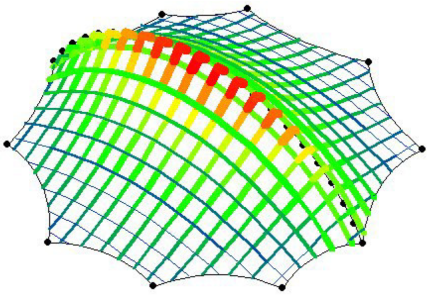

Textile Roofs 2010

June 03rd - 05th 2010

Prof. Dr.-Ing. Lothar Gründig
Technical University of Berlin (TUB)
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Report

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"Shanghai Expo Axis" (from the spectacular presentation of Mr. D.Richter, Büro für Leichtbau, Radolfzell)

Introduction

Textile Roofs 2010, the Fifteenth International Workshop on the Design and Practical Realisation of Architectural Membranes, took place on 3–5 June at the Technische Universität Berlin and was chaired by Prof. Dr. Ing. Lothar Gründig. It was attended by 49 participants from 13 countries on three continents, once again demonstrating the success of the event, which has become firmly established since it was first held in 1995.

Design principles and requirements. J. Llorens, Barcelona School of Architecture.

The basic principles and requirements for designing membrane structures can be summarized as follows.

Left: gravity for compression (Egipt).

Center: rigidity for bending (Florence).

Right: curvature for tension (Alacant)

1. **Basics**: tension, curvature, pre-stress

More curvature (right) means less tension, improving drainage, increasing height and increasing the ratio: manufactured membrane / covered area.

2. **Structural requirements**: resistance, stability, redundancy, stiffness, flexibility

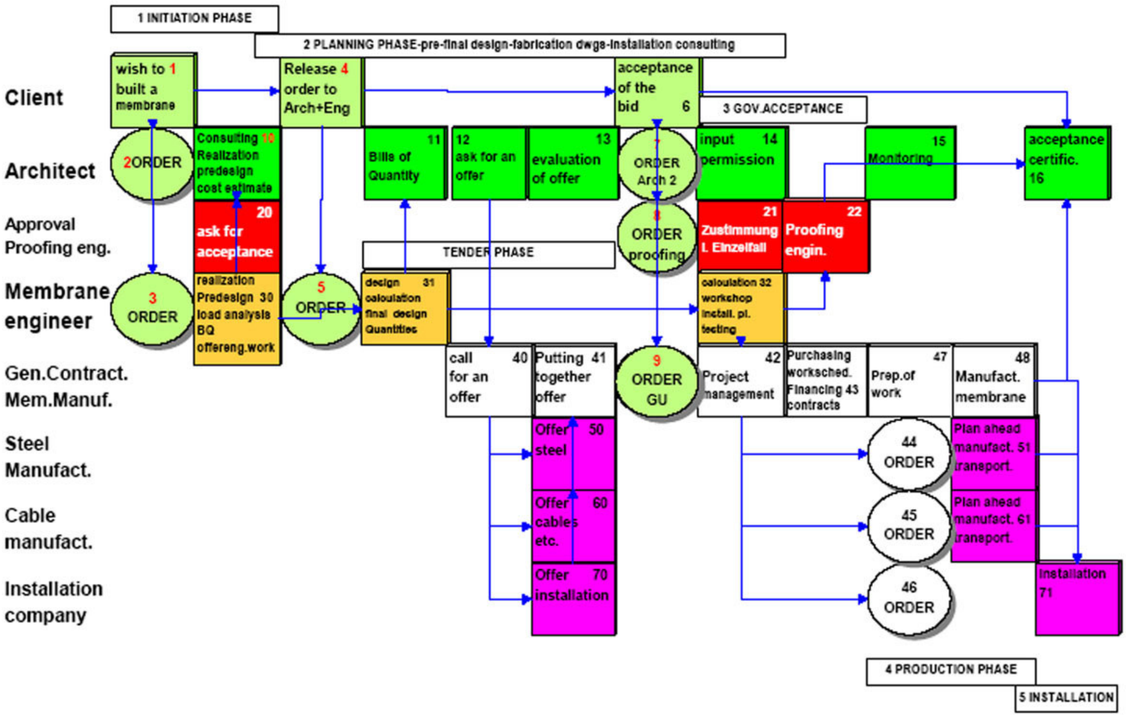
Two strategies of design: hiding (left) or following (right) the load paths..

The proportion between parts needs to be balanced

3. **Geometry**: form, funicularity, convergence, balance, need for space, scale effect, coordination.
4. **Material.**
5. **Visual expression**: overall expression, lightness, load paths, balance, proportion, translucency, boundaries, framing the views, common vocabulary, smoothness, style.
6. **Surroundings**: isolated, urban space, nature, buildings, enclosures.
7. **Environment and sustainability**.
8. **Installation process**.
9. **Economy**.
10. **Conclusion**: the design process for textile architecture.

Architects meet membranes. H.Dürr, R.Essrich & R.Dinort, IF Group.

Membranes are uncommon design challenges for most architects who seek special conditions. During the presentation, the concepts of "fertile soil" and "what to do and what to know" were described and examples from IF were presented.



Detailed flow-chart of the total development of the project.

