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APPLICATION OF SOFTWARE TOOLS IN CALCULATING THE DEFORMATION STATE OF A PLATE

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Abstract: In this article, the issue of using modern software tools for calculating the deformation process of a plate under external load is discussed. Based on the theory of deformation, a mathematical model of plate bending is presented, and its solution is implemented using a computer. The Maple software was used for the calculations, and the stress and displacement distribution of the plate under various loading conditions was analyzed. The results were presented in graphical form, and the advantages of computational analysis over traditional methods were substantiated.

Key words: Plate deformation, load-induced deflection, elasticity theory, stress and displacement distribution, computational mechanics, rectangular plate bending.

PLASTINKANING DEFORMASIYALANGANLIK HOLATINI HISOBLASHDA DASTURIY VOSITANI QO‘LLASH

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Annotatsiya: Ushbu maqolada plastinkaning tashqi kuch ta’sirida deformatsiyalanish jarayonini hisoblashda zamonaviy dasturiy vositalardan foydalanish masalasi yoritilgan.

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Deformatsiya nazariyasiga asoslangan holda, plastinka egilishining matematik modeli keltirilgan va uning yechimi kompyuter yordamida amalga oshirilgan. Hisoblash uchun Maple dasturi qo‘llanilib, turli yuklama sharoitlarida plastinkaning kuchlanish va siljish taqsimoti tahlil qilindi. Natijalar grafik ko‘rinishida taqdim etilib, dasturiy hisoblashning an’anaviy usullarga nisbatan afzalliklari asoslab berilgan.

Kalit so‘zlar: Plastinka deformatsiyasi, kuch ta’siri ostidagi egilish, elastiklik nazariyasi, mexanik tahlil, kuchlanish va siljish taqsimoti, to‘g‘ri to‘rtburchak plastinka.

ПРИМЕНЕНИЕ ПРОГРАММНЫХ СРЕДСТВ ПРИ РАСЧЁТЕ ДЕФОРМИРОВАННОГО СОСТОЯНИЯ ПЛАСТИНЫ

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Аннотация: В данной статье рассматривается проблема использования современных программных средств для расчета процесса деформирования пластины под действием внешней нагрузки. На основе теории деформации приведена математическая модель изгиба пластины, и её решение выполнено с помощью компьютера. Для вычислений была использована программа Maple, проведён анализ распределения напряжений и перемещений пластины при различных условиях нагружения. Результаты представлены в графическом виде, и обоснованы преимущества программного расчёта по сравнению с традиционными методами.

Ключ слова: Деформация пластины, прогиб под действием нагрузки, теория упругости, механический анализ, распределение напряжений и перемещений, изгиб прямоугольной пластины.

INTRODUCTION

Today on the day mechanical engineering, construction , aerospace and electrical engineering in the fields plate-shaped constructions are widely used. Their strength and reliability provision for external power under the influence deformation status clear calculation necessary . Traditional analytical methods complicated geometry and borderline under the circumstances enough accuracy not giving because of computer technologies based calculation methods are being widely used.

Of the plates bending status in determining don't download type, borderline reinforcement conditions, material modulus of elasticity and thickness such factors are of crucial importance. In this article right rectangle of the plate central to the part applied static power under the influence deformation process theoretical in terms of analysis will be done and

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bending sizes is also taken. Results based on optimal design of structures according to recommendations working will be released .

MAIN PART

To study the bending of a plate, we begin with the expressions of displacements and deformations We consider the effect of loads applied along the normal tot he middle surfaceof the plate. Such strengthening under the influence plate their migrations acceptance made hypotheses according to we express [1].

$$\varepsilon_z = \frac{\partial w}{\partial z} = 0 \qquad (1)$$

From this plate w bends z from the coordinates related not being come it comes out , that is ; $w = w(x, y)$

This and plate middle surface bending everyone points are vertical joints w with to be expressed indicates .

