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[www.upc.es/ca1/cat/recerca/tensilestruc/portada.html](http://www.upc.es/ca1/cat/recerca/tensilestruc/portada.html)

The TR 2002 Seventh International Workshop on the Design and Practical Realisation of Architectural Membrane Structures took place from 30 May to 1 June at the Technische Universität Berlin and was chaired by Prof. Dr. Ing. Lothar Gründig (<http://www.survey.tu-berlin.de>)

It attracted 91 participants from 18 countries, thus consolidating the 1995 initiative to promote the design of architectural membrane roof structures.

Main lectures, specialist and participant presentations, together with hands-on physical and computational modelling workshops were held over three days including general overviews, specialist points of view, valuable data, up-to-date information and advice.

**1. Jürgen Hennicke** (<http://www.uni-stuttgart.de/ilek>), the long-standing activist of the Stuttgart Institute for Lightweight Structures, reminded us of the principles, applications and aspects of lightweight and natural architecture. Building in a way that respects the natural environment, conserving resources, creating human architecture, guaranteeing our survival and “fulfilling the long-held dream of reconciling man and nature” are idealistic principles more relevant today than ever before.

He commented on physical modelling, pattern lines, meshes, pneumatic tubes, tree columns, grid shells and wire meshes.

His thoughts provided enough fresh air and energy to resist attacks from technicalities and materials.



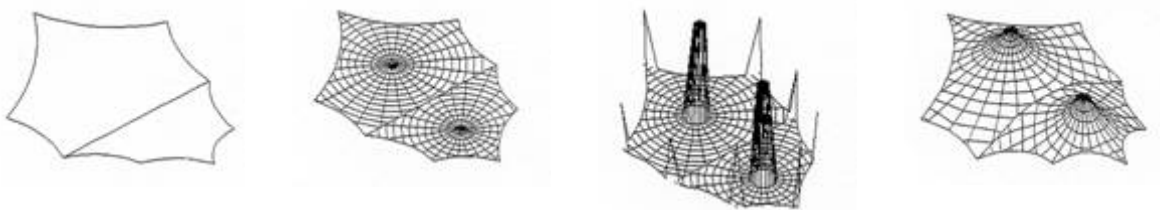
Spider's web in the dew



Prestressed cable net stabilizing the sphere

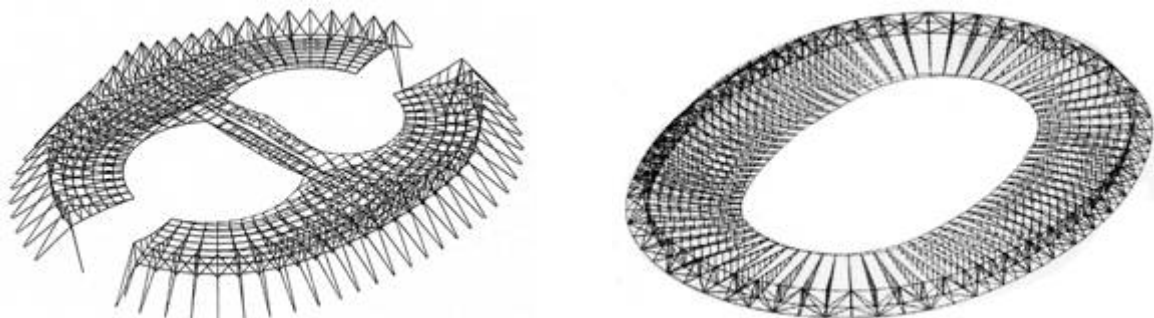
**2. Dr.-Ing. Dieter Ströbel** (<http://www.technet-gmbh.com>) "Computational modelling of lightweight structures" summarised the form-finding process, load analysis and cutting pattern generation based on the force density method and the "Easy" design system and tools. It was a worthwhile experience to encompass the whole process, from initial definitions to compensation values.

The algorithmic approach for the net was introduced by **Joachim Bahndorf** in the afternoon participant presentations. He removed the mathematical abstraction by assigning people to the knots and the relation "drinking beer with" to the links.



