TEXTILE ROOFS 2004 REPORT

Dr.Josep Llorens
School of Architecture of Barcelona
Technical University of Catalunya (UPC), Spain
E-mail: ignasi.llorens@upc.edu
http://www.upc.edu/ca1/cat/recerca/tensielstruc/portada.html

Textile Roofs 2004, the Ninth International Workshop on the Design and Practical Realisation of Architectural Membrane Structures, took place on 10-12 June at the Technische Universität Berlin and was chaired by Dr. Lothar Gründig (http://www.survey.tu-berlin.de).

It attracted 86 participants from 24 countries and five continents, whose presence demonstrated the continuing success of the original 1995 initiative to promote the design of architectural membrane roof structures. The main lectures, the presentations by specialists and participants, the hands-on physical, computational modelling workshops and the climbing of the cladding of the TUB's main building were held over three days. The viewpoints offered ranged from general overviews to the opinions of specialists; all yielded valuable data and advice.

CLIMBING THE FAÇADE

The main attraction this year involved climbing the façade of the TUB's main building. Ingo Lishke (info@textilbau.de) and Jörg Wehner (wehner@generalbeklettern.de) introduced industrial climbing, the purposes of which include window cleaning, sealing building parts and erecting steel, glass or membrane structures from hard-to-reach places. This exciting theme is another very interesting aspect of working with textile roofs. It needs hard and experienced workmanship and was illustrated by means of several examples, such as the installation of steel arches on a supporting cable system and the changing of the masts of an existing structure without resorting to cranes or scaffolding. After the lecture, the participants were invited to climb the façade of the University, and most of them had a go.

Main Lectures

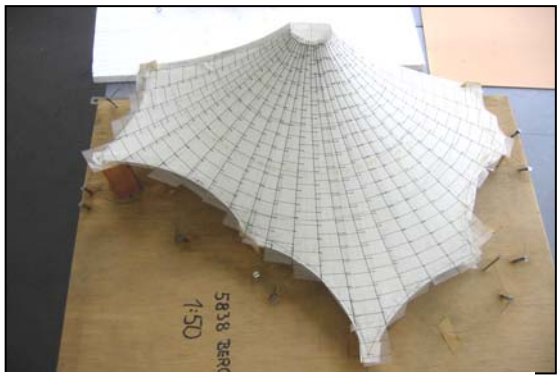
1. "From the Architect's Idea to the Site" by Dr. Stefania Lombardi (stefania.lombardi@cannobio.com)

A general overview on tensile membrane structures was presented, which included typology, functionality, design process, materials, manufacturing and installation. Many examples of expertise from Canobbio were also included.

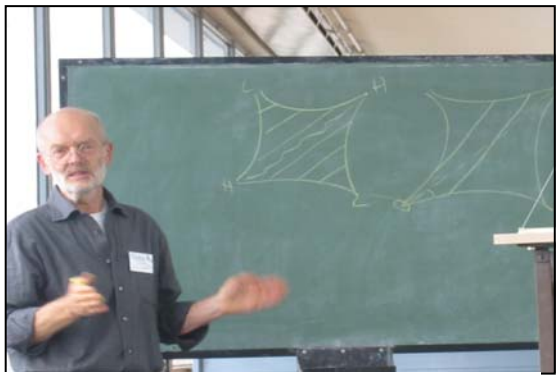
EXPO 1996, Lisboa

2. “Computational Modelling Concepts” by Dr. Dieter Ströbel (dieter.strobel@technet-gmbh.com)

The task of selecting appropriate forms for stressed membrane surface structures was considered. Primitive form-finding techniques and general concepts that are common to all equilibrium modelling systems were described, together with the Force Density Method and its extension to geometrically non-linear elastic analysis. Cutting patterning and its practical constraints were presented subsequently. Several approaches were discussed, including the combined flat and planar sub-surface regeneration strategy used in the “Easy” design system.



The paper strip method



Jürgen Hennicke at work

3. “The Lightweight Architectural Approach” by Jürgen W.Hennicke (juergen.hennicke@ilek.uni-stuttgart.de)

The preliminary steps in the design of lightweight structures were summarised with reference to grid shells, pneumatic structures, nets and tents. The question of how to find the shape was answered for every type by means of simple models, rough calculations, schemes and diagrams, all of which were illustrated with examples seen at the ILEK, Stuttgart and supplemented by useful hints and tips.

