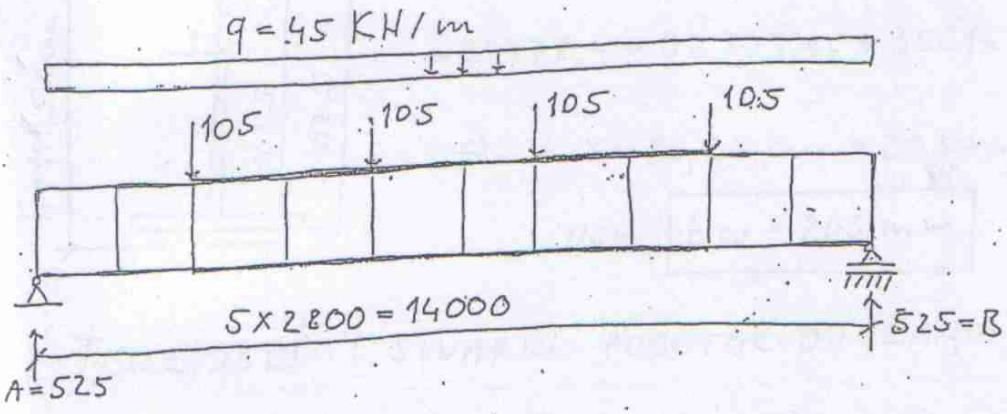
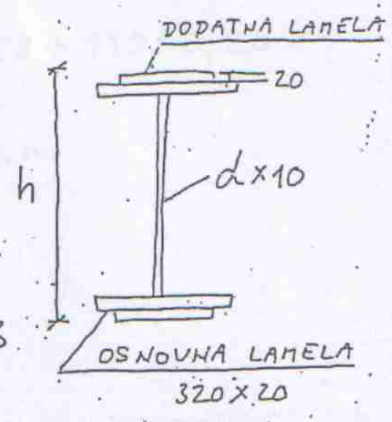
17. JANUAR 2005





Č. 0361 → S235 } ⇒ $\sigma_{dop} = 16\ KN/cm^2$ $f_{dop} = L/500 = 2,8\ cm$

I SL. OPT. $\tau_{dop} = 9\ KN/cm^2$

a) VISINA h ZA ISTOVREMENO ISKORIŠĆENJE NORMALNOG NAPONA I UGIBA U SREDINI NOSAČA

$$A = B = \frac{1}{2}(105 \cdot 4 + 45 \cdot 14) = 525\ KN$$

$$M = M_{max} = 525 \cdot 7 - 105 \cdot (2,8 + 1,4 + 1,4) - 45 \cdot \frac{7^2}{2} = 1984,5\ KNm$$

$$W_{otp} = \frac{M}{\sigma_{dop}} = \frac{1984,5 \cdot 10^2}{16} = 12403,13\ cm^3 = \frac{I_x}{h/2} \Rightarrow I_x = 6201,6h$$

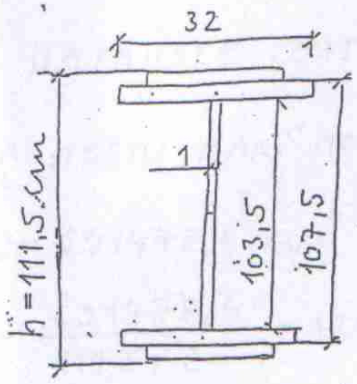
$$f_1 = \frac{5}{384}\frac{q\ell^4}{EI} \qquad f_2 = \frac{F \cdot \ell^3}{15,87\,EI} \qquad f = f_1 + f_2$$

$$2,8 = \frac{5}{384} \cdot \frac{45 \cdot 10^{-2} \cdot (1400)^4}{21000\,I} + \frac{105 \cdot (1400)^3}{15,87 \cdot 21000\,I} \Rightarrow 2,8 = \frac{1071875}{I} + \frac{864524,3}{I}$$

$$2,8 = \frac{1071875 + 864524,3}{6201,6h} \Rightarrow h = 111,51 \quad USV.\ \boxed{h = 111,5\ cm}$$

POTREBNA ŠIRINA LAMELA AKO IM JE DEBLJINA 20 mm?

$$I_x = 6201,6h = 6201,6 \cdot 111,5 = 691478,4\ cm^4$$



$$I_x = \frac{1}{12}\cdot 1\cdot 103{,}5^3 + 2\cdot\left(52{,}75^2\cdot 32\cdot 2 + 54{,}75^2\cdot x\cdot 2\right)$$

$$691478{,}4 = 92393{,}16 + 356168 + 11990{,}25x$$

$$\Rightarrow \quad x = 20{,}26\ cm = 203\ mm$$

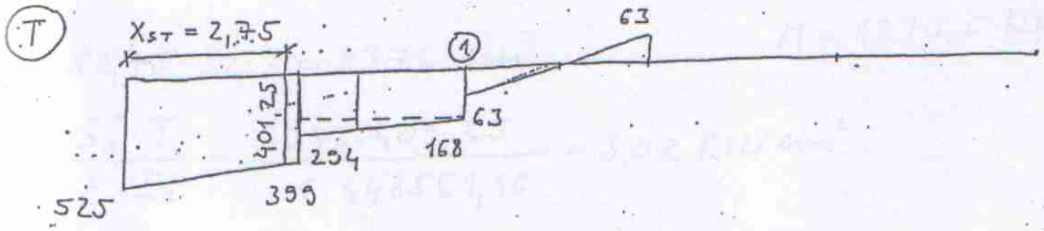
USV. $\boxed{b_{fd} = 205\ mm}$

c) TEORIJSKI I STVARNI POČETAK OJAČANJA

OSNOVNI PRESEK: $I_x = \frac{1}{12}\cdot 103{,}5^3 + 2\cdot\left(52{,}75^2\cdot 32\cdot 2\right) = 448561{,}16\ cm^4$

$$W_{OSN} = \frac{I_x}{h/2} = \frac{448561{,}16}{107{,}5/2} = 8345{,}32\ cm^3$$

$$\sigma_{dop} = 16 = \frac{M}{W_{OSH}} \Rightarrow M = 16\cdot 8345{,}32\cdot 10^{-2} = 1335{,}25\ KNm$$



$$\frac{525+399}{2}\cdot 2{,}8 = 1293{,}6 + 168\cdot x + \frac{126+126+45\cdot x}{2}\cdot x = 1335{,}25$$

$$\Rightarrow \quad 1293{,}6 + 168x + 126x - 22{,}5x^2 = 1335{,}25$$

$$x^2 - 13{,}067x + 1{,}851 = 0 \Rightarrow x_{1,2} = \frac{13{,}067 \pm \sqrt{13{,}067^2 - 4\cdot 1{,}85}}{2} = \begin{cases} 12{,}92\ m \\ 0{,}14\ m \end{cases}$$

$x_{1TE} = 2{,}8 + 0{,}14 = 2{,}94\ m \qquad X_{2TE} = 11{,}06\ m$

$x_{1ST} = 2{,}94 - \frac{0{,}32}{2} = 2{,}78\ m \qquad X_{2ST} = 11{,}06 + \frac{0{,}32}{2} = 11{,}22\ m$

USVAJA SE $\boxed{X_{1ST} = 2{,}75\ m \ \text{ i } \ X_{2ST} = 11{,}25\ m}$

d) NAPONSKE KONTROLE U KARAKTERISTIČNIM PRESECIMA

- NA MESTU MAX. MOMENTA. ($\max M = 1984,5$ KNm, $T_{odg} = 0$)

$I_x = 691478,4$ cm^4

$W = \frac{691478,4}{111,5/2} = 12403,2$ cm^3

$\sigma = \frac{\max M}{W} = \frac{1984,5 \cdot 10^2}{12403,2} = 16$ KN/cm^2 $= \sigma_{dop}$

- NA MESTU T_{max} ($T_{max} = 525$ KN, $M = 0$)

$\max \tau = \frac{T_{max} \cdot S_x}{t \cdot I_x}$

$S_x = 52,75 \cdot 2 \cdot 32 + 51,75 \cdot 1 \cdot \frac{51,75}{2} = 4715$ cm^3

$I_x = 448561,16$ cm^4

$\max \tau = \frac{525 \cdot 4715}{1 \cdot 448561,16} = 5,52$ KN/cm^2 $< \tau_{dop}$

- NA MESTU OJAČANJA ($T = 401,25$ KN, $M = \frac{401,25 + 525}{2} \cdot 2,75$

$M = 1273,6$ KNm)

$= 52,75 \cdot 32 \cdot 2 = 3376$ cm^3

$\frac{S_x \cdot T}{t \cdot I_x} = \frac{3376 \cdot 401,25}{1 \cdot 448561,16} = 3,02$ KN/cm^2

$\frac{1273,6 \cdot 10^2}{448561,16} \cdot 51,75 = 14,69$ KN/cm^2

$\sqrt{\sigma_1^2 + 3\tau_1^2} = \sqrt{14,69^2 + 3,02^2 \cdot 3} = 15,6$ KN/cm^2 $< \sigma_{dop}$

- NA MESTU TAČKE ① ($T = 168$ KN, $M = \frac{525 + 399}{2} \cdot 2,8 + \frac{294 + 168}{2} \cdot 2,8$

$M = 1940,4$ KNm)