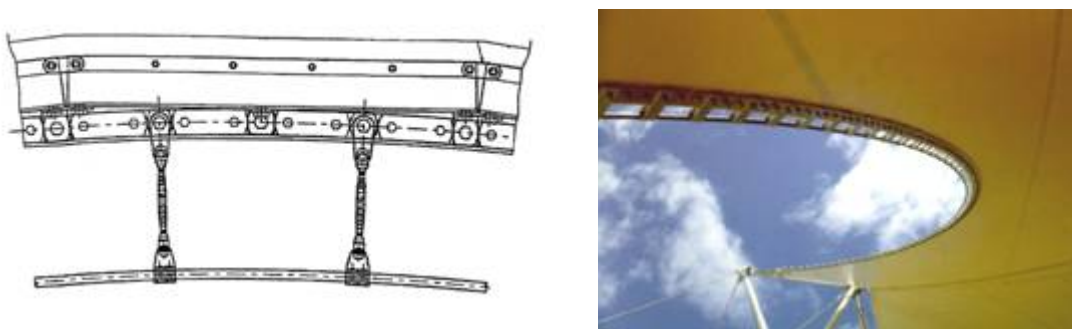
Various stages in the mesh generation and form finding

**3. Professor Massimo Majowiecki** (<http://web.inav.it>) introduced the lightweight structures by emphasizing their peculiarities, such as reducing the ratio between dead and live loads more than 100 times, using high-strength materials subjected to tensile stresses and exploiting the inherent stability of tension. Observations from in-service performance, damage and collapses illustrated the main causes of failure to be taken into account in the early stages of the design process. The Olympic Stadiums in Montreal and Rome and the Thessaloniki Olympic sport complex were mentioned.



Torino stadium roof fluctuations pressures      Rome olimpic stadium fluctuating

**4. "Detail and connection design"** by **Josep Llorens** was an updated demonstration of principles, types and examples aimed at assessing good design practice, (<http://www.upc.es/ca1/cat/recerca/tensilestruc/portada.html>).



External steel cables connected by metal fittings allow for different elongations

He also considered the problems of compatibility raised by the formal, resistant and deformation characteristics of the material. The consequences of poor detailing were elucidated by the presentation of two case studies concerning collapsed structures.

**5. Mrs. Françoise Fournier** from Ferrari (<http://www.ferrari-textiles.com>) reminded us of the main components of a coated fabric: the base cloth, coating and surface treatment, emphasizing durability, fire behaviour and recycling technology. She presented a tension meter machine based on the propagation of acoustic waves, capable of reading the actual tension of the membrane on site to an accuracy of  $\pm 10\%$ .



The tensometer measures the tension when installing the membrane and checks the evolution of the tension in the membrane over time

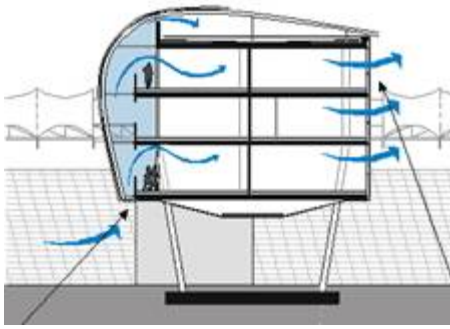
The tensometer measures the tension when installing the membrane and checks the evolution of the tension in the membrane over time

**6. "Project management and the design process"** by **Marc Malinowsky** summarized the origins of projects, the most common typology and the main stages of the design process. Initial conditions, choice of supporting structure, sketching, form finding, structural analysis, patterning and detailing were explained on the basis of his own experience.



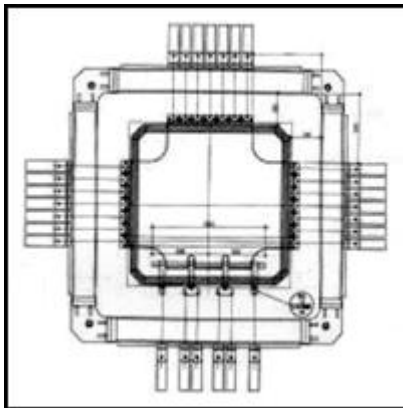
Le Zenith de Montpellier – Groupe Arcora

**7.** The innovating "Technology and media centre" in Erfurt was described by **Göran Pohl** (<http://www.pohlarchitekten.de>). A textile roof and façade favour ventilation and translucency, opening up a new field of application for membranes on non-textile buildings in the style of the GSW headquarters top roof terrace in Berlin.

