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THE DEPENDENCE OF THE DEFLECTION OF THE CANTILEVER TRUSS ON THE NUMBER OF PANELS OBTAINED IN THE SYSTEM MAPLE

E. V. Domanov[1]

National Research University “MPEI”

Russia. Moscow

[1]Student, tel.: *+7(999)602-98-50*; e-mail: domanov312@mail.ru

A symmetrical cantilever-beam trussed grid is loaded on the lower or upper belt. The method of induction with the use of special operators of symbolic mathematics Maple shows the dependence of the deflection of the middle of the span of the truss on the number of panels in the span and on its console parts. To determine the coefficients of the desired formula, recurrence equations are compiled and solved. The graphs of the dependences obtained reveal extreme points that can be used to optimize the stiffness design

Keywords: truss, deflection, induction, analytical solution, Maple, Mohr's integral

ВЫВОД ЗАВИСИМОСТИ ПРОГИБА КОНСОЛЬНОЙ ФЕРМЫ ОТ ЧИСЛА ПАНЕЛЕЙ В СИСТЕМЕ MAPLE

Е. В. Доманов[1]

Национальный исследовательский университет “МЭИ”

Россия, г. Москва

[1]Студент, тел.: *+7(999)602-98-50*; e-mail: domanov312@mail.ru

Рассматривается симметричная консольно-балочная ферма с треугольной решеткой, которая загружена по нижнему или верхнему поясу. Методом индукции с привлечением специальных операторов символьной математики Maple выводится зависимость прогиба середины пролета фермы от числа панелей в пролете и на консольных ее частях. Для определения коэффициентов искомой формулы составлены и решены рекуррентные уравнения. Графики полученных зависимостей обнаруживают экстремальные точки, которые могут быть использованы для оптимизации конструкции по жесткости.

Ключевые слова: ферма, прогиб, индукция, аналитическое решение, Maple, интеграл Мора

You can use not only numerical methods to calculate truss. The development of computer systems of symbolic mathematics makes it possible to find formulas for calculating regular-type constructions. The induction method in [1-6] obtained formulas for the dependence of the deflection on the number of panels, the load, and the size of the truss. In [7-10] the induction method derived formulas for the deflection of arches, and in [11-22] for the deflection of lattice trusses. The problems of deformations of spatial constructions are solved in [23-30]. As a rule, in these problems, we conducted induction on one parameter — the number of panels in the span. More complex generalizations can be carried out on two parameters – the number of panels in the span and on the consoles. It is this task that is being solved in this work.

Consider a truss with 2n panels in the span and m panels on consoles (Fig. 1). The truss is loaded on the upper belt. For the solution we use the system of computer mathematics Maple [31].

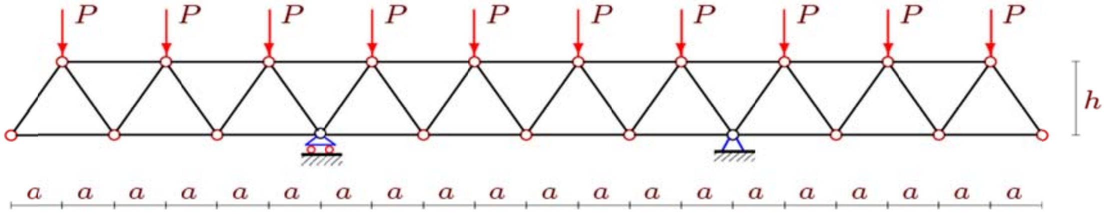

Fig. 1. A truss with n = 2, m = 3. Load on the upper belt

The program numbers the rods and nodes (Fig. 2). The origin is located at the left end of the truss on the console. Define the coordinates of the nodes.

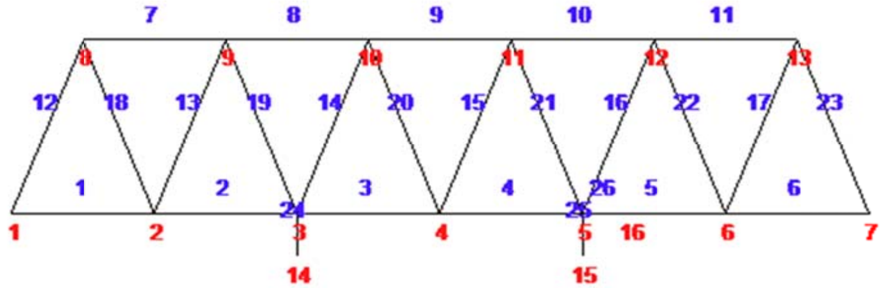

Fig. 2. Numbering of knots and rods, n = 1, m = 2

The fragment of the coordinate input program has the form

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

A matrix of the system of equations of all nodes in truss equilibrium is formed in the program. Among the unknowns, the three reactions of two supports are includedIn the right part of the system write the load value. Vertical forces are written in even lines:

```
> for i from 2*(m+n)+2 to 4*(m+n)+1 do np:=i;  Bp[2*np]:=1: od:
```