$3376 + 54,75 \cdot 20,5 \cdot 2 = 5620,75$ cm^3

$691478,4$ cm^4

$\frac{5620,75 \cdot 168}{1 \cdot 691478,4} = 1,37$ KN/cm^2

$\frac{1940,4 \cdot 10^2}{691478,4} \cdot 51,75 = 14,52$ KN/cm^2

$\sigma_u = \sqrt{\tau_1^2 \cdot 3 + \sigma_1^2} = 14,71$ KN/cm^2 $< \sigma_{dop}$

e) KONTROLA NOSAČA NA BOČNO TORZIONO IZVIJANJE

(GORNJI POJAS JE BOČNO PRIDRŽAN U PETINAMA RASPONA)

$$I_y = \frac{1}{12} \cdot 2 \cdot 32^3 + \frac{1}{12} \cdot 2 \cdot 20{,}5^3 = 6897{,}19 \text{ cm}^4$$

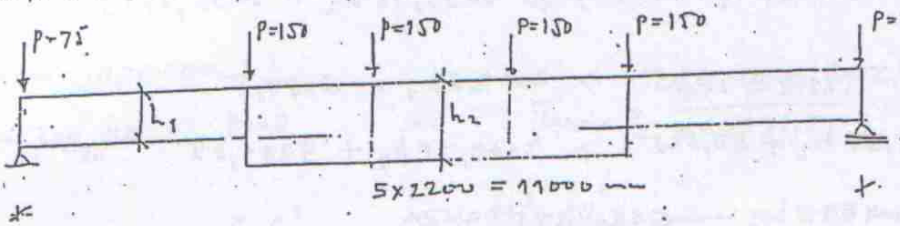
$$A_t = 2 \cdot (20{,}5 + 32) = 105 \text{ cm}^2$$

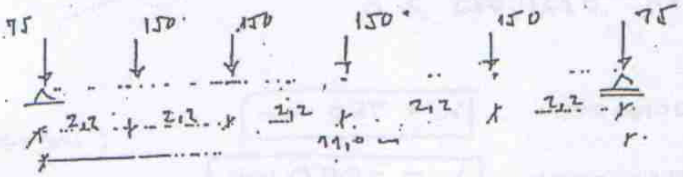
$$i_y = \sqrt{\frac{I_y}{F}} = \sqrt{\frac{6897{,}19}{105}} = 8{,}11 \text{ cm} \qquad l_z = 2{,}8 \text{ m} = 280 \text{ cm}$$

$$\lambda_y = \frac{l_y}{i_y} = \frac{280}{8{,}11} = 34{,}52 < 40 \Rightarrow$$ NEMA OPASNOSTI OD BOČNO TORZIONOG IZVIJANJA

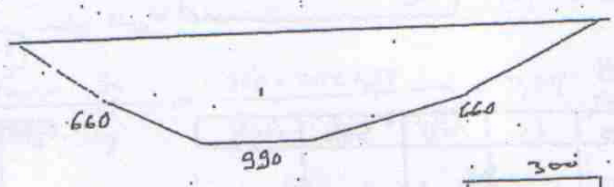
08.07.2002.

Носач статичког система просте греде распона 11,0 m оптерећен је системом концентрисаних сила као што је приказано на слици. Носач је применљиве висине са ножицама 300 x 15 mm и ребром дебљине 10 mm. Одредити висине ребра h_1 и h_2 и извршити све потребне напонске контроле у карактеристичним пресецима: димензионисати угаоне шавове за везу ножица и ребра. Извршити контролу угиба ($f_{dop} = l/300$) и контролу стабилности ребра на избочавање у пољу. За основни материјал Č.0361 ($\sigma_{dop} = 160$ MPa) — I случај оптерећења.

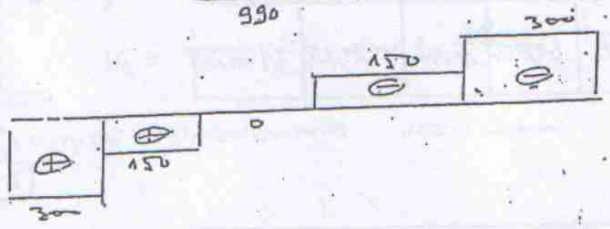




(M) [kNm]



(T) [kN]



Одређивање h_1 и h_2:

(1) $\sigma = \frac{M^1_{max}}{W^1_y} \leq 16 \Rightarrow \frac{M^1_{max}}{I^1_y} \cdot \frac{h_1}{2} \leq 16$

(2) $\sigma = \frac{M^2_{max}}{W^2_y} \leq 16 \Rightarrow \frac{M^2_{max}}{I^2_y} \cdot \frac{h_2}{2} \leq 16$

$I^1_y = \frac{1}{12} h_1^3 + 90 (0,5 h_1 + 0,75)^2$

$I^2_y = \frac{1}{12} h_2^3 + 90 (0,5 h_2 + 0,75)^2$

$I^1_y = \frac{1}{12} h_1^3 \cdot 1 + 2 \cdot 30,0 \cdot 1,5 \cdot \left(\frac{h_1 + 1,5}{2}\right)^2$

$I^2_y = \frac{1}{12} h_2^3 \cdot 1 + 2 \cdot 30,0 \cdot 1,5 \cdot \left(\frac{h_2 + 1,5}{2}\right)^2$

$W(h) = \frac{I(h)}{\frac{h+3}{2}}$

$\sigma = \frac{M_{max}}{W}$

$W(h) \geq W_{dop}$

5

$W(h_1) \geq W^1_{потр.} \Rightarrow \dfrac{I(h_1)}{\frac{h_1+3}{2}} \geq \dfrac{660\cdot 10^2}{16}$

$W(h_2) \geq W^2_{потр.} \Rightarrow \dfrac{I(h_2)}{\frac{h_2+3}{2}} \geq \dfrac{990\cdot 10^2}{16}$

$I(h_1) \geq 4125\cdot\dfrac{h_1+3}{2} \Rightarrow \frac{1}{12}h_1^3 + 90\cdot(0,5h_1+0,75)^2 \geq 2062,5(h_1+3)$

$I(h_2) \geq 6187,5\cdot\dfrac{h_2+3}{2} \Rightarrow \frac{1}{12}h_2^3 + 90\cdot(0,5h_2+0,75)^2 \geq 3093,75(h_2+3)$

$\frac{1}{12}h_1^3 + 90((0,5h_1)^2 + 2\cdot 0,75\cdot 0,5h_1 + 0,75^2) \geq 2062,5h_1 + 2062,5\cdot 3$

$\frac{1}{12}h_2^3 + 90((0,5h_2)^2 + 2\cdot 0,75\cdot 0,5h_2 + 0,75^2) \geq 3093,75h_2 + 3093,75\cdot 3$

$\frac{1}{12}h_1^3 + 22,5h_1^2 + 67,50h_1 + 50,625 \geq 2062,5h_1 + 6187,5$

$\frac{1}{12}h_2^3 + 22,5h_2^3 + 67,50h_2 + 50,625 \geq 3093,75h_2 + 9281,25$

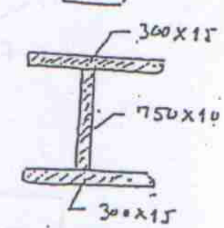
$\frac{1}{12}h_1^3 + 22,50h_1^2 - 1995h_1 - 6136,875 \geq 0$

$\frac{1}{12}h_2^3 + 22,50h_2^2 - 3026,25h_2 - 9230,625 \geq 0$

$h_1 \geq 72,79$ cm $\Rightarrow$ усвоено $h_1 = 750$ mm

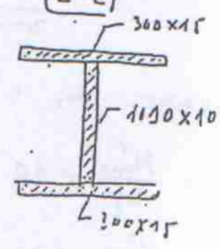
$h_2 \geq 100,87$ cm $\Rightarrow$ усвоено $h_2 = 1050$ mm

1-1



A	I_y	I_z	W_y	W_z	i_y	i_z	$S_{y,0}$	S_y
165	166831,87	6750	4277,74	450	31,80	6,40	1721,25	2424,37

2-2



A	I_y	I_z	W_y	W_z	i_y	i_z	$S_{y,0}$	S_y
191	322249,04	6750	6197,10	450	41,07	5,94	2306,25	3581,37

на плоча:

$\sigma = \dfrac{M_{max}}{W} = \dfrac{660\cdot 10^2}{4277,74} = 15,43 \frac{kN}{cm^2} < 16,0 \frac{kN}{cm^2}$

$\tau^{1-1}_{max,1} = \dfrac{T_{max}\cdot S_y}{I_y\cdot t_w} = \dfrac{300\cdot 2424,37}{166831,87\cdot 1} = 4,36 < 9$

$\sigma_1 = \dfrac{M_{max}}{I_y}\cdot\dfrac{d}{2} = \dfrac{660\cdot 10^2}{166831,87}\cdot\dfrac{75}{2} = 14,83 \frac{kN}{cm^2}$

$\tau_1 = \dfrac{T_{max}\cdot S_{y,0}}{I_y\cdot t_w} = \dfrac{300\cdot 1721,25}{166831,87\cdot 1} = 3,09$

$\sqrt{\sigma_1^2 + 3\tau_1^2} = 15,77 \frac{kN}{cm^2}$

$\sigma_{max}^{2-2} = \frac{M_{max}}{W} = \frac{990 \cdot 10^2}{6197,10} = 15,97 \frac{kN}{cm^2} < 16,0 \frac{kN}{cm^2}$

