

Textile Roofs 2007

June 7th - 9th 2007

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

Report

Prof.Dr.-Architect Josep Llorens
Technical University of Catalunya (UPC)
Barcelona, Spain

Introduction

Textile Roofs 2007, the Twelfth International Workshop on the Design and Practical Realisation of Architectural Membranes, took place from 7 to 9 June at the Technische Universität Berlin and was chaired by Prof. Dr.- Ing. Lothar Gründig.

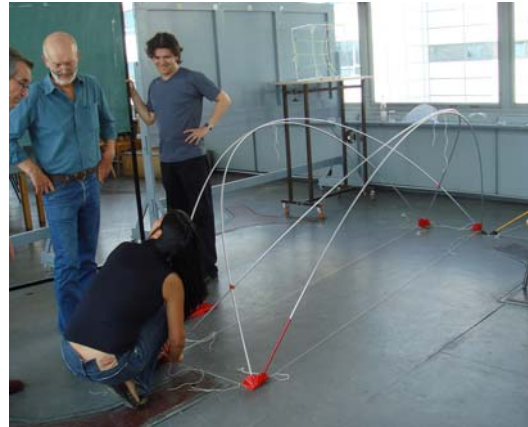


It attracted 71 participants from 24 countries and three continents who celebrated its 12th anniversary, once again demonstrating the success of the event, which has become firmly consolidated since it was first held in 1995.

