

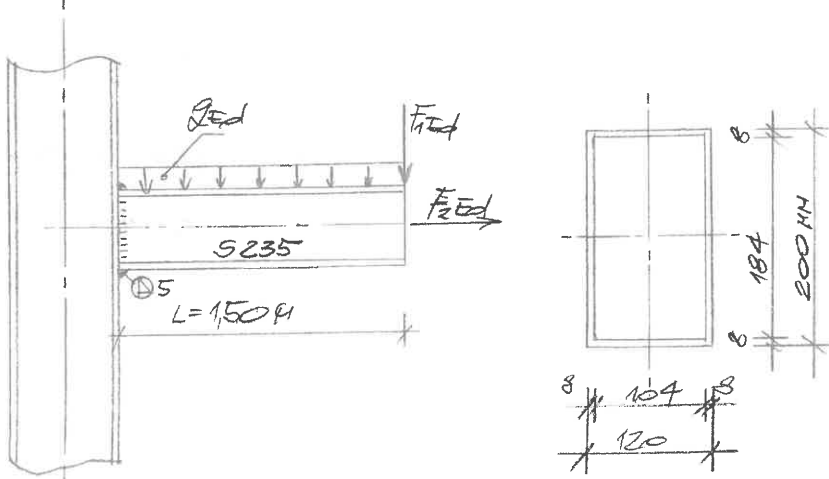


## 1. KOLOKVIJ JEKLENE KONSTRUKCIJE

Kandidat:

### 1. Naloga

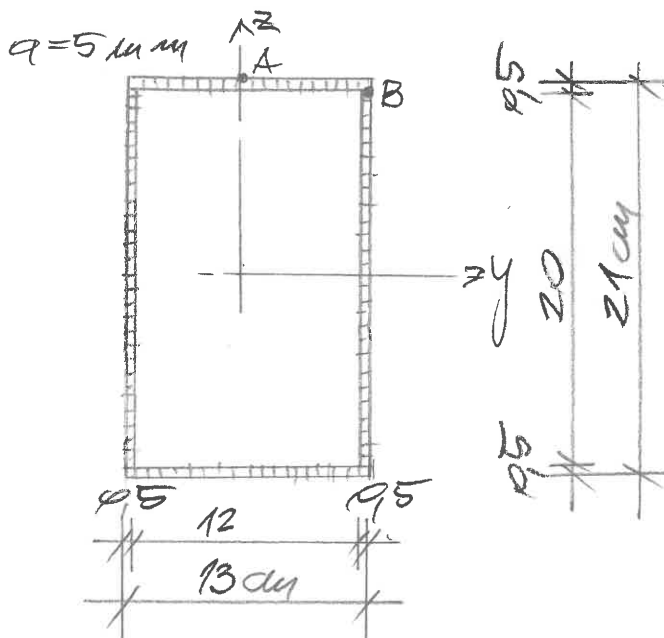
Konzolni nosilec škatlastega prereza 120x200x8 mm<sup>2</sup> je okrog in okrog privarjeno s kotnimi zvari debeline a=5 mm na jeklen steber. Konzola je obremenjena z zvezno obtežbo q<sub>Ed</sub>=10 kN/m<sup>1</sup> in s silama F<sub>1Ed</sub>=10 kN ter F<sub>2Ed</sub>=25 kN. Uporabi jeklo S 355. Ali zvari prenesejo dano obremenitev?



$$M_{Ed} = \frac{q_{Ed} \cdot L^2}{2} - F_{1Ed} \cdot L = -\frac{10 \cdot 1,5^2}{2} - 10 \cdot 1,5 = 26,25 \text{ kNm}$$

$$V_{Ed} = q_{Ed} \cdot L + F_{1Ed} = 10 \cdot 1,5 + 10 = 25,0 \text{ kN}$$

$$N_{Ed} = F_{2Ed} = 25,0 \text{ kN}$$



$$A_{zv} = 2 \times 0,5 (20 + 13) = 33,0 \text{ cm}^2$$

$$I_{zv,y} = 2 \frac{13 \cdot 95^3}{12} + 2 \frac{95 \cdot 20^3}{12} + 2 (13 \cdot 95) \cdot 10,25^2$$