$\tau_{max}^{2-2} = \frac{T_{max} \cdot S_y}{I_y \cdot t_w} = \frac{150 \cdot 3581,37}{322249,04 \cdot 1} = 1,67 \frac{kN}{cm^2} < 9,0 \frac{kN}{cm^2}$

$\sigma_1 = \frac{M_{max}}{I_y} \cdot \frac{d}{2} = \frac{990 \cdot 10^2}{322249,04} \cdot \frac{101}{2} = 15,51 \frac{kN}{cm^2}$

$\tau_1 = \frac{T_{max} \cdot S_{y,1}}{I_y \cdot t_w} = \frac{150 \cdot 2306,25}{322249,04 \cdot 1} = 1,073 \frac{kN}{cm^2}$

$\sigma_{cu} = \sqrt{\sigma_1^2 + 3\tau_1^2} = 15,62 \frac{kN}{cm^2} < 16,0 \frac{kN}{cm^2}$

ослабчен пресек:

$T_{max} = 300 kN, \quad M = 0 \Rightarrow \quad \tau_{max} = \frac{300 \cdot 2424,37}{166831,87 \cdot 1} = 4,36 \frac{kN}{cm^2} < 9,0 \frac{kN}{cm^2}$

УГИБ: $f = \frac{F \cdot \ell^3}{(K_j) EI} = \frac{150 \cdot 11^3 \cdot 10^6}{15,87 \cdot 21000 \cdot 166831,87} = 3,59 cm < f_{dop} = \frac{1100}{3} = 3,67$

Збирка 869

УГАОНИ ШАВОВИ:

претпоставка $min\ a_w = 3 mm$ — книга стр. 288

$\tau_{max} = \frac{T_{max} \cdot S_y}{2 \cdot a_w \cdot I_y} = \frac{300 \cdot 2424,37}{2 \cdot 0,3 \cdot 166831,87} = 7,27 \frac{kN}{cm^2}$

$\tau = \tau_{max} \Rightarrow V_H = 7,27 \frac{kN}{cm^2} < 12 \frac{kN}{cm^2} \Rightarrow$ УСВАЈАМ $a_w = 3 mm$

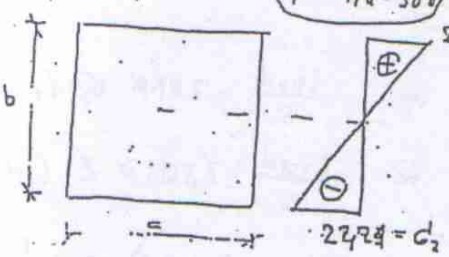
ЗБОГ СЕ ОСТВАРУЈЕ ШАВОВИМА од 3 mm И ГОРЕ И ДОЛЕ!

Контрола вертикалног ребра

Класа стр. 585

$a = 2200$ mm
$b = 750$ mm
$\alpha = \frac{a}{b} = 2{,}933$

$M^* = 1{,}5 \cdot 660$
$T^* = 1{,}5 \cdot 306$ — поједрисана сила



$K_\tau = 5{,}34 + \frac{4}{\alpha^2} \Rightarrow \boxed{K_\tau = 5{,}80}$

$\sigma = \frac{M^*}{I_y} \cdot \frac{b}{2} = \frac{1{,}5 \cdot 660 \cdot 10^2}{166831{,}87} \cdot \frac{75}{2} = 22{,}24 \ kN/cm^2$

$\psi = \frac{\sigma_1}{\sigma_2} = \frac{22{,}24}{-22{,}24} = -1 \Rightarrow \boxed{K_\sigma = 23{,}9}$

$K_\sigma = 5{,}98(1-\psi)^2 = 5{,}91 \cdot 4 = 23{,}92$

$\sigma_e = \frac{\pi^2 \cdot E}{12(1-\mu^2)} \left(\frac{t_w}{b}\right)^2 = \frac{\pi^2 \cdot 21000}{12(1-0{,}3^2)} \cdot \left(\frac{1}{75}\right)^2 = 3{,}37$

$\sigma_{kr} = K_\sigma \cdot \sigma_e = 23{,}9 \cdot 3{,}37 = 80{,}54 \ \frac{kN}{cm^2}$

$\bar\lambda_p = \sqrt{\frac{f_y}{\sigma_{kr}}} = \sqrt{\frac{24}{80{,}54}} = 0{,}546 \Rightarrow \chi_p = \frac{0{,}6}{\sqrt{\bar\lambda_p^2 - 0{,}13}} = 1{,}464 \quad \chi_p = \min(\chi_p, 1) = 1$

$K_\sigma \cdot \alpha^2 = 23{,}9 \cdot 2{,}933^2 > 1 \Rightarrow$ Није испуњен услов чистог избочавања $\underline{f = 0}$

$\bar\sigma_u = (1-f^2) \cdot \chi_p + f^2 \cdot \bar\sigma_c^{\,0} \Rightarrow \bar\sigma_u = \chi_p = 1$

$C_\sigma = 1{,}25 - \psi \cdot 0{,}25 = 1{,}50 > 1{,}25 \Rightarrow C_\sigma = 1{,}25$

$\sigma_u = C_\sigma \cdot \bar\sigma_u \cdot f_y = 1{,}25 \cdot 1 \cdot 24 = 30 \ \frac{kN}{cm^2} = \sigma_{u,dop}$

$\sigma^I = 22{,}24 < \sigma_{u,dop} = 30 \ \frac{kN}{cm^2} \Rightarrow$ стабилност задовољена

$\tau_{kr} = K_\tau \cdot \sigma_e = 5{,}80 \cdot 3{,}37 = 19{,}55 \ \frac{kN}{cm^2}$

$\bar\lambda_p = \sqrt{\frac{f_y}{\sqrt{3}\,\tau_{kr}}} = \sqrt{\frac{24}{\sqrt{3} \cdot 19{,}55}} = 0{,}842 \Rightarrow \chi_p = \frac{0{,}6}{\sqrt{\bar\lambda_p^2 - 0{,}13}} = 0{,}788 < 1$

$\tau_u = C_\tau \cdot \chi_p \cdot \frac{f_y}{\sqrt{3}} = 1{,}25 \cdot 0{,}788 \cdot \frac{24}{\sqrt{3}} = 13{,}65 \ \frac{kN}{cm^2}$

$\tau_{u,dop} = \min\left(\tau_u, \frac{f_y}{\sqrt{3}}\right) \Rightarrow \tau_{u,dop} = 13{,}65 \ \frac{kN}{cm^2}$

$\tau^I = \frac{T^*}{h \cdot t_w} = \frac{1{,}5 \cdot 306}{75 \cdot 1} = 6 \ \frac{kN}{cm^2}$

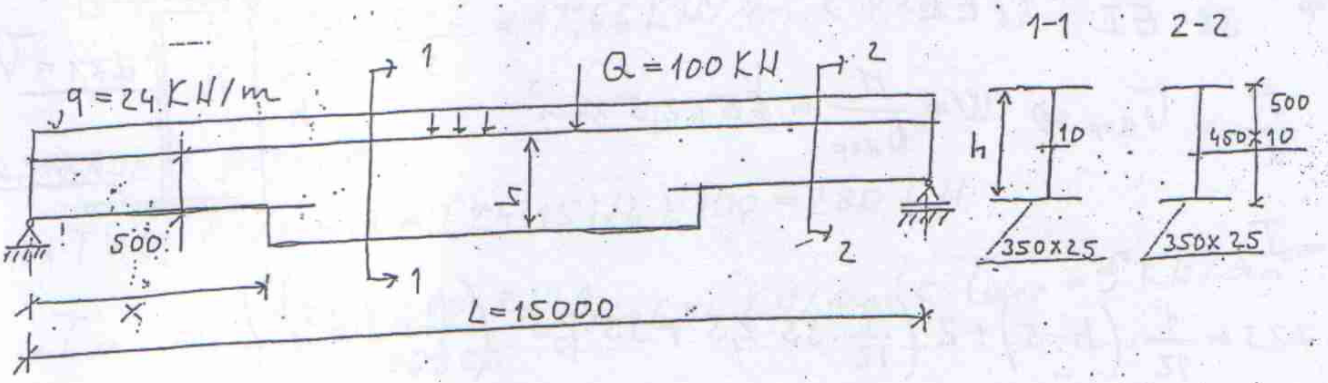
$\tau^I = 6 < \tau_{u,dop} = 13{,}65 \ \frac{kN}{cm^2} \Rightarrow$ стабилност НЕ задовољена !

