TEXTILE ROOFS 2018

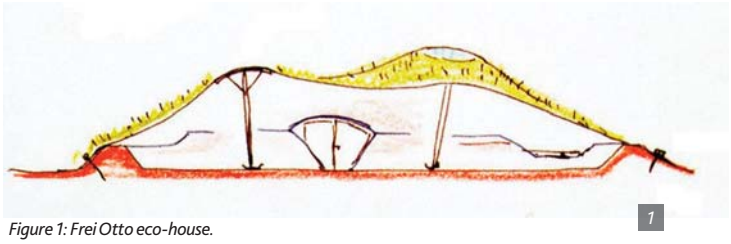

Figure 1: Frei Otto eco-house.

Textile Roofs 2018, the twenty-third International Workshop on the Design and Practical Realisation of Architectural Membranes, took place on 26–28 May, 2018 at the Moscow Architectural Institute (State Academy), and was chaired by Prof. Vladimir Ermolov (Verteco Co.ltd.) and Dr.-Ing. Bernd Stary (Academus). It was attended by 74 participants from 6 countries covering two continents. Once again, the attendance demonstrated the success of the event, which has become firmly established since it was first held in 1995.

Figure 2: Two lightweight design approaches (O.Myskova).

Introduction and overview

Jürgen Hennicke in his lecture "Membrane structures" illustrated with an enriching sequence of slides that lightweight structures include much more than textile roofs. He started with the history to show that it is not a new issue at all, looking not only at human constructions, but also at the contributions of nature. A parade of Bedouin and Middle-Age tents, radiolarian, Roman velum roofs, nets, suspended bridges, nomadic shelters, primitive constructions, cantilevers, arches, shells, grid shells, bubbles, balloons, trees and much more exemplified the different concepts on which light structures are based to reduce the self-weight. Professor Frei Otto's works and schemes were also worthy of mention, because they explored the available solutions as well as the possibility of improving them (Fig. 1).

Some outstanding achievements completed the demonstration of principles, ways and possibilities of the lightweight design approach. They included the peak and hump tents for the Federal Garden Exhibitions, the Bad Hersfeld open-air theatre, the threatened Mannheim Multipurpose Hall, the historical Montréal and IL Pavilions, the Nimes Arena inflated cushion, the Munich Olympic Stadium and aviary, the Pink Floyd USA Tour umbrellas, the Hamburg Tennis Court and the Frankfurt Pavilion among many others.

The lecturer ended up issuing his favorite message regarding lightweight and membrane structures as "everyday architecture which can satisfy all our needs as living beings in a built environment, increasing our physical, mental and social quality of life in harmony with the natural environment as a reconciliation between man and nature and with himself".

Olga Myskova went also into general concepts with her "Architecture of tensile constructions. Form and perception" conference. She presented an international wide selection of tensile constructions to show their main architectural characteristics and possibilities. They ranged from pavilions, stages, stadiums, sport halls, railway stations, airports, sunshades, umbrellas, awnings, tents, parking lots, coloured interior decoration, urban furniture, sculptures, covered squares and streets. She demonstrated that tensile constructions offer a wide range of possibilities, although some of them do not correspond exactly to the lightweight design approach mentioned in a previous presentation (Fig. 2).

Materials

In "Tensile wraps for two FIFA World Cup Arenas in Russia", Katja Bernert mentioned two important issues that play a role in decision making when designing a textile roof concerning the material and its company. The material could be PVC coated polyester, a performing long lasting material as it has been found when replacing the Mercedes Benz Arena roof and the Elspe Grand Stand canopy. The membrane roof of the Mercedes Benz Arena in Stuttgart has been in place since 1993. Estimated lifespan was 20 years, 25 maximum. Local authorities decided in 2016 its replacement. During the 2017 summer break, the Pfeifer cable construction team equipped the first-division stadium for VfB Stuttgart with a completely new membrane roof (Fig. 3). The project involved removing and replacing all 40 segments of the delicate roof structure, measuring more than 38.000m². Made of a special dense woven fabric coated with a fluoridated nano-topcoat which makes it easier to clean the MEHGIES® Valmex® Mehatop® membrane was pre-produced, shipped to the site and erected directly saving valuable time.