Mr Dürr explained that "**fertile soil**" refers to the need for people to think innovatively and to be open-minded and creative. He compared conventional stadiums and stations with textile roofs, in which new forms emerge with new details and materials. Curved surfaces in tension can be used to overcome problems involved in creating round designs and 90º and 60º angles, but special software that can manage form and equilibrium together is required. Materials tend to be composites for lightness, translucency, foldability, fire resistance, UV barriers, dirt repellency, insulation, energy saving and energy collection. The typology of structural membranes is a hybrid of surfaces curved in two directions, masts, beams, arches and other structural supports.

To explain "**what to do and what to know**", the following design aspects were provided: space, positioning, orientation, form, function, construction, legibility, conceptual reference, sustainability, ecology, power consumption and cost.

After the concept phase, which is conducted by the architect and the client, the engineer carries out the planning and project-management phases. These require a series of leadership and organizational techniques and resources for initiating, defining, planning, managing and completing the project.

10 Steps of design:

1 Define design
2 Look for an idea
3 Draw in 3D
4 Find form of membrane
5 Complete 2D drawing
6 Pre-calculation, pre-dimensioning
7 Find measures
8 Make a presentation
9 Define details
10 Make a budget price

Membrane Lightweight Structures. R. Wehdorn-Roithmayr, Vienna, Austria

Robert Wehdorn presented Membrane Lightweight Structures, a MEng programme at the Vienna University of Technology.

The aim of the master's programme is to combine the pioneering spirit of Frei Otto and his team with current and future building technologies with a view to providing graduates with adequate tools and an understanding of appropriate technologies in the field of fabric architecture and fabric engineering.

Mr Wehdorn, who considers knowledge to be the most powerful source of innovation, said that the master's programme would prepare postgraduate students to work in the "fastidious" field of building with membranes and provide them with the knowledge required to work as qualified architecture and engineering professionals in the private or public sectors.

The five core topics of the course were presented.
1. Design: form finding for equilibrium, functionality and aesthetics.
2. Geometry (typology and proportion): given the high number of geometries, few details are re-used.
3. Element catalogue: build, appearance.
4. Building physics: climate, acoustics, fire protection.
5. Manufacture: installation process, maintenance.

Individual modules have been designed to raise awareness of the entire operational sequence, from the first sketch to the realization of membrane architecture. The aim of the programme is to enable graduates to develop projects independently and to become part of a unique network of experts. The exchange of information and long-term co-operation form the basis for a successful career in the field of fabric architecture.

Several "finders" are used, including the typology finder, the project finder, the image finder, the material finder, the form finder and the value finder (the one-click cost estimation tool for the design of form-active structures was presented at Textile Roofs 2009).

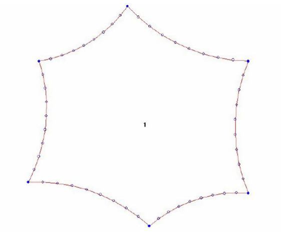
The course will be scheduled in 4 semester part-time in 4 units each lasting 12 days: Unit 1: Nov. 8th to 19th 2010. Unit 2: Feb 21st 2011, Unit 3: Oct. 17th 2011. Unit 4: Jan. 16th 2012 plus one optional unit.

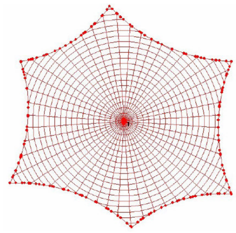
And the teaching staff will include Christoph Achammer, Peter Bauer, Martin Bechthold, Rainer Blum, Horst Dürr, Jürgen Hennicke, Ali Heshmati, Alex Heslop, Waltraut Hoheneder, Barbara Imhof, Peter Kneen, Johann Kollegger, Ami Korren, Peter Mandl, Lars Meeß-Olsohn, Riklef Rambow, Peter Resch, Michael Schultes, Vinzenz Sedlak, Michael Seidel, Bernhard Sommer, Hannes Stiefel, Dieter Ströbel and Robert Wehdorn-Roithmayr.

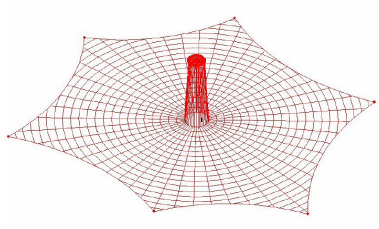
Computational modelling of lightweight structures. D.Ströbel, P.Singer & J.Holl, technet GmbH

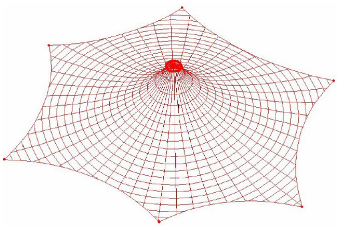
Dieter Ströbel presented the requirements and possibilities of the computer models for membrane engineering based on the Easy suite of software modules for the complete design of lightweight structures.

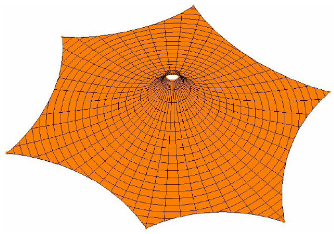
The computer models must be correct, precise and complete (realistic approach), rapidly generated and used for mass production. They must also use information from a variety of experts: architects, membrane engineers, wind consultants, geological surveys, material consultants (mechanical, acoustic, heat, light, humidity) and universities.

