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Geometrical Analysis of the Formation of Lattice Structures

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ABSTRACT

The issue of controlling the geometric parameters of lattice structures is considered. Solutions to the problems of transformation of the original polyline by moving the node under various geometric conditions are given.

KEYWORDS: *statics, knot, design, modeling, discrete.*

Unlike solid shells used as architectural coverings, lattice structures in their structural essence represent a discrete structure. The body of such a two-belt lattice structure is a geometrically unchangeable system consisting of specially arranged rods connected at nodes. The presence of two belts, spaced from each other at the distance required by the calculation, provides the necessary rigidity of the structure, and, as a consequence, the load-bearing capacity. As a rule, this distance is significantly greater than, for example, the thickness of the reinforced concrete shell, and therefore the greater construction height of the structure. However, due to the discreteness of the design, this factor does not affect the weight of the structure: both physical (rod structures have a smaller volume of material) and visual (the rhythmic nature of the arrangement of rods, on the contrary, can provide visual ease of perception and act as an ornament).

Based on the discrete nature of the design, it is advisable to use methods of discrete modeling of rod systems, in particular, static-geometric methods, to design lattice structures.

The static-geometric approach to the formation of point frames is based on the compilation of finite-difference equilibrium equations that describe the stressed state of the system. Internal stresses in the rods and external load on the system are geometrically represented as a set of vector forces.

implement this approach about two-belt lattice structures in two stages:

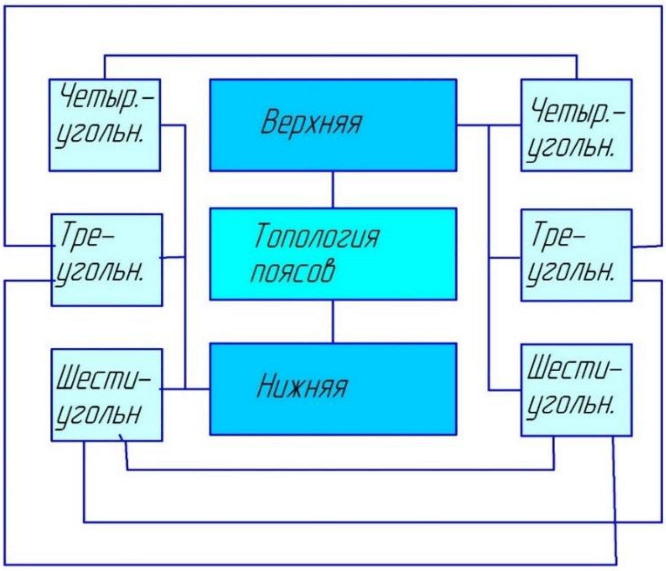
1. Conduct numerical analysis of structures.
2. Derive functional dependencies that describe the equilibrium of structural nodes.

A two-belt lattice structural design is a combination of two mesh structures (belts), the nodes of which are interconnected by connections.

The upper and lower belts of the structure are formed by families of broken lines, the intersection points of which are called nodes. A segment of a broken line connecting two adjacent nodes of one of the families is called a structure connection. The numerical characteristics of the nodes and cells of the system are: the number of connections converging in a common node and the number of connections limiting the cell. Depending on the infinite or finite number of elements, the geometric model of the inspiratory system can be infinite or finite. A closed system limited by cells is called finite. In what follows, we will consider two-belt systems, when the upper and lower parts are formed by a finite number of elements. The two-belt system can be organized in various configurations of cells and nodes on the surface. If the relative position of the nodes and cells of the upper and lower belts obeys some law, then the system is called order. One of the special cases of an ordered structure is a structure in which all cells except the boundary have the same numerical characteristics and all nodes, except the nodes belonging to the boundary, also have the same numerical characteristics.

The upper and lower chords of the system can be formed symmetrical when both belts have the same types of cells or combinations of cells.

The belts of the two-belt lattice structure individually represent network structures. The latter, as shown in [1], are of three types. Possible combinations of networks forming two-pole structures are shown in Figure 1.



Rice. 1. Formation of two-belt lattice structures.

Along with lattice structures made up of rigid rods, structures made up of interconnected trusses can also be considered.

Table 1.

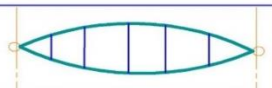
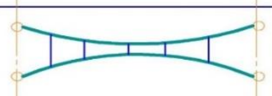
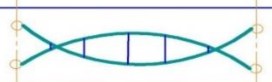
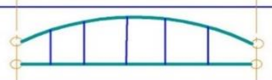
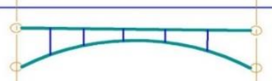
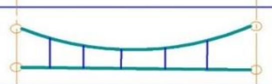
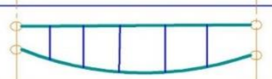
Виды ферм	Верхний пояс	Нижний пояс	Связка поясов
	Вант	Вант	Стержень
	Вант	Вант	Вант
	Вант	Вант	Стержень
	Вант	Стержень	Стержень
	Стержень	Стержень	Стержень
	Стержень	Вант	Вант
	Вант	Стержень	Вант
	Стержень	Вант	Стержень

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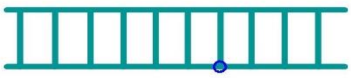
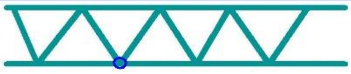
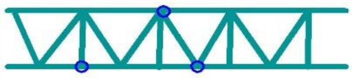
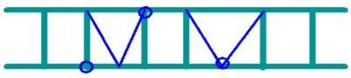
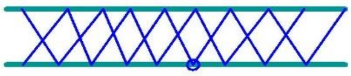
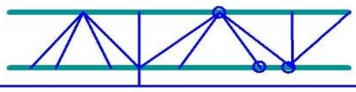
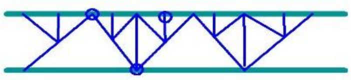
Table 2.

Виды ферм	Типы ячеек	Число связей сходящ. в узле
	четырех-угольные	3-связи
	треугольные	4-связи
	треугольные	3-4-5 связи
	треугольные	3-5 связи
	треугольные-четырехугол.	3-4 связи
	треугольные	4-связи
	треугольные	4-связи
	треугольные	3-5-6 связи
	треугольные	3-4-5 связи

Trusses consist of supporting and stabilizing cables or rods . Prestressing of the trusses is carried out using connecting elements of belts.

There are various types of trusses, differing in the voltage, the location of the chords, and the design of the connecting grid.

In Table I Possible types of trusses used for lattice structures are shown, indicating the types of elements that make them up .

Table 2. The topological structure of the trusses and the nature of their elements are shown.

When implementing the static-geometric approach, an important role is played by the numerical characteristics of the discrete structure, which are different for the two types of structure indicated above. Since the forces in the connections, which determine the type of functional dependence of the finite-difference equilibrium equation of nodes, largely depend on the topological diagram of the structure, the process of parameterization of such structures should be considered in more detail.

Considering the joint work of both belts of the structure, we can talk about four types of efforts that arise in connections:

- external conditional forces acting on a pair of nodes of the corresponding surfaces (forces from the own weight of the coating,
- weight of insulation, weight of engineering equipment, wind and snow loads);
- conditional efforts in the connections of the structure;

- reactions in the reference loop;
- compressive or tensile conditional forces

spacer posts (suspensions).

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