TO‘RTBURCHAKAKLI IKKI QARAMA-QARSHI TOMONI ERKIN PLASTINKANING ERKIN TEBRANISHINI TEKSHIRISH

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Annotatsiya

Ushbu ishda elastik plastinkaning chiziqli tebranishlari masalasi qaralgan. Plastinka materiali gisterezis tipidagi elastik dissipativlik xossasiga ega bo‘lib. Qaralayotgan sistemaning matematik modeli olingan holda bir nechta holda plastinkaning tebranishlari qarab o‘tilgan.

Kalit so‘zlar: Plastinka tenglamasi, burulish funktsiyasi, plastinkasining antisimmetirya o‘qi, juft funksiyalar saqlanishi, plastinka erkin tebranish.

Plastinka tenglamasi quyigagi ko‘rinishda berilgan bo‘lsa, quyida bir nechta holini qarab o‘tamiz.

$$D\nabla^4 w + \rho \frac{\partial^2 w}{\partial t^2} = 0, \qquad (1)$$

Aniqlik uchun quyida y o‘qiga parallel bo‘lgan chetlari uchun klassik chegara shartlaritakrorlanadi (masalan chegaralari x=0 yoki x=a). Qistirilgan chekkasi uchun.

$$w = \frac{\partial w}{\partial x} = 0, \qquad (2)$$

oddiy qo‘yilgan cheti uchun ,

$$w = \frac{\partial^2 w}{\partial x^2} + v\frac{\partial^2 w}{\partial y^2} = 0 \qquad (3)$$

va bo‘sh cheti uchun

$$\frac{\partial^2 w}{\partial x^2} + v\frac{\partial^2 w}{\partial y^2} = \frac{\partial^3 w}{\partial x^3} + (2 - v)\frac{\partial^3 w}{\partial x\,\partial y^2} = 0. \qquad (4)$$

y=0 va y=a qirralarining mos keladigan chegaraviy shartlar (2) , (3) va (4) tenglamalarda x va y ni o‘zaro almashtirishdan olinadi. Ikki bo‘sh qirralarining olinishidan hosil bo‘lgan erkin burchak uchun burchakda qo‘shimcha shart

$$\frac{\partial^2 w}{\partial x\,\partial y} = 0 \qquad (5)$$

bajarilishi kerak, garchi ikkita qarama-qarshi tomoni erkin bo‘lsa, bu hol yuzga kelmaydi, Erkin tebranish uchun sinusoidal vaqt reaksiyasi faraziga ko‘ra

ISSN: 2835-3730 Website: econferenceseries.com

$$w(x,y,t) = w(x,y)e^{i\omega t}, \qquad (6)$$

klassik Voiyt yechimi

$$w_m = [A_m \sin\sqrt{k^2-\alpha^2}\,y + B_m \cos\sqrt{k^2-\alpha^2}y + C_m \sinh\sqrt{k^2+\alpha^2}y + D_m \cosh\sqrt{k^2+\alpha^2}y]\sin\alpha x \qquad (7)$$

olinadi, bu yerda $k^4 = \rho\omega^2/D$, va $\alpha = m\pi/a$, m=1,2,…, va bu yerda k^2 dan katta deb qabul qilingan. Burulish funktsiyasi (6) boshqaruv maydon tenglamasini (1) va oddiygina qo‘llab quvatlanadigan chegaraviy shartlarni almashtirish har bir m uchun to‘rtinchi tartibli xarakterli determinantga olib keladi. Determinantni kengaytirish va hadlarni yig’ish xarakterli tenglamani beradi. Olti holat uchun xarakteristik tenglamalar quyida keltirilgan.

1-hol. SS-SS-SS-SS

$$\sin\varphi_1 \sinh\varphi_2 = 0 \qquad (8)$$

2-hol. SS-C-SS-C

$$\varphi_1\varphi_2(\cos\varphi_1\cosh\varphi_2 - 1) - m^2\pi^2\left(\frac{b}{a}\right)^2 \sin\varphi_1\sinh\varphi_2 = 0. \qquad (9)$$

3-hol. SS-C-SS-SS

$$\varphi_1\tanh\varphi_2 - \varphi_2\tan\varphi_1 = 0. \qquad (10)$$

4-hol. SS--SS-F

$$\varphi_1\varphi_2[\gamma^2 - m^4\pi^4(1-v)^2] + \varphi_1\varphi_2[\gamma^2 + m^4\pi^4(1-v)^2]\cos\varphi_1\cosh\varphi_2 + m^2\pi^2\left(\frac{b}{a}\right)^2[\gamma^2(1-2v) - m^4\pi^4(1-v)^2]\sin\varphi_1\sinh\varphi_2 = 0. \qquad (11)$$

