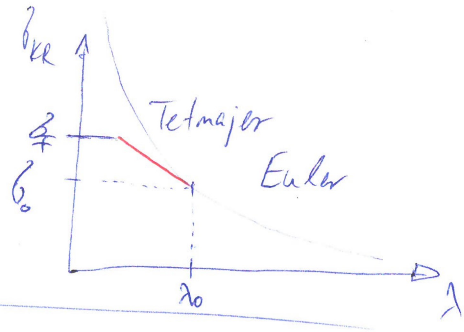
Statikus kihajlás, nyomott egyenes rudak

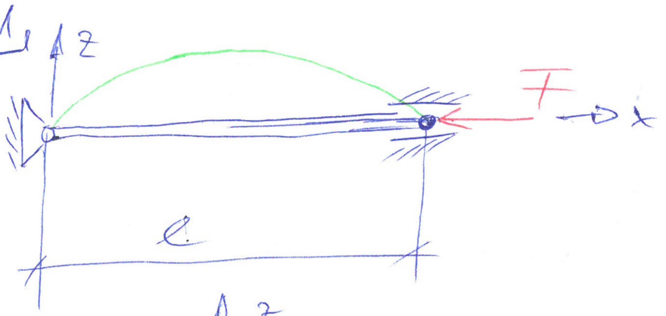
$i_2 = \sqrt{\frac{I_2}{A}}$ inerciasugár, $\lambda = \frac{l_0}{i_2}$ karcsúság, l_0: kihajlási hossz

fél minimumhullám a rúd hosszával kifejezve

$\sigma_{KR} = \left(\frac{\pi}{\lambda}\right)^2 E$, $F_{KR} = \sigma_{KR} \cdot A$, $n = \frac{\sigma_{KR}}{\sigma_{MAX}}$

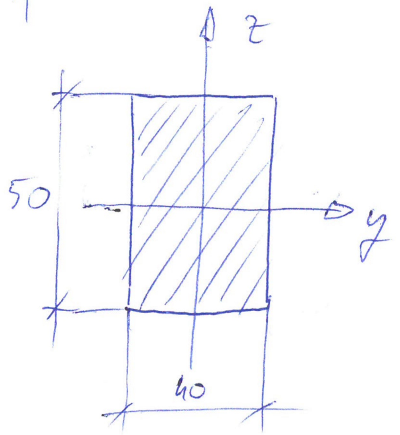


13.1.



l_{min}? Euler képlettel számolhatunk

$E = 200\,GPa$, λ_0-hoz $\sigma_0 = 230\,MPa$



$I_2 = \frac{40^3 \cdot 50}{12} = \underline{2.6 \cdot 10^5\,mm^4}$

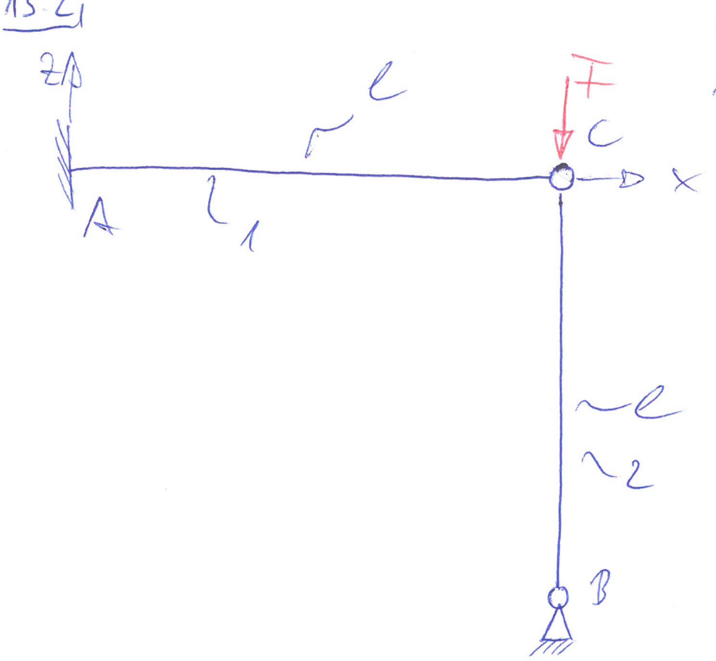
$A = 40 \cdot 50 = \underline{2 \cdot 10^3\,mm^4}$

