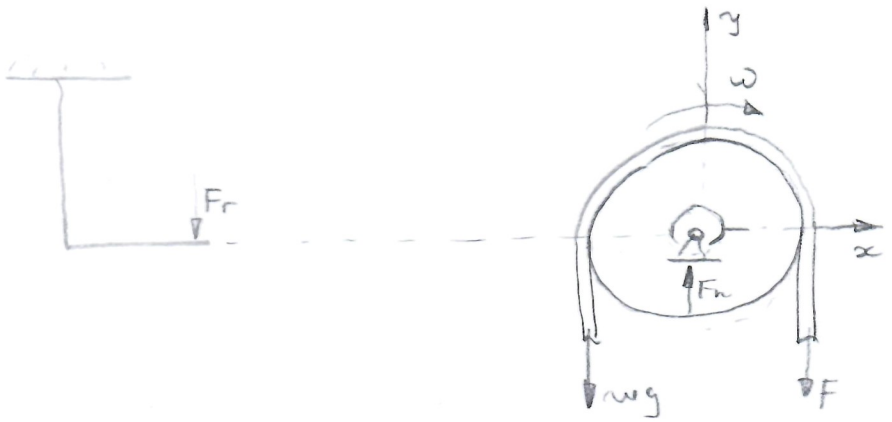
2.1 Механички модел носача:



$\Sigma x_i = 0$:

$-mg - F + F_n = 0$

$F_n = mg + F$

$|F_r| = |F_n|$

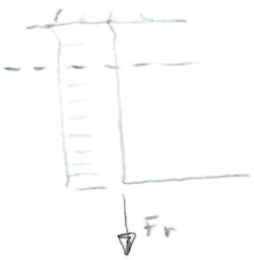
а)

• Радно оптерећење носача: 120 (150) 2400 (3000)

$$F_r = mg + F = 2mg = 2 \cdot 200 \cdot 10 = 4000\,N$$

• Напрезање носача

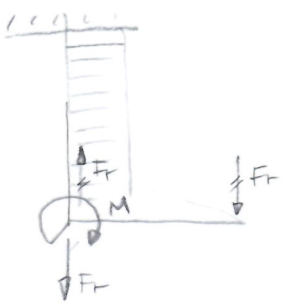
- Затезање услед дејства силе F_r 4,9 (6,2)



$$\sigma_z = \frac{F}{A} = \frac{F_r}{A} = \frac{4000}{490,9} = 8,2\ \frac{N}{mm^2}$$

$$A = \frac{d^2\pi}{4} = \frac{25^2\pi}{4} = 490,9\ mm^2$$

- Савијање 125,2 (156,5)



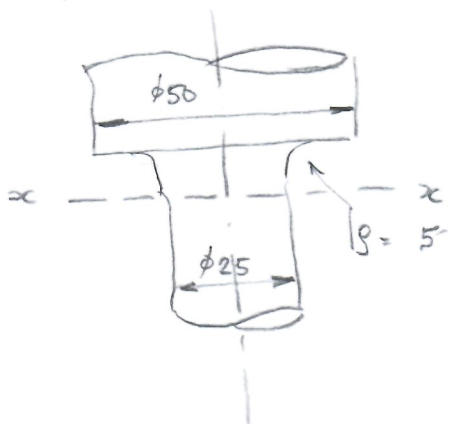
$$\sigma_j = \frac{M}{W} = \frac{320\,000}{1534} = 208,6\ \frac{N}{mm^2}$$

192 000 (240 000)

$$M = F_r \cdot c = 4000 \cdot 80 = 320\,000\ N\,mm$$

$$W = \frac{d^3\pi}{32} = 1534\ mm^3$$

• Критични попречни пресек



$D/d = 50/25 = 2$ } $\alpha_{k2} = 1,65$

$\rho/d = 5/25 = 0,2$ } $\alpha_{k1} = 1,45$

- фактор динамичке чврстоће

  - Зачешљање

$$K_{D_2} = \frac{\beta_{k_2}}{\xi_{1_2}\ \xi_2\ \xi_3} = \frac{1{,}52}{0{,}95 \cdot 0{,}9} = 1{,}78$$

$$\beta_{k_2} = (\alpha_{k_2} - 1)\,\eta_k + 1 = (1{,}65 - 1)\,0{,}8 - 1 = 1{,}52$$

Е 295 → $R_e = 295 \frac{N}{mm^2}$, $R_m = 500 \div 600 = 500 \frac{N}{mm^2}$ } $R_m = 500$, $\varrho = 5$ } $\eta_k = 0{,}8$

