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Toshkent Arxitektura Qurilish Instituti

"Qurilish konstruktsiyalari " kafedrasi

"Metall konstruktsiyalari" fanidan

# *KURS ISHI*

**Mavzu:** To'sinli katak hisobi.

Bajardi :  10b-11 guruh talabasi
Ismatov D.
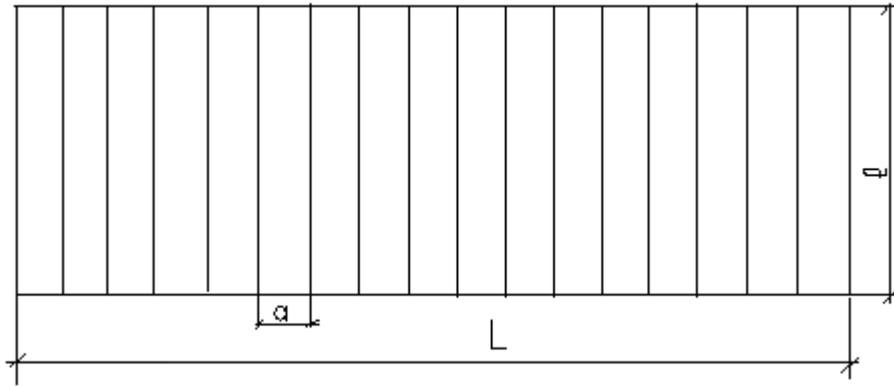Qabul qildi: Shukurova K.Q.

TOSHKENT-2014

**Hisoblash tartibi**

I. Biz "to'sinli katak" ustida ishlaganda eng arzon, tejamli va tez bitadigan, mustahkam to'sinli katakka ega bo'lishimiz uchun variantli loyihalash orqali bu masalani yechamiz.

I variant.

Oddiy to'sinli katak



Masalaning shartlari quyidagicha berilgan:

L= 14 m

l= 6.3 m

h= 4.6m

$q_0^H$=38kN/m$^2$

**1.To'shamani hisoblash.**

To'shama uchun varaqasimon prokat po'latning qalinligi 6-14mm gacha bo'lgani ishlatiladi.

Bizning 1 tur masalamizda

$$\frac{l_T}{t_T}=112 \qquad \left[\frac{f}{l}\right]=\frac{52121}{54555} \qquad l_T=\frac{14}{14}=1m$$

$$t_T=\frac{l_T}{115}=\frac{103}{108}=0.95sm$$

To'shama qalinligini $t_T$=10 mm qabul qilamiz.

**2.To'shama to'sinni hisoblash**

a)      to'shama to'singa ta'sir etayotgan hisobli yoyma yukni topamiz

$$q=(q_0^H\gamma_f+q_{to'o}\gamma_f)\cdot a=(38\cdot1.2+0,785\cdot1.05)\cdot1=46.42kN/m$$

Bu yerda $q_{to'o}$ quyidagi formula orqali topiladi:

$$q_{to'o}=t_t\cdot\gamma=0.01\cdot78.5=0.785kN/m^2$$

$\gamma_f$ -ta'sir etayotgan yuk bo'yicha ishonchli koeffitsiyent.

b)      Tashqi yukdan to'shama to'sinida hosil bo'layotgan tayanchlar oralig'idagi maksimal momentni topamiz.

$$M_{max}=\frac{ql^2}{8}=\frac{46.42\cdot6.3^2}{8}=230.3kNm$$

c)  Talab qilingan qarshilik momentini topamiz.

   Material elastik holatda ishlaganda

$$W_{tk}=\frac{M_{max}}{R_y\gamma_c}=\frac{23030}{24.5\cdot1}=940sm^2$$

Material elastik va plastik holatda ishlaganda

$$W_{tk}=\frac{M_{max}}{C_1R_y\gamma_c}=\frac{23030}{1.1\cdot24.5\cdot1}=85405sm^3$$

Shveller sortamentidan geometrik tavsifnomalarga asoslanib yuza tanlab olamiz, qrshilik momenti $W_x$=953sm$^3$ № 40

$J_x=19062\ sm^4$

$S_x=545\ sm^3$

$q_{to'o}=57kg$

$t_w=0.83\ mm$

*To'sinning o'z og'irligini e'tiborga olib tanlab olingan yuzaning mustahkamligini tekshiramiz.*

$$\sigma = \frac{M_{max} + M_{tto'o}}{C_1 W_x \gamma_c} = \frac{23030 + 297}{953 \cdot 1} = 24.47 kg / sm^2$$

Bu yerda to'sinni o'z og'irligidan mavjud bo'lgan eguvchi moment quyidagicha topiladi:

$$M_{tto'o} = \frac{q_{tto'o} \gamma_f l^2}{8} = \frac{57 \cdot 1.05 \cdot 6.3^2}{8} = 297 kgsm$$

farqi $\quad \dfrac{R_y - \sigma}{R_y} \cdot 100\% = \dfrac{24.5 - 24.47}{24.5} \cdot 100\% = 0.12\ \% < 5\%$

$$\tau = \frac{Q_{max} S_x}{J\ t_w} = \frac{148.1 \cdot 545}{19062 \cdot 0.83} = 5.1\,\text{kg/sm}^2 < R_s = 0.58 R_y$$

bu yerda Qtayanch orasidagi qirquvchi kuch quyidadi formula orqali aniqlanadi.

