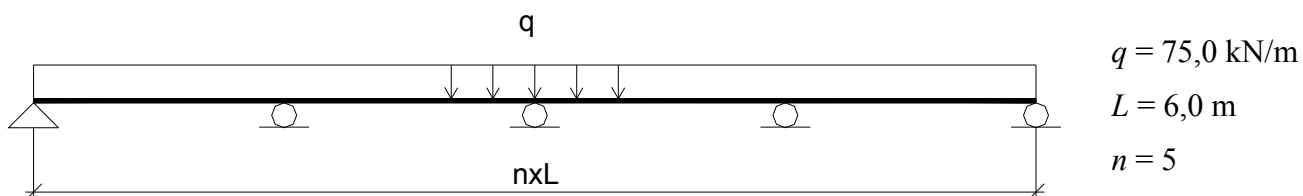


11a.

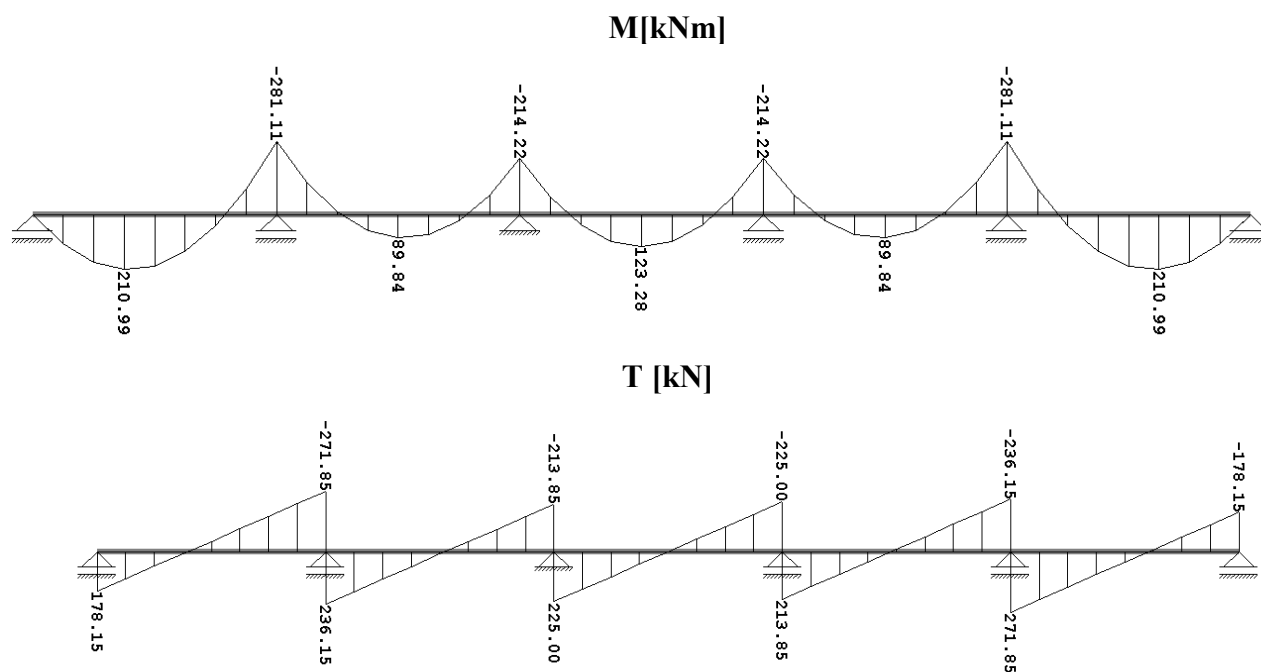
Dimenzionisati podužni nosač koji je opterećen zadatim opterećenjem. Nosač je kontinualno bočno pridržan. Sračunati i konstruisati krutu vezu podužnog sa poprečnim nosačem na označenom osloncu. Vezu ostvariti pomoću obrađenih zavrtnjeva klase čvrstoće 5.6