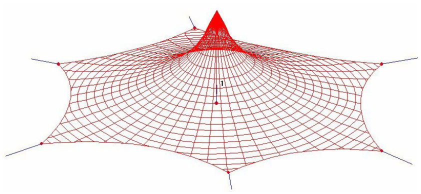

Boundary parameters

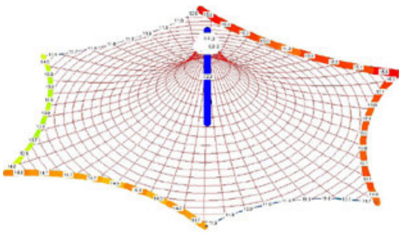

Net parameters

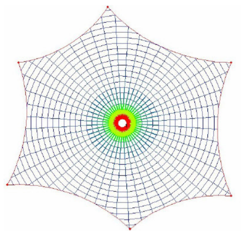

Fixed points

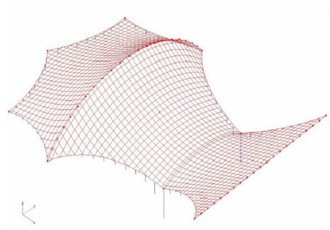

Form finding


Generation of surface elements


Support forces


Force distribution


Stress distribution


Slope lines: drainage

Analytical **form finding** is the procedure for determining the shape of a surface. Double curved shapes in force equilibrium are typically sought.

Static analysis is based on the energy method and non-linear system, and the approximate starting values are provided by the previous form-finding process. This type of analysis may include beam elements and the results are exported to RSTAB from Dlubal GmbH to check the steel elements.

Additional tools are force finding, flexibility ellipsoids and sensitivity analysis by redundancy numbers.

Cutting patterns are obtained by means of small flattening distortion using geodesic lines that optimise the use of material and minimise deformation energy.

Some **examples** were mentioned: Velodrome in Abuja, Allianz Arena in Munich, Matti Orpana Big Air Hall in Finland, Swiss Expo Chambered Pneumatic Structures, Astana Cable Tower and the National Stadium in Beijing.

Easy modelling. An introduction. J.Holl & U.Gründig, technet GmbH

Membranes are made of flexible materials that carry only tensile (and shear) forces. They transfer loads through double-curved pre-tensioned surfaces. Pre-tension is introduced mechanically (leading to anticlastic forms) or pneumatically (leading to synclastic forms). They are form-active. There is a direct relationship between form and force distribution and forms are figures of equilibrium. The designer influences the form through definitions of marginal parameters: boundaries, supports and pre-stress distribution.

Ulrike and Júrgen presented the Easy suite of software modules for modelling membrane structures and divided it into three main sections:

1) **Easy** for membranes with struts, cables and pneumatic structures.

1.1 **Easy.Form**: analytical form finding based on the force density method. A solution (form and force distribution) is obtained in a single calculation step.

1.2 **Easy.Stat**: non-linear static analysis covering external load generation, material property assignment, visualisation of stresses and forces and results (deflections and stress distribution). Additional tools include contour lines and slope lines for fast drainage dimensioning.

1.3 **Easy.Cut**: cutting pattern generation for creating planar cloth geometries from double-curved surfaces envisaging cut-off and distortion minimisation, exporting to cutting machines and ensuring fully automated optimisation in standard cases. The number, width and direction of the patterns are set to calculate the strips and the process can be iterated to adjust them.

2) **Easy Beam**: calculation of bending elements **combined with** structural membranes for hybrid structures (membrane elements combined with beam elements and struts). This leads to reliable results and prevents over-dimensioning of steel framework structures. The model data from the easy static analysis are imported to the Beam Editor, which creates a Beam Model. Cross sections and material dimensioning is possible with RStab. After the forces, stresses, deformation, torsion and bending moments of the hybrid model are calculated, a report is produced to check if the model is in balance. The residual force values must be smaller than the stop criterion values. If the model is not in balance then more iterations with changes in the cross sections or materials are needed.

3) **RStab**: the calculation of steel frameworks was presented.

The advantage of hybrid modelling was illustrated by the Chambered Pneumatic Structures of the Expo in Switzerland. The separation of the structure into two subsystems (pneumatic membrane plus steel ring, struts and cables) led to a 0.5-m deflection and a 30,000-mkN maximum bending moment, whereas one hybrid system resulted in a 0.25-m deflection and a 18,000-mkN maximum bending moment.

Conclusion: the separation of non-linear lightweight systems is only an initial imprecise and expensive estimation.

Engineering software for structural analysis and design. W.Rustler, Dlubal GmbH

DLUBAL Engineering Software, based in Tiefenbach (Germany) and with development facilities in Prague, has over 20 years of experience in developing structural analysis software. The company currently employs about 100 people. Its software is used in over 40 countries by more than 7000 users.

Dlubal solutions:

RSTAB Beam Elements, the framework program and additional modules:

- Stress-Analysis
- Stability Analysis
- Connection Design
- Dynamic Design
- CAD Interfaces
- Concrete and Timber Design
- Composite Beam Design

RFEM Beams, Plates, Shells, Solids, the FEM program and additional modules:

- Stress-Analysis
- Stability Analysis
- Dynamic Design
- CAD Interfaces
- Concrete and Timber Design

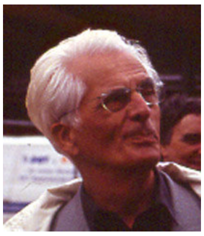
Dlubal solutions were used in the development of the following constructions.