$$Q_{max} = \frac{(q + q_{tto'o)} \cdot \gamma_c )l}{2} = \frac{(46.42 + 0.57 \cdot 1.05)6.3}{2} = 148.1 kH$$

d)       Tanlab olgan to'sinimizni egiluvchanligini ham tekshiramiz.

$$\frac{f}{l} = \frac{5 \cdot q^H l^3}{384 \cdot EJ} = \frac{5 \cdot 39.355 \cdot 6.3^3}{384 \cdot 19062 \cdot 210000} = 0.0032 \le \left[ \frac{f}{l} \right]$$

Bu yerda $q^H$ quyidagi formula bilan topiladi.

$$q^H = (q_0^H + q_{tto'o})a + q_{tto'o} = (38 + 0.785) \cdot 1 + 0.57 = 39.355 kN / m$$
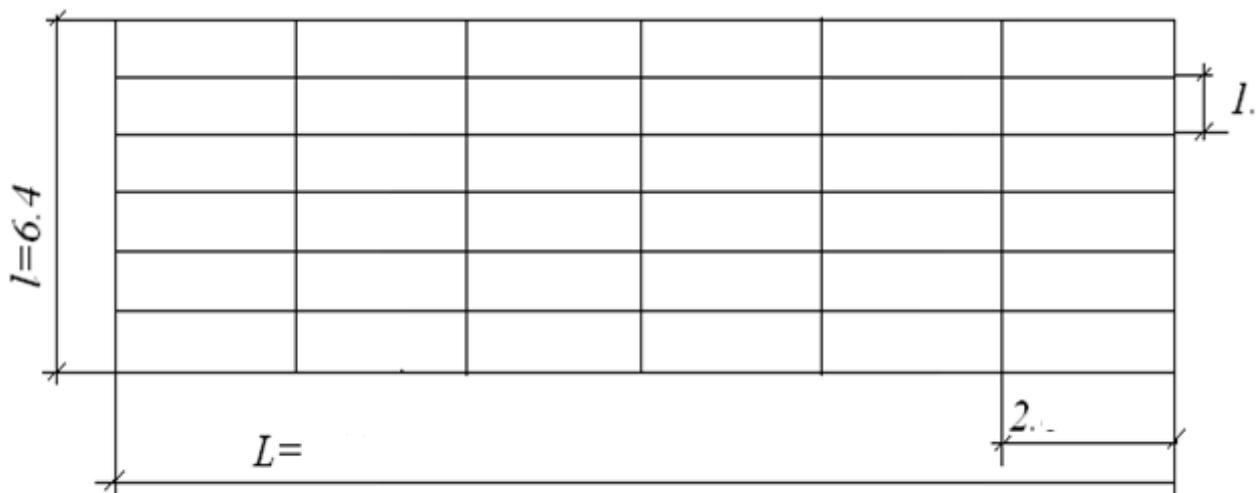
Tanlab olgan to'sinimiz mustahkamlik va egiluvchanligi bo'yicha qo'yilgan talablarga javob beradi.

1- variant bo'yicha 1 m$^2$ ga to'sinli katakni qurish uchun ketadigan po'latning og'irligini hisoblaymiz.

$$q_I = q_{to'o} + \frac{q_{tto'o}}{a} = 0.785 + \frac{0.57}{1} = 1.355 kN / m^2$$

## II. To'sinli katakni  2-variant bo'yicha hisoblash

Murakkab to'sinli katak



1.       To'shama qalinligini topamiz:     $l_1 = \dfrac{14}{4} = 3.5 \quad a = \dfrac{6.3}{6} = 1.05$

$$\frac{l_t}{t_t} = 112 \qquad \left[\frac{f}{l}\right] = \frac{1}{120} \text{ da } \quad t_t = \frac{l_t}{108} = \frac{103}{108} = 0.95 \text{ sm}$$

To'shamaning qalinligini 10mm deb olamiz.