Tensi **et**

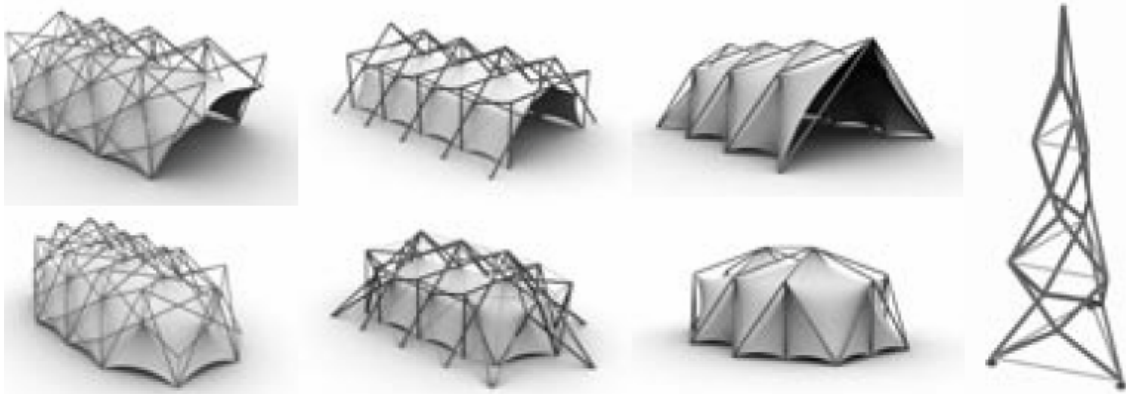
FERRARI 

TECHET



Student seminar

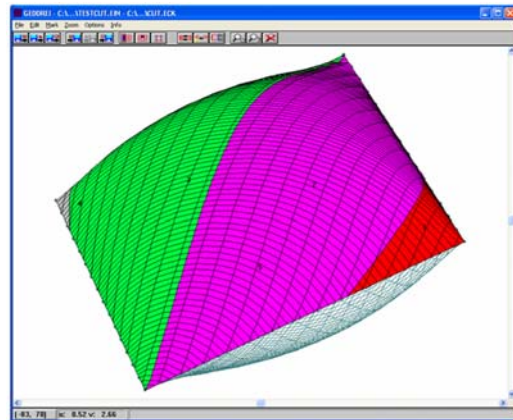
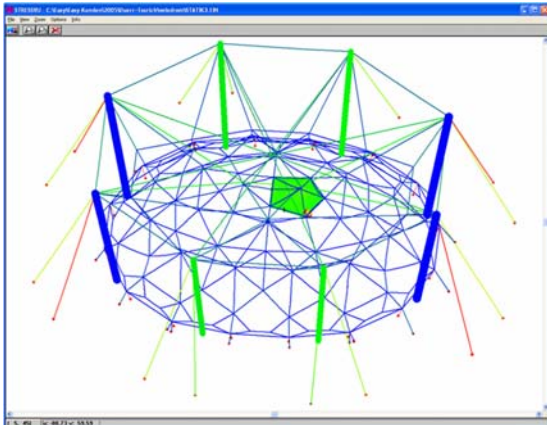
The workshop was preceded by the International Student Seminar “Free Field Sales for Ecological Fruits and Vegetables”, which was organised by Dr. Lothar Gründig (Berlin), Joachim Bahndorf (Bielefeld/Minden), Dr. Rosemarie Wagner (Munich) and P. Michael Schultes (Vienna). The students with different fields of study and great interest in tensioned structures had the chance to develop a sense for these structures by practical experience. They had the possibility to discuss their work with the participants and professionals of the workshop.



Main lectures

1. “Deployable and Retractable Tensile Structures” by Prof. Marijke Mollaert, Vrije Universiteit, Brussels

This presentation was based on the PhD Research developed with Niels De Temmerman and Tom Van Mele. Tensile surface structures were summarized referring to the material, structural behaviour, stability, pretension, basic shapes, supporting structure, form finding, and statical analysis. Deployable structures and retractable roofs were also mentioned, including their characteristics, the design brief, configurations, skins, scissor-like elements (polar, translational, angulated), foldable plates, geometries and applications to units for a 6m span, deployable masts, series of retractable beams/arches



2. "Computational Modelling Concepts" by Dr.-Ing. Dieter Ströbel, technet GmbH

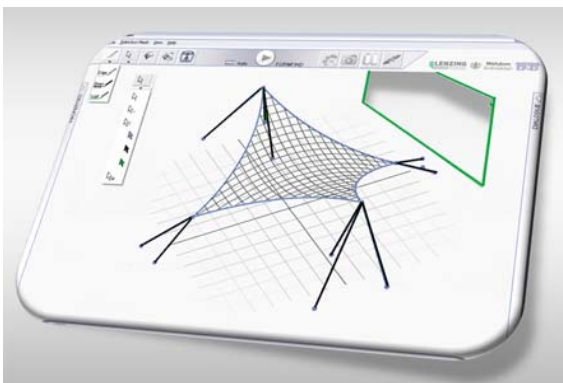
A comprehensive view of analytical form finding, static analysis and cutting patterning was completed with:

a) additional tools:

- is a cable structure able to carry loads without deflection ?
- flexibility ellipsoids to calculate deflections in a point
- sensitivity of a system according to redundancy

b) examples:

- redesign of the Abuja Velodrome
- 1400 different cushions of the Allianz Stadium in Munich
- efficient patterning of silos
- Tensotech air hall in Finland
- exact modelling of boundary cables
- chambered pneumatic structures (EXPO Switzerland) showing that the separation of nonlinear systems is only a first very imprecise and very expensing estimation.



3. "Introducing Formfinder" by Dr. techn. Robert Wehdorn-Roithmayr, Wehdorn Architekten Ziviltechniker GmbH, Vienna, Austria

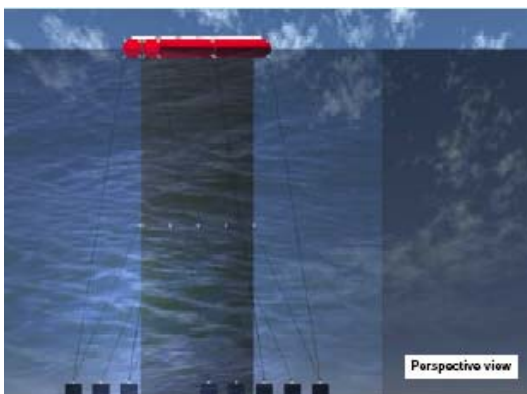
Formfinder is a software to assist the design of form-active structures. It starts from a sketching board to input the information, outlining the perimeter with 10% sag/span ratio lines and generating the net. Points, edges and the net can be selected and modified. A typology to find similar surfaces, projects from the TensiNet data base, materials and details from the UPC web site are also provided..