5-hol. SS-SS-SS-F

$$\varphi_1[\gamma + m^2\pi^2(1-v)]^2\tanh\varphi_2 - \varphi_2[\gamma + m^2\pi^2(1-v)]^2\tan\varphi_1 = 0. \qquad (12)$$

6-hol. SS-F-SS=F

$$2\varphi_1\varphi_2[\gamma^2 - m^4\pi^4(1-v)^2]^2(\cos\varphi_1\cosh\varphi_2 - 1) + \{\varphi_1^2[\gamma + m^2\pi^2(1-v)]^2 - \varphi_2^2[\gamma - m^2\pi^2(1-v)]^4\sin\varphi_1\sinh\varphi_2 = 0$$

(13)

(8) dan (13) tenglamalarda γ parameter bilan aniqlanadi

$$\gamma = \omega a^2\sqrt{\rho/D} \qquad (14)$$

va $\varphi_1$va φ_2 berilgan funksiyalardir

$$\varphi_1 = \frac{b}{a}\sqrt{\gamma - m^2\pi^2}.$$

$$\varphi_2 = \frac{b}{a}\sqrt{\gamma + m^2\pi^2}. \qquad (15)$$

Adabiyotda tez-tez e’tibordan chetda qoladigan nuqta shundaki k^2 kichik bo‘lishi mumkin (ya’ni $m^2\pi^2$ dan kichik) Bu sodir bo‘lganda (7) tenglamadagi $\sin\sqrt{k^2-\alpha^2}\,y$ va $\cos\sqrt{k^2-\alpha^2}\,y$ ni mos ravishda $\sinh\sqrt{k^2-\alpha^2}\,y$

va cosh $\sqrt{k^2-\alpha^2}\,y$ bilan almashtirish kerak bo‘ladi. Keyin xarakteristik tenglamalar quydagicha bo‘ladi.

1-hol. SS-SS-SS-SS

$$\sin\beta_1 \sinh\beta_2 = 0 \qquad (16)$$

2-hol. SS-C-SS-C

$$\beta_1\beta_2(\cos\beta_1\cosh\beta_2-1)-m^2\pi^2\left(\frac{b}{a}\right)^2\sin\beta_1\sinh\beta_2=0. \qquad (17)$$

3-hol. SS-C-SS-SS

$$\beta_1\tanh\beta_2-\beta_2\tan\beta_1=0. \qquad (18)$$

4-hol. SS--SS-F

$$\beta_1\beta_2[\gamma^2-m^4\pi^4(1-v)^2]+\beta_1\beta_2[\gamma^2+m^4\pi^4(1-v)^2]\cos\beta_1\cosh\beta_2+ m^2\pi^2\left(\frac{b}{a}\right)^2[\gamma^2(1-2v)-m^4\pi^4(1-v)^2]\sin\beta_1\sinh\beta_2=0. \qquad (19)$$

5-hol. SS-SS-SS-F

$$\beta_1[\gamma+m^2\pi^2(1-v)]^2\tanh\beta_2-\beta_2[\gamma+m^2\pi^2(1-v)]^2\tan\beta_1=0. \qquad (20)$$

6-hol. SS-F-SS=F

$$2\beta_1\beta_2[\gamma^2-m^4\pi^4(1-v)^2]^2(\cos\beta_1\cosh\beta_2-1)+\{\beta_1^2[\gamma+ m^2\pi^2(1-v)]^2-\beta_2^2[\gamma-m^2\pi^2(1-v)]^4\sin\beta_1\sinh\beta_2=0$$

(21)

(16)-(21) tenglamalar (8)-(13) tenglamalar bilan bir xil shakilda bo‘ladi, birinchisi ikkinchisida sin , cos va tanni oddiygina sinh , cosh va tanh bilan almashtirish orqali olingan $\varphi_1\varphi_2$ va $\beta_1\beta_2$ almashtirishlardir.

