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2. SĒRIJA

**ARHITEKTŪRA
UN BŪVZINĀTNE**

**ARCHITECTURE
AND CONSTRUCTION SCIENCE**

**ARHITEKTŪRA
UN PILSĒTPLĀNOŠANA
BŪVZINĀTNE**

**ARCHITECTURE AND URBAN PLANNING
CONSTRUCTION SCIENCE**

1. SĒJUMS

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COMPOSITE STRUCTURE OF SADDLE SHAPE CABLE ROOF

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Key words: steel cables; cable net; saddle shape cable roof, main rational geometrical characteristics

1. Introduction

Saddle shape cable roofs are formed by two orthogonal groups of cables and a supporting contour. The most widely used constructions of the supporting contour are inclined or vertical arches, contour beams of different shapes and tension cables, which may be fixed at the anchors [1]. The main rational geometrical characteristics of the saddle shape cable roofs, which are supported by the arches and beams, are generally known. The rational values of the initial deflections of suspension cables of the structure are equal to 0,067 - 0,125 from their span. The rational values of the initial deflections of the stressing cables are equal to 0,04 - 0,1 from their span. Rational step of the suspension and stressing cables varies from 1 to 4 m [2-4].

In accordance with the data published in [5], the rational geometrical characteristics of the saddle shape cable roof, which is supported by tension cables, are the following: the initial deflections of the suspension, stressing, tension cables and rational step of the suspension and stressing cables are equal to 0,41; 0,193; 0,057 from the length of one side of the structure, accordingly. However, the results are valid for the square in plane roof with its size in the plan 20 x 20 m. So, the object of the paper is to estimate of the main rational geometrical characteristics of the square in plane saddle shape cable roof, which is supported by the tension cables, with several sizes in the plan. The characteristics are the initial deflections of the stressing, suspension and tension cables, as well as the step of the stressing and suspension cables.

2. Solution of the problem

The correlation between the main geometrical characteristics of the structure and the expenditure of the cable net material is determined in the form of nonlinear equation by the method of experiment planning. Coefficients of the equation are defined by using the results of numeral experiment. The experiment was conducted with such values of the main geometrical characteristics of the structure, which were chosen according to the rules of experiment planning. The numeral experiment is connected with calculation of forces in the cables of the net. The forces are necessary for calculations of cable cross sections and the volume of cable net material.

The cross sections of the cables are determined in accordance with the recommendations of [2]. The cable net (Fig.1) which is loaded by prestressing and loads, which are applied to the cable nets, is considered as a scheme of analysis.

The numeral experiment is conducted by using the program "ANSYS/ED 5.3" for WINDOWS. During the analysis of the cable net the program is based on the Newton-Rapson iterative method. The cable net is modeled by a finite element mesh. The finite element type is LINK 10, which has 6 degrees of freedom in each node. All the nodes of the support of the cable net are completely

fixed. The cable net has two planes of symmetry. It enables to consider only a quarter of the cable net.

