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Белянкин Н.А., Бойко А.Ю., Кирсанов М.Н. Индуктивный вывод прогиба стержневой ограждающей конструкции в системе Maple

Belyankin N.A., Boyko A.Yu., Kirsanov M.N. Inductive derivation of rod cladding structures deflection in the system Maple

Рассмотрена статически определимая симметричная ферма с четырьмя опорами. К середине пролета приложена нагрузка. Дается вывод зависимости прогиба от числа панелей в ригеле. Число панелей в боковых частях фиксировано. Усилия в стержнях определяются методом вырезания узлов. Обобщение решения на произвольное число панелей выполняется методом индукции
Ключевые слова: *ферма, прогиб, формула Максвелла-Мора, Maple*

Considered statically determinate symmetric truss with four hinges. By the mid-span applied a load. Conclusion given the dependence of the deflection of the number of panels in the bolt. The number of panels in the lateral parts are fixed. The forces in the rods are determined by cutting out the nodes. Generalization of the solution for an arbitrary number of panels is performed by the method of induction
Key words: *truss, deflection, Maxwell-Mohr' formula, Maple*

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Hinged core structure (Fig. 1) is a statically determinate truss. In General, the vertical lateral parts of the m panels and the horizontal middle part – $2n$ panels. The total number of cores in the truss, N=8(n+m+1) number of nodes 4(n+m+1). Derive formula for deflection of this structure under the action of a concentrated force P at Midspan.

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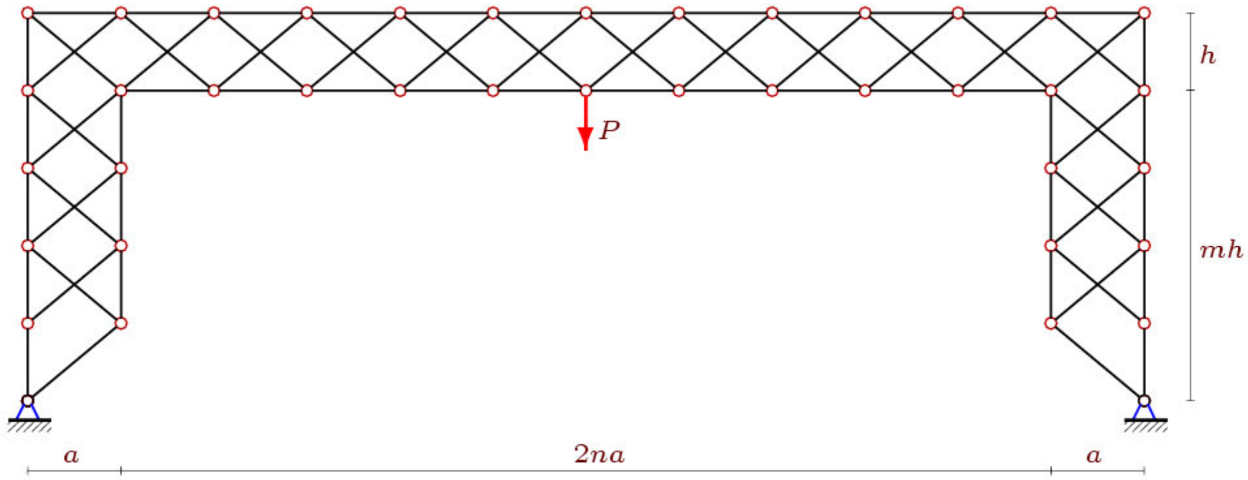

Fig. 1. Truss, n=5, m=4

To determine the stresses in the bars will use the program [1] written in systems of symbol mathematics Maple. The program incorporates a method of cutting of knots. In the original these programs are introduced the coordinates of the nodes and vectors that specify the order of connection of nodes and cores in the same way as in discrete mathematics a graph is defined by edges and vertices. Next, create a matrix ***G*** of the system of equilibrium equations of nodes, consisting of the guides of the cosines of the rods, which in turn are calculated using the coordinates of the nodes. Two fixed supports are modeled by rods whose lengths can be chosen arbitrarily, since the supporting rods are assumed to be rigid. It should be noted that a feature of the proposed design is that the traditional calculation scheme of trusses are not held. The calculation usually begins with the determination of reactions of supports. However, to determine the four reactions of supports of the three equilibrium equations of the whole structure in General is impossible. The method of partitioning in part by analogy with the solution of problems in compound structures, where there is the same problem here also out. The reaction in this case you can define together with the efforts of all the rods from the solution of the global system of equilibrium equations for all nodes. The system of equations ***GS=B*** is solved analytically using the built-in operators of the system Maple.