4. “Precontraint Membrane for Light, Durable and Recyclable Architecture”, by Ms. Françoise Foinier, S.Ferrari S.A. La Tour-du-Pin, France.

Ferrari is a vertical integrated company that controls all activities involved in the chain of production: spinning, weaving, formulation, coating, extrusion and RECYCLING. Its sustainable development strategy is based on the light weight flexible skin, the durability provided by the resistance to corrosive environment and recycling the components: polyester and PVC.

The substitution of the Lords Cricket Club Grand Stand roof was presented. 1.200 Square meters of type II membrane looked dirty after 19 years in service as the surface treatments in those days were basic acrylics. They were dismantled in one day and re-installed in seven days with Precontraint 1002 T2. The original membrane was recycled with the Texyloop technology.



5. “Arabian Tensile Structures and Submerged Hydro Membranes”, by Mr. Nassar Al Ali, Qatar Sat–Structures and Tensile, Doha, Qatar

Qatar Sat is a specialized company for tensile structures. It offers design, structural engineering, and manufacturing of steel items & membranes, and installation. A special project was the silt screen cofferdams at Ras Lafaan Seawater System made of PVC coated polyester, 1300 g/sqm resistant to chemicals and salt water. The result of the project turned out to be very successful. The screens protect the entrances of the pump stations very effectively.



6. “The Textile Structures Market in Turkey and Vicinity” by Dr. Fevzi Dansik, Assistant Professor in Mimar Sinan Fine Arts University

The textile structures are very young in the construction market of Turkey. The first significant textile structure is less than 15 years old. Nevertheless, the textile structure market is growing especially by using PVC coated material. There are implementations of other types of membrane, but their development does not appear to be promising in the near future because of their prices and lack of know-how of the local manufacturers. Hence, the international companies have a big advantage. The development process can be accelerated by a support of material manufacturers



7. “Two different membrane structures” by Mr. Jan Dolejsi, AA SKA Design Office, Bratislava, Slovakia

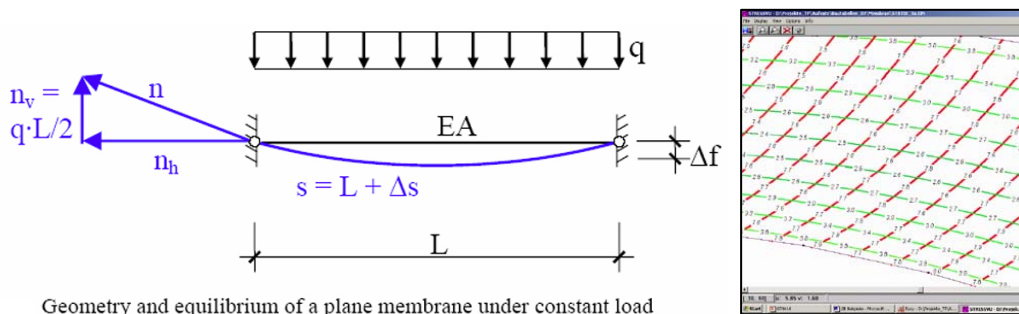
A totally hung structure was designed and built for a tram station in Barrandov, Prague. Two saddles stretched by leaning arches and eight conical shapes surround the tracks. The total surface is 1.000 m² and the installation took 3 weeks and all the process took 1 year more.

The other membrane structure presented by Mr. Dolejsi was the Letecka Aviation Museum in Kosice, a 6000 m² roof subdivided in eight parts, made of 1202 Fluotop Ferrari PVC coated fabric, welded by high frequency. It took ½ year more to design because the lack of accuracy of the steel parts that required the re-make of the 3D model and cutting patterning.



