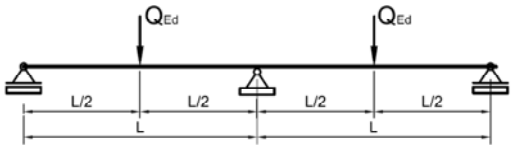
5. Zadatak

Dimenzionisati nosač statičkog sistema zadatog na skici. Nosač je bočno pridržan na mestima oslonaca.

Na nosač deluju sledeća opterećenja:

F_g = 7,0 kN F_p = 16,0 kN F_s = 5,0 kN



L= 7 m

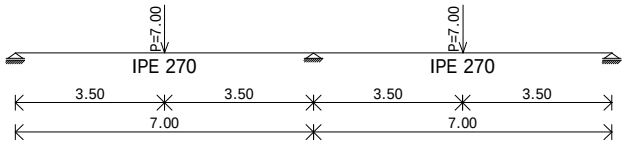
Za poprečni presek nosača usvojiti vrućvaljani profil: IPE

Osnovni materijal je čelik: S235

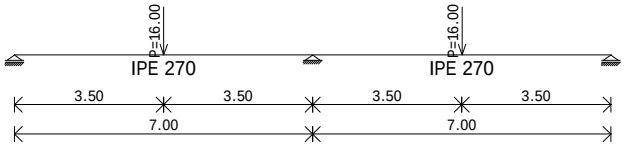
Maksimalni dopušteni ugib nosača je: L/300

Ulazni podaci - Opterećenje

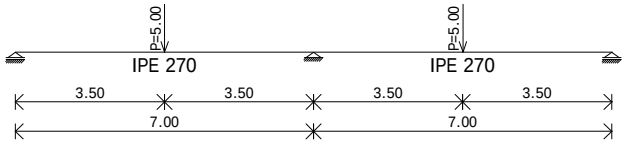
Opt. 1: Stalno G



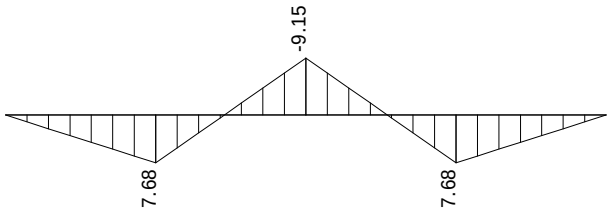
Opt. 2: Korisno P



Opt. 3: Sneg S

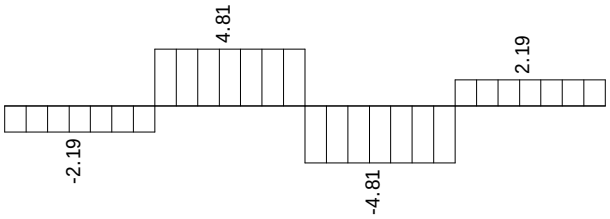


Opt. 1: Stalno G



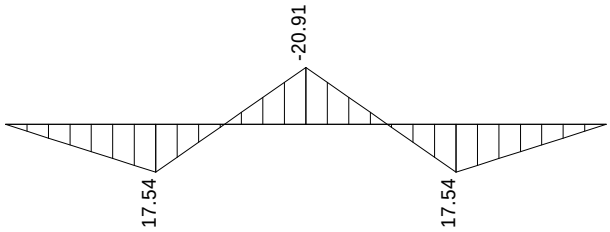
Uticaji u gredi: max M3= 7.68 / min M3= -9.15 kNm

Opt. 1: Stalno G



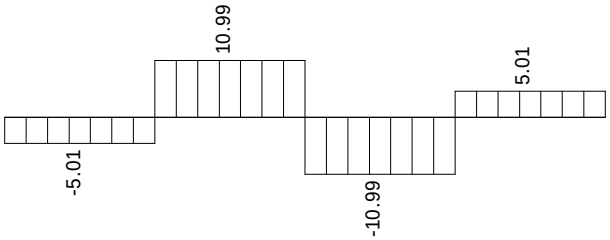
Uticaji u gredi: max T2= 4.81 / min T2= -4.81 kN

Opt. 2: Korisno P



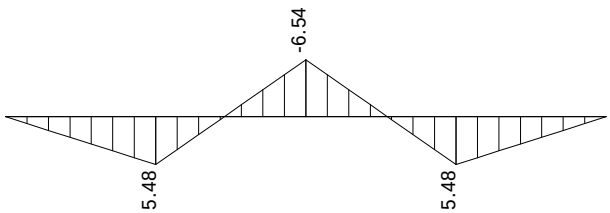
Uticaji u gredi: max M3= 17.54 / min M3= -20.91 kNm