Podužni nosač je u odnosu na poprečni upušten za $a = 0,10$ m



Osnovni materijal: Č0361
Slučaj opterećenja: I
Radionički crtež dati u razmeri: 1:5

1. Statički uticaji



Maksimalni uticaji:

$$M_{max} = 281,11 \text{ kNm}$$

$$V_{max} = 271,85 \text{ kN}$$

Uticaji na mestu veze:

$$M_c = 214,18 \text{ kNm}$$

$$V_c = 225,00 \text{ kN}$$

2. Dimenzionisanje

Pretpostavlja se valjani profil IPE 500 sa sledećim geometrijskim karakteristikama:

$$b_f = 200 \text{ mm}$$

$$t_f = 16 \text{ mm}$$

$$t_w = 10,2 \text{ mm}$$

$$r = 21 \text{ mm}$$

$$A = 116 \text{ cm}^2$$

$$W_x = 1930 \text{ cm}^3$$

$$S_x = 1100 \text{ cm}^3$$

$$I_x = 48200 \text{ cm}^4$$

$$S_{x,0} = 20 \cdot 1,6 \cdot (50 - 1,6) / 2 = 774,4 \text{ cm}^3$$

2.1 Kontrola napona

$$\sigma = \frac{M_{\max}}{W_x} = \frac{28121}{1930} = 14,57 \text{ kN/cm}^2 < 16,0 \text{ kN/cm}^2 = \sigma_{\text{dop}}$$

$$\tau = \frac{V_{\max} \cdot S_x}{I_x \cdot t_w} = \frac{271,87 \cdot 1100}{48200 \cdot 1,02} = 6,08 \text{ kN/cm}^2 < 9,0 \text{ kN/cm}^2 = \tau_{\text{dop}}$$

Uporedni napon u tački 1 ($y_1 = 23,4 \text{ cm}$)

$$\sigma_1 = \frac{M_{\max}}{I_x} \cdot y_1 = \frac{28121}{48200} \cdot 23,4 = 13,65 \text{ kN/cm}^2$$

$$\tau_1 = \frac{V_{\max} \cdot S_{x,0}}{I_x \cdot t_w} = \frac{271,87 \cdot 774,4}{48200 \cdot 1,02} = 4,28 \text{ kN/cm}^2$$

$$\sigma_u = \sqrt{\sigma_1^2 + 3 \cdot \tau_1^2} = \sqrt{13,65^2 + 3 \cdot 4,28^2} = 15,53 \text{ kN/cm}^2 < 16,0 \text{ kN/cm}^2 = \sigma_{\text{dop}}$$

2.2 Kontrola deformacija

Maksimalan ugib je $\delta_{\max} = 0,64 \text{ cm} < \delta_{\text{dop}} = 600/300 = 2,0 \text{ cm}$

2.3 Proračun veze

Uticaji na mestu veze: $M_c = 214,22 \text{ kNm}$ $V_c = 225,0 \text{ kN}$
 $N_t = -N_c = M_c/h = 214,18/0,5 = 428,36 \text{ kN}$

Na nožicama se usvajaju zavrtnjevi M27...5.6.

Slabljenje preseka rupama za zavrtnjeve

$$\Delta A = n \cdot d_0 \cdot t_f = 2 \cdot 2,8 \cdot 1,6 = 8,96 \text{ cm}^2$$

$$\Delta I = \Delta A \cdot \left(\frac{h - t_f}{2} \right)^2 = 8,96 \cdot \left(\frac{50 - 1,6}{2} \right)^2 = 5247 \text{ cm}^4$$

$$I_{\text{net}} = I - \Delta I = 48200 - 5247 = 42953 \text{ cm}^4$$

$$W_{\text{net}} = \frac{I_{\text{net}}}{h/2} = \frac{42953}{50/2} = 1718 \text{ cm}^3$$

