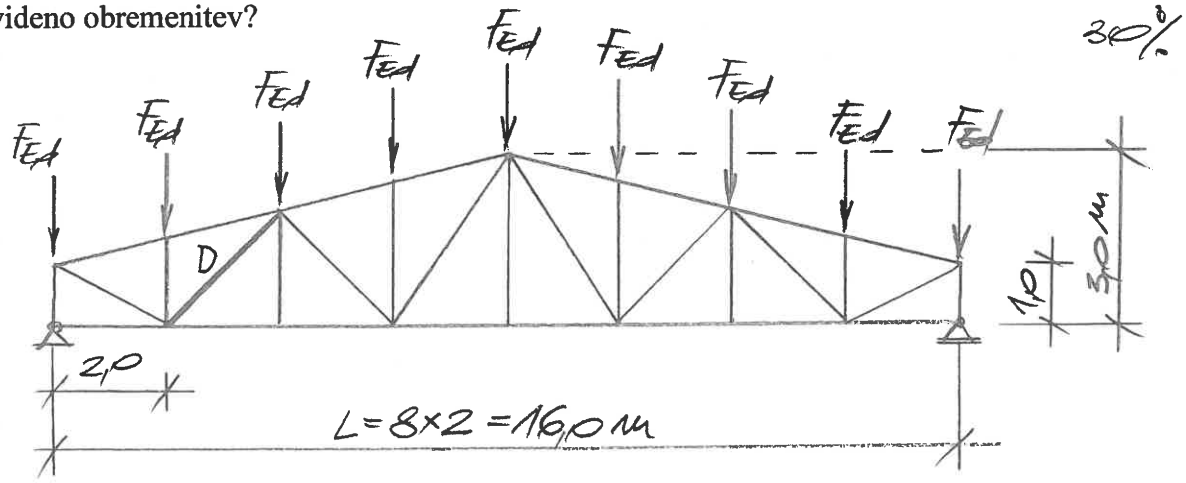
Kandidat:

1. Naloga

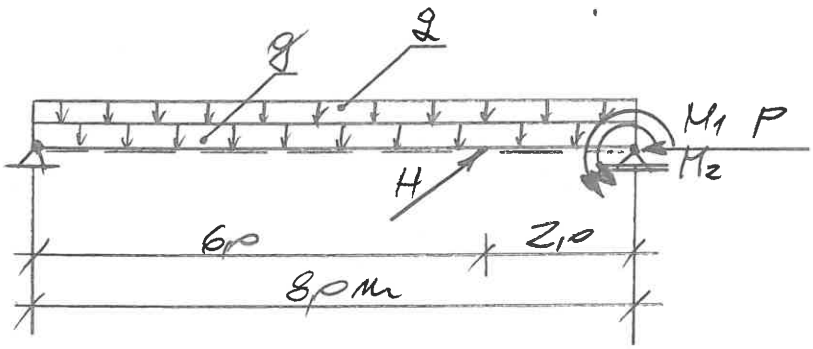
Jekleni palični nosilec razpona 16 m je obremenjen z vozliščnimi točkovnimi silami F_{Ed}=50 kN. Dimenzioniraj označeno diagonalo iz prereza [100 in materiala S 235. Ali diagonala prenese predvideno obremenitev? 30%



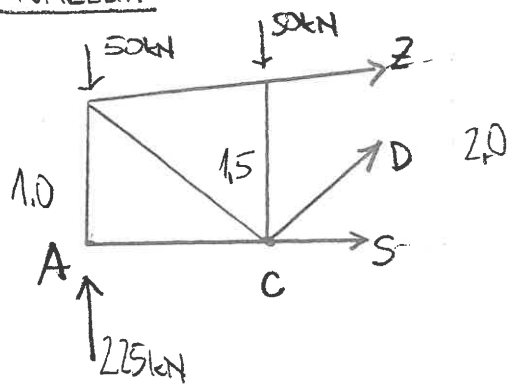
2. Naloga

Strešni nosilec dolžine L=8 m iz valjanega prereza HEA 400 in materiala S 275 je obremenjen z zvezno obtežbo g=25 kN/m (stalna obtežba), q=15 kN/m (koristna obtežba), z momentom M_1=60 kNm (stalna obtežba), M_2=40 kNm (koristna obtežba), s silo P=200 kN (stalna obtežba) in z bočno vodoravno silo H=3 kN (veter). Lastno težo nosilca zanemari. V kombinaciji obtežb upoštevaj koristno obtežbo kot dominantni spremenljivi vpliv.