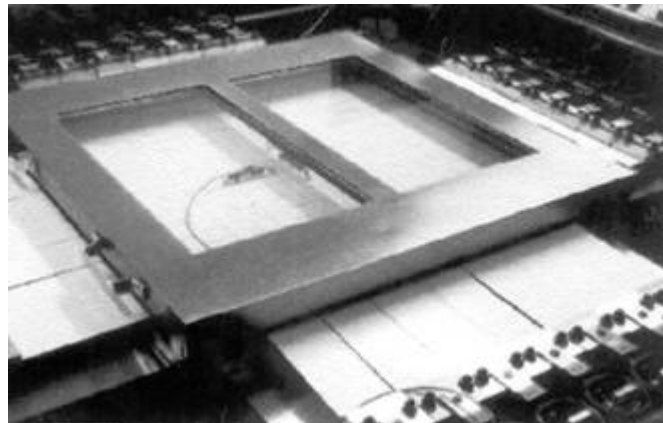


Technology and media centre in Erfurt. Pohl Architekten Stadplaner

**8. Rainer Blum** immersed the audience into the EU Directive concerning mechanical resistance and stability, safety in case of fire, hygiene, health, environment, safety in use, protection against noise, energy economy and heat retention. He specified in detail the design steps influenced by the values of the material according to the aforementioned requirements.



Biaxial testing installation



Biaxial testing installation with climatic chamber

**9. Marijke Mollaert** (<http://dtwws1.vub.ac.be/arch/team/mm/pers.htm>) continued with "Environmental aspects in textile architecture" updating and providing further knowledge and data on climate, shelter for rain, thermal performance, lighting, acoustic aspects and recycling. Her extensively illustrated presentation proved that sustainability is feasible.



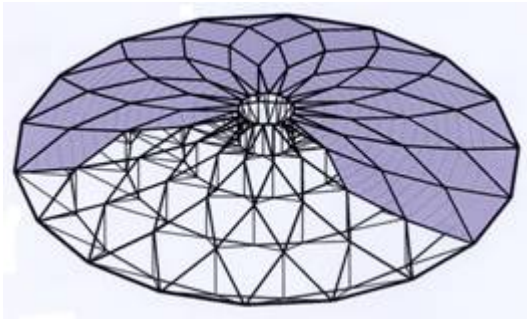
Yurts adapt to arctic climate and becomes a



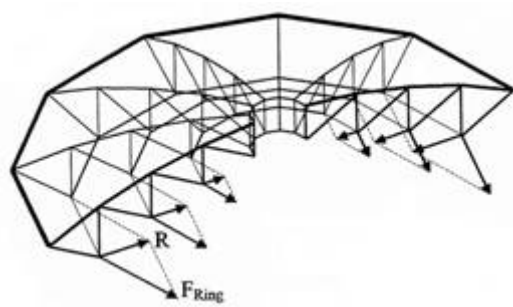
The BOP in Paris uses daylight lantern at night

**10. "Tensegrity and cable domes"** by **Rosemarie Wagner** (<http://www.lrz-muenchen.de/~architektur>) offered an in-depth analysis of D. Geiger structures starting from the B. Fuller "aspension" dome. The cable dome developed by D. Geiger is simpler and can be analysed by reducing it into a plane system. It has a high degree of kinematics because the possibilities of movements are multiple. They offer flexibility and easy

pretension. Differences in geometry and cross-section are also significant. The widespread use of tensegrity and cable domes for large spans is expected.



B. Fuller cable dome



D. Geiger cable dome

**11.** At the **Panel Discussion on “Economic Factors”** moderated by **E. Moncrieff** (Technet), **F. Fournier** (Ferrari), **I. Lishke** (Textile Bau), **H. Reiter** (Covertex) and **M. Maul** (Skyspan) pointed out that cost is dependent on material, size, repetition, detailing, erection process and shape. Looking to the market, the Asia/Pacific area is growing faster than Europe, which is highly dependent on big events, and the USA, where more could be done. Great potential is foreseen for the future, provided that standards and master details are developed, reliability is increased and knowledge is taught at universities.

