"TOSHKENT IRRIGATSIYA VA QISHLOQ XO'JALIGINI MEXANIZATSIYALASH MUHANDISLARI INSTITUTI" MILLIY TADQIQOT UNIVERSITETI

Fan: Materiallar qarshiligi

Mavzu 11

Sof egilish

Yuldoshev Bakhtiyor Shodmonovich

Mexanika va kompyuterli modellashtirish kafedrasi dotsenti

Reja:

1.Sof egilishda kuchlaniishlarni aniqlash.

2.Normal kuchlanish epyurasi.

3.Qarshilik momenti

4.Balkalarni hisoblash formulasi.

5.Ko‘ndalang kesim tanlash masalasi.

6.Egilishdagi urinma kuchlaniishlar.

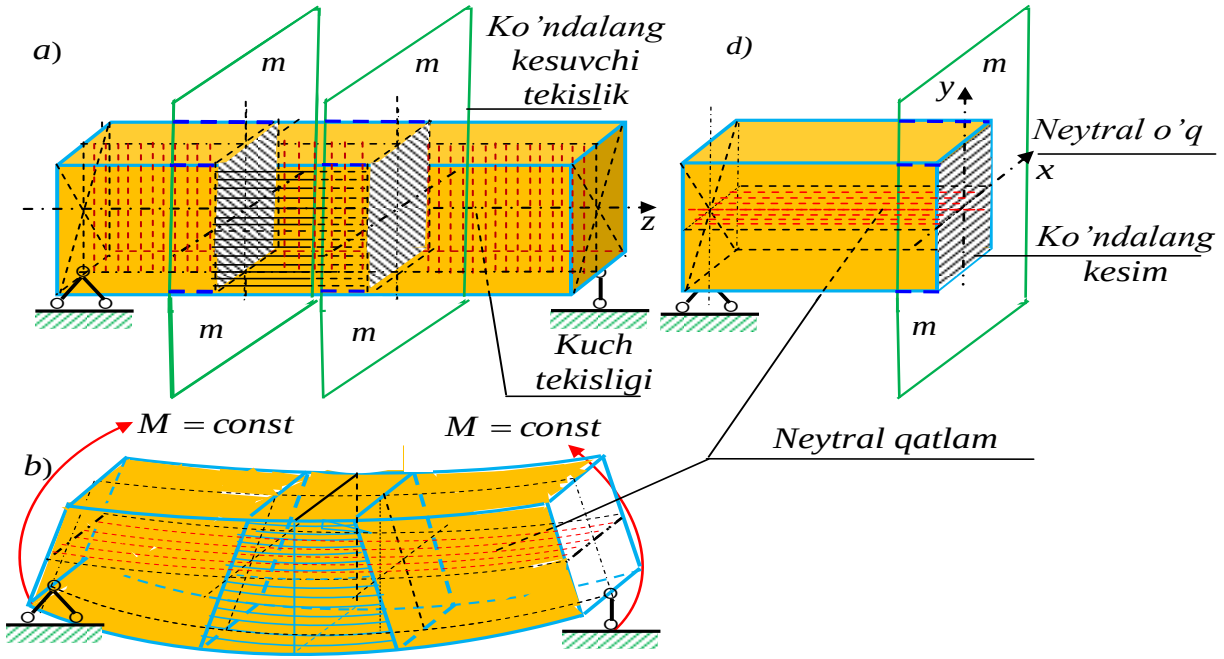
7.Egilishdagi bosh kuchlaniishlar.

8.Eguvchi moment (M_{eg}), kundalang kich (Q) va tashqi nagruzkaning intensivligi q urtasidagi bog’lanish.

1 Umumiy qoidalar

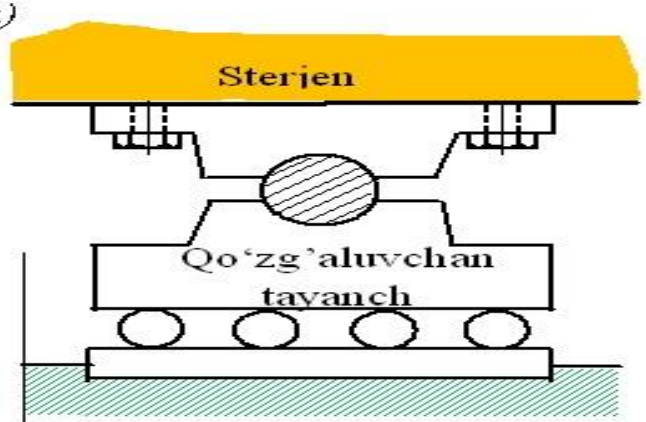
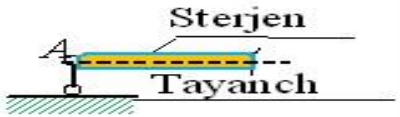
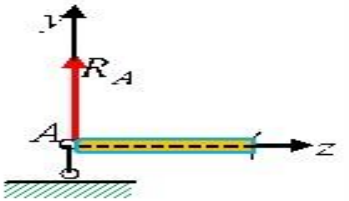
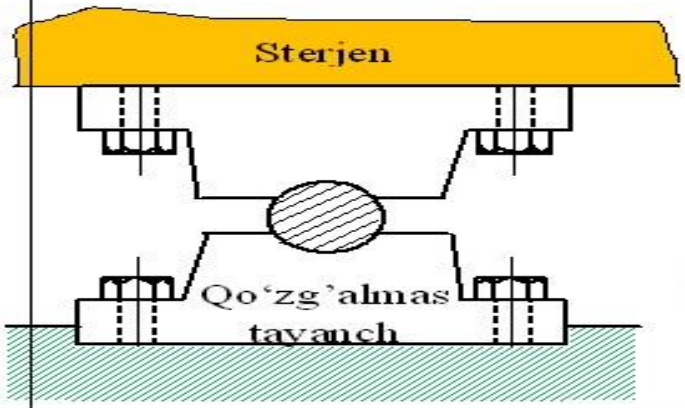
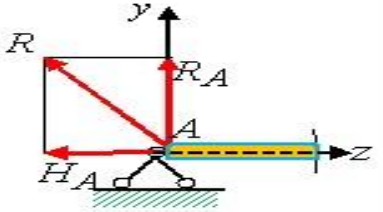
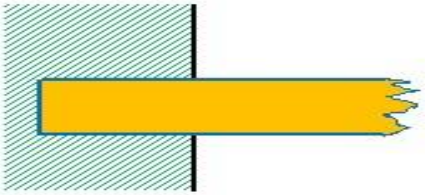
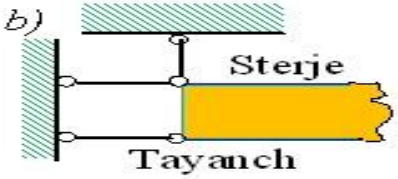
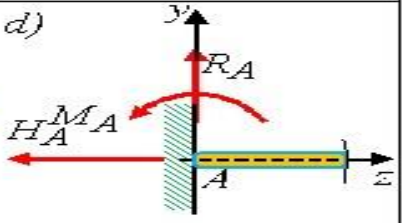
Agar tashqi yuklamalar ta'sirida sterjen ko'ndalang kesimlarida shu ko'ndalang kesimga tik ichki kuchlar momenti hosil bo'lsa ***egilish*** yuzaga keladi. Agar sterjen kesimlarida faqat ichki kuchlar momenti - ***M*** hosil bo'lsa, ***sof egilish***, momentdan tashqari ko'ndalang kuch ***Q*** ham hosil bo'lsa ***ko'ndalang egilish*** deyiladi.

