

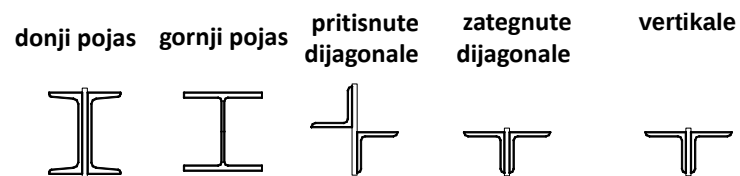
REŠETKASTI NOSAČI

ZADACI

1

Zadatak

Dimenzionisati rešetkasti nosač koji je prikazan na skici. Veze štapova u čvorovima ostvariti zavarivanjem, a montažne nastavke pomoću neobrađenih zavrtnjeva klase čvrstoce 5.6. Za štapove rešetkastog nosaca upotrebiti valjane profile sledećih oblika:



Raspon nosaca: $L = 16 \text{ m}$

Razmak susednih rešetkastih nosaca je: $l = 6,0 \text{ m}$

Totalno vertikalno opterećenje: $q = 10,0 \text{ kN/m}^2$

Sopstvena težina rešetke: $g = 2,0 \text{ kN/m}$

Osnovni materijal: Č0361 (I slučaj opterećenja)

Radionički crtež dati u razmeri: 1:10

2

Dopušteni naponi

Osnovni materijal: Č0361

Zavrtnjevi: klase čvrstoće 5.6

Ugaoni šavovi

$$\sigma_{\text{dop}} = 16,0 \text{ kN/cm}^2$$

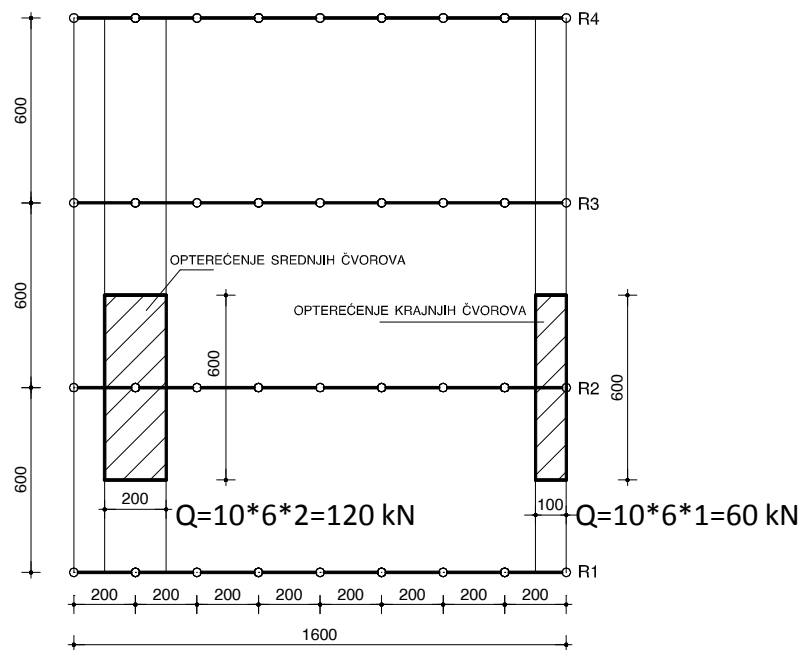
$$\tau_{\text{dop}} = 14,0 \text{ kN/cm}^2$$