$\xi_{1_2} = 0{,}95$

ø25, зачешљање

$\xi_2 = 0{,}9$

  - Савијање

$$K_{D_1} = \frac{\beta_{k_1}}{\xi_{1_1}\ \xi_2\ \xi_3} = \frac{1{,}36}{0{,}9 \cdot 0{,}9} = 1{,}68$$

$$\beta_{k_1} = (\alpha_{k_1} - 1)\,\eta_k + 1 = (1{,}45 - 1)\,0{,}8 + 1 = 1{,}36$$

$\xi_{1_1} = 0{,}9$

ø25, савијање, увећани челик

- Критични пресек

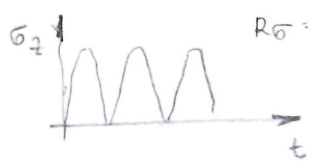
Е 295:

зачешљање

$\sigma_{D(-1)} = 160 \div 200 = 160$

$\sigma_{D(0)} = 280 \div 340 = 280$

  - Зачешљање



$R_\sigma = 0 \longrightarrow \sigma_{DM_2} = \frac{\sigma_{D(-1)M_2}}{1 - 0{,}5\ tg\alpha_{M_2}}$

$$\sigma_{D(-1)M} = \frac{\sigma_{D(-1)}}{K_{D_2}} = \frac{160}{1{,}78} = 90 \frac{N}{mm^2}$$

$$tg\alpha_M = 1 + \left(1 - \frac{2\,\sigma_{D(-1)}}{\sigma_{D(0)}}\right)\frac{1}{K_{D_2}} = 1 + \left(1 - \frac{2 \cdot 160}{280}\right)\frac{1}{1{,}78} = 0{,}9197 \rightarrow \alpha_{M_2} = 42{,}6°$$

$$\sigma_{DM_2} = \frac{90}{1 - 0{,}5 \cdot 0{,}9197} = 166{,}6 \frac{N}{mm^2}$$

- Савијање

E 295

савијање:

$\sigma_{D(-1)} = 220 - 270 = 220$

$\sigma_{D(0)} = 350 - 420 = 350$

$$\sigma_{DM_j} = \frac{\sigma_{D(-1)M_j}}{1 - 0{,}5\ tg\alpha_{M_j}} = \frac{131}{1 - 0{,}5\ 0{,}8469} = 227{,}2\ \frac{N}{mm^2}$$

$$\sigma_{D(-1)_{M_j}} = \frac{\sigma_{D(-1)_j}}{K_{D_j}} = \frac{220}{1{,}68} = 131\ \frac{N}{mm^2}$$

$$tg\alpha_{M_j} = 1 + \left(1 - \frac{2\ \sigma_{D(-1)}}{\sigma_{D(0)}}\right)\frac{1}{K_{D_j}} = 1 + \left(1 - \frac{2 \cdot 220}{350}\right)\frac{1}{1{,}68} = 0{,}8469 \rightarrow \alpha_{M_j} = 40{,}26^\circ$$

- Сложена напрезања

- Затезање: $S_z = \frac{[\sigma]_z}{\sigma_z} = \frac{\sigma_{DM_z}}{\sigma_z} = \frac{166{,}6}{6{,}2\ 4{,}9} = 26{,}8$ 34

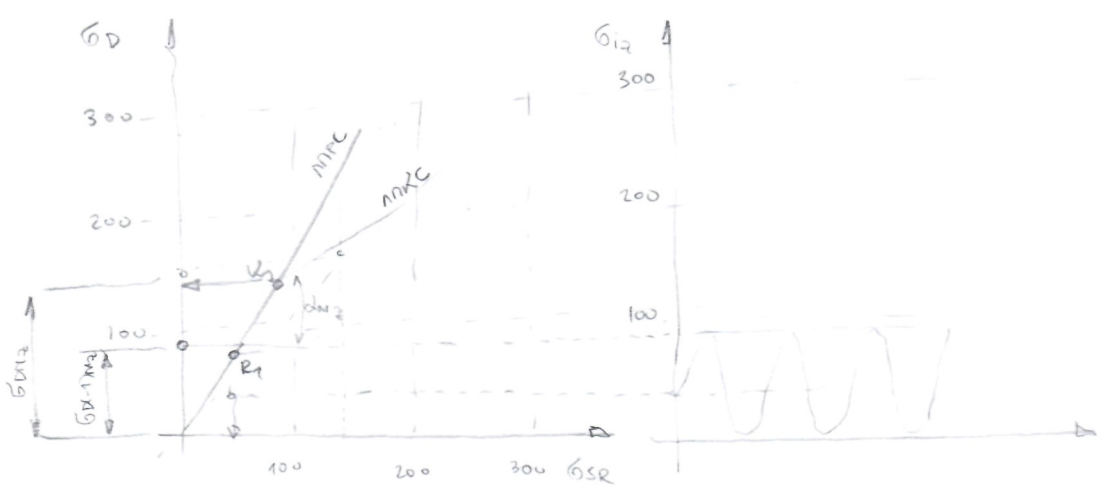
- Савијање: $S_j = \frac{[\sigma]_j}{\sigma_j} = \frac{\sigma_{DM_j}}{\sigma_j} = \frac{227{,}2}{156{,}5} = 1{,}45$ 1,81

