

Proračun i konstruisanje veza pod uglom

Krute veze - ZADACI

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1. 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.

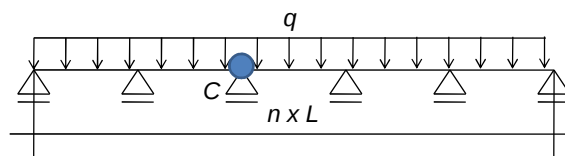
Vezu ostvariti pomoću obrađenih zavrtnjeva klase čvrstoće 5.6

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

Osnovni materijal: Č0361

Slučaj opterećenja: I

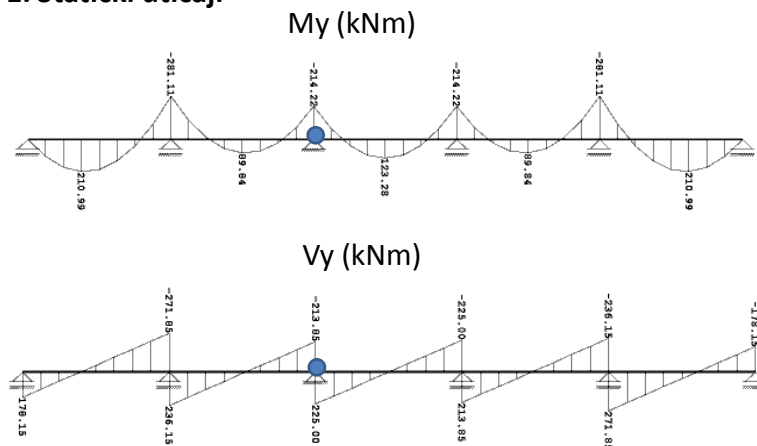
Radionički crtež dati u razmeri: 1:5



$q = 75,0 \text{ kN/m}$
 $L = 6,0 \text{ m}$
 $n = 5$

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1. Statički uticaji



Maksimalni uticaji:

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

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

Uticaji na mestu veze:

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

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

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2. Podaci potrebni za proračun

Osnovni materijal Č0361 (I sl.o.) $\sigma_{\text{dop}} = 16 \text{ kN/cm}^2$ $\tau_{\text{dop}} = 9 \text{ kN/cm}^2$

Neobrađeni zavrtnjevi k.č. 5.6 $\sigma_{\text{b,dop}} = 32 \text{ kN/cm}^2$ $\tau_{\text{dop}} = 17,5 \text{ kN/cm}^2$

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

3. Dimenzionisanje nosača

$$W_{\text{pot}} = M_{\text{max}} / \sigma_{\text{doz}}$$

$$W_{\text{pot}} = 281,21 \cdot 10^2 / 16 = 1757,56 \text{ cm}^3$$

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Pretpostavlja se valjani profil **IPE 500** sa sledećim geometrijskim karakteristikama:

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

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

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

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

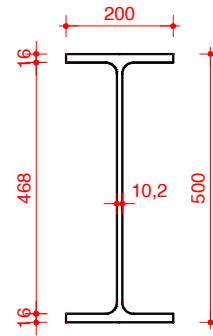
$$A = 116 \text{ cm}^2$$

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

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

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

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



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3.1 Kontrola napona

$$\sigma = \frac{M_{\max}}{W_y} = \frac{281,21 \cdot 10^2}{1930} = 14,57 \text{ kN/cm}^2 < \sigma_{\text{dop}} = 16 \text{ kN/cm}^2$$

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

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

$$\sigma_1 = \frac{M}{I} \cdot d / 2 = \frac{281,21 \cdot 10^2}{48200} \cdot 46,8 / 2 = 13,65 \text{ kN/cm}^2 < \sigma_{\text{dop}} = 16 \text{ kN/cm}^2$$

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

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

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3.3 Proračun veze

Uticaji na mestu veze:

$$M_c = 214,22 \text{ kNm} \quad V_c = 225,0 \text{ kN}$$

$$N_t = -N_c = M_c/h = 214,18/0,5 = 428,36 \text{ kN}$$

Na nožicama se usvajaju zavrtnjevi M27...5.6.