- Po mejnem stanju nosilnosti dimenzioniraj nosilec, ki je bočno podprt samo na obeh svojih podporah. Nariši diagrame notranjih statičnih količin. 50%
- Po mejnem stanju uporabnosti preveri vertikalno deformacijo za koristno obtežbo na sredini razpona nosilca. 20%



1. NALOGA



$\beta = \operatorname{arctg}\frac{2,0}{8,0} = 14,03°$

$\alpha = \operatorname{arctg}\frac{2,0}{2,0} = 45°$

$\Sigma M^C = \emptyset \quad -225 \cdot 2,0m + 50 \cdot 2,0m - Z \cdot \cos\beta \cdot 1,5 = \emptyset$

$$Z = \frac{-225 \cdot 2,0 + 50 \cdot 2,0}{\cos\beta \cdot 1,5} = -240,51kN$$

$\Sigma F_y = \emptyset \quad 225 - 50 - 50 + Z \cdot \sin\beta + D \cdot \sin\alpha = \emptyset$

$$D = \frac{-225 + 50 + 50 - (-240,51) \cdot \sin\beta}{\sin\alpha}$$

$D = -94,32kN$ (TLAK)

- ODZRNOST PREREZA NA TLAČNO UKLONSKO SILO:

$\lambda_z = \frac{\sqrt{2^2+2^2} \cdot 100}{1,47} = 192,41 \qquad \overline{\lambda}_z = \frac{192,41}{93,9 \cdot 1,0} = 2,05$

UKLONSKA KRIVULJA c) $\chi_z = 0,188$

$$D \leq N_{b,rd} = \chi_z \cdot \frac{A \cdot f_y}{\gamma_{M1}} = 0,188 \cdot \frac{13,5 \cdot 23,5}{1,0}$$

$94,32kN \not\leq 53,64\,kN$ DIAGONALA NE USTREZA.

2 NALOGA

RAČUNSKA OBTEŽBA

$g_{Ed} = 1{,}35 \cdot 25 = 33{,}75\ kN/m$

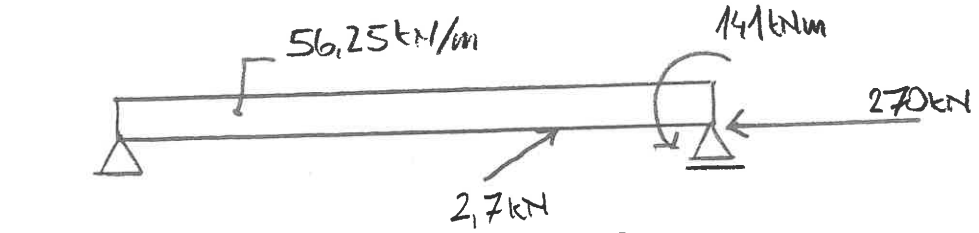
$q_{Ed} = 1{,}5 \cdot 15 = 22{,}5\ kN/m$