Figure 3: Replacement of the membrane roof of the Stuttgart Stadium.

The membrane roof of the Karl May Festival in Elspe was erected in 1978 and replaced in 2015 because the Festival company wanted a bright new colour impression. Mehler Texnologies developed a membrane as close as possible to the original material bearing the same colour and adapted to the requirements of the new directive for chemicals. It has been an opportunity to measure the longevity under real life conditions such as heavy snow loads during winter time, better than any artificial weathering tests: the measured loss of tensile strength of the dismounted fabric was 20%.

The second issue concerns the company, in this case Mehler, founded in 1837, with a long experience in a large number of projects, including F.Otto's early works such as the retractable roof over the open-air theatre in the monastery ruins in Bad Hersfled. Mehler stands out for the capability of customizing products and providing Life Cycle Assessments and Environmental Product Declarations. Recent achievements include the Nizhny Novgorod and Volgograd Stadiums in Russia.

The manufacturing of PVC materials for tensile architecture was approached by Irina Grigoryan

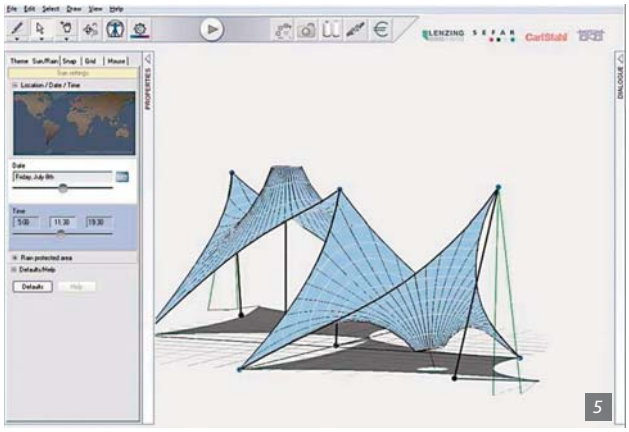

Figure 4: Three innovation stages undergone by Ruchaika.
Figure 5: Screenshot of "formfinder".
Figure 6: The interaction between membrane and stiff elements is taken into account by the software "easy.technet" because it tends to be significant.

from Ruchaika, a modern developing enterprise in the Republic of Belarus, specialized in the manufacture with the mixed yarns ring spinning process of technical and decorative fabrics with PVC impregnated composition.
Ruchaika has undergone three innovation stages (Fig. 4). In 2007 the modernization was launched with the purchase of modern weaving and spinning equipment made by «SmitTextile» (Italy). In 2009 old equipment was replaced by the newest weaving machines and in 2010 the third modernization phase was launched with the acquisition of the most effective technology in terms of performance, energy saving and sustainability. Following the modernization, the new equipment made by «ISOTEX» Italy, was put into operation, which allowed to produce textile fabrics impregnated PVC composition. The ability to produce textile base for any PVC material densities, widths and weaves allows the development of a wide range of products.

Design

Professor Robert Roithmayr introduced the initial phases of the design process with the assistance of the software "formfinder" aimed to the design, plan and estimated cost-effectiveness of tensile membrane structures (Fig. 5). He mentioned three main steps: get inspired, be creative and make it real. To get inspired, "formfinder" provides a data base with an extensive typology and the description of 2.000 projects collected over decades. To be creative, the powerful "Membrane Design tool" is provided to encourage designers in the creation of beautiful and quality membrane architecture checking different proportions, curvatures and sags. And to make it real, the results go to the engineer and the "easy.technet" software to proceed with the structural analysis and cutting pattern generation.

In addition, the Lightweight Membrane Structures Master of Engineering course held at the Danube University in Krems was announced. It combines the state of the art in building materials and the latest fabrication technologies with the highest engineering knowledge provided by leading experts in the field in order to provide skills and applied knowledge translating these elements into creative designs and actual project implementation and recognize and exploit the full commercial and environmental potential of Lightweight Membrane Structures.