$$\sigma_{\text{b,dop}} = 27,0 \text{ kN/cm}^2$$

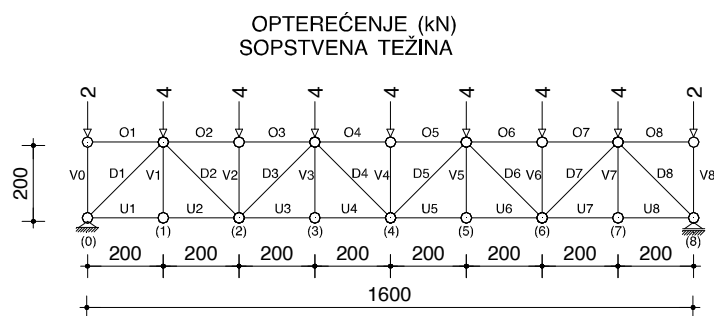
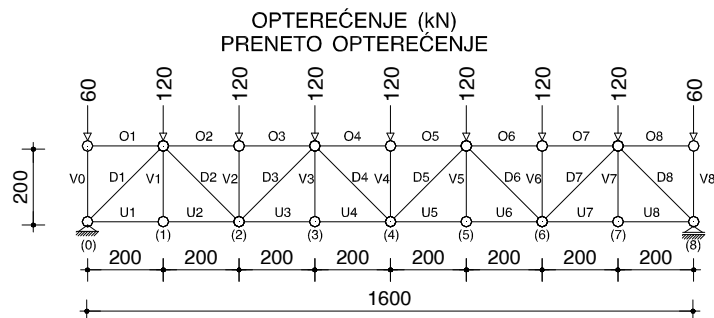
$$\sigma_{\text{w,dop}} = 12,0 \text{ kN/cm}^2$$

Opterećenje u čvorovima rešetke**Preneto opterećenje** $Q = 10 \cdot 6 \cdot 2 = 120 \text{ kN}$ – Opterećenje srednjih čvorova $Q = 10 \cdot 6 \cdot 1 = 60 \text{ kN}$ – Opterećenje krajnjih čvorova**Sopstvena težina rešetke** $Q = 2 \cdot 2 = 4 \text{ kN}$ – Opterećenje srednjih čvorova $Q = 2 \cdot 1 = 2 \text{ kN}$ – Opterećenje krajnjih čvorova

3

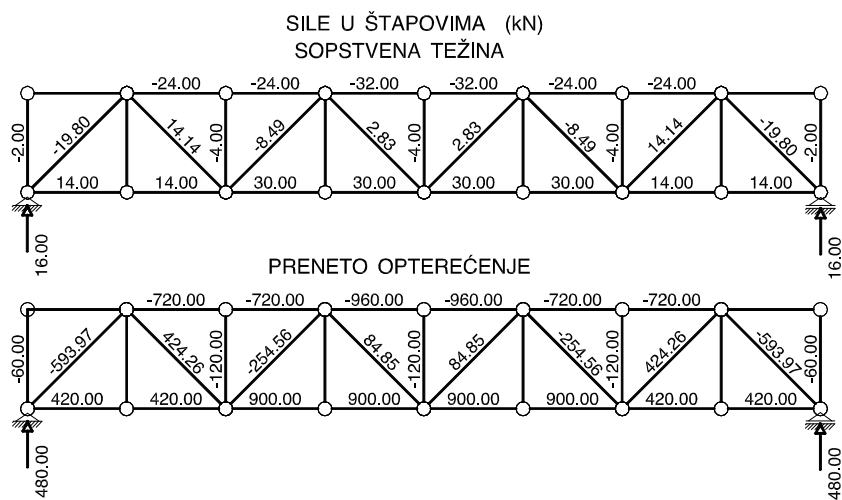


4

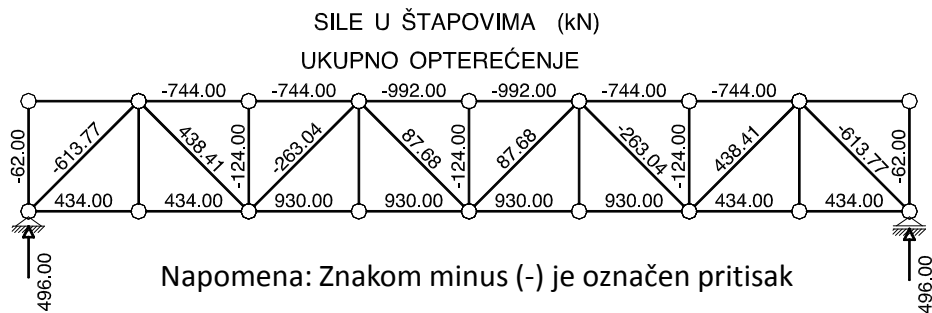


5

1. Rezultati



6



2. DIMENZIONISANJE ŠTAPOVA

2.1 Donji pojas – Centrično zategnuti štapovi

Maksimalni uticaji (štapovi U3, U4, U5, U6): $N_t = 930$ kN

$$A_{\text{pot}} = \frac{N_t}{\sigma_{\text{dop}}} = \frac{930}{16} = 58,125 \text{ cm}^2$$

