DOI: 10.17117/na.2016.03.03.075 **http://ucom.ru/doc/na.2016.03.03.075.pdf**
Поступила (Received): 24.03.2016

Казьмирук И.Ю.

О деформации арочной фермы под действием боковой нагрузки

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On the arch truss deformation under the action of lateral load

Методом индукции с применением системы компьютерной математики Maple получено точное решение о смещении среднего узла плоской статически определимой упругой фермы с произвольным числом панелей. Для определения усилий в стержнях использован метод вырезания узлов и формула Максвелла – Мора для вычисления перемещения

Ключевые слова: *ферма, прогиб, Maple, точное решение*

By using the computer algebra system Maple and induction method an exact solution of the displacement of the middle node in statically determinate elastic flat truss with an arbitrary number of panels is obtained. To determine forces in the rods used method of cutting nods and the formula of Maxwell – Mohr to calculate the displacement

Key words: *truss, displacement , system Maple, exact solution*

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Evaluation of the effect of side loading on the deformation of the truss studied not enough. In the case of large aerodynamic resistance of the construction of the magnitude of these loads may be considerable large. Without considering the load perpendicular to the plane of the truss, we examine the impact on truss by the uniform loads with lateral (longitudinal) sides in the plane of the truss. Initialization of such a load may, for example, wind. Of course, the magnitude of wind load depends on the height of the flow. In the simplest case we can consider the efforts that are uniformly distributed along the lateral truss nodes (Fig. 1). The truss is a three hinges spacer system [1]. Find the horizontal displacement of the middle node in the truss. The main objective of the task is to find the dependence of the deflection on the number of panels. This will allow the designer to choose the optimal system configuration by changing the number of panels in a given span length. Existing analytical solutions (an overview of D. Tinkov [2]) typically obtained for the vertical load and vertical deflection.

· http://ucom.ru/na · ISSN 2411-7609 ·

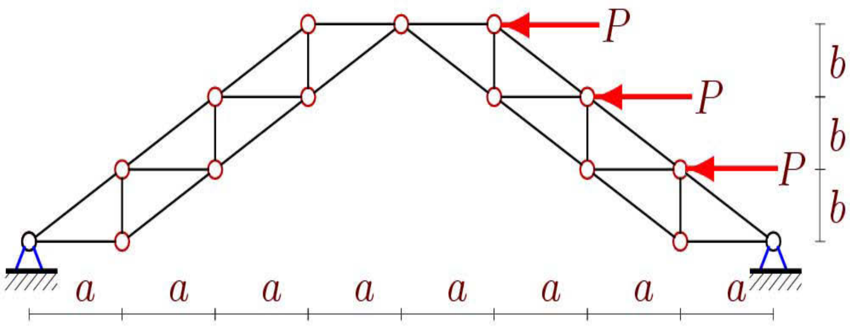

Fig. 1. n=3

To determine the offset we'll use is known in structural mechanics [3] a formula of Maxwell – Mohr: $\Delta = \sum_{i=1}^{m} S_i s_i l_i / (EF)$, where EF is the stiffness is the same for all cores in the truss, S_i – the effort stems from the distributed nodes on the side of the load P, s_i – stress in the rods from the action of unit horizontal force applied to the middle node, bridging part of the arch, l_i – the length of rods, $m = 8n + 2$ – number of rods truss along with four support rods simulating the stationary hinges. The number of panels in half span is equal to n. Forces in the rods is determined by cutting nodes [4] method with the use of Maple computer system. Software code written in Maple the construction of the matrix of system of linear equations balance method is as follows:

```
> G:=Matrix(m,m):
> for i to m do
> Lxy[1]:=x[Nend[i]]-x[Nbeg[i]]:
> Lxy[2]:=y[Nend[i]]-y[Nbeg[i]]:
> L[i]:=subs(a^2+b^2=c^2,sqrt(Lxy[1]^2+Lxy[2]^2)):
> for j to 2 do
> jj:=2*Nend[i]-2+j:
> if jj<=n3 then G[jj,i]:=-Lxy[j]/L[i]:fi;
> jj:=2*Nbeg[i]-2+j:
> if jj<=n3 then G[jj,i]:= Lxy[j]/L[i]:fi;
> od;
> od:
```

Here **G** – is the matrix of the system, the **Nend[i]** and **Nbeg[i]** – number of conditional ends of the rod number i. Induction method, previously used in several works for the analysis of flat [5-9] and spatial [10,11] truss, gives the following result $\Delta EF = P(Aa^3 + Bb^3 + Cc^3)/(24a^2), c = \sqrt{a^2 + b^2}$, where the coefficients: $A = (n+1)(2n^2 + 4n + 3), B = n(1 + 2n^2), C = n(n+1)(2n^3 - 2n^2 + 12n + 3)/5$.