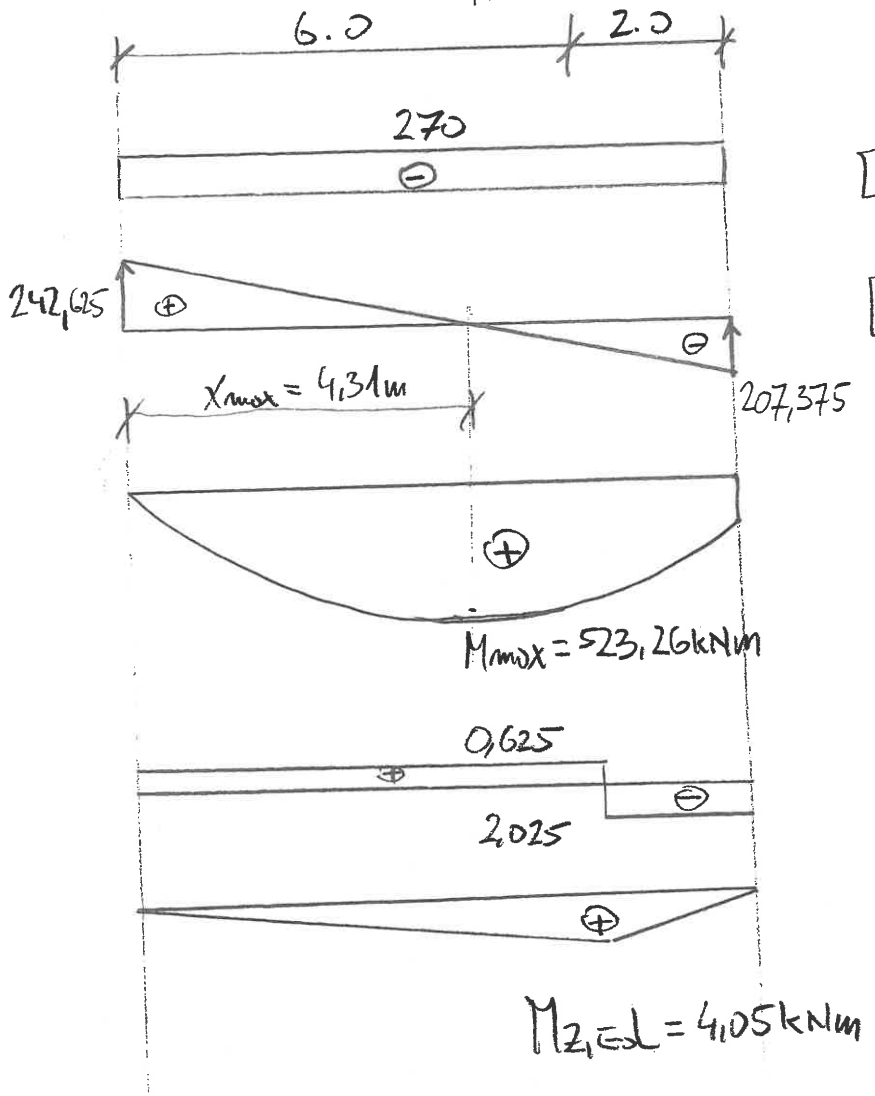
$P_{Ed} = 1{,}35 \cdot 200 = 270\ kN$

$M_{1Ed} = 1{,}35 \cdot 60 = 81\ kNm$

$M_{2Ed} = 1{,}5 \cdot 40 = 60\ kNm$

$H_{3Ed} = 1{,}5 \cdot 0{,}6 \cdot 3 = 2{,}7\ kN$





$[N_{Ed}]$ kN

$[V_{z,Ed}]$ kN

$[M_{y,Ed}]$ kNm

$[V_{y,Ed}]$ kN

$[M_{z,Ed}]$ kNm

- KLASIFIKACIJA PREREZA: HEA 400 i S275 ; $\varepsilon = 0{,}92$

- STOJINA: $\alpha = \frac{270}{2 \cdot 1{,}1 \cdot 27{,}5} = 4{,}46$

$$\alpha = \frac{1}{29{,}8}\left(\frac{29{,}8}{2} + 4{,}46\right) = 0{,}65$$

$$\frac{c}{t_w} \leq \frac{396 \cdot \varepsilon}{13\alpha - 1} = \frac{396 \cdot 0{,}92}{13 \cdot 0{,}65 - 1}$$

$$\frac{29{,}8}{1{,}1} = 27{,}09 \leq 48{,}9 \quad \checkmark \quad \text{1. R. P.}$$

- PAŠNICA:

$$\frac{c}{t_f} \leq 9 \cdot \varepsilon \qquad c = \frac{b}{2} - \frac{t_w}{2} - r = 177{,}5\,mm$$

$$\frac{177{,}5}{19} = 6{,}18 \leq 8{,}28 \quad \text{1. R. P.}$$

PREREZ HEA 400 SPADA V 1. R. P.!

