STRUCTURAL MEMBRANES 2013

VI INTERNATIONAL CONFERENCE ON TEXTILE COMPOSITES AND INFLATABLE STRUCTURES

The "Sixth International Conference on Textile Composites and Inflatable Structures" was held in Munich in October 2013. It was organized by the International Centre for Numerical Methods in Engineering (CIMNE) and chaired by E. Oñate (UPC) and K.U. Bletzinger (TUM). It was the sixth of a series of symposiums that began in Barcelona in 2003. The next conference will again be held in Barcelona in 2015.
At the three-day event, 8 lectures and 91 presentations in 13 invited and contributed sessions were given to 122 participants from 25 countries and 4 continents. The main topics covered building physics, materials, testing, and advanced methods for analysis and simulation. A wide range of different applications were also shown for dealing with adaptive and deployable structures, active bending, parachutes, inflatable arches and beams, roofs and façades. Environmental and energy issues were also considered, both in regard to life cycle analysis, and the capture and storage of solar heat.

Main lectures

P. Gosling began the plenary lectures with an introspective look into how material properties are considered in the design. He referred to the round-robin exercise carried out to understand the current state of analysis practice, which has high levels of variability. He suggested a neural network to represent the strain/stress behaviour of the membrane.
K. Göppert entertained the audience with a wealth of impressive achievements by Schlaich, Bergermann und Partner. Most interesting were the new roofs and façades on existing buildings, such as the renovation of the Bay Arena in Leverkusen (Fig. 1).

Observing the thermal behaviour of polar bear fur and skin, and taking into account the amount of energy provided by the sun, T. Stegmaier presented a solar, active roof based on a selective, multilayered membrane. It consists of a transparent insulation (on the top), a black collector (in the middle) and heat insulation (at the bottom) (Fig. 2).

M. Mollaert and S. Pellegrino expressed concern about folding membranes. The first speaker addressed whether a retractable membrane system could be stable in intermediate configurations. The second speaker covered hinges for tightly- packaged thin-shell structures.

M. Fritze impressed everyone with the parachute dance, which was devised to improve the average descent speed, fluctuations and contacts by means of modifying the geometric porosity with windows and gaps (Fig. 3).

K. Linkwitz told the gripping story of the patterning of the Munich Olympic Stadium cable roof. He was contracted to produce the cutting pattern by photogrammetry. As he realized that the accuracy was insufficient, he was forced to deduce a new method that was heretofore entirely unknown (later called "force density"). According to his memory, the most exciting moment of the experience was the first uplift of the cable net (Fig. 4). The result was a major achievement.

R. Rossi confronted the difficulty of simulating the wrinkling in low-pressure inflated tubes subjected to wind by separating the structure (the tube) from the fluid domain (the wind), adding nodes at the interface and performing local subdivisions (Fig. 5).

Invited and contributed sessions

The invited sessions were organized by guest experts, which focused on adaptive and deployable structures, advanced methods for analysis, active bending, building physics, detailing, case studies, installation process, space applications, materials, fluid-structure interaction, and environmental impact.

Design

B. Philipp addressed the problem of the lack of unified approaches and standards as a limiting factor to the further propagation of architectural membranes. The material properties, loads, load combination, safety factors, non-linearity and design tasks make the simulation a challenging task. The development of tensile structures is far from being finished.
"Selected examples for the optimization of cutting patterns for textile membranes" was the contribution of D. Ströbel. He showed fast and automatic "Easy/Technet" patterning tools to solve the costly and time-consuming engineering process of cutting patterning. He introduced different flattening theories, and focused on optimizing procedures based on variables such as width or position.

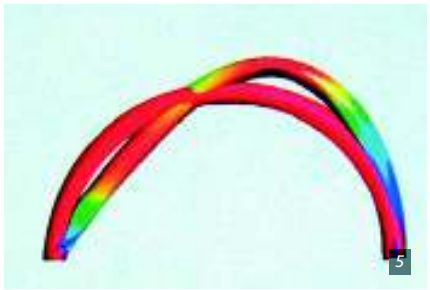


Figure 1. Renovation of the Bay Arena, Leverkusen - K. Göppert
Figure 2. Solar-active roof, Denkendorf - T. Stegmaier
Figure 3. The "parachute dance", modifications on the geometric porosity - M. Fritze
Figure 4. Erection of the cable net of the Munich Olympic Stadium - K. Linkwitz
Figure 5. Low pressure inflated tubes under wind simulation - R. Rossi

R. Pauletti presented the implementation of a simple wrinkling model by using both the tangent or secant stiffness-matrices. He compared the results obtained for the membrane roof of the "Memorial dos Povos de Belém do Pará" (Fig. 6), and concluded that the finite difference approximation provides a systematic, straightforward way to keep quadratic convergence, which requires the sole definition of force vectors.

