Elastik Poydevor Ustidagi Nurlarni Hisoblash Uchun

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Elastik poydevor - bu nurning og'irligi va uning ustida joylashgan yuk ta'sirida deformatsiyalanadigan va shu bilan birga egiluvchanlikka elastik qarshilik ko'rsatadigan poydevor.

Bunday poydevorda yotadigan nurlar elastik poydevor ustidagi nurlar deb ataladi.

Elastik poydevordagi nurlar turli maqsadlar uchun zamonaviy muhandislik inshootlarida keng qo'llaniladi. Bularga payvandlangan relslar kabi cheksiz uzun nurlar kiradi.

Qurilishda ko'plab turdagi poydevorlarni hisoblash elastik poydevor ustidagi nurlarni hisoblash uchun qisqartiriladi. Transport qurilishida bunday tuzilmalar, masalan, suv o'tkazgichlari, suv osti tunnellari, shuningdek, har xil turdagi quvurlarni o'z ichiga oladi.

Shuning uchun, elastik poydevorda nurlarni hisoblash usullarini bilish kerak. Haqiqiy dizaynda nurlarni mahkamlash va yuklash shartlari har xil bo'lishi mumkin. Nurlar turli xil statik va dinamik effektlarni, shuningdek, rulmanlarning joylashishi va haroratining ta'sirini boshdan kechiradi.

Hozirgi vaqtda elastik poydevorda nurlarni hisoblashning ko'plab usullari ishlab chiqilgan: chekli elementlar usuli (FEM), chekli farqlar usuli (FDM), variatsion usullar, kolokatsiya usulining navlari, ularning aksariyati haqiqiy muammolarni hal qilishga imkon beradi. uzunligi bo'ylab nurning qattiqligi o'zgaruvchilarini hisobga olgan holda dizayn muammolari

Nur taglik tomondan reaktiv qarshilikni boshdan kechiradi. Elastik poydevorda nurni hisoblash vazifasi statik jihatdan noaniqdir, chunki statik tenglamalar faqat yukning umumiy qiymatini aniqlashga imkon beradi q (tayanch reaktsiyasi). Nurning uzunligi bo'ylab yukning taqsimlanishi juda murakkab tenglama bilan tavsiflanadi:

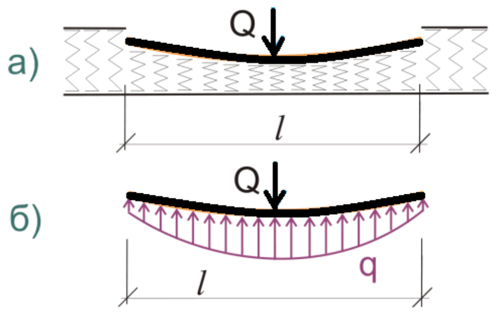
Ma'lumki, Winkler elastik poydevoridagi nurlarni hisoblash to'rtinchi tartibli chiziqli differensial tenglamani echish uchun qisqartiriladi.

$$y(x)^{1V} + ay(x) = f(x), \quad a = k / EI; \quad f(x) = q(x) / EI \quad (1)$$

qayerda $q(x)$ - tashqi yuk, $y(x)$ - nurning burilishi, k - «коэффициент постели», ko'rib chiqilayotgan asos uchun doimiy va uning qattiqligini tavsiflovchi, o'lchangan N/sм^3, eksperimental tarzda aniqlanadi.

Bugungi kunga kelib, elastik poydevorning ideal modeli mavjud emas. Eng oddiy gipotezani prof. Winkler 1867. Bu gipotezaga ko'ra, poydevorning har bir nuqtadagi reaktsiyasi shu nuqtadagi elastik o'rnashish y ga proportsionaldir. Elastik poydevorning nurga nisbatan reaktsiyasi - bu nur uzunligi bo'ylab o'zgaruvchan intensivlik yukidir. $q = -ky$.

Asosiy model (1-rasm) mutlaqo qattiq asosga joylashtirilgan va bir-biridan mustaqil ravishda ishlaydigan bir xil qattiqlikdagi buloqlar seriyasi bo'lishi mumkin..