Ferrari World Theme Park: a roof structure of about 195,000 m^2 was erected on Al Yas Island (United Arab Emirates) for an amusement and leisure facility. The Mero spatial framework, with around 170,000 bars and 42,200 joints, is the largest spatial framework ever built.

Eden Project in Cornwall (England): based on a 180 x 131 x 62.5-m structure created in CAD and imported into RSTAB. The load cases and load groups correspond to BS 5950 and the project was analyzed using second-order theory. Nicholas Grimshaw and Partners (London) carried out the architectural design following a static pre-design by MERO.

A demo version can be downloaded from **www.dlubal.com**

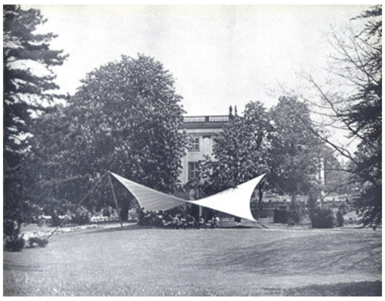
Visions – Ideas – Projects. Un hommage à Frei Otto. J. Hennicke, IL, Stuttgart University.



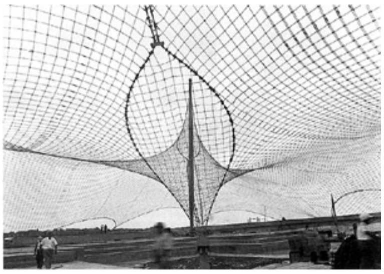
F.Otto, 2000

With F.Vivas

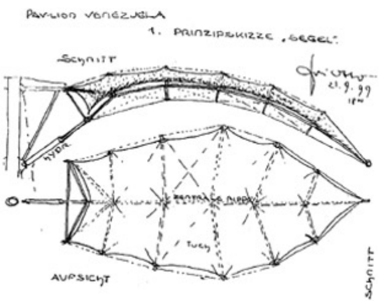
Das hängende dach, 1954



Music Pavilion, Kassel, 1955



German Pavilion, Montreal, 1967



Petal for Venezuela, 1999

Frei Otto, the creator of lightweight structures, contributed many ideas. Although most of his designs were never built, he succeeded in stimulating others to work in the field.

He earned a doctorate in tensioned constructions in 1954.

His saddle-shaped cable-net music pavilion garnered a great deal of attention at the Federal Garden Exposition in Kassel (Germany) in 1955.

Many of his ideas began with small sketches or models. He believed in "building the model and finding the problems" and learning from nature—looking at its principles, behaviour and shaping mechanisms—rather than imitating it.

The most renowned achievement of his career was the 1972 Munich Olympic Stadium, whose preliminary model was the West German Pavilion for the Montreal Expo in 1967. The pavilion was an experiment using a pre-stressed cable net and its test building was the Institute for Lightweight Structures at the University of Stuttgart, founded by Otto in 1964. Here he started an interdisciplinary research movement involving engineers, biologists, physicists and philosophers.

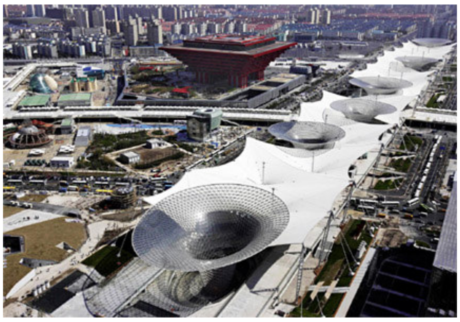
The extensive research conducted at the Institute involved testing cable nets and membranes, pneumatic and tree structures, suspended chains and domes made of steel and timber rods. Tents and pneumatics, membrane-covered cable nets, grid shells, space frames and various hybrid combinations offer an abundance of creative, structural and functional possibilities that conventional structures either cannot provide or can provide only insufficiently.

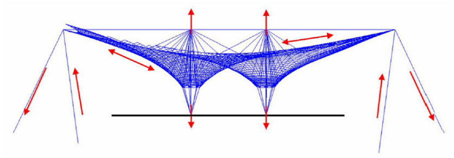
The objectives were to improve the aesthetic quality, create a visual and functional attraction by means of a variety and diversity of forms and structures, save material and energy, optimise resources and achieve sustainability and recycling capacity.

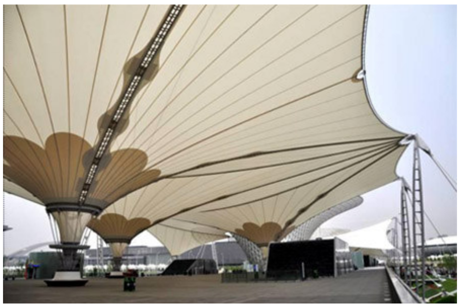
A series of experiments using soap bubbles was conducted to calculate the ideal surface curvature required for the enormous space to be constructed on the cable net and membrane structures. The resulting structures are considered a beautiful architectural creation that is in harmony with nature.

Everything was published in the IL magazine of the Institute where famous (and not so famous) people went to learn and lecture about their experiences.

Expo Axis 2010, Shanghai. D. Richter, Büro für Leichtbau, Radolfzell.