Opt. 2: Korisno P



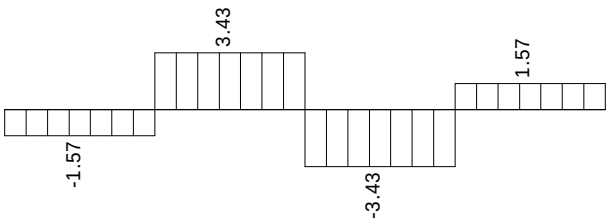
Uticaji u gredi: max T2= 10.99 / min T2= -10.99 kN

Opt. 3: Sneg S



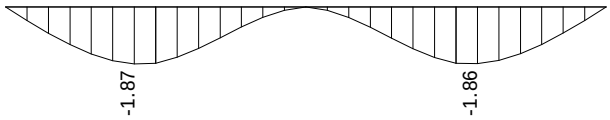
Uticaji u gredi: max M3= 5.48 / min M3= -6.54 kNm

Opt. 3: Sneg S



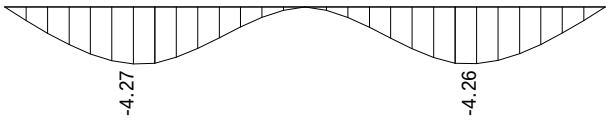
Uticaji u gredi: max T2= 3.43 / min T2= -3.43 kN

Opt. 1: Stalno G



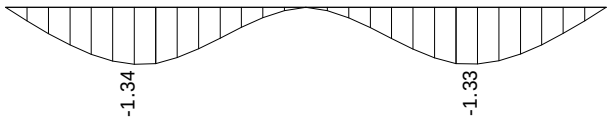
Uticaji u gredi: max Zp= -0.00 / min Zp= -1.87 m / 1000

Opt. 2: Korisno P



Uticaji u gredi: max Zp= -0.00 / min Zp= -4.27 m / 1000

Opt. 3: Sneg S



Uticaji u gredi: max Zp= -0.00 / min Zp= -1.34 m / 1000

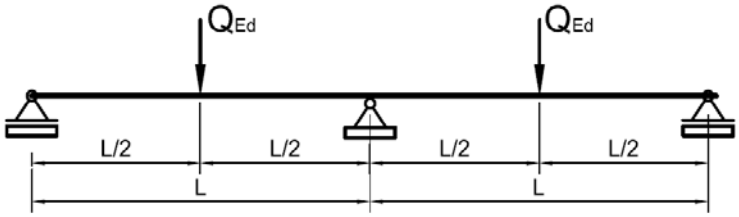
Zadatak 5 - Bočno - torziono izvijanje, kontinualni nosač na dva polja. Nosač je opterećen koncentrisanim silama u sredini raspona. Raspon nosača je 7.0 m. Konstrukcija se izvodi od čelika S235.

Statička šema i opterećenje:

Stalno opterećenje: $F_g := 7kN$

Korisno opterećenje: $F_p := 16kN$

Opterećenje snegom: $F_s := 5kN$



Parcijalni koeficijenti: stalna dejstva $\gamma_G := 1.35$

promenljiva dejstva $\gamma_Q := 1.5$

Koeficijenti za reprezentativne vrednosti: p - prostorije za stanovanje
s - nadmorska visina <1000mnm

$\psi_{0p} := 0.7$ $\psi_{0s} := 0.7$

Uticaji u nosaču

Srednji oslonac

$M_{yg} := 9.17kN \cdot m$ $M_{yp} := 20.95kN \cdot m$ $M_{ys} := 6.55kN \cdot m$

$V_{zg} := 4.81kN$ $V_{zp} := 11.0kN$ $V_{zs} := 3.44kN$

$M_{Edo} := \gamma_G M_{yg} + \gamma_Q \cdot M_{yp} + \gamma_Q \cdot \psi_{0s} \cdot M_{ys} = 50.682\,m \cdot kN$

$V_{Edo} := \gamma_G V_{zg} + \gamma_Q \cdot V_{zp} + \gamma_Q \cdot \psi_{0p} \cdot V_{zs} = 26.605 \cdot kN$

U polju

$M_{yg} := 7.67kN \cdot m$ $M_{yp} := 17.52kN \cdot m$ $M_{ys} := 5.48kN \cdot m$

