MUHAMMAD AL-XORAZMIY
NOMIDAGI TATU FARG'ONA FILIALI

FERGANA BRANCH OF TUIT
NAMED AFTER MUHAMMAD AL-KHORAZMI

"AL-FARG'ONIY AVLODLARI"

ELEKTRON ILMIY JURNALI | ELECTRONIC SCIENTIFIC JOURNAL

TA'LIMDAGI ILMIY, OMMABOP VA ILMIY TADQIQOT ISHLARI

4-SON 1(4)
2023-YIL

TATU, FARG'ONA
O'ZBEKISTON

ISSN 2181-4252

O'ZBEKISTON RESPUBLIKASI RAQAMLI TEXNOLOGIYALAR VAZIRLIGI

MUHAMMAD AL-XORAZMIY NOMIDAGI TOSHKENT AXBOROT TEXNOLOGIYALARI UNIVERSITETI FARG'ONA FILIALI

Muassis: Muhammad al-Xorazmiy nomidagi Toshkent axborot texnologiyalari universiteti Farg'ona filiali.
Chop etish tili: O'zbek, ingliz, rus.
Jurnal texnika fanlariga ixtisoslashgan bo'lib, barcha shu sohadagi matematika, fizika, axborot texnologiyalari yo'nalishida maqolalar chop etib boradi.

Учредитель: Ферганский филиал Ташкентского университета информационных технологий имени Мухаммада ал-Хоразми.
Язык издания: узбекский, английский, русский.
Журнал специализируется на технических науках и публикует статьи в области математики, физики и информационных технологий.

Founder: Fergana branch of the Tashkent University of Information Technologies named after Muhammad al-Khorazmi.
Language of publication: Uzbek, English, Russian.
The magazine specializes in technical sciences and publishes articles in the field of mathematics, physics, and information technology.

2023 yil, Tom 1, №4
Vol.1, Iss.4, 2023 y

ELEKTRON ILMIY JURNALI **ELECTRONIC SCIENTIFIC JOURNAL**

«Al-Farg'oniy avlodlari» («The descendants of al-Fargani», «Potomki al-Fergani») O'zbekiston Respublikasi Prezidenti administratsiyasi huzuridagi Axborot va ommaviy kommunikatsiyalar agentligida 2022-yil 21 dekabrda 054493-son bilan ro'yxatdan o'tgan.

Jurnal OAK Rayosatining 2023-yil 30 sentabrdagi 343-sonli qarori bilan Texnika fanlari yo'nalishida milliy nashrlar ro'yxatiga kiritilgan.

Tahririyat manzili:
151100, Farg'ona sh.,
Aeroport ko'chasi 17-uy,
202A-xona
Tel: (+99899) 998-01-42
e-mail: info@al-fargoniy.uz

FARG'ONA - 2023 YIL

TAHRIR HAY'ATI

Jurnal quyidagi bazalarda indekslanadi:

Eslatma! Jurnal materiallari to'plamiga kiritilgan ilmiy maqolalardagi raqamlar, ma'lumotlar haqqoniyligiga va keltirilgan iqtiboslar to'g'riligiga mualliflar shaxsan javobgardirlar.

MUNDARIJA | ОГЛАВЛЕНИЕ | TABLE OF CONTENTS

MUNDARIJA | ОГЛАВЛЕНИЕ | TABLE OF CONTENTS

IKKI QATLAMLI NOELASTIK PLASTINKANING KO‘NDALANG TEBRANISHI UMUMIY TENGLAMASINI TAHLIL QILISH

Djalilov Mamatisa Latibdjanovich
Muhammada Al-Xorazmiy nomidagi Toshkent axborot texnologiyalari universiteti Farg‘ona filiali,
Kompyuter tizimlari kafedrasi, k.t.n. dotsent
E-mail: mamatisodjalilov@gmail.com

Annotatsiya: Ushbu maqolada “O‘zgarmas qalinlikdagi ikki qavatli plastinkalarning tebranishlari” nomli [1] maqoladan olingan bo‘laklari bir jinsli noelastik plastinkaning ko‘ndalang tebranishlari uchun umumiy tenglama tahlil qilingan. Masala yechilishini soddalashtiruvchi gipotezalarni jalb qilmasdan, aniq uch o‘lchovli ko‘rinishda qatlamlari bir jinsli plastinalarning tebranishi o‘rganilgan, ular asosida bunday plastinkalarning tebranishlarining umumiy va taqribiy tenglamalarini oligan.

