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PRESENT TRENDS OF TEXTILE TENT STRUCTURES

Thousand years old tradition of the development of the tent architecture forms has come to its breaking point under the influence of Frei Otto´s work in 1954. Although most important elements marking its direction were known already in the 70ies of the last century, a significant progress was achieved thanks to the development of new materials. These materials open for the textile architecture perspectives of considerable application in the new millennium. Nowadays, textile architecture represents the most flexible method of building. It can be proved by increasing number of typological kinds of buildings already built. Mobility and capability of adjusting to the needs of the day belong to the most important contributions. The building practice faces an ever-increasing demand in this direction. Buildings today don't have to last for so many decades or even centuries than they had to in the past. In spite of that there are still only few architects, engineers and investors who would decide for textile architecture when designing a more important building. Elegance of these fascinating forms can attract attention in spite of any argumentation. On the other hand, the complicated spatial curves together with demanding supporting constructions take surprise and thus can negatively influence the final decision.

The form of a textile structure is determined by a suspension cable construction and unlike other constructions by static parameters in much larger extent. One of the demands representing a point of departure when looking for the right form must be an optimal static strain enabling to bridge over as great space as required. Ideal cooperation of the external form and internal pressure forces completes the purity of the form. Organic forms and spatial curves taken over from nature, basic geometrical forms and figures and structures created by application of modified combinations of geometrical figures and geometrical curves belong to the rich sources of inspiration for architects when looking for appropriate forms.

The most frequent examples are, in practice, represented by circular or semicircular modified forms offering an ideal possibility of space closed by domes of considerable dimensions. Pure forms of elementary geometrical figures – enables to simplify the statics of the supporting construction more than impure geometrical forms.

It is the designer's choice that will decide whether an organic form or a geometrical one (verified in practice for so many times) will be used, or if the designer decides to search for a completely new one.

The form of a tent structure must be designed unconventionally regarding the specific qualities of the material. The elasticity of the membrane material, first of all by the multilaterally pre stressed membranes, leads to changes in size compared to the projected size. This influences the dimension of external perimeter, but also localization of high points, panel structures and materials. The project has to take into account the instability of material due to the draught tension. If it cannot keep a constant tension in rational limits life of the technical prefabricates can be reduced considerably.

It is especially important for the project to fix the minimal surface of the area determined by external perimeter line. If this way of designing is not respected, eventual change in loading can cause reduction of the area and lead to folds or ripples.

This is due to the isotropic property of the material, meaning that it is exposed to the equal force influence in all directions like a soap bubble.

There are, in principal, two ways of designing tent structures.

An experimental method, used more frequently in past. This method was grounded on model construction.

An analytic method starts with initial fixing of geometry of perimeter within which is then generated a network with fixed points of membrane.

This mathematic numerical method is based on creating a cable net and construction

structure. This method is able to substitute even a model solution. But this one is necessary especially when shape-demanding designs are concerned.

Small scale of a model and a great plasticity of the material often lead to the fact that aesthetic and structural relations of the designed objects have to be estimated.

The word „ membrane" originates in latin and it originally means parchment or leather.

Subtlety is one of the most important characteristics of the modern membrane materials. If they are applied as pre stressed, loaded special areas, they can take up curved lines. Thanks to the specific qualities of membranes they can be used in exterior, interior, of new buildings but also at reconstructions of internal spaces, at roofing of halls in administrative buildings, at hotels, shopping centres, exhibition pavilions, culture and sport arenas, stadiums, hangars, industrial halls, etc. These are only a few examples of the presently applied forms. Top world companies count on their applying even in cosmic space.

According to the applied manner of membrane tensioning the membranes can be divided into several groups. The most famous are:

- membranes tensioned by means of pressure in a number of ways
- membranes tensioned by means of ballast
- membranes tensioned by means of pressure differences
- membranes set in rotation

The first three mentioned groups of membrane tensioning are the most frequently used. The first way of tensioning uses several ways of membrane tensioning. At all of them, the current mechanical tension arises. It is caused by leather tensioning between high and low points defining the perimeter line. Bearing elements are poles and bearing cables / ropes /. The easiest solution as far as construction is concerned, is the direct anchoring in the ground or draining perimeter, or through tensioning supports anchored by cables to the ground. But this solution has increased demands on the surrounding space.

Rigidity and stability of these structures is attained by double curved surfaces and complementary armouring constructions.

Tensioning by means of ballast is another well-known method applied by construction of membrane structures. This method uses the membranes's weight or gradual loading of the membrane in its final points. The bearing construction is created by cable, wooden or steel-netting structure characterized by the closed static principle. The advantage is that the structure does not require additional space in the surrounding area.