4. “ETFE: the Future Foil Material Used in the Building of the Allianz Arena and the Football Globe” by Hubert Reiter (info@covertex.de)

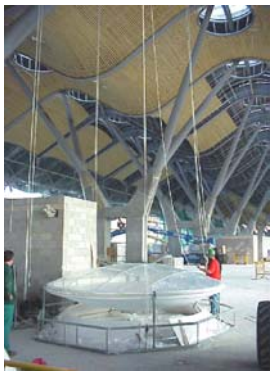
The composition, properties, technical data and architectural applications of ETFE (ethylene tetra fluoro ethylene) were presented. Its main advantages are high permeability to light in the visual and UV range, great chemical resistance to acids and alkalis, long life (more than 30 years), almost complete recyclability and very good anti-adhesive surface properties, in addition to it being light in comparison to other transparent construction materials, weldable and printable. Its main disadvantage is low tear resistance up to 420 N/mm. The estimated cost is 300 €/m2 for the complete roof and 50 €/m2 for the material, which makes it cheaper than glass and more expensive then PVC-coated polyester.

The Football Globe, 2003 (610 m2)

Football Stadium, Munich, 2004 (66,000 m2)

5. “Sky 300: A New Silicone Glass Membrane for Barajas Airport, Madrid” by P. Burnat, F. Reitsma and J. Tejera (philippe.burnat@tesf.fr)

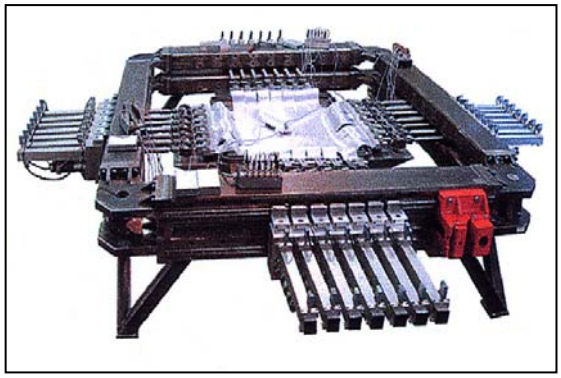
The requirements for membranes for interior public space applications are flame retardancy performance, translucency, better aesthetic properties, environmental qualities and durability. These are all met by “Sky 300”, the new silicone-coated, glass-fibre material launched by Ferrari. It has been extensively used (70,000 m2) for the light diffusers at the Madrid airport.



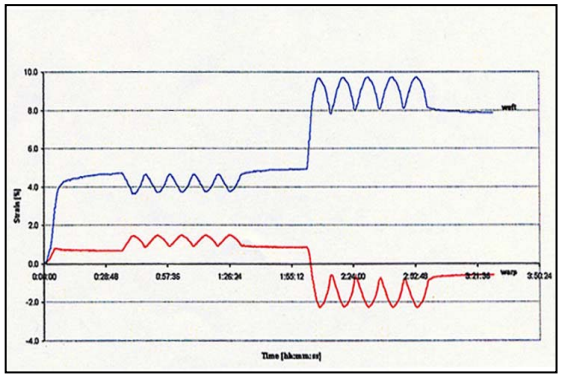
Light diffusors, Barajas Airport, Madrid

6. “Material Properties of Fabrics and Films: Theory and Measurement” by Dr. Rainer Blum (r.blum@labor.blum.de)

The main material properties of fabric and films are optical and thermal (light, heat transfer, radiation and acoustics) and mechanical (anisotropy, strength and stiffness). Some of these properties can be measured in the laboratory (by means of bursting tests, biaxial tests and folding apparatus) or on site (pre-stressing of membranes and forces in cable), such as at the new Bangkok airport, the Olympic Stadium in Berlin and the new terminal at the Cologne-Bonn airport.