- Укупни: $S = \frac{S_j \cdot S_z}{S_j + S_z} = \frac{1{,}45 \cdot 26{,}8}{1{,}45 + 26{,}8} = 1{,}37$ 1.71 > S_{min} ком.

- Сложен дуготрајан

$$\sigma_{iz} = \sigma_z + \frac{[\sigma]_{M_z}}{[\sigma]_{M_j}} \cdot \sigma_j = \sigma_z + \frac{\sigma_{DM_z}}{\sigma_{DM_j}} \cdot \sigma_j = 4{,}9 + \frac{166{,}6}{227{,}2} \cdot 125{,}2 = 96{,}7\ \frac{N}{mm^2}$$

Провера: $S_z = \frac{\sigma_{DM_z}}{\sigma_{iz}} = 1{,}72 \approx$



б) • Разно опъване на оста

$F_r = m \cdot g + F = 2mg = 2 \cdot 150 \cdot 10 = 3000$ N

• Разни напони:

- Затегване: $\sigma_z = \frac{F_r}{A} = \frac{3000}{490,9} = 6,2 \frac{N}{mm^2}$

- Огъване: $\sigma_{-1} = \frac{M}{W} = \frac{240\,000}{1534} = 156,5 \frac{N}{mm^2}$

$M = F_r \cdot \ell = 3000 \cdot 80 = 240\,000$ Nmm

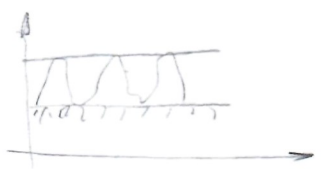
• Критични напони

- Затегване

$\sigma_{zd} = \frac{F_{rd}}{A} = \frac{600}{490,9} = 1,2 \frac{N}{mm^2} \approx 0$

$F_{rd} = 2 \cdot m_d \cdot g = 2 \cdot 30 \cdot 10 = 600$ N

- Огъване



$\sigma_{-1d} = \frac{M_d}{W} = \frac{48\,000}{1534} = 31,3$

$M_d = F_{rd} \cdot \ell = 600 \cdot 80 = 48\,000$ Nmm

$\sigma_{-1g} = \frac{M_g}{W} = 156,5 \frac{N}{mm^2}$

$M_g = F_{rg} \cdot \ell = 3000 \cdot 80 = 240\,000$

За случай когато $\sigma_d = const \Rightarrow \sigma_{DM} = \frac{2 \cdot \sigma_{D(-1)M} + \sigma_d \cdot tg\alpha_M}{2 - tg\alpha_M}$

$\sigma_{DM_z} = \frac{2 \cdot \sigma_{D(-1)M_z} + \sigma_{d_z} \cdot tg\alpha_{M_z}}{2 - tg\alpha_{M_z}} = \frac{2 \cdot 90 + 1,2 \cdot 0,9197}{2 - 0,9197} = 167,6 \frac{N}{mm^2}$

$\sigma_{DM_{-1}} = \frac{2 \cdot \sigma_{D(-1)M_{-1}} + \sigma_{d_{-1}} \cdot tg\alpha_{M_{-1}}}{2 - tg\alpha_{M_{-1}}} = \frac{2 \cdot 131 + 31,3 \cdot 0,8469}{2 - 0,8469} = 250,2 \frac{N}{mm^2}$

• Сигурност:

- Затегване: $S_z = \frac{[\sigma]_z}{\sigma_z} = \frac{\sigma_{DMz}}{\sigma_{z_g}} = \frac{167,6}{6,2} = 27$