Sufficient rigidity of the armouring construction is a guarantee for the resistance to- wards adverse weather and suction caused by wind. Such rigidity enables to construct buildings with larger span.

Tensioning by means of pressure differences is represented by pneumatic structures, where the inflatable hall is the most common example. This inflatable hall is based on the principle of the internal excess pressure. The bearing construction principle of pneumatic structures is based on pressure differences. The pressure difference can be attained also by means of water or other fillings. Division of the structure to greater amount of independent chambers attains more interesting surface division.

The applied principles of bearing constructions divide objects of pneumatic constructions into high pressure, skeleton or rib, cushion or combined pneumatic structures.

As far as statics is concerned, pneumatics constructions differ from classical objects. Common pressure of the construction on the foundation / basis / is replaced by pull, so it is important to anchor the construction in perimeter or to make it safe against lifting by sufficient loading.

Frequent fitting dismantling connected with seasonal use can cause damage and impairing of the air – tightness of the coat what can shorten the service life of the object.

Architecture of the pneumatic constructions does not use only basic geometrical forms. It is possible to create diverse forms by means of different pneumatic principles in connection with armouring constructions based on wood, steel or concrete.

Plane character of simple parts of the de-tensioned membrane requires certain graduality in the process of construction. The tensioned membrane surface creates triple curving what causes that the greater membrane has to be divided into smaller segment parts – membrane prefabricated part components. After building the bearing construction is the roof exposed to gradual process of tensioning and balancing.

Material of membrane construction is very sensitive in points of bearing and so division of bearing in joints has to be a balanced as possible.

Welding of membrane segments is carried out at greater grounds usually by sewing up the seams, welding the seams or combination of the two ways.

Polyester, PVC prefabricated part components are most frequently welded by means of high frequency welding.

Disadvantage of sewing up of membranes is their perforation, what can cause problems with waterproof ness of the prefabricated part components. Sewed parts are therefore covered with safety strips. Margins of the tensioned membrane are fixed by adding of panels /prefabricated part components/ to the firm periphery by means of cable placed in box, bordering the perimeter of the prefabricated part. Straining of these details by friction and variance of temperature requires a special material fitting – cables and firm membranes joints are therefore made of stainless steel or in galfon coat.

Parts where the greatest pressure is concentrated, are the highest and lowest points of fastening. Therefore membrane is usually in the highest point of the closing supported by cable segment of the cylindrical lining that carries the loading from prefabricated part components to hanging parts. The advantage of pneumatic membranes is their easy fitting and dirmanthing. After the surface coat has been joined into one part and after its anchoring can the whole construction of the object be raised by means of a swelling machine.

Great sizes /of pressurised halls/ of pneumatics objects cause their light weight , so the coat has to be divided for fitting and handling into several pieces. Several ways can be used to join these pieces. Joints however, do not always sufficiently airtight.

A great range of materials can nowadays be used for coating of tent membranes. Just to mention several of them improved cotton fabrics, membranes of synthetics and natural fabrics (PVC, polyester, fibre-glass laminate, glass), metallic covers pleated of thin steel or aluminium sheets /tilts/ foil covers or sandvichlike panels composed of more layers. Polyester based materials are the most frequently used material nowadays. Light permeability belongs to their great advantages moving by different compositions from 15 to 65%. Flontex glass net membranes of PTFE fabric are especially suitable for this purpose. Using a special insert, they can acquire a higher heat – proofing standard. PTFE glass fabric is not combustible, it is dirt repugnant and it has a long life and duration even when exposed to aggressive influence of environment and ultra violet radiation.

Material selection has to take into account loading caused by wind and snow so that sufficient static safety could be offered.

A relatively short services life of membrane structures, represented by fibre – glass laminate PTFE fabrics about 20 years, is a problem that has not yet been solved.

Relatively short service life of tent architecture in comparison with the service life of buildings built by means of traditional construction methods evokes certain doubts as to its value status in architecture is concerned.

Measure of the buildings and their form creativity by keeping competition ability requires application of prefabricated part components. This shows how it is possible to take designed object to pieces, of them arises afterwards an „identical object" and high architectonic quality can be achieved also by applying of industrial methods.

This proves that art of architecture is not a question of material, technology or length of building's existence but rather a question of creation and sensuality.

Lightness and subtlety by the built constructions by prices 30 – 70% lower than prices of buildings built by traditionally and based on traditional materials, by pneumatics structures even only 20 – 30% of costs on comparable units of current objects, predetermine building of this character for wide application.

This open system finds nowadays ever-new ways of application in other spheres.

A great number of interesting architectonic and construction types built in the world shows, how can architects build large – areal objects with sufficient safety using a relatively small base of materials.

It is also a challenge for our architects, designers and investors, to create a piece of architecture, that will – thanks to its exceptionality - disperse their doubts.