Kalit so‘zlar: tahlil; taqribiy; tebranish; ikki qatlamli plastinka; chegaraviy masala; kuchlanish; deformatsiya; tebranish tenglamasi.

Kirish. Ikki qavatli va ko‘p qatlamli plastinkalar qurilish va texnikaning turli sohalarida keng qo‘llaniladi. Ikki qavatli, uch qatlamli va ko‘p qatlamli tuzilmalardan foydalanishning ko‘payishi bunday elementlarni hisoblashning samarali usullariga ehtiyoj paydo bo‘lishiga yordam berdi. Shu sababli, ikki qavatli plitalardan foydalanishning boshlanishi bilan birga, hisoblash nazariyalari ham paydo bo‘ldi. Shu munosabat bilan plastinkalar tebranishiga oid bir nechta tadqiqot ishlari olib borilgan. Ushbu tadqiqot ishlari ko‘plab maqolalarni, shu jumladan [1] maqolani o‘z ichiga oladi.

Masalaning qo‘yilishi va yechish usullari. Qalinligi o‘zgarmas, qatlamlari bir jinsli yelimshak elastik plastinkalarning [1] da berilgan tebranishlarining uchumiy teglamalari tuzilish jihatidan murakkab va *x*, *y* koordinatalari va vaqt *t* bo‘yicha yuqori tartibli hosilalarni o‘z ichiga oladi va shuning uchun amaliy masalalarni yechish hamda muhandislik hisoblashlarni amalga oshirish uchun mos emas.

Amaliy masalalarni yechish uchun umumiy tenglamalar o‘rniga, hosilalarda chekli tartibni o‘z ichiga olgan taqribiy tenglamalardan foydalanish maqsadga muvofiqdir.

Plastinkaning ko‘ndalang tebranishlari uchun klassik tenglamalar 4-tartibdan yuqori bo‘lmagan hosilalarni o‘z ichiga oladi va qatlamlari bir jinsli ikki qatlamli plastinkalar uchun eng oddiy taqribiy tebranish tenglamasi oltinchi tartibli tenglama bo‘ladi.

Agar [1] da berilgan (3.8) operatorlarda dastlabki ikki had bilan cheklansak, u holda (3.11) tenglamadan

$$L_1(W_2) = F_1(x, y, t)$$

bu yerda L_1 va $F_1(x, y, t)$ operatorlar quyidagi ifodalarga teng:

$$\begin{aligned}
L_1 = {} & (M_{1(n)}K_{2(n)} - M_{2(n)}K_{1(n)})(H_{3(n)}E_{4(n)} - H_{4(n)}E_{3(n)}) + \\
& + (M_{1(n)}K_{3(n)} - M_{3(n)}K_{1(n)})(H_{4(n)}E_{2(n)} - H_{2(n)}E_{4(n)}) + \\
& + (M_{1(n)}K_{4(n)} - M_{4(n)}K_{1(n)})(H_{2(n)}E_{3(n)} - H_{3(n)}E_{2(n)}) - \\
& - (M_{2(n)}K_{3(n)} - M_{3(n)}K_{2(n)})(H_{4(n)}E_{1(n)} - H_{1(n)}E_{4(n)}) - \\
& - (M_{2(n)}K_{4(n)} - M_{4(n)}K_{2(n)})(H_{1(n)}E_{3(n)} - H_{3(n)}E_{1(n)}) + \\
& + (M_{3(n)}K_{4(n)} - M_{4(n)}K_{3(n)})(H_{1(n)}E_{2(n)} - H_{2(n)}E_{1(n)});
\end{aligned}$$