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**To'shama to'sinni hisoblash**

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To'shama to'sinida hosil bo'layotgan hisobli yukni aniqlaymiz.

$$q = (q_0^H \gamma_f + q_{tto} \gamma_f)a = (38 \cdot 1.2 + 0.785 \cdot 1.05) \cdot 1 = 48.74 kN/m$$

a) Tashqi ta'sir etayotgan yukdan to'sinda mavjud bo'ladigan katta eguvchi momentni topamiz.

$$M_{\max} = \frac{ql_1^2}{8} = \frac{48.74 \cdot 3.5^2}{8} = 74.63 kN \cdot m$$

b) Talab qilingan qarshilik momentini topamiz.

$$W_{tk} = \frac{M_{\max}}{R_y \gamma_c} = \frac{7463}{24.5} = 304.61 sm$$

Qo'shtavr sortamentidan yuza tanlab olamiz, qarshilik momenti $W_x = 308 sm^3$ ga teng bo'lgan №22
$J_x = 4160 sm^4$
$S_x = 178 sm^3$
$t_w = 0.6 mm$
$q_{tto'o} = 27.7 kg/m$

c) Tanlangan yuza to'sinning o'z og'irligini e'tiborga olgan holda mustahkamlikka tekshiramiz.

$$\sigma = \frac{M_{\max} + M_{tto'o}}{W_x \gamma_c} = \frac{7463 + 44.6}{308 \cdot 1} = 24.37 kg \cdot sm$$

$$M_{tto'o} = \frac{q_{tto'o} \gamma_f l^2}{8} = \frac{27.7 \cdot 1.05 \cdot 3.5^2}{8} = 44.6 kgsm$$

Farqi

$$\frac{R_y - \sigma}{R_y} \cdot 100\% = \frac{24.5 - 24.37}{24.5} \cdot 100\% = 0.53\% \ < 5\%$$

Kesim bo'yicha ham

$$\tau = \frac{Q_{\max} S_x}{J_x t_w} = \frac{85.8 \cdot 178}{4160 \cdot 0.6} = 6.2 kg/sm^2$$

Tayanchlar orasidagi qirquvchi kuchni aniqlaymiz.

$$Q_{\max} = \frac{(q + q_{tto'o}) \cdot l_1}{2} = \frac{(48.74 + 0.77 \cdot 1.05) \cdot 2.92}{2} = 85.8 \text{ kH}$$

Tanlab olgan to'sinimizni egiluvchanligini ham tekshiramiz

$$\frac{f}{l} = \frac{5 \cdot q^H \cdot l_1^3}{384 EJ} = \frac{5 \cdot 41 \cdot 350^3}{384 \cdot 2100000 \cdot 4160} = 0.0026 \le \left[\frac{f}{l}\right]$$

$$q^H = (q_0^H \cdot 1 + q_{to'o} + \frac{q_{tto'o}}{a}) \cdot a = (38 + 0.785) \cdot 1.05 + 0.277 = 41 kN/m$$

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**2.Ikkinchi darajali to'sinni hisoblash**

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Ikkinchi darajali to'singa ta'sir 'tayotgan hisobli yukni aniqlaymiz.

$$q = \left[q_0^H \gamma_f + \left(q_{to'o} + \frac{q_{tto'o}}{a}\right) \cdot \gamma_f\right] \cdot l_1 = \left[38 x 1.2 + \left(0.785 + \frac{0.27.7}{1.05}\right) \cdot 1.05\right] \cdot 3.5 = 163.45 kN/m$$

Tashqi ta'sir etayotgan yukdan to'sinda mavjud bo'ladigan kata eguvchi momentni topamiz.

$$M_{\max} = \frac{ql^2}{8} = \frac{163.45 \cdot 6.3^2}{8} = 810.9 kN \cdot m$$

Talab qilingan qarshilik momentini topamiz.

$$W_{tk} = \frac{M_{\max}}{R_y \cdot \gamma_c} = \frac{81090}{24.5 \cdot 1} = 3008.94 sm^3$$

Qo'shtavr sortamentidan geometrik tavsifnomalarga qarab № 60БI nomerli yuzani tanlab olamiz.

$W_x = 3630$ sm$^3$

$J_x = 146000$ sm$^4$
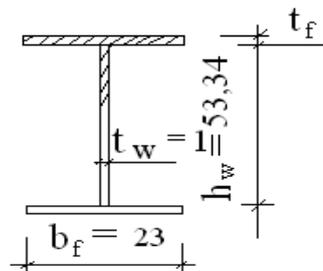
$t_w = 11.5$mm

$q_{tto'o} = 140$kg/m

Tanlab olingan to'sinning o'z og'irligini e'tiborga olib mustahkamligini tekshiramiz.

$$\sigma = \frac{M_{\max} + M_{tto'o}}{W_x \gamma_c} = \frac{81091 + 729.3}{3630 \cdot 1 \cdot 1.1} = 22.5 kg/sm^2$$

$$M_{tto'o} = \frac{q_{to'o} \cdot \gamma_f \cdot l}{8} = \frac{140 \cdot 1.05 \cdot 6.3^2}{8} = 729.3 kg \cdot m$$

Farqi

$$\frac{R_y - \sigma}{R_y} \cdot 100\% = \frac{24.5 - 22.5}{24.5} \cdot 100\% = 8.2\% \leq 10\%$$

Yuzaning static momentini quyidagi formula orqali topamiz.

$$S_x = A_f \frac{h_w + t_f}{2} + \frac{h_w t_w}{2} \cdot \frac{h_w}{4} = 26 \cdot 1.55 \cdot \frac{66.26 + 1.55}{2} + \frac{66.26 \cdot 1}{2} \cdot \frac{66.26}{4} = 1915.17 sm^3$$