The Shanghai Expo Axis, an enormous membrane roof that covers the Expo Boulevard, was presented. With a total surface area of 65,000 m^2, the membrane roof is the largest of its kind in the world and its free span of almost 100 m sounds the limits of technical feasibility.

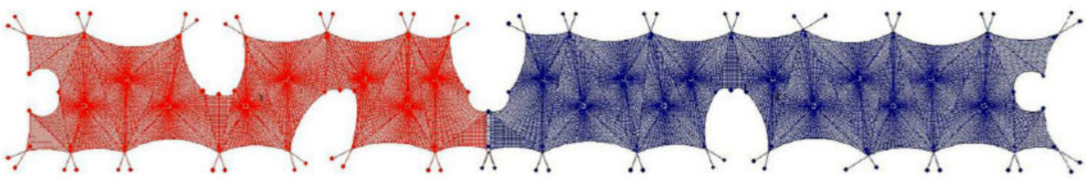
The basic architectural design idea was developed by SBA Architects and Knippers Helbig and initially consisted of a boulevard covered by a glass canopy, but during the design process it was changed to six sun valleys and a textile membrane.

The roof has a height of 45 m and a free projection of 80 m. It is supported by 19 interior masts, 31 exterior masts and six funnel-shaped framework shells made of steel and glass. They are called sun valleys because they direct natural light into the basements.

In terms of structure and shape, the roof lives up to Stuttgart's tradition of internationally respected lightweight constructions and follows in the series of outstanding architectural engineering works such as the German Pavilion at the Montreal World Exposition 1967 and the Munich 1972 Olympic Stadium.

The first attempts at form finding and preliminary analysis were carried out using Rhino and Sofistik, respectively, but in the end the Easy suite of software modules was used for the complete design of lightweight structures. However, deformations—up to 6 m—were a major problem, which was solved by introducing inner masts that reduced the deformations to 1 / 1.5 m.

Loads included 0.3 kN/m^2 of snow and 0.55 kN/m^2 of wind. Failure scenarios were simulated. Physical modelling proved to be useful at all design stages. The structure was created by the Chinese partners. The design and construction of the roof are a successful example of German–Chinese cooperation.



Façade design is now. **Textile façades**. M. Vohn, Ferrari S.A.

Stamisol Textiles are part of the Ferrari textile architecture range. They are expressive materials for architects and builders. Lightness, transparency, solar and thermal protection, colour tones, rapid installation, UV resistance, curved volumes, graphic personalization and longevity, are possible.

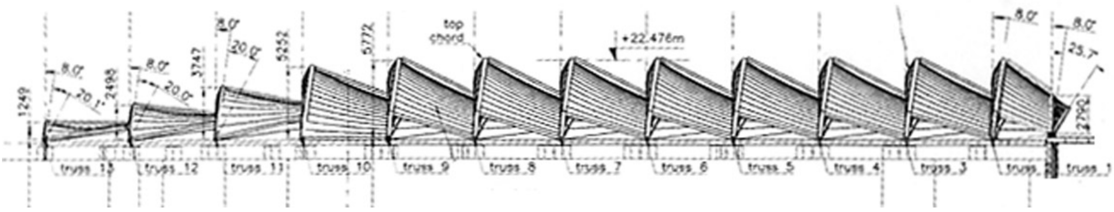
With Stamisol the Ferrari Group offers a product range of technical membranes specifically developed for facade and roofing. This range's major innovation is that it embodies a comprehensive technical solution specific to facades.

Composed of Stamisol FT façade textile and Stamisol Color coloured membrane, the range offers multiple finishing options through its scenic usage of light and 3D design. This solution is attractive because of its relevance, technical performance, reliability and durability.

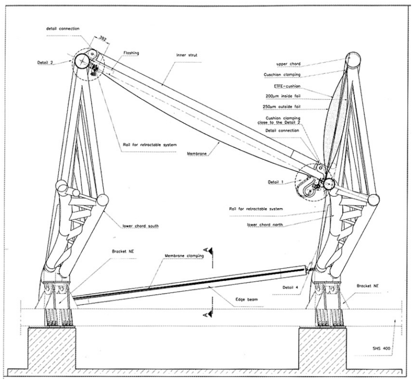
The Stamisol FT & Color combination is the ideal answer to architects' and investors' requirements for modern ventilated façades. Stamisol also offers an extensive selection of membranes for transparent and openwork façades and for under-roof screening. The cutting-edge coating technology of Stamisol breather membranes mean they work just like our skin: they breathe, protect from external aggression and control building humidity and thermal performance.

Retractable roofs. Material Choice. D.P.Emmer & J.Tritthardt, Vector Foiltec GmbH & Büro für Leichtbau–lightweight design.


A presentation was given about the material choice and design of retractable roofs and how they were applied to the Athens Heart Shopping Centre. The atrium is covered with a membrane roof and the membrane panels can be reefed in parallel to open the atrium.



The goal during the design stage was to find a light roof with a direct view to the blue sky. The solution was a north-light roof with highly translucent membrane panels giving shade from the south and with a transparent cladding on the north side of the parallel steel girders to allow a direct view and the entrance of cool northern light.