$\sigma_0 = \left(\frac{\pi}{\lambda_0}\right)^2 E \rightarrow \lambda_0 = \sqrt{\frac{E}{\sigma_0}}\,\pi = 92.64$

csuklós – csuklós $l_0 = l$ $\quad \lambda_0 = \frac{l_{0,min}}{i_2}$; $i_2 = \sqrt{\frac{I_2}{A}} = 11.55\,mm$

$l_{min} = \lambda_0 \cdot i_2 = 1.07\,m$ $\quad l \geq l_{min}$ Euler képlet alkalmazása

13.2.



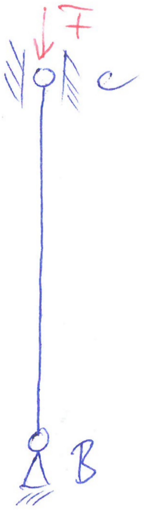
mutassuk meg, hogy a rúd lehajlásakor szükséges erő elhanyagolható a kritikus erő mellett

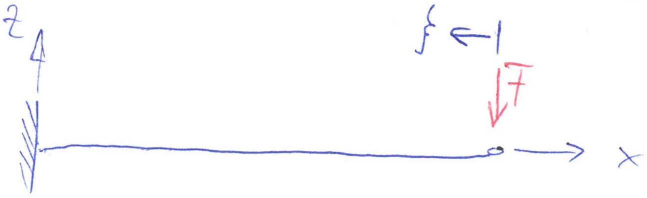
kritikus erőhöz tartozó összenyomódásnak megfelelő lehajlást okozó erő és a kritikus erő hányadosa.

$\lambda = 110$

ϕd

$$F_{KR} = \sigma_{KR} \cdot A = \left(\frac{\pi}{\lambda}\right)^2 E \cdot A \qquad w_{C2} = \frac{F_{KR}}{AE} \cdot \ell = \left(\frac{\pi}{\lambda}\right)^2 \cdot \ell$$

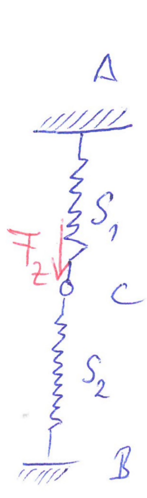




$$w_{C2} = w_{C1} = \frac{\partial U}{\partial F}$$

$$w_{C1} = \frac{\partial U}{\partial F} = \frac{1}{IE} \int_{(\ell)} F \cdot \xi \cdot \frac{\partial (F \cdot \xi)}{\partial F} d\xi = \frac{F \cdot \ell^3}{3IE}$$

$$\underbrace{\frac{3I\cancel{E}}{\ell^{\cancel{3}2}} \cdot \cancel{\left(\frac{\pi}{\lambda}\right)^2} \cdot \cancel{\ell}}_{F_{KR1}} \Big/ \cancel{\left(\frac{\pi}{\lambda}\right)^2} \cdot \cancel{E} \cdot A = \frac{3}{\lambda^2} \approx 2.48 \cdot 10^{-4}$$



13.3, Kihajlik-e az F terhelés hatására, hogyan módosítsuk, kihajlás elkerülésének?