**12. Afternoon participant presentations** included:

“Atrium sculpture membrane” by **Robert Off** (<http://www.ims-institute.org>), an astonishing membrane with a “free roll”. The description of the design process and erection was of educational interest.



“Blob architecture or structural fabric” by **Rogier Houtman**, an imaginative attempt to extend the variety of shapes. (<http://www.tentech.nl>)

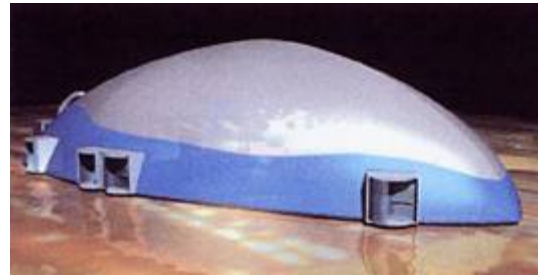
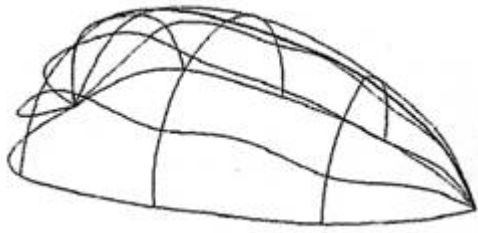


Free-formed blobby design



Membrane structures are form - active

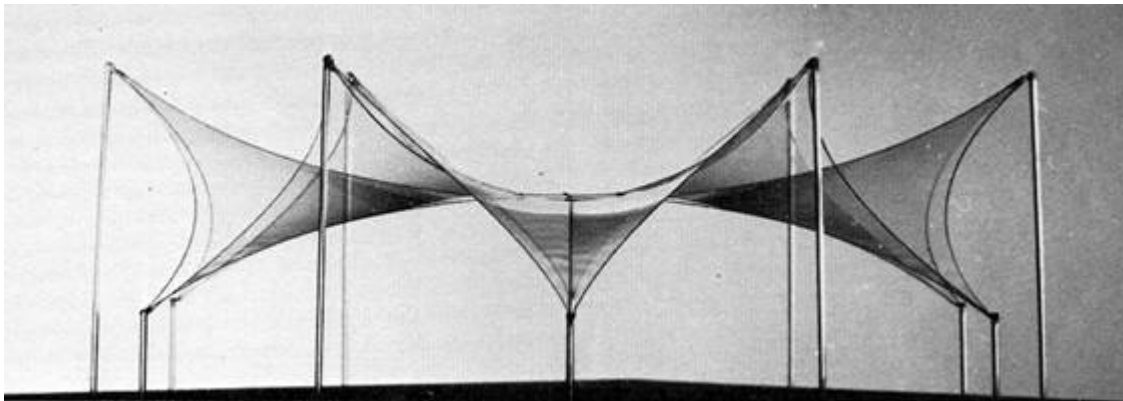
“Sails in architecture” by **Robert Wehdorn** (<http://www.stainless.at>) focused on the optimisation of a membrane surface of a building based on sail technology.



**Jürgen Haase** reminded us of the "Tensinet", the communication network for tensile structures: <http://.tensinet.com>, with plenty of useful information and links, developed at the Vrije Universiteit Brussel. The task of Tensinet is to exchange and share basic and multi-disciplinary knowledge relating to tensile structures technology by collecting and structuring this data in knowledge bases, and to disseminate basic knowledge in working group meetings and intranet web sites.

"Ropes, fittings and anchors" was presented by **Josep Llorens**.

13. The daily afternoon hands-on physical modelling workshop was conducted by **Jürgen Hennicke**. Participants could benefit from his large experience and advice.



Soap film model of the Tanzbrunnen in Cologne

14. The practical activities were completed by the computational modelling workshop at a computer room of the Berlin Technische Universität.

Based on the high level of attendance and participation, the renewed and enlarged content of the lectures and the interest shown in the workshop, the eighth edition: "Textile Roof 2003" will take place from 19 June to 21 June. Updated information, inside views, expert lectures and practical training are expected, brought together by the expertise of successful engineers and architects and the enthusiasm of newcomers and repeating participants.

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