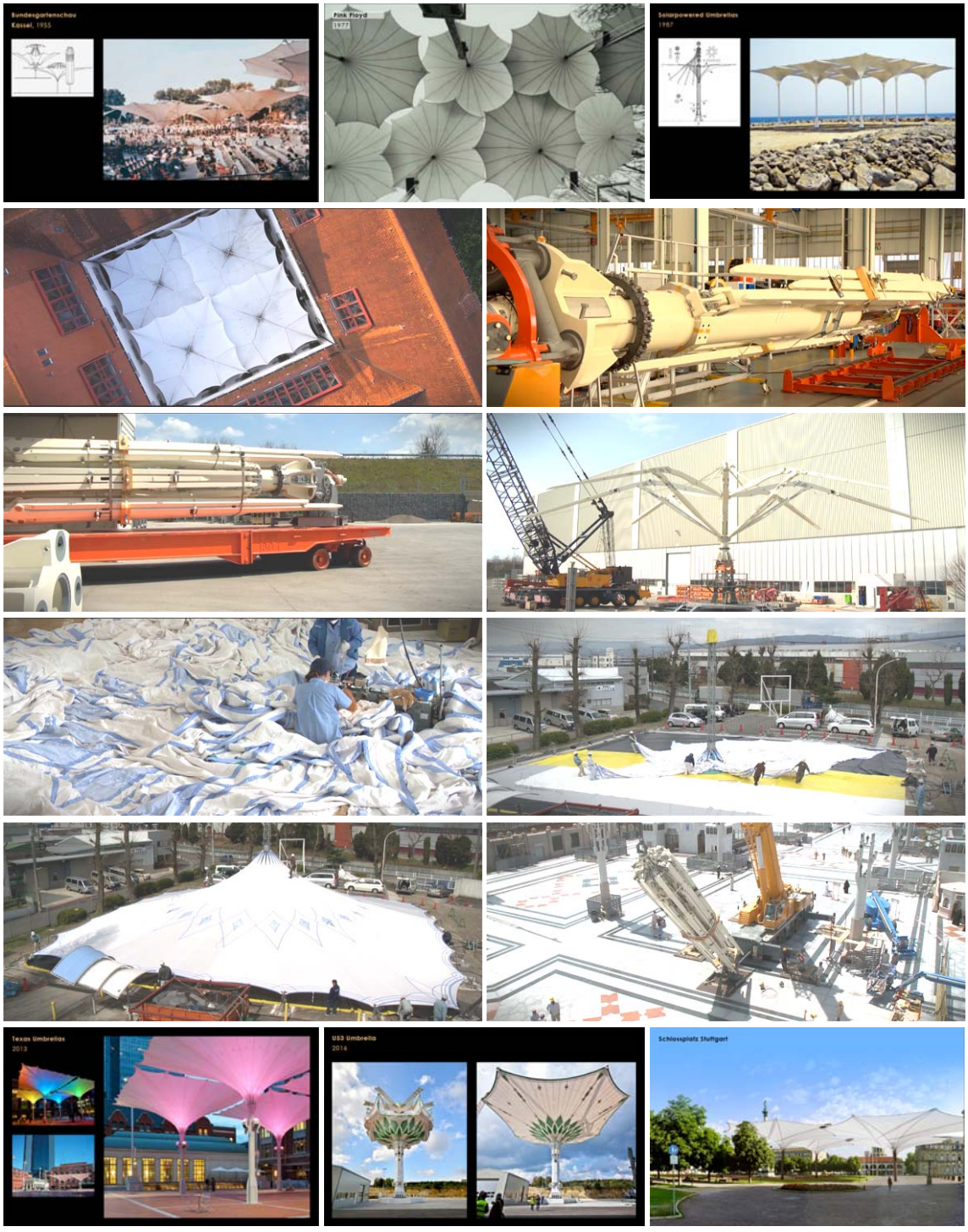
Regarding the definition of the form, Jürgen Holl stressed once again that the form is not free because equilibrium depends on the prestressed state and the boundary conditions. The analytical form finding can be based on the force density method and the non-linear static analysis, including the membrane, 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.

