

Textile Roofs 2025

May 25th - 27th, 2025

Prof. Rosemarie Wagner, KIT

Dr.-Ing. Bernd Stary, akademus GmbH

AEDES Architectural Forum, Berlin

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Introduction

Textile Roofs 2025, the twenty-seventh International Workshop on the Design and Practical Realisation of Architectural Membranes, took place on 25–28 May, 2025 at the AEDES Architectural Forum, Berlin, and was chaired by Prof. Rosemarie Wagner (Karlsruhe Institute of Technology) and Dr.-Ing. Bernd Stary (Academus GmbH). It was attended by 81 participants from 21 countries covering four continents. Once again, the attendance demonstrated the success of the event, which has become firmly established since it was first held in 1995.



1 History

Structures. Then and now - Prof. Ruy Marcelo Pauletti, University of Sao Paulo.

Professor Pauletti made a long journey in a short time showing the footprint that men leave on the earth, regarding the world of structures. He highlighted the progressive decrease of the self weight in relation to the loads to be supported (figures 1 and 2), until the middle of the XXth century when finally the structure became lighter (figure 3).

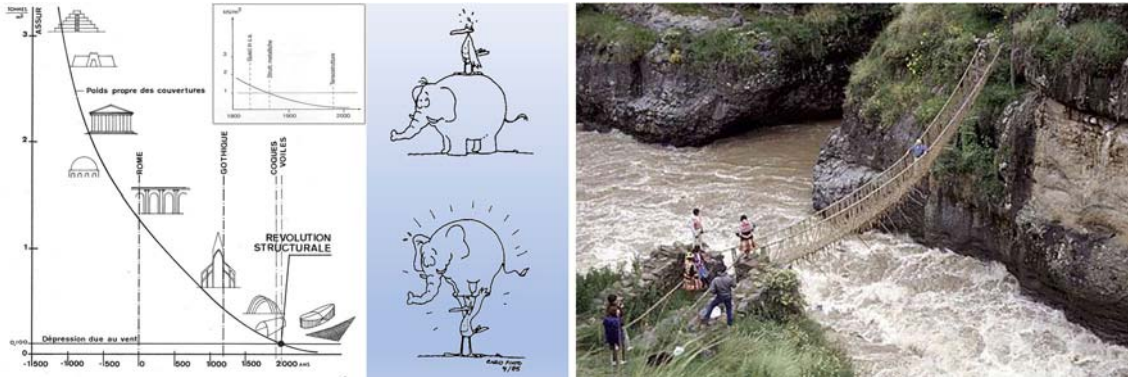


Figure 1: Self-weight through history (R.Sarger, 1967). Figure 2: Detail (M.Majowiecki, 2012). Figure 3: From more self weight than load (top) to more load than self weight (E.Pinto, 1985).



Figure 4: Rope suspension bridge under tension.

The application of ropes and cables in the construction of suspended bridges (figure 4) and roofs (figure 5) began a commented slide show that also featured cable-stayed bridges and structures as well as spoke wheels and tenesgrities. Reference was also made to compression and bending illustrated with natural (figure 6) and artificial arches, skyscrapers and intricate patterns (figure 7).



Figure 5: Dulles Airport. Figure 6: Rainbow bridge, Utah. Figure 7: Intricate pattern (Louvre Abu Dhabi)

Some clarifications were made regarding the difference between suspension bridges and cable-stayed bridges (figure 8).



Figure 8: Suspended and cable-stayed Brooklyn Bridge

2 Design

Textile roofs: building system or architecture? - Prof.J.Llorens, School of Architecture, Barcelona.

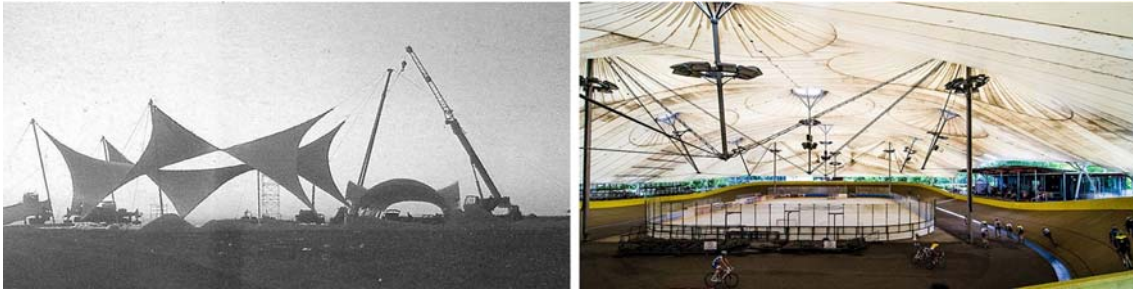


Figure 9: Tensoforma. Bretella Autostradale. Figure 10: sbp. Wolfgang-Meyer Sportanlage, Hamburg.

Most literature and contributions referred to textile roofs structures deal with engineering issues as if they were only a building system. Form finding, computer modelling, patterning, energy consumption, life cycle analysis, materials or project descriptions are preferred topics. But the architectural characteristics have been very little addressed which does not favour appropriate applications, to the point where the paradox of heavy lightweight structures occurs. Therefore, the architectural and urban characteristics of the tensioned surface structures have been reviewed, illustrated with references to the history of architecture and works completed to date.



Figure 11: SMS Campus. Figure 12: Ephesus Roman terrace house. Figure 13: Levante Stadium

Membranes can completely configure the architectural space (figures 9,10) but they can also be used dialoguing with conventional structures (figure 11) or hybridized (figure 12). The variability of forms is one of their hallmarks, that allows to fit a wide range of building footprints, a feature that makes them very useful for refurbishment (figure 13).



Figure 14: Plasencia Congress Centre

Figure 15: Textile hall clad with fabric.

They can even be used only as enclosure (figure 14) or cladding (figure 15), but in these cases the spatial configuration, (that is architectural), is given by the rules of steel or concrete. The membrane becomes a building system only, which is not without interest as demonstrated by the growing number of textile facades and claddings being built.

Computational modelling of lightweight tensile structures - Dipl.-Ing.Jürgen Holl, technet GmbH.

Membrane structures are lightweight, load-bearing systems primarily under tension. Their form is not free, it results from a balance of acting forces. This is why a key concept is form-finding, the process of finding a shape in equilibrium with a favourable distribution of membrane stresses, considering aesthetic and building aspects. It can be approached physically (to gain direct knowledge) and digitally (for a fast and intuitive shape generation, calculation of equilibrium states and integration into digital planning workflows).