7

Usvajaju se dva valjana profila U200 $A = 2 \times 32,2 = 64,4 \text{ cm}^2$

Kontrola napona

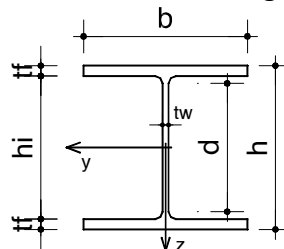
$$\sigma = \frac{N_t}{A} = \frac{930}{64,4} = 14,44 \text{ kN/cm}^2 < 16 \text{ kN/cm}^2 = \sigma_{\text{dop}}$$

2.2 Gornji pojas – Centrično pritisnuti štapovi

Maksimalni uticaji (štapovi O4 i O5): $N_c = 992$ kN

Predpostavlja se valjani profil HEA 240 sa sledećim geometrijskim karakteristikama:

$b_f = 240$ mm, $t_f = 12$ mm,
 $d = 230$ mm, $t_w = 7,5$ mm
 $A = 76,8 \text{ cm}^2$, $I_y = 7760 \text{ cm}^4$
 $i_y = 10,1$ cm, $I_z = 2770 \text{ cm}^4$
 $i_z = 6,0$ cm



8

Izvijanje oko y-y ose (videti JUS U.E7.086)

$$I_{iy} = \beta \cdot I = 1,0 \cdot 200 = 200 \text{ cm}$$

$$\text{Vitkost štapa} \quad \lambda_y = \frac{I_{iy}}{i_y} = \frac{200}{10,1} = 19,8$$

$$\text{relativna vitkosti štapa } (\lambda_v = 92,9) \quad \bar{\lambda}_y = \frac{\lambda_y}{\lambda_v} = \frac{19,8}{92,9} = 0,213$$

$$\alpha = 0,339 \text{ (kriva izvijanja B)}$$

$$\beta_y = 1 + \alpha \cdot (\bar{\lambda}_y - 0,2) + \bar{\lambda}_y = 1 + 0,339(0,213 - 0,2) + 0,213^2 = 1,05$$

$$\chi_y = \frac{2}{\left(\beta_y + \sqrt{\beta_y^2 - 4\bar{\lambda}_y^2} \right)} = \frac{2}{\left(1,05 + \sqrt{1,05^2 - 4 \cdot 0,213^2} \right)} = 0,995$$

9

izvijanje oko z-z ose štapa

$$I_{iz} = \beta \cdot I = 1,0 \cdot 200 = 200 \text{ cm}$$

vitkost štapa

$$\lambda_z = \frac{I_z}{i_z} = \frac{200}{6} = 33,33$$

relativna vitkosti štapa ($\lambda_v = 92,9$)

$$\bar{\lambda}_z = \frac{\lambda_z}{\lambda_v} = \frac{33,33}{92,9} = 0,358$$

$$\alpha = 0,489 \text{ (kriva izvijanja C)}$$

$$\beta_z = 1 + \alpha \cdot (\bar{\lambda}_z - 0,2) + \bar{\lambda}_z = 1 + 0,489(0,358 - 0,2) + 0,358^2 = 1,207$$

$$\chi_z = \frac{2}{\left(\beta_z + \sqrt{\beta_z^2 - 4\bar{\lambda}_z^2} \right)} = \frac{2}{\left(1,207 + \sqrt{1,207^2 - 4 \cdot 0,358^2} \right)} = 0,919$$

Kontrola napona: $\chi_{\min} = \min(0,995, 0,919) = 0,919$

$$\sigma = \frac{N_c}{A} = \frac{992}{76,8} = 12,92 \text{ kN/cm}^2 < \sigma_{\text{idop}} = \chi_{\min} \cdot \sigma_{\text{dop}} = 0,919 \cdot 16 = 14,70 \text{ kN/cm}^2$$

Usvojen profil HEA 240 – Č0361

2.3 Zategnuta dijagonala**Maksimalni uticaji (štapovi D2 i D7): $N_t = 438,41$ kN**

$$A_{\text{pot}} = \frac{N_t}{\sigma_{\text{dop}}} = \frac{438,41}{16} = 27,40 \text{ cm}^2$$

Usvajaju se dva valjana profila L100x100x10.