Kontrola napona u oslabljenom preseku

$$\sigma = \frac{M_c}{W_{\text{net}}} = \frac{21418}{1718} = 12,47 \text{ kN/cm}^2 < 16,0 \text{ kN/cm}^2 = \sigma_{\text{dop}}$$

Proračun kontinuitet lamele

$$t_{pf} = \frac{N_t}{\sigma_{\text{dop}} \cdot (b_f - n \cdot d_0)} = \frac{428,36}{16 \cdot (20 - 2 \cdot 2,8)} = 1,86 \text{ cm}$$

Usvaja se kontinuitet lamela = 200x20 mm

Proračun zavrtnjeva na nožici

$$F_v = \frac{2,8^2 \cdot \pi}{4} \cdot 17,5 = 107,7 \text{ kN}$$

$$F_b = 2,8 \cdot 1,6 \cdot 32,0 = 143,4 \text{ kN} \Rightarrow F_{v,\text{dop}} = 107,7 \text{ kN}$$

$$n = \frac{428,36}{107,7} = 3,98 \quad \text{Usvaja se 4M27...5.6.}$$

Proračun zavrtnjeva na rebru

$$V_c = 225 \text{ kN}$$

$$M_e = V_c \cdot e = 225 \cdot 0,045 = 10,125 \text{ kNm} = 1012,5 \text{ kNcm}$$

- zavrtnevi serije "1" (M20...5.6)

$$F_v = 2 \cdot \frac{2,1^2 \cdot \pi}{4} \cdot 17,5 = 121,3 \text{ kN}$$

$$F_b = 2,1 \cdot 1,02 \cdot 32,0 = 68,54 \text{ kN} \Rightarrow F_{v,dop} = 68,54 \text{ kN}$$

$$m \cdot n = \frac{1}{F_{v,dop}} \sqrt{V_c^2 + \left(\frac{6M_e}{h} \right)^2} = \frac{1}{68,54} \sqrt{225^2 + \left(\frac{6 \cdot 1012,5}{50} \right)^2} = 3,73$$

Pretpostavlja se 5M20...5.6 ($m=1$; $n=5$)

$$F_v = \frac{V_c}{n} = \frac{225}{5} = 45 \text{ kN} \quad F_M = \frac{M_e \cdot h_{\max}}{\sum h_i^2} = \frac{1012,5 \cdot 32}{32^2 + 16^2} = 25,3 \text{ kN}$$

$$F_R = \sqrt{F_v^2 + F_M^2} = \sqrt{45^2 + 25,3^2} = 51,63 \text{ kN} < 68,54 \text{ kN} = F_{v,dop}$$

Usvaja se 5M20...5.6

- zavrtnevi serije "2" (M20...5.6)