Контрола употребног стања:

$\left(\frac{\sigma^I}{\sigma_u}\right)^2 + \left(\frac{\tau^I}{\tau_u}\right)^2 < 1 \Rightarrow \left(\frac{22{,}24}{30}\right)^2 + \left(\frac{6}{13{,}65}\right)^2 = 0{,}742 < 1$

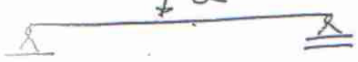
15. APRIL 2006

Q - POKRETNA SILA

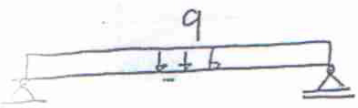


S 235, SL. OPT $\Rightarrow \sigma_{dop} = 16\ KN/cm^2 \quad \tau_{dop} = 9\ KN/cm^2$

$f_{dop} = L/500 = 1500/500 = 3\ cm$



$$M(x) = \frac{Q \cdot (l-x) \cdot x}{l}$$



$$M(x) = \frac{ql}{2} x - \frac{1}{2} q x^2$$

$$\frac{Q}{l} \cdot (l-x) \cdot x + \frac{ql}{2} x - \frac{1}{2} q x^2$$

$$x) = \frac{Q}{l} \cdot (l-2x) + \frac{ql}{2} - qx = 0 \Rightarrow x = 7{,}5\ m \qquad \max M = 1050\ KNm$$

OVNI PRESEK (2-2)

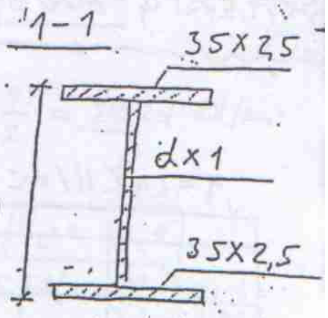
$$= \frac{1}{12} \cdot 45^3 + 2 \cdot 2{,}5 \cdot 35 \cdot 23{,}75^2 = 106305\ cm^4$$

$$= 2{,}5 \cdot 35 \cdot 23{,}75 + \frac{45^2}{8} = 2331\ cm^3$$

$$= 4252\ cm^3$$

$$= W_x \cdot \sigma_{dop} = 4252 \cdot 16 = 680{,}35\ KNm$$

- POTREBNA VISINA NOSAČA h NA SREDINI ($M = 1050\ kNm$)



$$f_{dop} = \frac{5\,q\,l^4}{384\,EI} + \frac{Q\,l^3}{48\,EI} = 3 \Rightarrow I_1 \geq 362723\ cm^4$$

$$\sigma = \frac{M}{W} = \sigma_{dop} \Rightarrow W = \frac{M}{\sigma_{dop}} = 6562{,}5\ cm^3$$

$I_1 = I_2 = \dots$

$$62723 = \frac{1}{12}\cdot(h-5)^3 + 2\cdot\left(\frac{1}{12}\cdot 35\cdot 2{,}5^3 + 35\cdot 2{,}5\cdot\left(\frac{h}{2} - 1{,}25\right)^2\right)$$

$$\Rightarrow \frac{1}{12}\cdot(h-5)^3 + 91{,}146 + 175\cdot\left(\frac{h}{2} - 1{,}25\right)^2 - 362723 = 0$$

$$\frac{1}{12}(h-5)^3 + 175\cdot\left(\frac{h}{2} - 1{,}25\right)^2 - 362631{,}85 = 0 \Rightarrow h \geq 87{,}475\ cm$$

SVAJA SE $\boxed{h = 87{,}5\ cm = 875\ mm}$

$$\left.\begin{aligned} I_x &= 362723\ cm^4 \\ W_x &= 8291\ cm^3 \end{aligned}\right\} (1\text{-}1)$$

TEORIJSKI I STVARNI POČETAK ODAČANJA NOSAČA

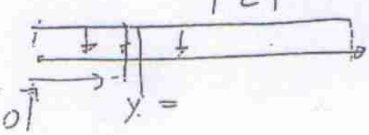
$$0{,}35 = \frac{100}{15}\cdot(15-x)\cdot x + \frac{24\cdot 15}{2}\cdot x - \frac{1}{2}\cdot 24\cdot x^2$$

$$0{,}35 = 100x - \frac{100}{15}x^2 + 180x - 12x^2$$

$$-15x + 36{,}447 = 0 \Rightarrow x_{1,2} = \frac{15 \pm \sqrt{15^2 - 4\cdot 36{,}447}}{2} = \begin{cases} x_1 = 11{,}95\ m \\ x_2 = 3{,}05\ m \end{cases}$$

$x_{STV_1} = 3{,}05 - \frac{0{,}35}{2} = 2{,}875\ m$ USV $\boxed{x_{STV_1} = 2{,}85\ m}$

$x_{V,2} = 11{,}95 + \frac{0{,}35}{2} = 12{,}125\ m$ USV $\boxed{x_{STV_2} = 12{,}15\ m}$



$$x\cdot 280 - 9\cdot x\cdot\frac{x}{2}$$

KONTROLE NAPONA U KARAKTERISTIČNIM PRESECIMA

* SREDINA NOSAČA *

$$\sigma = \frac{M}{W} = \frac{1050 \cdot 10^2}{362723} \cdot \frac{87,5}{2} = 12,66\ KN/cm^2 < \sigma_{dop} = 16\ KN/cm^2$$

* KRAJEVI NOSAČA *

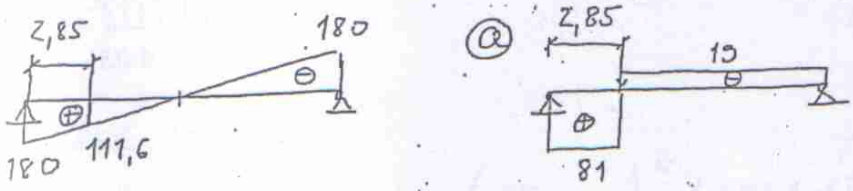
$$\max T = (q \cdot l)/2 + Q = (24 \cdot 15)/2 + 100 = 280\ KN$$

$$\max \tau = \frac{\max T \cdot S_x}{I_x \cdot t_w} = \frac{280 \cdot 2331}{106305 \cdot 1} = 6,14\ KN/cm^2 < \tau_{dop} = 9\ KN/cm^2$$

* MESTO ODSEČAKA *

$$M(2,85) = \frac{100}{15} \cdot (15-2,85) \cdot 2,85 + \frac{24 \cdot 15}{2} \cdot 2,85 - \frac{1}{2} \cdot 24 \cdot 2,85^2 = 646,38\ KNm$$

$$T(2,85) = 111,6 + 81 = 192,6\ KN$$



$$\tau_1 = \frac{646,38 \cdot 10^2}{106305} \cdot 22,5 = 13,68\ KN/cm^2$$

$$\tau_{-1} = \frac{192,6 \cdot 2,5 \cdot 35 \cdot 23,75}{106305 \cdot 1} = 3,77\ KN/cm^2$$

$$\tau_w = \sqrt{13,68^2 + 3 \cdot 3,77^2} = 15,14\ KN/cm^2 < \sigma_{dop} = 16\ KN/cm^2$$

ZADOVOLJENO !!!

UPOREDNI NAPON NA SREDINI NOSAČA *

$$\sigma = \frac{1050 \cdot 10^2}{362723} \cdot 41,25 = 11,94\ KN/cm^2$$

$$\tau = \frac{50 \cdot 2,5 \cdot 35 \cdot 42,5}{362723 \cdot 1} = 0,51\ KN/cm^2$$

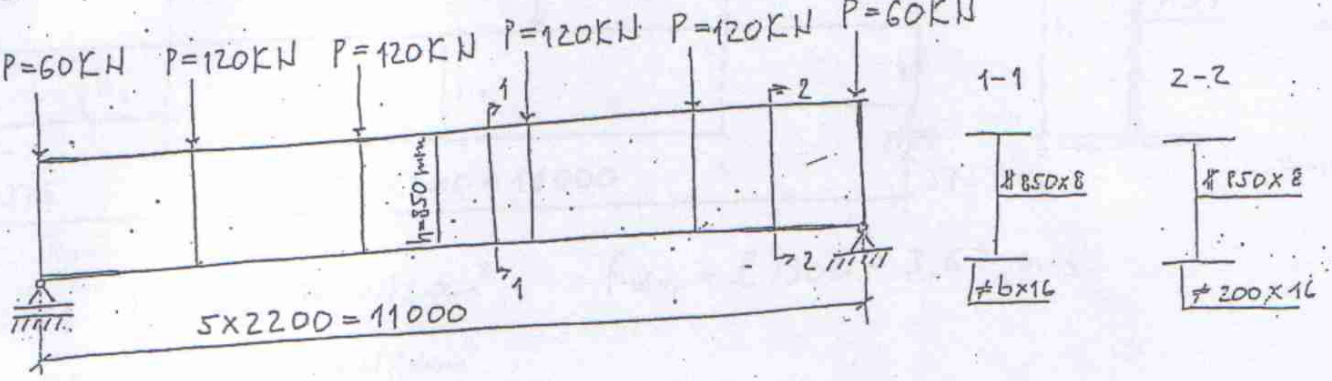
$$\sigma_{red} = \sqrt{11,94^2 + 3 \cdot 0,51^2} = 11,97\ KN/cm^2 < \sigma_{dop}$$

KONTROLA UGIBA NOSAČA

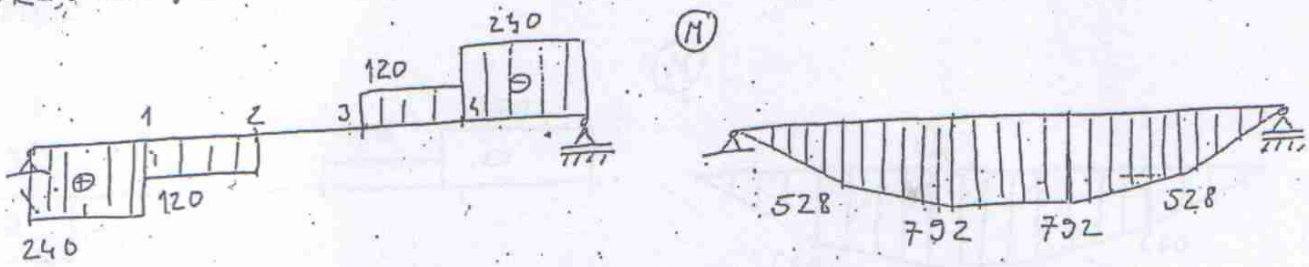
$$= \frac{5 \cdot q \cdot l^4}{384 \cdot EI} + \frac{Q \cdot l^3}{48 EI} = \frac{5 \cdot 24 \cdot 1500^4 \cdot 10^{-2}}{384 \cdot 21000 \cdot 362723} + \frac{100 \cdot 1500^3}{48 \cdot 21000 \cdot 362723} = 3 \text{ cm}$$