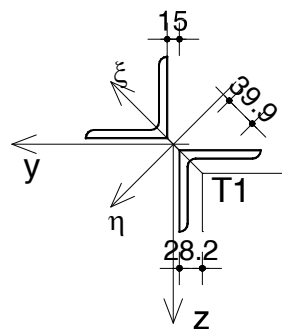
$$A = 2 \times 19,2 = 38,4 \text{ cm}^2$$

Kontrola napona

$$\sigma = \frac{N_t}{A} = \frac{438,41}{38,4} = 11,42 \text{ kN/cm}^2 < 16 \text{ kN/cm}^2 = \sigma_{\text{dop}}$$

2.4 Pritisnuta dijagonala**Maksimalni uticaji (štapovi D1 i D8): $N_c = 613,77$ kN**

11

**Predpostavljaju se dva valjana profila L100x100x10.**

Geometrijske karakteristike štapa:

$$A = 2 \times 19,2 = 38,4 \text{ cm}^2$$

$$i_{\min,1} = 1,95 \text{ cm}$$

$$i_{\min} = i_{\xi} = 3,82 \text{ cm}$$

NAPOMENA: Razmak veznih limova:

$$a = 450 \text{ mm} < 70 \times i_{\min,1} = 70 \times 19,5 = 1365 \text{ mm}$$

Kontrola stabilnosti štapa se može sprovesti kao za jednodelni štap.

(videti JUS U.E7.091/1986)

12

Kontrola stabilnosti štapa:

$$l_{i\xi} = \beta_{\xi} \cdot l = 0,9 \cdot 282,8 = 254,5 \text{ cm}$$

$$\text{Vitkost štapa} \quad \lambda_{\xi} = \frac{l_{i\xi}}{i_{\xi}} = \frac{254,5}{3,82} = 66,62$$

$$\text{relativna vitkosti štapa } (\lambda_v = 92,9) \quad \overline{\lambda}_v = \frac{\lambda_{\xi}}{\lambda_v} = \frac{66,6}{92,9} = 0,717$$

$$\alpha = 0,489 \text{ (kriva izvijanja C)}$$

$$\beta_{\xi} = 1 + \alpha \cdot (\overline{\lambda}_{\xi} - 0,2) + \overline{\lambda}_{\xi} = 1 + 0,489(0,717 - 0,2) + 0,717^2 = 1,767$$

$$\chi_{\xi} = \frac{2}{\left(\beta_{\xi} + \sqrt{\beta_{\xi}^2 - 4\overline{\lambda}_{\xi}^2} \right)} = \frac{2}{\left(1,767 + \sqrt{1,767^2 - 4 \cdot 0,717^2} \right)} = 0,714$$

Kontrola napona:

$$\sigma = \frac{N_c}{A} = \frac{613,77}{38,4} = 15,98 \text{ kN/cm}^2 > \sigma_{\text{idop}} = \chi_{\min} \cdot \sigma_{\text{dop}} = 0,714 \cdot 16 = 11,42 \text{ kN/cm}^2$$

Profil ne zadovoljava!

13

Usvajamo profil L120x120x12

$$A = 55 \text{ cm}^2 \quad i_{\xi} = 4,60 \text{ cm}$$

$$\text{Vitkost štapa} \quad \lambda_{\xi} = \frac{l_{i\xi}}{i_{\xi}} = \frac{254,5}{4,60} = 55,32$$

$$\text{relativna vitkosti štapa } (\lambda_v = 92,9) \quad \overline{\lambda}_v = \frac{\lambda_{\xi}}{\lambda_v} = \frac{55,32}{92,9} = 0,595$$

$$\alpha = 0,489 \text{ (kriva izvijanja C)}$$

$$\beta_{\xi} = 1 + \alpha \cdot (\overline{\lambda}_{\xi} - 0,2) + \overline{\lambda}_{\xi} = 1 + 0,489(0,595 - 0,2) + 0,595^2 = 1,547$$

$$\chi_{\xi} = \frac{2}{\left(\beta_{\xi} + \sqrt{\beta_{\xi}^2 - 4\overline{\lambda}_{\xi}^2} \right)} = \frac{2}{\left(1,547 + \sqrt{1,547^2 - 4 \cdot 0,595^2} \right)} = 0,789$$