Kesim bo'yicha ham tekshiramiz

$$\tau = \frac{Q_{\max} S_x}{J_x t_w} = \frac{519.5 \cdot 1915.17}{146000 \cdot 1.15} = 5.93 kg/sm < R_s$$

Tayanch orasidagi kesuvchi kuch,

$$Q_{\max} = \frac{(q + q_{to'o} \cdot \gamma_f) \cdot l}{2} = \frac{(163.45 + 1.4 \cdot 1.05) \cdot 6.3}{2} = 519.5 kN$$

Egiluvchanlik quyidagicha tekshiriladi:

$$\frac{f}{l} = \frac{5}{384} \cdot \frac{q^H l^3}{EJ_x} = \frac{5 \cdot 100,69 \cdot 640^3}{384 \cdot 2060000 \cdot 77430} = 0.0022$$

$$q^H = (q_0 + q_{to'o} + \frac{q_{tto'o}}{a}) \cdot l_1 + q_{2to'o} = \left(38 + 0.785 + \frac{0.277}{1,05}\right) \cdot 3.5 + 1.4 = 138.07 kN/m$$

2-chi variant bo'yicha 1m$^2$ ga to'sinli katakni qilish uchun ketadigan po'lat og'irligini hisiblaylik.

$$q_{II} = q_{to'o} + \frac{q_{tto'o}}{a} + \frac{q_{2tto'o}}{l_1} = 78.5 + \frac{2.7}{1,05} + \frac{140}{3.5} = 144.9 \, kg/m^2$$

Variantlarni solishtirib to'sinli katakni qilish uchun kamroq po'lat ketadigan variantni aniqlaymiz.

### Katta to'sinni hisoblash

Tanlab olgan yuzamiz tashqi ta'sir etayotgan yukni ko'taribturishga qobiliyatli bo'lishi kerak. Mustahkam umumiy va alohida elementlarning turg'unligi ta'minlanishi kerak va shu to'sinni tayyorlash arzonga tushishi kerak.

Katta to'singa tushadigan normal va hisobli yukni aniqlaymiz.

$$q_{kt}^H = (q_0^H + q_{to'o} + \frac{q_{tto'o}}{a})l \cdot 1.02 = \left(38 + 0,785 + \frac{0.57}{1}\right) \cdot 6.3 \cdot 1.02 = 255.46 kN/m$$

$$q_{kt} = \left[ q_0^H \gamma_f + (q_{to'o} + \frac{q_{tto'o}}{a}) \cdot \gamma_f \right] \cdot l \cdot 1.02 = \left[ 38 \cdot 1.2 + \left( 0.785 + \frac{0.57}{1} \right) \cdot 1.2 \right] \cdot 6.3 \cdot 1.02 = 304.87 kN/m$$

Katta to'singa ta'sir etayotgan yukdan tayanchlar orasida hosil bo'ladigan katta momentni topamiz.

$$M_{max}^H = \frac{q_{kt}^H \cdot L^2}{8} = \frac{255.46 \cdot 14^2}{8} = 6258.77 kN \cdot m$$

$$M_{max} = \frac{q_{kt} L^2}{8} = \frac{304.87 \cdot 14^2}{8} = 7469.315 kN \cdot m$$

Katta to'sinda tashqi yuklardan hosil bo'ladigan qirquvchi kuchni topamiz:

$$Q = \frac{q_{kt} L}{2} = \frac{612 \cdot 14}{2} = 2134.09 kN \cdot m$$

Talab qilinfgan qarshilik momentini topamiz:

$$W_{tk} = \frac{M_{max}}{R_y \gamma_c} = \frac{1628025}{24.5 \cdot 1} = 30487 sm^3$$

Qulay yuza topish uchun katta to'sinning balandligini to'g'ri qabul qilib olishimiz lozim:

a) $h_{min}$ – to'sinni eng kichik balandligidagi ruxsat etilgan egiluvchanligini e'tiborga olib:

$$h_{min} = \frac{5}{24} \cdot \frac{R_y L}{E \left[ \frac{f}{l} \right]} \cdot \frac{M^H}{M} = \frac{5 \cdot 2450 \cdot 1400 \cdot 6258.77}{24 \cdot 2100000 \left[ \frac{1}{350} \right] \cdot 7469.315} = 99.79 sm$$

b) $h_{opt}$ –to'sinning optimal balandligini quyidagi formula bilan aniqlaymiz:

$$h_{opt} = \sqrt{\frac{3 W_{tk}}{2 \cdot t_w}} = \sqrt{\frac{3 \cdot 30487}{2 \cdot 1}} = 213 sm$$

$t_w$- katta to'sin devorining qalinligi.
Devorning qalinligini imperik formuladan foydalanib topamiz:

$$t_w = 7 + \frac{3 h_{min}}{1000} = 7 + \frac{3 \cdot 99.79}{1000} = 9.99 mm$$

Devorning qalinligini 1.2m qilib qabul qilamiz. Katta to'sinning balandligini 185 sm qabul qilamiz.
Katta to'sin tokchasining yuzasini aniqlaymiz:

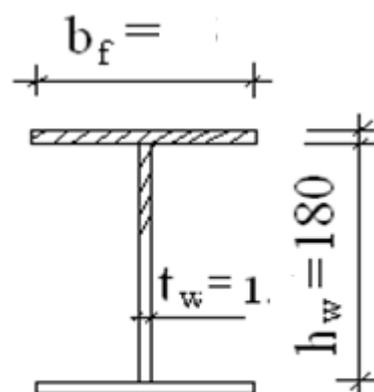$$A_f = \frac{W_{tk}}{h} - \frac{h t_w}{6} = \frac{30487}{170} - \frac{170 \cdot 1}{8} = 151 sm^2$$

Varaqasimon prokatli po'latdan 530x32 qabul qilamiz. Yuzasi $A_f= 169.6 sm^2$, shunday olsak to'sinning umumiy turg'unligi

$$b_f = (\frac{1}{3} \div \frac{1}{5}) h$$

va tokchaning turg'unligi bajariladi.
$b_f < 30 t_f$
67<90

Qabul qilib olgan katta to'sinimizning geometric tavsifnoomasini topamiz.

$$J_x = \frac{h_w^3 t_w}{12} + 2A_f\left(\frac{h_w + t_f}{2}\right)^2 = \frac{170^3 \cdot 1}{12} + 2 \cdot 169.6\left(\frac{170 + 3.2}{2}\right)^2 = 2718856.56 sm^3$$

$$W_x = \frac{2J_x}{h} = \frac{2 \cdot 2718856.56}{170} = 31986.55 sm^3$$

$$S_x = A_f \frac{h_w + t_f}{2} + \frac{t_w h_w}{2} \cdot \frac{h_w}{4} = 169.6 \cdot \frac{163.6 + 3.2}{2} + \frac{1 \cdot 163.6^2}{2 \cdot 4} = 17490.26 sm^3$$

Katta to'sinning 1m uzunligidagi og'irligini aniqlaymiz.

$$q_{kto'o} = (2A_f + A_w)\gamma = (2 \cdot 0.01696 + 0.01636)78.5 = 3.95 kN/m$$

Qabul qiliingan katta to'sin mustahkamligini tekshiramiz.

$$\sigma = \frac{M}{W_x \gamma_c} = \frac{746931.5}{31986.55} = 23.35 < 24.5 kg/sm^2$$

farqi

$$\frac{24.5 - 23.35}{24.5} \cdot 100\% = 4.6\% < 5\%$$

$$\tau = \frac{QS_s}{J_{xt_w}} = \frac{2134.09 \cdot 17490.26}{2718856.56 \cdot 1} = 13.73 kg/sm^2 < R_s$$

Egiluvchanligini ham:

$$\frac{f}{l} = \frac{5}{48} \cdot \frac{M^H L}{E \cdot J_x} = \frac{5 \cdot 1400 \cdot 625877}{48 \cdot 21000 \cdot 2718856} = 0.00159 < \left[\frac{1}{350}\right]$$

**Katta to'sinning umumiy turg'unligini tekshiramiz**

Quyidagi talablar, shartlar bajarilsa:
- ta'sir etayotgan uzluksiz mustahkam to'shama orqali katta to'sinni tepa tokchasiga ta'sir etsa.
- Katta to'sinning hisobiy uzunligi tokchasi eniga bo'lgan nisbati quyidagi shartni bajarsa.

$$\frac{l_{ef}}{b} \leq \left[0.41 + 0.0032\frac{b_f}{t_f} + \left(0.73 - 0.016\frac{b_f}{t_f}\right)\frac{b_f}{h} \cdot \sqrt{\frac{E}{R_y}}\right]$$

$$\frac{117}{67} = \left[0.41 + 0.0032 \cdot \frac{53}{3.2} + \left(0.73 - 0.016 \cdot \frac{67}{3.2}\right)\frac{53}{170} \cdot \sqrt{\frac{21000}{24.5}}\right] = 17,8$$

Unda katta to'sinning umumiy turg'unligini tekshirishga hojat yo'q.
$$1.75 < 17,8$$

**Alohida elementlarning turg'unligini tekshiramiz**

1. Siqilishga ishlayotgan katta to'sin tokchasining turg'unligini tekshiramiz.

$$\frac{b_{sv}}{t_f} \leq \left(0.5\sqrt{\frac{E}{R_y}}\right) = 0.5\sqrt{\frac{21000}{24.5}} = 15.3 \qquad \frac{\frac{53}{2}}{3.0} = 8.83 < 15.3$$

Shunday qilib tokchaning turg'unligi bajarilgan.
2. katta to'sin devorining turg'unligini tekshirish uchunkeltirilgan shartli egiluvchanligigni topamiz.

$$\lambda_w = \frac{h_w}{t_w}\sqrt{\frac{R_y}{E}} = \frac{163.6}{1}\sqrt{\frac{24.5}{21000}} = 5.58 > 3.5$$