In terms of mechanical description, textile membranes are defined with warp, weft, crimp and shear stiffnesses with additional boundary conditions for pneumatic structures. The static analysis has to ensure structural safety, guarantee serviceability, size and optimize components and check the global and local stability, avoiding buckling, collapsing, or local failure.

As for the model, the systems (membrane and supports) should not be separated, pneumatic systems should consider the gas law and the form finding should consider bending elements. The separation of the structure into different subsystems (membrane, steel sections and cables) leads to inaccurate results and increased costs as has been illustrated in previous editions of Textile Roofs.

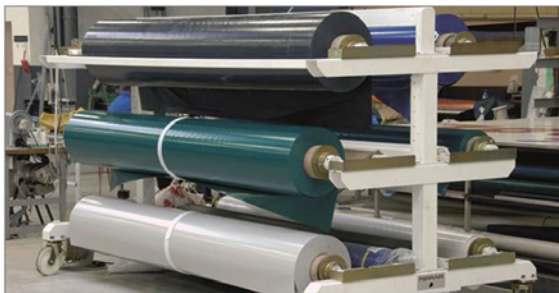


Figure 16: flat fabric panels

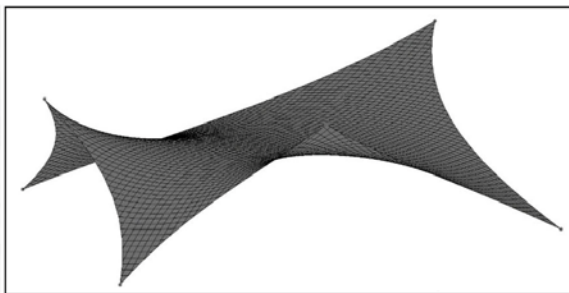
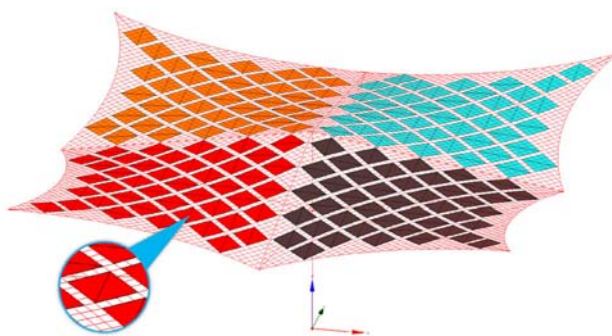


Figure 17: 3D curved pre-stressed surface

Regarding the cutting pattern, flat fabric panels have to be converted into three-dimensional curved pre-stressed surfaces according to efficient flattening strategies, minimizing material waste, compensating for elongations under tension, checking the length of the corresponding seam lines and evaluating the results.



Figures 18 and 19: lightweight cable structure covered with PV modules.

Application: Design and development of lightweight cable structures with innovative photovoltaic modules for the architectural and energy upgrade of urban and residential environments including the development and construction of a lightweight equidistant cable net covered with PV modules including the energy yield in the planning (figures 18 and 19).

Lightweight footprint: membrane design - DI Dr.techn. Robert Roithmayr, formfinder GmbH.

Robert Roithmayr recalled basic aspects of membrane design such as curvature, sagging, waterponding, wind load, geometry and proportion. He also showed the 3D scan facilities provided by "formfinder", the design tool for proper design of tensile pre-stressed surfaces with light footprint. So that the environment can be scanned precisely to define a boundary and create a mesh (figure 20).

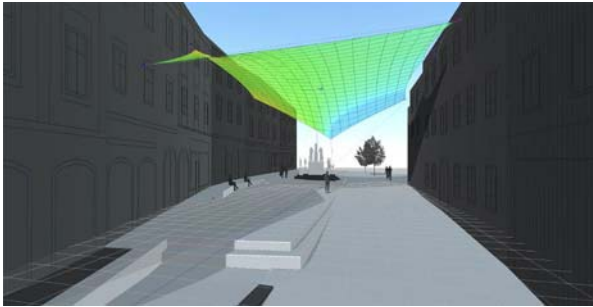


Figure 20: Scan of the environment and mesh.

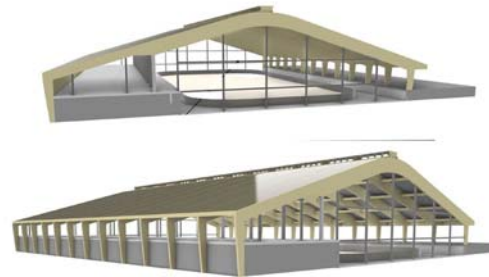


Figure 21: Indoor skating ring.

The second part of the presentation was dedicated to Strategyfinder, a software platform to work with complexity. It enables a distributed team to visualize interconnections, uncover deep patterns and develop effective solutions. Working in distributed teams online has unique challenges since online discussions can be confusing and hinder progress. Instead Strategyfinder assists the collaborative work clarifying complex issues and making informed decisions. All voices are heard, interconnections become visible and shared insights emerge providing structures, method-based workflows to help teams understand complexity and develop sound, actionable solutions. It was illustrated with the design of an indoor ice skating ring (figure 21).



Figures 22 and 23: FlectoLine façade.

He finally showed the "FlectoLine Façade", the first large scale active outdoor demonstrator of responsive fiber reinforced façade shading elements to harmonize with their environment minimizing building energy consumption while maximizing comfort and functionality (figures 22 and 23). The system calculates optimal panel angles by continuously analyzing real-time and forecasted inputs, ensuring efficient operation throughout the day and balancing occupant comfort, energy efficiency, and renewable energy generation. Thin-film organic photovoltaic cells are incorporated into the design to harvest solar energy, ensuring the responsive façade sustains its energy needs independently.

Beyond specialization: the expert's role in lightweight tensile fabric structures - Raju Mahadevan, Techno Specialist Consulting Engineers.

Raju Mahadevan introduced Techno Specialist Consulting Engineers as a civil and structural engineering company, committed to providing services taking up complete solutions for tensile fabric structures, roofs and canopies. Their specialized services cover all aspects of tensile fabric structures, encompassing feasibility studies and engineering, from the manufacturing to the installation processes. Projects include retail, leisure, health, residential, commercial, entertainment, institutional, transportation and sports, that require these kind of specialized engineering services: schematic design, detailed design development, structural analysis, production details, fabric patterning, tender specification, construction documents, third party review, checking, cost evaluation, analysis, value engineering and construction support services.