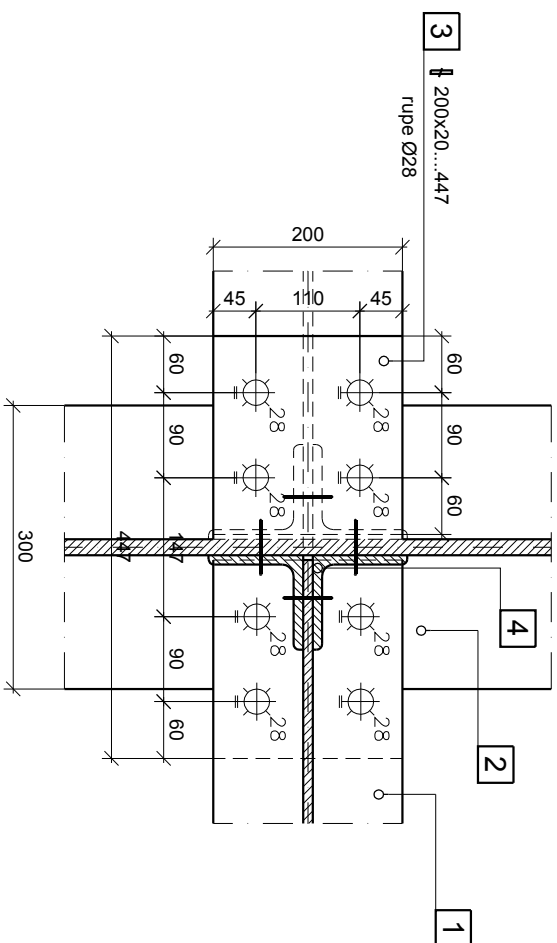
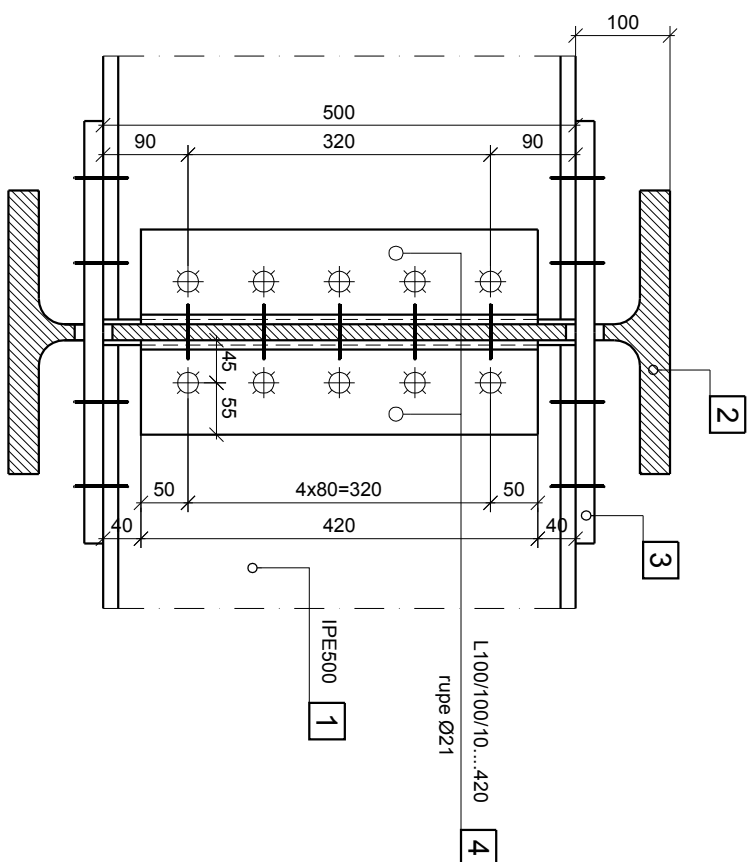
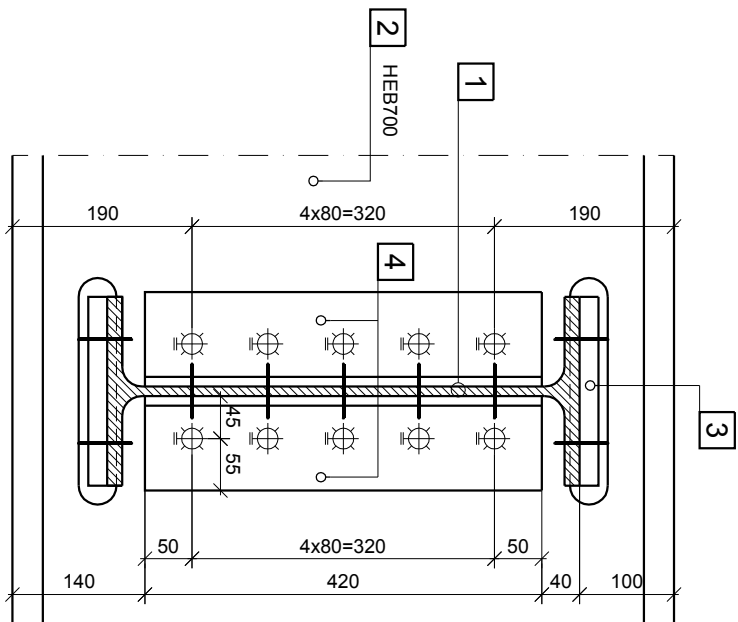
$$F_v = 2 \cdot \frac{2,1^2 \cdot \pi}{4} \cdot 17,5 = 121,3 \text{ kN}$$