To‘g‘ri o‘qli bruslarning markaziy cho‘zilishi, siqilishi va buralishida dastlabki to‘g‘ri o‘qi, deformatsiyadan keyin ham to‘g‘riligicha qolishi **materiallar qarshiligi fani** cho‘zilish (siqilish) va buralish boblaridan ma’lum.

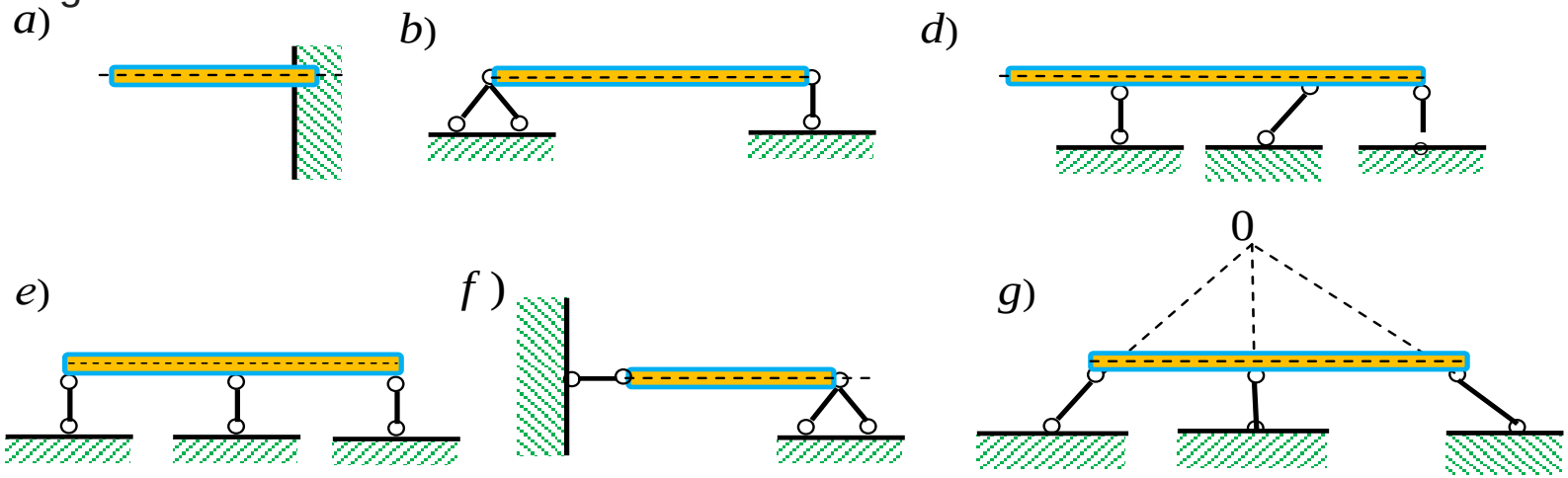


1-chizma. Tashqi kuchlar ta’sirida sterjenning egilishi.

2.Sterjen va tayanch turlari

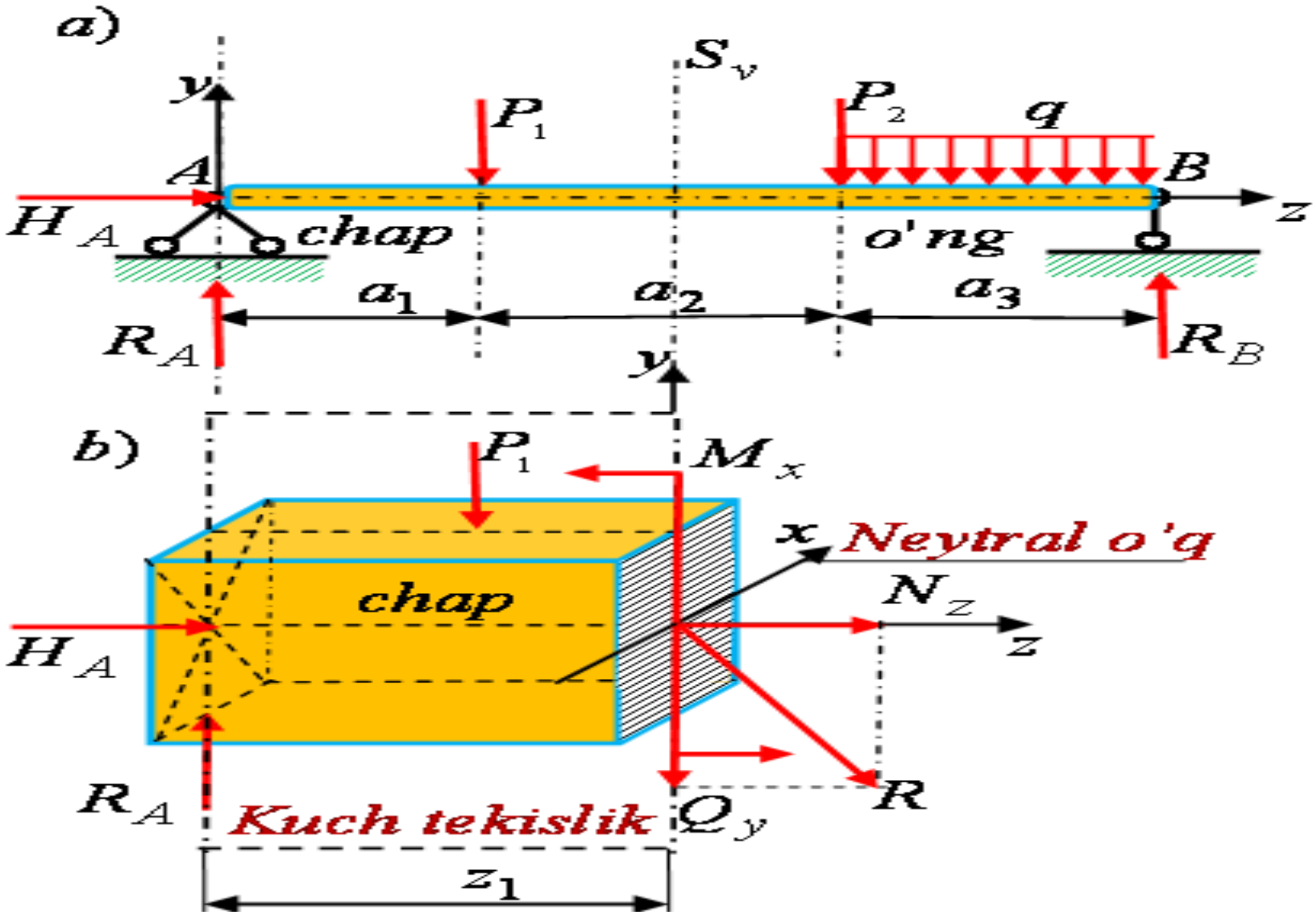
№	Tayanchlar turlari	Tayanchlar sxemasi	Tayanchlar reaksiya kuchlari
3-chizma. Sharnirli qo'zg'aluvchan tayanch	a) 	b) 	d) 
4-chizma. Sharnirli qo'zg'almas tayanch.		b)  bog'lanishlar	d) 
5-chizma. Qistirib mahkamlangan tayanch	a) 	b)  bog'lovchilar	d) 

Yuqorida keltirilgan tayanch sxema tasvir chizmalardan ko‘rinadiki, sterjen geometrik o‘zgarmas bo‘lishi uchun, uning tayanch reaksiya kuchlari tashkil etuvchilari soni nechta bo‘lsa, tayanch bog‘lanishlar soni ham shuncha bo‘lishi shart.