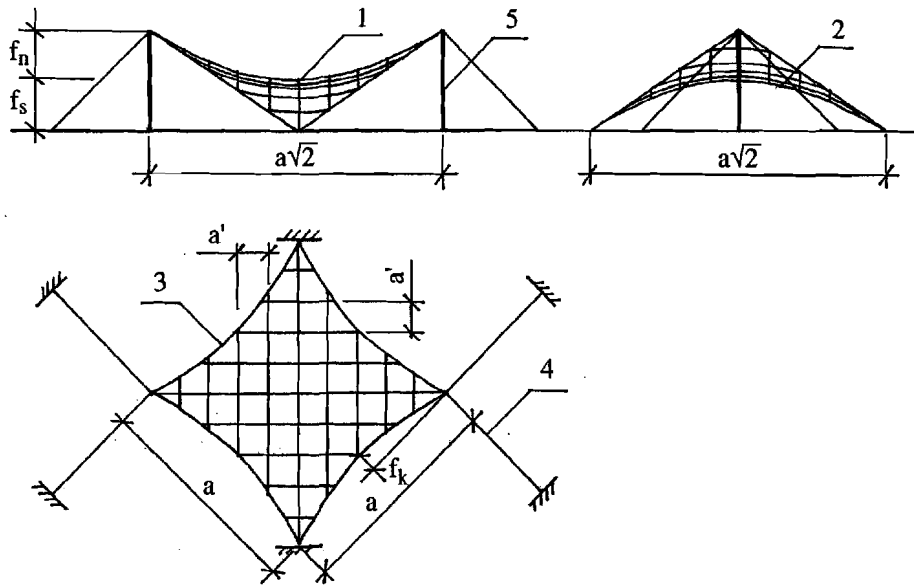


Fig.1 Scheme of Cable Net

1 - suspension cables; 2 - stressing cables; 3 - tension cables; 4 - anchor supports; 5 - columns; f_n - initial deflection of suspension cable; f_s - initial deflection of stressing cable; f_k - initial deflection of tension cable; a - length of one side of the structure; a' - step of stressing and suspension cables

Rational values of the main geometrical characteristics of the structure are determined by the system of equations

$$\begin{cases} \frac{\partial y}{\partial X_1} = b_1 + b_{12}X_2 + b_{13}X_3 + b_{123}X_2X_3 + 2b_{11}X_1 = 0 \\ \frac{\partial y}{\partial X_2} = b_2 + b_{12}X_1 + b_{23}X_3 + b_{123}X_1X_3 + 2b_{22}X_2 = 0 \\ \frac{\partial y}{\partial X_3} = b_3 + b_{13}X_1 + b_{23}X_2 + b_{123}X_1X_2 + 2b_{33}X_3 = 0 \end{cases}$$

where: y - correlation between the main geometrical characteristics of the structure and the expenditure of cable net material;

- $b_i; b_{ij}; b_{ijk}$ - coefficients of nonlinear equation ($i, j, k = 1, 2, 3$)
- X_1 - initial deflection of suspension and stressing cables;
- X_2 - initial deflection of tension cable;
- X_3 - step of suspension and stressing cables.

3. Numeral result

Values of the main geometrical characteristics of the structure vary in the way, shown in Table 1.

Values of the main geometrical characteristics of the structure

Table 1

Geometrical characteristics of the structure	Length of one side of the structure, m				
	10	20	30	40	50
Initial deflections of suspension and stressing cables, m	2 - 5	4 - 10	6 - 15	8 - 20	10 - 25
Initial deflections of tension cables, m	1,5 - 2,5	3 - 5	3 - 6	6 - 10	7,5 - 12,5
Step of suspension and stressing cables, m	0,707 - 1,414	0,707 - 1,414	1,414*	1,414*	1,414*

*The step of suspension and stressing cables is limited by the plywood sheet size

The structure is analyzed to the action of the main load combination [6]. The main load combination is dead weight of the structure and snow. The calculated value of dead weight is 0,27 kPa. The calculated value of load is 1,39 kPa. Thickness of layers of the roof cross section is shown in Fig.2. Wire rope with modulus of elasticity in $1,3 \cdot 10^5$ mPa is considered as cable net material.

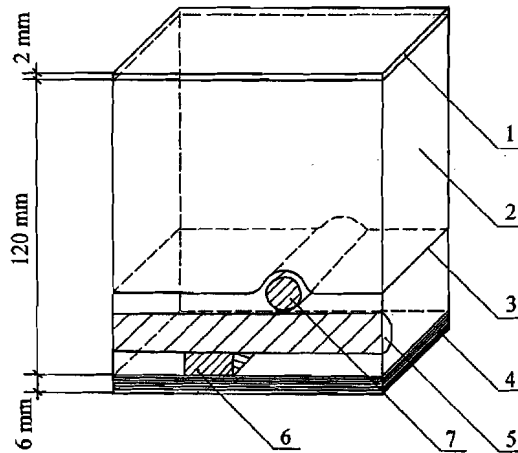


Fig.2 Cross section of the roof

1 - glass fabric which is covered by polymer resin; 2 - foamplastic; 3 - glass net; 4 - saddle shape plywood sheets; 5 - suspension cable; 6 - a detail of tension and distancing of strengthening elements of plywood sheets; 7 - stressing cable