Figures 24 and 25: Anantara Resort, Sri Lanka

For the Anantar resorts in Sri Lanka the client challenge was to construct an iconic structure in the form of a coconut shell (figures 24 and 25). Techno Specialist was appointed directly by the client to support the fabricator to address the needs of the architect. In this case the fabric acted only as a cladding that had to comply with the geometry of the tilted ellipsoidal domes.

The challenge of the tensile fabric roof for the Nagpur metro station was to build a unique structure above a working station supported by the existing steel structure (figure 26). The role of Techno Specialist was to work in entire coordination with multi-disciplines and seek authority approvals including erection strategy. A combination of translucent and opaque fabrics was chosen to play with the shading.



Figure 26: Nagpur Metro Station



Figure 27: Gulf Fab Shade, Dubai

The Ø120 m cable supported structure for shade in Dubai needed comprehensive engineering from concept to detailing together with methods for fabrication and installation. They included tied tapered columns, cost optimization, generation of BIM models, adoption of CKD for framing aimed to quick installation and the generated fabric patterning using the Technet Easy software (figure 27).

3 Projects

Designing for the future: embracing lightweight materials in versatile architectural solutions. Antonio Diaferia, Maffeis Engineering SpA.

Antonio Diaferia showed 3 recent examples of application of membranes as building systems for exterior and interior envelopes.



Figure 28: Sulaibikhat Stadium, Kuwait - Figure 29: Under Armour building, Baltimore -

The first was the Sulaibikhat football stadium in Kuwait that covers an area of 102.000 m² for 15.000 spectators (figure 28). Maffeis Engineering for Taiyo Europe GmbH carried out the full design of the ETFE cladding system including clamping and air distribution layout. Its roof and façade are clad with double layer ETFE inflated cushions anchored directly to the steel structure, with no need for sub-frame. The outer layer is printed to provide protection from solar radiation while the inner layer is transparent ensuring natural light transmission inside the stadium concourses. the cushions are completed with upper suction cables and lower ponding cables.



Figure 30: Temporary ceiling, Grand Palais, Paris.

The ETFE façade of the Under Armour building in Baltimore offers a fluid continuous surface that envelops the building without adding excessive structural weight (figure 29). It is a second skin for solar control and architectural expression, installed as a single-layer printed membrane allowing diffused daylight to penetrate, minimizing glare and reducing energy loads. With a thickness of 500 µm, it is stretched across a series of vertical steel trusses fixed to the timber slabs. The edges are secured using aluminium clamping profiles, while horizontal stainless-steel cables provide additional tension control and wind resistance.

The third example was the added ceiling to the Grand Palais, Paris, to host the Olympic Fencing Games (figure 30). A temporary shading solution was needed to protect the interior from direct sunlight without invasive anchoring and preserving the integrity of the historic structure. A PVC-coated polyester fabric was selected for its shading capabilities, fire resistance and light diffusion properties. It was suspended delicately across the vast spans, shaped to evoke classical drapery and respect the elegance of the architectural space. A previous mock-up made it possible to reduce the seams to a minimum.

Transparent and translucent roofs in open spaces. Bernd Stimpfle, form TL.

With a collection of works made by form TL, Bernd Stimpfle illustrated the performance of the translucent and transparent membranes that provide not only protection against environmental impacts because they enrich the architecture by creating comfortable places. Structural membranes are characterized by their low self weight, wide span and high light transmission. The wide range of available materials gives many possibilities for architectural applications (figures 31 to 45).



Fig.31: Bundestagsarena



Fig.32: Meilenwerk



Fig.33: Botanic Garden Arhus



Fig.34: Tropical Islands



Fig.35: Bushhof Aarau



Fig.36: Lilienthalhaus



Fig.37: TemporActive Pavilion



Fig.38: SMS Campus



Fig.39: Velodrome Abuja



Fig.40: Luigi Einaudi Campus Torino



Fig.41: Zénith Strasbourg



Fig.42: La Nuvola, Roma



Fig.43: Batumi Stadium



Fig.44: Raumwelten Pavilion - Lichtwolk



Fig.45: Park Belval

Translucent material provides shading, but in comparison with metal or other opaque materials, still a reasonable amount of natural light under the roof is provided. Transparent material like ETFE opens the view to the sky. Even with a dense printing still a relative clear view is possible so that also clouds and birds can be seen. Whereas in the evening or at night, illuminated membranes appear like a bulb, coloured or white and they can be used as projection screens.

Integration of computational and CAD software in membrane structure projects - Lukasz Dlucik, abastran sp.z.o.o.

Lukasz Dlucik presented his company "abastran" dedicated to structural membrane design and implementation using SolidWorks, easy, Sofistik and AutoCad software. He showed some of their completed works such as the ETFE Kedzierzyn Kozle 2020 and the PVC summer amphitheatre in Szczecin, 2022.



Figure 46: Activity Centre, Kedzierzyn Kozle Figure 47: Summer Theatre, Kasprowicz Park

The skylights of the swimming pool of the Activity Centre in Kedzierzyn Kozle have been covered with two longitudinal ETFE cushions with a total area of 102 m² (figure 46). They are stretched over the steel frames of the building and provide natural light. Additionally, the air supply system keeps the cushions in the right tension, which guaranties their durability and proper shape.



Figures 48 and 49: Summer Theatre, Kasprowicz Park

The Summer Theatre in Kasprowicz Park is the cultural centre of Szczecin and its architectural icon (figures 47 to 49). It is one of the largest facilities of its kind in Europe. Designed by Zbigniew Abrahamowicz in the 1970s, it has been the venue for many important cultural events ever since. The reconstruction was carried out according to the winning concept of the British architectural firm Flanagan Lawrence, which aimed to preserve the original symbol of the amphitheatre - the reinforced concrete arch. In addition, the new roof was designed as a structure composed of membrane rhombuses, lined with special acoustic fabric on the underside to improve significantly the acoustics, which is crucial for the reception of musical and theatrical performances.



Figures 50 and 51: tent-like structure

Last example was a tent-like structure supported by wooden A frames without concern for visible joints (figures 50 and 51).

4 Research

Tensile structures and energy benefit? Rosemarie Wagner, Karlsruhe Institute of Technology.