8. "Installation process" by Prof. Josep I.de Llorens, University of Catalonia, Barcelona, Spain.

Textile roofs are installed on-site by assembling prefabricated elements and components. Though the installation process affects the design and comprises a significant percentage of the cost of textile roof structures, general installation guidelines are difficult to define because each case has its own particularities. Experience is helpful in resolving unexpected situations and it provides knowledge to retro-feed into subsequent designs. The presentation illustrated different approaches to dealing with the influence of the installation process in response to particular requirements.



9. "Basics in Tension Structures" by Prof.Dr.-Ing.Rosemarie Wagner, Munich University of Applied Science, Germany.

Design and manufacturing of membrane structures is closely related to computer programs. Nevertheless, there is a necessity for simple methods to describe the load carrying behaviour, to define the stresses for the shape of equilibrium, to help understanding the load transfer and to check numerical results. Some examples of simple methods were presented:

- plane membranes: taking into account the elastic strain of the material, equilibrium is possible between the tension stress and external loads acting perpendicular to the membrane.
- single curved members: transferring the approach of the plane membrane a solution is possible taking onto account the equilibrium in the deformed situation, known as geometrical non linear behaviour.
- double curved membranes: the relation between geometry, external load and deformation can be transferred. he membrane stress is defines by the ultimate stress of the fabric, the maximum stress which can be introduced into the membrane on site to avoid the slag of the membrane under external loads.



10. "Built Textile Constructions" by Dipl.-Ing. Jörg Tritthardt, Büro für Leichtbau, Radolfzell, Germany

Tritthardt Leichtbau Design offers overview engineering, design, analysis, workshop drawings, membrane detailing and material research for light weight structures, roofs, buildings and sculptures such as stage roofs, umbrellas, exhibition stands, cable nets, textile façades, shopping centres, restaurants, parks, yachts, sport events or advertising. Many examples were shortly described. Some of them are illustrated above.



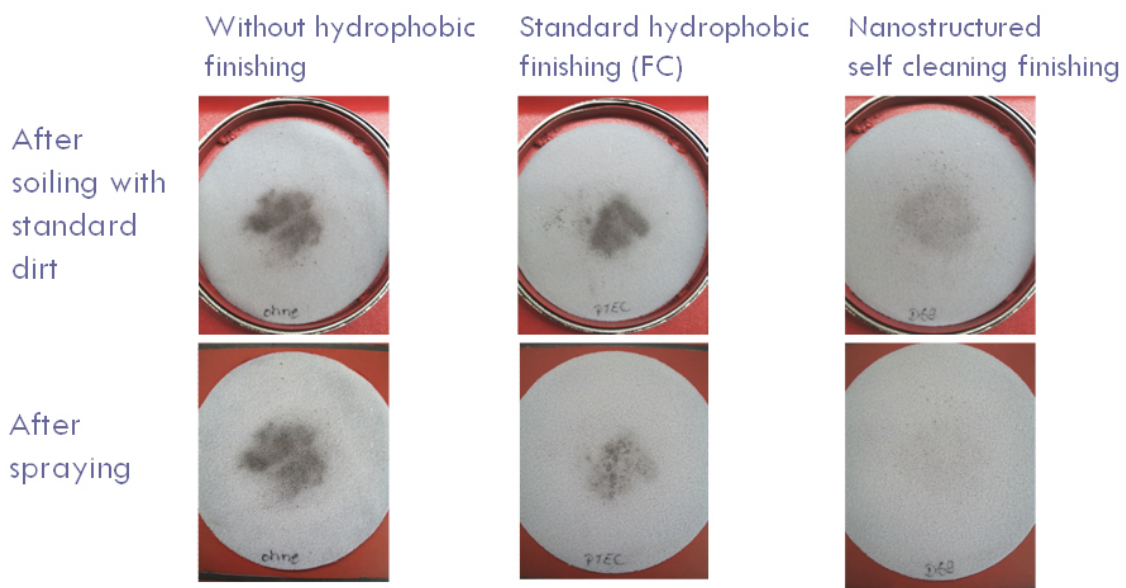
11.- "Detailing in Textile Structures" by Mr. Matti Orpana, Tensotech Consulting, Kokkola, Finland