The initial deflection of the suspension and stressing cables exerts the most significant influence on the expenditure of cable net material. The dependence of Fig.3 was obtained when the initial deflection of the suspension and stressing cables was constant and equal to 4,2; 8,2; 12; 16; 20 m for sizes in plane 10; 20; 30; 40; 50 m, accordingly.

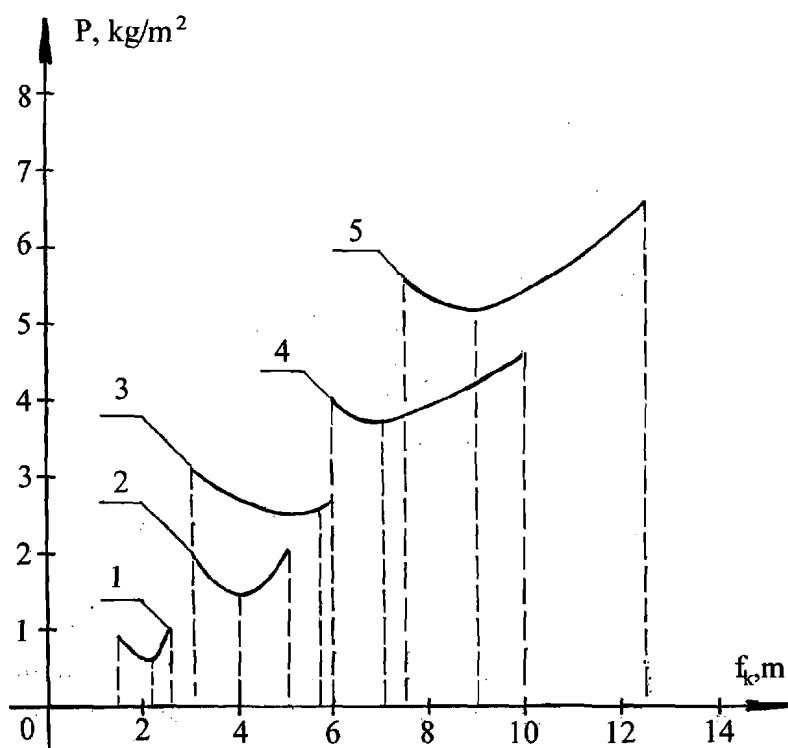


Fig.3 Dependences of the expenditure of cable net material on the initial deflections of tension cables.

P - expenditure of the cable net materials per m^2 of the covered area; f_k - means the same as in Fig.1; 1, 2, 3, 4, 5 dependences, which are obtained for lengths of one side of the structure 10, 20, 30, 40, 50 m, accordingly.

The main rational geometrical characteristics of the structure are shown in the Table 2 by taking into account the weight of cable net per the covered area.

The main rational geometrical characteristics of the structure

Table 2

Geometrical characteristics of the structure	Length of one side of the structure, m				
	10	20	30	40	50
Initial deflections of suspension and stressing cables, m	4,2	8,2	12	16	20
Initial deflections of tension cables, m	2,2	4	5,7	7,52	9
Step of suspension and stressing cables, m	0,8	1,15	1,414	1,414	1,414

The dependence of Fig.4 was obtained when the main geometrical characteristics of the structure were adapted from Table 2.