19. JAN 2004

1. ZADATAK Č. 0361 I SL. OPT ⇒ $\sigma_{dop} = 16\ KN/cm^2$ $\tau_{dop} = 9$



– ODREĐIVANJE POTREBNE ŠIRINE OJAČANE NOŽICE



PRESEK 1-1

$$I_x = \frac{1}{12}\cdot 85^3\cdot 0{,}8 + 2\cdot b\cdot 1{,}6\left(\frac{85}{2}+0{,}8\right)^2 = 40941{,}67 + 6000b \quad (I_x = 220952\ cm^4)$$

$$W_x = \frac{40941{,}67 + 6000b}{44{,}1} = 928{,}38 + 136{,}05b$$

$$\sigma_{dop} = 16 \geq \frac{max\ M}{W_x} = \frac{792\cdot 100}{928{,}38 + 136{,}05b} \Rightarrow b \geq 29{,}56\ cm$$

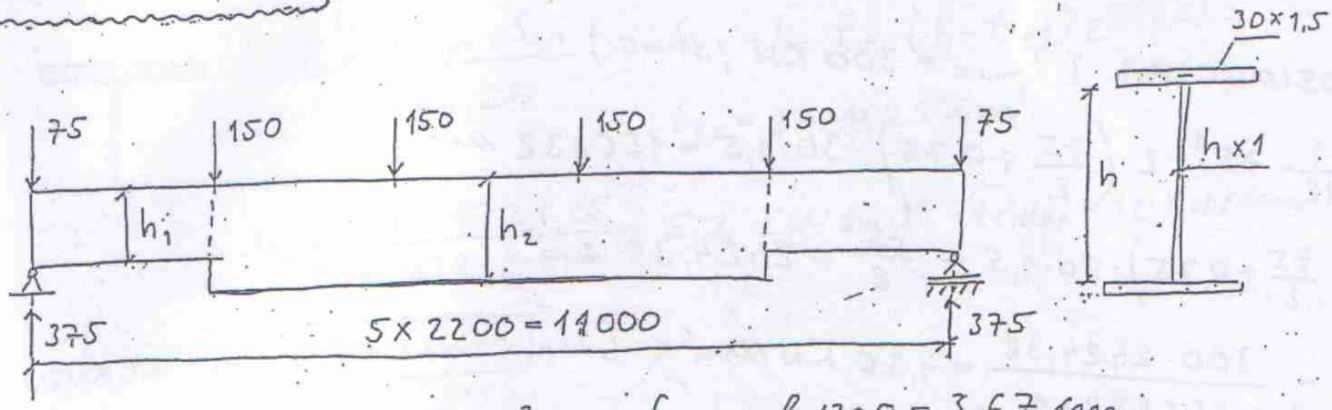
USVAJA SE ≠ 300 x 16 ($\sigma = 15{,}81\ KN/cm^2$)

$$S_x = \frac{85}{2}\cdot 0{,}8\cdot\frac{85}{4} + 30\cdot 1{,}6\cdot\left(\frac{85}{2}+0{,}8\right) = 2801\ cm^3$$

$$\tau = \frac{T\cdot S_x}{I_x\cdot t_w} = \frac{120\cdot 2801}{220952\cdot 0{,}8} = 1{,}9\ KN/cm^2 < \tau_{dop} = 9\ KN/cm^2$$

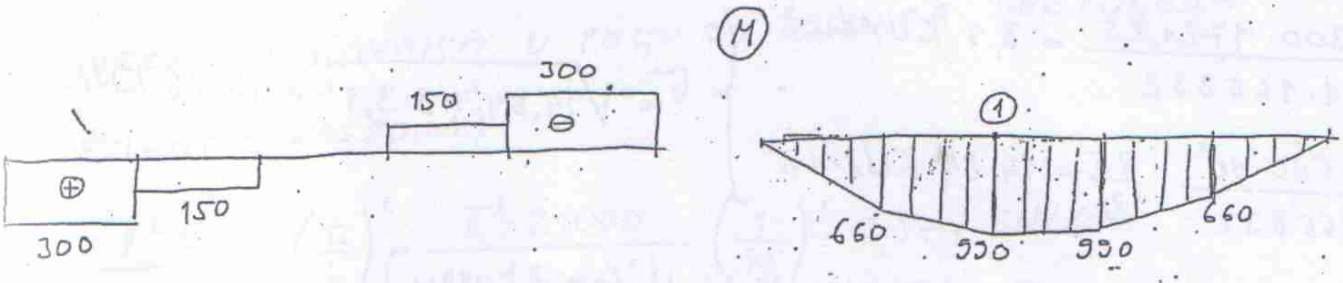
$$\sigma_u = \sqrt{\sigma^2 + 3\tau^2} = \sqrt{15{,}81^2 + 3\cdot 1{,}9^2} \cong 16\ KN/cm^2$$

8. JUL. 2002



Č 0361 } $\sigma_{dop} = 16\ KN/cm^2$ $f_{dop} = l/300 = 3,67\ cm$
I SL. OPT. } $\tau_{dop} = 9\ KN/cm^2$

STATIČKI UTICAJI:



$$I = \frac{M}{\sigma_d} \cdot \frac{h_1}{2}$$

$$= \frac{1}{12} \cdot h_1^3 + 2\left(\frac{h_1}{2} + 0,75\right)^2 \cdot 30 \cdot 1,5 = \frac{660 \cdot 10^2}{16}\left(\frac{h_1}{2} + 1,5\right)$$

$$\frac{1}{12} h_1^3 + 90\left(\frac{h_1}{2} + 0,75\right)^2 - 2062,5\, h_1 - 6187,5 = 0$$

$\Rightarrow h_1 = 72,79\ cm$ USVOJENO $\boxed{h_1 = 75\ cm}$ MALO VEĆE ZBOG ZANEMARENIH T SILA

$$= \frac{1}{12} h_2^3 + 2 \cdot \left(\frac{h_2}{2} + 0,75\right)^2 \cdot 30 \cdot 1,5 = \frac{990 \cdot 10^2}{16} \cdot \left(\frac{h_2}{2} + 1,5\right)$$

$$\frac{1}{12} h_2^3 + 90\left(\frac{h_2}{2} + 0,75\right)^2 - 3093,75\, h_2 - 9281,25$$

$h_1 = 100,88\ cm$ USVOJENO $\boxed{h_2 = 101\ cm}$ NIJE VEĆE ZBOG TOGA ŠTO ZA M_{max} $T = 0$

LAPONSKE KONTROLE

D OSLONCIMA ($T_{max} = 300\ KN$, $M = 0$)

$= \frac{1}{12} \cdot 75^3 + 2 \cdot \left(\frac{75}{2} + 0{,}75\right)^2 \cdot 30 \cdot 1{,}5 = 166832\ cm^4$

$= \left(\frac{75}{2} + 0{,}75\right) \cdot 30 \cdot 1{,}5 + \frac{75^2}{8} = 2424{,}38\ cm^3$

$\tau = \frac{300 \cdot 2424{,}38}{166832 \cdot 1} = 4{,}36\ KN/cm^2 < \tau_{dop}$

MESTU OJAČANJA ($T = 300\ KN$, $M = 660\ KNm$)

$= \left(\frac{75}{2} + 0{,}75\right) \cdot 30 \cdot 1{,}5 = 1721{,}25\ cm^3$ $\quad I_x = 166832\ cm^4$

$= \frac{300 \cdot 1721{,}25}{1 \cdot 166832} = 3{,}1\ KN/cm^2$

$= \frac{660 \cdot 10^2}{166832} \cdot \frac{75}{2} = 14{,}84\ KN/cm^2$

$\sigma_u = \sqrt{14{,}84^2 + 3 \cdot 3{,}1^2} = 15{,}78\ KN/cm^2$

MESTU TAČKE ① ($T = 150\ KN$, $M = 990\ KNm$)

$= \frac{1}{12} \cdot 101^3 + 30 \cdot \left(\frac{101}{2} + 0{,}75\right)^2 = 322249\ cm^4$

$= \left(\frac{101}{2} + 0{,}75\right) \cdot 30 \cdot 1{,}5 = 2306{,}25\ cm^3$

$= \frac{150 \cdot 2306{,}25}{322249 \cdot 1} = 1{,}07\ KN/cm^2$

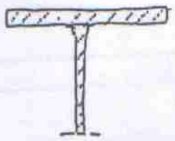
$= \frac{990 \cdot 10^2}{322249} \cdot \frac{101}{2} = 15{,}51\ KN/cm^2$

$\sigma_u = \sqrt{15{,}51^2 + 3 \cdot 1{,}07^2} = 15{,}62\ KN/cm^2$

SREDINI RASPONA ($T = 0$, $M = 990\ KN/m^2$)