6-chizma. Sterjenlar hisob sxemasi.

Balkalardagi zuriqish kuchlarni topamiz



bu yerda: Q_x – kundalang (kesuvchi) kuch, N – buylama kuch.

Balkaning ixtiyoriy kesimida hosil bo‘ladigan ichki kuchlarni aniqlash uchun statika muvozanat tenglamalarini qaralayotgan qism uchun tuzamiz:

1. $\sum_{chap} Z = 0; \quad -H_A - N_z = 0.$ **bundan:** $N_z = N = -H_A.$

2. $\sum_{chap} Y = 0; \quad R_A - P_1 - Q_y^{2.} = 0.$ **bundan:** $Q_y = R_A - P_1.$

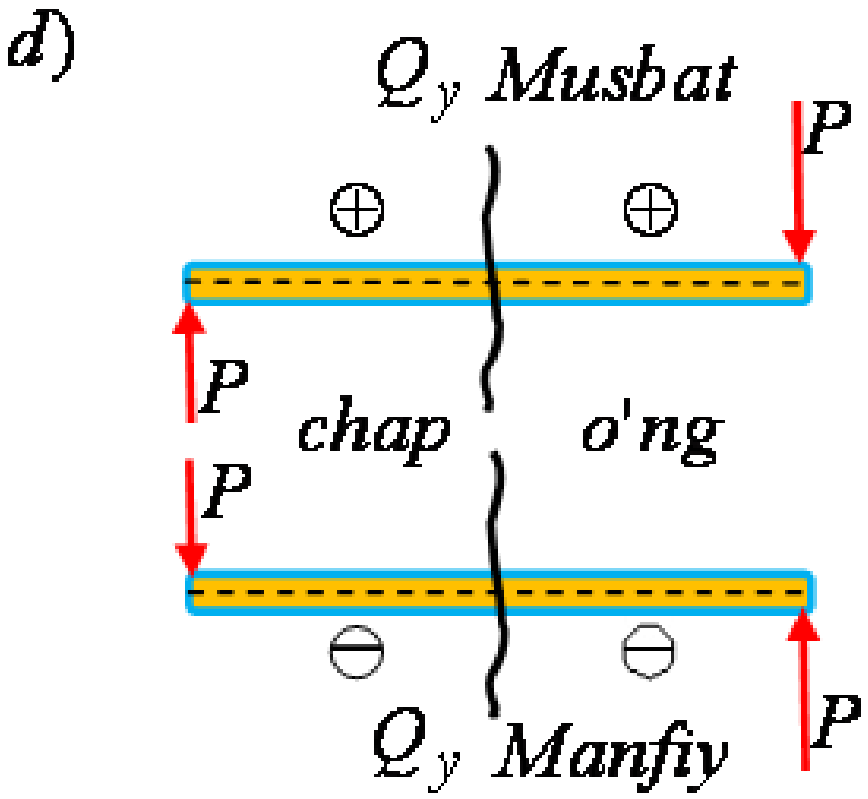
3. $\sum_{chap} mom_0 = 0; \quad R_A z - P_1(z - a_1) - M_x = 0.$ **bundan:**

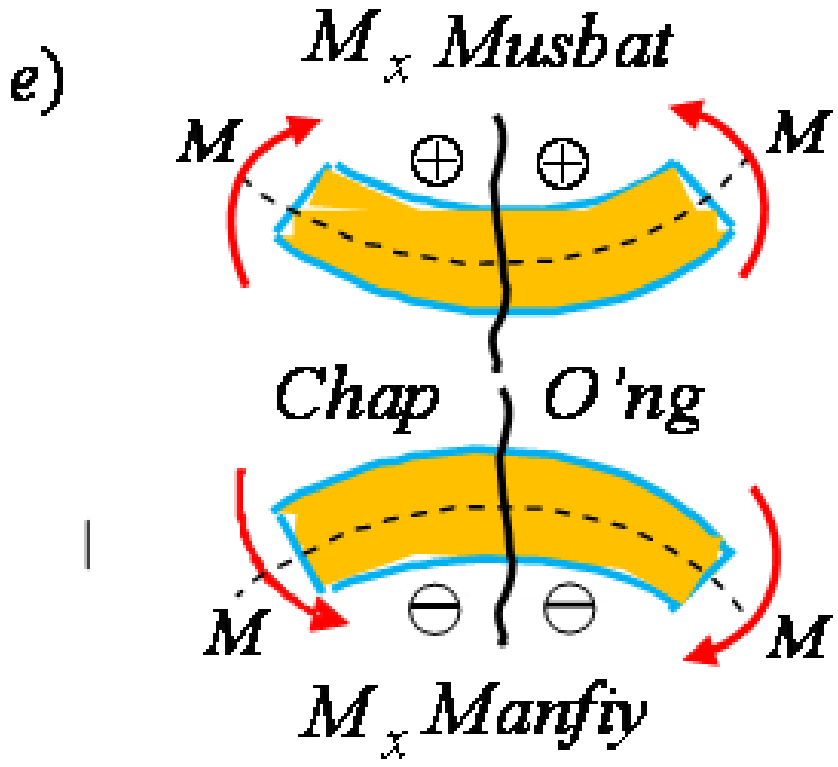
$$M_x = R_A z - P_1(z - a_1).$$

3. Kindalang kuch va Eguvchi momentning ishoralari

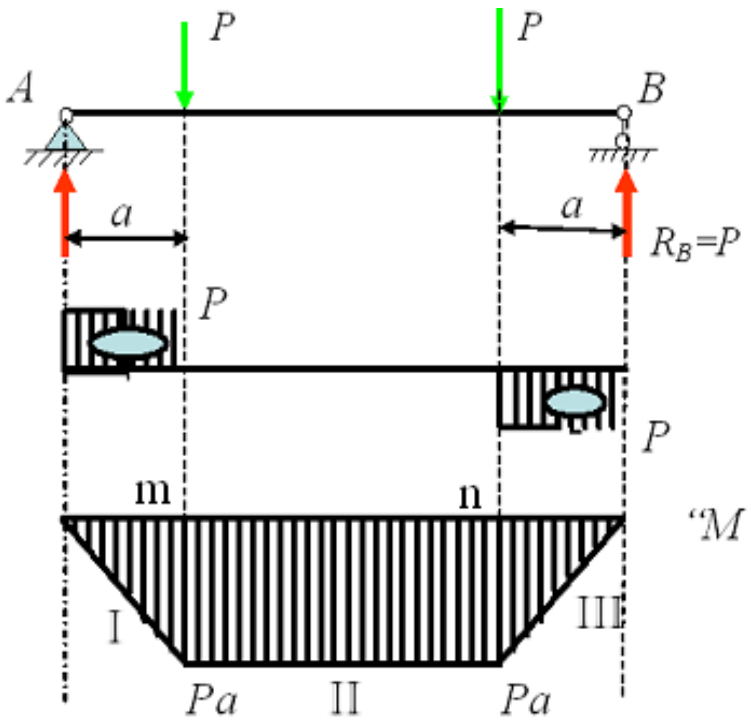
Q – kundalang (kesuvchi) kuch,

M – eguvchi moment





a)