Kontrola napona:

$$\sigma = \frac{N_c}{A} = \frac{613,77}{55,0} = 11,16 \text{ kN/cm}^2 < \sigma_{\text{idop}} = \chi_{\min} \cdot \sigma_{\text{dop}} = 0,789 \cdot 16 = 12,62 \text{ kN/cm}^2$$

14

Usvojen profil L120x120x12

Za štapove D3 i D6 $N_c=263,04$ kN

Usvajamo profil L100x100x10

Kontrola napona:

$$\sigma = \frac{N_c}{A} = \frac{263,04}{38,4} = 6,85 \text{ kN/cm}^2 < \sigma_{\text{idop}} = \chi_{\text{min}} \cdot \sigma_{\text{dop}} = 0,714 \cdot 16 = 11,42 \text{ kN/cm}^2$$

2.5 Vertikale

Maksimalni uticaji (štapovi V2, V4, V6): $N_c=124,0$ kN

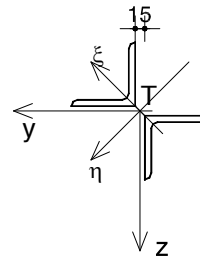
**Predpostavljaju se dva valjana profila
L60x60x6**

Geometrijske karakteristike štapa:

$$A = 2 \times 6,91 = 13,80 \text{ cm}^2$$

$$i_{\text{min},1} = 1,17 \text{ cm}$$

$$i_{\text{min}} = i_{\xi} = 2,29 \text{ cm}$$



Kontrola stabilnosti štapa:

$$l_{i\xi} = \beta_{\xi} \cdot l = 0,9 \cdot 200 = 180 \text{ cm}$$

$$\text{Vitkost štapa} \quad \lambda_{\xi} = \frac{l_{i\xi}}{i_{\xi}} = \frac{180}{2,29} = 78,60$$

$$\text{relativna vitkosti štapa } (\lambda_v = 92,9) \quad \overline{\lambda}_v = \frac{\lambda_{\xi}}{\lambda_v} = \frac{78,60}{92,9} = 0,846$$

$\alpha = 0,489$ (kriva izvijanja C)

$$\beta_{\xi} = 1 + \alpha \cdot (\overline{\lambda}_{\xi} - 0,2) + \overline{\lambda}_{\xi}^2 = 1 + 0,489(0,846 - 0,2) + 0,846^2 = 2,032$$

$$\chi_{\xi} = \frac{2}{\left(\beta_{\xi} + \sqrt{\beta_{\xi}^2 - 4\overline{\lambda}_{\xi}^2} \right)} = \frac{2}{\left(2,032 + \sqrt{2,032^2 - 4 \cdot 0,846^2} \right)} = 0,634$$

Kontrola napona:

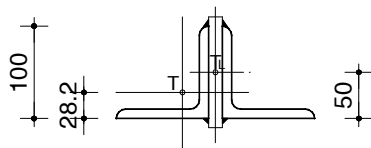
$$\sigma = \frac{N_c}{A} = \frac{125}{13,82} = 9,04 \text{ kN/cm}^2 < \sigma_{\text{idop}} = \chi_{\text{min}} \cdot \sigma_{\text{dop}} = 0,634 \cdot 16 = 10,14 \text{ kN/cm}^2$$

Profil se usvaja!

