

## Textile Roofs 2008

May 22<sup>h</sup> - 24<sup>th</sup> 2008

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

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## Report

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### Introduction

Textile Roofs 2008, the Thirteenth International Workshop on the Design and Practical Realisation of Architectural Membranes, took place from 22 to 24 May at the Technische Universität Berlin and was chaired by Prof. Dr.- Ing. Lothar Gründig.



It attracted 88 participants from 24 countries and four continents who celebrated its 13<sup>th</sup> anniversary, once again demonstrating the success of the event, which has become firmly consolidated since it was first held in 1995.

**Tensi**  **et**

**FERRARI** 

**TECH**

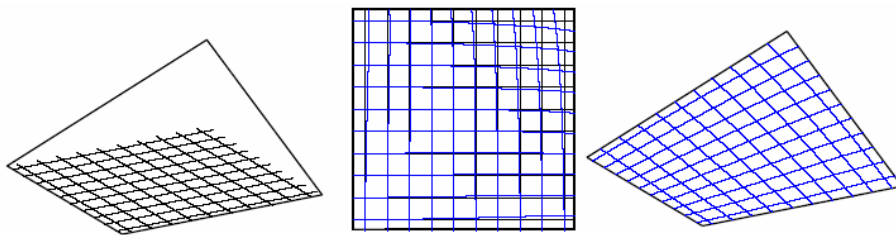
**Standards, Codes and Regulations”** by Prof. Dr. Ing. Rosemarie Wagner, Munich University of Applied Science, Germany

An overview of the current practice related to the application of standards, codes and rules to membrane structures was presented.



Foil cushions with supporting structure, cable net and belts

Most of the norms concerning membranes are not for membrane structures, starting from the material itself (foils, coated and uncoated fabrics and cable nets) and its properties (weight, ultimate tensile strengths, breaking loads, tear, aging tests for plastics and composite materials, etc.)



Shear distortion of a plane net while spanning into rigid boundaries

Other properties and requirements to be considered are: dead load, tensile strength, Young's module, breaking strain, tear resistance, pulsating tensile strength, creep, relaxation, fatigue, temperature resistance, abrasion. fold ability, lateral pressure resistance, surface adhesion, light transmission, thermal isolation, sound propagation, joining methods, fire resistance, surface contamination, colouring, gas tightness, water tightness, water steam tightness, aging, radiation consistency, chemical consistency, biological consistency, expenditure in manufacturing, energy consumption, reuse, recycling, disposal.

Loading is not contemplated on deformable surfaces and provision is not made for their particularities, as for example the concentration of stress associated to stiffness or relief associated to deformation.

The structural behaviour is also concerned. Conventional structures are force driven with high amount of material, while membrane structures are deformation driven determined by material rules and less stiffness.

In addition, different functions are assigned to different layers in wall or roofs structures looking at conventional buildings. In membrane structures all requirements have to be taken over by a 1 mm to 2 mm thin coated fabric.

As a result, the lack of regulation concerning membrane structures is emphasized once again. So, the “Structural Design of Tensile Surface Structures – Eurocode 12” under development will be welcome.

**“The design process of a membrane structure with respect to material properties”** by Dr. Ing. habil. Rainer Blum, Laboratorium Blum, Stuttgart, Germany



To encourage dialogue and thinking, the way to design and analyse a membrane structure was presented differing considerably from the normal procedure in civil engineering.

An explanation was made of these differences and a general overview on the design process was introduced.

From this overview, the required material properties for the design process were worked out.

These required material properties and their measurement may serve as a basis for a general admission of membrane materials.

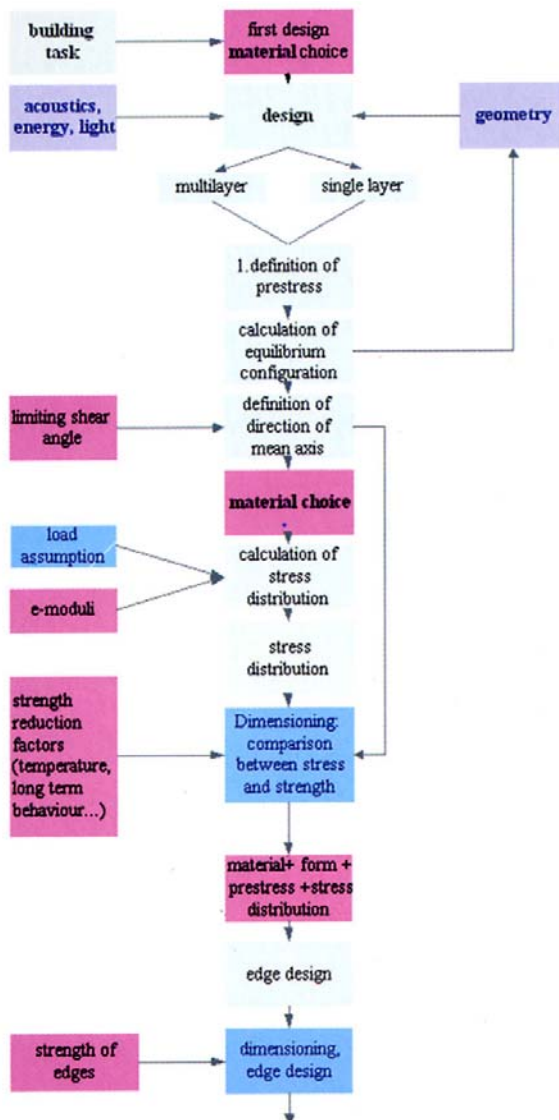
The thermal behaviour was specially emphasized.