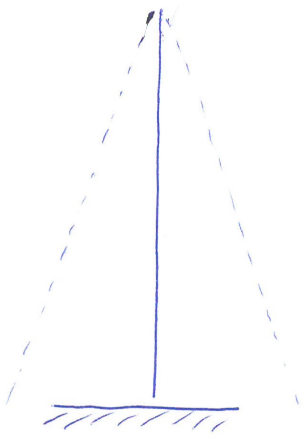
$l_0 = 2l$, $A = \frac{d^2\pi}{4}$, $I_2 = \frac{d^4\pi}{64}$, $i_2 = \sqrt{\frac{I_2}{A}} = \frac{d}{4} = 5mm$

$\lambda = \frac{2l}{i_2} = 400$ KARCSÚ!

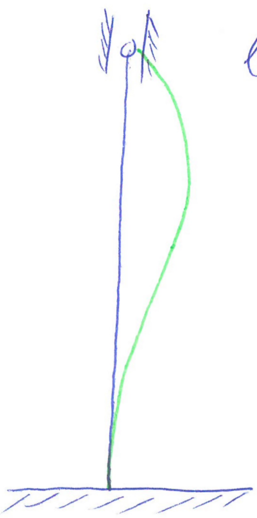
$F_{KR} = \left(\frac{\pi}{\lambda}\right)^2 E \cdot A = 3.88kN$ $F_{KR} < F \Rightarrow$ kihajlik

$l = 1m$, $d = 20mm$, $E = 200GPa$, $F = 10kN$

MÓDOSÍTÁS



$\Rightarrow$

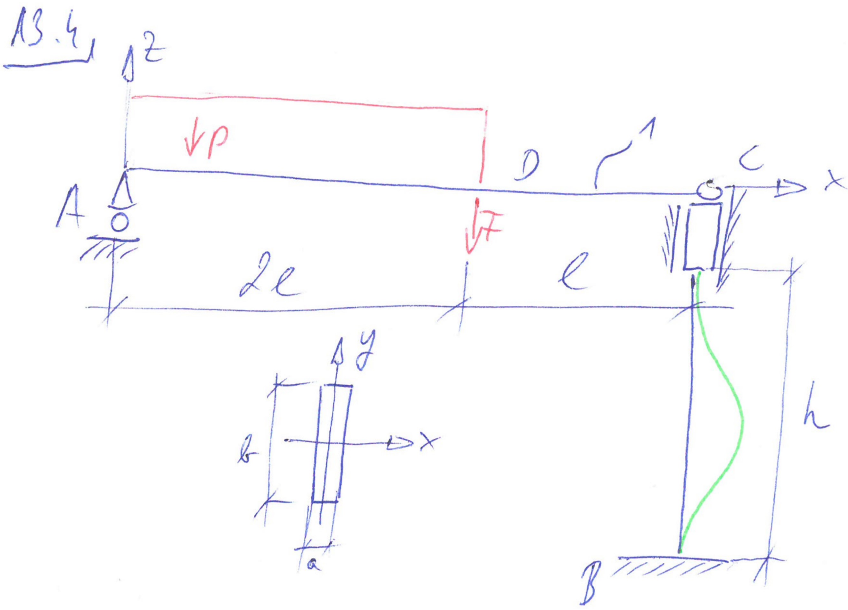


$l_0 = 0.7l$

$\lambda' = \frac{0.7l}{i_2} = 140$

$F_{KR}' = \left(\frac{\pi}{\lambda'}\right)^2 E \cdot A = 31.64kN > F$

13.4



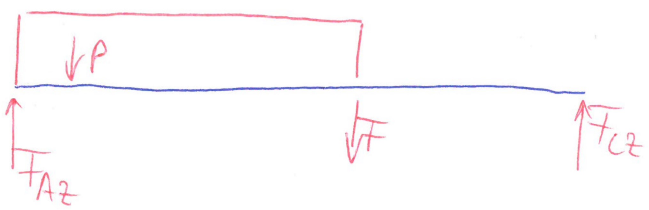
Ellenőrzés kihajlásra

Kihajlással szembeni biztonság csökkenése, ha 25%-kal csökken a és b

$l = 0.3\,m$, $h = 0.5\,m$, $a = 10\,mm$, $b = 30\,mm$, $p = 30\,kN/m$, $F = 12\,kN$