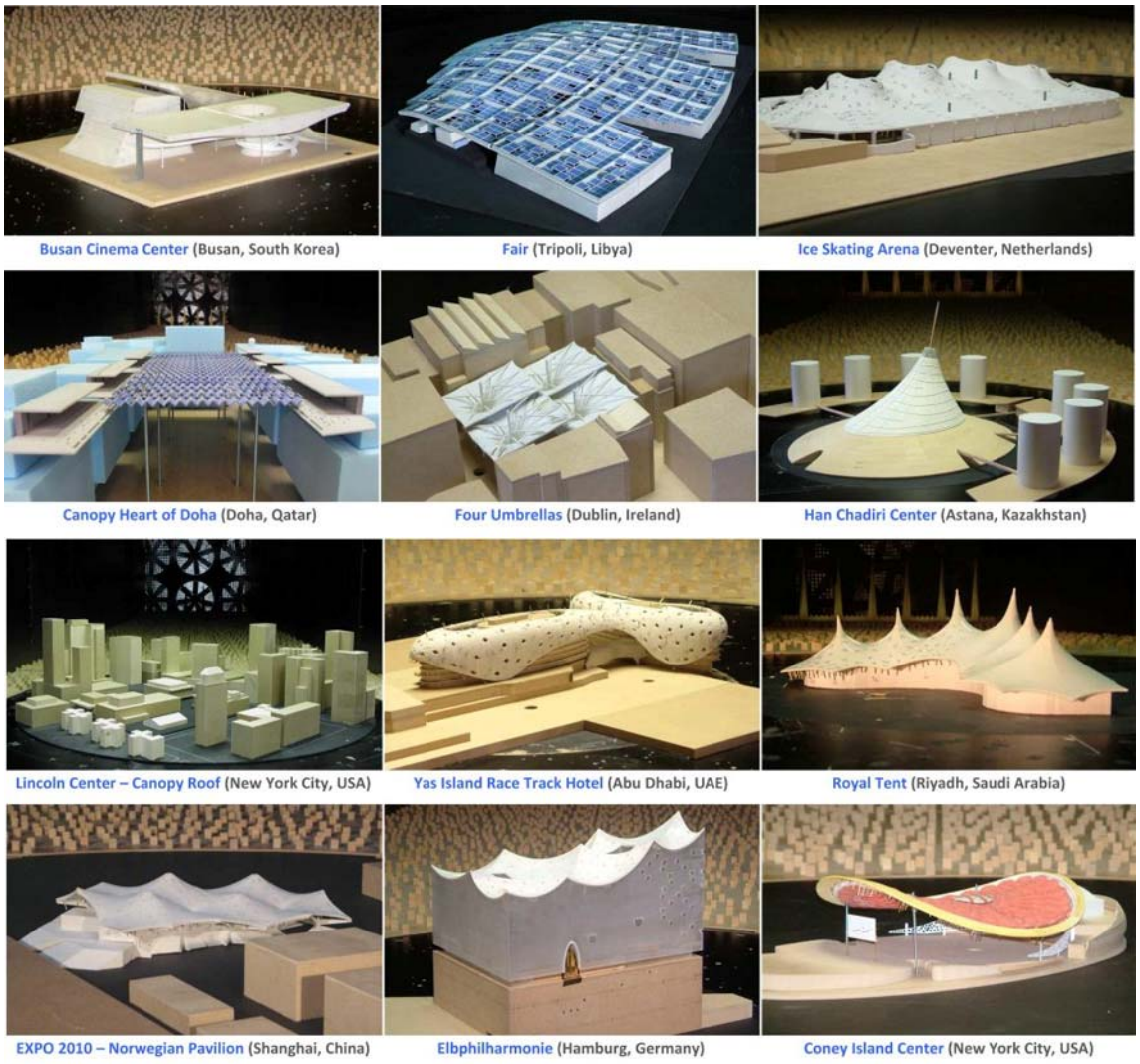


Among the works presented, umbrellas were examples of the most representative and evolved. They started from the umbrellas of Kassel 1955, Pink Floyd 1977, the solar powered umbrellas 1987, Madinah 1991 and 2011, Texas 2013, the U53 umbrella 2016, and the future project for the Schlossplatz in Stuttgart. He revealed that the biggest umbrellas don't fit into the stereotypical classification of lightweight structures.

Wind loads on fabric structures and corresponding dynamic response , Martin Zaschke, 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.



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.