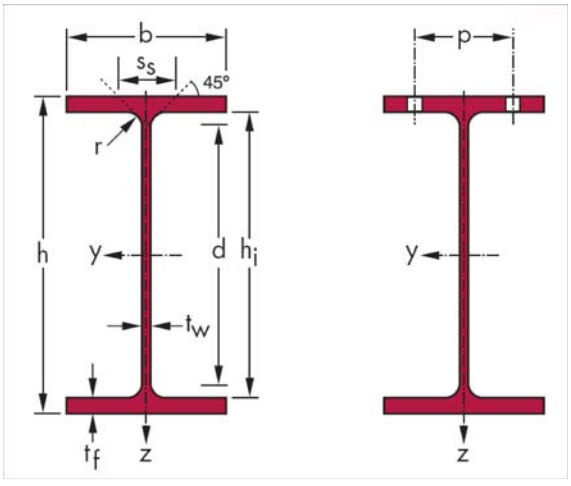
$V_{zg} := 4.81kN$ $V_{zp} := 11.0kN$ $V_{zs} := 3.44kN$

$M_{Edp} := \gamma_G M_{yg} + \gamma_Q \cdot M_{yp} + \gamma_Q \cdot \psi_{0s} \cdot M_{ys} = 42.389\,m \cdot kN$

$V_{Edp} := \gamma_G V_{zg} + \gamma_Q \cdot V_{zp} + \gamma_Q \cdot \psi_{0p} \cdot V_{zs} = 26.605 \cdot kN$

Dimenzionisanje poprečnog preseka

Usvaja s poprečni presek **IPE 270**



$A := 45.9cm^2$ $h := 270mm$

$I_y := 5790cm^4$ $b_f := 135mm$

$I_z := 419.9cm^4$ $t_f := 10.2mm$

$i_y := \sqrt{\frac{I_y}{A}} = 0.112\,m$ $t_w := 6.6mm$

$r := 15mm$

$i_z := \sqrt{\frac{I_z}{A}} = 0.03\,m$

$W_{ely} := 428.9cm^3$

$W_{elz} := 62.2cm^3$

$W_{ply} := 484cm^3$

$W_{plz} := 96.95cm^3$

$I_t := 15.94cm^4$

$I_w := 70580cm^6$

Osnovni materijal S235

$f_y := 23.5\,\frac{kN}{cm^2}$ $E := 21000\,\frac{kN}{cm^2}$ $G := 8100\,\frac{kN}{cm^2}$ $\lambda_1 := \pi\cdot\sqrt{\frac{E}{f_y}}$ $\varepsilon := \sqrt{\frac{235MPa}{f_y}} = 1$

Parcijalni koeficijent sigurnosti:

$\gamma_{M0} := 1.0$ $\gamma_{M1} := 1.0$ $\gamma_{M2} := 1.25$

Raspon nosača i kritična dužina nosača

$L := 7.0m$ $L_{cry} := L$ $L_{crz} := L$ $L_t := L$

Klasa poprečnog preseka

$\frac{\left(b_f - t_w\right)}{2} - r}{t_f} = 4.824$ $9\cdot\varepsilon = 9$ Nožica je klase 1

$\frac{\left(h - 2\cdot t_f - 2r\right)}{t_w} = 33.273$ $72\varepsilon = 72$ Rebro je klase 1

Poprečni presek je klase 1

Nosivost poprečnog preseka

Savijanje

$M_{yRd} := W_{ply}\cdot\frac{f_y}{\gamma_{M0}}$ $M_{yRd} = 113.74\cdot kN\cdot m$

$\frac{\max\left(M_{Edo}, M_{Edp}\right)}{M_{yRd}} = 0.446$

Smicanje

$A_{Vz} := A - 2\cdot b_f\cdot t_f + \left(t_w + 2r\right)\cdot t_f = 22.093\cdot cm^2$