$$\begin{aligned}
F_1 = {} & -[K_{1(n)}(H_{2(n)}E_{3(n)} - H_{3(n)}E_{2(n)}) + K_{2(n)}(H_{3(n)}E_{1(n)} - H_{1(n)}E_{3(n)}) + \\
& + K_{3(n)}(H_{1(n)}E_{2(n)} - H_{2(n)}E_{1(n)})]\{M_0^{-1}(f_z^{(0)})\} + \\
& + [M_{1(n)}(H_{2(n)}E_{3(n)} - H_{3(n)}E_{2(n)}) + M_{2(n)}(H_{3(n)}E_{1(n)} - H_{1(n)}E_{3(n)}) + \\
& + M_{3(n)}(H_{1(n)}E_{2(n)} - H_{2(n)}E_{1(n)})]\{M_1^{-1}(\frac{\partial f_{xz}^{(0)}}{\partial x} + \frac{\partial f_{yz}^{(0)}}{\partial y})\} - \\
& - (M_{1(n)}(K_{2(n)}E_{3(n)} - K_{3(n)}E_{2(n)}) + M_{2(n)}(K_{3(n)}E_{1(n)} - K_{1(n)}E_{3(n)}) + \\
& + M_{3(n)}(K_{1(n)}E_{2(n)} - K_{2(n)}E_{1(n)})]\{M_1^{-1}(f_z^{(1)})\} + \\
& + (M_{1(n)}(K_{2(n)}H_{3(n)} - K_{3(n)}H_{2(n)}) + M_{2(n)}(K_{2(n)}H_{1(n)} - K_{1(n)}H_{2(n)}) + \\
& + M_{3(n)}(K_{1(n)}H_{2(n)} - K_{2(n)}H_{1(n)})]\{M_1^{-1}(\frac{\partial f_{xz}^{(1)}}{\partial x} + \frac{\partial f_{yz}^{(1)}}{\partial y})\};
\end{aligned}$$

quyidagi taqribiy integro-differetsial teglamani hosil qilamiz

$$Q_1\left(\frac{\partial^4 W}{\partial t^4}\right)+Q_2\left(\Delta\frac{\partial^2 W}{\partial t^2}\right)+Q_3\left(\Delta^2 W\right)+Q_4\left(\frac{\partial^6 W}{\partial t^6}\right)+Q_5\left(\Delta\frac{\partial^4 W}{\partial t^4}\right)+$$
$$+Q_6\left(\Delta^2\frac{\partial^2 W}{\partial t^2}\right)+Q_7\left(\Delta^3 W\right)=F_1(x,y,t).$$

(1)

(1) tenglamadagi Q_j va $F_1(x,y,t)$ operatorlarni aniqlash formulalari:

$$Q_1=M_1^{-2}\left(h_0\rho_0+h_1\rho_1\right)^2;$$
$$Q_2=-2M_1^{-2}(2\left(h_0P_2D_0+h_1D_1\right)\left(h_0\rho_0+h_1\rho_1\right)+$$
$$+\left(P_2-1\right)\left(h_0\rho_0\left(h_0+h_1\right)-(h_0{}^2D_0\rho_0+h_1{}^2D_1\rho_1)\right));$$
$$Q_3=4(P_2-1)(h_0{}^2P_2D_0+h_1{}^2D_1+h_1{}^2D_1+2h_0h_1P_2D_0);$$
$$Q_4=-\frac{1}{6}M_1^{-2}(h_0{}^2\rho_0M_0^{-1}(3h_1{}^2\rho_1^2+h_0\rho_0(h_0\rho_0+4h_1\rho_1))(2-D_0)+$$
$$+h_1^2\rho_1M_1^{-1}(3h_0^2\rho_0^2+h_1\rho_1(h_1\rho_1+4h_0\rho_0))(2-D_1));$$
$$Q_5=-\frac{1}{6}M_1^{-2}(h_0{}^2P_2\rho_0^2M_0^{-2}(2P_2(4D_0(1-D_0)+(P_2-1)(4+D_0^2))-$$
$$-h_1^4\rho_1^2M_1^{-2}(2(4D_1^2-4D_1-1)-(P_2-1)D_1(2-D_1))+$$
$$+6h_0^2h_1^2(\rho_0\rho_1M_0^{-1}M_1^{-1}(4(P_2^2D_0+D_1)+(P_2-1)(2P_2(1-D_0)-P_2D_1(2-D_0)$$
$$+D_1(1+D_0)))++M_1^{-1}(\rho_0^2+\rho_1^2))+$$
$$+2P_2h_0h_1(2\rho_0\rho_1M_0^{-1}M_1^{-1})(h_0{}^2(2+4D_0-D_0^2)+h_1^2(2P_2-P_2D_1+5D_1-D_1^2))+$$
$$+h_0^2h_1^2M_0^{-2}((P_2-1)(4-3D_0)+2D_1(4-D_0))+2h_1^2\rho_1^2M_1^{-2}D_0(4-D_1));$$