- ODPORNOST PREREZA:

$$\frac{270}{159 \cdot \frac{27{,}5}{1{,}0}} + \frac{523{,}26 \cdot 100}{2562 \cdot \frac{27{,}5}{1{,}0}} + \frac{4{,}05 \cdot 100}{873 \cdot \frac{27{,}5}{1{,}0}} \leq 1{,}0$$

$$0{,}061 + 0{,}742 + 0{,}017 = 0{,}82 \leq 1{,}0$$

- STRIŽNA ODPORNOST PREREZA:

V y-y smeri:

$$V_{y,Ed} = V_{y,pl,Rd} = \frac{120{,}28 \cdot 27{,}5}{\sqrt{3} \cdot 1{,}0} = 1909{,}7\,kN$$

$2{,}025\,kN \leq 1909{,}7\,kN \qquad V_{y,Ed} \leq 0{,}5\, V_{y,pl,Rd}$ ✓

NA Z-Z smer:

$$V_{z,Ed} \le V_{z,pl,Rd} = \frac{57,35 \cdot 27,5}{\sqrt{3} \cdot 1,0} = 910,55\,kN$$

$242,625\,kN \le 910,55\,kN$ ✓ $V_{z,Ed} \le 0,5 \cdot V_{z,pl,Rd}$

- ODPORNOST NOSILCA : TLAK + UPOGIB (ZVRNITEV)

- Izracun χ_y:

$$\lambda_y = \frac{800}{16,8} = 47,62 \qquad \bar{\lambda}_y = \frac{47,62}{93,9 \cdot 0,92} = 0,55$$

$\frac{h}{b} \ge 1,2$, $t_f \le 40\,mm$ } UKONSKA KRIVULJA a) $\chi_y = 0,908$

- Izracun χ_z:

$$\lambda_z = \frac{800}{7,34} = 108,99 \qquad \bar{\lambda}_z = \frac{108,99}{93,9 \cdot 0,92} = 1,26$$

$\frac{h}{b} \ge 1,2$, $t_f \le 40\,mm$ } UKONSKA KRIVULJA b) $\chi_z = 0,446$

- Izracun χ_{LT}:

$C_1 = 1,77$ $\quad I_t = 188\,cm^4$ $\quad E = 21000\,kN/cm^2$

$C_2 = 0,46$ $\quad I_\omega = 2942000\,cm^6$ $\quad G = 8077\,kN/cm^2$

$z_a = 19,5\,cm$ $\quad I_z = 8560\,cm^4$ $\quad L = 800\,cm$

$M_{cr} = 109118\,kNcm$

$$\bar{\lambda}_{LT} = \sqrt{\frac{2562 \cdot 27,5}{109118}} = 0,803$$

$\frac{h}{b} \le 2$ UKONSKA KRIVULJA b)

$$\Phi_{LT} = 0{,}5\left[1 + 0{,}34\left(0{,}803 - 0{,}4\right) + 0{,}75 \cdot 0{,}803^2\right] = 0{,}81$$

$$\chi_{LT} = \frac{1}{0{,}81 + \sqrt{0{,}81^2 - 0{,}803^2 \cdot 0{,}75}} = \underline{0{,}816}$$