$$I_{zv,y} = 2032,75 \text{ cm}^4$$

$$W_{zv,y}^A = \frac{I_{zv,y}}{l/2} = \frac{2032,75 \cdot 12}{21,0} = 1193,60 \text{ cm}^3$$

$$W_{zv,y}^B = \frac{I_{zv,y}}{(l/2 - a)} = \frac{2032,75}{(\frac{21}{2} - 95)} = 2033,00 \text{ cm}^3$$



Točka A

$$N_A = \frac{N_{ed}}{A_{zv}} + \frac{M_{ed}}{W_{zv}^A} = \frac{25,0}{33,0} + \frac{26,25 \times 100}{193,60} = 14,32 \text{ kN/cm}^2$$

$$\sigma_{\perp} = \tau_{\perp} = \frac{N}{\sqrt{2}} = \frac{14,32}{\sqrt{2}} = 10,12 \text{ kN/cm}^2$$

$$\tau_{\parallel} = \phi$$

$$\sqrt{\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)} \leq \frac{f_u}{\beta_w \cdot \gamma_{M2}}$$

$$\sqrt{10,12^2 + 3(10,12^2 + \phi)} < \frac{51,0}{0,9 \cdot 1,25}$$

$$\underline{20,25 \text{ kN/cm}^2} < \underline{45,33 \text{ kN/cm}^2} \text{ o.k.}$$

$$\sigma_{\perp} \leq 0,9 \frac{f_u}{\gamma_{M2}}$$

$$10,12 < 0,9 \frac{51,0}{1,25}$$

$$\underline{10,12} < \underline{36,72 \text{ kN/cm}^2} \text{ o.k.}$$

Točka B

$$N_B = \frac{N_{ed}}{A_{zv}} + \frac{M_{ed}}{W_{zv}^B} = \frac{25,0}{33,0} + \frac{26,25 \cdot 100}{203,30} = 13,67 \text{ kN/cm}^2$$

$$\sigma_{\perp} = \tau_{\perp} = \frac{13,67}{\sqrt{2}} = 9,67 \text{ kN/cm}^2$$

$$\tau_{\parallel} \approx \frac{V_{ed}}{2 \alpha \cdot I_a} = \frac{25,0}{2 \cdot 0,95 \cdot 21} = 1,19 \text{ kN/cm}^2$$

$$\sqrt{9,67^2 + 3(9,67^2 + 1,19^2)} \leq \frac{51,0}{0,9 \cdot 1,25}$$

$$\underline{19,45 \text{ kN/cm}^2} < \underline{45,33 \text{ kN/cm}^2} \text{ o.k.}$$

$$9,67 < 0,9 \frac{51,0}{1,25}$$

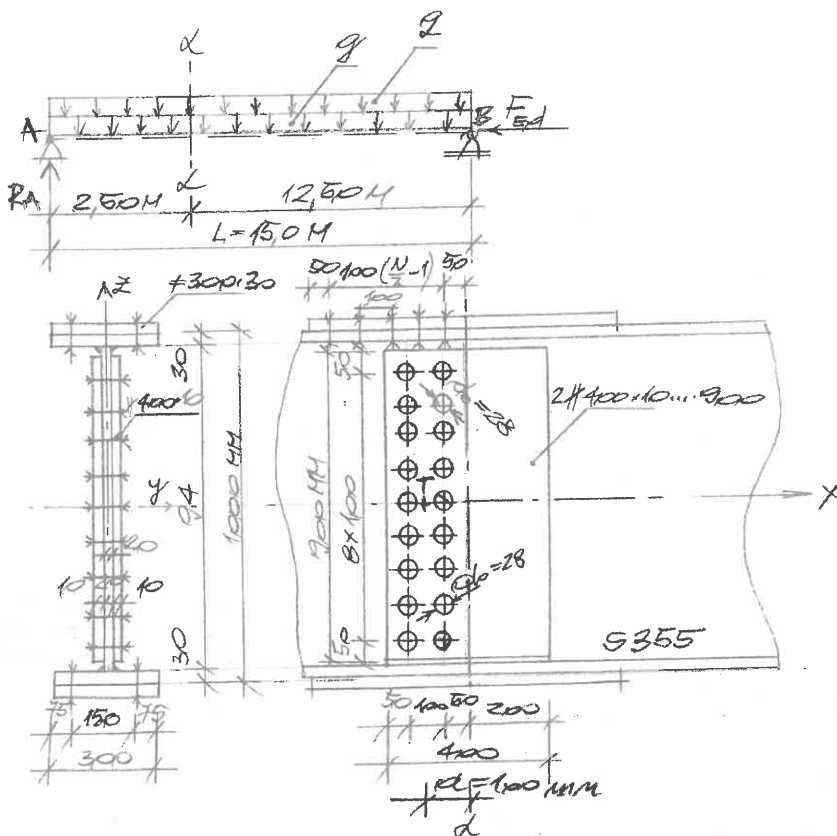
$$\underline{9,67} < \underline{36,72 \text{ kN/cm}^2}$$