Dr. Dieter Ströbel introduced step by step the procedure of designing tensile surface structures with the software easy-technet. After highlighting the requirements of modelling, he went into the computational form finding based on the force density method, summarizing its fundamentals and advantages. The combination with stiff elements was also taken into account as the interaction tends to be significant (Fig. 6). It was illustrated by two examples: the pneumatically stressed galets of the 2002 Swiss Expo in Neuchatel and the optimization of textile halls supported by aluminium frames.

After obtaining the form, it was the turn of the non-linear static analysis, starting from approximate values, membrane, cables, struts, material properties and external loads. References were made to the influence of the material direction, the application of the gas law (for pneumatic structures) and the effects of the incorporation of stiff bending elements.
The third step was the patterning needed to manufacture a doubly curved and prestressed surface from rolls of plane material. The doubly curved surface cannot be represented on a plane without distortion. It is not developable. In addition, the planar strips have to be as straight as possible (in order to keep the cutting out waste as low as possible) and the width of the 2D strips should be as wide as possible (in order to minimize the amount of work, considering that the maximum strip width depends on the roll width). Moreover, the developed surface has to be corrected to allow for the deformations caused by the prestressing and the corresponding seam lines must have the same length to avoid problems by joining the strips. The patterning ends with the cutting drawings, welding marks and the checking of areas, widths and lengths.

Research projects were also mentioned such as biogas storage systems, together with special applications including the automatic form finding and patterning of ETFE cushions and the fast patterning of cones, saddles and textile halls.

Okeanov Gennady Vadimovich, architect, addressed the situation of standardization in Russia. He presented the regulations and recommendations for the design and calculation of buildings and structures containing membranes starting with the procedures developed for the 2018 FIFA Championship stadi-

ums. Currently, the Central Scientific Research Centre of Industrial Construction is developing regulations and recommendations for textile construction structures which are expected to be available next year.

"Detailing" was presented by Professor Josep Llorens who alluded to his usual remarks regarding their relevance as a significant part of the design process. He listed and illustrated the requirements emphasizing the needs of the installation process (Fig. 7). A typology of details was presented including seams, edges, corners, high and low points, ridges and valleys, base plates for masts and cables, fittings, and anchors. And finally, two conclusions were highlighted: 1) Details cannot be directly transplanted from a repertoire, since they have to be adapted to the requirements of each case. Solutions are successful when they meet the specific requirements of every application. *Changing the requirements means that the design must be changed.* 2) Detailing has to be taken into account from the beginning of the design process. It is not an independent step, because it is also essential to the general requirements of the whole structure. *Details are not an afterthought.*

Figure 7: Ice Skating Ring, Montafon. Attachment of holding devices and tensioning equipment (Courtesy of R.Off).

Realizations

The lectures that usually bring the latest news are those devoted to recent works such as the Volgograd Arena presented by Dip.Eng.Ivan Uroshlev (Fig. 8). The Volgograd Arena is one of the stadiums for the FIFA 2018 world cup. Its roof consists of a tensioned spoke wheel system cable structure supporting 76.800m2 of PVC coated membrane and ETFE panels. The inner tension ring consists of two cables that support a steel platform which in turn supports the ETFE panels. The outer roof of the foyer consists of structural steel trusses. They act as