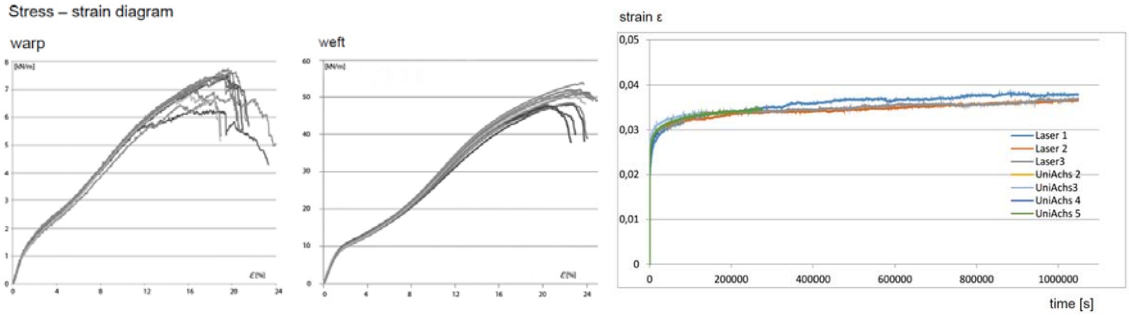
Martin Zaschke ended his lecture stating that the sooner the wind engineer is involved in the structural planning in an early stage, the greater the optimization potential is.

Development of transparent textile structures for applications in architecture, Rosemarie Wagner, Karlsruhe Institute of Technology.

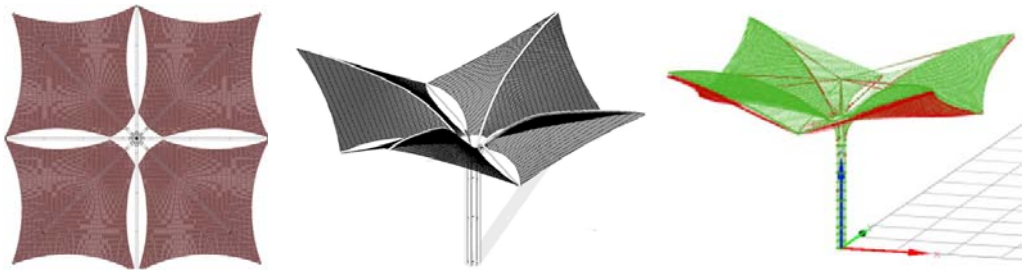
Rosemarie Wagner presented a research concerning "ETTLIN black," a fabric for exterior use which is UV-resistant and fade-resistant. The research was conducted at the Karlsruhe Institute of Technology. (*http://www.ettlin-textiles.de/produkte/gewebe/ettlin-black*).

Main characteristics of "ETTLIN black": straight warp, straight weft, connection yarn, watertight, airflow through fabric, no coating. Functional properties investigated: water tightness (depending on the steepness) and different shading according to the angle.

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.

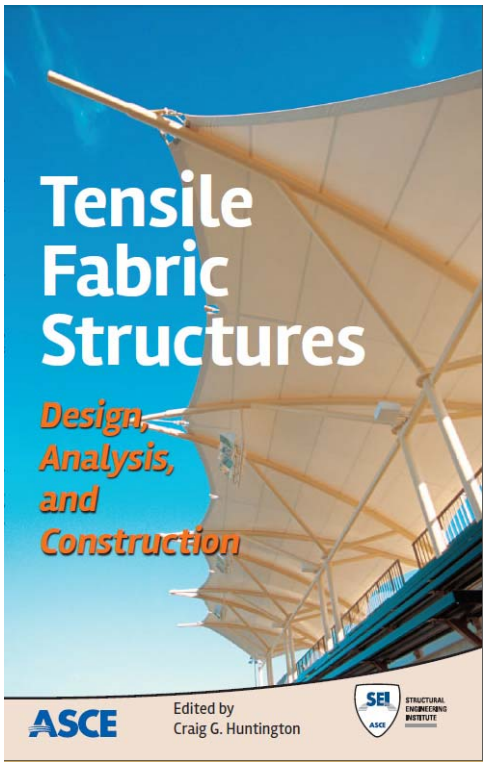


Submitted to uniaxial tensile strength tests the material revealed to be highly anisotropic and presented a considerable plastic deformation. However, creep values were not as high. The biaxial behaviour under tension and shear was also tested and the stress-strain diagram calculated from the pressure-displacement values obtained by a photogrammetric system.



The investigation was completed with the design of a prototype of a modular canopy for parking lots.

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.