Based on event canopies, Matti Orpana focussed on initial requirements (dimensions, shape constraints, site conditions, accessibility), form finding, materials (properties over time, weather, stress-ability), detailing, transport, installation, safety and storage.

Examples were taken from Tensotech experience: Kaustinen Festival Tent ($\varnothing = 45\text{m}$), Kuopio Open Air Theatre (400 m^2), Savonlinna Castle Roof (2.000 m^2), Helsinki Festival Tent (1.700 m^2), Dalhalla Open Air Theatre and Hausjarvi Open Air Theatre (400 m^2)



12. "Michael Schultes" by Dipl.-Ing. Michael Schultes, University of Vienna, Austria
 Starting from welded water gadgets as illustrated by the LIFE magazine, 1946, M. Schultes focuses mainly on emotion: the touch, the light and the sound. His way goes through architecture, interior design, art, stage, exhibitions, fashion, design, product development and advertisement. His interest is much more spread than membranes, but membranes are a good material for sustainable architecture. Since 2002 he develops a network to support universities worldwide in the field of sustainable architecture.

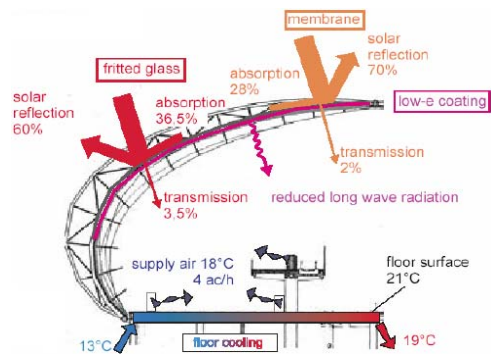


Afternoon sessions

13. "Context-T: Textile Material Development for Textile Construction", by Konstantin Bertet, Denkendorf Institute for Textile Technology, Germany.

Mr. Bertet began the series of presentations of Context-T, the research project funded by the EU aimed to improve membranes, their supports, modelling, architectural aspects and structural behaviour through the definition of requirements, proof of the concepts at lab-scale and industrialisation.

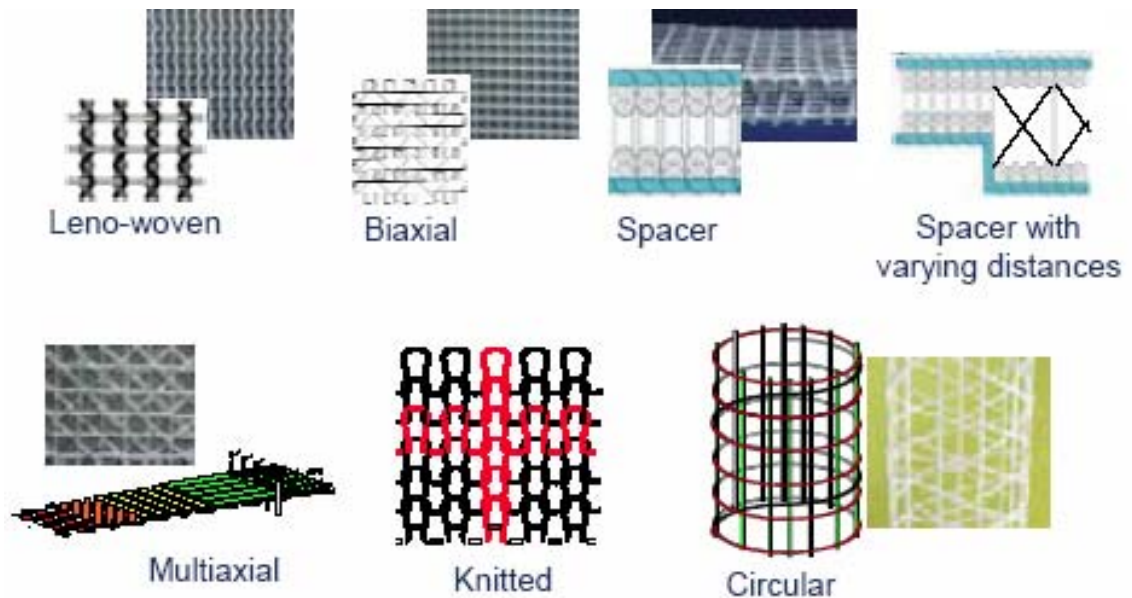
The task 1.3: "Easy cleaning of membranes" was exposed. It transfers the easy cleaning technology of the nanostructured surface roughness of the lotus leaf to membrane structures through ultra hydrophobic finishing. For checking purposes, test methods for standard dirt, soiling and cleaning are applied.