$= \frac{990 \cdot 10^2}{322249} \cdot \frac{101 + 3}{2} = 15{,}98\ KN/cm^2$

- UGAONI ŠAVOVI ZA VEZU NOŽICE I REBRA



$$V_{II} = \frac{V_{max} \cdot S_{y,1}}{I_x \cdot 2a} \qquad S_{y,1} = b_F \cdot t_F \cdot (h - t_F)/2$$

$$S_{y,1} = 1721{,}25\ cm^3$$

$$V_{II} = \frac{300 \cdot 1721{,}25}{166832 \cdot 2 \cdot 0{,}3} = 5{,}2\ KN/cm^2 < \sigma_{s,dop} = 12\ KN/cm^2$$

USVAJA SE $\boxed{a_w = 3\ mm}$

- KONTROLA UGIBA

$$f = \frac{F\ell^3}{15{,}87\,EI} = \frac{150 \cdot (1100)^3}{15{,}87 \cdot 21000 \cdot 322249} = 1{,}86\ cm < f_{dop}$$

PROVERA IZBOČAVANJA U POLJU DO OSLONCA (UKRUĆENJA U PETINAMA RASPONA)

$$\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)} \cdot \left(\frac{t}{b}\right)^2 = \frac{\pi^2 \cdot 21000}{12 \cdot (1-0{,}3^2)} \left(\frac{1}{75}\right)^2 = 3{,}374\ KN/cm^2$$

$$\alpha = a/b = 2{,}2/0{,}75 = 2{,}933 > 1 \qquad k_\tau = 5{,}34 + \frac{4}{\alpha^2} = 5{,}34 + \frac{4}{2{,}933^2} = 5{,}805$$

$$k_\sigma = 23{,}9$$

$$\sigma_{cr} = \sigma_E \cdot k_\sigma = 23{,}9 \cdot 3{,}374 = 80{,}64\ KN/cm^2$$

$$\tau_{kr} = \sigma_E \cdot k_\tau = 5{,}805 \cdot 3{,}374 = 19{,}59\ KN/cm^2$$

$$\bar{\lambda}_{p\sigma} = \sqrt{f_y/\sigma_{kr}} = \sqrt{24/80{,}64} = 0{,}546 \qquad \bar{\lambda}_{p\tau} = \sqrt{f_y/(\sqrt{3} \cdot \tau_{kr})} = \sqrt{24/(\sqrt{3} \cdot 19{,}59)} = 0{,}841$$

$$\chi_\sigma = \frac{0{,}6}{\sqrt{\bar{\lambda}_{p\sigma}^2 - 0{,}13}} = \frac{0{,}6}{\sqrt{0{,}546^2 - 0{,}13}} = 1{,}463 \qquad \chi_\tau = \frac{0{,}6}{\sqrt{0{,}841^2 - 0{,}13}} = 0{,}79$$

$$\chi_\sigma = \min(1, \chi_\sigma) \qquad \chi_\tau = \min(1, \chi_\tau)$$

$\tau_u = C_\tau \chi_\tau \cdot f_y/\sqrt{3}$ $\quad C_\tau$ JE UVEK 1,25 !!!

$\tau_u = 1{,}25 \cdot 0{,}79 \cdot 24/\sqrt{3} = 13{,}68\ KN/cm^2 < f_y/\sqrt{3} = 13{,}86$

$\tau = (1{,}5)\ \frac{300 \cdot 1721{,}25}{166832 \cdot 1} = 4{,}64\ KN/cm^2 < \tau_u \quad (T^* = 1{,}5\,T)$

(1,5) ✓ KOEF. SIGURN.

$f = 2 - \frac{\sigma_{cr}}{\sigma_c} \qquad \sigma_c = \frac{\sigma_E}{\alpha^2} \qquad \sigma_{cr} = K_\sigma \cdot \sigma_E$

$f = 2 - \frac{K_\sigma \cdot \sigma_E}{\sigma_E / \alpha^2} = 2 - 23{,}9 \cdot 2{,}033 < 0 \Rightarrow f = 0$

$\sigma = 1{,}25 - 0{,}25\,\psi = 1{,}25 - (-1) \cdot 0{,}25 = 1{,}5 > 1{,}25 \Rightarrow$ USV. $C_\sigma = 1{,}25$

$\bar{\sigma}_u = (1 - f^2) \cdot \chi_{p\sigma} + f^2 \chi_c \Rightarrow \bar{\sigma}_u = \chi_{p\sigma} = 1$

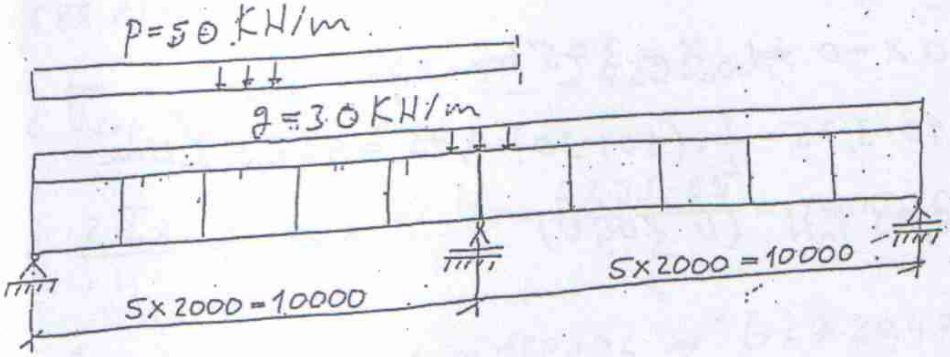
$\tau_{ux} = C_\sigma \cdot \bar{\sigma}_u \cdot f_y = 1{,}25 \cdot 1 \cdot 24 = 30 > \sigma_{dop} = 24 \Rightarrow \sigma_{ux} = 24\ KN/cm^2$

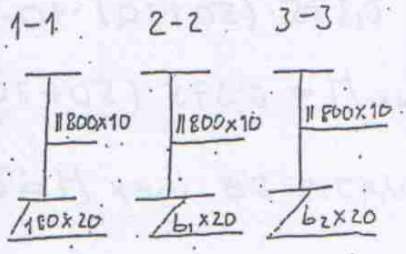
$\tau = 1{,}5 \cdot \frac{660 \cdot 10^2}{166832} \cdot \frac{75}{2} = 1{,}5 \cdot 14{,}83 = 22{,}25 < \sigma_{ux}$

1. POREDNI

$\left(\frac{\sigma_x}{\sigma_{ux}}\right)^2 + \left(\frac{\tau}{\tau_u}\right)^2 = \left(\frac{22{,}25}{24}\right)^2 + \left(\frac{4{,}64}{13{,}68}\right)^2 = 0{,}975 < 1$

03. OKTOBAR 2004

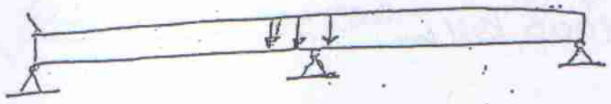




Č 0361
I SL. OPT $\Rightarrow \sigma_{dop} = 16\ KN/cm^2 \quad \tau_{dop} = 9\ KN/cm^2$

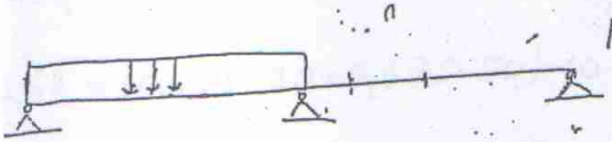
MAX. UTICAJI

(g)



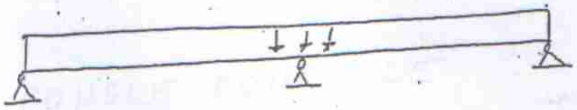
$$M_g(x) = 0{,}375\, q\ell x - \frac{1}{2} q x^2$$

(P) NA POLA



$$M_p(x) = 0{,}438\, p\ell x - \frac{1}{2} p x^2$$

(P) NA ČITAVOM



$$M_p(x) = 0{,}375\, p\ell x - \frac{1}{2} p x^2$$

- DELUJU g i P NA POLA

$$M = (0{,}375 q\ell + 0{,}438 p\ell)x - \frac{1}{2}(q+p)x^2$$

$$0{,}375 \cdot 3 \cdot 10 + 0{,}438 \cdot 5 \cdot 10 - 8x = 0 \Rightarrow x = 4{,}14\ m$$

$$\max M = (0{,}375 \cdot 30 + 0{,}438 \cdot 50) \cdot 10\ 4{,}14 - \frac{1}{2}(50+30) \cdot 4{,}14^2 = 686{,}83\ KNm$$

$\max M = 686{,}83\ KN$ (MOMENT U POLU)

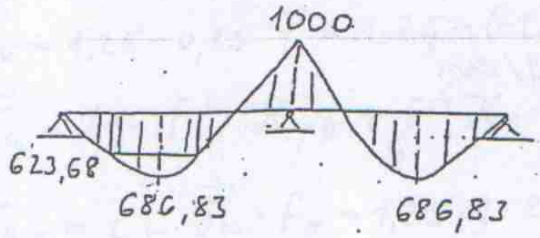
)ELUJU P i g

$' = 0{,}375\cdot(g+p)\cdot \ell x - \frac{1}{2}(g+p)x^2$

$0{,}375\cdot(50+30)\cdot 10 - 80x = 0 \Rightarrow x = 3{,}75\ m$

$_{max} M = 0{,}375\cdot(50+30)\cdot 10\cdot 3{,}75 - \frac{1}{2}\cdot(50+30)\cdot 3{,}75^2 = 562{,}5\ KNm$