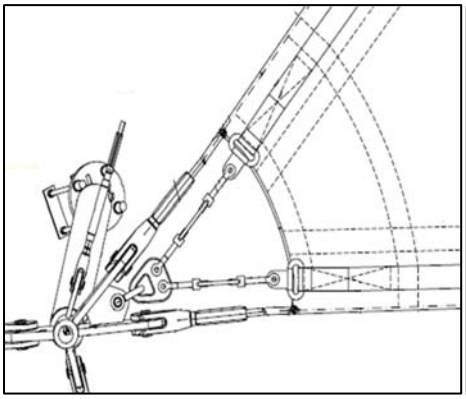
He dedicated the second part of the lecture to special structures that combine fabric with other materials. "*When a costumer asks for an apple, you can offer a fruit salad,*" was his philosophy. His firm "Specialty Structures USA" aims to bridge the gap between architects and engineers, connecting creative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

Details in membrane architecture. "My way to enthusiasm". Horst Dürr, Tensile Evolution: *http://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 "t*he 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.



Specification	material	Quantity unit	Q total	€/unit	€ total
Membrane	PVC/PES	m²	0,5	80	40
Doubling	PVC/PES	m²	0,5	80	40
Border pocket	PVC/PES	m	1	40	40
Cable +fitting	niro	pcs	2	120	240
Belt +triangle	niro	pcs	2	50	100
Belt seam	hf/.....	m	2	25	50
Turnbuckle	niro	pcs	2	80	160
Belt plate	niro	pcs	1	50	50
Seam hf pocket	hf/.....	m	2	25	50
Seam hf doubling	hf/.....	m	2	25	50
					880

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. 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.

The Msheireb retractable roof in the heart of Doha, Qatar, announced by Thomas Hermeking during the previous edition of "Textile Roofs" has been installed. It consists of 1,080 individual membrane-covered frame modules suspended on 60 structural cables that span the rectangular 35 m-wide square. The length of the square is 90 m. The cables are anchored in the roof area of the six buildings located at both ends of the square. The elements are stored vertically and are folded in packages.

Left: The Rosa Parks Transit Center in Detroit provides a state-of-the-art transit area for bus riders. It is a key component in the revitalization of downtown Detroit. At the heart of the centre there is a 6,000 square meter custom-made tensile structure made of Teflon-coated fibreglass fabric.

Right: The ASU Skysong Innovation Center, Scottsdale, Arizona is a mixed-use. 5.2 million US dollar project, consisting of 100,000 square meters of office, research, and retail space. It also includes a hotel/conference centre and residential units. The centerpiece of the development is an enormous custom tensile fabric structure supplied by Fabritec.

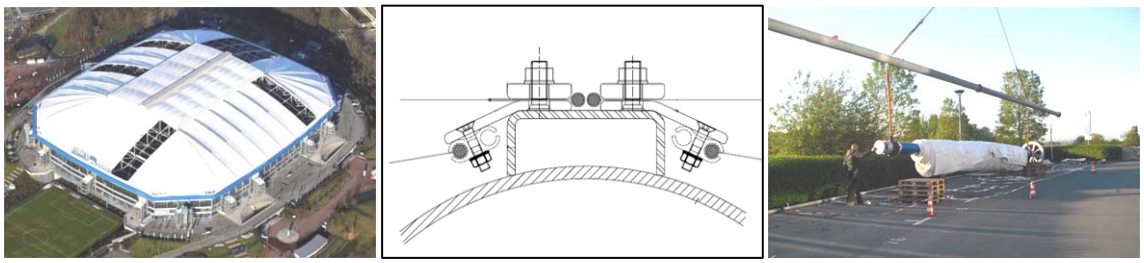
Imagine tomorrow. Replacement and renovation of textile structures.
Alexander Rüther, CENO Membrane Technology GmbH: *www.ceno-tec.de.*

The presentation of Dipl.-Ing.Alexander Rüther was truly instructive. His main theme was "*Imagine Tomorrow.*"

When designing and building textile projects, various construction materials with different lifespans 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.

Munich Airport Center. PTFE-coated glass-fibre fabric. 5 of 7 existing panels were replaced while the airport was in full service.

Metronom Theater, Oberhausen. PES/PVC fabric. The replacement of the outer skin while the theater was in full service.