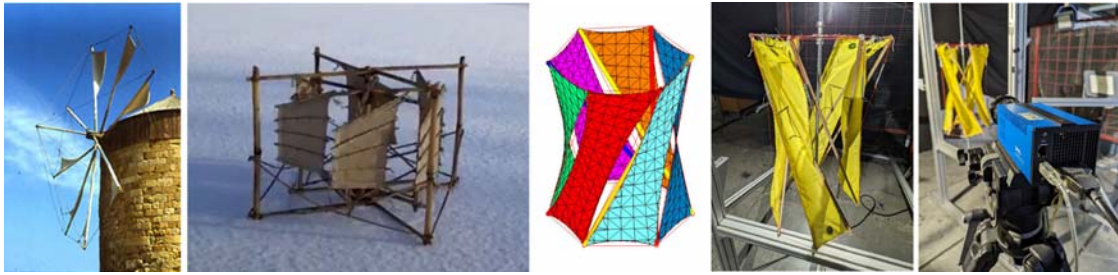
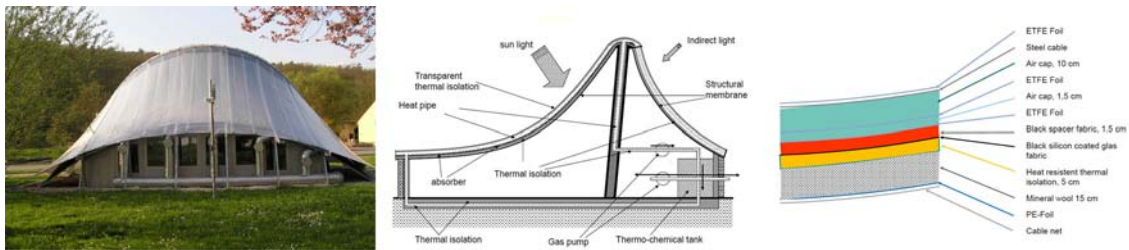


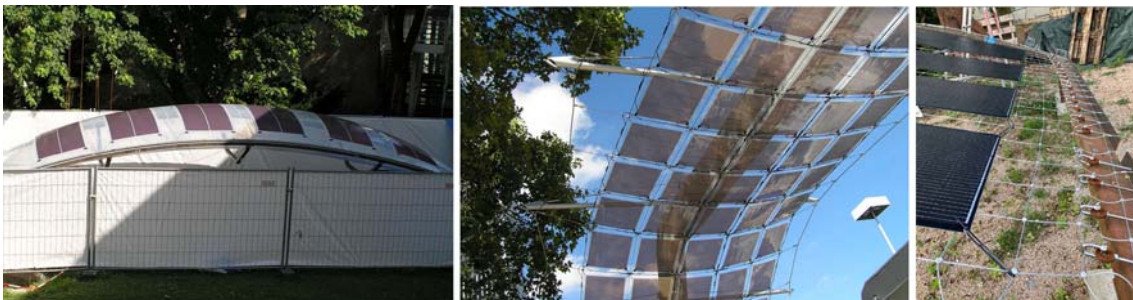
Figure 52: Mandrakis windmill - Figure 53: Chinese windmill - Figures 54 to 56: computer and physical models and test of vertical axis windmills

Prof. Rosemarie Wagner discussed some tests carried out to harvest wind and solar energy from membranes. As for the wind, in addition to traditional solutions (figures 52 and 53), vertical axis windmills have been tested (figures 54 to 56).



Figures 57 to 59: Energy efficient textile building, Denkendorf.

She mentioned the energy efficient textile building, experienced in the Deutsches Institute für Textil und Farserforschung, Denkendorf, inspired by the polar bear as solar collector complemented with seasonal chemical heat storage (figures 57 to 59). It was based on a multilayered membrane, including foils, black collector, insulations, spacers and cable nets. Their combination resulted in an energy independent house with high solar and storage efficiency, able to manage the harvested energy in a seasonal level. The energy of the summer time is stored to winter time, where it is needed without any technical losses.



Figures 60 to 62: PV modules with membrane, cable-net and detail.

She noted that the supposedly promising solution of combining PV modules with membranes faces the problem that PV modules are not flexible enough (figure 60). To keep them flat, they could be fitted into a double curved cable net, resulting in an energy harvesting and sun protection device, which could be favourable for certain crops (figures 61 and 62). If a complete enclosure were necessary to obtain 100% coverage for waterproofing, a continuous membrane would have to be added, which would increase the cost considerably.

Textile potentials. Of soft constructions and active materials. Prof. Christiane Sauer, Weißensee School of Art and Design.

Professor Christiane Sauer proposed the use of fabrics, beyond passive and complementary applications for specific purposes to become a means of constructing, as the pioneers of textile construction did. Since ancient times, curtains have been used to configure or complete interior spaces (figures 63 to 66).



Changing the space with curtains: 63: Lily Reich & Mies - 64 and 65: Shigeru Ban - 66: Aires Mateus-

She led the research "Architectures of Weaving" to encompass not just the crossing of warp and weft on a loom, but all textile construction techniques, as well as theoretical approaches such as woven mathematical topologies, and political contexts such as social fabrics or even trans-species practices like bacterial weaving. She presented several examples beginning with traditional practices such as woven bamboo houses (figure 67) and black hair tents (figure 68).



Figure 67: Woven bamboo house - Figure 68: Black hair tent - Figure 69: paper bridge.

The woven paper bridge was inspired by muscle contraction. Two paper stacks were fixed and interleaved. Upon pulling the two stacks apart, a perpendicular force is created that holds the sheets together at the overlap region. As a result, the total friction between the sheets grows exponentially. A 4,5 m length bridge was built which, with a weight of 55 kg, is capable of supporting 400 kg (figure 69).

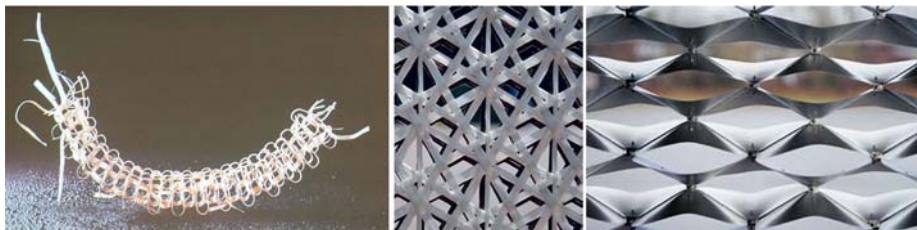


Figure 70: Humidity changes the form - Figure 71: Adaptex Mesh - Figure 72: Adaptex Wave.