$$F_b = 2,1 \cdot 1,7 \cdot 32,0 = 114,24 \text{ kN} \Rightarrow F_{v,dop} = 114,24 \text{ kN}$$

$$n = \frac{V_{c,l} + V_{c,d}}{F_{v,dop}} = \frac{225,0 + 213,83}{114,24} = 3,84$$

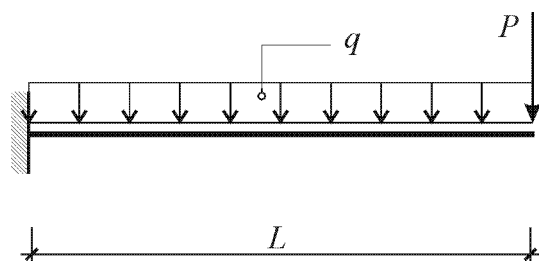
Usvaja se 2x5=10M20...5.6 (iz konstruktivnih razloga)

Usvajaju se ugaonici L100/100/10



11b.

Dimenzionisati konzolni nosač i njegovu vezu sa stubom, prema zadatom opterećenju. Vezu ostvariti preko čelone ploče uz primenu visokovrednih zavrtnjeva sa punom silom pritezanja klase čvrstoće 10.9. Za konzolu usvojiti zavareni I profil.



$$q = 10,0 \text{ kN/m}$$

$$P = 25 \text{ kN}$$

$$L = 3,0 \text{ m}$$

Osnovni materijal: Č0361

Slučaj opterećenja: I

Radionički crtež dati u razmeri: 1:5

Podaci potrebni za proračun:

Osnovni materijal:

$$\sigma_{dop} = 16 \text{ kN/cm}^2 \quad \tau_{dop} = 9 \text{ kN/cm}^2$$

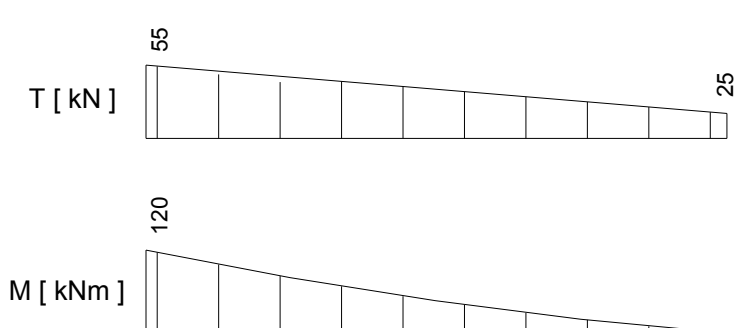
Ugaoni šavovi:

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

Zavrtnjevi klase 10.9

$$\sigma_{b,dop} = 28 \text{ kN/cm}^2 \quad \tau_{dop} = 24 \text{ kN/cm}^2$$

1. Uticaji u nosaču



$$T_{max} = 55 \text{ kN}$$

$$M_{max} = 120 \text{ kNm}$$

2. Dimenzionisanje nosača

$$W_{pot} = \frac{M_{max}}{\sigma_{dop}} = \frac{12000}{16} = 750 \text{ cm}^3$$

Usvaja se zavareni I presek: rebro = 350 x 8
nožice = 180 x 15

Geometrijske karakteristike preseka:

$$I_y = \left[\frac{35^3 \cdot 0,8}{12} + 2 \cdot 18 \cdot 1,5 \cdot \left(\frac{38 - 1,5}{2} \right)^2 \right] = 20844 \text{ cm}^4 \quad I_{y,w} = \frac{35^3 \cdot 0,8}{12} = 2858,33 \text{ cm}^4$$