The main structure consists of 13 crescent-shaped tri-chord trusses (one at the top and two at the bottom) between 13 m and 60 m in length. The diagonally orientated trusses are covered on their northern side with two ETFE cushions each. The cushions are double-layered and clamped to the top and bottom chords. Between the top chord of one truss and the bottom chord of the neighbouring truss, one layer of silicone-coated glass fibre membrane is spanned. The membrane is attached with travellers to an aluminium rail and can be opened and closed with a motor-driven cable pull system. The chosen silicone-coated glass fibres are highly transparent. Together with the ETFE, the shopping centre has a convenient ambient light, even on cloudy days, which transforms the atrium into a pleasant area.

Timber and membranes. B.Briegert & R.Burri, Membranbau.

"It does not always have to be steel" summarizes the message of the presentation quite well.

Membranbau was established in 1991 for the production of roof windows. In 1999 membrane structures were added to the business based on the advantages of timber-membrane constructions: thermal conductivity, in-house manufacture with special connection points that enables very fast assembly, and on-site machinab

Inlinedrom Weinfelden (2006)

BUGA 2011 Cablecar, Koblenz (2919)

Wind and snow loads on membrane roofs. M.Buselmeier, Wacker-Ingenieure, Birkenfeld.

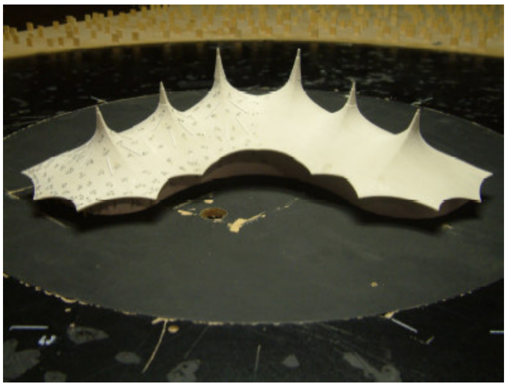
The structural design of a membrane roof requires realistic wind and snow loads. Information may be obtained from wind and snow load standards (for example DIN, Eurocode and ASCE, whose specifications are only valid for simple structures), theoretical estimations, experience from former projects with similar geometry, literature, numerical simulations and wind-tunnel tests.

3 Wind tunnels are available at Wacker Ingenieure:

Wind tunnel	**1**	**2**	**3**
Type	Boundary layer wind tunnel	Boundary layer wind tunnel	Aeronautical wind tunnel
Cross section	2,50 x 1,85 m	2,05 x 1,85 m	1,30 x 1,30 m
Speed	17 m/s	20 m/s	30 m/s
Exposure	Suburban	Open	Uniform flow

The geometric similarity (typical scales: 1/150–1/400), the similarity of the approaching flow and the similarity of the flow around the structure are important modelling laws to be taken into account.

Rigid models are typically used if the deflections do not influence the pressure distribution. If deflections are influential then additional tests considering the deflected shape, theoretical estimations or numerical calculations of flow–structure interaction may be carried out because the aeroelastic modelling of a textile structure is extremely complex, approximate and expensive.



Local wind pressures are measured at several locations (typically < 300). Pressure taps are installed in the model. Numerical integration shows contour plots of the wind pressures for each wind direction.

Wind pressure time series are measured instead of mean wind pressures with optional dependency of the design wind velocity on the wind direction.

Wind loads are classified as exterior, interior and overall wind loads on the main supporting structure, wind loads on tributary areas (membrane design, substructure), local wind loads on cladding, quasi-steady wind loads and dynamic wind loads that induce vibrations.

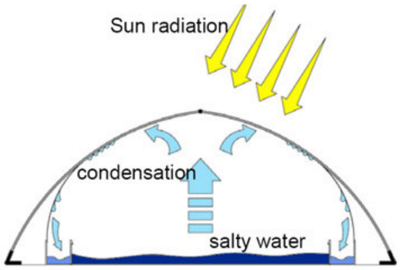
Further wind engineering aspects include snow drift and accumulation simulations, wind-induced vibrations and accelerations, wind load impact on neighbouring buildings, dispersion of exhausted air, natural ventilation, indoor airflow, smoke extraction in case of fire, pedestrian comfort at the base of the building, impact on ventilation of neighbouring districts and wind-induced noise.

Costs for 2010:
€25,000 for a stadium (4 to 6 weeks)
€10,000 for small structures
€100 to €800 for estimations based on former tests

Design of membrane structures. R.Wagner, Karlsruhe Institute of Technology

On the printed paper, Mrs Wagner presented new applications for textile fabrics developed within the EU project Contex-T (www.contex-T.eu):

- New PC coatings for use as outdoor covers, featuring easy cleaning and sufficient seam strength.
- Soft, flexible silicone-coated polyester fabric for deployable membrane roofs.
- Low-E coatings to improve thermal behaviour.
- Improved fire resistance and acoustic performance.
- Translucent and thermal insulation of membranes.



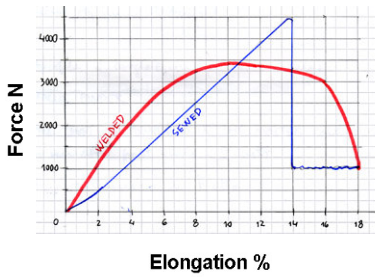
New applications include the exploitation of natural resources such as water and the use of solar energy by integrating PV units in the membrane.