Veltnis Arena, Geisenkirchen. PES/PVC fabric (former PTFE-coated glass-fiber fabric). The replacement of the outer membrane with changes in the structure

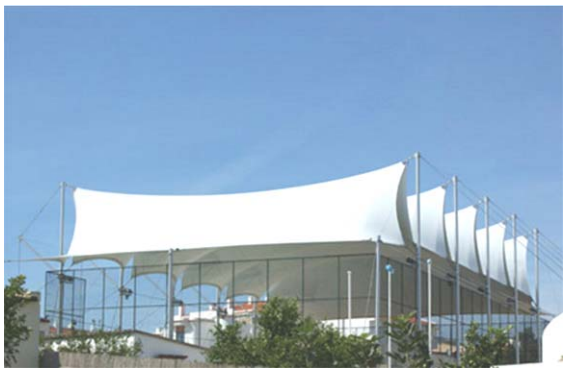
Gerry-Weber Stadium, Halle. PES/PVC fabric. The replacement of outer

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 Potugal. 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.

Their best credentials are the works they've done in textile architecture, tents, covers, façades, ceilings, advertising, and transport.



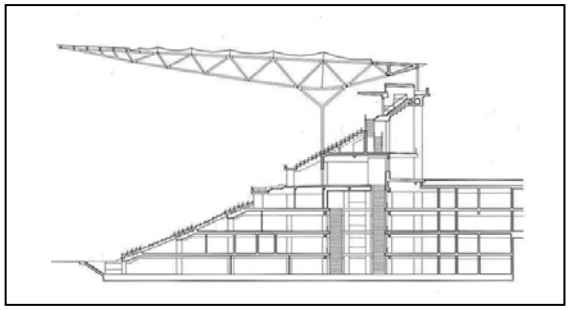
IEFP Portimao, 2012, 1.722 m^2

Resende, 2012, 767 m^2

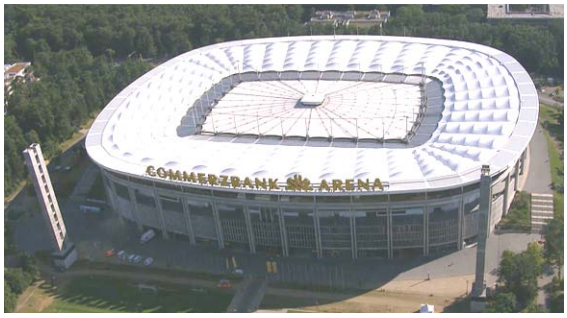
The most surprising work that Antonio Galhardo presented was the replacement of ETFE by PVC-coated polyester for the 10 x 10 m cushions of the "Dolce Vita Tejo" shopping mall in Lisbon. Could the replacement of ETFE cushions be considered a new market potential for PVC-coated polyester?

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.

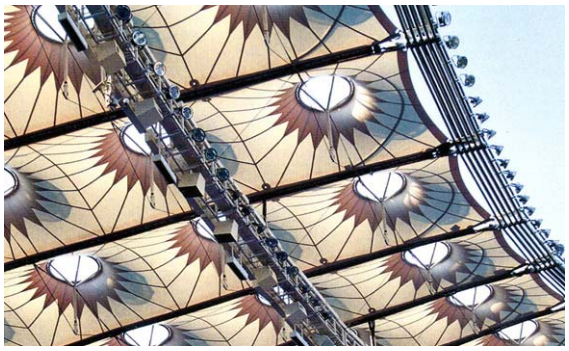


The refurbished Berlin Olympic stadium encloses not so evident new features.

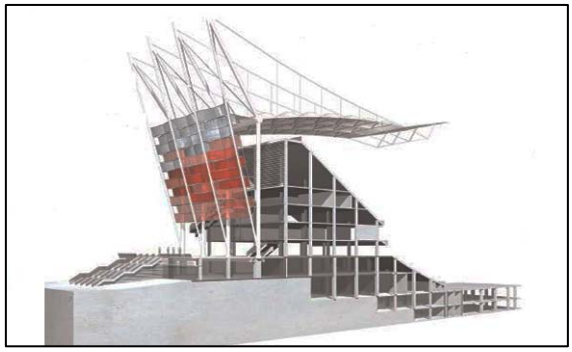


Mixed textile/policarbonate, fixed/retractable roof of the Frankfurt Commerzbank Arena.

The additional roof of the Jawaharlal Nehru Stadium in New Delhi.



The Kiev Olympic Stadium is a single layered composition of conical shapes.



The Warsaw Stadium is notable (left) for being built above a volcano shape, its compression ring and the cables penetrating the membrane (right).

Arena de Amazonia, Manaus, with its inner compression ring.

Santiago Bernabeu Stadium renovation, Madrid, to expand the capacity and covering it.

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.