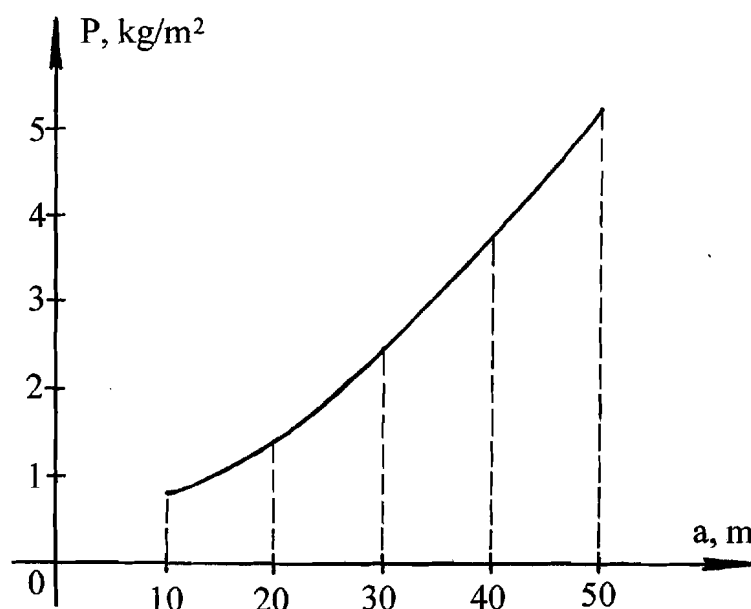


Fig.4 Dependence of expenditure of cable net materials on the length of one side of the structure a - as in Fig.1; P - as in Fig.3.

4. Conclusions

The main rational geometrical characteristics of square in plane saddle shape cable roof, which is supported by tension cables, are estimated by the numeral experiment by taking into account the weight of cable net per the covered area. It is shown, that rational initial deflections of the suspension, stressing, tension cables and rational step of the suspension and stressing cables are equal to 0,42 - 0,4; 0,22 - 0,18; 0,08 - 0,028 from the length of one side of the structure, accordingly.

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Serdjuks, D., Rocēns, K., Pakrastinš, L. Kompozīta konstrukcija sedlveida vanšu pārsegumam.

Rakstā tiek apskatīts sedlveida vanšu pārsegums, kas veidots no divām ortogonālu vanšu grupām, un padevīgo ar atbalsta kontūru. Pārseguma kinemātiskā nemainība, kas sasniegta izmantojot iepriekš saspriestas vantis, jāver iespēju atteikties pārseguma konstrukcijās no smagajām dzelzsbetona plātnēm aizstājot tās ar vieglākiem kompozītiem materiāliem.

Ar skaitlisko eksperimentu noskaidroti galvenie racionālie raksturojumi vanšu pārsegumam, ņemot vērā vanšu pārseguma svāra attiecību pret pārsedzamo laukumu.

Serdjuks D., Rocens K., Pakrastinsh L. Composite structure of saddle shape cable roof.

The paper considers the saddle shape cable roof, which is formed by two orthogonal groups of cables, joined with tensioned cables. The kinematic invariability of the roof obtained by prestressing of the cables, enables to refuse from the hard ferroconcrete slabs in the construction of the cable roof and use light composite materials.

The main rational geometrical characteristics were ascertained by a numeral experiment for a square in plane saddle shape cable roof, which is supported by the tensioned cables by taking into account the weight of cable net per the covered area.

Сердюк Д., Роценс К., Пакрастинш Л. Композитная конструкция седловидного вантового покрытия.

В статье рассматривается седловидное вантовое покрытие, образованное двумя ортогональными группами вант, и податливым опорным контуром. Кинематическая неизменяемость покрытия, достигнутая предварительным натяжением вант, даёт возможность отказаться от тяжелых железобетонных плит в конструкции покрытия и использовать лёгкие композитные материалы.

Путём численного эксперимента установлены основные геометрические характеристики седловидного вантового покрытия с податливым опорным контуром в виде вант, исходя из веса вантовой сети, отнесенного к перекрываемой площади.