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Расчет прогиба балочной фермы, загруженной по нижнему поясу в системе Maple

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Calculation of the deflection of girder beam loaded on the bottom flange in the system Maple

Методом индукции получена точная формула для прогиба плоской фермы в зависимости от числа панелей. В решении использована формула Максвелла – Мора и операторы решения рекуррентных уравнений системы Maple. Найденная зависимость обнаруживает точку минимума

Ключевые слова: *ферма, прогиб, индукция, Maple*

By induction method the explicit formula for the deflection of flat tuss depending on the number of panels is obtained. The Maxwell – Mohr's formula and operators the solution of recurrent equations system Maple are used. The dependence has a minimum point

Key words: *truss, deflection, induction, Maple*

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Analytical calculation of deflection of building structures is of great practical and theoretical value [1,2]. In the engineering practices a simple and reliable formula is needed to estimate the projected and operated designs, the theorists for the analysis of prospects of development of the proposed schemes and to optimize their size to save material and reduce the cost of installation works. Let us consider one of the most common girders with a rectangular lattice (Fig. 1). In [3] it was proposed an analytical solution of a similar construction with the load on the bottom belt.

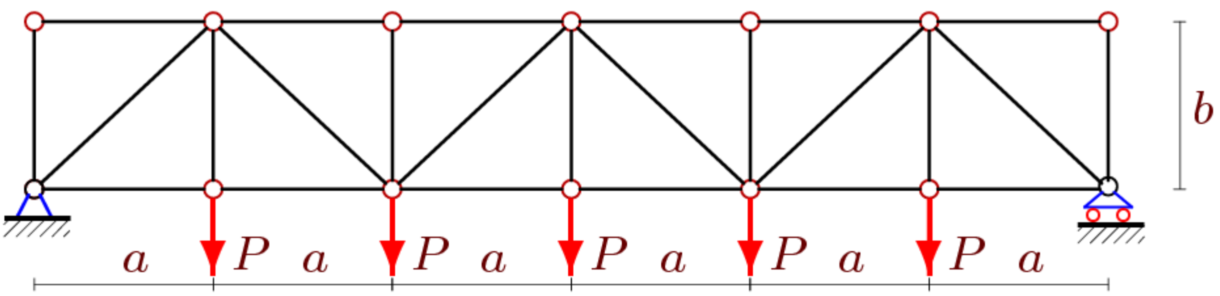

Fig. 1. Truss with three panels n=3

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To determine the deflection we have the equation of Maxwell – Mora, fair for the elastic stage of the work of structural elements: $\Delta = \sum_{i=1}^{m-3} S_i s_i l_i / (EF)$, where EF is the stiffness adopted to simplify the calculations the same for all cores in the truss, S_i – the forces in the rods from the distributed in the lower zone of the load P, s_i – the forces in the rods from the action of a unit vertical force applied at mid-span, l_i – length of rods, $m = 8n + 4$ – number of rods truss with the three support bars simulating fixed hinges (they are taken to be rigid). The forces in the rods are in analytical form according to the algorithm developed in [4]. The corresponding program written in the Maple language, although without the special difficulties can be implemented in other systems of computer mathematics. The Maple was chosen because it contains also a powerful tool for constructing and solving recurrence equations, which will be required for inductive inference the desired formula. In [5-7] based on this algorithm the analytical expressions for influence lines in flat trusses, in [8-12] derived formulas for the deflections of the flat, and in [13-15] – space trusses. Sequential solution of the problem of trusses with number of panels 1,2, 3,...,14 gives the number of coefficients in the expression of deflection. To identify the recurrence equation that governs the members of this sequence, we apply a special operator **rgf_findrecur**. Get the following expression:

$$\Delta EF = P(Aa^3 + Bb^3 + Cc^3)/(2b^2),\ \ c = \sqrt{a^2 + b^2}\ ,$$

where the coefficients:

$$A = (5n^2 + 1)n^2 / 6,\ B = 1 - (-1)^n,\ C = n^2.$$

To detect patterns it is needed to calculate the 14 trusses and to obtain a sequence 1,14, 69, 216, 525,...17304, 23829, 32046. The definition of a General member of this sequence is possible with the help of computational mathematics with **Maple** by using specialized package **genfunc**. Recurrent equation to determine a General member of the sequence has the form:

$$A_n = 5A_{n-1} - 10A_{n-2} + 10A_{n-3} - 5A_{n-4} + A_{n-5}.$$

A similar equation for determining the coefficient B has very simple form:

$$B_n = B_{n-2}.$$

Let's introduce the designation for the relative displacement $\tilde{\Delta} = \Delta EF / P_{sum}$, where $P_{sum} = (2n-1)P$ – the total load on the truss. Fix the length of the half span: $a = L/2n, P = 1/(2n-1), L = 60$ м. Will get a graph (fig. 2) that has explicitly visible minima, allowing to optimize the construction. The broken curves are obtained due to the flashing term $(-1)^n$.

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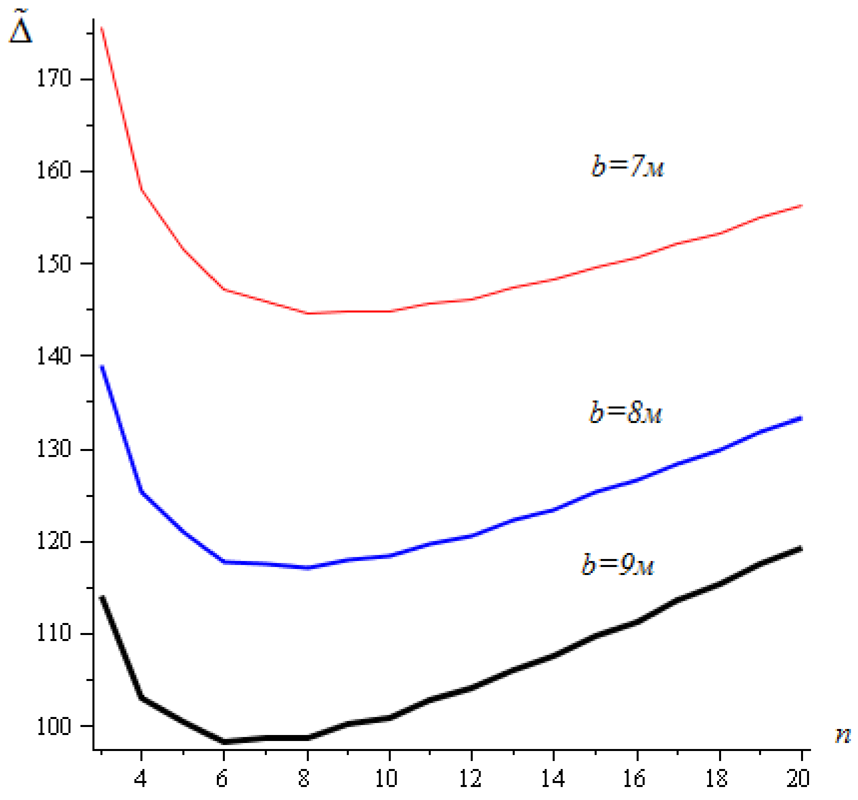

Fig. 2. The dependence of the deflection on the number of panels

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