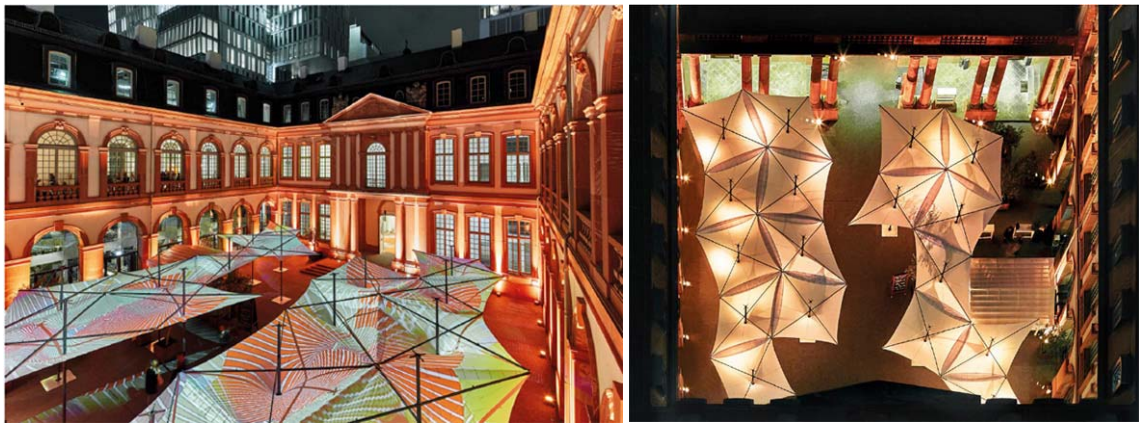
Nice Stadium. End customer: City of Nice. General contractor: VINCI. Architect: Willemotte, Paris. Material: 20,000 m^2, 1002 Fluotop T2. Fabrication time: 7,000 hours. Installation time: 5 months (8 people).

Lyon Stadium: End customer: Olympique Lyonnais. General contractor: VINCI. Architect: Populous, London. Material: 20,000 m^2 1202 TX 30. Fabrication time: 15,000 hours. Installation time: 7 months (15 people).

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 tradeshows and events, combining light and membranes

The Riverside Lounge of Light, light installation for the light art festival LUMINALE 2016, Frankfurt, between 13 and 18 March, 2016.

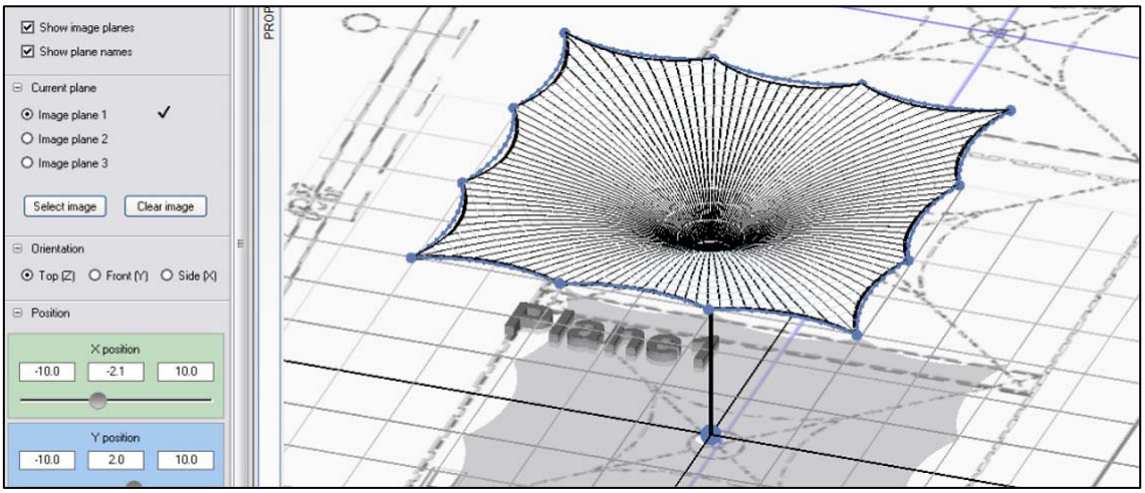


Square and diamond-shaped screens can be combined.

LOOPS pavilion, BAU 2011 Munich, introduced innovative products and services around the light and membrane construction.

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.