A. Habraken described an approach aimed at significantly saving structural materials by increasing efficiency by means of adaptability to static and dynamic environmental conditions. He categorized the structural adaptability in passive adaptability, using flexibility (Fig. 7) and active adaptability controlling the structure with actuators.

"People just want to have a price before the design is fixed" was the statement of R. Wehdorn to introduce a simple tool designed to foresee the influence of the primary variables in the final cost. Variation of membrane and edge curvatures and inclination of guying cables were analyzed for a 10x10m four-point sail. This study is expected to lay the basis for the inclusion of cost-influences in design guides and software applications, such as "Formfinder".

Realisations, recent projects

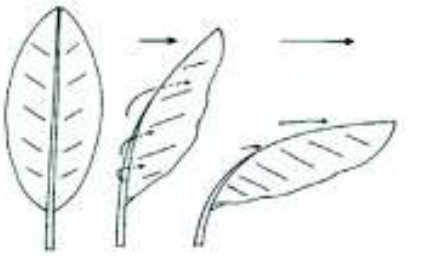
J. Oliva presented two cases of designing membranes on existing buildings. The first one, for the University Drama Centre in Mexico City (Fig. 8), included an improvement of the lanterns over what was experienced previously ("The design and application of lanterns in tent structures", SM 2011). The second case covered the cafeteria of the new campus housing the National School for Higher Studies in León (Fig. 9).

D. Campbell from Geiger Engineers proved the compatibility of insulation and translucency requirements with the applications of Tensotherm, a combination of PTFE-coated fiberglass and Aerogel insulating blankets. It has been used for the roof replacement at the Dedmon Center Gymnasium and Pool in Radford, and the Talisman Center in Calgary (http://www.makmax.com/business/tensotherm.html).

"Irregularity" was an arguable concept put forward by G. Filz to present the tensile sculpture "cut.enoid.tower" (Fig. 10). It merges different structural members into an overall system such that irregularity is necessary in order to achieve a state of equilibrium.

J. Tejera's presentation was concerned with textile façades, an emerging field application of structural membranes. He lucidly listed these façades' main characteristics and focused on the protection of the Oasis Hotel curtain wall located in subtropical Lanzarote (Fig. 11 & 12). He applied the BAT Tenso Textile façade framing system, and managed to reduce the prescribed wind loads by modelling the complete façade with the CFDtex calculation method developed by himself. The results look promising, in view of the large quantity of glass façades oriented to the west that have been built in hot climates.

Multilayer textile cladding was also discussed in "Textile and film-based building envelopes, lightweight and adaptive" by F. Schmid. A fabric envelope was described by P. Casaldàlga in "The Magical Lleida Technology Park as an example of environmental building rehabilitation strategy."
A membrane installed 17 stories above ground was the topic of C. Armendariz (Fig. 13). The requirements were challenging, because the building was fully operational. Additionally, anchors, supports and membrane had to be adapted to the existing rooftop terrace and views. Nevertheless, the result was successful,



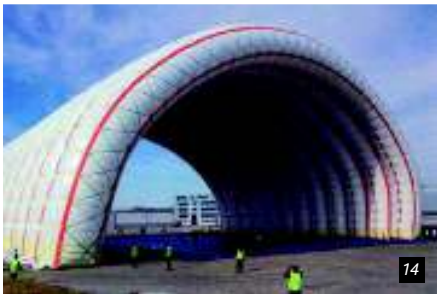


Figure 6. Membrane roof of the "Memorial dos Povos de Belém do Pará" - R. Pauletti
Figure 7. Passive adaptive behaviour of a banana-leaf - A. Habraken
Figure 8. University Drama Centre, Mexico City - J. Oliva
Figure 9. Cafeteria, León - J. Oliva
Figure 10. "cut.enoid.tower" - G. Filz
Figures 11& 12. Initial state and after retrofitting Oasis Hotel, Lanzarote - J. Tejera
Figure 13. Terra Alta Sky Lounge, El Salvador.- C. Armendariz
Figure 14. Pressurized arches for portable hangars - J. Marcipar

and the project opened the door to similar applications.

J. Marcipar presented a remarkable application of pressurized arches for portable hangars (Fig. 14). A wide range of clear spans (from 15 to 54m) can be accommodated for aeronautical maintenance, defence, emergency, industrial and corporate utilisations. The length can be easily extended by the addition of arches. A variety of doors or end enclosures provide adaptability.