(2)

$$Q_6=\frac{1}{3}M_1^{-2}(h_0{}^2P_2\rho_0M_0^{-1}(2P_2((P_2-1)(2+9D_0-3D_0^2))-2D_0(1-3P_2+4D_0))+$$
$$+h_1^4\rho_1M_1^{-1}(4D_1(1-2D_1)-4D_1+(P_2-1)D_1(3-D_1))+$$
$$+3h_0^2h_1^2((4P_2D_0(P_2(1-D_1)-D_1)-(P_2-1)(2(P_2-1)D_1(1-D_0)-$$
$$+P_2(2-D_0-2D_0D_1)))\rho_0M_0^{-1}+(4D_1(1+D_0+P_2D_0)-(P_2-1)(6D_0D_1(P_2-1)-$$
$$-6P_2D_0+D_1))\rho_1M_1^{-1})-2h_0h_1P_2(\rho_0M_0^{-1}(2h_0{}^2((P_2-1)(D_0^2-2D_0-1)-$$
$$-2D_1(1+D_0))-h_1^2(2(P_2-1)+D_1(P_2+3))))-$$
$$-4\rho_1M_1^{-1}(h_0{}^2+h_1{}^2)(2(P_2-1)(1-D_1)+P_2D_1+(1+D_1))))));$$
$$Q_7=\frac{2}{3}(h_0^4P_2D_0(4D_0-5(P_2-1)+h_1^4D_1(4D_1-(P_2-1))-$$
$$+3h_0^2h_1^2(8P_2D_0D_1-(P_2-1)((2(P_2+1)D_0D_1-3P_2D_0-D_1(1-D_1)))-$$
$$-4h_0h_1P_2D_0(h_0{}^2(P_2-1)+2D_1)+h_1^2(2(P_2-1)+(P_2+1)D_0)));$$

va

$$F_1(x,y,t)=M_1^{-2}\frac{\partial^2}{\partial t^2}(\left(h_0\rho_0+h_1\rho_1\right)(f_z^{(0)}-f_z^{(1)}))+$$
$$+(h_0+h_1)(h_1\rho_1(\frac{\partial^2 f_{xz}^{(0)}}{\partial x^2}+\frac{\partial^2 f_{yz}^{(0)}}{\partial y^2})+h_0\rho_0(\frac{\partial^2 f_{xz}^{(1)}}{\partial x^2}+\frac{\partial^2 f_{yz}^{(1)}}{\partial y^2}))+$$

(3)

$$+(h_0^2D_0\rho_0+h_1^2D_1\rho_1)((\frac{\partial^2 f_{xz}^{(0)}}{\partial x^2}+\frac{\partial^2 f_{yz}^{(0)}}{\partial y^2})-(\frac{\partial^2 f_{xz}^{(1)}}{\partial x^2}+\frac{\partial^2 f_{yz}^{(1)}}{\partial y^2}))-$$
$$-2\Delta(2M_1^{-2}(\left(h_0P_2D_0+h_1D_1\right)(M_0f_z^{(0)}-M_1f_z^{(1)}))+$$

(3)

$$+2P_2h_0h_1)(D_0M_0^{-1}(\frac{\partial^2 f_{xz}^{(0)}}{\partial x^2}+\frac{\partial^2 f_{yz}^{(0)}}{\partial y^2})+D_1M_1^{-1}(\frac{\partial^2 f_{xz}^{(1)}}{\partial x^2}+\frac{\partial^2 f_{yz}^{(1)}}{\partial y^2}))+$$
$$+M_1^{-1}(h_0^2P_2D_0+h_1^2D_1)(\frac{\partial^2 f_{xz}^{(0)}}{\partial x^2}+\frac{\partial^2 f_{yz}^{(0)}}{\partial y^2})+(\frac{\partial^2 f_{xz}^{(1)}}{\partial x^2}+\frac{\partial^2 f_{yz}^{(1)}}{\partial y^2})).$$