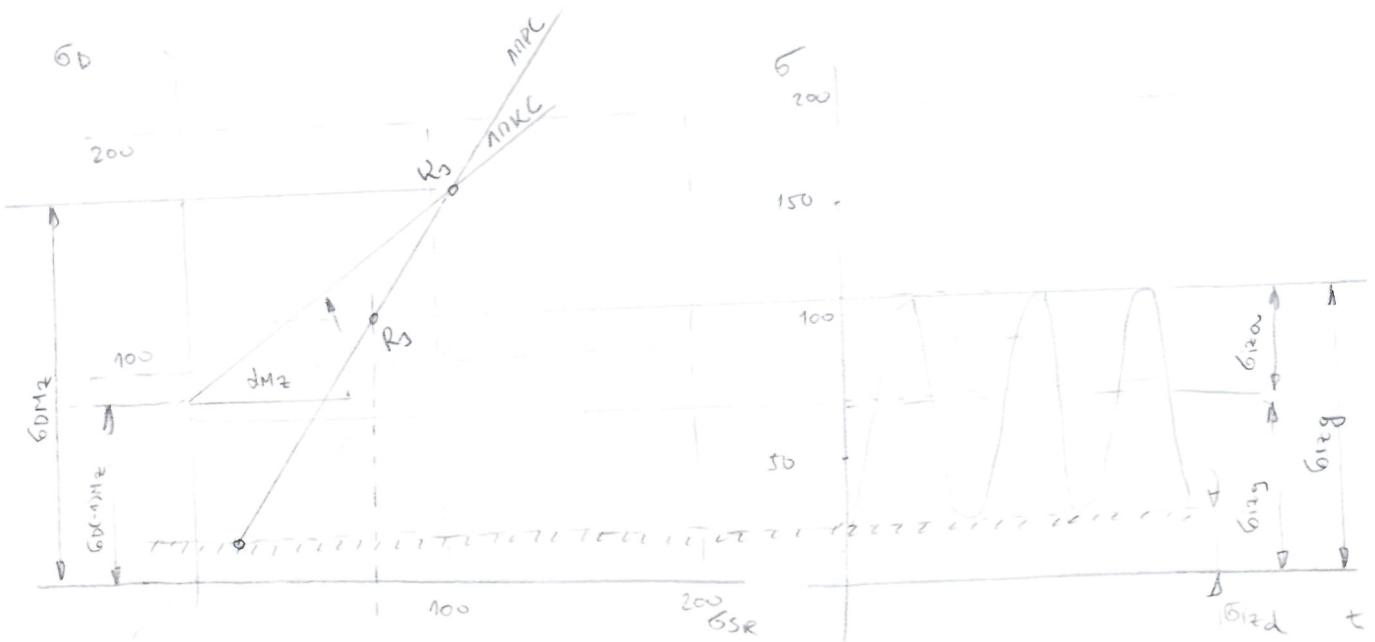
- Огъване: $S_{-1} = \frac{[\sigma]_{-1}}{\sigma_{-1}} = \frac{\sigma_{DM_{-1}}}{\sigma_{-1_g}} = \frac{250,2}{156,2} = 1,6$

- Уморна: $S = \frac{S_z \cdot S_{-1}}{S_z + S_{-1}} = \frac{27 \cdot 1,6}{27 + 1,6} = 1,51 > S_{min}\,(1,5)$

- Смешанный диаграмм

$$\sigma_{1z} = \sigma_z + \frac{[\sigma]_z}{[\sigma]_j}\sigma_j = \sigma_z + \frac{\sigma_{DM_z}}{\sigma_{DM_j}}\cdot\sigma_j = 6{,}12 + \frac{167{,}6}{250{,}2}\cdot 156{,}5 = 111\ \frac{N}{mm^2}$$

Практически $S_z = \frac{\sigma_{DM_z}}{\sigma_{1z}} = \frac{167{,}6}{111} = 1{,}51$



$\sigma_{1zg} = 111$

$$\sigma_{1zd} = \sigma_{zd} + \frac{[\sigma]_z}{[\sigma]_j}\cdot\sigma_{jd} = 1{,}2 + \frac{167{,}6}{250{,}2}\cdot 31{,}3 = 22{,}1\ \frac{N}{mm^2}$$

$\sigma_{1z_{SR}} = 88{,}7$

* Погледати пример 1, стр. 80 из книге ME 1 (Машински елементи, Машинске конструкције, Роситер)