OTPORNOST MATERIJALA 1

grupa G

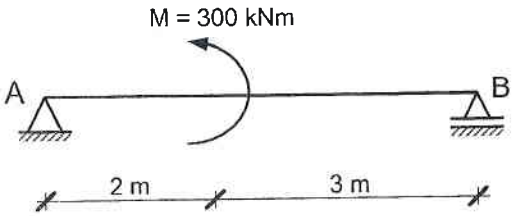
2. KOLOKVIJ 12. siječnja 2011. godine

Prezime i ime:_____

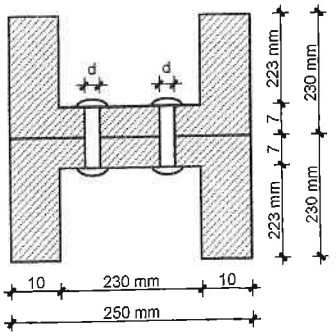
1. Za sastavljeni nosač prikazan na slici odredite potreban razmak zakovica "e".

Zadano:

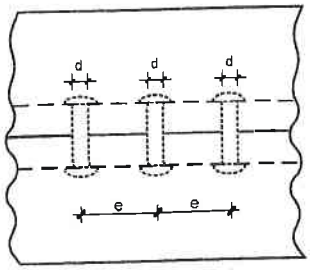
d = 20 mm, σ_{odop} = 220 MPa, τ_{dop} = 130 MPa



Pop. presjek



Uzdužni presjek



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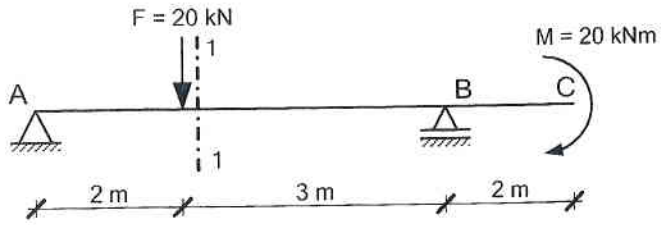
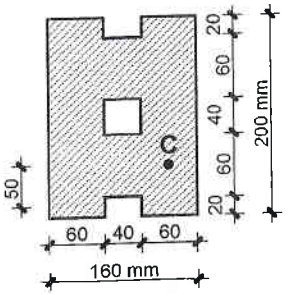
2. Za nosač prikazan na slici treba odrediti:

a) Maksimalno normalno i posmično naprezanje u kritičnim presjecima i nacrtati odgovarajuće dijagrame naprezanja.

b) Smjerove i iznose glavnih naprezanja u točki **C** presjeka **1 – 1**.



Presjek 1 - 1



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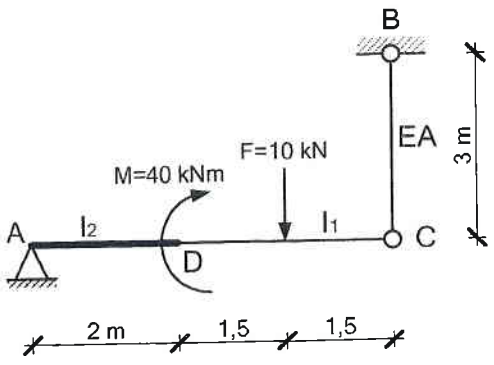
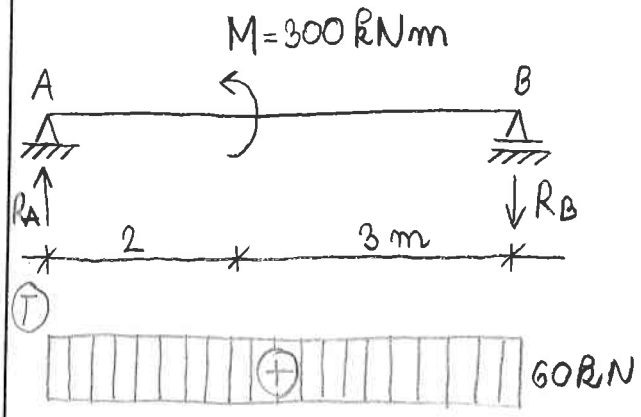
3. Za nosač prikazan na slici treba grafoanalitičkim postupkom odrediti progib u točkama **C** i **D** te kut nagiba na elastičnu liniju u točki **A**.