14. “Context-T: New Textile Fluopolymer Composites and Transparent Membrane Technology” by Walter Dürbaum, Polymade ITT, Bergheim, Germany

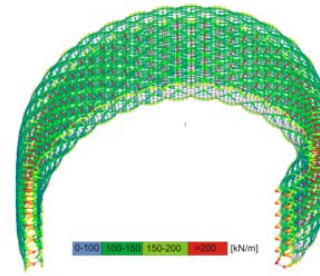
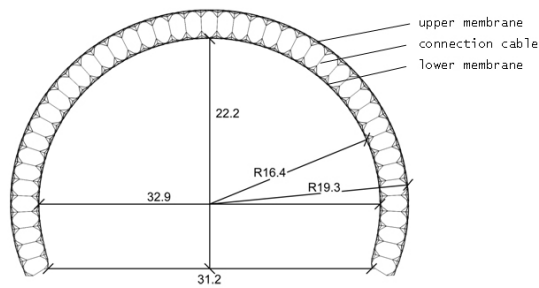
The Solaflon top coatings are an application of liquid fluopolymer technology to improve the shortcomings in appearance, thermal properties, acoustics or functionality of the PTFE, Silikon and PVC. They are transparent, 100% polymer, solvent based and cold applicable with embedding capacity of colours, aluminisation, UV protection, wear resistance, heat stop, printable and easy cleaning, coated in single or multiple layers.

At the Bangkok Airport Solaflon was used on a three layer membrane: PTFE coated glass outer leaf (outside noise) + 6mm PC-sheet middle layer (sound reduction) + open wave inner layer with low-e and fluoric polymer coating (sound absorption) ⇒ 200 \$/m² of acoustic insulation were saved.



15. “Context-T: Textile Reinforced Concrete”, by Jan Watiels, Vrije Univesiteit Brussel, Belgium

The main characteristics of GRC (glass reinforced concrete) were compared with TRC (textile reinforced concrete). Benefits of TRC are: slender lightweight elements (5 to 20 mm thickness), high quality surface finish (fine grained matrix) and sharp edges (high fibre content, self compacting) suited for structural application needs such as ductility, high tensile strength, significant post-cracking stiffness and strict crack width control



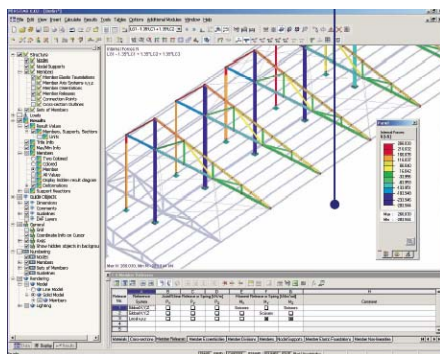
chamber	volume V_i [m ³]	pressure Δp_i [kN/m ²]	$V_i \cdot p_i$ [kNm]	s[m]
1	3006,07	45,31	436806,10	3,95
2	15413,04	5,22	1621828,43	3,95