Shift (1) conditions for as follows we get ;

$$\gamma_{yz} = \frac{\partial v}{\partial z} + \frac{\partial w}{\partial y} = 0; \qquad \gamma_{zx} = \frac{\partial w}{\partial x} + \frac{\partial u}{\partial z} = 0; \qquad (2)$$

this from the streets the following we get :

$$\frac{\partial u}{\partial z} = -\frac{\partial w}{\partial x}. \qquad \frac{\partial v}{\partial z} = -\frac{\partial w}{\partial y}; \qquad (3)$$

This equations z according to integrating , the following we get ,

$$u = -z\frac{\partial w}{\partial x} + f_1(x, y); \qquad v = -z\frac{\partial w}{\partial y} + f_2(x, y); \qquad (4)$$

$f_1(x, y)$ and $f_2(x, y)$ private derivatives from integration harvest was functions find for extreme surface non-deformation from the hypothesis We use the formula (4).

For *z=0*; the following appearance takes :

$$u_0 = f_1(x, y) = 0; \qquad v_0 = f_2(x, y) = 0;$$

accordingly *(a)* takes the following form:

$$u = -z\frac{\partial w}{\partial x}; \qquad v = -z\frac{\partial w}{\partial y}. \qquad (5)$$

This means that the displacements of the plate points in the *x* and *y* directions are expressed by the plate mid-surface deflection function [4] .

The non-zero deformations of the plate according to (5) are expressed as follows:

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$$\varepsilon_x = \frac{\partial u}{\partial x} = -z\frac{\partial^2 w}{\partial x^2};$$

$$\varepsilon_y = \frac{\partial v}{\partial y} = -z\frac{\partial^2 w}{\partial y^2}; \quad (6)$$

$$\gamma_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} = -2z\frac{\partial^2 w}{\partial x \partial y}$$

Therefore, the deformations and displacements during bending of the midsurface of the plate are represented by a single function.

We take an infinitesimal element of internal stress in the plate $dxdydz$ and represent it as shown in the figure. x In a plane parallel to the plane normal axis σ_x, τ_{yx} the stresses σ_x and are located, τ_{zx} the stress along the external normal of the section corresponds to the positive direction of the coordinate axes, and the direction of the external normal of the section x corresponds to the positive direction of the axis.

The normal internal force per unit width of the section under consideration is

N_x We denote it by . This x is the projection σ_x of the internal forces acting on the cross section parallel to the axis onto the axis. Only x the stress is projected onto this axis [2] .

The internal forces on $dxdydz$ an infinitesimal surface are $dxdz$ equal to $\sigma_x dz$ the force per unit area of cross-section. The sum of such elementary forces through the thickness of the plate represents the normal force.

$$N_x = \int_{-\frac{h}{2}}^{\frac{h}{2}} \sigma_x dt$$

If we substitute formula for z the normal stress σ_x and extract the quantities independent of the integral sign,

$$N_x = -\frac{E}{1-\nu^2}\left(\frac{\partial^2 w}{\partial x^2} + \nu\frac{\partial^2 w}{\partial y^2}\right)\int_{-\frac{h}{2}}^{\frac{h}{2}} zdt$$

From this $N_x = 0$ that come It comes out. Just like so bending moment M_x what $\sigma_x dz$ z elementary moments sum in the form of if we write

$$M_z = \int_{-\frac{h}{2}}^{\frac{h}{2}} \sigma_x zdt = -\frac{E}{1-\nu^2}\left(\frac{\partial^2 w}{\partial x^2} + \nu\frac{\partial^2 w}{\partial y^2}\right)\int_{-\frac{h}{2}}^{\frac{h}{2}} z^2 dt \quad (7)$$

From this

$$M_x = -D(\frac{\partial^2 w}{\partial x^2} + \nu \frac{\partial^2 w}{\partial y^2})$$

Here

$$D = \frac{Eh^3}{12(1-\nu^2)} \qquad (8)$$

The quantity (8) is called the cylindrical stiffness. It consists of the physical geometric characteristics of the plate.