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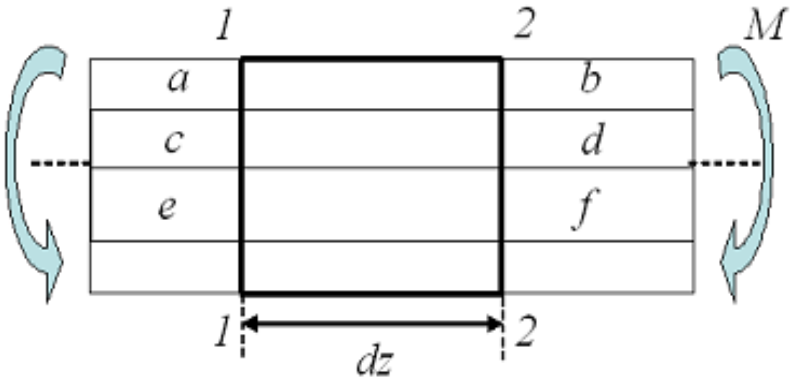


Sof egilishda balkaning ko‘ndalang kesimlarida eguvchi moment o‘zgarmas, kesuvchi kuch nolga teng bo‘ladi. Eguvchi moment o‘zgaruvchi, kesuvchi kuch nolga teng bo‘lmasa, bunday egilish ko‘ndalang egilish deyiladi. Balka ko‘ndalang kesimining bosh o‘qlaridan o‘tgan tekisliklar bosh tekisliklar deyiladi. Tashqi kuchlar bosh tekisliklardan birida yotsa, balkada to‘g‘ri egilish sodir bo‘ladi.

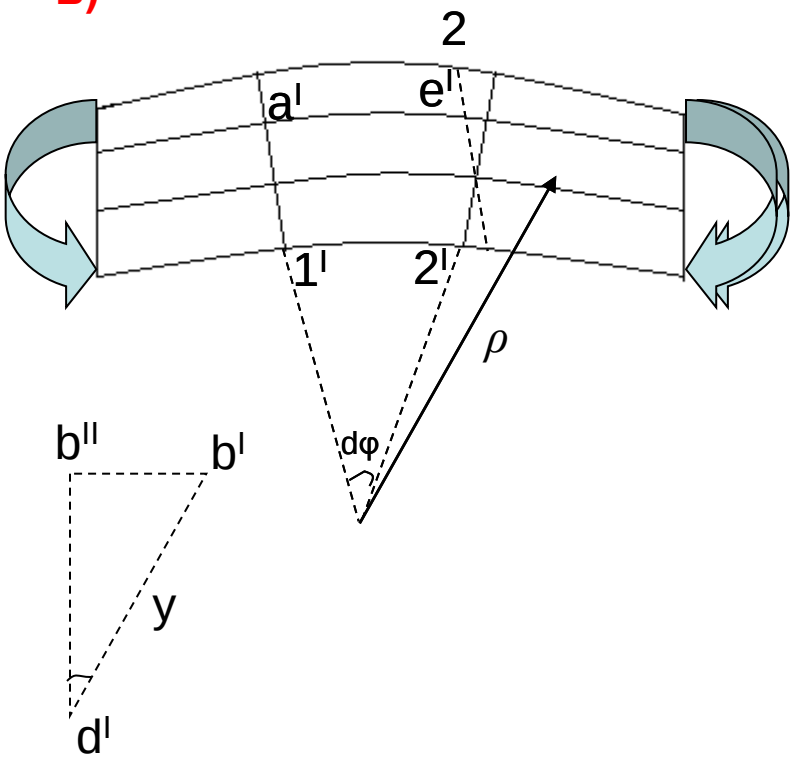
a) misolda II – uchastkada sof egilish bo‘ladi,

I, III – da ko‘ndalang egilish bo‘ladi.

b) chizmadagi sof egilish uchun normal kuchlanishlarni topamiz.

Zo‘riqish kuchlarini ko‘ndalang kesim bo‘yicha taqsimlanish qonunini faqat statika tenglamalaridan topib bo‘lmaydi, buning uchun qo‘shimcha deformatsiya tenglamasi tuziladi.

в)



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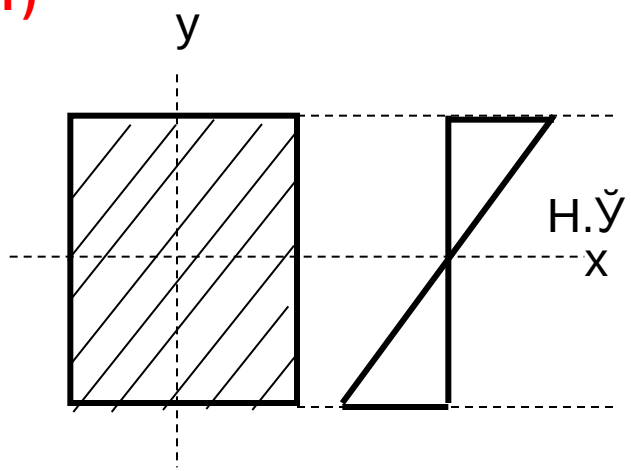


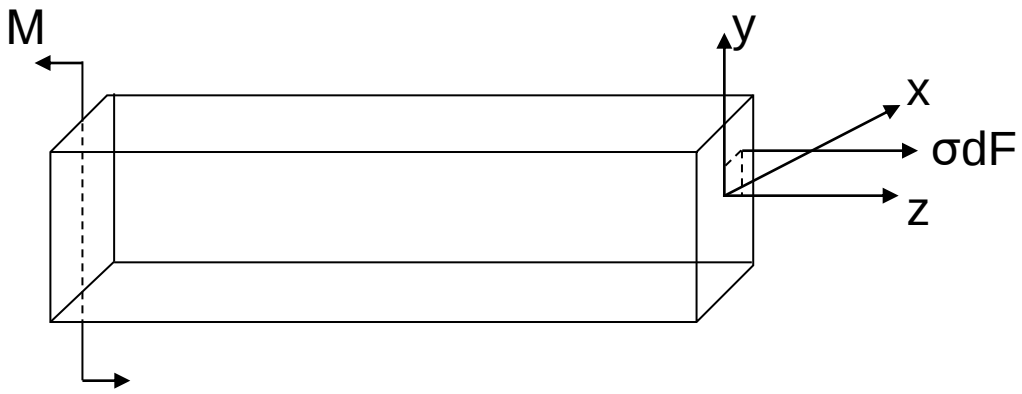
v) Chizmadan ko‘rinib turibdiki, deformatsiyadan keyin ko‘ndalang kesimlar yuzi tekisligicha qoladi, faqat juda kichik burchakka og‘adi.

