

SYMMETRY IN SHAPING OF VARIOUS TYPES OF SPATIAL STRUCTURES

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Publications and/or Exhibitions: Rębielak Janusz: Space structures shaping and visualisation of their digital models by means of Formian, in: Proceedings of the Fifth Interdisciplinary Symmetry Congress and Exhibition, Sydney, Australia, July 8-14, 2001, *Symmetry: Art and Science*, Quarterly of the ISIS-Symmetry, pp. 158-161.

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Abstract: *The subject of the paper refers to some basic rules of the processes of shaping of various types of spatial structures. In the main part it is devoted to the methods of design of lightweight roof structures in particular in forms of the tension-strut systems developed by the author and proposed for various roof covers of large spans. All shapes of the proposed spatial structures were described by means of numerical models. These numerical models are prepared in programming language Formian. This language is based on the formex algebra and uses numerous symmetrical functions. The paper presents a short description of various concepts of the spatial tension-strut structures. One group of these systems is built by means of the especially shaped tetrahedron modules suitably spaced above chosen triangular fields of the triangular-hexagonal grid of struts. Another group of structures is composed of different types of concentric hoops formed also by means of appropriate chosen tetrahedron modules with sets of three or two struts. The symmetry rules have to be respected in the shaping processes of all those structural systems as well as in the procedures of preparing the numerical models of them. Therefore symmetry is easy to notice in the all types of patterns of the proposed spatial structural systems.*

1 FIRST GROUP OF LIGHTWEIGHT ROOF STRUCTURES

The dead weight of large span cover can be an important part of the total design load of a structure. That is why various forms systems of tension-strut structures have attached consideration of engineers and architects. Very spectacular type of the system, called as *cable dome* has been developed by an American engineer David Geiger, Geiger (1986). Roofs of two main halls of the Olympics in Seoul in Korea were built in this system. In this place one should necessary mention about the roof of the Hall "Spodek" in Katowice, in Poland, which was designed by Wacław Zalewski and erected in early 70s of the 20th century, Robbin (1996). Typical forms of these structures have to be suitably pre-stressed and almost all of them need application of a compression ring located along the perimeter of a roof cover. The force distribution between components of an engineering structure should provide the whole system with an equilibrium. That is why the arrangement of component parts of the structure plays a significant role. The symmetric positions of these parts are easy to observe in numerous types of tension-strut structures proposed by the author, Rębielak (2000, 2002, 2003a, 2003b, 2003c).

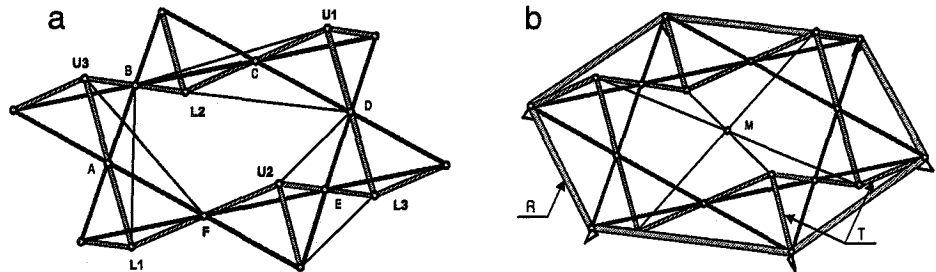


Figure 1: Schemes of two chosen modules of tension-strut structures, a) module of the V(TH)No1 system, b) module of the V(TH)No2 system.

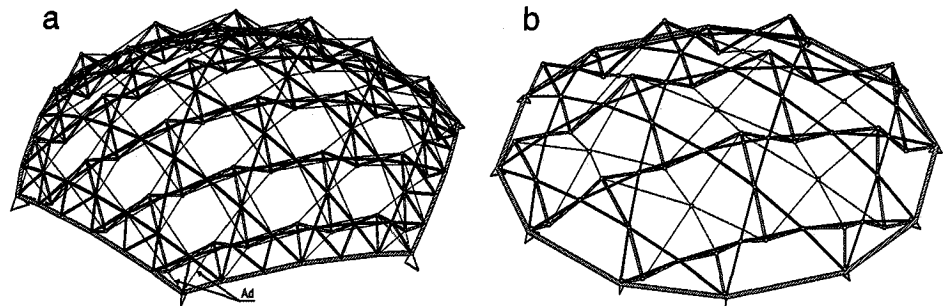


Figure 2: General views of exemplary dome covers designed by means of, a) the V(TH)No1 tension-strut structure, b) V(TH)No2 tension-strut structure.