16. "An Airship Hall as Pneumatic Construction", by Burkhart Trost, Munich University of Applied Science, Germany

The presentation was a feasibility study of the application of an airship hall as a pneumatic construction. 4 Variations were envisaged:

- 1.- pneumatic arch tubes with membranes and bracings
- 2.- pneumatic arch tubes in a tilted position with membranes
- 3.- pneumatic arch tubes in a diagonal position with membranes
- 4.- flocks of interlocking tubes

A high influence of shear stiffness at pneumatic structures was observed and different possibilities to optimize pneumatic constructions were envisaged.



17. "Dlubal Engineering Software for Structural Analysis and Design", by Dipl.-Ing. Walter Rustler, Ing.-Software Dlubal GmbH, Tiefenbach, Germany.

2 Families of software for engineering were presented:

RSTAB: version 6 of the framework program complies with the up to date state of the art view for matters of structural analysis and programming standards. It allows flexible customization, the ability to do structural analysis "of a piece" and provides the platform for all add-on modules that are available for the fields of activity: steel, concrete, timber construction, connections, etc. as necessary.

RFEM. version 3 models and calculates structures with finite elements to carry out static analysis of any kind. It is suited for building construction projects as well as for mechanical engineering and combines CAD modelling with structural analysis going from draft to final blueprints

Selected features of both families together with the interface between Easy and RSTAB/RFEM were also shown.

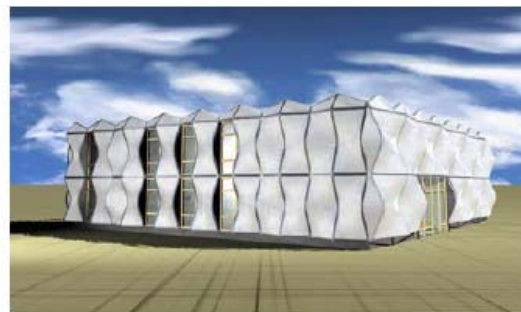


18. “Almuñecar Aquarium Textile Roof”, by Prof. Josep I.de Llorens, University of Catalonia, Barcelona, Spain.

The Almuñecar Aquarium is a 3000 m² underground installation which shows Mediterranean fauna on two levels below the Kuwait Square next to the market and near the City Hall of the andalusian town of Almuñecar (Spain). The Aquarium emerges to the surface by means of its control building, staircase and lift, all arranged around an open courtyard. Ch.Garcia-Diego, J.Llorens & H.Pöppinghaus designed a textile roof in order to protect this courtyard from direct sunshine and rain. As the only part of the building that shows above is the membrane, it has also been envisaged as an eye catcher in order to attract visitor's attention. Two water ponds reflect the white and lofty membrane set in front of the backdrop of white apartment buildings. More information is available at TensiNews13, December 2007, p.9.



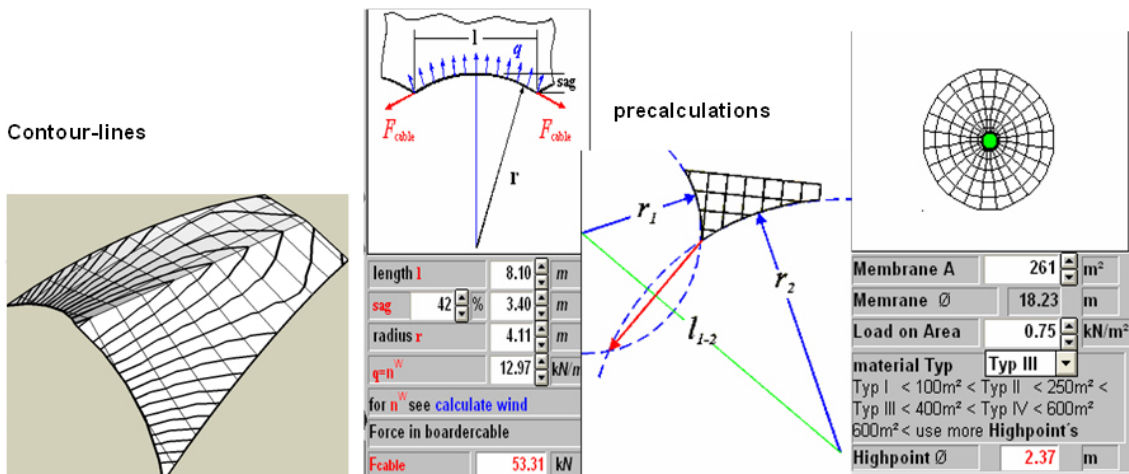
Large size membrane structures
TSS-Singapore, www.tensinet.com