The transverse force in the section will have the following form:

$$Q_x = \int_{-\frac{h}{2}}^{\frac{h}{2}} \tau_{zx} dx$$

to formula (7) according to

$$Q_x = -\frac{E}{2(1-\nu^2)} \frac{\partial}{\partial x} {}^{2}w \int_{-\frac{h}{2}}^{\frac{h}{2}} (\frac{h^2}{4} - z^2) dx$$

From integration then

$$Q_x = -D \frac{\partial}{\partial x} {}^{2}w$$

Sliding forces as S_x if we take it internal forces z on the axis projections sum is calculated. It can be seen that according to formula (7) $S_x = 0$. The torque and as follows is expressed .

$$M_{yx} = \int_{=\frac{h}{2}}^{\frac{h}{2}} \tau_{yx} z dz = -D(1-\nu) \frac{\partial^2 w}{\partial x \partial y}$$

Same so y arrow according to

$$M_y = -D(\frac{\partial^2 w}{\partial y^2} + \nu \frac{\partial^2 w}{\partial x^2})$$

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$$M_{xy} = -D(1-\nu)\frac{\partial^2 w}{\partial x \partial y}$$

$$Q_y = -D\frac{\partial}{\partial y} \quad {}^2 w$$

$M_{xy} = M_{yx} = H$ if we say plate middle to the surface perpendicular in the section under the influence of transverse load harvest to be internal forces:

Bending moments to the following equal will be :

$$M_x = -D\left(\frac{\partial^2 w}{\partial x^2} + \nu\frac{\partial^2 w}{\partial y^2}\right)$$
$$M_y = -D\left(\frac{\partial^2 w}{\partial y^2} + \nu\frac{\partial^2 w}{\partial x^2}\right) \qquad (9)$$

DISCUSSIONS. Let all four sides of a rectangular plate be hinged. Then the equation of bending of the plate is

$$D\left(\frac{\partial^4 w}{\partial x^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4}\right) = q(x,y), \qquad (10)$$

where $D = \frac{Eh^3}{12(1-\mu^2)}$. We find the solution of equation (3.13) using a two-fold trigonometric series of the following form,

$$w(x,y) = \sum_{n=1} \sum_{m=1} w_{nm} \sin\frac{n\pi x}{a} \sin\frac{m\pi y}{b}, \qquad (11)$$

where w_{nm} is the numerical coefficient [5] .

The boundary conditions will be as follows

a) on the line $x=0$ and $x=a$, $w = 0,$ $\frac{\partial^2 w}{\partial x^2} = 0$;

b) on the line $y=0$ and $y=b$, $w = 0,$ $\frac{\partial^2 w}{\partial y^2} = 0$.

The external load $q(x,y)$ in the form of the following two-fold trigonometric series.

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$$q(x,y) = \sum_{n=1}\sum_{m=1} q_{nm} \sin\frac{n\pi x}{a}\sin\frac{m\pi y}{b} \qquad (12)$$

this series can be found from the following formula based on the theory of Fourier series known to us.

$$q_{nm} = \frac{4}{aв}\int_0^b\int_0^a q(x,y)\sin\frac{n\pi x}{a}\sin\frac{m\pi y}{b}dxdy \qquad (13)$$

Substituting (3.14) and (3.15) into (3.13) and reducing both sides $\sin\frac{n\pi x}{a}\sin\frac{m\pi y}{b}$ to , we get the following.

$$\pi^4\left(\frac{n^4}{a^4}+2\frac{m^2n^2}{b^2a^2}+\frac{m^4}{b^4}\right)w_{nm} = \frac{q_{nm}}{D}, \qquad (14)$$

from this
$$w_{nm} = \frac{q_{nm}}{\pi^4 D\left(\frac{n^2}{a^2}+\frac{m^2}{b^2}\right)^2} \qquad (15)$$

Then the deformations of the elements are found according to expression (11) as follows.

$$M_x = D(\chi_x + \mu\chi_y) = D\sum_{n=1}\sum_{m=1} w_{nm}\left(\frac{n^2\pi^2}{a^2}+\mu\frac{m^2\pi^2}{b^2}\right)\sin\frac{n\pi x}{a}\sin\frac{m\pi y}{b};$$

$$M_y = D(\chi_y + \mu\chi_x) = D\sum_{n=1}\sum_{m=1} w_{nm}\left(\frac{m^2\pi^2}{b^2}+\mu\frac{n^2\pi^2}{a^2}\right)\sin\frac{n\pi x}{a}\sin\frac{m\pi y}{b}; \qquad (16)$$

$$M_{xy} = D(1-\mu)\chi_{xy} = D(1-\mu)\sum_{n=1}\sum_{m=1} w_{nm}\frac{nm\pi^2}{ab}\cos\frac{n\pi x}{a}\cos\frac{m\pi y}{b}.$$

RESULTS. A steel plate with rectangular sides hinged together $q(x,y)=(1-x)(1-y)$ is subjected to a visible load. $a=\frac{1}{2}$, $b=\frac{1}{2}$ Given the dimensions of the plate, we find expressions for the displacements, deformations, stresses, moments, and shear forces at the mid-surface of the plate.

