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DETERMINATION OF THE DEFLECTION OF A BEAM USING INITIAL PARAMETERS METHOD

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This article describes the determination of the deflection of a cantilever I-beam using the method of initial parameters. A comparative analysis of theoretical calculations and calculations in the program of finite-element analysis ANSYS is shown in this article.

Introduction. The method of initial parameters has been widely used in a variety of engineering problems. It was originally developed by Soviet scientists such as N.P. Puzyrevsky, P.G. Kulikovskii, N.K. Snitko, N.I. Bezukhov, A.A. Umansky and others.

This method doesn't require the composition of bending moments expressions and integration of the differential equation of the bent axis of the beam. The number of constants to be determined does not exceed two regardless of the number of sections in the beam.

Task formulation. The study of a cantilever I-beam loaded with a system of external forces**.**

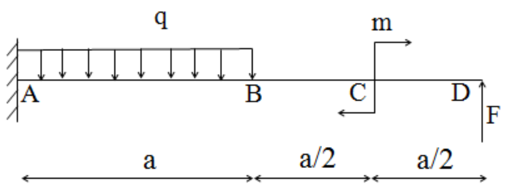

Fig. 1. The schema of loading the I-beam

We write the displacement and slope equations for the sections at points B, C and D. For the cross-section at point B, the equations will have the form:

$$EJ_z f_B = EJ_z f_A + EJ_z \theta_A \cdot a + M_A \frac{(a-0)^2}{2} + R_A \frac{(a-0)^3}{6} - q\frac{(a-0)^4}{24}; \quad (1)$$

$$EJ_z \theta_B = EJ_z \theta_A + M_A (a-0) + R_A \frac{(a-0)^2}{2} - q\frac{(a-0)^3}{6}. \quad (2)$$

For the cross-section at point C, the equations will have the form:

$$EJ_z f_C = EJ_z f_A + EJ_z \theta_A \cdot 1,5a - M\frac{(1,5a-1,5a)^2}{2} + M_A \frac{(1,5a-0)^2}{2} + \\ + R_A \frac{(1,5a-0)^3}{6} - q\frac{(1,5a-0)^4}{24} + q\frac{(1,5a-a)^4}{24}; \quad (3)$$

$$EJ_z \theta_C = EJ_z \theta_A - M(1,5a-1,5a) + M_A(1,5a-0) + R_A \frac{(1,5a-0)^2}{2} - q\frac{(1,5a-0)^3}{6} + q\frac{(1,5a-a)^3}{6}. \quad (4)$$

For the cross-section at point D, the equations will have the form:

$$EJ_z f_D = EJ_z f_A + EJ_z \theta_A \cdot 2a - M\frac{(2a-1,5a)^2}{2} + M_A \frac{(2a-0)^2}{2} + F\frac{(2a-2a)^3}{6} + \\ + R_A \frac{(2a-0)^3}{6} - q\frac{(2a-0)^4}{24} + q\frac{(2a-a)^4}{24}; \quad (5)$$

$$EJ_z\theta_D = EJ_z\theta_A - M(2a-1{,}5a) + M_A(2a-0) + F\frac{(2a-2a)^2}{2} + R_A\frac{(2a-0)^2}{2} - $$
$$-q\frac{(2a-0)^3}{6} + q\frac{(2a-a)^3}{6}. \quad (6)$$

Where f_A, θ_A are respectively equal to the displacement and curvature slope at the origin at point A, which by this type of consolidation at the left end of the beam, are equal to zero.

The numerical values of displacements and curvature slopes of the given points are shown in Table 1.

The results of the calculations: To determine the numerical values of deflections and slopes, the following data are used: $q = 20$ kN/m; $M = 15\,kN \cdot$ m; $F = 50$ kN; $a = 3$ m. The material of the beam is steel of first kind modulus $E = 2\cdot10^5$ MPa . The cross-section of the I-beam has the profile № 16. The axial moment of inertia for this I-beam is $J_z = 873\,\text{cm}^4$.

As well as in the program of finite-element analysis ANSYS, the bending of the I-beam was modeled (simulated) and the results of displacements and slopes at critical (key) points where calculated.

The comparative analysis of theoretical calculations by formulas (1) – (6) and the computer modeling by the program ANSYS are listed in Table 1.

Table 1 – Results of the calculations of deflection theoretically and by ANSYS

	Displacement of the section at *B*, cm	Displacement of the section at *C*, cm	Displacement of the section at *D*, cm	Slope at *B*, degrees	Slope at *C*, degrees	Slope at *D*, degrees
Theoretical calculations	0,005154	0,01411	0,0239	0,003608	0,0061849	0,009407
Program ANSYS	0,0063135	0,0014579	0,0024659	0,00045586	0,0062105	0,00069417

The deformation of the beam caused by the external forces are shown in (Fig. 2).

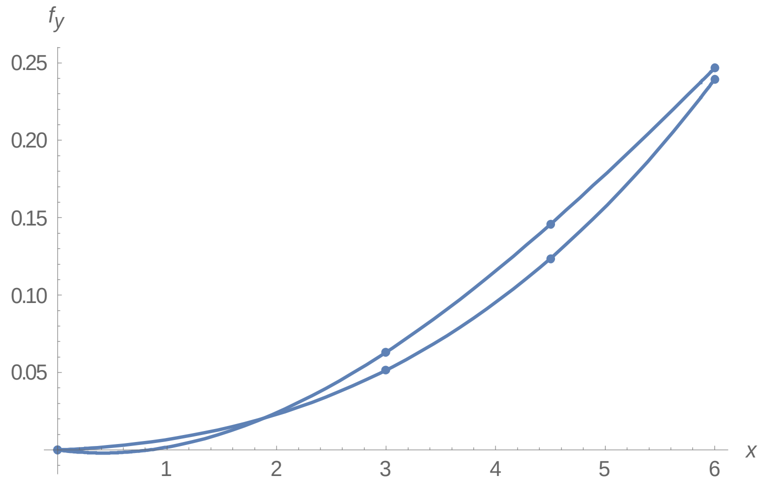

Fig. 2. Beam flexural deformation

Conclusion. Displacements and curvature slopes of the cantilever beam due to bending are calculated using the method of initial parameters. Theoretical calculations are approximately consistent with calculations in the program finite-element analysis ANSYS.

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