Demak devorning turg'unligini oshirish uchun qovurg'alar ko'ndalang kesim uchun quyidagi.
Qovurg'alarning masofasi 2h dan oshib ketmasligi kerak emas. Bizning shartimiz bo'yicha 180x2=360
Qovurg'aning enini quyidagi formula orqali topamiz:

$$b_k = \frac{h}{30} + 40 = \frac{170}{3.0} + 40 = 96.67 mm$$
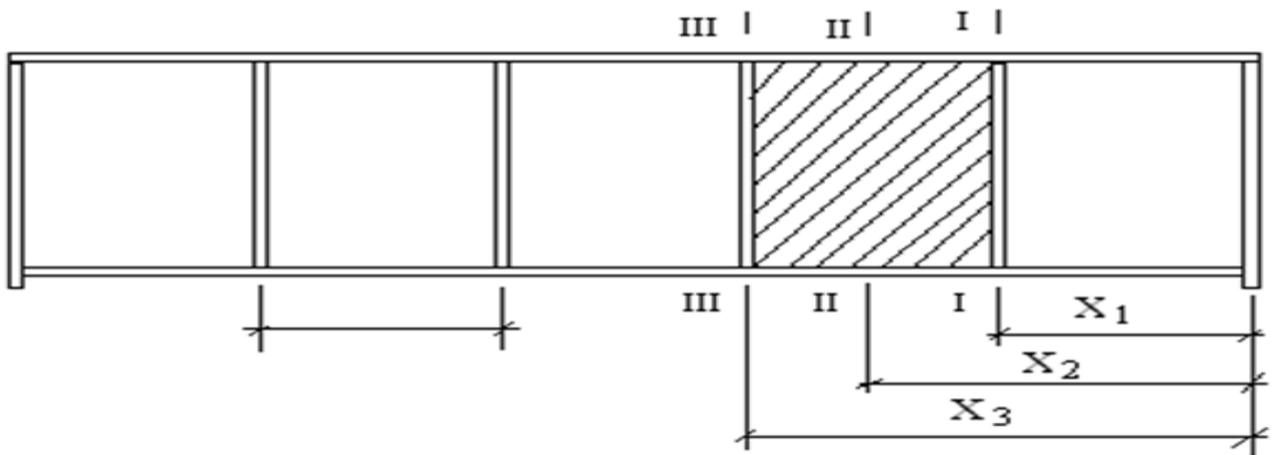
$b_k = 105 mm$ deb qabul qqilamiz.

Qovurg'aning qalinligi quyidagi nisbatdan topiladi: $t_k = 2b_k \sqrt{\frac{R_y}{E}} = 2 \cdot 10.5 \sqrt{\frac{24.5}{21000}} = 7.17 sm$

Qovurg'aning qalinligini …mm qabul qilib olamiz.
Qovurg'ali katta to'sin devorining turg'unligini quyidagi formula orqali aniqlaymiz.

$$\sqrt{\left(\frac{\sigma}{\sigma_{cr}} + \frac{\sigma_{l_0 f}}{\sigma_{l_0 fcr}}\right)^2 + \left(\frac{\tau}{\tau_{cr}}\right)^2} \leq \gamma_c$$

$\delta, \tau$ - qurilayotgan yacheykada tashqi kuchlar otsida yuzada hosil bo'layotgan kuchlanishlar.



$$\sigma = \frac{M_{cr}}{W_x \gamma_c} = \frac{146.223}{21.7 \cdot 1} = 6.74 kg/sm^2$$

$$M_{cr} = \frac{M_I + M_{II} + M_{III}}{3} = \frac{5602 + 7002.48 + 7469.315}{3} = 6691.265 kNm$$

$$R_B = \frac{qL}{2} = \frac{304.87 \cdot 14}{2} = 2134.09 kN$$

$$M_I = R_b \cdot x_I - \frac{qx_I^2}{2} = 2134.09 \cdot 3,5 - \frac{304.87 \cdot 3.5^2}{2} = 5602 kNm$$

$$M_{II} = R_B \cdot x_2 - \frac{qx_2^2}{2} = 2134.09 \cdot 5,25 - \frac{304.87 \cdot 5.25^2}{2} = 7002.48 kNm$$

$$M_{III} = R_B \cdot x_3 - \frac{qx_3^3}{2} = 2134.09 \cdot 7,0 - \frac{304.87 \cdot 7,0^2}{2} = 7469.315 kNm$$

$$\sigma_{l_0 s} = \frac{F}{t_w l_{ef}} = \frac{146.223}{1 \cdot 21.7} = 6.74 kg/sm^2$$

$$F = \frac{q_{tt} l}{2} = \frac{46.42 \cdot 6.3}{2} = 146.223$$

$$l_{ef} = b + 2t_f = 15.3 + 2 \cdot 3,2 = 21.7$$

$$\tau = \frac{Q_{sr} S_x}{J_x t_w} = \frac{669126.5}{31986.56 \cdot 1} = 20.92 kg/sm^2$$