Bu tekis kesimlar yoki Bernulli gipotezasi deyiladi. SHakldagi ab tolalar cho‘zilib, ef tolalar siqiladi, u xolda oraliqda biror cd tolalarda uzunlik o‘zgarmaydi, bu tolalar yotgan qatlam Neytral qatlam deyiladi. Neytral qatlam bilan ko‘ndalang kesim kesishgan chiziq ko‘ndalang kesim neytral o‘qi deyiladi, ko‘ndalang kesim shu o‘q atrofida aylanadi.

ab tolaning deformatsiyasini ko‘ramiz:

$$\varepsilon = \frac{\Delta \ell}{\ell} = \frac{kf'}{\text{cd}} = \frac{yd\varphi}{\rho d\varphi} = \frac{y}{\rho}$$

ρ – neytral qatlamning egrilik radiusi deyiladi.

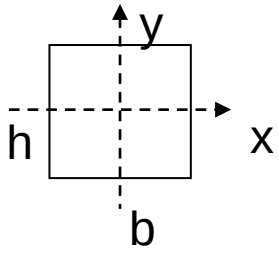


Balka tolalari cho‘zilib, siqilganda bir – biriga bosim ko‘rsatmaydi, yani balka o‘qiga tik yo‘nalgan kuchlanish nolga teng deb faraz qilinadi.

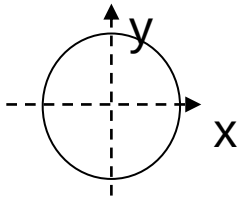
Guk qonunidan:

$$\sigma = E \cdot \varepsilon = \frac{y}{\rho} \cdot E \qquad (1)$$

Normal kuchlanishlarning miqdorini aniqlaymiz, buning uchun kesish usulidan foydalanamiz;



$$y_{\max} = h/2 \Rightarrow W_x = \frac{bh^2}{6}; \quad J_x = \frac{bh^3}{12};$$



$$y_{\max} = d/2, W_x = \frac{\pi d^3}{32}; \qquad J_x = \frac{\pi d^4}{64};$$

$$M = \int_F \sigma \cdot dF \cdot y = \int_F \frac{y}{\rho} \cdot E \cdot dF \cdot y = \frac{E}{\rho} \int_F y^2 \cdot dF = \frac{E}{\rho} \cdot J_x$$

$$\frac{1}{\rho} = \frac{M}{EJ_x};$$ - Bu egilish nazariyasining asosiy formulasi. Bu formulani (1) tenglamaga quysak,

EJ_x – balkaning egilishdagi bikrligi deyladi.

$$\sigma = \frac{M}{J_x} y$$ - hosil bo'ladi. Bu egilishdagi normal kuchlanish tenglamasi.

$$\sigma = \frac{M}{J_x} y \quad \Longrightarrow \quad W_x = \frac{J_x}{y_{\max}}$$ - qarshilik momenti deyiladi.

$$\sigma_{\max} = \frac{M_{\max}}{W_x}$$ - Bu egilishdagi normal kuchlanish formulasi.

$$\sigma_{\max} = \frac{M_{\max}}{W_x} \le [\sigma].$$ - Bu egilishdagi mustahkamlik sharti *(a)*

1. Mustahkamlikka tekshirish: *(a)* dan $\pm 5\%$ farq bilan olinadi.

Mo'rt materiallar uchun:

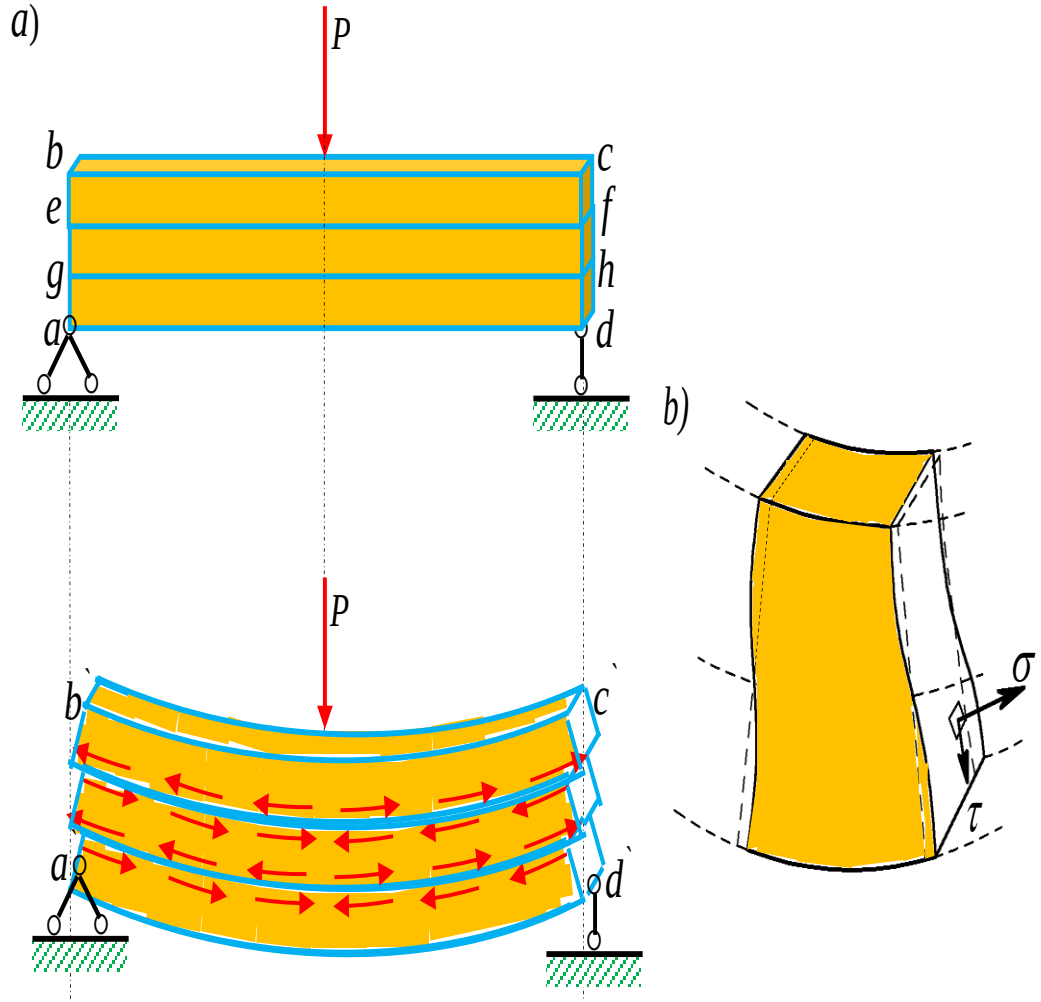
$$\sigma^r_{\max} = \frac{M_{\max}}{W_x} \le [\sigma]_r, \sigma^c_{\max} = \frac{M_{\max}}{W_y} \le [\sigma]_c;$$