3. Veza štapova ispune za čvorni lim

3.1 Zategnute dijagonale

Maksimalni uticaji (štapovi D2 i D7): $N_t = 438,41 \text{ kN}$



$$e = 50 - 28,2 = 21,8 \text{ mm}$$

$$N_t = 438,41 \text{ kN}$$

$$M_e = 438,41 \times 2,18 = 955,73 \text{ kNcm}$$

Za vezu se predpostavljaju četiri ugaona šava: $a_w = 7 \text{ mm}$, $l_w = 250 \text{ mm}$.

$$l'_w = l_w - 2 \times a_w = 25,0 - 2 \times 0,7 = 23,6 \text{ cm}$$

Geometrijske karakteristike šavova:

$$A_w = 4 \times (23,6 \times 0,7) = 66,08 \text{ cm}^2$$

$$V_{II,N} = \frac{N_t}{A_w} = \frac{434}{66,08} = 6,57 \text{ kN/cm}^2$$

$$V_{II,M} = \frac{M_e/h}{2 \cdot a_w \cdot l'_w} = \frac{955,73/10}{2 \cdot 0,7 \cdot 23,6} = 2,89 \text{ kN/cm}^2$$

$$\sigma_u = V_{II,N} + V_{II,M}$$

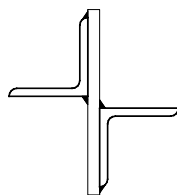
$$\sigma_u = 6,57 + 2,89 = 9,46 \text{ kN/cm}^2$$

$$\sigma_u < \sigma_{w,dop}$$

17

3.2 Pritisnute dijagonale

Maksimalni uticaji (štapovi D1 i D8): $N_c = 613,77 \text{ kN}$



Za vezu se predpostavljaju četiri

ugaona šava: $a_w = 7 \text{ mm}$, $l_w = 250 \text{ mm}$.

$$l'_w = l_w - 2 \times a_w = 25,0 - 2 \times 0,7 = 23,6 \text{ cm}$$

Geometrijske karakteristike šavova:

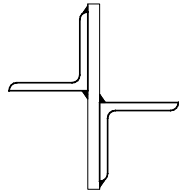
$$A_w = 4 \times (23,6 \times 0,7) = 66,08 \text{ cm}^2$$

$$V_{II} = \frac{N_t}{A_w} = \frac{613,77}{66,08} = 9,28 \text{ kN/cm}^2 < 12 \text{ kN/cm}^2 = \sigma_{w,dop}$$

18

3.3 Vertikale

Maksimalni uticaji : $N_c = 125 \text{ kN}$



Za vezu se predpostavljaju četiri ugaona šava: $a_w = 3 \text{ mm}$, $l_w = 100 \text{ mm}$.

$$l'_w = l_w - 2 \times a_w = 10,0 - 2 \times 0,3 = 9,4 \text{ cm}$$

Geometrijske karakteristike šavova:

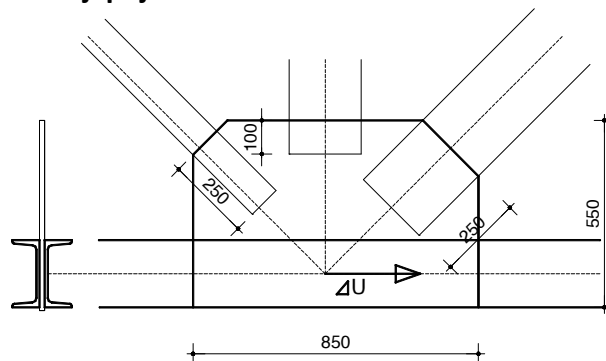
$$A_w = 4 \times (9,4 \times 0,3) = 11,28 \text{ cm}^2$$

$$V_{II} = \frac{N_t}{A_w} = \frac{125}{11,28} = 11,08 \text{ kN/cm}^2 < 12 \text{ kN/cm}^2 = \sigma_{w,dop}$$

19

4. Veze čvornih limova za pojasne štapove

4.1 Donji pojas:



Veza će se izvesti pomocu četiri ugaona šava

$$a_w = 4 \text{ mm}, l_w = 100 \times a_w = 100 \times 4 = 400 \text{ mm}$$

$$A_w = 4 \times a_w \times l_w = 40,0 \times 0,4 \times 4 = 64,00 \text{ cm}^2$$