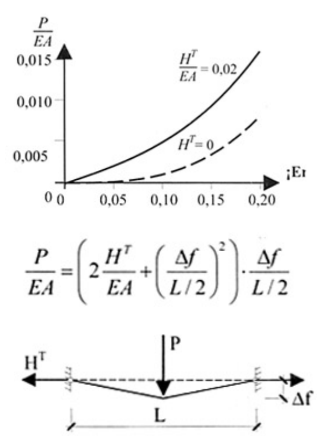
"It is the responsibility of architects and engineers to recognize the potential of membranes in buildings".

How accurate are our designs?

The oral presentation was more challenging. Some interesting points on membrane structure design were discussed:

- Safety concepts: does every imprecision go to the load safety factor?
- Stiffness attracts forces.
- Wind tunnel tests and simulation models.
- Tensions influence deformations and vice-versa: with large deformations, it makes a difference to start with the deformed situation.
- It is necessary to know stresses and strains coming from imperfections.
- It is important to know the pending of the pretension elements.
- Starting the static analysis with form finding is not exact. Re-meshing from the deformed situation is needed.
- How can the compensation factors be defined?
- Welded joints are plastic; sewn joints are elastic.
- Biaxial tests may not be accurate enough.
- Non-orthogonal fabrics resulting from the manufacture process lead to distortion.
- Poisson's ratio is a surface rather than a number.
- Ask the supplier/manufacturer of the fabric.





$$\frac{P}{EA} = \left(2\frac{H^T}{EA} + \left(\frac{\Delta f}{L/2}\right)^2\right) \cdot \frac{\Delta f}{L/2}$$

Load carrying behaviour of a horizontal cable

Lastly, Wagner asked the question "**how accurate are our designs?**" and gave a warning: "**don't forget to conduct experiments** to know how far away you are".

From Tent Culture to Textile Architecture, I.Sariay, Arch & Art Architectural Design and Application Group, Alancak,Izmir

Tents were traditionally used in the Anatolian peninsula. Turks associated the sky with the tent and the "pole of the sky" with the pole of the tent. This belief spread across the world and became universal. The ancient Roman and Greek cultures called this pole *Universalis columna.*

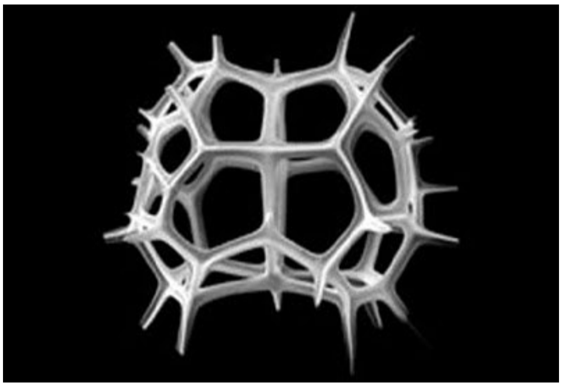
The rider Turks of Middle Asia used to compare their tents to the sky. This was a Middle Asian belief, because neither Babylon tents nor Israeli tents were shaped like a dome.

Some examples of Turkish tents are the tent of the Sultan, the Pasha tent, the council tent, the Grand Vizier's tent, the tent with curtains (tent for the governor of Sanjak), the treasury tent, the Turkish bath tent, the hospital tent, the tent for food storage, the tent for leather crafters, the kitchen tent, the punishment tent and the soldiers' tent.

With the establishment of permanent settlements, tents and similar structures lost importance. However, by the end of 1980 the historical forms were reinterpreted with new, high-strength, improved textile membrane materials similar to those found in Europe in the 1970s.

Lightweight Architecture, J.Hennike, IL, Stuttgart University.

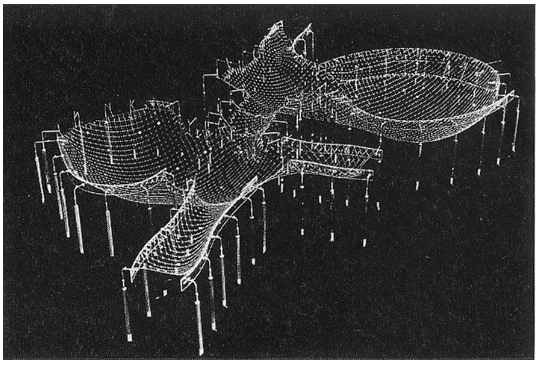
The whole field of lightweight architecture was presented by J.Hennike, not only restricted to pre stressed membranes and new developments, because "nothing is really new": principles may be found in nature.



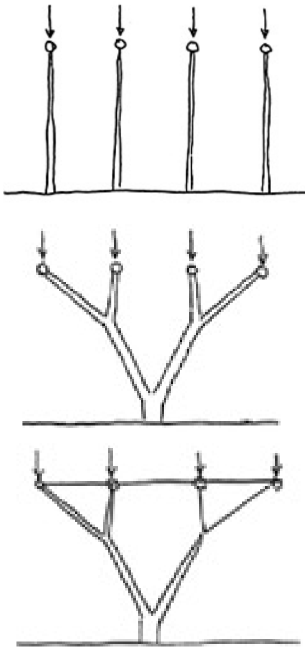
Radiolarians: a skeleton that supports natural pre-stressing

The Bedouin tent has a hump instead of a high "point"

Mongolian yurt: straight lines, top ring, and vertical enclosure for transport purposes



Multipurpose Hall Model, Federal Garden Exhibition, Mannheim, 1975



How to bring forces down saving material ?