- faktorji C_{my}; C_{mz}; C_{mLT}

$$C_{my} = 0{,}95 + 0{,}05 \cdot 0{,}269 = 0{,}963$$

$$\lambda_h = \frac{M_h}{M_s} = \frac{141}{523{,}26} = 0{,}269$$

$$C_{mz} = 0{,}9$$

$$C_{mLT} = 0{,}963$$

- faktorji k_{yy}; k_{yz}; k_{zz}; k_{zy}

$k_{yy} = 0{,}986$

$$0.963 \cdot \left(1 + \left(0{,}55 - 0{,}12\right)\frac{270}{0{,}908 \cdot \frac{4372{,}5}{1.0}}\right)$$

$$\leq 0{,}963\left(1 + 0{,}8\frac{270}{0{,}908 \cdot \frac{4372{,}5}{1}}\right)$$

$$0{,}986 \leq 1{,}01$$

$k_{yz} = 0{,}6 \cdot k_{zz} = 0{,}644$

$k_{zz} = 1{,}074$

$$0{,}9\left(1 + \left(2 \cdot 1{,}26 - 0{,}6\right)\frac{270}{0{,}446 \cdot \frac{4372{,}5}{1}}\right)$$

$$\leq 0{,}9\left(1 + 1{,}4 \cdot \frac{270}{0{,}446 \cdot \frac{4372{,}5}{1}}\right)$$

$$1{,}139 \leq 1{,}074$$

$k_{zy} = 0,981$

$$\left[1 - \frac{0,1 \cdot 1,26}{0,963 - 0,25} \cdot \frac{270}{0,446 \cdot \frac{4372,5}{1}}\right]$$

$$\geq \left[1 - \frac{0,1}{0,963 - 0,25} \cdot \frac{270}{0,446 \cdot \frac{4372,5}{1}}\right]$$

$$0,975 \geq 0,981$$

$$\frac{270}{0,928 \cdot \frac{153 \cdot 27,5}{1.0}} + 0,986 \cdot \frac{52326}{0,816 \cdot \frac{2562 \cdot 27,5}{1.0}} + 0,644 \cdot \frac{405}{\frac{873 \cdot 27,5}{1.0}} \leq 1.0$$

$$0,068 + 0,310 + 0,0108 = \underline{0,989 \leq 1.0}$$

$$\frac{270}{0,446 \cdot \frac{153 \cdot 27,5}{1.0}} + 0,981 \frac{52326}{0,816 \cdot \frac{2562 \cdot 27,5}{1.0}} + 1,074 \frac{405}{\frac{873 \cdot 27,5}{1.0}} \leq 1.0$$

$$0,138 + 0,905 + 0,0181 = \underline{1,06 \leq 1.0}$$

NOSILEC NE USTREZA PO MSN!

- DEFORMACIJA NOSILCA:

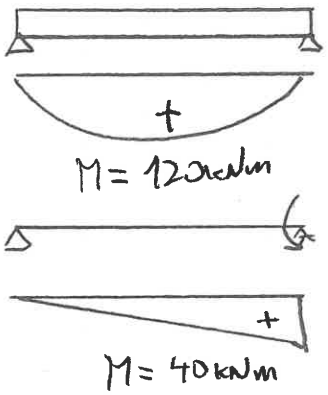
$q_{EL} = 15 \text{ kN/m}$

$M_{EL} = 40 \text{ kNm}$

$E = 21000 \text{ kN/cm}^2$

$I_y = 45070 \text{ cm}^4$

$L = 800 \text{ cm}$



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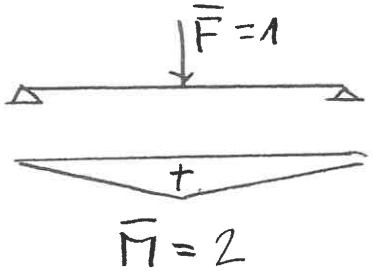

$$w = \frac{1}{E \cdot I_y} \int_0^L M \cdot \bar{M} \, dx = \frac{1}{E \cdot I_y} \cdot \left[\frac{1}{3} \cdot 120 \cdot 2 \cdot (1 + 0,25) + \frac{1}{6} \cdot 40 \cdot 2 \cdot (1 + 0,5)\right] \cdot 8m$$

$$= \frac{960}{210 \cdot 10^6 \frac{kN}{m^2} \cdot 4,507 \cdot 10^{-4}} = 0,0101 m = 1,01 cm \leq \frac{L}{250} \checkmark$$