Biaxial test



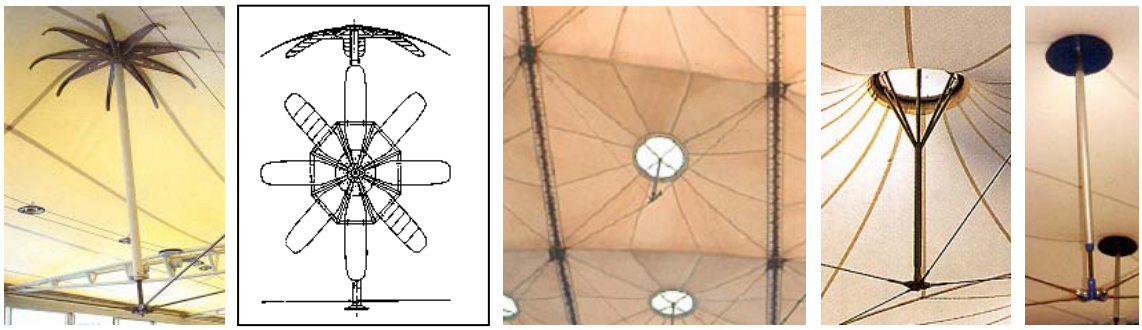
Measured strains

7. “Detailing” by Dr. Josep Llorens (ignasi.llorens@upc.edu)

Detailing for fabric roofs is not yet a well-established, thoroughly documented or widespread practice. Nevertheless, choosing, designing and evaluating connections and joints are critical to the overall concept and the resulting structure.

The design of a membrane structure influences the construction of the details. Therefore, details need to be linked to the entire structure. They attend to the following principles and requirements: visual expression (coherence, homogeneity, lightness, simplicity, balance, proportion, smoothness and style), structural principles (strength, stability, redundancy, flexibility for displacements and compatibility), geometry (funicular shapes, space, scale and coordination), climate and environment (water-tightness and corrosion protection) and installation (hinges, auxiliary clamps, adjustable devices and accessibility).

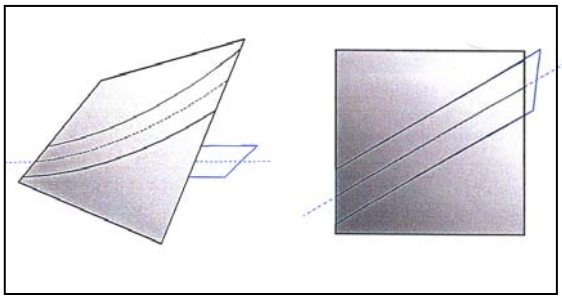
The following typology was stated: seams, edges, ridges, valleys, corners, high and low points, base plates and anchors. It was illustrated with a wealth of examples.



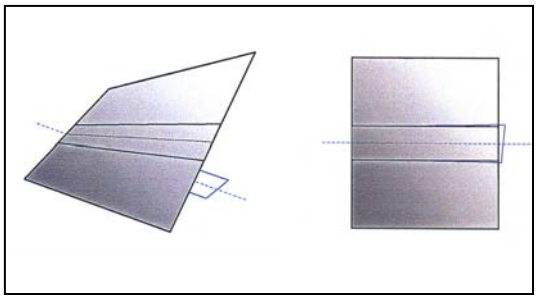
Flying masts (Imagination Headquarters, London. Hamburg International Exhibition. La Grande Arche, Paris. Munich Waste Management Office. Venezuela Pavilion Cafeteria, Hanover)

8. “Recent Developments in the Design of Tensioned Structures” by Dr. Rosemarie Wagner (r.wagner@fhm.edu)

The need to design membrane structures in systematic steps and loops of optimisation in order to handle the complex coupling of three-dimensional geometry and material behaviour was discussed. Work is currently being carried out on a system for modelling and simulating membrane structures that allows the design process and all the factors that play a part in each step of it to be described. Shapes of equilibrium can be related to stress distribution, anisotropy, pre-tension, boundary conditions, curvature, shear stiffness, distortion, orientation of warp and fill and the cutting pattern. A set of rules have been derived to cope with excess over the maximum allowable stresses in a single strip, wrinkles, local stress peaks, shear deformation and differences in form.