Slabljenje preseka rupama za zavrtnjeve

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

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

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

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

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Kontrola napona u oslabljenom preseku

$$\sigma = \frac{M_c}{W_{\text{net}}} = \frac{214,18 \cdot 10^2}{1718} = 12,47 \text{ kN/cm}^2 < \sigma_{\text{dop}} = 16 \text{ kN/cm}^2$$

Proračun kontinuitet lamele

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

Usvaja se kontinuitet lamela #200x20 mm

Proračun zavrtnjeva na nožici

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

$$F_b = 2,8 \cdot 1,6 \cdot 32 = 143,40 \text{ kN}$$

$$F_{\text{dop}} = 107,7 \text{ kN}$$

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$$n = \frac{428,36}{107,7} = 3,98 \quad \text{Usvaja se 4M275.6}$$

Proračun zavrtnjeva na rebru

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

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

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

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

$$F_b = 2,1 \cdot 1,02 \cdot 32 = 68,54 \text{ kN}$$

$$F_{dop} = 68,54 \text{ kN}$$

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Proračun potrebnog broja zavrtnjeva

$$n = \frac{1}{m \cdot F_{dop}} \sqrt{V_c^2 + \left(\frac{6 \cdot M_e}{h} \right)^2} = \frac{1}{1 \cdot 43,98} \sqrt{225^2 + \left(\frac{6 \cdot 1012,5}{50} \right)^2} = 3,73$$

Predpostavimo 5M205.6 (m=1, n=5)

$$F_v = \frac{V_c}{n} = \frac{225}{5} = 45 \text{ kN}$$

$$F_M = \frac{M_e \cdot h_n}{\sum h_i^2} = \frac{1012,5 \cdot 16}{2(8^2 + 16^2)} = 25,3 \text{ kN}$$

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

Usvaja se 5M205.6

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

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

$$F_b = 2,1 \cdot 1,7 \cdot 32 = 114,24 \text{ kN}$$

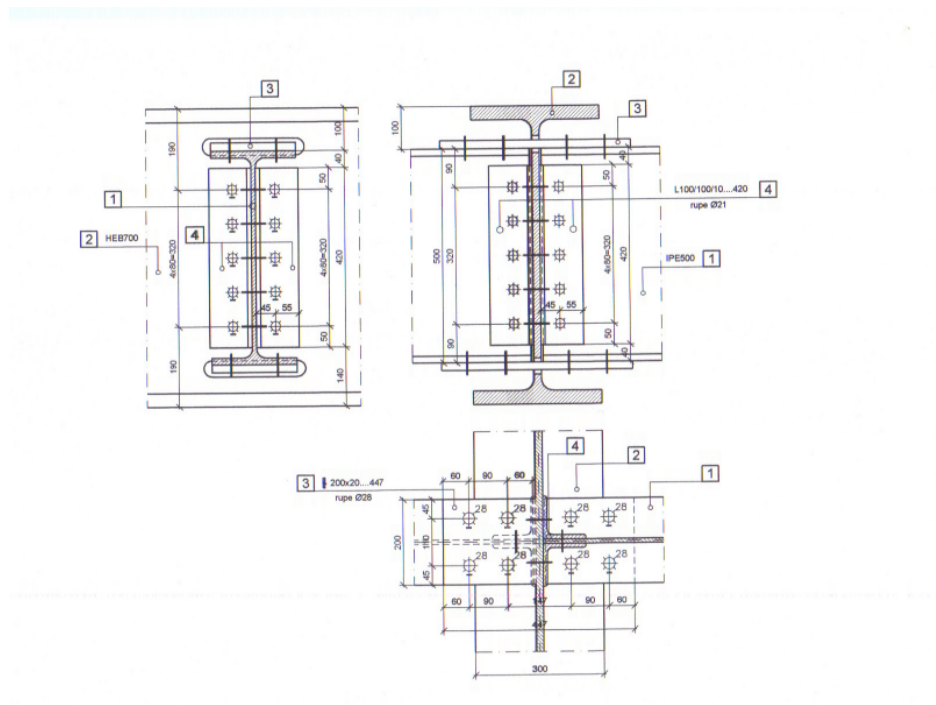
$$F_{\text{dop}} = 114,24 \text{ kN}$$

$$n = \frac{V_{c,1} + V_{c,d}}{F_{v,\text{dop}}} = \frac{225 + 213,83}{114,24} = 3,84$$

Usvaja se 2x5M205.6 iz konstruktivnih razloga

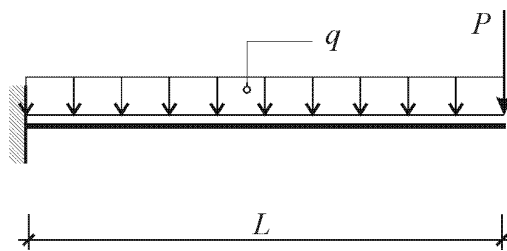
Usvajaju se ugaonici L100/100/10

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2.