The method of inverse matrix is used, the more that it is implemented in Maple is very simple. The inverse matrix ***G1*** is calculated by simple division: ***G1:=1/G***. the Vector of the right part of the system of equations associated with external loads. In odd-numbered items are horizontal loads (in this problem they are not), even vertical ***B*[2*(*n*+*m*)]:=1**. The solution is obtained by multiplying the inverse matrix by the vector of loads **S1:=G1.B.** To determine the deflection using the formula of Maxwell – Mohr $\Delta = P\sum_{i=1}^{N-4} S_i^2 l_i / (EF)$ to calculate the deflection. Here *EF* is the stiffness of the rods, S_i – stress in the rods from the action of a unit vertical force applied at the middle node, l_i is the length of the rods. Four rigid support rods are not included in the sum. We consider the case of a fixed number of panels in the lateral parts of the truss, *m*=5. Consistent calculation of trusses with *n*=1,2,... 12 showed that the equation for the deflection has the form $EF\Delta = P(A_n a^3 + C_n c^3 + H_n h^3)/(2h^2)$, where $c = \sqrt{h^2 + a^2}$. The method of induction with the involvement of operators rgf_findrecur and rsolve package genfunc we obtain the total members of the sequence of the coefficients:

$$A_n = (4n^3 - 15n^2 + 27(-1)^n n^2 + 83n - 69(-1)^n n)/6 - 8(-1)^n + 9,$$

$$C_n = 11 - 10(-1)^n + n \text{ , } H_n = (53 - 43(-1)^n)/2.$$

Figure 2 shows the curves of the dependences for a fixed span of L=2an=100 m. Indicated dimensionless deflection $\Delta' = \Delta EF/(PL)$. Noticeable surges trough and a marked dependence on the height h.

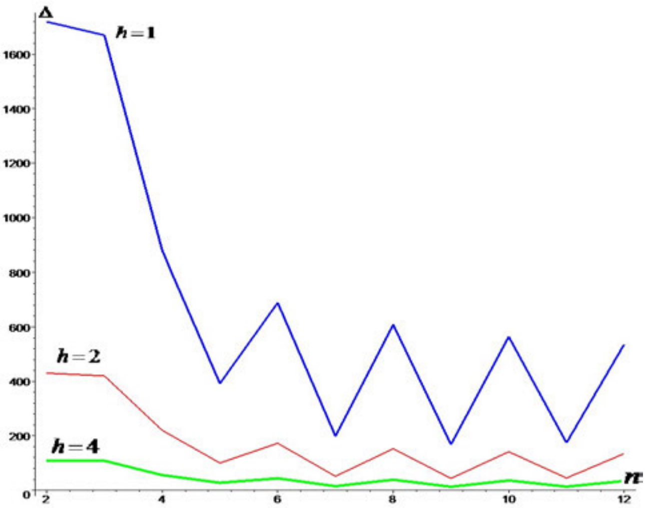

Fig. 2. The deflection-number of panels dependence

The reaction of supports are also obtained in a symbolic form by induction from the solution of the General system of equilibrium equations for all nodes. Horizontal reaction depends on the parity of n: $X_A = Pa((-1)^n - 1)/(4h)$, the vertical is constant $Y_A = P/2$. In addition, as shown by the bill, these decisions do not depend on the number m of the side panels. Note that almost all mathematical operations used in the algorithm can be performed in other systems of computer mathematics. The most convenient alternative may be the free system Maxima close to the language of a widely accepted and powerful Mathematica. Earlier analytical solutions for flat trusses were obtained in [2-11] spatial in [12-14].

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