$$Q_{sr} = \frac{Q_1 + Q_2 + Q_3}{3} = \frac{1067.045 + 533.52 + 0}{3} = 533.52 kN$$

$$Q_1 = R_B - q \cdot x_1 = 2134.09 - 304.87 \cdot 3.5 = 1067.045 kN$$

$$Q_2 = R_B - q \cdot x_2 = 2134.09 - 304.87 \cdot 5.25 = 533.52 kN$$

$$Q_3 = R_B - q \cdot x_3 = 2134.09 - 304.87 \cdot 7,0 = 0 kN = \frac{{}_{cr} R_y}{\lambda_w^2}$$

$$\sigma = \frac{76.5 \cdot 24.5}{5,58^2} = 60.19 sm^2$$

c$_{cr}$- koeffitsiyent ;advaldan olamiz b- qarab

$$\delta = \beta \frac{b_f}{h_{ef}} \left(\frac{t_f}{t_w}\right)^3 = 0.8 \frac{67}{180} \left(\frac{3.0}{1.2}\right)^3 = 4,7$$

$$\sigma_{loger} = \frac{c_I \cdot R_y}{\lambda_a^2} = \frac{59,4 \cdot 2450}{5,17^2} = 5444 sm^2$$

$$\tau_{cr} = 10.3 \left(1 + \frac{0.76}{\mu^2}\right) \frac{R_s}{\lambda_{ef}^2} = 10.3 \left(1 + \frac{0.76}{1.94^2}\right) \cdot \frac{1421}{5,17^2} = 658 kg/sm^2$$

$$\mu = \frac{d}{h_{ef}} = \frac{350}{180} = 1.94$$

$$\sqrt{\left(\frac{\sigma}{\sigma_{cr}} + \frac{\sigma_{los}}{\sigma_{loscr}}\right)^2 + \left(\frac{\tau}{\tau_{c\check{4}}}\right)^2} = \sqrt{\left(\frac{1986}{3215} + \frac{589}{5444}\right)^2 + \left(\frac{374}{658}\right)^2} = 0,92 < 1$$

**Ustunni hisoblash**

Ustunga ta'sir etayotgan yukni hisoblaymiz:

$$N = 2 \cdot Q_{kt} = 2 \cdot 2134.09 = 4268.16 kN$$

Ustunning talab qilingan yuzasi quyidagi formula orqali aniqlanadi:

$$A_{tk} = \frac{N}{\varphi R_y \gamma_c} = \frac{4268.16}{0.999 \cdot 24.5 \cdot 0.95} = 183.56 sm^2$$

$$\lambda = 70$$

$$\bar{\lambda} = \lambda\sqrt{\frac{R_y}{E}} = 70\sqrt{\frac{24.5}{21000}} = 2.4$$

$$\varphi = 1 - \left(0.073 - 5.53 \cdot \frac{R_y}{E}\right) \cdot \lambda\sqrt{\lambda} = 1 - \left(0.073 - 5.53\frac{24.5}{21000}\right) \cdot 0.0018\sqrt{0.0018} = .0999$$

Ustunning talab qilingan inertsiya radiusi quyidagi ifoda orqali aniqlanadi:

$$i_{tk} = \frac{l_{ef}}{\lambda} = \frac{520}{70} = 7,4 sm$$

Ustunning kesim yuzasini talab qilingan tomonlarini jadvaldan foydalanib aniqlaymiz:

$$h_{tk} = \frac{i_{tk}}{\alpha_1} = \frac{7,4}{0.43} = 17,2 sm$$

$$b_{tk} = \frac{i_{tk}}{\alpha_2} = \frac{7,4}{0.24} = 30,8 sm$$

Ustunning $A_{tk}$ yuzasini eniga qarab alohida elementlardan tashkil topgan qo'shtavr formasiga ega bo'lgan yuzani tanlab olamiz, so'ngra ustunning devorini va tokchalarini varaqasimon prokatli po'latdan tanlab olamiz 300x10,      380x25x2 ta

Ustunning umumiy yuzasi A=190sm² ga teng. Tanlab olgan yuzamizni geometrik tafsifnomalarini aniqlaymiz:

$$J_x = \frac{h_w^3 \cdot t_w}{12} + 2b_f t_f \left(\frac{h_w + t_f}{2}\right)^2 = \frac{38^3 \cdot 2.5}{12} + 2 \cdot 38 \cdot 2.5\left(\frac{38 + 2.5}{2}\right)^2 = 52421.87 sm^4$$

$$J_y = \frac{b_f^3 t_w}{12} \cdot 2 + \frac{t_w^3 h_w}{12} = \frac{38^3 \cdot 2.5}{12} \cdot 2 + \frac{1,0^3 \cdot 30}{12} = 22865.83 sm^4$$