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

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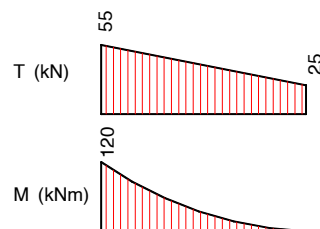
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2. Podaci potrebni za proračun

Osnovni materijal Č0361 (I sl.o.) $\sigma_{\text{dop}} = 16 \text{ kN/cm}^2$ $\tau_{\text{dop}} = 9 \text{ kN/cm}^2$

Zavrtnjevi k.č. 10.9 $\sigma_{\text{b,dop}} = 28 \text{ kN/cm}^2$ $\tau_{\text{dop}} = 24 \text{ kN/cm}^2$

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

3. Uticaji u nosaču

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

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

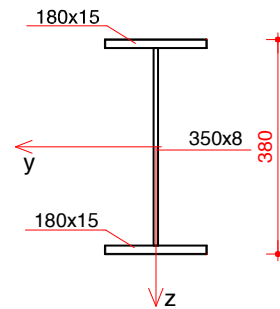
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3. Dimenzionisanje nosača

$$W_{\text{pot}} = M_{\text{max}} / \sigma_{\text{dop}}$$

$$W_{\text{pot}} = 120 \cdot 10^2 / 16 = 750 \text{ cm}^3$$

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



Geometrijske karakteristike preseka:

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

$$I_{y,w} = \frac{35^3 \cdot 0,8}{12} = 2858,33 \text{ cm}^4$$

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

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Geometrijske karakteristike oslabljenog preseka:

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

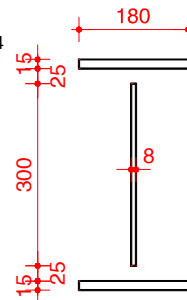
$$W_y = \frac{19785}{19} = 1041,3 \text{ cm}^3$$

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

Kontrola napona

$$\sigma = \frac{M_{\text{max}}}{W_y} = \frac{120 \cdot 10^2}{1041,3} = 11,52 \text{ kN/cm}^2 < \sigma_{\text{dop}} = 16 \text{ kN/cm}^2$$

$$\tau_{\text{max}} = \frac{V_{\text{max}} \cdot S_y}{t_w \cdot I_y} = \frac{55 \cdot 582,75}{19785 \cdot 0,8} = 2,02 \text{ kN/cm}^2 < \tau_{\text{dop}} = 9 \text{ kN/cm}^2$$



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Kontrola deformacija

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

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

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

4. Veza nosača za čeonu ploču

Predpostavljaju se šavovi:

- veza nožice za čeonu ploču $a_1 = 8 \text{ mm}$
- veza rebra za čeonu ploču $a_2 = 4 \text{ mm}$

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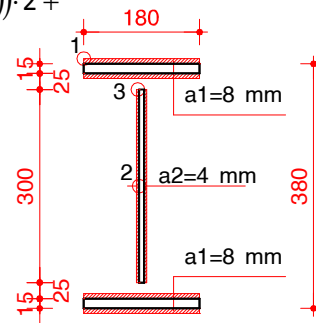
$$I_{y,w} = (0,8 \cdot 18 \cdot ((19 - 1,5 - 0,4)^2 + (19 + 0,4)^2)) \cdot 2 +$$

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

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

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

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

**Tačka 1**

$$n = \frac{M}{W_{y,w}} = \frac{120 \cdot 10^2}{1056,6} = 11,36 \text{ kN / cm}^2 < \sigma_{w,dop} = 12 \text{ kN / cm}^2$$

Tačka 2

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

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Tačka 3

$$n = \frac{M}{I_{y,w}} \cdot z_3 = \frac{120 \cdot 10^2}{20920} \cdot 15 = 8,6 \text{ kN / cm}^2$$

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

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

5. Veza čeone ploče za nožicu stuba

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

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

$$F_t = \frac{M}{4 \cdot h'} = \frac{120 \cdot 10^2}{4 \cdot (h - t_f)} = \frac{120 \cdot 10^2}{4 \cdot (38 - 1,5)} = 82,2 \text{ kN} < F_{t,dop}$$

Debljina čeone ploče $d_p = 1,25 \times d = 1,25 \times 20 = 25 \text{ mm}$

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

Debljina nožice stuba:

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

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

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

Potreban broj zavrtnjeva za prijem smičuće sile:

$$n = \frac{T}{F_{s,dop}} = \frac{55}{37} = 1,49 \quad \text{Usvajaju se 2M2010.9}$$

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