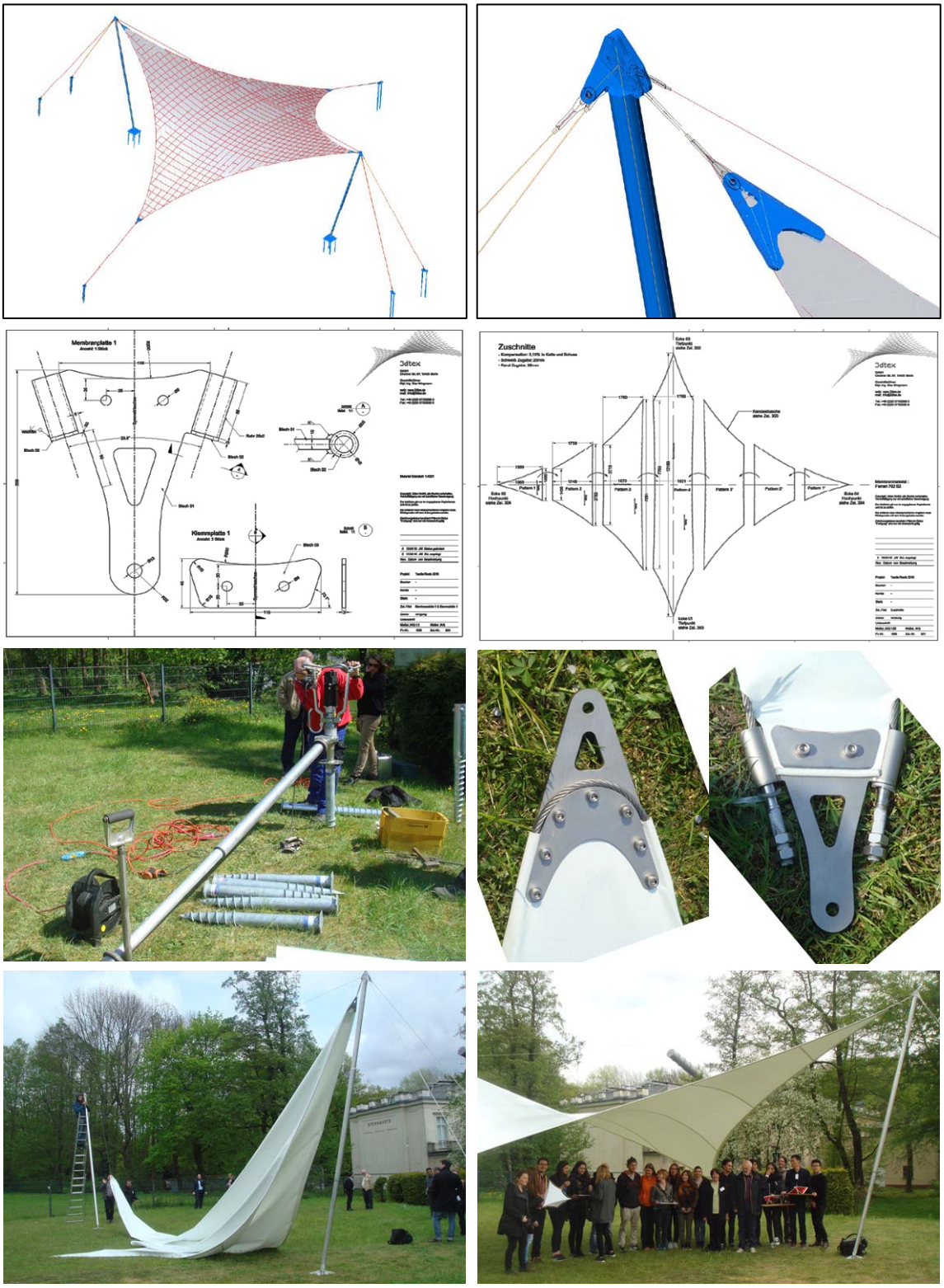


In fact, "formfinder" starts from a hand-drawn sketch that was examined in terms of its physical, geometrical, and architectural characteristics.

The design is compared with projects, materials, and details that have been implemented as a database.

