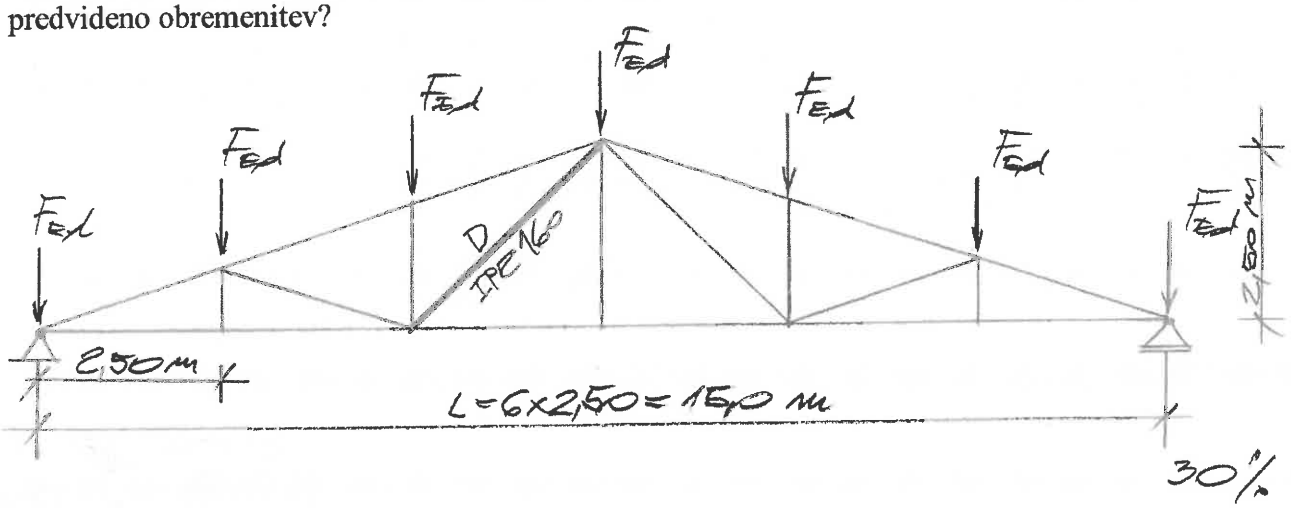
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JEKLENE KONSTRUKCIJE

Kandidat:

1. Naloga

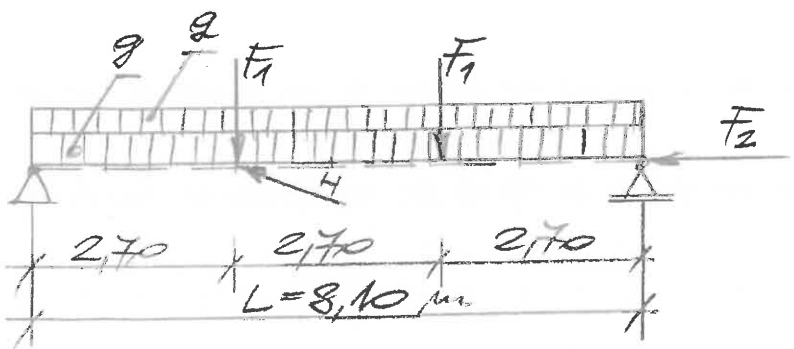
Jekleni palični nosilec razpona 15 m je obremenjen z vozliščnimi točkovnimi silami F_{Ed}=40 kN. Dimenzioniraj označeno diagonalo iz prereza IPE 160 in materiala S 235. Ali diagonala prenese predvideno obremenitev?