Change of strip geometry by flattering orientated to the main direction



Change of strip geometry by flattering orientated parallel to the edges

Afternoon Presentations

9. “Messearchitektur” by Rainer Lenz (info@ktp.architekten.de)

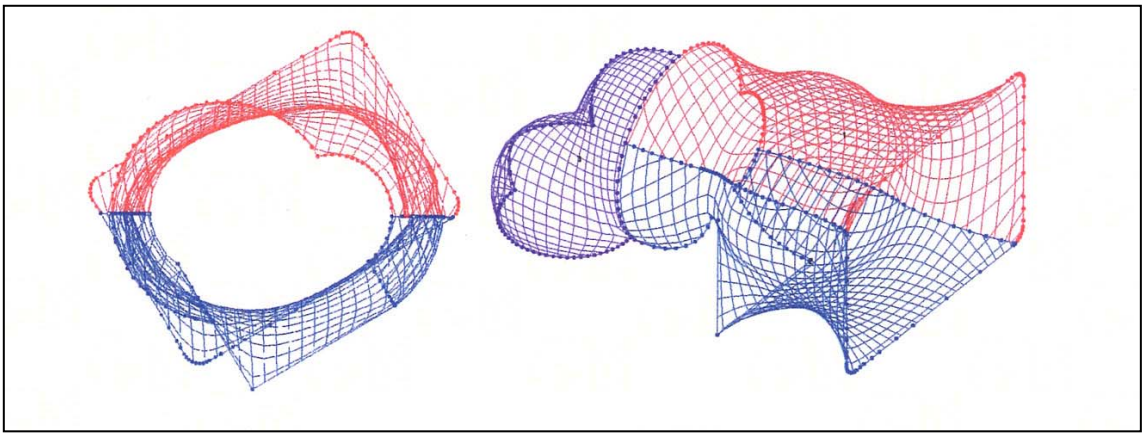
The main characteristics of architecture in exhibitions were mentioned: the spatial (3D) scene ensures that the visitor actually perceives the exhibits, enables powerful images to , atmosphere and the brand’s identity. As a result, the spatial, communicative event, the astonishing rooms and the pictures are adequately displayed. These concepts were thoroughly illustrated by examples taken from Lenz’s ten-year cooperation with Mercedes Benz in Leipzig, Berlin, Detroit, Paris and Frankfurt.

Mercedes-Benz presentation in Leipzig, 1996 – Photographer Vaclav Reischl

Mercedes-Benz presentation in Paris. Photographer Andreas Keller

10. “An Art Pavilion Made by Rigidizing A Membrane Mould with Polyester” by M. Rougier Houtman (rogier@tentech.nl)

Houtman described the concept and engineering design for an art pavilion in Eindhoven. The surface was made of glass-fibre-reinforced polyester and a mould of PVC-coated polyester membrane. The manipulation of form-active surfaces made it possible to use membranes as a mould. The way the artist made his model and how it was used as a starting point was presented. Furthermore, the form-active structure was calculated and patterned to make the fabric mould, and finally the polyester surface was engineered and built.



Three different conforming areas

11. “Design Module for Pure Tensile Stress Membranes” by Pedro Alva (alvedrop@hotmail.com)

Alva developed an ingenious way of finding the form, starting from a tree branch. The implementation of five platonic polyhedrons resulted in an astonishing variety of tension- and compression-operating structures.

11.- “Design module for pure tensile stress membranes”, by Mr.Pedro Alva (alvedrop@hotmail.com)

Pedro Alva developed as ingenious way to find the form starting from a tree branch. With the implementation of the five platonic polyhedrons it resulted in an astonishing variety of tension and compression operating structures.