## 2. Naloga

Prostoležeči nosilec iz varjenega I prereza (glej sliko) in jekla S 355 je obremenjen s stalno obtežbo  $g=25$  kN/m<sup>1</sup>, s koristno obtežbo  $q=30$  kN/m<sup>1</sup> in s horizontalno projektno silo  $F_{Ed}=150$  kN. Na razdalji 2,5 m od leve podpore (prerez  $\alpha-\alpha$ ) je potrebno varjeni I profil skupne dolžine  $L=15$  m stikovati z vijačnim stikom. Uporabi navadne vijake  $\Phi M27$  kakovosti 10.9. Stojina je stikovana z dvema-obojestranskima zaplatama debeline 10 mm vsaka, pasnica pa z eno zaplato debeline 30 mm. Premer luknje vijakov znaša  $d_0=28$  mm. Vijaki so med seboj narazen 100 mm ter 50 mm do roba pločevine.

1. Ali vijaki stojine prenesejo dano obremenitev? Obvezno uporabi  $\psi_m$  koeficient!
2. Koliko vijakov je potrebno za stikovanje pasnice? Pri tem uporabi enak vijak  $\Phi M27$  10.9.



I profil

$$A = 2 \cdot 30 \cdot 3 + 94 \cdot 20$$

$$A = 368 \text{ cm}^2$$

$$I_{SE} = \frac{2 \cdot 94^3}{12} = 138430 \text{ cm}^4$$

$$I_y = I_{SE} + 2 \cdot \frac{30 \cdot 3^3}{12} + 2 \cdot (30 \cdot 3) \cdot 48,5^2$$

$$I_y = 561970 \text{ cm}^4$$

vijaki:  $\Phi M27$  10.9

$$n = 9 \quad d = 27 \text{ cm}$$

$$m = 2 \quad d_0 = 28 \text{ cm}$$

$$f_{ub} = 100 \text{ kN/cm}^2$$

$$A_s = 4,59 \text{ cm}^2$$

$$F_{Ed} = \sqrt{g \cdot q + F_{Ed} \cdot q} = \sqrt{25 \cdot 30 + 150 \cdot 30} = 78,75 \text{ kN/m}$$

$$R_A = \frac{F_{Ed} \cdot L}{2} = \frac{78,75 \cdot 15}{2} = 590,62 \text{ kN}$$

$$M_{Ed} = M_x = R_A \cdot 2,5 - \frac{F_{Ed} \cdot 2,5^2}{2} = 590,62 \cdot 2,5 - \frac{78,75 \cdot 2,5^2}{2} = 1230,47 \text{ kNm}$$

$$V_{Ed} = V_x = R_A - F_{Ed} \cdot 2,5 = 590,62 - 78,75 \cdot 2,5 = 393,75 \text{ kN}$$