2. Naloga

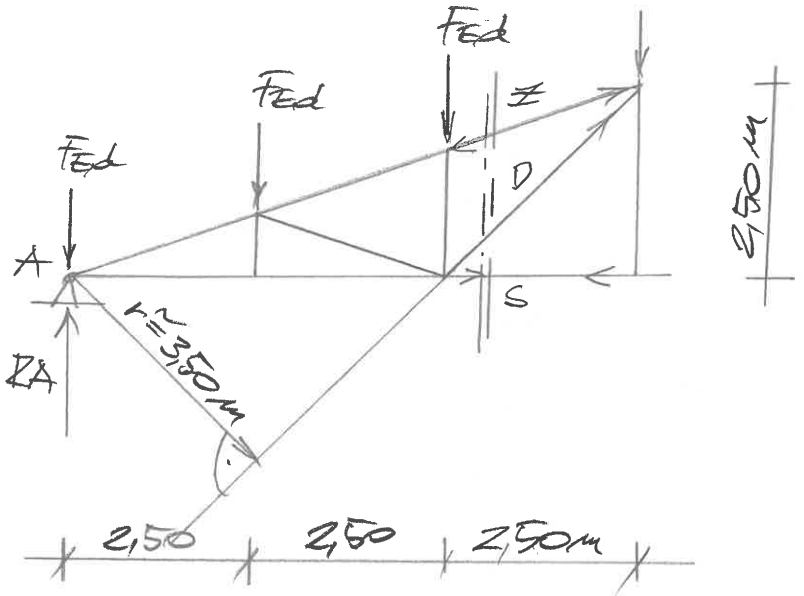
Strešni nosilec dolžine L=8,10 m iz valjanega prereza HEA 650 in materiala S 355 je obremenjen z zvezno obtežbo g=30 kN/m (stalna obtežba), q=25 kN/m (koristna obtežba), z navpičnima silama F_1=75 kN (stalna obtežba), vodoravno silo F_2=150 kN (veter) in z bočno vodoravno silo H=3 kN (veter). Lastno 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. 40%
- Po mejnem stanju uporabnosti preveri za skupno vertikalno deformacijo na sredini razpona nosilca. 30%



JEKLENE KONSTRUKCIJE

1. NALOGA



M = 1:100

FEd = 40 kN

$\sum M_A = \phi$ (+)

$(R_A - F_{Ed}) \cdot \phi + S \cdot \phi + Z \cdot \phi + F_{Ed} \cdot (2{,}50 + 5{,}0) - D \cdot (r = 3{,}50) = \phi$

$D = \frac{F_{Ed} \cdot (2{,}5 + 5{,}0)}{3{,}50} = \frac{40 \cdot 7{,}5}{3{,}5} \simeq \underline{85{,}7 \text{ kN}}$ (natezna)

IPE 160 S 235

$A = 20{,}1 \text{ cm}^2$

$f_y = 23{,}5 \text{ kN/cm}^2$

natezna odpornost:

$N_{Rd} = A \cdot f_y / \gamma_{M0} = 20{,}1 \times 23{,}5 / 1{,}0 = \underline{472{,}35 \text{ kN}}$

$N_{Rd} > D$ O.K ✓

diagonala prenese silo!

2. NÁLOŽÍ

$q_{Ed} = 1{,}35 \cdot 30 = 40{,}50\ kN/m'$

$g_{Ed} = 1{,}50 \cdot 25 = 37{,}50\ kN/m'$

$F_{1Ed} = 1{,}35 \cdot 75 = 101{,}25\ kN$

$F_{ZEd} = 1{,}50 \cdot 0{,}6 \cdot 150 = 135{,}0\ kN$ (tlak)