Zadano:

$E = 2 \cdot 10^5$ MPa
$I_1 = 10 \cdot 10^6$ mm^4
$I_2 = 20 \cdot 10^6$ mm^4
A = 70 mm^2



ZADATAK 1



$$R_A = R_B = \frac{M}{5} = 60\ kN$$

$$A = 20 \cdot 10 \cdot 460 + 14 \cdot 230 = 12420\ mm^2$$

$$J_y = \frac{250 \cdot 14^3}{12} + 4 \cdot \left(\frac{10 \cdot 223^3}{12} + 10 \cdot 223 \cdot 118{,}5^2 \right)$$

$$J_y = 162{,}28 \cdot 10^6\ mm^4$$

$$T_{max} = 60\ kN$$

$$S_y = 250 \cdot 7 \cdot 3{,}5 + 2 \cdot 10 \cdot 223 \cdot 118{,}5$$

$$S_y = 53{,}46 \cdot 10^4\ mm^3$$

$$R_x = \frac{T_{max} \cdot S_y}{J_y} \cdot e$$

$$R_x = \frac{60 \cdot 10^3 \cdot 53{,}46 \cdot 10^4}{162{,}28 \cdot 10^6} \cdot e, \quad R_x = 197{,}67 \cdot e$$

$$\tau = \frac{R_x}{2 \cdot \frac{d^2 \pi}{4}} \leq \tau_{dop}, \quad 197{,}67 \cdot e \leq 130 \cdot 2 \cdot \frac{20^2 \pi}{4}$$

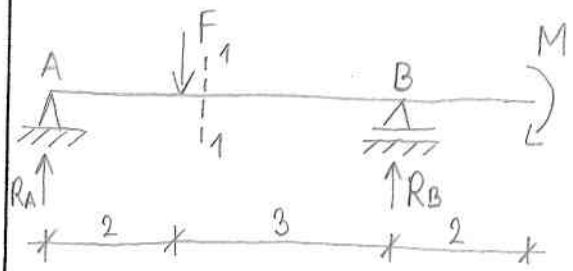
$$e \leq 413{,}22\ mm$$

$$\sigma = \frac{R_x}{2 \cdot d \cdot 7} \leq \sigma_{odap}, \quad 197{,}67 \cdot e \leq 220 \cdot 2 \cdot 20 \cdot 7$$

$$e \leq 311{,}63\ mm$$

ODABRANO: $e = 310\ mm$

ZADATAK 2

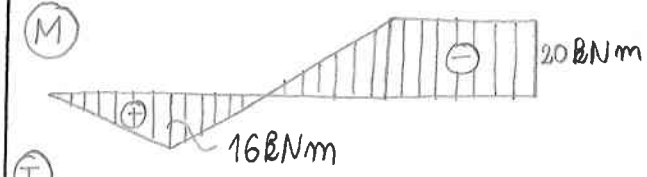


$\Sigma M_A = 0, \quad R_B = 12\,kN$

$\Sigma M_B = 0, \quad R_A = 8\,kN$

$$J_y = \frac{160 \cdot 200^3}{12} - \frac{40 \cdot 40^3}{12} - 2\cdot\left(\frac{40 \cdot 20^3}{12} + 40 \cdot 20 \cdot 90^2\right)$$

$$J_y = 93{,}45 \cdot 10^6\ mm^4$$

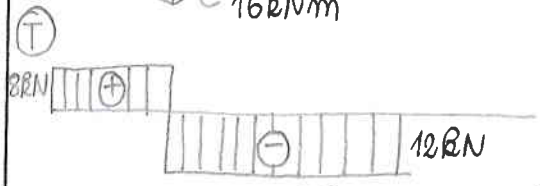


$$S_{y\,max} = 160 \cdot 100 \cdot 50 - 40 \cdot 20 \cdot 90 - 40 \cdot 20 \cdot 10$$