Wooden filaments can be triggered by environmental stimuli such as temperature or humidity. The cell walls of wood consist of cellulose micro fibrils that swell with humidity (figure 70). This causes the plant structure to move, twist or bend in relation to the angle and orientation of the micro fibrils, so its behaviour can be programmed. Shape memory alloys (SMAs) are smart metals that react to temperature by changing shape. The research prototypes *Adaptex Mesh* (figure 71) and *Adaptex Wave* (figure 72) use the SMA wire as filament for a textile structure. This enables to transfer its performance onto a building scale using temperature to close or open their textile structure.

Self-cooling textiles. Energy free method using radiative cooling technology - PD Dr.-Ing. Thomas Stegmaier, DITF, Denkendorf.

Due to climate change, population increase, and the urban heat island effect (UHI), the demand for cooling energy, especially in urban areas, has increased and will further increase in the future.



Figure 73: Conventional solution for cooling - Figure 74: Silver ant - Figure 75: Triangular geometry.

Conventional solutions for cooling consume a lot of energy and produce additional waste heat and CO₂ emissions (figure 73). Instead, nature offer heat protection when needed. It is the case of the silver ant (figure 74), one of the land creatures best adapted to high temperatures of the Sahara, Sinai and deserts of the Arabian Peninsula under >50°C daytime temperatures. The heat protection enables the silver ant to come out of their nest at lunchtime to look for heat-stricken animals. Due to its hair triangular geometry, the light is completely reflected back, depending on the angle of incidence (figure 75).

Technologies such as radiative cooling offer a sustainable and energy-free solution. Radiative cooling is a common process in which a surface loses heat through thermal radiation. Effective daytime cooling is realized when the emitted thermal radiation exceeds the absorbed solar and atmospheric radiation (figure 76)

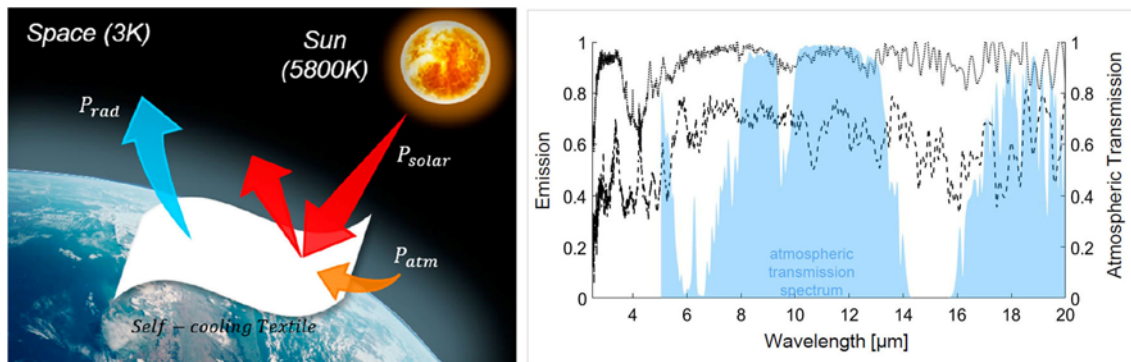


Figure 76: P_{solar} : solar radiation; P_{atm} : atmospheric downward radiation; P_{rad} : thermal radiation between 8-13 μm . - Figure 77: Upper curve: textile with cooling coating. Lower curve: textile without coating.

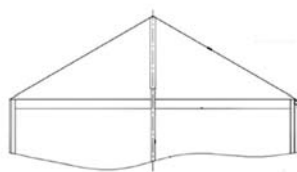
This research describes the development of a novel substrate-independent coating with spectrally selective radiative properties. By adapting the coating parameters and combining low-emitting and solar-reflective particles, along with a matrix material emitting strongly in the mid-infrared range, substrate-independent cooling below ambient temperature is achieved (figure 77) .

Moreover, the coating is designed to be easily applicable, with a low thickness, to ensure high flexibility and scalability, making it suitable for various applications such as membrane architecture, textile roofs, or tent construction. The results show a median daytime temperature reduction.



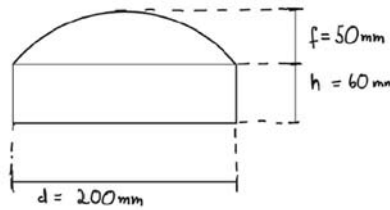
Figure 78: Biogas storage with membranes.

Oliver Lippert attempted to compare different guidelines for the static analysis of biogas membrane storage systems (figure 78), including the DWA-M377 "Biogas storage systems–Ensuring the usability and load-bearing capacity of membrane covers" and DIN 4134 "Air-supported structures; structural design, construction and operation".



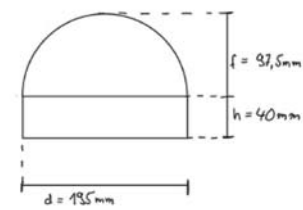
d = 40 m
h = 5 m
height of mast = 10,3

Figure 79: cone shaped



d = 20 m
h = 5 m

Figure 80: 1/4 calotte



d = 20 m
h = 5 m

Figure 81: hemisphere

Models included were the cone shaped (figure 79), 1/4 calotte (figure 80) and hemisphere (figure 81) considering inner pressure, wind (pressure or suction) and snow loads.