2. Balka ko'taradigan maksimal yuk: $$M_{\max} \le [\sigma] W_x$$

3. Ko'ndalang kesim tanlash: $$W_x \ge M_{\max} / [\sigma]$$

Egilishdagi urinma kuchlaniishlar

Urinma kuchlanishlarning juftlik qonuniga asosan ular buylama kesimlarda ham paydo buladi, ular ayrim tolalarni bir-biriga nisbatan siljitadi



Urinma kuchlanishlarning kesimlar bo‘yicha taqsimlanishi

Bundan kelib chiqadigan xulosalar:

1. Ko‘ndalang kesimlarida hosil bo‘lgan τ urinma kuchlanishlar ko‘ndalang kuchga parallel yo‘nalgan bo‘ladi;
2. Ko‘ndalang kesimlarida neytral o‘qdan teng o‘zoqlikdagi nuqtalarda urinma kuchlanishlar o‘zaro teng, ya’ni ko‘ndalang kesim eni bo‘yicha tekis taqsimlanadi;

Egilishdagi urinma kuchlaniish, egilishdagi urinma kuchlaniishlar mavjudligini aniqlagan olim nomi bilan Журавский формуласи deb nomlanadigan formula orqali topiladi:

$$\tau = \frac{Q_y \cdot S_x}{b \cdot J_x} \quad \left[kg/sm^2\right]$$ **Bu egilishdagi urinma kuchlaniish**

Q_y - ichki kundalang kuch, S_x – x uqiga nisbatan statik moment, (mm^3, sm^3); J_x - x o‘qiga nisbatan inersiya moment, (mm^4, sm^4), b – ko‘ndalang qirqim yuzasining eni.

Egilishdagi bosh kuchlaniishlar

Urinma kuchlaniish *0* ga teng bulgan maydonga bosh maydon deyiladi va shu maydonga ta’sir qilayotgan kuchlanishga bosh kuchlanish deyiladi.

Egilishda balkaning ixtiyoriy nuqtasida tekis kuchlanganlik xolati mavjud buladi. Bosh maydonga ta’sir qiluvchi bosh kuchlanishlarni quyidagi formula orqali topiladi, яъни:

$$\sigma_{\substack{\max \\ \min}} = \frac{\sigma}{2} \pm \frac{1}{2}\sqrt{\sigma^2 + 4\tau^2}; \quad \left[kg/sm^2\right]$$

Bosh maydonni topish uchun quyidagi formuladan foydalanamiz:

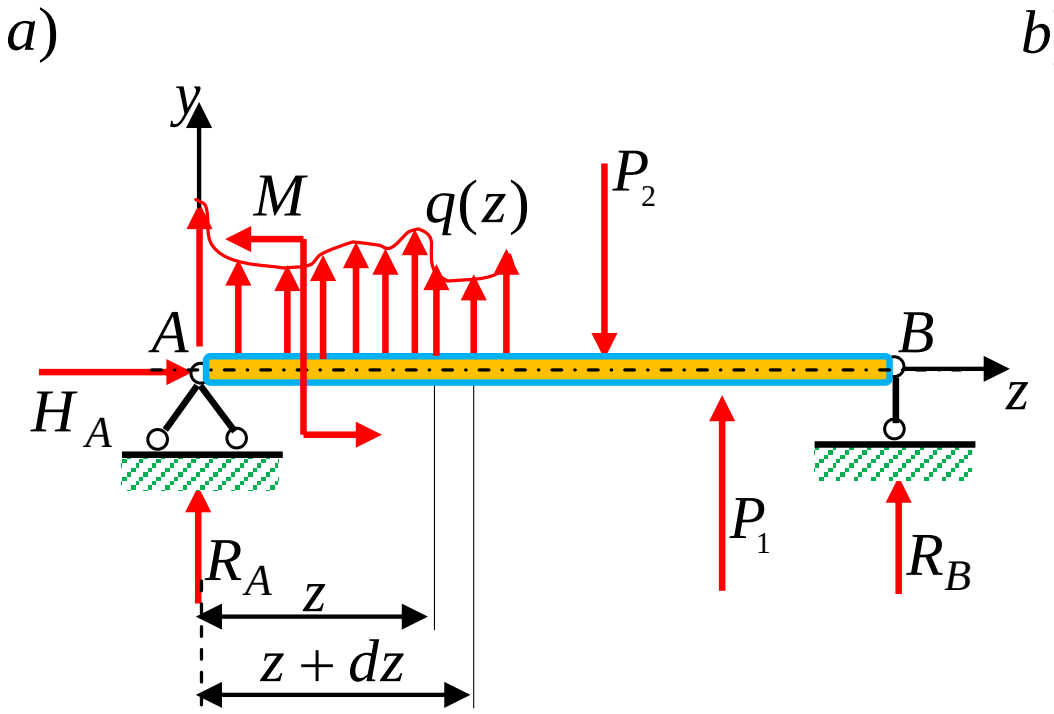
$$tg2\alpha = -\frac{2\tau}{\sigma}$$

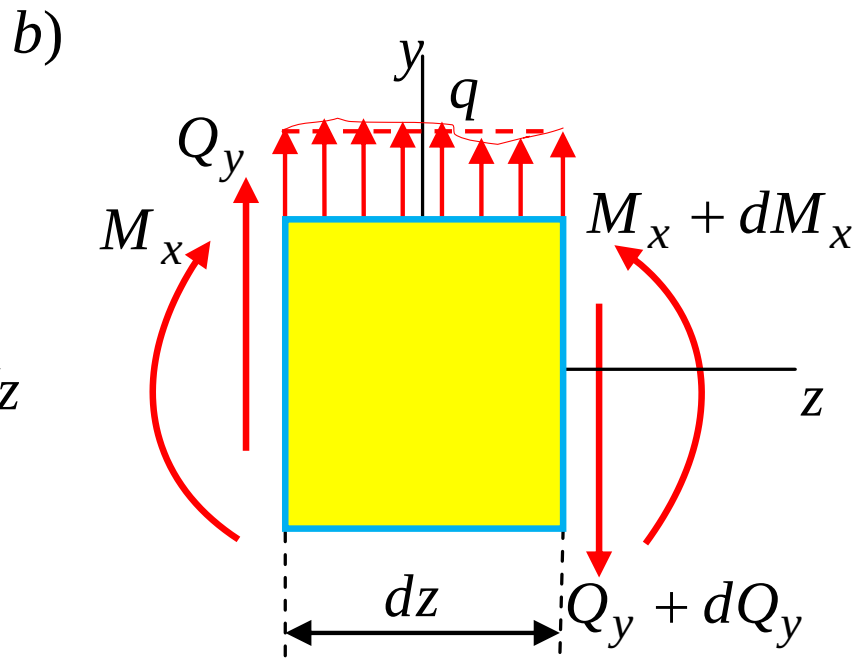
Balkalarning mustahkamligini bosh kuchlanishlar buyicha tekshirishda quyidagi 2 shart bajarilgandagina qullanilad:

1.Balkalarning biror kesimida eguvchi moment bilan kesuvchi kuch birgalikda uzining eng katta qiymatiga ega bulishi kerak.

