ŠOL. L.:	LETNIK:	IME IN PRIIMEK:	PREDMET:	VAJA ŠT.:	LIST ŠT.:
			LK I	7	44

7. VAJA: TORZIJA

7.1. Zasnova:

$i = 42$ (glica - priložen list)

$l_k = 100 - i$ [cm] $= 100 - 42 = 58$ cm

$L = 4{,}0$ m ; $l_1 = 2{,}5$ m ; $l_2 = 1{,}5$ m

$F_g = 2$ kN

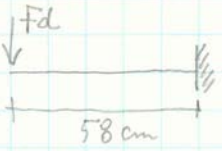
$F_q = 0{,}5 + \frac{i}{20} = 0{,}5 + \frac{42}{20} = 2{,}6$ kN

les C 30 M

vijaki S 235

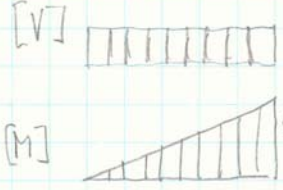
7.2. Dimenzioniranje konzole

$F_d = 1{,}35 \cdot F_g + 1{,}5 \cdot F_q = 1{,}35 \cdot 2$ kN $+ 1{,}5 \cdot 2{,}6$ kN $= 6{,}6$ kN



$V_d = F_d = 6{,}6$ kN

$M_d = F_d \cdot l_k = 6{,}6 \cdot 58 = 382{,}8$ kNcm



- kontrola upogibnih napetosti:

$$\sigma_{md} = \frac{M_d}{\frac{b \cdot h^2}{6}} \leq f_{md} = 1{,}846 \text{ kN/cm}^2 \rightarrow \text{IZBEREM } b = 12 \text{ cm}$$

$$h = \sqrt{\frac{M_d \cdot 6}{b \cdot f_{md}}} = \sqrt{\frac{382{,}8 \cdot 6 \text{ kNcm cm}^2}{12 \text{ cm } 1{,}846 \text{ kN}}} = 10{,}18 \rightarrow \text{IZBEREM}$$

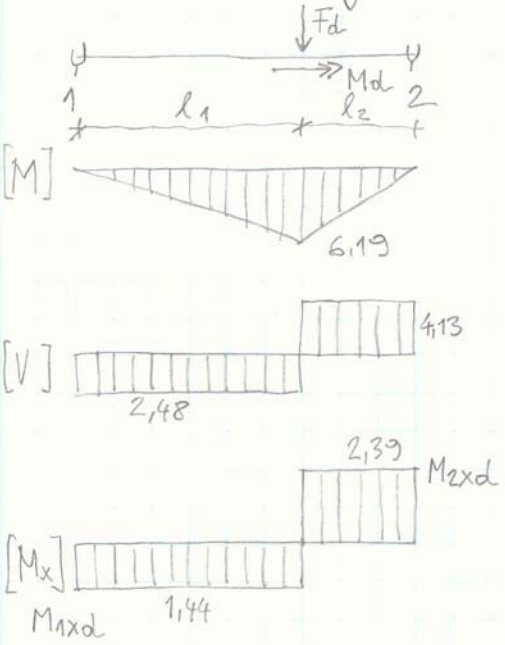
$b/h = 12/12$ cm

- kontrola strižnih napetosti:

$$\tau_{od} = \frac{V_d}{\frac{2}{3} b h} \leq f_{vd} = 0{,}185 \text{ kN/cm}^2$$

$$\tau_{od} = \frac{6{,}6}{\frac{2}{3} \cdot 12 \text{ cm} \cdot 12 \text{ cm}} = 0{,}069 \frac{\text{kN}}{\text{cm}^2} < f_{vd} \checkmark \text{ PREREZ USTREZA}$$

7.3 Dimenzioniranje izdobženega nosilca



$$M_{d,max} = F_d \cdot \frac{l_1 \cdot l_2}{L} = 6,6 \cdot \frac{2,5 \cdot 1,5}{4} = 6,19\ kNm$$

$$V_{1d} = F_d \cdot \frac{l_2}{L} = 6,6 \cdot \frac{1,5}{4} = 2,48\ kN$$

$$V_{2d} = F_d \cdot \frac{l_1}{L} = 6,6 \cdot \frac{2,5}{4} = 4,13\ kN$$

$$M_{xd} = F_d \cdot l_k = 6,6 \cdot 0,58 = 3,83\ kNm$$

$$M_{1xd} = M_{xd} \cdot \frac{l_2}{L} = 3,83 \cdot \frac{1,5}{4} = 1,44\ kNm$$

$$M_{2xd} = M_{xd} \cdot \frac{l_1}{L} = 3,83 \cdot \frac{2,5}{4} = 2,39\ kNm$$

- Kontrola upogibnih napetosti:

$$\sigma_{md} = \frac{M_d}{\frac{b h^2}{6}} \leq f_{md} = 1,846\ kN/cm^2 \qquad b = h$$

$$h = \sqrt[3]{\frac{M_d \cdot 6}{f_{md}}} = \sqrt[3]{\frac{6,19 \cdot 100 \cdot 6}{1,846}} = 12,62\ cm$$