Design study of modular membrane structures

19. “The New Face of Membrane Architecture”, by Dipl.-Ing. Gregor Grunwald, Technische Universität Berlin, Germany.

Instead of using large wide-span construction techniques, an alternative solution was presented. It dealt with small-scale membrane modules. The starting point for this solution looks at the idea of two membrane layers being fixed on trusses inside a frame construction and, by turning the screws that connect truss and frame, the membrane becomes tensioned towards the edges of that frame. In this way, pretension can be implemented in the membrane module. To minimize the tension in the membrane and on the frame, the module is shaped in an anticlastic form allowing for these modules to construct and envelop the building: structuring and forming facades and roofs. Due to the small scale of the modules, the anticlastic form of the membrane is not dominant - enabling the construction to shape forms beyond the classical conundrum of membrane structures.



Special Guest Lecture

20.- "Development of Textile Structures over the Years", by Dipl.-Arch. Horst Dürr, Ingenieurgesellschaft Flächentragwerke, Reichenau, Germany

The development of textile structures was explained through the cooperation between TechNet and IF.

In 1986 the design of the voliere in Hannover was based on physical modelling.

In 1993 they adopted the Easy system, a software made for engineers. Architects are educated to think in pictures. The result of this dissatisfaction was ISIMEM (Integrated Simulation Method for Membranes), a common cooperation EU project in 1997.

ISIMEM was a design method for mechanically tensioned structures for use by architects, engineers and designers. It consisted of 2 parts: learning program and design method. The design method proceeds in 6 steps:

- A. Problem definition (needs)
- B. Situation analysis
- C. Idea finding (see template catalogue)
- D. Synthesis loop (make a new form with CADISI)
- E. Structural system (go to the library and take building parts, check and change the structural system, see checklist)
- F. Final presentation.

In addition to the presentation, the client needs an offer for planning services and a budget price (that requires a pre-calculation for determining the quantities).

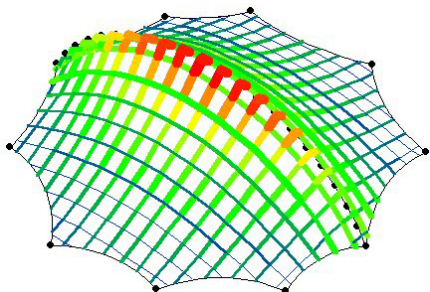
This process could be optimized defining how architects should be prepared to do with the engineer the tasks related to structural behaviour, design, construction, materials and construction. Rough pre-calculations for basic membrane surfaces can help to define loads, dimensions and cost estimates.

As a conclusion, Mr. Horst Dürr made a wish:

"I wish to see in this room young people who are full of enthusiasm to take the challenge and realize further new things. May I remember you the architect is the key to membrane structures, so support him that he dares to do membrane proposals"



2007 City Sightseeing Cruise. Participants enjoyed Berlin textile architecture.



Textile Roofs 2008

May 22nd - 24th 2008

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

The Thirteenth International Workshop on the Design and Practical Realisation of Architectural Membrane Structures will take place from 22 to 24 May, 2008. Its format will be similar to that of TR 2007 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.