Agar plastinka bir jinsli va W - "o‘rta" sirt nuqtalarining ko‘ndalang - plastinka tekisligi siljishi bo‘lsa, bu holda quyidagi bog`liqliklar bajariladi.

$$N_0=N_1;\quad M_0=M_1;\quad P_2=1;\quad h_0=h_1;\quad C_0=C_1;\quad D_0=D_1.$$

va (1) tenglama quyida ko‘rsatilgan tenglamaga aylanadi

$$((1-C_0)^2\lambda_{10}^{(1)}+(1+C_0)^2\Delta)((\lambda_{20}^{(1)}+\Delta)+$$
$$+\frac{h_0^2}{6}((3D_0(\lambda_{20}^{(1)}+\Delta)^2)+4D_0\lambda_{20}^{(1)}\Delta)+4\lambda_{10}^{(1)}(\lambda_{20}^{(1)}+\Delta)))(W)=$$
$$=\frac{1}{h_0}(M_0^{-2}\frac{\partial^2}{\partial t^2}((f_z)+h_0(\frac{\partial^2 f_{xz}^{(0)}}{\partial x^2}+\frac{\partial^2 f_{yz}^{(0)}}{\partial y^2}))-$$
$$-4D_0M_0^{-1}\Delta((f_z)+h_0\frac{\partial^2 f_{xz}^{(1)}}{\partial x^2}+\frac{\partial^2 f_{yz}^{(1)}}{\partial y^2})))$$

(4)

(4) ning chap tomonda ikkita operatorning ko‘paytmasi mavjud: birinchisi bo‘ylama tebranish, ikkinchisi esa - ko‘ndalang tebranish jarayonlarini tavsiflaydi.

Xuddi shunday, [1] da berilgan (1.3.12) umumiy tenglamadan $\left(\frac{\partial U_1}{\partial y}-\frac{\partial V_1}{\partial x}\right)$ uchun taxminiy tenglama keltirib chiqariladi va uning ko‘rinishi (5) orqali ifodalangan integro - diffentsial tenglama bo‘ladi

$$(G_1\frac{\partial}{\partial t^2}+G_2\Delta+G_3\frac{\partial^4}{\partial t^4}+G_4\Delta\frac{\partial^2}{\partial t^2}+G_5\Delta^2+G_6\frac{\partial^6}{\partial t^6}+$$
$$+G_7\Delta+G_8\Delta^2+G_9\Delta^3)(\frac{\partial U_1}{\partial y}-\frac{\partial V_1}{\partial x})=F_2(x,y,t),$$

(5)

bu yerda G_j va $F_2(x,y,t)$ operatorlar quyidagi formulalar orqali aniqlanadi:

$$G_1 = M_1^{-1}(h_0\rho_0 + h_1\rho_1)\ ;$$

$$G_2 = -(h_0 P_2 + h_1)\ ;$$

$$G_3 = \frac{1}{6}M_1^{-2}(h_0^2(h_0\rho_0 + 3h_1\rho_1)\rho_0 M_0^{-1} + h_1^2(h_1\rho_1 + 3h_0\rho_0)\rho_1 M_1^{-1});$$

(6)

$$G_4 = -\frac{1}{6}(h_0^{\ 2}(2P_2h_0\rho_0M_0^{-1} + 3h_1(\rho_0M_0^{-1} + \rho_1M_1^{-1})) + h_1^2(2h_1\rho_1M_1^{-1} + 3P_2h_0(\rho_0M_0^{-1} + \rho_1M_1^{-1})));$$

$$G_5 = \frac{1}{6}M_1^{-2}(h_0^2(P_2h_0 + 3h_1) + h_1^2(h_1 + 3P_2h_0));$$

$$G_6 = \frac{1}{120}(h_0^5P_2\rho_0^2M_0^{-2}(10\rho_1M_1^{-1} + \rho_0M_0^{-1}) + h_1^5\rho_1M_1^{-1}(10\rho_0M_0^{-1} + \rho_1M_1^{-1}) + \\ + 5h_0h_1\rho_0\rho_1M_0^{-1}M_1^{-1}(h_0^3\rho_0M_0^{-1}(3 - 3D_0 - D_0^2) - h_1^3P_2\rho_1M_1^{-1}(3 - 3D_1 - D_1^2)));$$