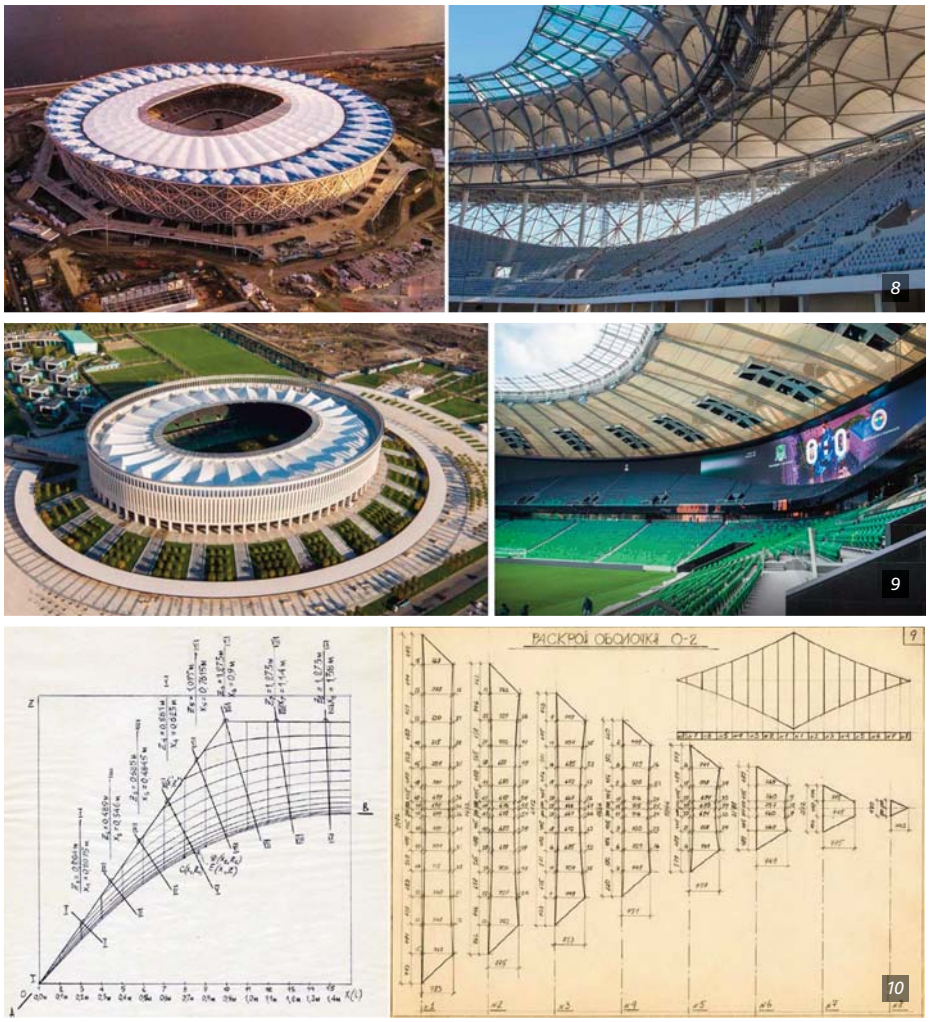

Figure 8: Volgograd Arena.
Figure 9: Krasnodar Arena for 34.000 spectators, equipped with heating.
Figure 10: Patterning by hand.

the compression ring of the spoke wheel system. The final arrangement looks like a gmp & sbp stadium but excessively complex to accommodate only 35.000 spectators after the FIFA 2018 World Cup.

The group Kurganstalmost, a holding that offers services in the field of design, fabrication of metal structures, construction, installation and delivery on a turn-key basis, took an active part in the design, supply and installation of 10 football stadiums, such as Krasnodar (Fig. 9), Volgograd, Nizhny Novgorod, Novgorod, Yekaterinburg and Rostov-on-Don in cooperation with Maffeys and Kubantent, a company that works in the field of membrane tension construction, design, production, and installation. Thanks to these successful projects, membrane architecture is gaining popularity in Russia. Costumers and designers appreciate the advantages of this technology, speed of installation, quality, durability and aesthetics.

Membrane architecture in Russia was the topic of Vladimir Ermolov, from Verteco Co.Ltd. He presented a parade of textile roofs made in Russia from the 16th century to the present day starting from icons and chronicles. He mentioned, before 1917, fairs, markets, tents and patents. Vladimir Shukhov deserved special attention corroborated by the technical visit made during the workshop. Air supported structures began in 1936 with military purposes and mechanically stressed structures are recorded from 1961. From 1981 to 1989 attempts were made to quantify snow loads, stress relaxation, shear modulus and testing. Efforts were also made to develop form finding and patterning (Fig. 10). Minimal surfaces were adopted in 1983 for a tennis court. Verteco Co.Ltd. began in 1991. His record of achievements covers a wide variety of types and sizes, both utilitarian and decorative. Finally, the lecturer referred to some problems derived from snow loads, drainage and lack of maintenance.