$$\beta_1=\frac{b}{a}\sqrt{m^2\pi^2-\gamma}$$

$$\beta_2=\frac{b}{a}\sqrt{m^2\pi^2+\gamma} \qquad (22)$$

1, 2, va 6 holatlardagi y=b/2 o‘qiga nisbatdan mavjud bo‘lgan simmetirya (ya’ni ‘y-simmetitya’) tufayli, bu holatdagi tebranishlar rejimlari y bo‘lganlarga bo‘linadi y-simmetirik yoki y-antisimmetirik. Bu rejimga mos keladigan xarakteristik tenglamalar (8), (9), (13), (16), (17) va (21) tenglamalardan faktor yo‘li bilan yoki y’ koordinatasi bo‘yicha yangi hosilalar yordamida olish mumkin . Sistema kelib chiqishi plastinka o‘rtasida (y’=y-b/2 va , masalan $k^2>\alpha^2$ $(\gamma^2>m^2\pi^2)$ ga ega bo‘lgan Sistema uchun (7) tenglamada y ning faqat juft funksiyalarini saqlab qolgan hol) olingan xarekteristik tenglamalar quydagilardir

1-hol. SS-SS-SS-SS

simmetirik: $\cos\frac{\varphi_1}{2}\cosh\frac{\varphi_2}{2}$ (23a)

$\gamma^2>m^2\pi^2$

antisimmetirik: $\sin\frac{\varphi_1}{2}\sinh\frac{\varphi_2}{2}$ (23b) simmetirik: $\cos\frac{\beta_1}{2}\cosh\frac{\beta_2}{2} = 0$ (23c)

$\gamma^2 < m^2\pi^2$

antisimmetirik: $\sin\frac{\beta_1}{2}\sinh\frac{\beta_2}{2} = 0$ (23d)

2-hol. SS-C-SS-C

simmetirik: $\varphi_1\tan\frac{\varphi_1}{2} + \varphi_2\tanh\frac{\varphi_2}{2} = 0.$ (24a)

$\gamma^2 > m^2\pi^2$

antisimmetirik: $\varphi_1\tan\frac{\varphi_1}{2} - \varphi_2\tanh\frac{\varphi_2}{2} = 0.$ (24b)

simmetirik: $\beta_1\tan\frac{\beta_1}{2} + \beta_2\tanh\frac{\beta_2}{2} = 0.$ (24c)

$\gamma^2 < m^2\pi^2$

antisimmetirik: $\beta_1\tan\frac{\beta_1}{2} - \beta_2\tanh\frac{\beta_2}{2} = 0.$ (24d)

6-hol.

simmetiirik: $\varphi_1[\gamma + m^2\pi^2(1-v)]^2\tan\frac{\varphi_1}{2} + \varphi_2[\gamma + m^2\pi^2(1-v)]^2\tanh\frac{\varphi_1}{2} = 0.$ (25a)

$\gamma^2 > m^2\pi^2$

tisimmetirik: : $\varphi_1[\gamma + m^2\pi^2(1-v)]^2\tan\frac{\varphi_1}{2} - \varphi_2[\gamma + m^2\pi^2(1-v)]^2\tanh\frac{\varphi_1}{2} = 0.$ (25b)

simmetiirik: $\beta_1[\gamma + m^2\pi^2(1-v)]^2\tan\frac{\beta_1}{2} + \beta_2[\gamma + m^2\pi^2(1-v)]^2\tanh\frac{\beta_1}{2} = 0.$ (25c)

$\gamma^2 < m^2\pi^2$

tisimmetirik: : $\beta_1[\gamma + m^2\pi^2(1-v)]^2\tan\frac{\beta_1}{2} - \beta_2[\gamma + m^2\pi^2(1-v)]^2\tanh\frac{\beta_1}{2} = 0.$ (25d)

bundan tahqari (24b) va (24d) tenglamalar bilan bir xil ekanligi ko‘rinib turibdi , bunan tashqari φ_1 va φ_2 lar , $\frac{\varphi_1}{2}$ va $\frac{\varphi_2}{2}$ bilan almashtirildi. Buning ahamiyati shundaki , SS-C-SS-C kengligi b bo‘lgan SS-C-SS-SS plastinkaning y-antisimmetirik tebranish rejimlari SS-C-SS-SS plastinkaniki bilan bir xil. Kengligi b/2 . buning sababi SS=C-SS-C plastinkasining antisimmetirya o‘qi bo‘ylab shartlar oddiy tayanch shartlari bilan bir xil. SS-F-SS-F plastinka va tenglamalar (12) va (20) uchun.

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