Measuring the temperature distribution in a membrane roof, whether it be a single layer or a multilayer structure, whether it be insulated or not insulated, one gets surprising results, Dr. Blum said.

These results cannot be explained on the basis of the classical ideas of insulation. A theoretical analysis shows that one has to distinguish between the different modes of energy transport: radiation, convection and conduction. In doing this the strange results can be explained very simply.

This shows a way how to design better insulation coverings.

Other topics covered during the lecture were the Young modulus, acoustics and translucency, looking at a comparison between simulations and measurements, that were not so different.



“**Budget pricing based on predimensioning Membrane Structures** ( $\leq 1.000 \text{ m}^2$ )” by Mr. Horst Dürr, Ingenieurgesellschaft Flächentragwerke Reichenau, Germany.

A project in progress was reported to follow:

1. **Client –architect:** Client ask the designer an alternative in form of a membrane structure. At the same time he also wants to have a budget price. In this case the designer has a problem. What to do?

2. **Force-form** by the designer. With “Form finder” or other form finding software you can play with the prestress-force and you modify the form by changing the stress in warp and weft. Therefore, it is necessary that you understand the force flow in the structure. Study the different load cases and you see the reactions of the structure.

3. **Analysis of prestress form.** Objective: **identify interdependence of force-form** in the structure. How to analyse it?: 1 do a sketch 3D – 2 realize measurements – 3 study influences (snow, wind, rain, ice, hanging loads) – 4 see the effects of 3 (snow sack, water sack, vibration, flapping, etc) – 5 effects on building parts (membrane highpoint, end –middle arch, cable sag, connection to building, obstruct under roof) - Result: the optimal form-system is confirmed

4. **Predimensioning:** a system of 18 modules which allow a short precalculation of the building parts, by accepting that we get a result with an uncertainty of up to 30%:

Wind: M1 Dynamic pressure – M2 Shape coefficient – M3 Wind suction, uplift force

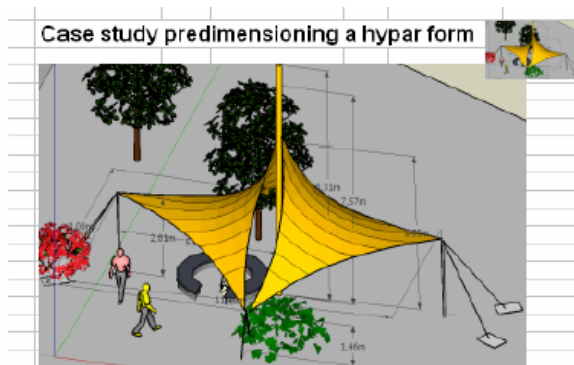
Snow: M4 Snow load

Membrane: M5 Membrane stress caused by wind load - M6 Stress of membrane along the border – M7 Membrane stress caused by snow load – M8 Stress of membrane at highpoints

Highpoint, mast, post, girder, arch, cantilever: M9 Steel: masts, posts, compression members- M10 Diameter of top ring – M11 Diameter of border – ridge – gutter cables – M12 Diameter tension strut/cable

Cables: M13 Resulting force with 2 cables - M14 Primary steel structure – M15 Steel and cable combination -M16 Beams and arches

Footings: M17 Footings (compression)– M18 Anchors (tension)



Case study predimensioning a hyper form

5. **Checking the modules in a small project:** 56 m<sup>2</sup> double hyper.