Izberem $b/h = 14/14$ cm

- Kontrola strižnih napetosti:

$$\frac{\tau_d(V_{2d})}{f_{vd}} + \frac{\tau_{tor,d}(M_{2xd})}{k_{shape} \cdot f_{vd}} \leq 1$$

$$\frac{0,032}{0,185} + \frac{0,444}{1,15 \cdot 0,185} = 2,26 \leq 1\ //$$

$$\tau_d(V_{2d}) = \frac{V_{2d}}{\frac{2}{3} b \cdot h} = \frac{4,13}{\frac{2}{3} \cdot 14^2} = 0,032\ kN/cm^2$$

$$\tau_{tor,d}(M_{2xd}) = \frac{M_{2xd}}{W_{t1}} = \frac{2,39 \cdot 100}{538,78} = 0,444\ kN/cm^2$$

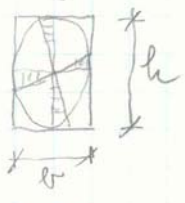
$$W_{t1} = \frac{\pi b^2 h}{16} = \frac{\pi \cdot 14^3}{16} = 538,78\ cm^3$$

$$k_{shape} = \min \begin{cases} 1 + 0,15 \frac{h}{b} = 1 + 0,15 = \underline{1,15} \\ 2,0 \end{cases}$$

→ preveč → Izbira novih dimenzij ($\tau_d(V_{2,d})$ zanemarimo):

$$W_{t1} = \frac{M_{xd}}{k_{shape} \cdot f_{vd}} = \frac{2,39 \cdot 100}{1,15 \cdot 0,185} = 1123,4\ cm^3$$

$$b = \sqrt[3]{\frac{16 \cdot W_{t1}}{\pi}} = \sqrt[3]{\frac{16 \cdot 1123,4}{\pi}} = 17,9\ cm \rightarrow \text{Izberem } b/h = \underline{20/20\ cm}$$



- Ponovna kontrola strižnih napetosti:

$$\frac{\frac{4,13}{\frac{2}{3} \cdot 20^2}}{0,185} + \frac{\frac{2,39 \cdot 100}{\frac{\pi \cdot 20^3}{16}}}{1,15 \cdot 0,185} = 0,084 + 0,715 = 0,799 \leq 1\ \checkmark$$

7.4 Izračun povesa pod silo F;

$F_g = 2{,}0\ kN$ $\quad M_{xg} = F_g \cdot l_k = 2{,}0 \cdot 0{,}58 = 1{,}16\ kNm$

$F_q = 2{,}6\ kN$ $\quad M_{xq} = F_q \cdot l_k = 2{,}6 \cdot 0{,}58 = 1{,}51\ kNm$

$l_1 = 2{,}5m$; $l_2 = 1{,}5m$; $L = 4{,}0m$; $l_k = 0{,}58m$; $E_{0,mean} = 1200 \frac{kN}{cm^2}$

$J_m = \frac{20 \cdot 20^3}{12} = 13333{,}3\ cm^4$ $\quad G = 75 \frac{kN}{cm^2}$

① POMIK NOSILCA (w_1)

$w_{inst} = w_{inst}(F_g) + w_{inst}(F_q) = \frac{(F_g+F_q) \cdot l_1^2 \cdot l_2^2}{3 \cdot E_{0,mean} \cdot J \cdot L} = \frac{(2+2{,}6) \cdot 250^2 \cdot 150^2}{3 \cdot 1200 \cdot 13333{,}3 \cdot 400} =$

$k_{def} = 0{,}8$; $\psi_2 = 0{,}6$

$= 0{,}34\ cm \leq w_{inst,lim} = \frac{L}{300} = \frac{400}{300} = 1{,}33\ cm$ ✓ (1+0,8)

$w_{net,fin} = w_{inst,g}(1+k_{def}) + w_{inst,q}(1+\psi_2 \cdot k_{def}) = 0{,}34 \cdot \frac{F_g}{F_g+F_q} \cdot (1+0{,}8) + 0{,}34 \cdot \frac{F_q}{F_g+F_q} \cdot (1+0{,}6 \cdot 0{,}8)$