To detect patterns when the ratio needed to calculate the 16 farms and to obtain a sequence 6, 42, 180,..., 311184, 428400. 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:

$$C_n = 6C_{n-1} - 15C_{n-2} + 20C_{n-3} - 15C_{n-4} + 6C_{n-5} - C_{n-6}.$$

A similar equation for determining the coefficient A is somewhat simpler and has the form $A_n = 4A_{n-1} - 6A_{n-2} + 4A_{n-3} - A_{n-4}$. To obtain this equation required the analysis of all eight farms. Solutions of recurrent equations are obtained with rsolve.

Let's introduce the designation for the relative displacement $\Delta = \Delta EF / P_{sum}$, where $P_{sum} = nP$ – the total load. Fix the height of the arch and the length of the half span: $H = nb,\ L = a(n+1) = 30$ m. Then we have the Graph like this:

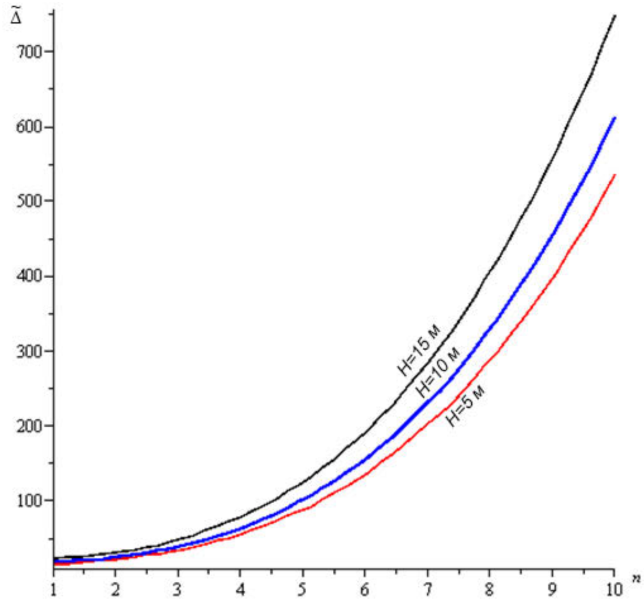

Fig. 2. The dependence of the deflection on the number of panels

A characteristic feature: extreme points, characteristic of analogous solutions for the vertical loads on a truss and the vertical displacement on the curves [5-8] are not detected.

Список используемых источников:

1. Сайпулаев Г.Р. Расчет регулярных стержневых систем на примере арочной фермы // Актуальные вопросы образования и науки. 2014. Ч. 4. С. 128–130.

2. Tinkov D.V. Comparative analysis of analytical solutions to the problem of truss structure deflection // Magazine of Civil Engineering. 2015. No.5(57). P. 66-73.

3. Потапов В.Д., Александров А.В., Косицын С.Б., Долотказин Д.Б. Строительная механика. Кн. 1. М.: Высш. шк., 2007. 511 с.

4. Кирсанов М.Н. Maple и Maplet. Решение задач механики. СПб.: Изд-во Лань, 2012. 512 с.

5. Кирсанов М.Н. Точные формулы для расчета прогиба и усилий в стержнях типовой фермы «Молодечно» с произвольным числом панелей // Инженерно-строительный журнал. 2016. №1(61). С. 33–41.

6. Кирсанов М.Н. Математическая модель балочной фермы с элементами упрочнения // Инженерно-строительный журнал. 2015. №4(56). С. 38–44.

7. Кирсанов М.Н. Индуктивный анализ влияния погрешности монтажа на жесткость и прочность плоской фермы // Инженерно-строительный журнал. 2012. № 5(31). С. 38–42.

8. Кирсанов М.Н. Аналитическое исследование деформаций плоской фермы арочного типа // Вестник государственного университета морского и речного флота им. адмирала С. О. Макарова 2015. № 3 (31). С. 42–48.

9. 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). P. 84–105.
10. Кирсанов М.Н. Изгиб, кручение и асимптотический анализ пространственной стержневой консоли // Инженерно-строительный журнал. 2014. № 5 (49). С. 37–43.
11. Кирсанов М.Н. Напряженное состояние и деформации прямоугольного пространственного стержневого покрытия // Научный вестник ВГАСУ. Строительство и архитектура. 2016. №1(41). С. 93-100.