The solution is obtained in symbolic form. The forces are determined separately for the given load and for the unit force applied at the deflection point. Calculation of the deflection is carried out using the Mohr's integral:

$$\Delta = \sum_{i=1}^{K-3} S_i s_i l / (EF),$$

where: EF — the stiffness of the rods, S_i — the forces in the rods from the load, s_i — the forces in the rods from the action of a single vertical force applied to the middle node of the lower belt, l_i — the length of the rods, $K = 8(m+n)+2$ — the number of rods, rods, modeling supports, they are taken rigid). The general form of the solution does not change for any numbers n and m (the regularity property of the problem):

$$EF\Delta = P(C_1 a^3 + C_2 b^3)/h^2. \quad (1)$$

First, we induction on the number of panels n for fixed m. For m = 1, we solve the problem of deflection of 10 trusses with a consecutive number of panels n = 1, 2, ... 10. Using the rgf_findrecur operator, we get the recursion equation for the coefficient for a^3, solve it with the rsolve operator and find the coefficient $C_1 = (10n^4 - 10n^2)/3$. Similarly, for m = 2, we get

$C_1 = (10n^4 - 46n^2)/3$. For m = 3, $C_1 = (10n^4 - 106n^2)/3$ etc. As a result, we obtain a sequence of the number of panels on consoles 10,46,106,190,298,430,586,766,970,1198 . We find the general term of this sequence and write down the general form of the coefficient for a^3

$$C_1 = (10n^4 - (12m^2 - 2)n^2)/3.$$

The other coefficient turns out to be independent of m and is simpler, without using the Maple operators

$$C_2 = n^2.$$

Omitting the computations and the intermediate results, we give the solution of the problem of the deflection of the middle of a truss under the action of a load distributed over the *lower* belt (Fig. 3):

$$C_1 = (10n^4 - (12(m^2 + m) + 1)n^2)/3, \ C_2 = n^2.$$

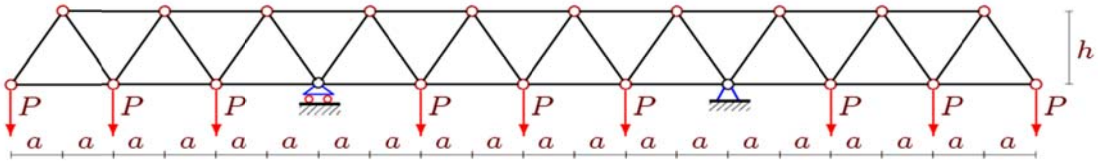

Fig. 3. A truss with n = 2, m = 3. Load on the lower belt

Denote $\Delta' = \Delta EF/(P_s L)$ the dimensionless relative deflection, where $P_s = (2n + 2m + 1)P$ the total load on the truss when loading the upper belt, $L = 2(n + m)a$. The constructed graphs reveal two characteristic regularities. First, the curves have pronounced minima. Secondly, the curves after some value of n change the order and the deflection begins to grow.

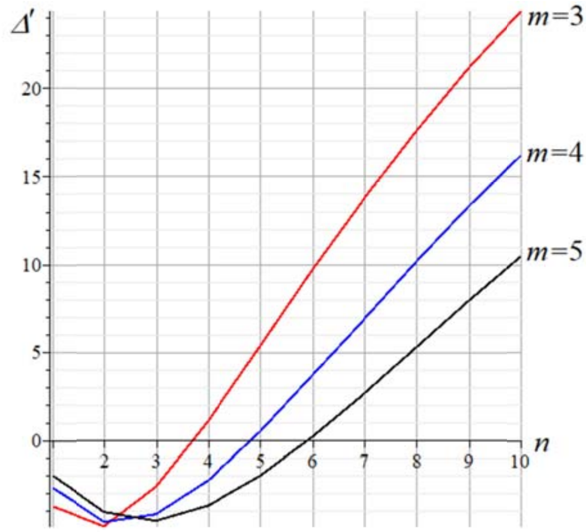

Fig. 4. Deflection depending on the number of panels *n*, *L*=100*m*, *h*=5*m*

Similar features reveal the curves of the dependence on the number of panels on the consoles (Fig. 5). At the same time it is noticed that the minimum essentially depends on the number of panels in the span.

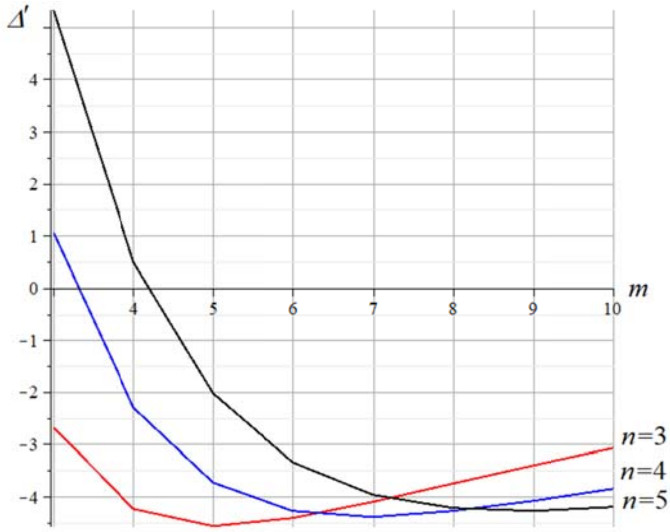

Fig. 5. Deflection depending on the number of panels *n*, *L*=100*m*, *h*=5*m*

Surveys of work in this direction applied to planart trusses can be found in [32,33].

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