$= 0{,}148 \cdot 1{,}8 + 0{,}192 \cdot 1{,}48$

$= 0{,}551\ cm \leq w_{net,fin,lim} = \frac{L}{250} = \frac{400}{250} = 1{,}6\ cm$ ✓

② POMIK KONZOLE ($w_2 + w_3$)

– POMIK ZARADI ZASUKA NOSILCA (w_2)

$M_{x1g} = M_{xg} \cdot \frac{l_2}{L} = 1{,}16 \cdot \frac{1{,}5}{4{,}0} = 0{,}435\ kNm$

$M_{x1q} = M_{xq} \cdot \frac{l_2}{L} = 1{,}51 \cdot \frac{1{,}5}{4{,}0} = 0{,}566\ kNm$

$tg\,\vartheta_g = \frac{M_{x1g} \cdot l_1}{G \cdot J_t} = \frac{0{,}435 \cdot 100 \cdot 250}{75 \cdot 15708} = 0{,}009$

$tg\,\vartheta_q = \frac{M_{x1q} \cdot l_1}{G \cdot J_t} = \frac{0{,}566 \cdot 100 \cdot 250}{75 \cdot 15708} = 0{,}012$

$J_t = \frac{\pi \cdot h^3 b^3}{16(h^2+b^2)} = \frac{\pi \cdot 20^3 \cdot 20^3}{16 \cdot (20^3+20^3)} = 15708\ cm^4$

$w_{inst}(ZASUK) = l_k \cdot tg\,\vartheta = l_k \cdot (tg\,\vartheta_g + tg\,\vartheta_q) = 0{,}58 \cdot 100 \cdot (0{,}009 + 0{,}012) = 1{,}22\ cm$

– POMIK ZARADI UPOGIBA KONZOLE (w_3):

$w_{inst}(UPOGIB) = \frac{(F_g+F_q) \cdot l_k^3}{3\,E_{0,mean} \cdot J_k} = \frac{(2+2{,}6) \cdot 58^3}{3 \cdot 1200 \cdot \frac{12^4}{12}} = 0{,}14\ cm$

$w_{inst} = w_{inst}(ZASUK) + w_{inst}(UPOGIB) = 1{,}22 + 0{,}14 = 1{,}36\ cm \leq w_{inst,lim} = \frac{l_k}{150} = \frac{58}{150} = 0{,}39\ cm$ //

$w_{net,fin} = w_{inst,g}(1+k_{def}) + w_{inst,q} \cdot (1+\psi_2 \cdot k_{def})$

$k_{def} = 0{,}8$; $\psi_2 = 0{,}6$ (stavbe, kjer se zbirajo ljudje)

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$$w_{net,fin} = \left(l_k \cdot tg\theta_g + \frac{T_g \cdot l_2^3}{3 \cdot E_{0,mean} \cdot J_2}\right) \cdot (1 + k_{def}) +$$

$$+ \left(l_k \cdot tg\theta_2 + \frac{T_2 \cdot l_k^3}{3 \cdot E_{0,mean} \cdot J_2}\right) \cdot (1 + \psi_2 \cdot k_{def}) =$$

$$= \left(58 \cdot 0{,}009 + \frac{2 \cdot 58^3}{3 \cdot 1200 \cdot \frac{12^4}{12}}\right) \cdot (1 + 0{,}8) +$$

$$+ \left(58 \cdot 0{,}012 + \frac{2{,}6 \cdot 58^3}{3 \cdot 1200 \cdot \frac{12^4}{12}}\right) \cdot (1 + 0{,}6 \cdot 0{,}8) =$$

$$= 0{,}585 \cdot 1{,}8 + 0{,}778 \cdot 1{,}48 = 2{,}20\ cm \leq w_{net,fin,lim} =$$

$$= \frac{l_2}{125} = \frac{58}{125} = 0{,}46\ cm \ //$$

→ POVEČATI PREREZ (NAJUČINKOVITEJŠE PREREZ NOSILCA)

OPOMBA: V splošnem je potrebno preveriti tudi končni skupni pomik – konstrukcijsko zahtevane omejitev pomika.

$w_1 + w_2 + w_3$

$$u_{net,fin} = u_{net,fin}(NOSILCA) + u_{net,fin}(KONZOLE) =$$

$$= 0{,}551\ cm + 2{,}20\ cm = 2{,}751\ cm$$

7.5. DIMENZIONIRANJE PRIKLJUČKOV (konzole na vzdolžnici)

Ni potrebno