$$G_7 = \frac{1}{120}(-13(h_0^5P_2\rho_0^2M_0^{-2} + h_1^5\rho_1^2M_1^{-2}) + 20(h_0^5P_2 + h_1^5)\rho_0\rho_1M_0^{-1}M_1^{-1} - \\ - 5h_0h_1(h_0^3\rho_0M_0^{-1}((3 - 3D_0 - D_0^2)\rho_0M_0^{-1} - (D_0 - 4)\rho_1M_1^{-1}) + \\ + h_1^3P_2\rho_1M_1^{-1}((3 - 3D_1 - D_1^2)\rho_1M_1^{-1} - (D_0 - 4)\rho_1M_1^{-1}\rho_0M_0^{-1})));$$

(6)

$$G_8 = \frac{1}{120}(23(h_0^5P_2\rho_0^2M_0^{-1} + h_1^5\rho_1^2M_1^{-2}) + 10(h_0^5P_2\rho_1M_1^{-1} + h_1^5\rho_0M_0^{-1}) + \\ + 5h_0h_1(h_0^3(\rho_1M_1^{-1} - (D_0 - 4)\rho_0M_0^{-1}) + h_1^4(\rho_0M_0^{-1} - (D_1 - 4)\rho_1M_1^{-1})));$$

$$G_9 = \frac{1}{120}(-24(h_0^5P_2\rho_0^2M_0^{-2} + h_1^5\rho_1^2M_1^{-2}) + 6(h_0^5P_2 + h_1^5)\rho_0\rho_1M_0^{-1}M_1^{-1} - \\ - 6h_0h_1(h_0^3\rho_0M_0^{-1}((1 - 3D_0 - D_0^2)\rho_0M_0^{-1} - (D_0 - 2)\rho_1M_1^{-1}) + \\ + h_1^3P_2\rho_1M_1^{-1}((3 - D_1 - D_1^2)\rho_1M_1^{-1} - (D_0 - 2)\rho_1M_1^{-1}\rho_0M_0^{-1})));$$

va

$$F_2(x,y,t) = P_2(N_0^{-1}(\frac{\partial^2 f_{xz}^{(0)}}{\partial x^2} - \frac{\partial^2 f_{yz}^{(0)}}{\partial y^2}) + N_1^{-1}(\frac{\partial^2 f_{xz}^{(1)}}{\partial x^2} - \frac{\partial^2 f_{yz}^{(1)}}{\partial y^2})) + \\ + \frac{1}{2}(P_2h_1^2\rho_1M_1^{-1}(N_0^{-1}\frac{\partial^2 f_{xz}^{(0)}}{\partial x^2} - \frac{\partial^2 f_{yz}^{(0)}}{\partial y^2}) - h_0^2\rho_0M_0^{-1}(N_1^{-1}\frac{\partial^2 f_{xz}^{(1)}}{\partial x^2} - \frac{\partial^2 f_{yz}^{(1)}}{\partial y^2}))\frac{\partial^2}{\partial t^2} - \\ - \frac{1}{2}(P_2h_1^2(N_0^{-1}\frac{\partial^2 f_{xz}^{(0)}}{\partial x^2} - \frac{\partial^2 f_{yz}^{(0)}}{\partial y^2}) - h_0^2(N_1^{-1}\frac{\partial^2 f_{xz}^{(1)}}{\partial x^2} - \frac{\partial^2 f_{yz}^{(1)}}{\partial y^2}))\frac{\partial^2}{\partial x^2}.$$

(1) - tenglama taqribiy bo‘lishiga qaramay, u juda murakkab. (2) - operatorlar qatlamlari bir jinsli qalinligi doimiy ikki qatlamli plastinka materialining mexanik va reologik xususiyatlarini va uning geometrik o‘lchamlarini tavsiflovchi barcha parametrlar va operatorlarni o‘z ichiga oladi.

(1) - taqribiy tenglama tebranish masalalarini hal qilishda alohida hollarda soddalashadi. Masalan, (2) - operatorlar platinkaning ikkala qatlamlar uchun Puasson koeffitsiyentlari doimiy va ularning qalinligi teng bo‘lganda hamda boshqa hollarda ancha soddalashdi.