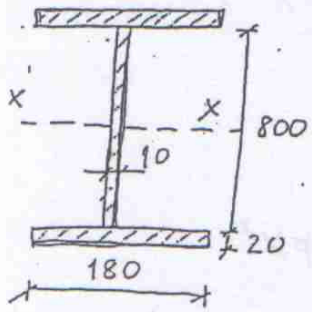
SVAJA SE $max M = 686{,}83\ KN$ (U POLJU)



PRESEK NAD OSLONCEM

$min M = (0{,}125\cdot 30 + 0{,}125\cdot 50)\cdot 10^2 = 1000\ KNm$

SHOVNI PRESEK



$I_x = 163723\ cm^4$

$S_x = 2276\ cm^3$

$A = 152\ cm^2$

$W_x = 3898\ cm^3$

$_{os} = W_x\cdot \sigma_{dop} = 3898\cdot 16 = 623{,}68\ KNm$

$,68 = (0{,}375\cdot 30 + 0{,}43^{\circ} 50)\cdot 10\cdot x - \frac{1}{2}\cdot(30+50)\cdot x^2$

$8{,}2875x + 15{,}592 = 0 \Rightarrow x_1 = 2{,}887\ m \quad x_2 = 5{,}4\ m$

$_{,1} = 2{,}887 - \frac{0{,}21}{2} = 2{,}782\ m$ USVAJA SE $\boxed{X_{STV,1} = 2{,}75\ m}$

(0,21 — VEĆE b)

$_{,2} = 5{,}4 + \frac{0{,}21}{2} = 5{,}49\ m$ USVAJA SE $\boxed{X_{STV,2} = 5{,}5\ m}$

PRESEK U POLJU

ESEK 2-2

686,83 KNm

$\leq \sigma_{dop} \Rightarrow W \geq \frac{686,83 \cdot 10^2}{16} = 4293\ cm^3$

$= \frac{2 I_x}{h} \Rightarrow I_x \geq \frac{W \cdot h}{2} = \frac{4293 \cdot 84}{2} = 180306\ cm^4$

$= \frac{1}{12} \cdot 80^3 \cdot 1 + 2 \cdot 2 \cdot b_f \cdot 41^2 = 180306 \Rightarrow b_f \geq 20,47\ cm$

USV $b_f = 21\ cm$

ESEK 3-3

$\geq \frac{1000 \cdot 10^2}{16} = 6250\ cm^3$

$\geq \frac{6250 \cdot 84}{2} = 262500 = \frac{1}{12} \cdot 80^3 + 2 \cdot 2 \cdot b_f \cdot 41^2 \Rightarrow b_f \geq 32,86\ cm$

USV $b_f = 40\ cm$

STO ODAČANJA BLIZU SREDNJEG OSLONCA

$23,68 = (0,375 \cdot 30 + 0,375 \cdot 50) \cdot 10 \cdot X - \frac{1}{2} \cdot (50+30) \cdot X^2$

$7,5 - 15,502 = 0 \Rightarrow X = 9,196\ m$

$= 9,196 - \frac{0,4}{2} = 8,996\ m \Rightarrow$ USV $X_{STUB} = 9\ m$

APONSKE KONTROLE

A MESTU MAX. MOMENTA U POLJU * (PRESEK 2-2)

$= \frac{1}{12} \cdot 80^3 \cdot 1 + 2 \cdot 2 \cdot 21 \cdot 41^2 + 2 \cdot \frac{1}{12} \cdot 21 \cdot 2^3 = 183899\ cm^4$

$= \frac{686,83 \cdot 10^2}{183899} \cdot \frac{84}{2} = 15,69\ KN/cm^2 < \sigma_{dop}$

KRAJNJEM OSLONCU * (PRESEK 1-1) ($T = 331,5\ KN$)

$\frac{T \cdot S_x}{I_x \cdot t_w} = \frac{331,5 \cdot 2276}{163723 \cdot 1} = 4,61\ KN/cm^2 < \tau_{dop}$

* U SREDNJEM OSLONCU * ($T = 500\ KN \quad M = 1000\ KN.m$)

$$I_x = \frac{1}{12} \cdot 80^3 \cdot 1 + 2\left(\frac{1}{12} \cdot 40 \cdot 2^3 + 40 \cdot 2 \cdot 41^2\right) = 311680\ cm^4$$

$$\bar{\tau} = \frac{1000 \cdot 10^2 \cdot 40}{311680} = 12{,}83\ KN/cm^2$$

$$S_x^\circ = 2 \cdot 40 \cdot 41 = 3280\ cm^3$$

$$\bar{\sigma} = \frac{T \cdot S_x^\circ}{I_x \cdot t_w} = \frac{500 \cdot 3280}{311680 \cdot 1} = 5{,}26\ KN/cm^2$$

$$\sigma_u = \sqrt{\bar{\sigma}^2 + \bar{\tau}^2} = \sqrt{12{,}83^2 + 3 \cdot 5{,}26^2} = 15{,}74\ KN/cm^2 < \sigma_{dop}$$

DIMENZIONISANJE ŠAVOVA ZA VEZU REBRA I GORNJE I DONJE NOŽICE $3\ mm \leq a_w \leq 7\ mm$.

USVAJA SE $a_w = 3\ mm$

$$\tau_{\parallel} = \frac{\max V \cdot S_x^\circ}{I_x \cdot 2 \cdot a_w} = \frac{500 \cdot 3280}{311680 \cdot 2 \cdot 0{,}3} = 8{,}77\ KN/cm^2 < \bar{\sigma}_{s,dop} = 12\ KN/cm^2$$

A KRAJNJI OSLONAC *

$$= \frac{331{,}5 \cdot 18 \cdot 2 \cdot 41}{163723 \cdot 2 \cdot 0{,}3} = 4{,}98\ KN/cm^2 < \bar{\sigma}_{s,dop}$$

KONTROLA STABILNOSTI NOSAČA NA BOČNO TORZIONO IZVIJANJE

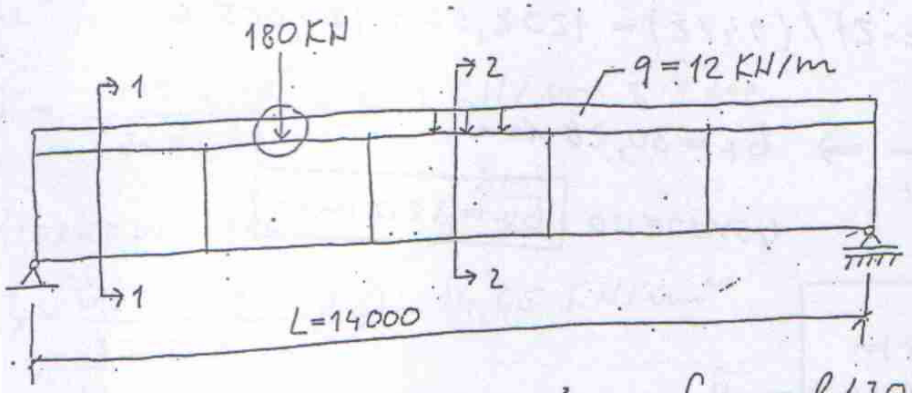
$= 200\ cm$

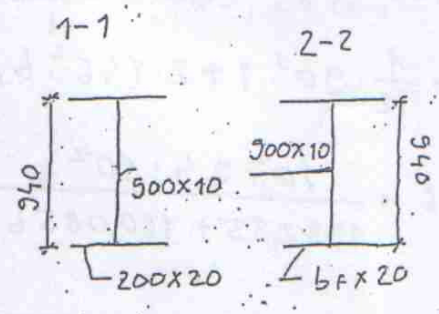
$$= \sqrt{\frac{\frac{1}{12} \cdot 18^3 \cdot 2}{21 \cdot 2}} = \frac{18}{\sqrt{12}} = 5{,}196\ cm$$

$$= \frac{l_y}{i_y} = \frac{200}{5{,}196} = 38{,}49 < 40 \rightarrow$$ NEMA OPASNOSTI OD BOČNO TORZIONOG IZVIJANJA

17. JANUAR 2006

VISINA ŠINE $h = 149\ mm$





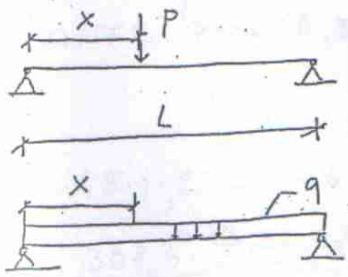
S 235, I. SL. OPT $\Rightarrow$ $\sigma_{dop} = 16\ KN/cm^2$, $\tau_{dop} = 9\ KN/cm^2$

$f_{dop} = l/300 = 4,67\ cm$

NOSAČ JE BOČNO PRIDRŽAN NA SVAKIH 2800 mm

$\psi = 1,1$ - KOEF. IZRAVNANJA (ZA STATIČKO OPTEREĆENJE)