$\sigma_{KR}(\lambda) = 314 - 1.14\lambda\,[MPa]$

$E = 210\,GPa$, $\lambda_0 = 105$



$$z:\ F_{Az} - p\cdot 2l - F + F_{Cz} = 0$$

$$y:\ M_{HA} = 0 = +p\cdot 2l\cdot l + F - F_{Cz}\cdot 3l = 0$$

$$F_{Az} = 16\,kN,\quad F_{Cz} = 14000\,N$$

$$I_2 = \frac{b a^3}{12},\quad A = ab$$

$$i_2 = \sqrt{\frac{I_2}{A}} = 2.89\cdot 10^{-3}\,m$$

$$l_0 = h/2 \qquad \lambda = \frac{h/2}{i_2} = 86.6 < \lambda_0 \rightarrow \text{Tetmajer}$$

$$\sigma_{KR}(\lambda) = 215.27\,MPa,\quad \sigma_{zz} = \frac{F_{Cz}}{A} = 46.6\,MPa$$

$$n_1 = \sigma_{KR}(\lambda)/\sigma_{zz} = \underline{4.61}$$

Keresztmetszet csökkentés

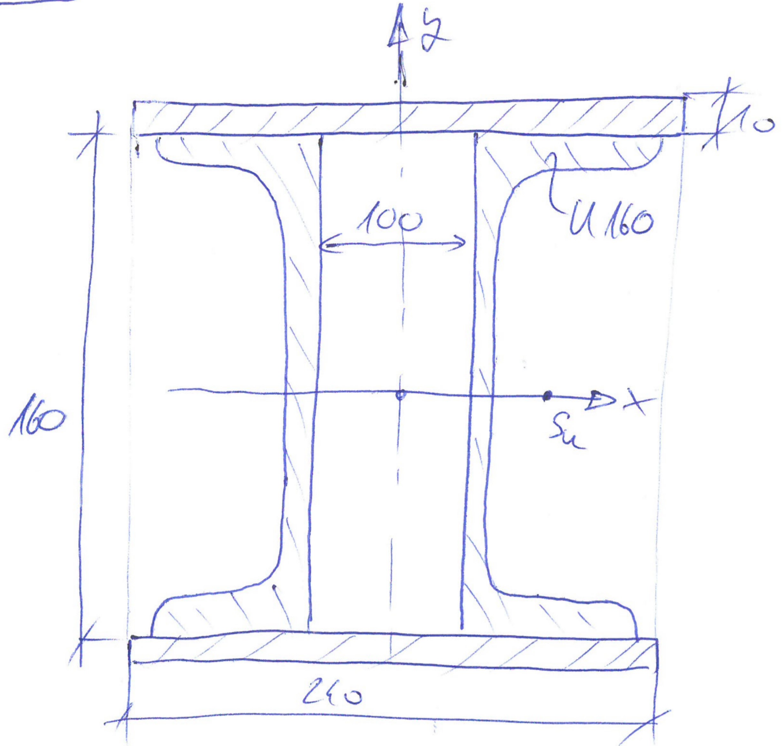
$$a \rightarrow a' = 0.75a,\quad b \rightarrow b' = 0.75b \qquad I_2' = \frac{b'(a')^3}{12},\quad A' = a'b'$$

$$i_2' = \sqrt{I_2'/A'} = 2.165\cdot 10^{-3}\,m,\quad \lambda' = \frac{h/2}{i_2'} = 115.4 \quad \sigma_{KR}' = \left(\frac{\pi}{\lambda'}\right)^2\cdot E = 155\,MPa$$