$\eta := 1$ $h_w := h - 2\cdot t_f = 24.96\cdot cm$

$\frac{h_w}{t_w} = 37.818$ $72\frac{\varepsilon}{\eta} = 72$

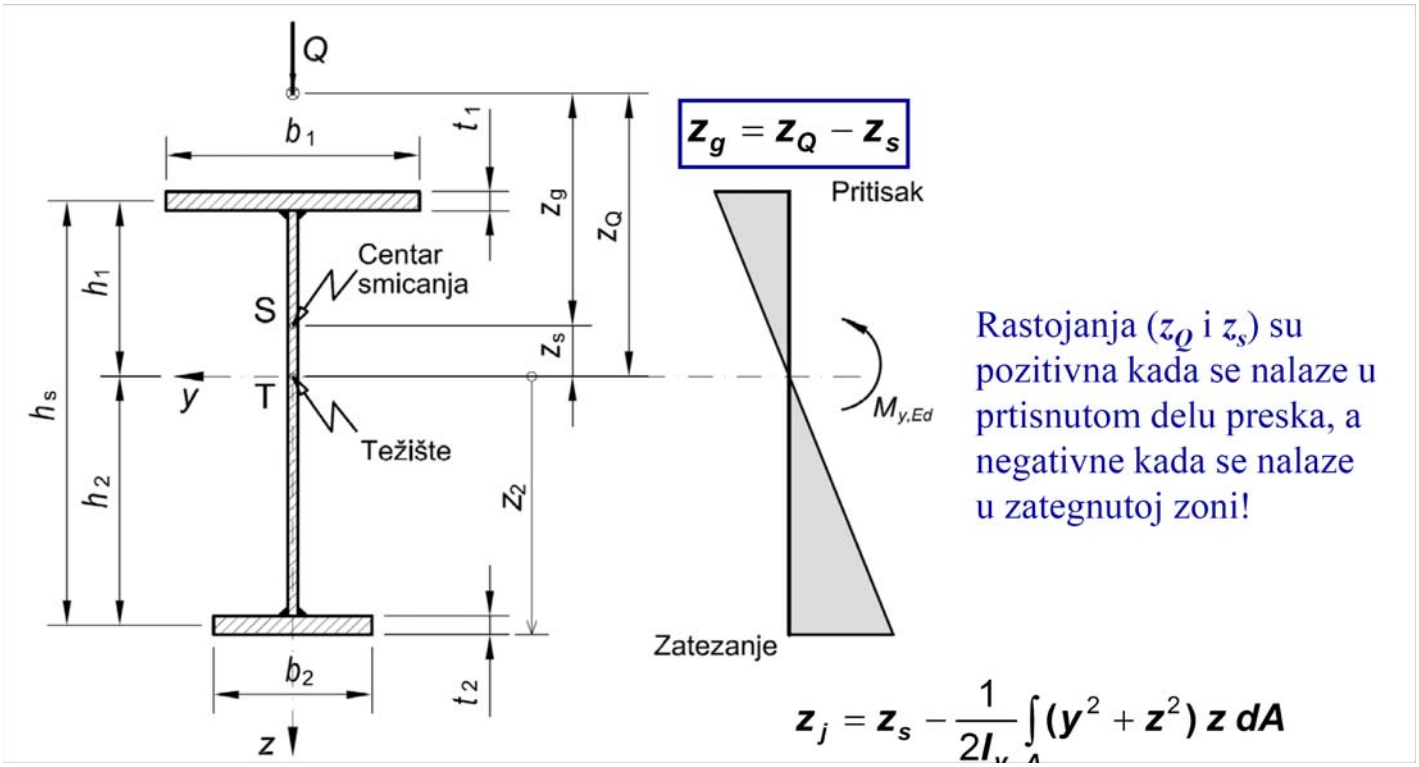
$\eta\cdot h_w\cdot t_w = 16.474\cdot cm^2$

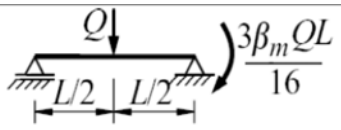
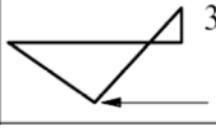
$V_{zplRd} := \frac{A_{Vz}\cdot\frac{f_y}{\sqrt{3}}}{\gamma_{M0}} = 299.755\cdot kN$

$\frac{\max\left(V_{Edo}, V_{Edp}\right)}{V_{zplRd}} = 0.089$ Nije potrebno kontrolisati M-V interakciju.

Kontrola stabilnosti: Bočno torziono izvijanje - opšti slučaj

$z_0 := 0\text{cm}$ $y_0 := 0\text{cm}$



		$1.35+0.15\beta_m$ $-1.2+3.0\beta_m$	$0\le\beta_m\le0.9$ $0.9\le\beta_m\le1$

$Q_{Ed} := \gamma_G \cdot F_g + \gamma_Q \cdot F_p + \psi_{0s} \cdot \gamma_Q \cdot F_s = 3.87 \times 10^4\,\text{N}$

$\beta_{m1} := 16\dfrac{M_{Edo}}{3Q_{Ed} \cdot L} = 0.998$

$\beta_{m2} := \left(1 - \dfrac{4M_{Edp}}{Q_{Ed} \cdot L}\right) \cdot \dfrac{8}{3} = 0.998$

$\alpha_m := -1.2 + 3\beta_{m2} = 1.793$

Alternativno vrednost koeficijenta C1 može se odrediti na osnovu vrednosti momenata u četvrtinama raspona segmenta.