20

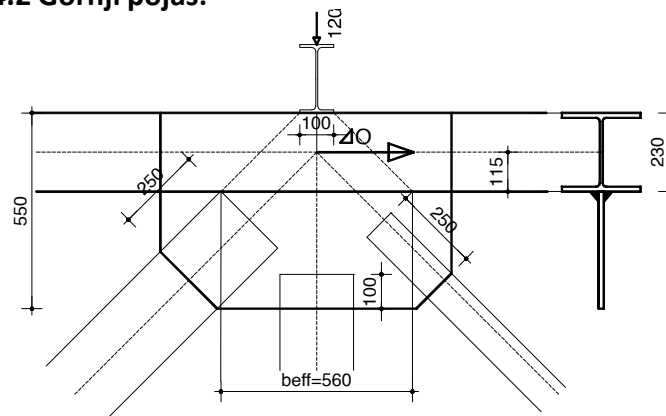
$$\Delta U = 930 - 434 = 496 \text{ kN}$$

$$V_{II} = \frac{496}{64} = 7,75 \text{ kN/cm}^2 < 12 \text{ kN/cm}^2 = \sigma_{w,dop}$$

Iz konstruktivnih razloga usvajaju se četiri ugaona šava **4x850 mm**

21

4.2 Gornji pojas:



Veza će se izvesti pomoću dva ugaona šava

$$a_w = 8 \text{ mm}, l_w = 100 \times a_w = 100 \times 8 = 800 \text{ mm}$$

$$b_{eff} = 100 + 2 \times 230 = 560 \text{ mm}$$

$$A_{w,eff} = 2 \times a_w \times b_{eff} = 56,0 \times 0,8 \times 2 = 89,6 \text{ cm}^2$$

$$A_w = 2 \times a_w \times l_w = 80,0 \times 0,8 \times 2 = 128,00 \text{ cm}^2$$

22

$$\Delta O = 744 \text{ kN} \quad M_e = 744 \cdot 11,5 = 8556 \text{ kNcm}$$

$$n_F = \frac{F}{A_{w,eff}} = \frac{120}{89,6} = 1,34 \text{ kN/cm}^2$$

$$n_M = \frac{M_e}{W_w} = \frac{8556}{2 \cdot \frac{0,8 \cdot 80^2}{6}} = 5,01 \text{ kN/cm}^2$$

$$V_{II} = \frac{\Delta O}{A_w} = \frac{744}{128} = 5,81 \text{ kN/cm}^2$$

$$\sigma_u = \sqrt{(n_F + n_M)^2 + V_{II}^2} = \sqrt{(1,34 + 5,01)^2 + 5,81^2} = 8,60 \text{ kN/cm}^2$$

$$\sigma_u < \sigma_{w,dop} = 12 \text{ kN/cm}^2$$

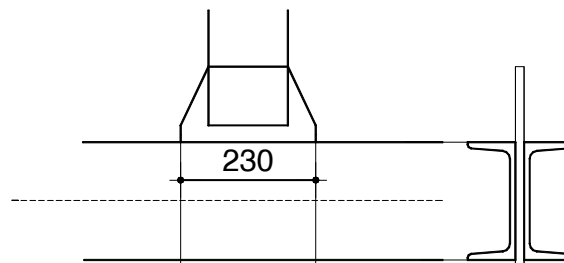
Iz konstruktivnih razloga usvajaju se dva ugaona šava **8x850 mm**

23

4.3 Čvorni lim vertikalne (donji pojas)

$$N=0 \text{ kN}$$

Iz konstruktivnih razloga veza ce se izvesti pomoću četiri ugaona šava $a_w = 3 \text{ mm}$, $l_w = 230 \text{ mm}$

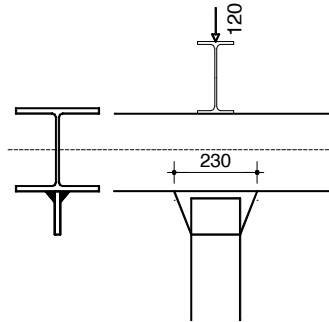


24

4.4 Čvorni lim vertikale (gornji pojas)

$$N=125 \text{ kN}$$

veza ce se izvesti pomoću dva ugaona šava $a_w = 3 \text{ mm}$, $l_w = 230 \text{ mm}$



$$a_w = 3 \text{ mm}, l_w = 230 \text{ mm}, l_w' = 230 - 2 \times a_w = 224 \text{ mm}$$

$$A_w = 2 \times a_w \times l_w = 2 \times 22,4 \times 0,3 = 13,44 \text{ cm}^2$$