$\sigma_{ZZ}' = F_{cr}/A' = 82.96\ MPa$

$n' = \sigma_{KR}' / \sigma_{ZZ}' = 1.87$ 59%-os csökkenés

13.5,



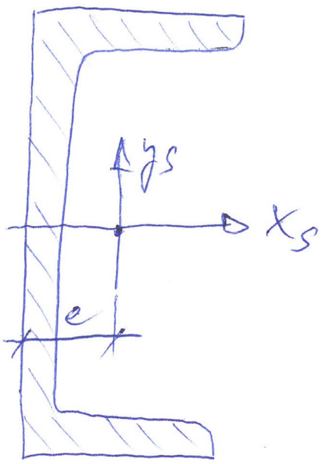
csuklós- csuklós

$l = 6m$, $E = 200\ GPa$

F_{KR} meghatározása

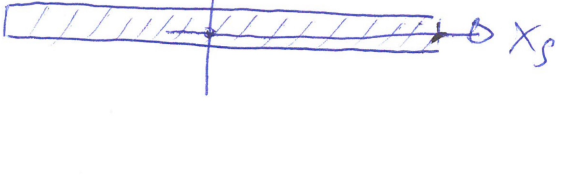
lemezzel és adlküle

$60 < \lambda < 105$ $\sigma_{KR}(\lambda) = 308 - 1.14\lambda\ [MPa]$



$I_{xs}^{u} = 925\ cm^4$, $I_{ys}^{u} = 85.3\ cm^4$, $A_u = 24\ cm^2$

$e = 1.84\ cm$



$$I_{xs}^{L} = \frac{240 \cdot 10^3}{12} = 2 \cdot 10^5\ [mm^4]$$

$$I_{ys}^{L} = \frac{240^3 \cdot 10}{12} = 1.152 \cdot 10^7\ [mm^4]$$

$$A_L = 10 \cdot 240 = 2.4 \cdot 10^3\ mm^2$$

$$\Delta x_u = \frac{100}{2} + e = 68.4 \text{ mm} \quad , \Delta y_u = 0 \text{ mm}$$

$$\Delta x_L = 0 \text{ mm} \qquad \Delta y_L = \frac{160}{2} + \frac{10}{2} = 85 \text{ mm}$$

$$I_{xS} = 2 \cdot I_{xS}^{u} + 2 \cdot \Delta y_u^2 \cdot A_u + 2 I_{xS}^{L} + 2 \Delta y_L^2 \cdot A_L = 5.0 \cdot 10^{-5} \, [m^4]$$

$$I_{yS} = 2 \cdot I_{yS}^{u} + 2 \Delta x_u^2 \cdot A_u + 2 I_{yS}^{L} + 2 \Delta x_L^2 \cdot A_L = 4.72 \cdot 10^{-5} \, m^4$$

$$I_2 = I_{yS} = \underline{4.72 \cdot 10^{-5} \, m^4}$$

$$A = 2 \cdot A_u + 2 \cdot A_L = \underline{9.6 \cdot 10^{-3} \, m^2} \qquad i_2 = \sqrt{I_2 / A} = 0.0701 \, m$$

$$\lambda = \frac{l_0}{i_2} = \frac{l}{i_2} = 85.6 \rightarrow \text{Tetmajer}$$

$$\sigma_{KR}(\lambda) \cdot A = F_{KR} = \underline{\underline{2.02 \, MN}}$$

Merevítő lemezek nélkül

$$\left.\begin{aligned} I_{xS}' &= 2 I_{xS}^{u} + 2 \Delta y_u^2 \cdot A_u = 1.85 \cdot 10^{-5} \, [m^4] \\ I_{yS}' &= 2 I_{yS}^{u} + 2 \Delta x_u^2 \cdot A_u = 2.42 \cdot 10^{-5} \, [m^4] \end{aligned}\right\} I_2' = I_{xS}'$$

$$A' = 2 A_u = 4.8 \cdot 10^{-3} \, m^2 \qquad i_2' = \sqrt{I_2' / A'} = 0.062 \, m$$

$$\lambda' = \frac{l_0}{i_2'} = \frac{l}{i_2'} = 96.65 \rightarrow \text{Tetmajer}$$

$$F_{KR}' = \sigma_{KR}(\lambda') \cdot A' = \underline{\underline{0.95 \, MN}}$$