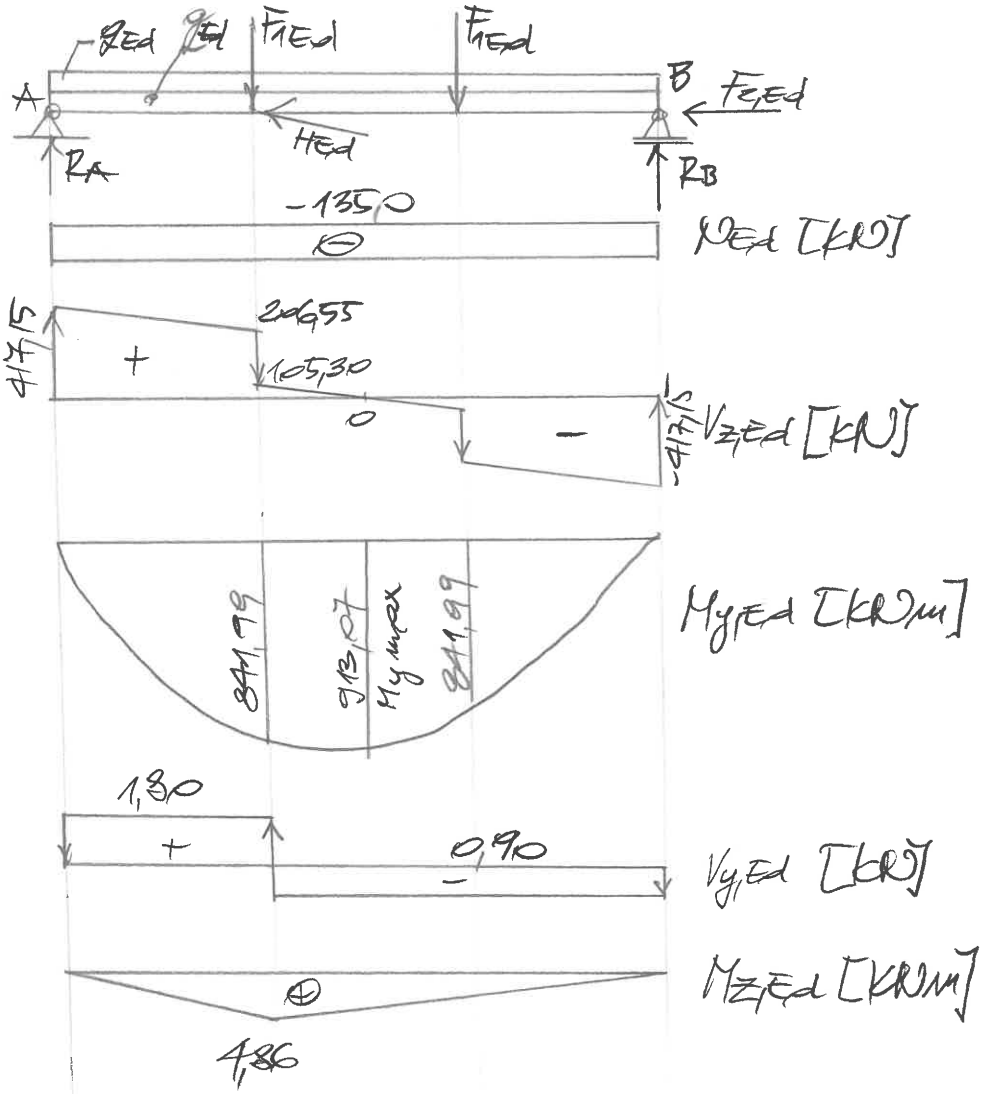
$H_{Ed} = 1{,}50 \cdot 0{,}6 \cdot 3{,}10 = 2{,}70\ kN$

$V_{z\,max\,Ed} = R_A = (40{,}5 + 37{,}5)\frac{8{,}10}{2} + 101{,}25 = 417{,}15\ kN$

$M_{y,Ed} = M_{max} = R_A \cdot L/2 - (g_{Ed} + g_{Ed}) \cdot \frac{L}{2} \cdot \frac{L}{4} - F_{1Ed} \cdot \frac{L}{6}$

$= 417{,}15 \cdot \frac{8{,}10}{2} - (40{,}5 + 37{,}5) \cdot \frac{8{,}10^2}{8} - 101{,}25 \cdot \frac{8{,}10}{6}$

$= 913{,}07\ kNm$



HEA 650 S 355

$A = 242\ cm^2$

$W_{pl,y} = 6136\ cm^3$ $W_{pl,z} = 1200\ cm^3$ $i_y = 26,9\ cm$ $i_z = 6,97\ cm$

$J_y = 175200\ cm^4$ $J_z = 11720\ cm^4$ $J_t = 450\ cm^4$ $J_w = 11027000\ cm^6$