$$\frac{I_{y,w}}{I_y} = \frac{2858,33}{20844} = 0,14 < 0,15$$

Geometrijske karakteristike oslabljenog preseka:

$$I_y = \left[\frac{30^3 \cdot 0,8}{12} + 2 \cdot 18 \cdot 1,5 \cdot \left(\frac{38 - 1,5}{2} \right)^2 \right] = 19785 \text{ cm}^4$$

$$W_y = \frac{19785}{19} = 1041,3 \text{ cm}^3$$

$$S_y = 18 \cdot 1,5 \cdot \left(19 - \frac{1,5}{2} \right) + 30 \cdot 0,8 \cdot \frac{30}{8} = 582,75 \text{ cm}^3$$

Kontrola napona:

$$\sigma = \frac{M}{W_y} = \frac{12000}{1041,3} = 11,52 \text{ kN/cm}^2$$

$$\tau = \frac{T \cdot S_y}{I_y \cdot t_w} = \frac{55 \cdot 582,75}{19785 \cdot 0,8} = 2,02 \text{ kN/cm}^2$$

Kontrola deformacija:

$$f_F = \frac{F \cdot l^3}{3 \cdot E \cdot I} = \frac{55 \cdot 300^3}{3 \cdot 21000 \cdot 19785} = 1,19 \text{ cm}$$

$$f_q = \frac{q \cdot l^4}{8 \cdot E \cdot I} = \frac{0,1 \cdot 300^4}{8 \cdot 21000 \cdot 19785} = 0,24 \text{ cm}$$

$$f = f_F + f_q = 1,19 + 0,24 = 1,43 \text{ cm} < f_{dop} = l / 300 = 2 \cdot 300 / 300 = 2 \text{ cm}$$

3. Veza nosača za čeonu ploču

Predpostavljaju se šavovi:

- veza nožice za čeonu ploču $a_1 = 8 \text{ mm}$

- veza rebra za čeonu ploču $a_2 = 4 \text{ mm}$

$$I_{y,w} = \left(0,8 \cdot 18 \cdot \left((19 - 1,5 - 0,4)^2 + (19 + 0,4)^2 \right) \right) \cdot 2 +$$

$$2 \cdot \frac{29,2^3 \cdot 0,4}{12} = 20920 \text{ cm}^4$$

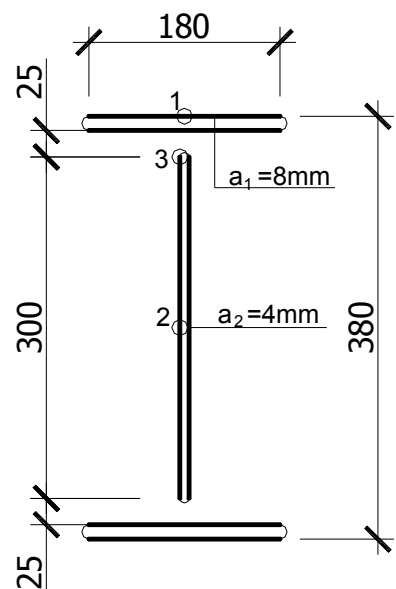
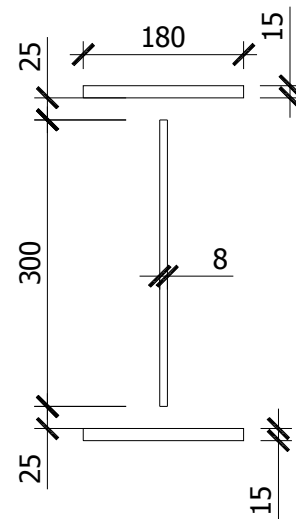
$$W_{y,w} = \frac{20920}{19,8} = 1056,6 \text{ cm}^3$$

$$S_{y,w,3} = 2 \cdot 0,8 \cdot 18 \cdot (38 - 1,5) / 2 = 525,6 \text{ cm}^3$$

$$S_{y,w,2} = 525,6 + 2 \cdot 0,4 \cdot \frac{29,2^2}{8} = 610,9 \text{ cm}^3$$

Tačka 1:

$$n = \frac{M}{W_{y,w}} = \frac{12000}{1056,6} = 11,36 \text{ kN/cm}^2 < \sigma_{w,dop} = 12 \text{ kN/cm}^2$$