These two examples of systems, which are shown in Figure 1 and in Figure 2, are formed by means of the tetrahedron modules. The spatial modules are symmetrically arranged around the triangular-hexagonal grid of bars. The grid is located in the middle layer of the structure. Tetrahedron modules are spaced over triangular fields of this grid and the half number of them are placed above this grid and the second half is placed beneath it. Top vertices of the tetrahedrons are connected together by means of suitably arranged sets of tension members by means of which the whole structure has to be pre-stressed. Roof structures designed by means of these structural systems can obtain optional shapes, they can be spaced over each form of the base projection and therefore they do not need the application of the perimeter compression ring.

2 SECOND GROUP OF TENSION-STRUT STRUCTURES

Typical forms of the *cable domes* consist of concentric hoops, which are connected together by means of suitable tension members. The author has developed a numerous family of tension-strut structures, which are composed of especially formed spatial concentric hoops. The morphological aspects of the complex form of spatial tension-strut systems require the applications of symmetry rules in all the processes of shaping of these types of structural systems. The symmetry is easy noticeable not only in the patterns of these structures but also in the shapes of the computing programs defining their numerical models in a programming language. Examples of some chosen forms of these structures are presented in Figure 3 and in Figure 4.

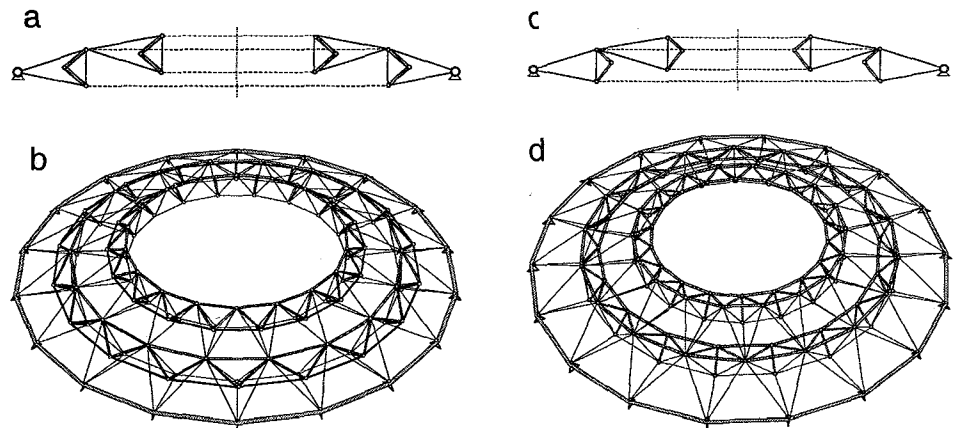


Figure 3: a,b) Schemes of the VU-TensO tension-strut structure, c,d) general schemes of the VU-ComPO tension-strut structure

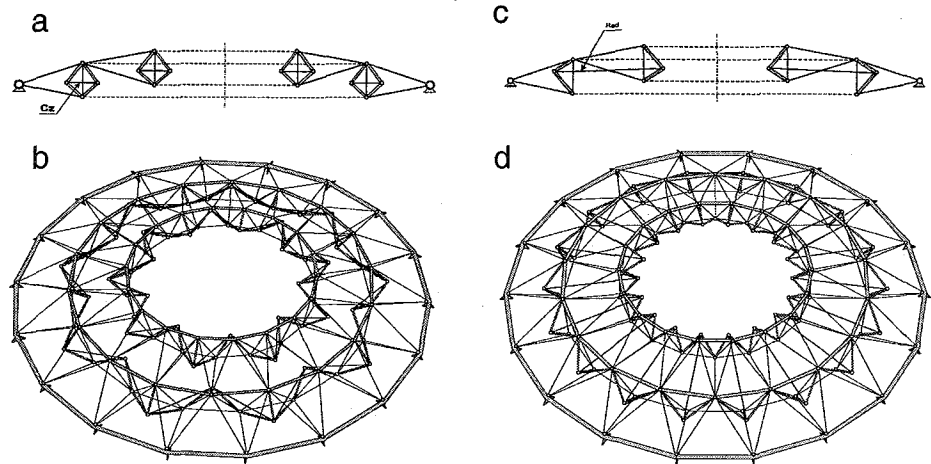


Figure 4: General schemes of the complex forms of the tension-strut structures, a,b) structure VL-TensZ1dO, c,d) structure VUL-1RadO

Roof structures designed by means of the proposed systems can be the lightweight structures capable to be applied as the main support structures of large span covers. They can obtain interesting and individual architectonic views. The numerical models of these structural configurations will be very helpful in the further and comprehensive analyses of all the shapes of the proposed structural systems.

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