ETFE

R. Houtman presented "Design recommendations for ETFE foil structures" (available at http://www.tensinet.com). Afterward, F. Reitsma showed the ETFE modules for the San Mamés Stadium in Bilbao. He pointed out the twisting of the frames (Fig. 15) and their specially-developed laminated tubes (Fig. 16).

The optimization of clamp profiles, from a thermal efficiency viewpoint, were examined by B. Urban in "Thermo technical optimization of membrane clamp profiles regarding static and assembly engineering aspects" (Fig. 17).

W. Pösl featured the accomplishment of the project announced in "Structural Membranes 2011" (TensiNews nº 22, Fig. 9, p. 21) for the roof of a waste management vehicle maintenance facility of Munich. It includes thin-film solar cells in the middle layer of the three-layered, inflated EFTE cushions that shelter the space (Fig. 18). The energy collected operates the ventilation units, which pressurize the cushions. Surplus energy is fed into the public grid.

Regarding the embodied energy of ETFE cushions, J. Chilton compared three cushion panels of different shapes, sizes and configurations. He concluded that geometry and configuration are at least as significant as the values provided by the "Environmental Product Declaration." In addition, for all three examples, the energy embodied is less than half that with a glass roof, demonstrating the advantage of ETFE foil cladding systems.
F. Weininger dealt with the hardening effect of ETFE foil and its application to the Coca-Cola Beatbox, London 2012 (Fig. 19). The hardening effect was also covered by R. Blum in "On the mechanical behaviour of ETFE films" and J. Llorens in "Tension anchors for structural membranes".
Figure 19. Hardening effect of ETFE foil, Coca-Cola Beatbox, London 2012 - F. Weininger

Conclusions

Structural Membranes 2013 perpetuated the trend of previous editions, grouping experts, researchers and practitioners, who presented their latest findings, as the participants who also attended Structural Membranes 2011 in Barcelona could verify. It is expected that this trend will continue, because as B. Philipp stated: "The development of tensile structures is far from being finished. Important research is needed to solve the mentioned problems and face the arising challenges."

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Figure 15. Detail of the twisted ETFE modules for the San Mamés Stadium in Bilbao - F. Reitsma
Figure 16. Special section for clamping ETFE modules - F. Reitsma
Figure 17. Detail of the optimized clamp profile - B. Urban
Figure 18. Detail of the three-layered ETFE cushion - W. Pösl
Figure 19. Hardening effect of ETFE foil, Coca-Cola Beatbox, London 2012 - F. Weininger


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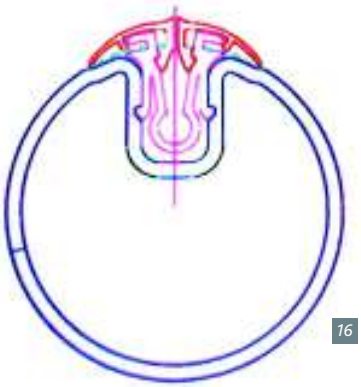
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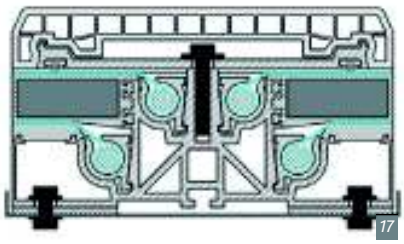
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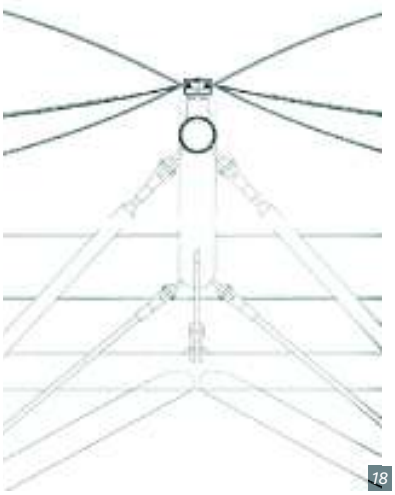
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More information:
http://congress.cimne.com/membranes2013/frontal/default.asp

The Proceedings of the Conference are available at:
http://congress.cimne.com/membranes2013/frontal/doc/ebook%20Membranes%202013.pdf

The next international Structural Membranes conference
will be held in Barcelona at the Technical University of Catalonia (UPC) in 2015.
Further information will be made available in the "Events" section at
http://its.cimne.com/cdl1.