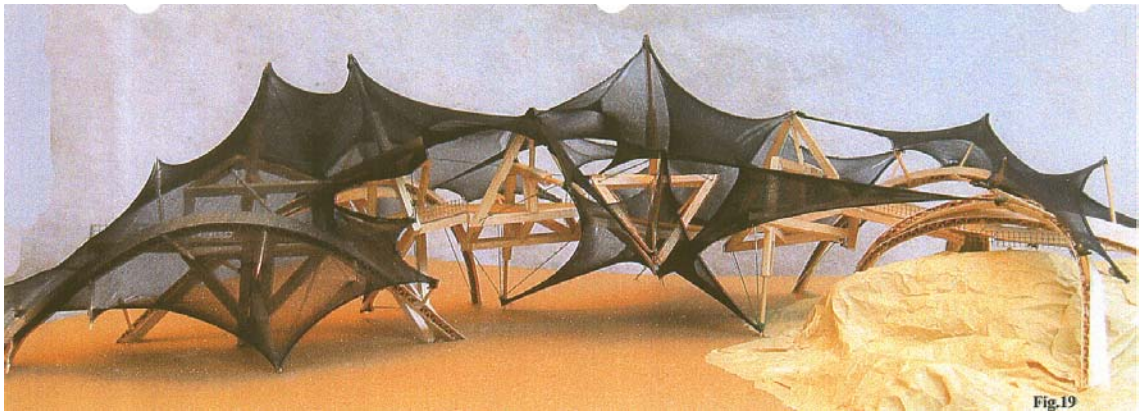


Fig.19

12. “Price Finding” by Werner Fröhlich (http://www.skyspan.com)

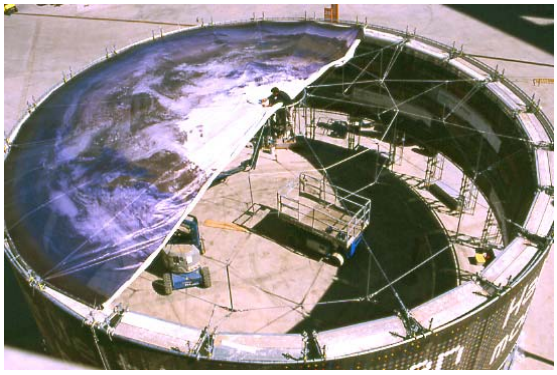
BASIC MATERIAL	PRICE (RAW MATERIAL €/M2)	PRODUCTION, INSTALLATION, CLAMPING, CABLES AND AIR SUPPLY (€/M2)	+ STEEL (€/M2)
ETFE 200μ INFLATED CUSHIONS	14-15 (1 layer)	200-400	350-800
PTFE-GLASS Type IV 1 layer	55-65	150-400	200-600
PVC-POLYESTER Type II-IV	4-12	80-250	150-350

Remarks:

1. Prices are highly dependent on cables, clamping, bolts, steel, aluminium and corrosion protection.
2. ETFE-inflated cushions are prone to condensation at the non-insulated edges. The maximum span in one direction is 3.80 m and the advisable curvature is span/10. Dry air is supplied under 350 Pa = 35 Kp/m2; under wind or snow 1000 Pa = 100 kp/m2. A weather station automatically raises the pressure. The leakage rate is 2-5% per hour. A repair kit is provided to patch holes or tears.
3. The surface of the manufactured membrane (one layer) is roughly the covered surface x 1.35.
4. Feasibility and preliminary studies are essential.

13. “Bifid Tension Dome for the Forum of Cultures, Barcelona: Less than 5 kp/m2”, by Dr. Josep Llorens (ignasi.llorens@upc.edu)

A temporary, 100% recoverable structure and roof were designed and engineered by architects J. Llorens, C. Garcia-Diego and H. Pöppinghaus. They were built for the “Living in the World” exhibition at the Barcelona 2004 Forum of Cultures event. Tensegrity structure principles and innovations in the cable-roof disposition were applied to reduce self-weight, facilitate erection, improve performance, increase efficiency and achieve 100% recoverability to fit in with the sustainability concept of the exhibition (the full paper is available in the TensiNet Database).



Bifid tensión dome at the Barcelona Forum of Cultures, 2004

Textile Roofs 2005

The tenth edition of the “Textile Roofs 2005” workshop (http://www.textile-roofs.de) will take place from 26 to 28 May. The successful turnout, high level of participation and the renewed and extended content of its lectures, presentations and workshops of previous editions looks set to continue. Participants will have access to up-to-date information, inside views, lectures by experts and practical training, and they will benefit from the expertise of successful engineers and architects and the enthusiasm of newcomers and returning participants.

(TR 2004 was organised by the Technische Universität in Berlin. It was sponsored by Tensinet, Serge Ferrari SA and Technet GmbH.)

Dr. Josep Llorens
School of Architecture of Barcelona
E-mail: ignasi.llorens@upc.es