Future trends

Professor Natalia Saprykina astonished the audience with the first part of her presentation for


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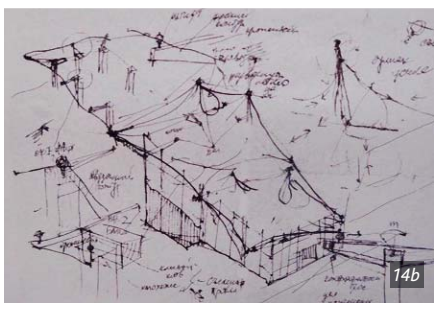
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dreamers. She began with the "flying city" project by G. Krutikova 1928, of the Soviet avant-garde, for the construction of new flying cities and flying agglomerations. More futuristic proposals were the flying gardens, skyscrapers and parks together with air purifiers to manage acid deposition in the atmosphere that have been proposed recently (Fig.11).

Professor Natalia Saprykina kept looking to the future in the second part of her lecture but she tended to be more realistic focusing on the use of airships for touristic purposes in the North of Russia due to the difficulties derived from the climatic conditions, relief and small population that require training, skills and tourist knowledge. The use of airships for touristic purposes was initiated by the Graf Zeppelin in 1931 that traveled to northern Russia. The contemporary aerostat technology for the tourism market, advertising and special tasks was shown with Zeppelin NT, Skyship, Airship/Lightship, Voliris, Mineseeker and Aeroscraft.

The closest examples to the purpose of the lecture were the Aeroscraft Hotel (that moves at a speed of 280 km/h with 250 passengers including casino, restaurant and comfortable cabins), the Air hotel Stratokraiser for a new type of tourism (air cruises along the whole globe with restaurant, spa, beauty salon, swimming pool and views. Filled with helium. It generates electricity with photovoltaic cells) and the Flying house "Wolke 7", a new concept of habitat including everything essential for permanent residence (Fig. 12).

"Harmonizing urban spaces with architectural membrane (tent) constructions" was presented by Anwar Khairoullin, from the Association of Creative Laboratories of Forms. He showed the newest technological capabilities of his company dedicated to the use of modern tent structures for solving a wide range of social problems, including the harmonization of the architectural and spatial environments (Fig. 13). The interventions were based mainly on the application of a variety of shapes and colours to create ludic and festive environments. He illustrated them clearly with many designs and summarized as "Making beauty!".

Figure 11 a: Left: Flying gardens with living quarters and offices, laboratories and plantation of microalgae to obtain bio hydrogen as the main fuel for the airship.
Figure 11b: Flying park and facilities in a large balloon with helium and propellers who work with solar energy to collect rain water for irrigation and purify the air of the city absorbing carbonate gas.
Figure 12: The Flying House "Wolke 7".
Figure 13: Coloured tents to harmonize architectural and spatial environments.
Figure 14a/b: The students exposed their designs that were commented by the participants.

Student designs review

In a room next to the conference-hall, the students exhibited their designs that were commented by the attendees (Fig. 14).

Technical visits

The top of the 2018 Textile Roof Workshop was the technical visit focusing on the figure of the architect and engineer Vladimir Shukhov. Vladimir Grigoryevich Shukhov, 1853-1939 was a Russian engineer, scientist and architect renowned for his pioneering works on new methods of analysis for structural engineering that led to breakthroughs in industrial design of the world's first hyperboloid structures, diagrid structures, gridshells, tensile structures, oil reservoirs, pipelines, boilers, ships and barges. He is also the inventor of the first cracking method. (His patent was used to invalidate Standard Oil's patents on oil refineries).

The GUM State Department Store was designed by A.N.Pomerantsev and V.G.Shukhov and constructed in 1894 in a Russian style to harmonize with the surrounding architecture of the Kremlin and the Historical Museum. It stands out for the lightness of the original steel structure of the roof (Fig. 15).


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Figure 15: The GUM State Department Store, 1894.
Figure 16: The Petrovsky Passage, 1906.

The Petrovsky Passage was designed by S.Kalougine, B.Freidenberg and V.Shukhov and opened in 1906. Vladimir Shukhov designed an arcade with two wide three-storey galleries covered with extremely light high-pitched semi-cylindrical glass vaulting taken over that of the GUM Department Store. The second floors of opposite galleries are connected by exquisitely designed ferroconcrete catwalks (Fig. 16).