More than simply a series of pictures, the lecture was a philosophical look at the field. Various efforts are underway to make technology and its consequences more endurable and less destructive for the environment. Among them, the search for natural laws that govern the relationships between form, structure, material, load, energy and function play an important role. The general aim is to understand what is needed now and in the future to enable humankind and man-made objects to become integrated in living and non-living nature. The creation of architecture using lightweight structures should be considered a holistic process, as a synthesis or seam of invention and production of forms and structures made for the constructed environment that is compatible with nature and satisfies economical and ecological needs as well as cultural demands.

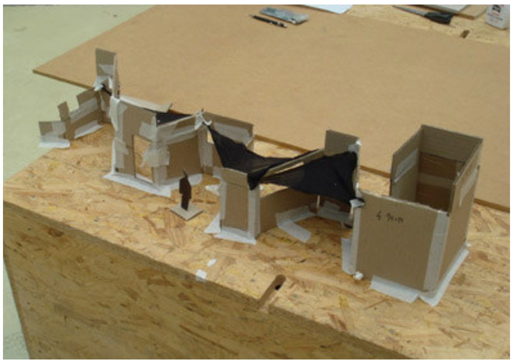
Student Seminar. Teaching staff: R.Wagner & M.Sedighi

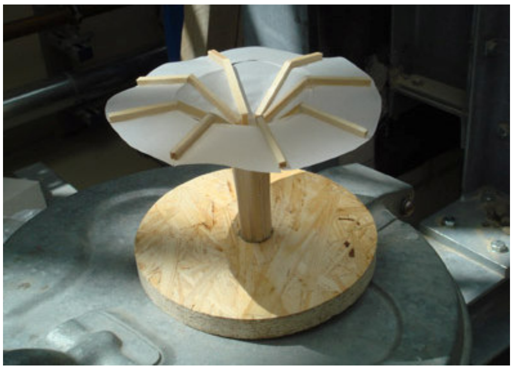
For the sixth time, an international student seminar was held in parallel to the **Textile Roofs** workshop. Students from several countries worked under the guidance of Prof. R. Wagner and Prof. M. Sedighi.

The following is taken from the conceptual formulation of the student seminar:

"The main objective of the design project consists in the architectural design of a public transport stop as a culture-oriented urban element that is open to visitors. This makes movement perceptible and establishes a connection with the issue of 'breaking the wall', or 'unity'. An additional feature of the public transport stop should be the capability to communicate with passers-by in many different ways while they wait. It is a temporary platform that can be used, for instance, as an information point, an exhibition, an art installation or a stage.

The concept and layout of public transport stops should act as an interface that demonstrates an objection to the formerly separating borderline and have its own motto and characterizing name. The stops, which will be installed at various locations throughout the city, could form a unique cross-town network and symbolize a place of motion with a connecting function (reunification or 'unity').

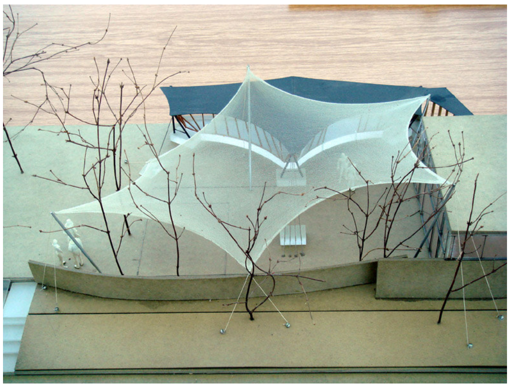




In doing so, the stop—as a hybrid, multidimensional architectural module—will be a new model that links function, form, material and construction.

The effect of the 'unity' can be achieved by representing lightness as part of the conceptual design, for example by applying transparent materials, textile fabric or membrane materials that reflect dynamic motion through their flexibility and transparency. The draft of a public transport stop (e.g., sketch, model, texts) and clear documentation on the design and the design process are very important for assessing the results of the workshop".

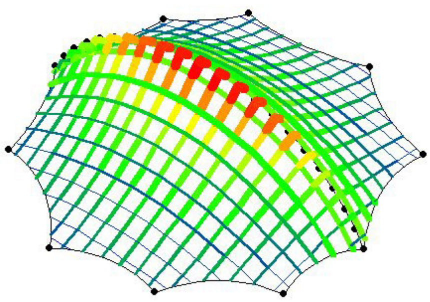
Hands-on physical modelling workshop



Hands-on physical modelling workshops were held in the afternoon. Participants worked on their own models before (or after) creating them onscreen.

Sightseeing cruise

The 2010 sightseeing cruise along the River Spree went through the city of Berlin, past famous sights including the Reichstag, Museum Island, Berlin Cathedral and a number of masterworks of contemporary architects.



Textile Roofs 2011

June 23rd - 25th 2011

Prof. Dr.-Ing. Lothar Gründig
Technical University of Berlin (TUB)
Berlin, Germany

The Sixteenth International Workshop on the Design and Practical Realisation of Architectural Membrane Structures will be held on 23-35 June 2011. Its format will be similar to that of TR 2010, with seminar-style lectures and hands-on activities. It will be preceded by the student seminar and sponsored by TU, TensiNet, Ferrari and Technet.