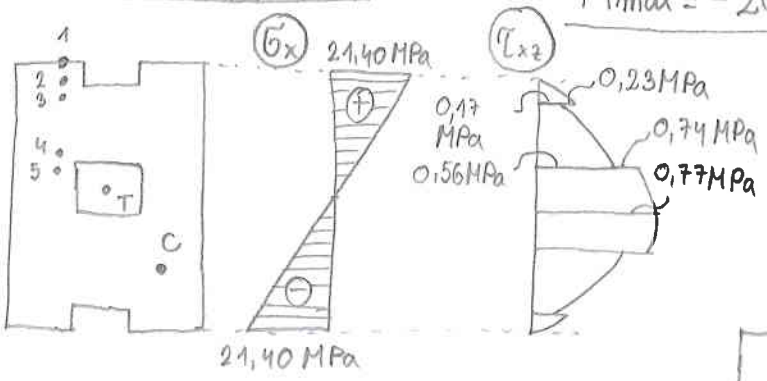
$$S_{y\,max} = 72 \cdot 10^4\ mm^3$$

$$S_y^{2,3} = 160 \cdot 20 \cdot 90 - 40 \cdot 20 \cdot 90 = 21{,}6 \cdot 10^4\ mm^3$$

$$S_y^{4,5} = 160 \cdot 80 \cdot 60 - 40 \cdot 20 \cdot 90 = 69{,}6 \cdot 10^4\ mm^3$$



$M_{max} = -20{,}0\,kNm, \quad T_{max} = -12\,kN$



$$\sigma_{x\,dolje}^{gore} = \frac{-20 \cdot 10^6}{93{,}45 \cdot 10^6} \cdot \mp 100$$

$$\sigma_{x\,dolje}^{gore} = \pm 21{,}40\,MPa$$

$$\tau_2 = \frac{12 \cdot 10^3 \cdot 21{,}6 \cdot 10^4}{93{,}45 \cdot 10^6 \cdot 120} = 0{,}23\,MPa$$

$$\tau_3 = \frac{12 \cdot 10^3 \cdot 21{,}6 \cdot 10^4}{93{,}45 \cdot 10^6 \cdot 160} = 0{,}17\,MPa$$

$$\tau_4 = \frac{12 \cdot 10^3 \cdot 69{,}6 \cdot 10^4}{93{,}45 \cdot 10^6 \cdot 160} = 0{,}56\,MPa$$

$$\tau_5 = \frac{12 \cdot 10^3 \cdot 69{,}6 \cdot 10^4}{93{,}45 \cdot 10^6 \cdot 120} = 0{,}74\,MPa$$

$$\tau_{kružok} = \frac{12 \cdot 10^3 \cdot 72 \cdot 10^4}{93{,}45 \cdot 10^6 \cdot 120} = 0{,}77\,MPa$$

Presjek 1-1

$M = 16\,kNm, \quad T = -12\,kN$

$$\sigma_x^c = \frac{16 \cdot 10^6}{93{,}45 \cdot 10^6} \cdot 50 = 8{,}56\,MPa$$

$$S_y^c = 160 \cdot 50 \cdot 75 - 40 \cdot 20 \cdot 90$$

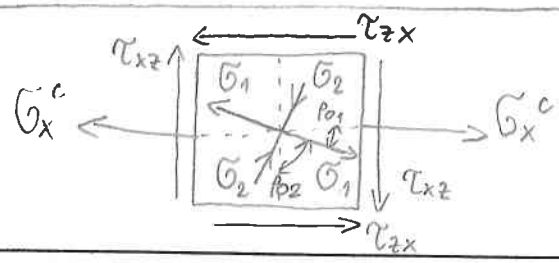
$$S_y^c = 52{,}8 \cdot 10^4\ mm^3$$

$$\tau_{xz}^c = \frac{12 \cdot 10^3 \cdot 52{,}8 \cdot 10^4}{93{,}45 \cdot 10^6 \cdot 160}$$