25

$$n = \frac{V}{A_w} = \frac{125}{13,44} = 9,30 \text{ kN/cm}^2 < 12 \text{ kN/cm}^2 = \sigma_{w,dop}$$

Usvajaju se dva ugaona šava dimenzija 3 x 230mm

5. Kontrola napona u čvornim limovima

Za debljinu čvornog lima usvaja se $t = 15 \text{ mm}$

5.1 Vertikale 2L60x60x6 ($N_c = 125,0 \text{ kN}$)

$$b_{eff} = 2 \times 6 + 1,5 + 2 \times 10 \times \tan(30) = 25,05 \text{ cm}$$

$$A_{eff} = b_{eff} \times t = 25,05 \times 1,5 = 37,6 \text{ cm}^2$$

$$\sigma = \frac{N_c}{A_{eff}} = \frac{125}{37,6} = 3,32 \text{ kN/cm}^2 < 16 \text{ kN/cm}^2 = \sigma_{dop}$$

26

5.2 Zategnute dijagonale 2L100x100x10 (Nt= 438,41 kN)

$$b_{\text{eff}} = 10 + 2 \times 25 \times \tan(30^\circ) = 38,9 \text{ cm} \quad A_{\text{eff}} = b_{\text{eff}} \times t = 38,9 \times 1,5 = 58,3 \text{ cm}^2$$

$$\sigma = \frac{N_t}{A_{\text{eff}}} = \frac{438,41}{58,3} = 7,52 \text{ kN/cm}^2 < 16 \text{ kN/cm}^2 = \sigma_{\text{dop}}$$

5.3 Pritisnuta dijagonala 2L120x120x12 (Nc= 613,77 kN)

$$b_{\text{eff}} = 2 \times 12 + 1,5 + 2 \times 25 \times \tan(30^\circ) = 54,35 \text{ cm}$$

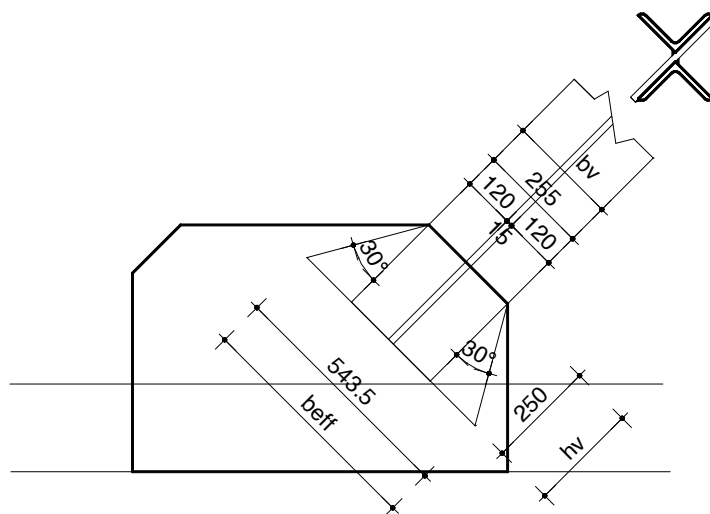
$$A_{\text{eff}} = b_{\text{eff}} \times t = 54,35 \times 1,5 = 81,53 \text{ cm}^2$$

$$\sigma = \frac{N_t}{A_{\text{eff}}} = \frac{613,77}{81,53} = 7,53 \text{ kN/cm}^2 < 16 \text{ kN/cm}^2 = \sigma_{\text{dop}}$$

27

Pritisnuta dijagonala

$$b_{\text{eff}} = b_v + 2 \times h_v \times \tan 30^\circ = 2 \times 12 + 1,5 + 2 \times 25 \times \tan(30^\circ) = 54,35 \text{ cm}$$



28

Veza sa zavrtnjevima

$$b_{\text{eff}} = 2xh_v \text{tg}30^\circ$$