$$i_x = \sqrt{\frac{J_x}{A}} = \sqrt{\frac{52421.87}{190}} = 16.61 sm$$

$$i_y = \sqrt{\frac{J_y}{A}} = \sqrt{\frac{22865.83}{190}} = 10.97 sm$$

X vaY o'qlari bo'yicha egiluvchanligini aniqlaymiz

$$\lambda_x = \frac{l_{efx}}{i_x} = \frac{3560}{16.61} = 21.07$$

$$\lambda_y = \frac{l_{efy}}{i_y} = \frac{350}{10.97} = 31.9$$

$$\bar{\lambda} = \lambda\sqrt{\frac{R_y}{E}} = 54,2\sqrt{\frac{24.5}{21000}} = 1,87$$

$$\varphi = 1 - \left(0.073 - 5.53 \cdot \frac{R_y}{E}\right) \cdot \lambda\sqrt{\lambda} = 1 - \left(0.073 - 5.53\frac{24.5}{21000}\right) \cdot 1,87\sqrt{1,87} = 0,97$$

Katta egiluvchanligiga qarab jadvaldan φ=0.768 koeffitsiyentini olamiz va tanlab olingan yuzani mustahkamlikka tekshiramiz:
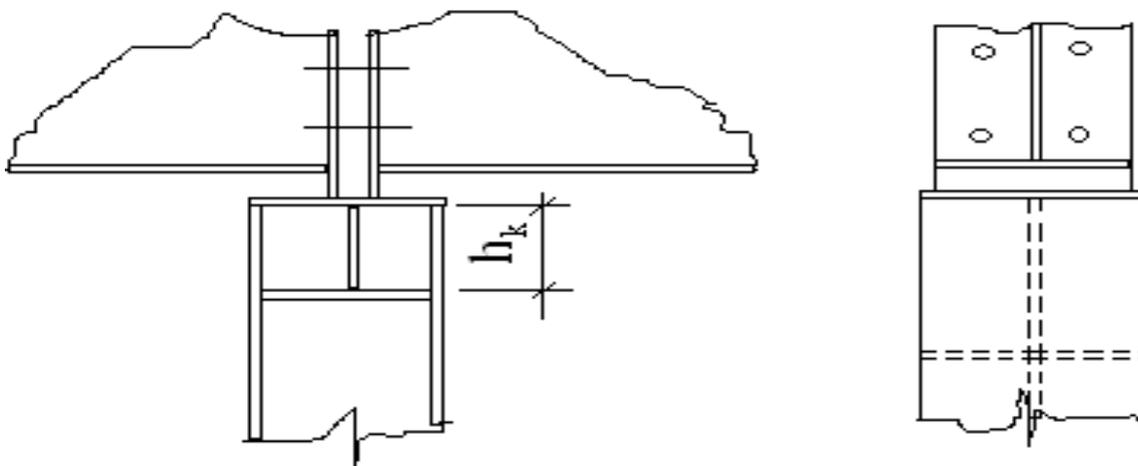
$$\sigma = \frac{N}{\varphi_{min} \cdot A \cdot \gamma_c} = \frac{4268.16}{0.97 \cdot 190 \cdot 0.95} = 24.38 kg/sm^2$$

Farqi

$$\frac{R_y - \sigma}{R_y} \cdot 100\% = \frac{24.5 - 24.38}{24.5} \cdot 100\% = 0.5\% < 5\%$$

### Ustunning tepa qismining konstruktiv elementlarini tanlash va joylashtirish

Ustunning tepa qismi to'sinlardan tushuvchi yukni qabul qilib oladigan plitalardan va bo'ylama, ko'ndalang qovurg'alardan iborat.



Bo'ylama bo'yicha qovurg'aning uzunligini hisoblaymiz.

$$h_k = \frac{N}{4K_f \beta_f \gamma_w R_{wf} \gamma_c} = \frac{4268.16}{4 \cdot 1 \cdot 0.7 \cdot 1 \cdot 1628 \cdot 1} = 93.63 sm$$

K$_f$- QMQ 11-23-81 jadval 36 bo'yicha K$_f$=1
B$_f$- QMQ 11-23-81 jadval 34 bo'yicha β$_f$=0.7
R$_{wf}$ - quyidagi formula bo'yicha aniqlanadi:

$$R_{wf} = 0.55 \frac{R_{wun}}{\gamma_{wm}} = 0.55 \frac{37}{1.25} = 16.28 kg/sm^2$$

*yoki*

$$h_k = \frac{N}{4K_f \beta_f R_{wz} \gamma_{wz} \gamma_c} = \frac{4268.16}{4 \cdot 1 \cdot 1 \cdot 16.65 \cdot 1} = 64.08 sm$$

Bo'ylama bo'yicha qovurg'aning uzunligi 100 sm deb qabul qilamiz.

Bo'ylama bo'yicha hosil bo'layotgan urinma kuchlanishni aniqlaymiz.

$$\tau = \frac{0.5N}{2h_k \cdot t_k} = \frac{0.5 \cdot 4268.16}{2 \cdot 100 \cdot 1} = 14.21 kg/sm^2 < R_s$$

R$_s$=1421kg/sm$^2$