- critical loads: wind, snow
- membrane type and dimension
- cable diameter and type: resolution of a force, resultant of 2 forces
- primary system steel

6. **Quality and quantity** of the building parts

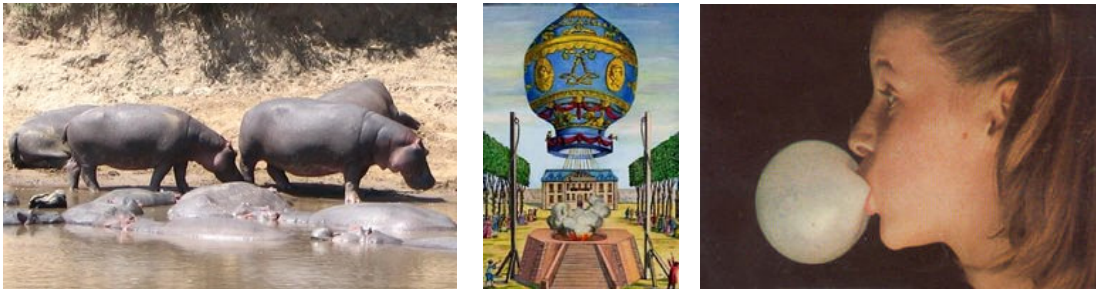
7. **Budget pricing:** 31.067 € for 56 m<sup>2</sup> → 555 €/m<sup>2</sup> (Germany, 2008)

**“About Lightness in Form and Structure. Fast overview of the whole field”** by Mr. Jürgen Hennicke, University Stuttgart, Germany.

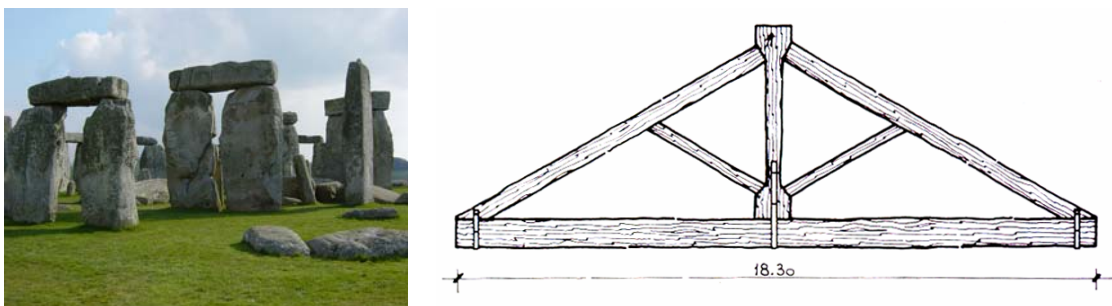
A fast overview of the whole field was remembered by an experienced pilgrim of the research at the former IL Institute.

Tents and pneumatics as well as membrane covered cable nets, grid shells and space frames, and various hybrid combinations, offer an abundance of creative, structural and functional possibilities which conventional structures cannot provide, or can provide only insufficiently.

There is an almost infinite variety of forms and shapes suitable for an incredibly wide range of demands and needs, adaptable, flexible, also mobile, for temporary use with limited lifetime as well as permanent and durable like any other structure, with an exceptionally low expense of material and energy, to be constructed in high-tech as well as with low cost and soft technology, to be taken down simply and quickly if not needed anymore.