$f_y = 35,5\ kN/cm^2$ $\varepsilon = 0,81$

klasifikacija:

stojina: $a = \frac{135}{2 \cdot 1,35 \cdot 35,5} = 1,408$

$$\alpha = \frac{1}{c}\left(\frac{c}{2} + a\right) = \frac{1}{53,4}\left(\frac{53,4}{2} + 1,408\right) = 0,526 > 0,5$$

$$\frac{c}{t_w} \leq \frac{396\varepsilon}{13\alpha - 1}$$

$$\frac{53,4}{1,35} \leq \frac{396 \cdot 0,81}{13 \cdot 0,526 - 1}$$

$39,55 < 54,94$ o.k. 1.R.P.

pasnica: $\frac{c}{t_f} \leq 9\varepsilon$ $c = \frac{b}{2} - \frac{t_w}{2} - r = \frac{30}{2} - \frac{1,35}{2} - 2,7 = 11,625\ cm$

$$\frac{11,625}{2,6} \leq 9 \cdot 0,81$$

$4,47 < 7,29$ o.k. 1.R.P.

profil:
1.R.P.

preklez

$$\frac{135,0}{\frac{242 \cdot 35,5}{1,0}} + \frac{313,07 \times 100}{\frac{6136 \times 35,5}{1,0}} + \frac{486 \times 100}{\frac{1200 \cdot 35,5}{1,0}} \leq 1,0$$

$0,446 < 1,0$ o.k.

strig z-z smer

$$V_{z,pl,Rd} = \frac{A_{vz} f_y}{\sqrt{3}\ \gamma_{M0}} = \frac{\{242 - 2 \cdot 30 \cdot 2,6 + (1,35 + 2 \cdot 2,7) 2,6\} \cdot 35,5}{\sqrt{3} \cdot 1,0} = 2122,35\ kN$$

$V_{z,pl,Rd} = 2122,35\ kN > V_{z,Ed} = 417,15\ kN$ o.k.

$V_{z,Ed} < 50\%\ V_{z,pl,Rd}$

strig y-y env 69

$$V_{y,pl,Rd} = \frac{A_{vy} \cdot f_y}{\sqrt{3} \cdot \gamma_{M0}} = \frac{\{242 - (64 - 2 \cdot 2,6) \cdot 1,35\}\ 35,5}{\sqrt{3} \cdot 1,0} = 3333,05\ kN$$

(A-hw·tw)

$V_{y,pl,Rd} = 3333,05\ kN > V_{y,Ed} = 180\ kN$ $\quad V_{yEd} < 50\%\ V_{y,pl,Rd}$

odporność wyboczeniowa

$$\lambda_y = \frac{l_{wy}}{i_y} = \frac{810}{26,90} = 30,11$$

$$\bar{\lambda}_y = \frac{30,11}{93,9 \cdot 0,81} = 0,40$$

$h/b > 1,2$ y-y → krzyw. a $\Big\}$ $\chi_y = 0,9528$

$$\lambda_z = \frac{l_{wz}}{i_z} = \frac{810}{6,97} = 116,21$$

$$\bar{\lambda}_z = \frac{116,21}{93,9 \cdot 0,81} = 1,53$$

$h/b > 1,2$ z-z → krzyw. b $\Big\}$ $\chi_z = 0,3314$

zwichrzenie:

$C_1 = 1,132$ $C_2 = 0,459$ $z_g = +h/2 = 32,0\ cm$ $k = k_w = 1,0$

$I_z = 1720\ cm^4$ $I_t = 450\ cm^4$ $I_w = 11\,027\,000\ cm^6$

$L = 810\ cm$ $E = 21000\ kN/cm^2$ $G = 8076\ kN/cm^2$

$$M_{cr} = C_1 \frac{\pi^2 E I_z}{L^2} \left\{ \sqrt{\frac{I_w}{I_z} + \frac{L^2 \cdot G \cdot I_t}{\pi^2 \cdot E \cdot I_z} + (C_2 z_g)^2} - C_2 z_g \right\}$$