In problem (11), to find the expression for the displacements, q_{nm} we need to find from expression (15), for this, according to (13),

$$q_{nm} = \frac{4}{a в}\int_0^b\int_0^a (1-x)(1-y)\sin\frac{n\pi x}{a}\sin\frac{m\pi y}{b}dxdy =$$

$$= \frac{4}{a в}\int_0^a (1-x)\sin\frac{n\pi x}{a}dx\int_0^b (1-y)\sin\frac{m\pi y}{b}dy =$$

$$= \frac{4}{ab}\left(-\frac{a}{n\pi}\left((-1)^n-1\right)+\frac{a^2}{n\pi}(-1)^n\right)\left(-\frac{b}{m\pi}\left((-1)^n-1\right)+\frac{b^2}{m\pi}(-1)^n\right).$$

If m and n are even,

$$q_{mn} = \frac{4ab}{nm\pi^2}.$$

If m and n are odd,

$$q_{mn} = \frac{4(2-a)(2-b)}{n^2m^2\pi^2}.$$

According to the condition of the problem, $a = \frac{1}{2}, \quad b = \frac{1}{2}$ is equal to according to this

$$q_{mn} = \frac{9}{\pi^2}.$$

From formula (15)

$$w_{nm} = \frac{9}{64\pi^6 D}.$$

Migration function $n=1$ and $m=1$ to (11) according to following in appearance will be:

$$w(x,y) = \frac{9}{64\pi^6 D}\sin 2\pi x\sin 2\pi y.$$

M_{xy} function graph as follows:

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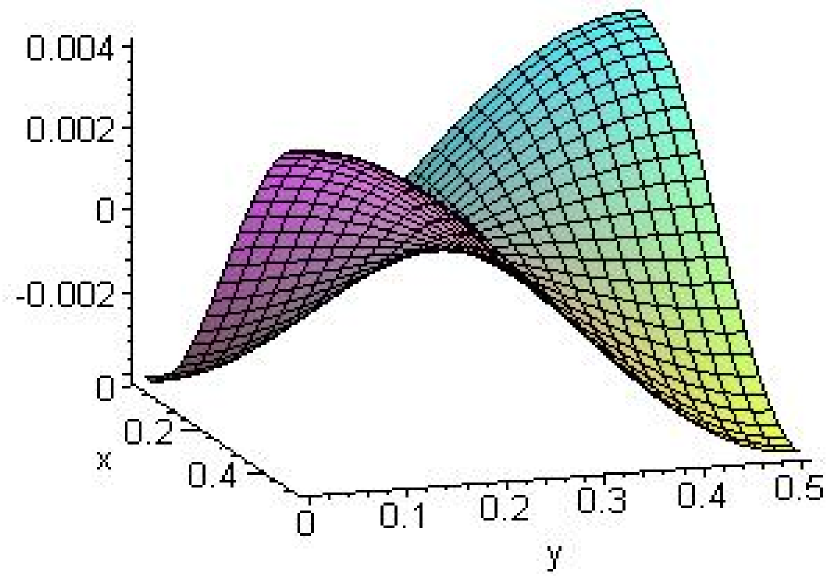

Figure 1. Twisting moment function graph

CONCLUSION. In this article of the plate external power under the influence deformation process theoretical and practical in terms of studied and Maple software in the environment modeling based on numerical analysis. Results showed that the computer modeling technologies using complicated of constructions bending and voltage status clear and fast accordingly assessment Maple program using taken graphic and numerical results analytical solutions with when compared, they mutual high at the level suitable arrival This, in turn, confirms the reliability of the chosen algorithm. Software calculations using not only deformation values, maybe voltage distribution, one of the important advantages is that displacement maps and yield contours can also be obtained in a visual form.

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