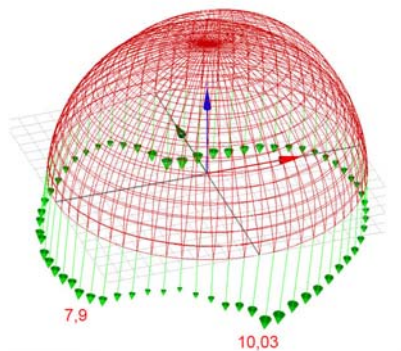


Figure 82: DIN EN resulting forces

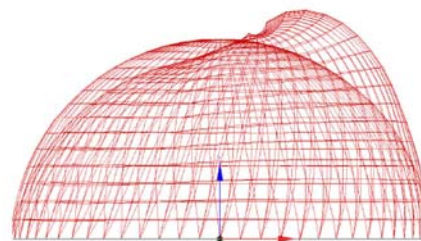
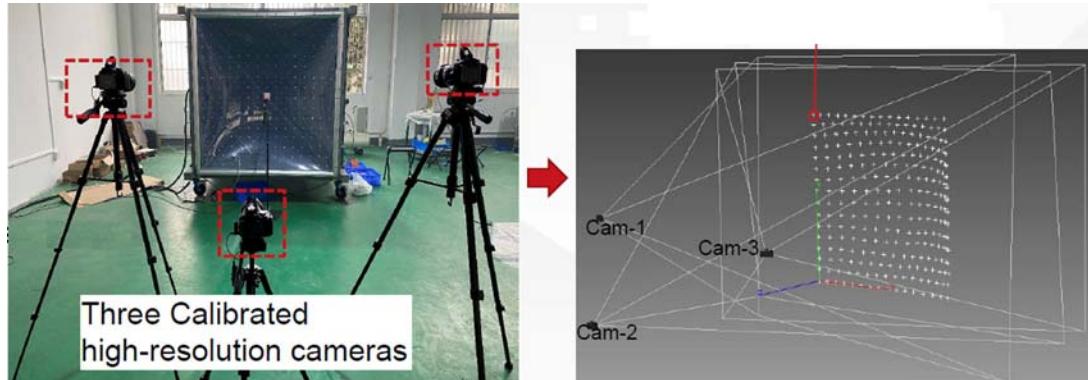


Figure 83: DIN EN deformation x 3

He showed the results regarding stresses, forces (figure 82) and deformations (figure 83) finding significant differences. The study could have been more complete including different temperatures, pressures, volumes, filling level of biogas and material properties.

A Photogrammetric based method for surface stress and strain measurement - Xuetao Zhao, Shanghai Jiao Tong University.

Xuetao Zhao presented an interesting method for measuring strains based only on geometry, assuming that the stress/strain relationship is known. It is based on photogrammetry and applicable to large surfaces.

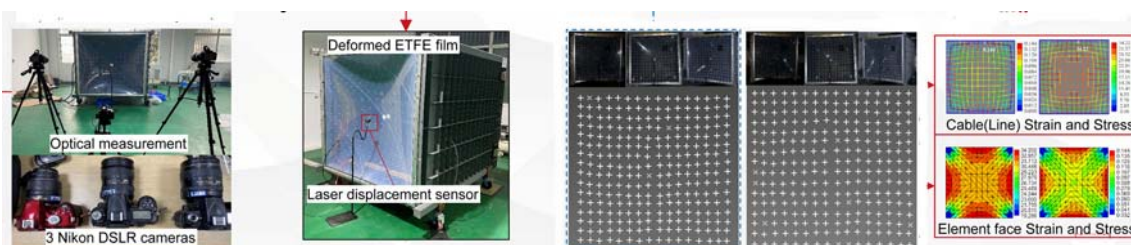


Figures 84 and 85: high resolution cameras and 3D measurement.

The surface, previously marked with reference points, is photographed with high resolution cameras (figures 84 and 85). Deformations are measured and stresses computed.

Two methods were applied:

- 1) from the virtual cable network the elongations were measured, the cable strains and, the cable stresses (resorting to stress-strain curves).
- 2) from triangular face elements delimited by the surface point-cloud array, the deformed geometry is measured, the element strains and from this data the element stress distribution.



Suction load	4 kPa				12 kPa			
	Max LE	Error	Max S	Error	Max LE	Error	Max S	Error
Method 1	0,02	-13%	17,36	-4,2%	0,152	-4,4%	34,70	+2,8%
Method 2	0,021	-8,7%	17,57	-3,1%	0,152	-4,4%	34,68	+2,8%
FEA	0,023	-	18,14	-	0,159	-	33,73	-

LE=principal strain; S=principal stress

Figure 86: verification of the two methods employed (cable network and triangular elements) and results

The procedure was verified testing an 1x1 m ETFE specimen together with a finite element analysis which led to the following conclusions:

- The two methods are valid and accurate for measuring strains in large sizes and deformations.
- The computation complexity of the triangular element method is higher but its results are more precise.

Some limitations were also mentioned:

- The constant strain element assumption is no accurate enough in large size surfaces.
- Stress estimations depend on material properties which rely on tests.

5 Products

Modern solutions for traditional requirements: Antalya fruit wholesale market - Bahadır Senol, snl tensi

SNL tensi is specialized in steel wire ropes and load tensioning elements, with expertise in tensioning systems and providing steel wire ropes and fitting equipments with in-house production capabilities delivering fast project-specific solutions with technical support.

For centuries, marketplaces have been the heart of civilizations, where merchants trade, cultures meet, and communities thrive. Despite the passage of time, the demand for reliable, durable and aesthetically pleasant shading systems has remained constant. Increase of efficiency, reduction of energy consumption and sustainable agriculture can be reached by combining traditional market needs with modern technology. As the demand for high-quality agricultural products grows, so does the need for well designed market infrastructures, such as the Antalya Wholesale Fruit Market. The goal is to protect the products from the harsh sun and heat, create healthier storage conditions and improve productivity.



Figures 87 and 88: Antalya wholesale fruit market.

The Antalya Wholesale Fruit Market Project required a custom-designed shading system to increase market functionality and efficiency, with 5.000 m² of total shade area (figures 87 and 88).

The approach of snl tensi focused on:

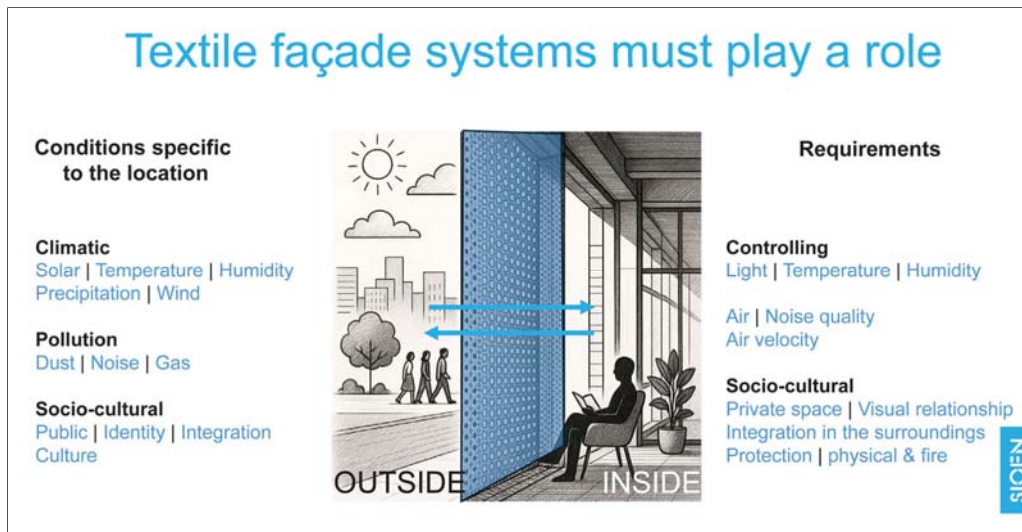
- High-strength steel cables and membrane materials, ensuring resistance to Antalya's high temperatures and strong winds.
- Light and robust design, maximizing coverage while minimizing structural loads.