The Shukhov Tower is a landmark in the history of structural engineering (Fig. 17). Known as the Shabolovka Radio Tower, it was built between 1919 and 1922, rising to the height of 148m. It was originally designed to be 350m high but steel shortage made it impossible. It consists of six stacked hyperboloids, which have the property of being constructed out of entirely straight segments. For the construction Shukhov employed his own original method of telescopic assembly. Today, the structure suffers from corrosion and, in addition, it sits close to the center of a growing Moscow, and demand for land, coupled with its poor condition and lack of public access, have led to the looming threat of demolition. In 2014, architects, preservation groups, and members of the local community, rallied to protest against a plan to dismantle the tower and re-erect it at a new location. The 2016 World Monuments Watch joins their voices in calling for continued vigilance in the fight to save this icon of modern Russian history.

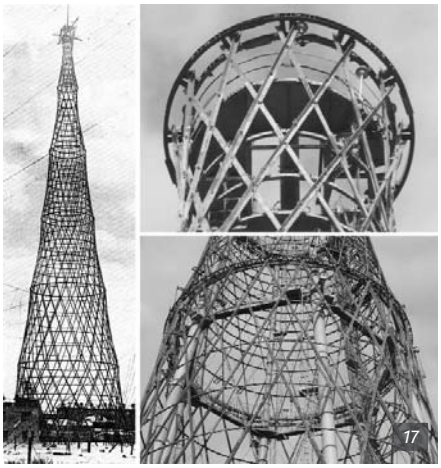

Figure 17: The Shukhov Tower or Shabolovka Radio Tower, 1922.

Figure 18: Manufacturing & erection of the "Joint participants' project".

Joint participants' project

The "Joint participants' project" was led by Stev Bringmann, 3dtex GmbH. A four point sail was designed and erected with the participants and the following contributions: supplier of the fabric: Low & Bonar (Valmex Mehatop F1). Form finding, structural analysis and patterning: technet GmbH. Physical modelling: Jürgen Hennicke. Membrane manufacture: Verteco. Foundations, set out anchoring points and tent pegs, preparing the masts, finishing the membrane, corner reinforcements, pulling in the edge cables, assembly of corner plates, installing the masts, erection of the membrane and tensioning and discussion: the participants (Fig. 18).

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The Twenty-fourth International Workshop on the Design and Practical Realisation of Architectural Membrane Structures will be held on 20-22 May 2019. Its format will be similar to that of TR 2017, with seminar-style lectures and hands-on activities and it will be preceded by the student seminar. More information will be available at http://www.textile-roofs.de.

7th IMS International Textile Architecture Symposium in Miami

From May 17th to May 19th 2018 the IMS e.V. Archineer® Institute held its 7th IMS International Textile Architecture Symposium. This year the symposium was hosted at the very prestigious School of Architecture at the University of Miami. About 90 people interested or involved in the membrane building business attended and made it a successful event.

Within the three days of the symposium, concentrated lectures were provided regarding planning, design and increasingly frequent inclusion of high-tech membrane structures within the modern architecture. The symposium was a didactic and academic event counting on the experience of great professionals in the field. Keynote speakers Nicholas Goldsmith, Prof. Dr. Günther Filz, David M. Campbell and many other specialists shared their expertise with the participants. At the same time the attendees took advantage of the symposium for networking. The event turned out to a great meeting occasion between professionals, students and craftsmen currently involved in the industry and the world of membrane or tensile structures especially during the two evening cocktail parties.

On its last day, the symposium was concluded after an interactive panel discussion where the specialists answered questions regarding education, future trends and development in the field of membrane and lightweight structure building.

Upcoming programs IMS Institute

The next educational events organized by the IMS e.V. Archineer® Institute are the **2nd TENSILE intense** in September (15.-22.09.2018) and the **14th Master Program Membrane Structures** at the Bauhaus Campus of the Anhalt University in Dessau-Rosslau, Germany, the home of the institute. TENSILE intense is a one-week focusing on membrane- and lightweight structures, addressed to architects, engineers, managers, salesmen and others interested and/or involved in the membrane business. More information is available at www.membranestructures.de or contact heike.kleine@ims-institute.org.