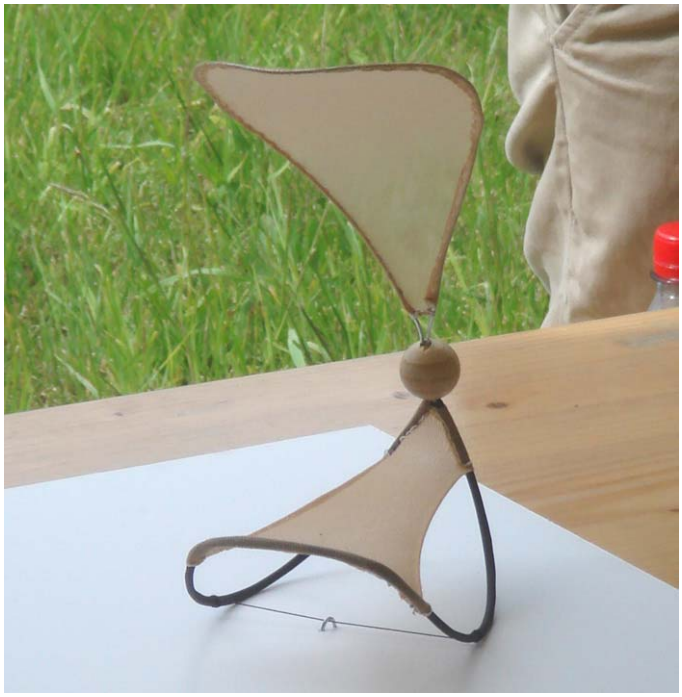
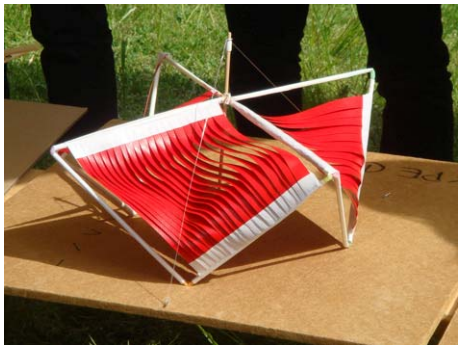
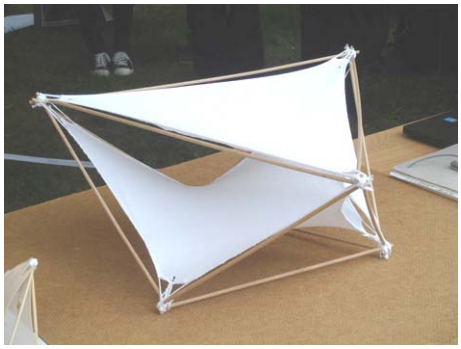
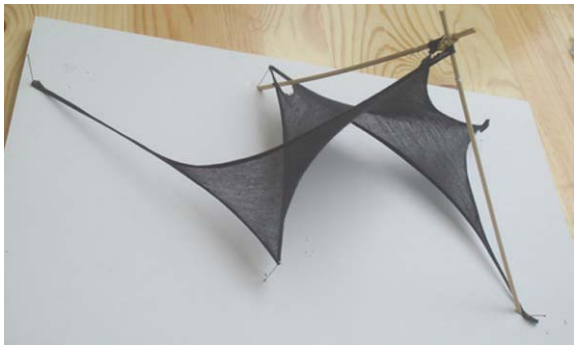
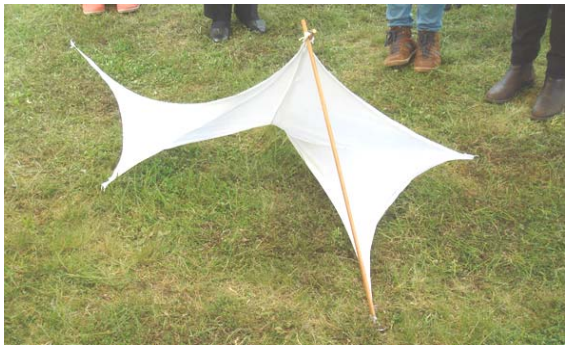
As an example of application, Robert Roithmayr showed the Palma Aquarium canopy to guide people into the building. He considered it as something new that could not have been constructed with concrete.

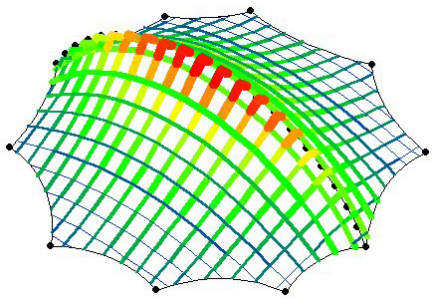
Joint participant project, Stev Bringmann, 3dtex GmbH.



Starting from the design, the entire manufacturing and installation process of a four-point sail was carried out during the TR 2016 Workshop. 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.



Textile Roofs 2017

May 15TH - 17th 2017

Prof. Dr.-Ing. Rosemarie Wagner

Dr.-Ing. Bernd Stary

Archenhold Observatory Berlin

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*.