Masalan, agar $h_0 = h_1$ va $\nu_0 = \nu_1$ bo‘lsa, (6) dagi operatorlar Q_j quyidagi ko‘rinishga ega bo‘ladi:

$$Q_1 = M_1^{-2}h_0^2(\rho_0 + \rho_1)^2;$$

$$Q_2 = -2M_1^{-2}h_0^2(2D_0(P_2 + 1)(\rho_0 + \rho_1) + (P_2 + 1)(2\rho_0 - D_0(\rho_0 - \rho_1)));$$

$$Q_3 = 4(P_2 - 1)h_0^{\ 2}D_0(3P_2 + 1);$$

(7)

$$Q_4 = -\frac{1}{6}M_1^{-2}h_0^{\ 4}(2 - D_0)(\rho_0M_0^{-1}(3\rho_1^2 + \rho_0(\rho_0 + 4\rho_1)) + \rho_1M_1^{-1}(3\rho_0^2 + \rho_1(\rho_1 + 4\rho_0)));$$

$$Q_5 = -\frac{1}{6}h_0^{\ 4}(P_2\rho_0^2M_0^{-2}(4D_0(4 - D_0) + P_2(8D_0(1 - D_0) + 5) + \\ + (P_2 - 1)(12 - 6D_0 + D_0^2)) + 2\rho_0\rho_1M_0^{-1}M_1^{-1}(2(6D_0 + P_2^2(2 + 5D_0) + \\ + P_2(2 + 9D_0 - D_0^2)) + (P_2 - 1)P_2(2 - 3D_0 + D_0^2) + D_0(1 + D_0)) + \\ + \rho_1^2M_1^{-2}(8(1 + D_0 - D_0^2) + 4P_2D_0(4 - D_0) + (P_2 - 1)D_0(2 - D_0)));$$

$$Q_6 = \frac{1}{3}h_0^{\ 2}(\rho_0M_0^{-1}(4P_2D_0(2 + 5P_2 - 3D_0(P_2 - 1)) + (P_2 - 1)(P_2(20 - 8D_0 - 13D_0^2) +$$

(7)

$$+ 6D_0(1 - D_0))) + \rho_1M_1^{-1}D_0(4(4 + D_0) + 4P_2(4 + 2P_2 + 5D_0) + \\ + 17(P_2 - 1)(D_0 + 2P_2(1 - D_0))));$$

$$Q_7 = \frac{4}{3}h_0^{\ 4}D_0(D_0(4 - 15P_2 - 5P_0^2) + (P_2 - 1)(1 - 13P_2));$$

(1) tenglamadagi oltinchi tartibli operator, agar plastinka elastik va Q_j koeffitsiyentlar

$$Q_2 \cdot Q_4 \cdot Q_7 = Q_1 \cdot Q_5 \cdot Q_7 + Q_3 \cdot Q_4 \cdot Q_6$$

ifoda bilan o‘zaro bog`liqlikga ega bo‘lsa, ikkinchi va to‘rtinchi tartibli operatorlarning ko‘paytmalari sifatida ifodalash mumkin.

Agar, Q_j va A_j operatorlar

$$Q_1 = A_1A_2;\quad Q_2 = A_1A_4 + A_2A_3;\quad Q_3 = A_2A_4;$$

$$Q_4 = A_1A_5;\quad Q_5 = A_2A_5;\quad Q_6 = A_1A_6;\quad Q_7 = A_2A_6;$$

bog`liqliklarga ega bo‘lsa, u holda ikki qatlamli elastik plastinkaning tashkil etuvchilarining berilgan qiymatlarida (7) ifoda h_2 / h_1 ga nisbatan 10-chi tartibli algebraik tenglamani beradi, bunda (1) dagi oltinchi tartibli operatorni nisbatan past tartibli operatorlar ko‘paytmasi ko‘rinishida quyidagicha yozish mukin

$$\left(A_1\frac{\partial^2}{\partial t^2}+A_2\frac{\partial^2}{\partial x^2}\right)\cdot\left(A_3\frac{\partial^2}{\partial t^2}+A_4\frac{\partial^2}{\partial x^2}+A_5\frac{\partial^4}{\partial t^4}+A_1\frac{\partial^4}{\partial x^4}\right)(W)=0$$