Figure 89: Misir Mall of Arabia - Figure 90: Atakoy International Youth Centre, Istanbul - Figure 91: FIFA Dünya Kupası.

Other realizations are the Misir Mall of Arabia, the Atakoy International Youth Centre, Istanbul and the FIFA Dünya Kupası (figures 89 to 91)

Beyond the surface: the art and science of architectural façade mesh -
Maxime Durka, Sioen.



New Sioen façade meshes were presented by Maxime Durka for the purpose of satisfying specific conditions and requirements (figure 92).



Figures 93 and 94: King Saud Medical City, Riyadh - Figure 95: King Fahd National Library, Riyadh



Figure 96: Luna Rossa America's Cup Base, Valencia - Figure 97: "Cours d'Appel", Fort de France -
Figure 98: Al Bahar Towers, Abu Dhabi

Among many applications, he mentioned:

- improvement of energetic performances, as in the King Saud Medical City, Riyadh (figures 93 and 94)
- creating additional structures on top and around existing buildings as in the King Fahd National Library, Riyadh
- reusing sails, as in the Luna Rossa America's Cup Base, Valencia (figure 96)
- creating transitions as in the "Cours d'Appel", Fort de France (figure 97)
- reducing noise pollution as in the Central St.Giles Court, London
- lightweight sustainable building practices such as passive airflow, solar shading and visual privacy as in Al Bahar Towers, Abu Dhabi (figure 98)
- creating iconic structures as the Burj Al Arab Hotel, Dubai and the Thyssen Krupps Tower, Rottweil.

In short: building pertinent systems with adapted materials.

Textile netting constructions: from granulate to the application - Achim Wichtler, Manfred Huck GmbH.

An introduction to the nets produced by Manfred Huck GmbH was presented, comprising around 1,000 different types of knotless nettings. It is a wide variety of nets with thicknesses ranging from 0.5 to 22 mm, mesh openings between 5 and 360 mm, various mesh designs and colours. General, safety related requirements and test procedures are regulated by "EN 1263 (1) Safety nets" and "EN 1176 Playground equipment and surfacing"

Manufacture is divided into two processes: the net fabric (with its production, cut and connection) and the confection of the net overlapping the edges and pulling in the edge ropes. In the case of knitted, knotless nets made of multifilament yarns, the manufacture in a large machine width means fewer joints in the mesh panel for higher quality and productivity. In the braided knotless nets the yarn is braided, not knitted. As a result, the net has minimal elongation and high breaking strength suitable for cages for American football, cricket, baseball, catamaran nets and work platform nets (figure 99).

	Construction	Flexibility	Durability	Application
Knotted	Individual ropes are knotted or connected at the knot points. Knots provide stability	Knots restrict the flexibility of the ropes.	Knots can curl, loosen or wear out over time. The durability is reduced by displaced knots	Fishing Sports Agriculture
Knotless	Smoother surface and less material	The nets are more adaptable and soft	More stable and higher structural durability	Building Industry, sports, safety nets

Comparison of knotted with knotless meshes. Knotted meshes are not as flexible as knotless meshes and therefore they are more suitable for applications that require more stability.



Figure 99: Work platform net - Figure 100: Side protection (railing net) - Figure 101: wire rope net for enclosure and protection - Figure 102: Horizontal net for fall protection - Figures 103 and 104: 685 kg rock fall test on Ø 6 mm wire rope net, mesh size 100 mm and specially produced steel frame

Wire rope nets are also possible for enclosure and protection of playgrounds and sport fields (figure 101) and horizontal nets for fall protection (figure 102).

6 Manufacture

High frequency welding solutions - Björn Bojara, FIAB HF

Principles of HF-Technology:

- Material is placed between upper and bottom electrodes (under pressure)
- Upper electrode is connected to RF supply (moves up and down during welding)
- Lower electrode is connected to electrical earth
- RF generator converts energy from supply network to radio frequency (usually 27,12 MHz)
- Dipole polarization process (orientation of dipoles is changing 27 mln times a sec to follow reversing electric field)
- Internal molecular friction heating
- Materials melt and fuse to produce a strong weld.



Figure 102: FIAB Welding machines

The range of FIAB welding machines (figure 102) for tarpaulins, halls, roofs, furniture, automobile industry, tents, outdoor advertising, stretched ceilings, water and gas tanks and oil barriers (among others) includes:

- FIAB 960 with Impuls welding: 2 in 1 machine with quick switching between the two welding technologies.
- FIAB 860 and FIAB HPS mini new welding solutions smaller and cheaper.
- FIAB Spider XYZ for large pieces.



Figure 103 Projects made with FIAB machines

A selection of projects made with FIAB machines was also shown (figure 103).

7 Maintenance

Give a little love to your structure - Aoife Brennan, Fabric Architecture.

Aoife Brennan made a timely call to action regarding the need for maintenance (figures 104 to 106). She mentioned the need for extending the life cycle, reducing the carbon footprint and extending the customer satisfactions.



Figures 104 to 106: Maintenance and inspection.

Canopies can be subject to vandalism, wind damage, dirt and grime, missing sections, lack of care and lack of knowledge (figures 107 to 109). Focus is needed on installers, fabric components, cables, fixings, steelwork and also increasing the awareness of the costumers.



Figures 107 to 109: What can go wrong?

Maintenance must be considered. A proactive maintenance programme is recommended that could mean the difference between the structure lasting 10 years or 50 years. Cleaning tensile fabrics preserves their long-term integrity – this should happen every 12 months with warm soapy water. It's important to design access for this maintenance into the structure with lugs for harness connections to enable appropriately qualified riggers to walk safely on the canopies, which can easily support the weight of several people.



