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Воропай Р.А., Кирсанов М.Н. О деформации пространственной консольной фермы под действием боковой нагрузки (на английском языке)

Voropai R.A., Kirsanov M.N.
On the deformation of spatial cantilever trusses
under the action of lateral loads

Получено точное выражения для смещения пространственной консольной фермы с треугольной решеткой под действием сосредоточенной на конце консоли горизонтальной силы. Усилия в стержнях найдены методом вырезания узлов, смещение – по формуле Максвелла-Мора. Использован метод индукции и система компьютерной математики Maple
Ключевые слова: ферма, прогиб, формула Максвелла-Мора, Maple

We have obtained exact expressions for the spatial displacement of the cantilever truss with a triangular lattice under the action of concentrated at the end of console horizontal force. The forces in the rods was found using cut nodes method, and the offset – according to the formula of Maxwell-Mohr. The induction method and system of computer mathematics Maple are used
Key words: truss, deflection, Maxwell-Mohr' formula, Maple

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The investigated design consists of three identical structure of panels, each of which is a flat truss with a cross lattice (Fig. 1). The system is statically determinate.

Indeed, in the truss with n panels contains $m=9(n+1)$ rods and $3(n+3)$ joints. The task is to determining formulas for the dependence on the number of panels deformation of a truss under a horizontal force applied to the extreme joint on the upper belt. To obtain an analytical result we use the program written in the language of the computer algebra system Maple [1]. The program introduces the coordinates of the joints:

```

> for i to n+1 do
> x[i,1]:=a*(i-1): x[i,2]:=0: x[i,3]:=0:
> x[i+n+1,1]:=x[i,1]: x[i+n+1,2]:=b: x[i+n+1,3]:=h:
    
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> x[i+2*n+2,1]:=x[i,1]:x[i+2*n+2,2]:=2*b:
> x[i+2*n+2,3]:=0:
> od:
```

Fig. 1. $n=3$

Here $x[i,1]$ is the longitudinal coordinate of x , $x[i,2]$ cross y , $x[i,3]$ – the vertical coordinate z . The deflection determined by the formula of Maxwell – Mohr [2]

$$\Delta = P \sum_{i=1}^{m-6} S_i^2 l_i / (EF),$$

where the following designations are used: S_i – the forces in the rods of the truss under the action of external loads, l_i – the length of rods, m is the number of rods along with six support rods. A rigid support rod in amount are not included. The fragment program determines the deflection has the form:

```
> DELT:=simplify(add(S[i]^2*L[i],i=1..m-6));
```

For determining the sequence of the coefficients of the terms a^3 occurring in the solutions the special operator $C1[n]:=coeff(DELT,a^3)$ is used. Similarly, the other sequences of coefficients are found. General members of sequences was searched using operators **rgf_findrecur** and **rsolve** [1, 3]. The result of induction [4-6] on eight trusses by generalizing the sequence of coefficients in the solutions was obtained by the following formula: $\Delta = P(a^3 A_n + b^3 B_n + c^3 C_n + d^3 D_n + f^3 F_n) / (8h^2)$, where $A_n = -4n^3 - 6n$, $B_n = 8((-1)^n - 1)$, $C_n = -8n$, $D_n = -2n$, $F_n = 4((-1)^n - 1)$, $c = \sqrt{a^2 + b^2 + h^2}$, $d = \sqrt{a^2 + 4b^2}$, $f = \sqrt{h^2 + b^2}$. Graphics solutions are obtained depending on the height of the truss find the extreme point (Fig. 2).

Especially interesting graphical representation of the dependence of lateral deformation on the number of panels (Fig. 3). Curves have points of self-intersections, indicating the possibility of rational choice of the height h of the truss and number of panels. Similar solutions for spatially and flat trusses obtained in [7-15]. The related work on inductive inference decisions are contained in [16,17].

Fig. 2

Fig. 3

Список используемых источников:

1. Kirsanov M.N. Maple and Maplet. Solving mechanics problems. Saint-Petersburg: Lan, 2012. 512 p.
2. Srivastava A.K., Gope P.C. Strength of Material. Prentice-Hall of India, New Delhi, 2007.
3. Fox W. P. Mathematical Modelling with Maple. Brooks Cole, 2011.
4. Voropai R. A., Kazmiruk I. Yu. Analytical study of the horizontal stiffness of the flat statically determinate arch truss. Bulletin of Scientific Conferences. 2016. No. 2-1(6). Pp. 10-12.
5. Kirsanov M. N. Inductive analysis of the effect of error mounting on the stiffness and strength of a plane truss// Magazine of Civil Engineering 5 (2012) pp. 38-42.
6. Kirsanov M.N. The exact formulas for calculating deflection and forces in the rods of the 'Molodechno' truss with an arbitrary number of panels// Magazine of Civil Engineering. 2016. No. 1. Pp. 33-41.
7. Kirsanov M. N. Analysis of the deflection of a strut-type lattice girder truss// Magazine of Civil Engineering. 2015. No.5(57). pp. 58-65.
8. Kirsanov M.N. Mathematical model of the truss with hardening elements// Magazine of Civil Engineering. 2015. No.4(56). Pp. 38-44.
9. Kirsanov M.N. Discrete model of the pile foundation// Magazine of Civil Engineering. 2015. No.3(55). Pp. 3-9.
10. Kirsanov M.N. Deflection analysis of rectangular spatial coverage truss// Magazine of Civil Engineering. 2015. No.1(53). Pp. 32-38.

10. Kirsanov M. N. *Bending, torsion and the asymptotic analysis of the spatial core console*// Magazine of Civil Engineering. 2014. No. 5. Pp. 37-43.
11. Kirsanov M.N., Andreyevskaya T.M. *Analysis of the effect of elastic deformation of the mast on the positioning of antenna and radar equipment*// Magazine of Civil Engineering. 2013. No.5(40). Pp. 52-58.
12. Kirsanov M.N. *Static calculation and analysis of spatial rod system*. Magazine of Civil Engineering. 2011. No. 6. Pp. 28-34.
13. Kirsanov M. N. *Stress State and Deformation of a Rectangular Spatial Rod Cover*// Scientific Herald of the Voronezh State University of Architecture and Civil Engineering. Construction and Architecture. 2016. N 3 (31). Pp. 71-79.
14. Kirsanov M. N. *Analytical calculation, marginal and comparative analysis of a flat girder*// Scientific Herald of the Voronezh State University of Architecture and Civil Engineering. Construction and Architecture. 2016. N 1 (29). Pp. 84-105.
15. Kiyko L.K. *Analytical evaluation of deflection of arched trusses under the action of wind loads* // Science bulletin. 2016. № 1 (7). Pp. 247-254.
16. Tinkov D. V. *Comparative analysis of analytical solutions to the problem of truss structure deflection*// Magazine of Civil Engineering. 2015. No.5(57). Pp. 66-73.

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