$M_{cr} = 132\,239\ kNcm$

$$\bar{\lambda}_{LT} = \sqrt{\frac{W_{pl,y} \cdot f_y}{M_{cr}}} = 1,28 \qquad \frac{h}{b} > 2 \rightarrow \text{krzyw. c } \alpha_a = 0,49$$

$$\Phi_{LT} = 0,5\left[1 + 0,49(1,28 - 0,4) + 0,75 \cdot 1,28^2\right] = 1,33$$

$$\chi_{LT} = \frac{1,0}{1,33 + \sqrt{1,33^2 - 0,75 \cdot 1,28^2}} = 0,48$$

$C_{My} = 0,95$

$C_{Mz} = 0,90$

$C_{MLT} = 0,95$

k_{yy}: $0,953 \leq 0,962$

k_{zy}: $0,989 \geq 0,993$

$k_{yz} = 0,6 \cdot k_{zz} = 0,575$

k_{zz}: $1,005 \leq 0,959$

①

$$\frac{135,0}{\frac{0,9528 \cdot 242 \cdot 35,5}{1,0}} + 0,953 \cdot \frac{913,07 \times 100}{\frac{0,48 \cdot 6136 \cdot 35,5}{1,0}} + 0,575 \frac{4,86 \times 100}{\frac{1200 \cdot 35,5}{1,0}} \leq 1,0$$

$0,016 + 0832 + 0,006 = 0,855 < 1,0$ O.K.

②

$$\frac{135,0}{\frac{0,3314 \cdot 242 \cdot 35,5}{1,0}} + 0,993 \frac{913,07 \times 100}{\frac{0,48 \cdot 6136 \cdot 35,5}{1,0}} + 0,959 \frac{4,86 \times 100}{\frac{1200 \cdot 35,5}{1,0}} \leq 1,0$$

$0,047 + 0867 + 0,011 = 0,926 < 1,0$ O.K.

Profil MSN mostlec ustreza!

MSU – deformacije

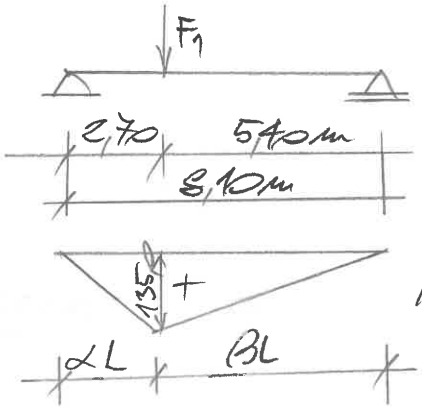
$g = 30\ kN/m^1 \quad q = 25\ kN/m^1$

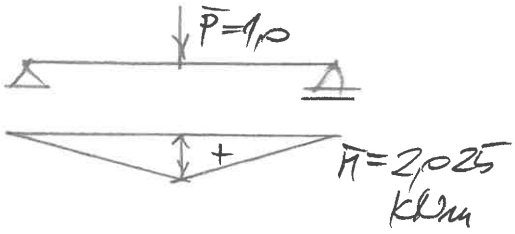
skupna enakomerna obtežba:

$p = g + q = 30 + 25 = 55\ kN/m^1 = 0{,}55\ kN/cm^1$

$$w_p = \frac{5 \cdot p \cdot L^4}{384 \cdot E \cdot J_y} = \frac{5 \cdot 0{,}55 \cdot 810^4}{384 \cdot 21000 \cdot 175200} = 0{,}838\ cm$$

točkovni sili $F_1 = 75{,}0\ kN$:





$M_{F_1} = 135{,}0\ kNm$

$\alpha = 1/3 \qquad \beta = 2/3$

$$w_{F_1} = \frac{\bar{M} \cdot M_{F_1}}{12\beta}\left(3 - 4\alpha^2\right) \cdot \frac{L}{E J_y} = \frac{2025 \cdot 13500}{12 \cdot 2/3}\left(3 - 4 \cdot \left(\tfrac{1}{3}\right)^2\right) \frac{810}{21000 \cdot 175200}$$

$w_{F_1} = 0{,}192\ cm$

2 sili F_1 ustvarita 2-x večjo deformacijo (simetrija)

deformacija celotne nosilne dolžine:

$w = w_p + 2 \cdot w_{F_1}$

$w = 0{,}838 + 2 \cdot 0{,}192 = 1{,}22\ cm < L/200 = \frac{810}{200} = 4{,}05\ cm$

O.K.

ustreza!