Rasm-1. a) Mustahkam elastik poydevor ustidagi nurning modeli, b) tayanch q ning ta'sir etuvchi konsentrlangan yukga reaksiyasi.

Bir jinsli tenglamaning (1) yechimi (o'ng tomoni bo'lmagan) klassik versiyada Eyler usuli bilan shaklda izlanadi. $y(x) = e^{\alpha x}$, где α to'rtta ildizi bir jinsli (1) tenglamaning to'rtta qisman yechimini beradigan to'rtinchi tartibli xarakteristik tenglamadan (1) kerakli yechimni almashtirgandan so'ng aniqlanadi. Ushbu yechimlarni o'zgartirish va boshlang'ich parametrlar usulini qo'llash natijasida shaklda umumiy yechim olinadi.

$$y(\beta x) = Y_0 V_0(\beta x) + \theta_0 V_1(\beta x) - \frac{M_0}{EI} V_2(\beta x) - \frac{Q_0}{EI} V_3(\beta x) \qquad (2)$$

где Y_0, θ_0, M_0, Q_0 - boshlang'ich parametrlari (burilish, burilish burchagi, egilish momenti va boshlang'ichdagi kesish kuchi), $\beta = \sqrt[4]{k/4EI}$, $V_r(\beta x)$ - A.N.Krylov tomonidan nur funktsiyalari:

$$V_0(x) = ch\beta x \cos\beta x \qquad V_1(x) = \frac{1}{2}(ch\beta x \sin\beta x + sh\beta x \cos\beta x)$$

$$V_2(x) = \frac{1}{2} sh\beta x \sin\beta x \qquad V_3(x) = \frac{1}{4}(ch\beta x \sin\beta x - sh\beta x \cos\beta x). \qquad (3)$$

Oddiy differensial tenglamalarda noaniq koeffitsientlar usuliga o'tadigan takroriy operator usuliga ko'ra, yechim ko'rinishda izlanadi.

$$Y_r(x) = \sum_{i=0}^{\infty} Q_i x^{4i+r,!}, \quad r = \overline{0,3}, \quad x^{k,!} = \frac{x^k}{k!}$$

Bu iborani (1) ga almashtirish $f(x) = 0$ va shunga o'xshashlarni berib, biz olamiz.

$$\sum_{i=0}^{\infty} (Q_i + aQ_{i-1}) x^{4i+r,!} = 0$$

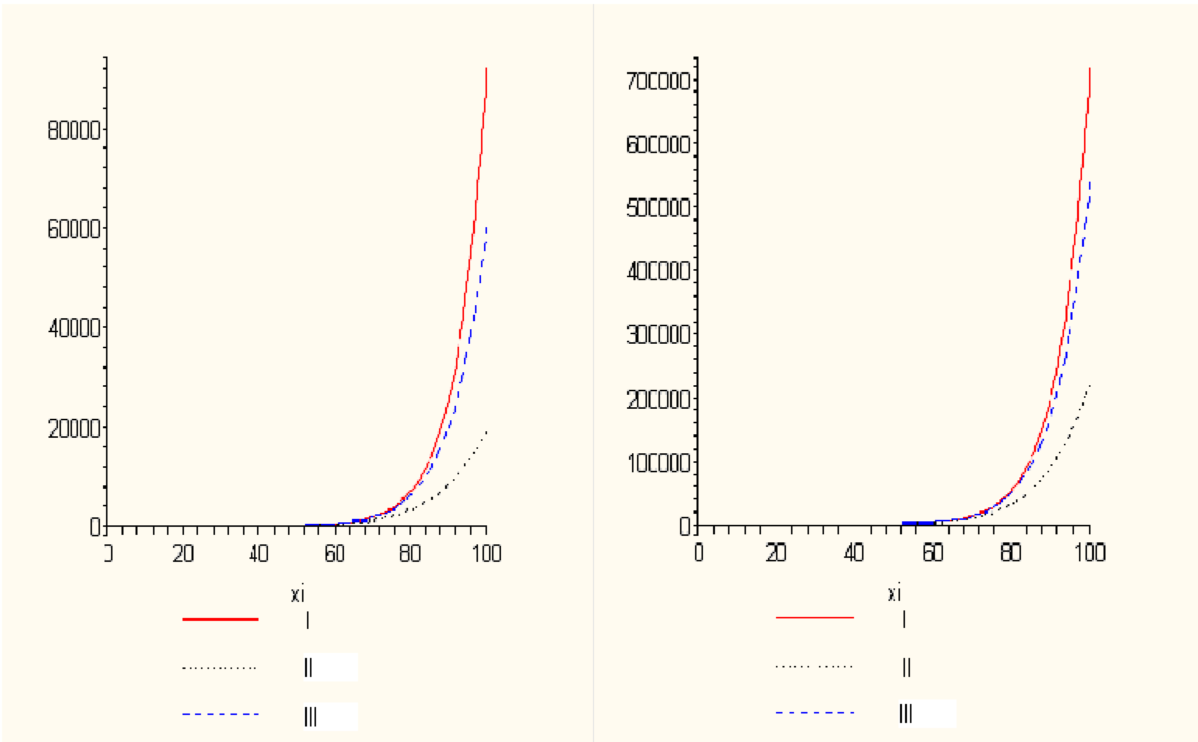
Qavslar ichidagi ifodani nolga tenglashtirib, takrorlanish munosabatini olamiz $Q_i = -aQ_{i-1}$ dastlabki sharoitlarda $Q_0 = 1;$ $Q_{-i} = 0.$ ketma-ket topamiz:

$$Q_0 = 1; \quad Q_1 = -a; \quad Q_2 = a^2; \quad Q_3 = -a^3; \quad \dots \quad Q_i = (-1)^i a^i .$$

Umumiy ifodani ga almashtirish Q_i в (1) при $f(x) = 0$, natijani olamiz:

$$Y_r(x) = \sum_{i=0}^{\infty} (-1)^i a^i x^{4i+r,!} = \sum_{i=0}^{\infty} (-1)^i 4^i (\beta x)^{4i+r,!} = x^{r,!} - a x^{4+r,!} + a^2 x^{8+r,!} - a^3 x^{12+r,!} + \quad \dots = \quad (4)$$
$$= (\beta x)^r - (\beta x)^{4+r,!} + (\beta x)^{8+r,!} - \quad \dots$$

Xarakteristik tenglamaning ildizlarini aniqlamasdan olingan bu funksiyalar Krilov funksiyalari bilan mos keladi. $Y_r(\beta x) = V_r(\beta x)$. Taqqoslash uchun ushbu funktsiyalarning birlashtirilgan grafiklari tuzilgan. (рис. 2)



Rasm-2 Funktsiyalarni taqqoslash grafiklari (3) (4)

Qattiq egri chiziqlar (I) formulalar (3) bo'yicha, nuqtali egri chiziqlar (4) formula bo'yicha (II va III egri chiziqlar) mos ravishda (4) dan uch va to'rt hadgacha qatorlar bilan chegaralanadi.

Agar masalaning shartiga ko'ra barcha boshlang'ich parametrlar berilgan bo'lsa, (2) - (Koshi) masalasining aniq yechimi. Ammo ko'pincha to'rtta parametrdan faqat ikkitasi ma'lum, qolgan ikkitasi esa nurning boshqa uchidagi chegara shartlaridan aniqlanadi. Nurning boshqa uchida chegaraviy shartlarning shakllanishi algebraik tenglamalar tizimiga olib keladi, ularning yechimidan noma'lum boshlang'ich parametrlar topiladi.

Eksperimental tadqiqotlar, asosan, yumshoq va nam tuproqlar uchun Winkler gipotezasiga ko'ra, elastik poydevorda tuzilmalarni hisoblash natijalari o'rtasida yaxshi kelishuvni o'rnatdi. Ushbu gipoteza asosida suzuvchi ko'priklar, kema korpusi, poydevor nurlari va plitalari, shuningdek, elastik qistirmalari bilan birga ishlaydigan asboblar va mashinalarning novda qismlari va murakkab va kompozit konstruktsiyalarning oraliq hisob-kitoblarida hisoblanadi..

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