$M_1 := 21.22\text{kN} \cdot \text{m}$ $M_2 := 42.43\text{kN} \cdot \text{m}$ $M_3 := -4.07\text{kN} \cdot \text{m}$ $\alpha_{m1} := \dfrac{1.75 \cdot \max\left(M_{Edo}, M_{Edp}\right)}{\sqrt{M_1^{\,2} + M_2^{\,2} + M_3^{\,2}}} = 1.863$

$C1 := \alpha_m$ $C2 := 0.553$ $C3 := 1.730$ $k := 1.0$ $k_w := 1$ Predavanje 7 slajd 12 i slajd 17

$z_j := 0$ $z_Q := \frac{h}{2}$ znak + opterecenje je na gornjem pojasu, opterećenje deluje ka cntru smicanja. $z_s := 0$

$z_g := z_Q - z_s = 0.135\ m$

$$M_{cr} := C1 \cdot \frac{\pi^2 \cdot E \cdot I_z}{(k \cdot L)^2} \cdot \left[\left[\left(\frac{k}{k_w} \right)^2 \cdot \frac{I_w}{I_z} + \frac{(k \cdot L)^2 \cdot G \cdot I_t}{\pi^2 \cdot E \cdot I_z} + \left(C2 \cdot z_g - C3 \cdot z_j \right)^2 \right]^{0.5} - \left(C2 \cdot z_g - C3 \cdot z_j \right) \right] = 74.415 \cdot kN \cdot m$$

$$\frac{\max(M_{Edo}, M_{Edp})}{M_{cr}} = 0.681$$

Pomoću programa "LT beam"

$M_{crLTB} := 61.397 kN \cdot m$

$\alpha_{LT} := 0.21$ Vruće valjani preseci h/b=2 slajd P7-26

$$\lambda_{LT} := \sqrt{\frac{W_{ply} \cdot f_y}{M_{cr}}} = 1.236 \qquad \Phi_{LT} := 0.5 \left[1 + \alpha_{LT} \cdot \left(\lambda_{LT} - 0.2 \right) + \lambda_{LT}^2 \right] = 1.373 \qquad \chi_{LT} := \frac{1}{\Phi_{LT} + \sqrt{\Phi_{LT}^2 - \lambda_{LT}^2}} = 0.508$$

$$M_{bRd} := \frac{\chi_{LT} \cdot W_{ply} \cdot f_y}{\gamma_{M1}} = 57.726 \cdot kN \cdot m$$

$$\frac{\max(M_{Edo}, M_{Edp})}{M_{bRd}} = 0.878$$

Metoda za vruće valjane profile , slajd P7-27

$\beta := 0.75$ $\lambda_{LT0} := 0.4$ $\alpha_{LT} := 0.34$

$$\Phi_{LT} := 0.5 \left[1 + \alpha_{LT} \cdot \left(\lambda_{LT} - \lambda_{LT0} \right) + \beta \cdot \lambda_{LT}^2 \right] = 1.215 \qquad \chi_{LT} := \frac{1}{\Phi_{LT} + \sqrt{\Phi_{LT}^2 - \beta \cdot \lambda_{LT}^2}} = 0.559$$

$$M_{bRd} := \frac{\chi_{LT} \cdot W_{ply} \cdot f_y}{\gamma_{M1}} = 63.527 \cdot kN \cdot m$$

$$k_c := \frac{1}{\sqrt{C1}} = 0.747$$

$$f := 1 - 0.5 \cdot \left(1 - k_c \right) \cdot \left[1 - 2 \cdot \left(\lambda_{LT} - 0.8 \right)^2 \right] = 0.922$$

$$\chi_{LTmod} := \frac{\chi_{LT}}{f} = 0.606$$

$$M_{bRd} := \frac{\chi_{LTmod} \cdot W_{ply} \cdot f_y}{\gamma_{M1}} = 68.93 \cdot kN \cdot m \qquad \frac{\max(M_{Edo}, M_{Edp})}{M_{bRd}} = 0.735$$

Kontrola upotrebljivosti

Kontrola ugima

$w_g := 2.0mm$ $w_p := 4.3mm$ $w_s := 1.3mm$

$w_{Ed} := w_g + w_p + \psi_{0s} \cdot w_s = 7.21 \cdot mm$ granična vrednost $w_{lim} := \frac{L}{300} = 23.333 \cdot mm$

$\frac{w_{Ed}}{w_{lim}} = 0.309$ kriterijum graničnog stanje upotrebljivisti je zadovoljen.