$$M_{Ed} = M_x = F_{Ed} = 150 \text{ kN}$$

stik stojine

$$M_{s,m} = M_{Ed} \cdot \frac{I_{st}}{I} = 1230,47 \cdot \frac{138430}{561970} = 303,10 \text{ kNm}$$

$$M_{s,v} = V_{Ed} \cdot a = 393,75 \cdot 0,10 = 39,38 \text{ kNm}$$

$$M_s = M_{s,m} + M_{s,v} = 342,48 \text{ kNm}$$



$$H_{max} = \frac{N_s}{n_{max}} \cdot \rho_m = \frac{342,48}{9,80} \cdot 0,266 = \underline{114,16 \text{ kN}}$$

$$\rho_m = \frac{6(m-1)}{m \cdot m(m+1)} = \frac{6 \cdot (9-1)}{2 \cdot 9 \cdot (9+1)} = 0,266$$

$$P_v = \frac{V_{ed}}{m \cdot n} = \frac{393,75}{2 \cdot 9} = \underline{21,88 \text{ kN}}$$

$$N_s = N_{ed} \frac{A_s}{A} = 150 \frac{2,94}{368} = 76,63 \text{ kN}$$

$$P_u = \frac{N_s}{m \cdot n} = \frac{76,63}{2 \cdot 9} = \underline{4,26 \text{ kN}}$$

$$F_{v,ed} = \sqrt{P_v^2 + (H_{max} + P_u)^2} = \sqrt{21,88^2 + (114,16 + 4,26)^2} = \underline{120,42 \text{ kN}}$$

vijak  $\Phi M 27 \times 10,9$  dvostranski

$$F_{v,Rd2} = 2 \frac{0,5 \cdot f_{ub} \cdot A_s}{\gamma_{M2}} = 2 \frac{0,5 \cdot 100 \cdot 4,59}{1,25} = \underline{367,20 \text{ kN}} > F_{v,ed} \text{ ok.}$$

$$F_{b,Rd} = \frac{k_1 \cdot a_b \cdot f_u \cdot d \cdot t}{\gamma_{M2}}$$

metalski vijak:  $k_1 = 1,4 \frac{e_2}{d_0} - 1,7$  ali 2,5

$$k_1 = 1,4 \frac{10}{28} - 1,7 = 3,3 \rightarrow k_1 = 2,5$$

$$a_b = a_d = \frac{e_1}{3 \cdot d_0} - \frac{1}{4} = \frac{10}{3 \cdot 28} - \frac{1}{4} = 0,94$$

kaleni vijak:  $k_1 = 2,8 \frac{e_2}{d_0} - 1,7$  ali 2,5

$$k_1 = 2,8 \frac{5}{28} - 1,7 = 3,3 \rightarrow k_1 = 2,5$$

$$a_b = a_d = \frac{e_1}{3 \cdot d_0} = \frac{5}{3 \cdot 28} = 0,60$$

merodajni

$$F_{b,Rd} = \frac{2,5 \cdot 0,60 \cdot 51 \cdot 27 \cdot 20}{1,25} = \underline{330,48 \text{ kN}} > F_{v,ed} \text{ ok.}$$

pažnica

$$M_p = M_{ed} - M_{sm} = 927,39 \text{ kNm}$$

$$P_{p,m} = \frac{M_p}{h_{I=10m}} = 927,39 \text{ kN}$$

$$P_{p,u} = \frac{N_{ed} - N_s}{2} = 36,68 \text{ kN}$$

$$P_p = P_{p,m} + P_{p,u} = \underline{964,07 \text{ kN}}$$

vijak  $\Phi M 27 \times 10,9$  dvostranski

$$F_{v,Rd} = F_{v,Rd2} / 2 = \underline{183,60 \text{ kN}}$$

$$F_{b,Rd} = \frac{2,5 \cdot 0,60 \cdot 51 \cdot 27 \cdot 30}{1,25} = \underline{495,72 \text{ kN}}$$

potrebno število vijakov:

$$n_v = \frac{P_p}{F_{v,Rd}} = 5,25 \rightarrow \boxed{\frac{n_v}{n_v} = 6}$$