Tačka 2:

$$V_{II} = \frac{T \cdot S_{y,w,2}}{I_{y,w} \cdot 2 \cdot a_2} = \frac{55 \cdot 610,9}{20920 \cdot 2 \cdot 0,4} = 2,01 \text{ kN/cm}^2 < \sigma_{w,dop} = 12 \text{ kN/cm}^2$$

Tačka 3:

$$n = \frac{M}{I_{y,w}} \cdot z_3 = \frac{12000}{20920} \cdot 15 = 8,6 \text{ kN/cm}^2$$

$$V_{II} = \frac{T \cdot S_{y,w,3}}{I_{y,w} \cdot 2 \cdot a_2} = \frac{55 \cdot 525,6}{20920 \cdot 2 \cdot 0,4} = 1,73 \text{ kN/cm}^2$$

$$\sigma_u = \sqrt{n^2 + V_{II}^2} = \sqrt{8,6^2 + 1,73^2} = 8,77 \text{ kN/cm}^2 < \sigma_{w,dop} = 12 \text{ kN/cm}^2$$

4. Veza čelone ploče za nožicu stuba

Tip veze A1. Predpostavljaju se VV zavrtnjevi **M20...10.9** sa punom silom pritezanja.

$$F_{t,dop} = v_3 \cdot F_p = 0,7 \cdot 154 = 107,8 \text{ kN}$$

$$F_t = \frac{M}{4 \cdot h} = \frac{12000}{4 \cdot (h - t_f)} = \frac{12000}{4 \cdot (38 - 1,5)} = 82,2 \text{ kN} < F_{t,dop}$$

Debljina čelone ploče $d_p = 1,25 \cdot d = 1,25 \cdot 20 = 25 \text{ mm}$

Usvaja se: $d_p = 25 \text{ mm}$

Debljina nožice stuba:

- sa ukrucenjima $t_{f,s} = 1,00 \cdot d_p = 25 \text{ mm}$

Usvaja se $t_{f,s} = 25 \text{ mm}$

$$F_{s,dop} = \mu \cdot \frac{v_1 \cdot f_{0,2} \cdot A_s}{v_2} = 0,3 \cdot \frac{0,7 \cdot 90 \cdot 2,45}{1,25} = 37,0 \text{ kN}$$

