USING MAIN METHODICS PROBLEMS OF NUMERICAL METHODS FOR THE CALCULATION OF LAYERED PLATES, TAKING INTO ACCOUNT THE DEFORMATION OF THE TRANSVERSE SHEAR.

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ANNOTATION: In this article we gave information about how to use methodical problems in calculation of the layered plates and also, we took into account types of deformation and internal force factors such as shear force.Calculation results are given also in this articles and formulas as well.

KEY WORDS: multilayer beam, plates, stress tensor, loading-bearing elements, roof panels, transverse shear

Multilayer structures such as beams, plates and shells are becoming widespread in construction as load-bearing elements, roof panels and fences. Typical multilayer structures are plates of road bridges, rigid road coating.

The problem of calculating multilayer beams and plates whose physical and mechanical characteristics are piecewise-continuous functions of the normal to the coordinate surface is considered. In this case, the plate (beam) may contain low-rigid layers that weakly resist transverse shear. Such systems are purposefully designed to satisfy a given set of structural properties: reduced material consumption with high strength, heat resistance, soundproofing, etc.

Estimation of the stress-strain state of such systems is a complex task of structural mechanics.

To a certain extent, this problem can be solved on the basis of the development of universal theoretical refined models for which the number and order of resolving equations do not depend on the degree of heterogeneity of structural elements on which they make it possible in a single solution process. [1].

The implementation of such models should be carried out using the methods of structural mechanics, the finite element method.[1,2]

This work presents the solution of problems of the stressed and thermally stressed state of multilayer plates of a piecewise-continuous structure in thickness. The solution is based on a refined (non-classical) theory of layered plates, which takes into account the influence of transverse shear and compression deformations, as well as transverse normal stresses. The layers of the plate have the property of transversal isotropy [1,3].

To reduce a three-dimensional problem to a two-dimensional one, the method of hypotheses is used that takes into account the specified deformations. Hypotheses are involved for the whole package of layers as a whole

For the strength problem, they have the following form:

$$e_{i3} = \varphi_{1,x}\eta_{1K}(z) + q_x^-\eta_{2K}(z) + q_x^+\pi_{3K}(z)$$
$$e_{33} = \varphi_1\varphi_{1K}(z) + q_{x,x}^-\varphi_{2K}(z) + q_{x,x}^+\varphi_{3K}(z) + q_z^-\varphi_{4K}(z) + q_2^+\varphi_{5K}(z)$$

The following hypotheses are introduced for the problem of the thermally stressed state.

$$2e_{i3} = \varphi_{p,i} F_{pK}(z)$$

$$e_{33} = o; \qquad (i = 1,2; p = 1,2,3)$$

The systems of resolving equations have an order that does not depend on the number of layers. The distribution functions over the package thickness are obtained from the solution of the problem in the first approximation according to the classical theory and take into account the hard contact condition

Calculation schemes based on the finite element method (FEM) and the finite difference method (FDM) were constructed. The discretization of objects was carried out only in plan, which makes it possible to obtain a significant reduction in the number of unknowns compared to the discretization scheme of inhomogeneous systems as three-dimensional bodies [2,3].

Analogy and approximation of displacements and shifts leads to the matrix rigidity of the block structure. Each block of the matrix consists of a subblock of the stiffness matrix built on the basis of the classical plate theory, multiplied by the corresponding stiffness factor. The construction of the stiffness matrix (MF) for such a model has a peculiarity: the expressions describing the stress tensor and the strain tensor include both the desired functions and the given load vectors on the surface of the structure. The form of the stiffness matrix is determined by the desired functions.

Part of the stress tensor, determined by the functions of loads on the surface, complements the vector of nodal loads. [1,2]

The results of studies of the stress state of layered plates with various applications are presented.

Consider the calculation of a three-layer beam according to the proposed calculation method, Find the largest deflection and normal tensile stress in a three-layer beam, pinched at the ends (Fig. 2).

Uniformly distributed load qz = q The characteristics of the layers are as follows:

h1=0,045 см; h2=1 см; E1=7·104 МПа; E2=90 МПа; υ1=0,3; υ2=0,22.

Taking into account the considered analogies with the known solutions of the technical theory of beams, we have: [1]:

$$u = 0 \qquad\qquad \overline{\psi}_{2\kappa}(z) = \overline{\psi}_{2\kappa}(z)$$

$$\Phi_{\text{мах}} = -\frac{ql^3}{192D_{11}}; \qquad \chi_{\max} = \frac{ql^2}{24D_{11}}; \qquad w_{\max} = -\frac{ql^3}{192D_{11}}\left(1 - \frac{16c_{21}}{l^2}\right)$$

we obtain the deflection and stresses, taking into account the proposed calculation method:

$$w(x) = \Phi(x) - \frac{\overline{D}_{12}}{\overline{D}_{11}}\chi(x) = \Phi(x) - \overline{C}_{21}\chi(x)$$

$$\sigma_x^{(k)} = -E_k\left[\frac{d^2w}{dx^2}z + \frac{d^2\chi}{dx^2}\psi_{2k}(z)\right] = \left\{\frac{d^2\Phi}{dx^2}z - \frac{d^2\chi}{dx^2}c_{21}z\left[1 - \frac{\psi_{2k}(z)}{c_{21}z}\right]\right\} =$$

$$= \frac{ql^2}{24D_{11}}E_k z\left\{1 + \frac{24c_{21}}{l^2}\left[1 - \frac{\psi_{2k}(z)}{c_{21}z}\right]\right\}$$

For considered beam: in: D11=387кN·cm2; c21=47,8 cm2;

$$\psi_{11}\left(\frac{h}{2}\right) = 23{,}38\,см^{3}; \qquad z = \frac{h}{2} = 0{,}555см,$$

$$w_{\max} = 2{,}91\frac{ql^{3}}{192D_{11}};$$

Thus, the deflection is 2.91 times, and the normal stress is 1.35 times greater than that found from the technical theory of beam bending:

The calculation results show that the calculation should be carried out according to the proposed calculation method

Since the technical theory is not applicable to the calculation of the considered problem

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