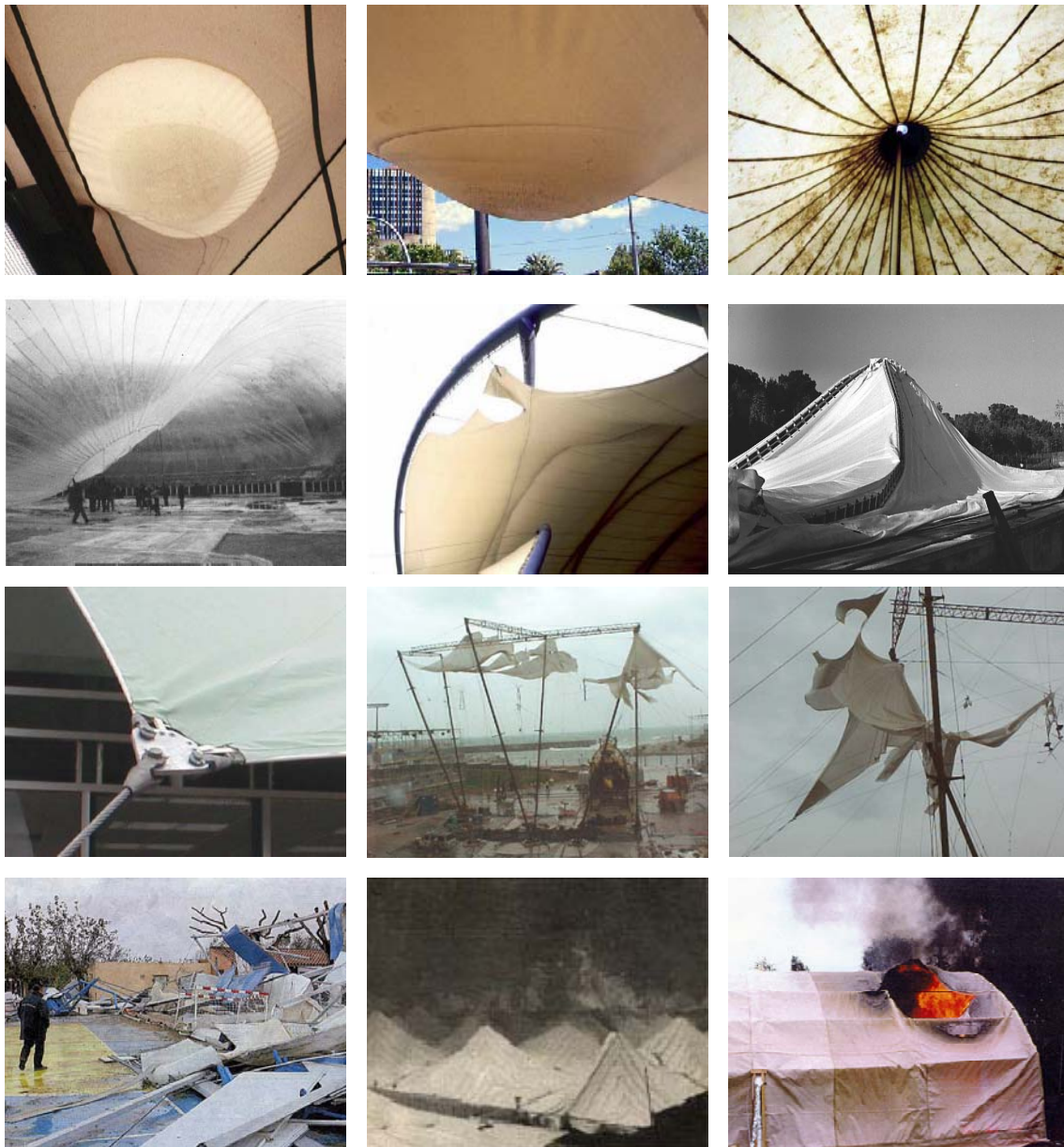
Their spatial forms and structural systems are generated in form finding processes, either physically or virtually. Form and structure are interdependent and inseparably linked with one another. Also in the living and non living nature, forms and structures are created in formation processes, both self-forming and based on physical, chemical and genetic laws. Forms and structures are a unity in every natural object. The underlying congruencies of the processes which produce equal or similar forms and structures in architecture and nature are the major reason why lightweight structures can be called natural structures.



The essential objectives of the concept are outlined clearly: improving the aesthetical quality and creating visual and functional attraction by variety and diversity of forms and structures, saving material and energy, taking care of resources, achieving sustainability and recycling capacity.

The matters are more than 50 years old but still present and pending.

“Pathology” by Prof. Josep Llorens, University of Catalonia, Barcelona Spain.



A research has been developed to find the causes of structural membranes pathology. It has been found that failures can be due to the materials, design, manufacture, installation, use or maintenance, that correspond to the owner, designer, manufacturer, builder, supplier or users.

Materials are concerned with structural, UV radiation, corrosion and fire resistances and the design is specially responsible for funicularity, flatness, ponding, load estimation, scale effect, multipliers and detailing.

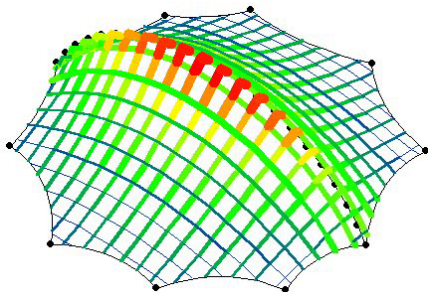
A list of cases and some examples were presented to prevent future troubles and failures and orientate further research on improving current practices.



Homage to Prof. Dr. Ing. Rosemarie Wagner



Flea market next to the "Textile Roofs" venue at Strasse des 17. Juni



## Textile Roofs 2009

June 11<sup>nd</sup> - 13<sup>th</sup> 2009

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Technical University of Berlin (TUB)  
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The Fourteenth International Workshop on the Design and Practical Realisation of Architectural Membrane Structures will take place from 11 to 13 May, 2009. Its format will be similar to that of TR 2008 with seminar-style lectures and hands-on activities. It will also be preceded by the student seminar. It will be sponsored by TU, TensiNet, Ferrari and Technet.