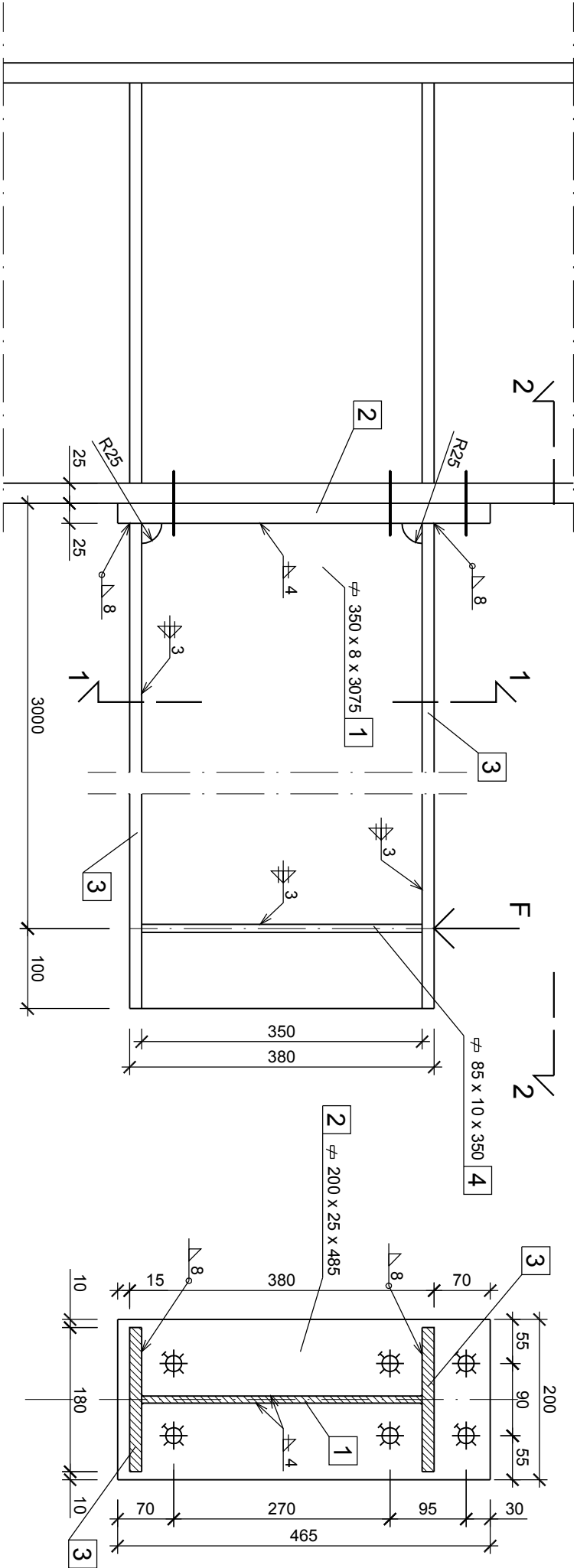
Potreban broj zavrtnjeva za prijem smičuće sile:
$$n = \frac{T}{F_{s,dop}} = \frac{55}{37,0} = 1,49$$

Usvajaju se: 2M20...10.9

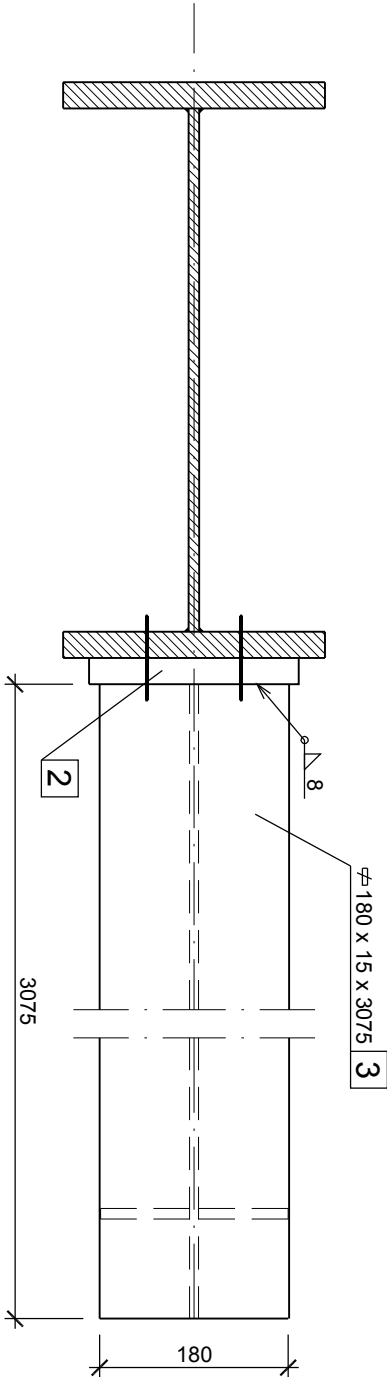
5. Konstrukcija veze

NAPOMENA: Videti knjigu ČELIČNE KONSTRUKCIJE U GRAĐEVINARSTVU

Prěsek 1-1



Prěsek 2-2



OSNOVNI MATERIÁL Č0361
M20 ... 10.9