XULOSALAR

1. Hech qanday farazlarni jalb qilmasdan, aniq uch o'lchovli ko'rinishda bo'lak-bo'lakli bir jinsli plastinalarning tebranishlarini o'rganish, plastikalarning tebranishlarining umumiy va ular asosida taqribiy tenglamalarini hosil qilish imkonini beradi.
2. Ikki qatlamli plastinkaning tebranishlari uchun eng oddiy taqribiy tenglama uning bo'ylama-ko'ndalang tebranishini tavsiflovchi hosilalar uchun oltinchi tartibli differensial tenglama ekanligi ko'rsatilgan.
3. Elastik ikki qatlamli plastinka uchun oltinchi tartib operator, agar plastinka qatlamlarining komponentlari ushbu komponentlarni o'z ichiga olgan keltirib chiqarilgan tenglamani qanoatlantirsa, ikkinchi tartibli - bo'ylama va to'rtinchi tartibli - ko'ndalang tebranish operatorlariga ajraladi.

ADABIYOTLAR

1. Филлипов И.Г., Джалилов М.Л. Теория колебания двухслойной кусочно-однородной вязкоупругой пластинки постоянной толщины - Деп. В ВНИИНТПИ, 4.09.89-№10373. 35 с.

2. Джалилов М.Л. Колебания прямоугольный и безграничной упругой двухслойной пластинки – Деп. В ВНИИНТПИ, 8.02.90-№10612. 7 с.

3. М.Л. Джалилов. С.Ф. Эргашев. Общее решение задачи для кусочно-однородной двухслойной среды постоянной толщины. НТЖ ФерПИ (STJ FerPI), 2017. Том 21. № 4.

4. Филиппов И.Г., Егорычев О.А. Волновые процессы в линейных вязкоупругих средах. М.: Машиностроение, 1983. 272 с.

5. Achenbach J.D. An asymptotic method to analyze the vibrations of elastic layer // Trans. ASME,1969. Vol. E 34, No 1. P. 37–46.

6. Brunelle E.J. The elastics and dynamics of a transversely isotropic Timoshenko beam // J. Compos. Mater., 1970. Vol. 4. P. 404–416.

7. Gallahan W.R. On the flexural vibrations of circular and elliptical plates // Quart. Appl. Math., 1956. Vol. 13, No 4. P. 371–380.

8. Dong S. Analysis of laminated shells of revolution // J. Esg. Mech. Div. Proc. Amer. Sac. Civil Engrs., 1966. Vol. 92, No 6.

9. Lexniskiy, S.G. (1977). Teoriya uprugosti anizotropnogo tela. (p.416). Moscow: Nauka.

10. Sarrera, E. (2001). Developments ideas and evaluations based upon the Reissner's mixed theorem in the modeling of multilayered plates and shells. Appl. Mech. Rev. 54(4), pp. 301-329.

11. Ambarsumyan, S.A. (1987). Teoriya anizotropnix plastin. (p.493). Moscow: Nauka.

12. Reissner, E. (1984). On a certain mixed variational theory and a proposed application. Int. Z. Numer. Methods Eng. 20, pp. 1366-1368.

13. Ren, Z.G. (1986). Bending theory of laminated plates. J.Comp.Sci. Technol, 27, pp. 225–239.

14. Khudoynazarov, Kh., & Khudoyberdiyev, Z. (2018). Symmetrical vibrations of a threelayered elastic plate//Int. J. of Advanced Research in Science, Engineering and Technology, 5(10), pp.7117-7121.

15. Volmir, A.S. (1972). Nelineynaya dinamika plastinok i obolochek. (p.432). Moscow: «Nauka».

16. Xalmuradov, R.I., Xudoynazarov, X.X., & Xudoyberdiyev, Z. (2018). Nestasionarniye kolebaniya trexsloynoy vyazkouprugoy plastinki. Nauchniy vestnik SamGU, 1(107), pp.30-39.

17. Xalmuradov, R.I., Xudoynazarov, X.X., & Xudoyberdiyev, Z. (2017). Svobodniye kolebaniya uprugoy trexsloynoy plastinki. Uzbekskiy jurnal Problemi mexaniki, 2, pp. 46- 52.