$\varphi = 1,2$ - KOEF. IZRAVNANJA (ZA DINAMIČKO OPTEREĆENJE)



$$M(x) = 1,2 \cdot \frac{P \cdot (L-x)}{L} \cdot x = 15,43\ x\ (14-x)$$

$$M(x) = 1,1 \cdot \frac{q}{2} x\,(L-x) = 6,6x \cdot (14-x)$$

$$M(x) = 22,03\ x \cdot (14-x)$$

$$M(x) = 1,2 \cdot \frac{P \cdot (L-x)}{L} \cdot x + 1,1\ \frac{q}{2} x\,(L-x)$$

$$M_{max} = M(7) = 1,2 \cdot \frac{180 \cdot 7}{14^2} \cdot 7 + 1,1 \cdot 6 \cdot 7 \cdot 7 = 1079,4\ KNm$$

$$I_1 = \frac{1}{12} 90^3 + 2 \cdot (46^2 \cdot 20 \cdot 2) = 230030\ cm^4 \qquad W_1 = \frac{2 I_1}{h} = \frac{2 I_1}{940} = 489 4,25\ cm^3$$

$$\sigma_{nos} = 16 \cdot 4894,25 \cdot 10^{-2} = 783,08\ KNm$$

$$783,08 = 1,2 \cdot \frac{180 \cdot (14-x)}{14} \cdot x + 1,1\ 6 \cdot x \cdot (14-x) = 216x - 15,429x^2 + 92,4x - 6,6x^2$$

$$x^2 - 14x + 35,55 = 0 \qquad x_{1,2} = \frac{14 \pm \sqrt{14^2 - 4 \cdot 35,55}}{2} = \begin{cases} 10,67\ m \\ 3,33\ m \end{cases}$$

SREDINU (max M)

$$\Gamma = \frac{1}{12}\cdot 90^3 \cdot 1 + 2\cdot(46^2 \cdot b_f \cdot 2)/(94/2) = 1292{,}55 + 180{,}085\, b_f$$

$$16 = \frac{1079{,}4\cdot 10^{-2}}{1292{,}55 + 180{,}085\, b_f} \Rightarrow b_f = 30{,}28 \text{ cm}$$

USVOJENO $\underline{b_f = 320 \text{ mm}}$

$$STV = 3{,}33 - \frac{0{,}32}{2} = 3{,}17 \text{ m}$$

$$STV = 10{,}67 + \frac{0{,}32}{2} = 10{,}83 \text{ m}$$

APONSKE KONTROLE

OK USLED LOKALNOG PRITISKA TOČKA

$$F = 3{,}2\sqrt[3]{\frac{I_{y,F}}{t_w}} \quad \text{ZA } h = 149 \text{ mm} \Rightarrow I_{y,\bar{s}} = 1819 \text{ cm}^4$$

E OJAČANJA $I_{y,F} = I_{y,\bar{s}} + \frac{2^3\cdot 20}{12} = 1819 + 13{,}33 = 1832{,}33 \text{ cm}^4$

$$b_{eff} = 3{,}2\sqrt[3]{\frac{1832{,}33}{1}} = 39{,}16 \text{ cm}$$

SLE OJAČANJA $I_{y,F} = I_{y,\bar{s}} + \frac{2^3\cdot 32}{12} = 1819 + 21{,}33 = 1840{,}33 \text{ cm}^4$

$$b_{eff} = 3{,}2\sqrt[3]{\frac{1840{,}33}{1}} = 39{,}21 \text{ cm}$$

$$\tau = \frac{\varphi\cdot P}{b_{eff}\cdot t_w}$$

RE OJAČANJA $\tau_z = \frac{1{,}2\cdot 180}{39{,}16\cdot 1} = 5{,}52 \text{ KN/cm}^2$

ILE OJAČANJA $\tau_z = \frac{1{,}2\cdot 180}{39{,}21\cdot 1} = 5{,}51 \text{ KN/cm}^2$

KONTROLA NA $\max M = 1079{,}4$ KNm odg $T = 1{,}2 \cdot 90 = 108$ KN

$I_z = \frac{1}{12} \cdot 90^3 + 2 \cdot (32 \cdot 2 \cdot 46^2) = 331598 \text{ cm}^4$ $W_1 = \frac{2 I_z}{h} = 7055{,}28 \text{ cm}^3$

$\sigma = \frac{1079{,}4 \cdot 10^2}{7055{,}28} = 15{,}3 \text{ KN/cm}^2 < \sigma_{dop}$

UPOREDNI NAPON $\frac{h_{reb}}{2}$

$\sigma_x = \frac{1079{,}4 \cdot 10^2}{331598} \cdot (45) = 14{,}65 \text{ KN/cm}^2$

$\sigma_z = 5{,}51 \text{ KN/cm}^2$

$S_{y,0} = 32 \cdot 2 \cdot 46 = 2944 \text{ cm}^3$

$\tau_{xz} = \frac{108 \cdot 2944}{331598 \cdot (1)} = 0{,}96 \text{ KN/cm}^2$ ($1 \rightarrow t_w$) $\tau_{zx} = 0{,}2 \cdot \sigma_{iz} = 1{,}102 \text{ KN/cm}^2$

$\sigma_u = \sqrt{\sigma_x^2 + \sigma_z^2 - \sigma_x \sigma_z + 3(\tau_{xz} + \tau_{zx})^2} =$

$= \sqrt{14{,}65^2 + 5{,}51^2 - 14{,}65 \cdot 5{,}51 + 3 \cdot (0{,}96 + 1{,}102)^2} = 13{,}3 \text{ KN/cm}^2$

KONTRLA NAD OSLONCEM $M = 0$

$T = 1{,}2 \cdot 180 + 1{,}1 \cdot 12 \cdot 14/2 = 308{,}4$ KN

$S = 45 \cdot 1 \cdot 22{,}5 + 46 \cdot 20 \cdot 2 = 2852{,}5 \text{ cm}^3$

$\tau = \frac{308{,}4 \cdot 2852{,}5}{230030 \cdot 1} = 3{,}82 \text{ KN/cm}^2 < \tau_{dop}$

KONTROLA NA MESTU ODAČANJA

$T(3{,}17) = 1{,}2 \cdot \frac{180 \cdot (14 - 3{,}17)}{14} \cdot 3{,}17 + 1{,}1 \cdot 6 \cdot 3{,}17 \cdot (14 - 3{,}17) = 756{,}27 \text{ KNm}$

$T(3{,}17) = 1{,}2 \cdot \frac{180 \cdot (14 - 3{,}17)}{14} + 1{,}1(12 \cdot 7 - 12 \cdot 3{,}17) = 217{,}65$ KN

$\sigma_x = \frac{756{,}27 \cdot 10^2}{230030} \cdot 45 = 14{,}79 \text{ KN/cm}^2$

$\tau_{xz} = \frac{217 \cdot 20 \cdot 2 \cdot 46}{230030 \cdot 1} = 1{,}74 \text{ KN/cm}^2$

$\sigma_z = 5{,}52 \text{ KN/cm}^2$ $\tau_{zx} = 0{,}2 \sigma_z = 1{,}104 \text{ KN/cm}^2$

$$\sigma_u = \sqrt{\sigma_x^2 + \sigma_z^2 - \sigma_x \cdot \sigma_z + 3 \cdot (\tau_{xz} + \tau_{zx})^2}$$

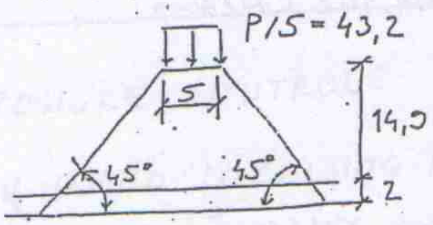
$$= \sqrt{14,79^2 + 5,52^2 - 14,79 \cdot 5,52 + 3 \cdot (1,74 + 1,104)^2} = 13,85 \text{ KN/cm}^2 < \sigma_{dop}$$

KONTROLA UGIBA NOSAČA

$$f = \frac{1,2 \cdot 180 \cdot (1400)^3}{48 \cdot 21000 \cdot 331589} + 1,1 \cdot \frac{5 \cdot 12 \cdot (1400)^4 \cdot 10^{-2}}{384 \cdot 21000 \cdot 331589} = 2,72 \text{ cm} < f_{dop}$$

DIMENZIONISANJE ŠAVOVA ZA VEZU REBRA I GORNJE, DONJE NOŽICE.

REBRO I GORNJA NOŽICA



$$l_w' = 2 \cdot (14,0 + 2) + 5 = 38,8 \text{ cm}$$

$V_{max} = 308,4$ KN $\quad V_{max} = 200,4$ KN

$$S_{y,0} = 20 \cdot 2 \cdot 46 = 1840 \text{ cm}^3$$

$$V_{\perp} = \frac{V_{max} \cdot S_{y,0}}{I_y \cdot 2a_w} = \frac{308,4 \cdot 1840}{230030 \cdot 2 \cdot a_w} = \frac{1,233}{a_w} = \frac{0,3015}{a_w}$$

$$n = \frac{P}{2 l_w' \cdot a_w} = \frac{1,2 \cdot 180}{2 \cdot 38,8 \cdot a_w} = \frac{2,784}{a_w}$$

$$\sigma_u = \sqrt{V_{\perp}^2 + n^2} = \sqrt{\left(\frac{2,784}{a_w}\right)^2 + \left(\frac{1,233}{a_w}\right)^2} < (12) \Rightarrow a_w \geq 0,25 \text{ cm}$$

($\sigma_{w,dop}$) $\quad a_w \geq 0,274$ cm.

USVAJA SE $\boxed{2 \times a_w = 3 \text{ mm}}$

KONTROLA NA BOČNO-TORZIONO IZVIJANJE NOSAČA

$= 280$ m, $I_{zf} = \frac{32^3 \cdot 2}{12} = 5461,33 \text{ cm}^4$

$= 2 \cdot 32 = 64 \text{ cm}^2$

$$i = \sqrt{\frac{5461,33}{64}} = 9,238 \text{ cm}$$

$\frac{280}{9,238} = 30,3 < 40$ nema opasnosti od bočnog izvijanja