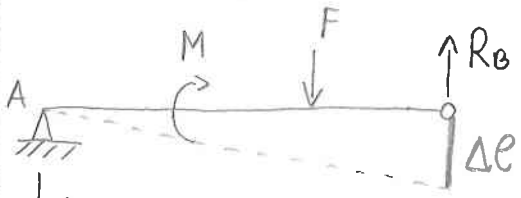
$$\tau_{xz}^c = 0{,}42\,MPa$$

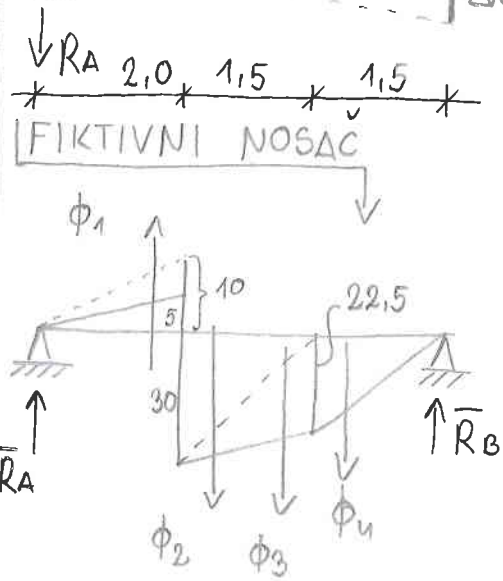
$\sigma_1 = 8{,}58\,MPa, \quad \rho_{01} = 2{,}80°$

$\sigma_2 = -0{,}02\,MPa, \quad \rho_{02} = -87{,}2°$



ZADATAK 3





$\Sigma M_B = 0, \quad R_A = 5\ kN$

$\Sigma M_A = 0, \quad R_B = 15\ kN$

$$\Delta e = \frac{R_B \cdot e}{E \cdot A} = \frac{15 \cdot 10^3 \cdot 3 \cdot 10^3}{2 \cdot 10^5 \cdot 70}$$

$\Delta e = 3{,}21\ mm = w_c$

$\phi_1 = \frac{1}{2} \cdot 5 \cdot 2 = 5\ kN\,m^2$

$\phi_2 = \frac{1}{2} \cdot 30 \cdot \frac{3}{2} = 22{,}5\ kNm^2$

$\phi_3 = \frac{1}{2} \cdot 22{,}5 \cdot \frac{3}{2} = 16{,}88\ kNm^2$

$\phi_4 = \frac{1}{2} \cdot 22{,}5 \cdot 1{,}5 = 16{,}88\ kN\,m^2$

$\Sigma \bar{M}_B = 0$

$-\bar{R}_A \cdot 5 - \phi_1 \cdot 3{,}67 + \phi_2 \cdot 2{,}5 + \phi_3 \cdot 2 + \phi_4 \cdot 1 = 0$

$\bar{R}_A = 17{,}71\ kN\,m^2$

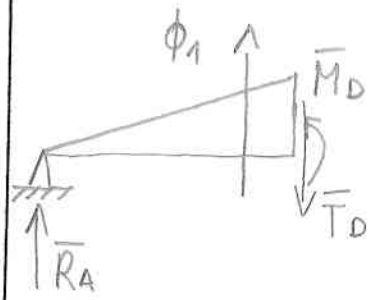
$\varphi_A = \varphi_A' + \varphi_A''$

$w_c = \Delta e$

$\varphi_A'' = \frac{3{,}2}{5000} = 0{,}00064\ rad$

$$\varphi_A' = \frac{17{,}71 \cdot 10^3 \cdot 10^6}{2 \cdot 10^5 \cdot 10 \cdot 10^6} = 0{,}008855\ rad$$

$\varphi_A = 0{,}008495\ rad$



$\bar{M}_D - \phi_1 \cdot 0{,}67 - \bar{R}_A \cdot 2 = 0, \quad \bar{M}_D = 38{,}77\ kNm^3$

$$w_D' = \frac{38{,}77 \cdot 10^3 \cdot 10^9}{2 \cdot 10^5 \cdot 10 \cdot 10^6} = 19{,}385\ mm$$

$\frac{w_D''}{2000} = \frac{3{,}2}{5000}, \quad w_D'' = 1{,}28\ mm$

$w_D = w_D' + w_D'' = 20{,}665\ mm$