Figure 110: Chester Racecourse by Fabric Architecture

Inspection and maintenance can be carried out by specialized companies such as Fabric Architecture, that also develops, manufactures and builds projects of tensile fabric structures (figure 110).

8 Practical project and workshops

Experimental project Aedes Gallery. Formfinding and patterning: Technet GmbH, Dieter Ströbel. Fabric: Sioen Industries NV; Maxime Durka. Welding machine: FIAB Sp. Björn Bojara. Confection (HF): Karsten Daedler, Karl Matthies Webblings (stitching): Stoffdach GmbH, Janek Jeschke. Installation: 3dtext, Stev Bringmann

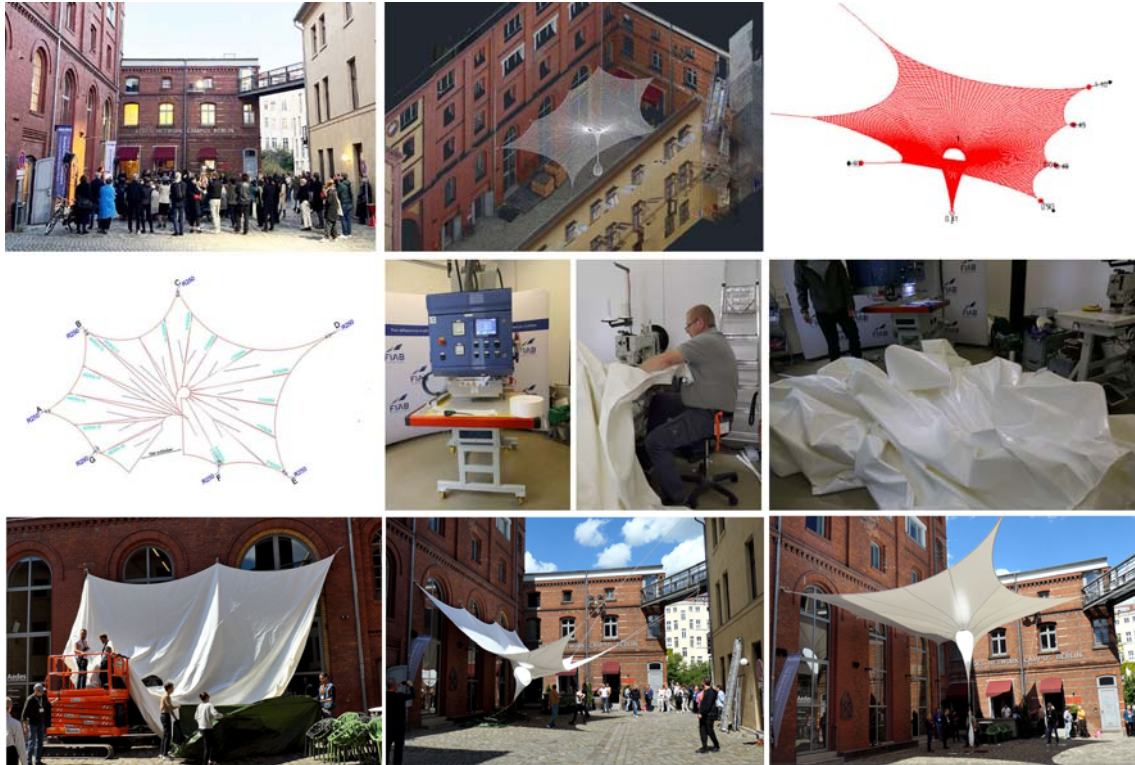


Figure 111: Design and installation of the experimental project.

A temporary cover was designed and built for the Aedes Architectural Forum courtyard. So that the intervention affected the existing building as little as possible, a funnel was designed to be anchored to the walls without drilling and the low point tensioned by a water bag instead of an anchor (figure 111).

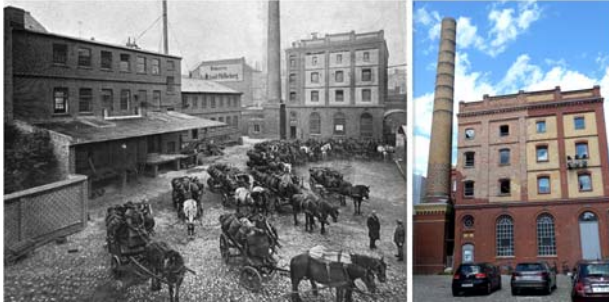


Figure 112: Computer, physical modelling and tension test.

Workshops and tension tests. In parallel, physical (Ruy Pauletti and Josep Llorens) and computer modelling (Technet GmbH) workshops and tensile tests (Claudius Dangel) were carried out (figure 112).

9 The venue, Dunya Bouchi, AEDES Metropolitan Laboratory.

Textile Roofs took place at the AEDES Architectural Forum in the former industrial complex at Pfefferberg in Berlin-Prenzlauer Berg (figures 113 and 114), which has since become home to the studios of artists as well as the Tchoban Foundation, Museum for Architectural Drawing and the ICI Berlin (Institute for Cultural Inquiry).



Figures 113 and 114: Pfefferberg brewery 1900 and today

AEDES Architectural Forum is an internationally independent network platform for the exhibition, discussion and mediation of contemporary space making. It was established in 1980 as the first private architecture forum in the world. It is complemented by the AEDES metropolitan laboratory, founded in 2009, it curates an international discussion and enquiry programme.

Its goal is to foster an interdisciplinary dialogue on spatial design, while framing it within broader societal contexts and provide a space for the next generation of architects and planners to explore and experiment.



Figure 115 (left): Museum of Architectural Drawing -

Figure 116 (right): Russian constructivist drawing.

Also belonging to the former Pfefferberg brewery, the Museum for Architectural Drawing (figure 115) appears as a striking four-storey solid corpus made of sculptural concrete topped by a glass penthouse. It contains outstanding drawings made by architects from the 16th to the 21st century with a focus on Russian Constructivists (figure 116).

10 Social programme.

Textile Roofs was completed with a barbecue in the Aedes garden, the cruise on the "Kaiser Friedrich", built in 1886 and refitted with an emission-free drive system (figure 117), and the workshop banquet at the Pfefferberg Schankhalle in the brewery founded in 1841 by the Bavarian Joseph Pfeffer (figure 118).



Figure 117: Kaiser Fiedrich Figure 118: Pfefferberg Schnakhalle