2. Balka kesimining eni uning ustki va pastki chetiga yaqin yerda, masalan: qushtavr kabi kesimlaridek bidaniga uzgarganda.

Eguvchi moment (Meg), kundalang kich (Q) va tashqi nagruzkaning intensivligi q urtasidagi bog'lanish.





Balkaning chap tomonida z masofada olingan kesim uchun kundalang kich (Q) tenglamasini tuzaiz:

$$\sum Y = Q_y + qdz - (Q_y + dQ_y) = 0.$$

Bu tenglamadan quyidagi ifodani hosil qilamiz:

$$\frac{dQ_y}{dz} = q.$$

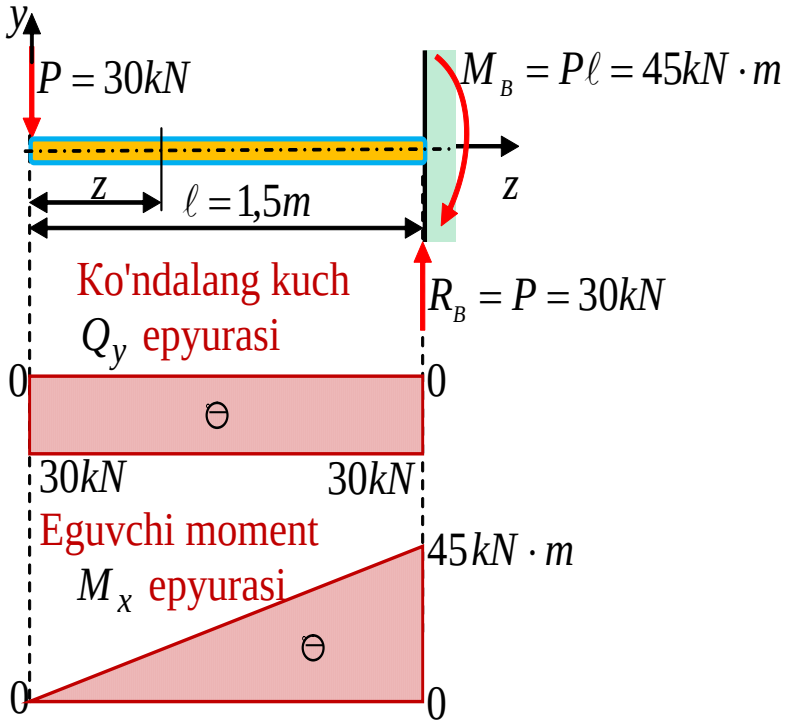
Demak, bundan ko‘rinadiki, ko‘ndalang kuchdan abssissa o‘qi *z* bo‘yicha olingan birinchi hosila tekis taqsimlangan kuch intensivligiga teng. Bu tenglik *Juravskiyning birinchi teoremasi* deb ham yuritiladi.

Endi xuddi shunday ajratib olingan cheksiz kichik element muvozanat holatda bo‘lishi uchun unga ta’sir etayotgan barcha kuchlarning o‘ng kesim og‘irlik markazi *B* ga nisbatan olingan momentlarining algebraik yig‘indisi nolga teng bo‘lishi shart, ya’ni:

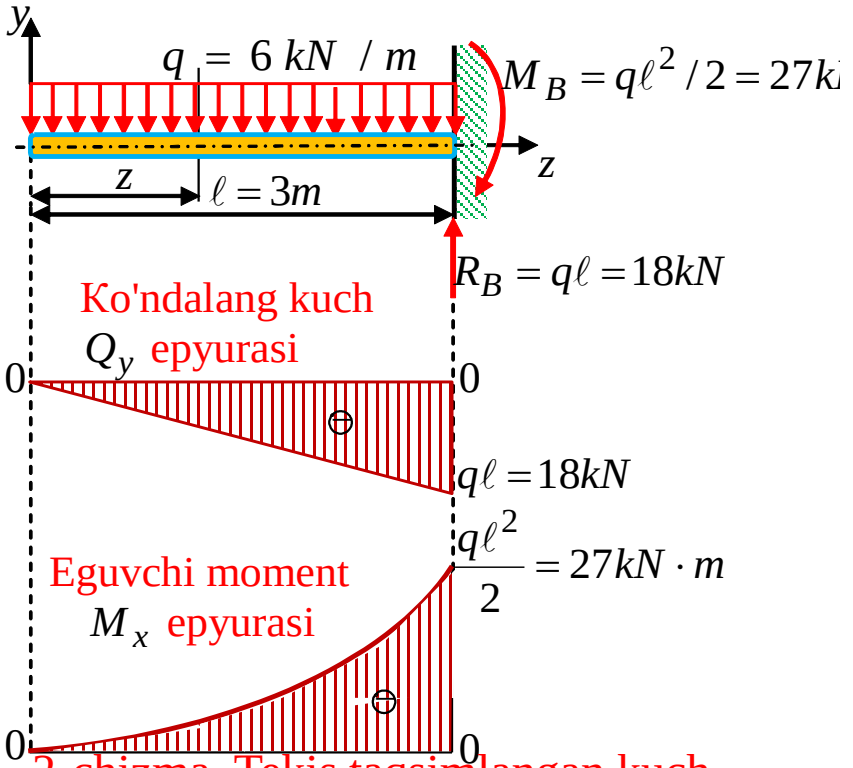
$$\sum mom_B = M_x - (M_x + dM_x) + Q_y dz + qdz\frac{1}{2}dz = 0.$$

Bu tenglamadagi oxirgi hadi boshqa hadlarga nisbatan ikkinchi tartibli kichik qiymat bo‘lgani uchun e’tiborga olmasa ham bo‘ladi, unda quyidagi tenglikni hosil qilamiz:

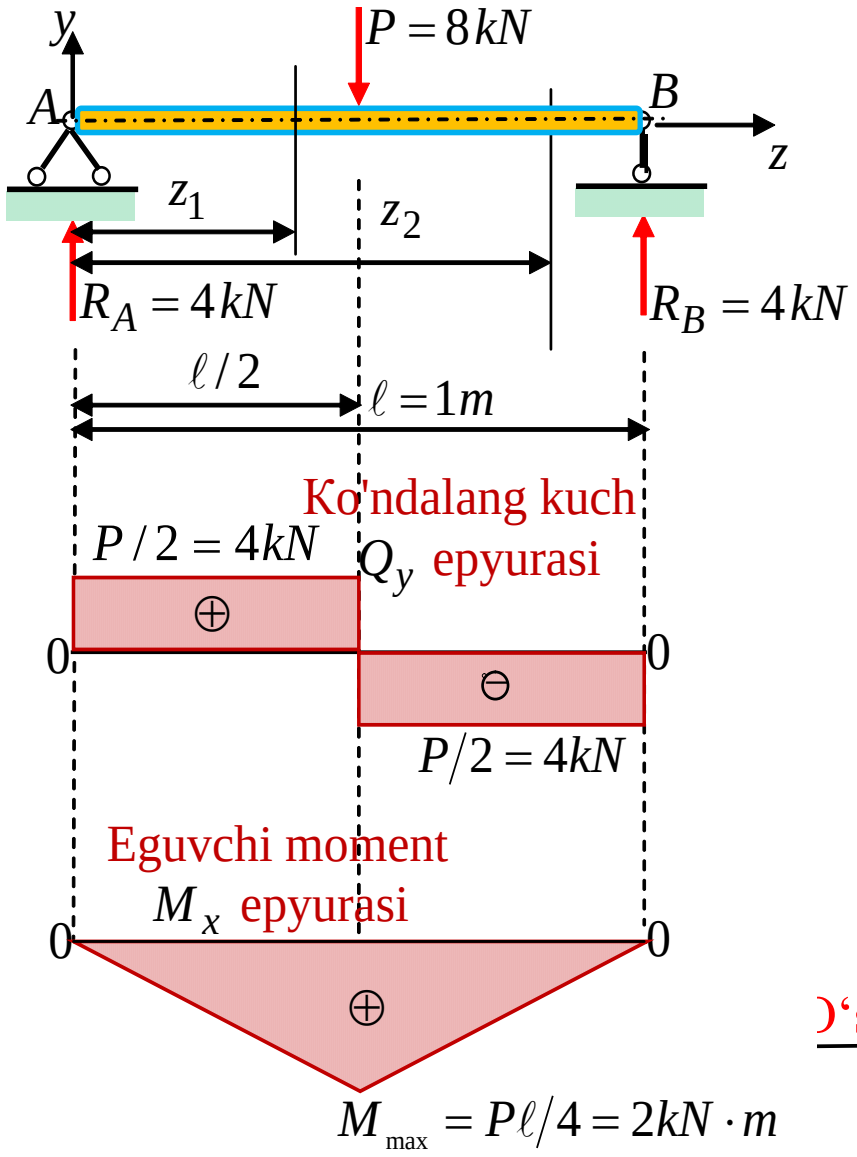
$$\frac{dM_x}{dz} = Q_y.$$



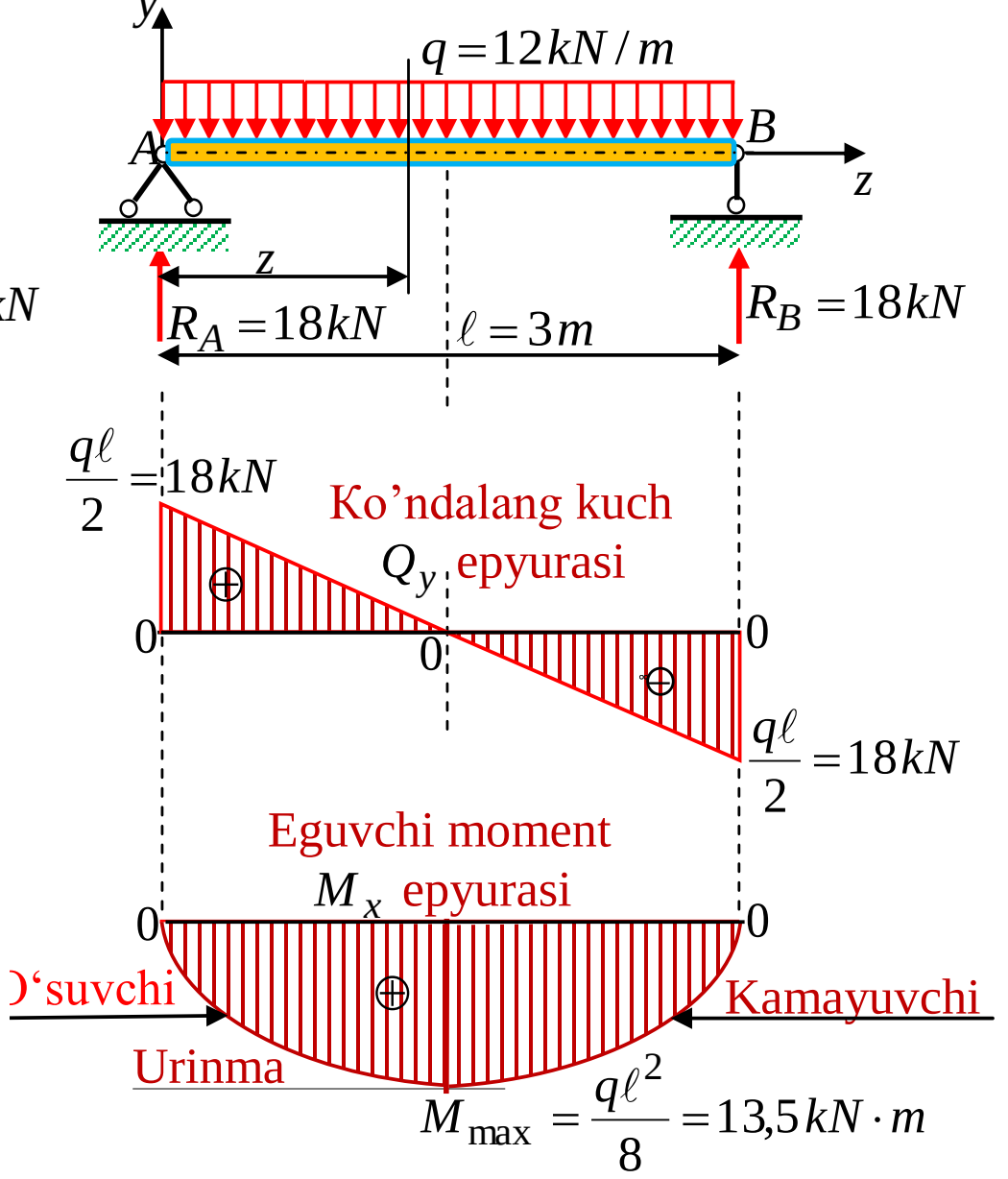
1-chizma. To‘plangan kuch ta’siridagi konsol.



2-chizma. Tekis taqsimlangan kuch ta’siridagi konsol.



3-chizma.To‘plangan kuch ta’siridagi oddiy balka.



4-chizma. Tekis taqsimlangan kuchlar ta’siridagi oddiy balka.

NAZORAT SAVOLLARI

1. Ko‘ndalang egilish deb qanday egilishga aytiladi?
2. Sof egilish - deb qanday egilishga aytiladi?
3. Qanday tayanch turlarini bilasiz?
4. Eguvchi moment ishorasi qanday qabul qilinadi?
5. Ko‘ndalang kuch ishorasi qanday qabul qilinadi?
6. Eguvchi moment epyurasi qanday maqsadda quriladi?
7. Ko‘ndalang kuch epyurasi qanday maqsadda quriladi?
8. Balkaning tayanch nuqtalarida hosil bo‘ladigan reaksiya kuchlari qanday aniqlanadi?
9. Balkaning tayanch nuqtalarida hosil bo‘ladigan reaksiya kuchlarini aniqlashdan maqsad nima?
10. Balkaning tayanch nuqtalarida hosil bo‘ladigan reaksiya kuchlarini aniqlashda qanday tenglamalardan foydalaniladi?

Foydalanilgan adabiyotlar

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