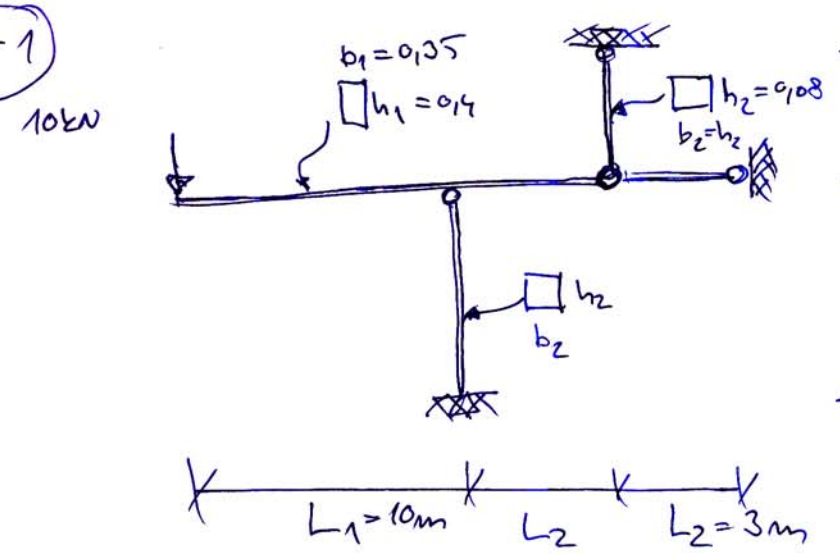
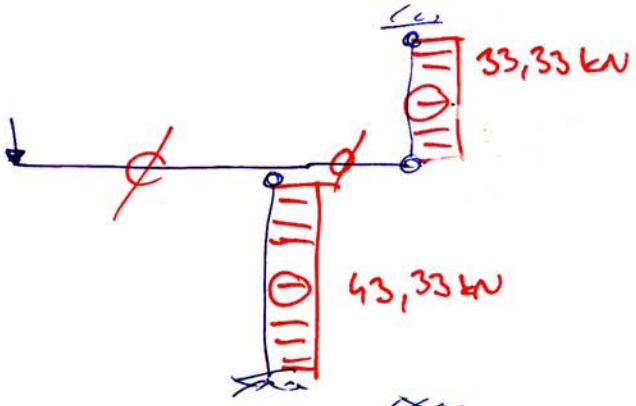
Př 1

Prp, cv. 8, str. 1

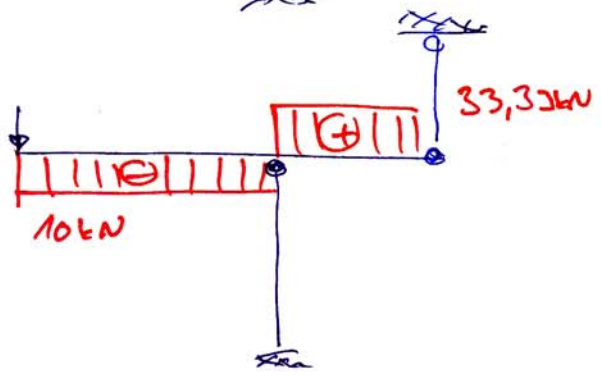


Určete průběhy vnitřních sil na zadané konstrukci

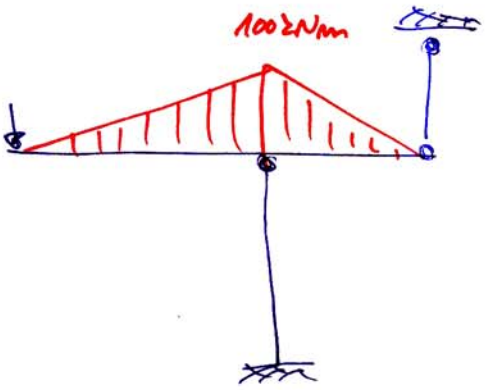
(N)



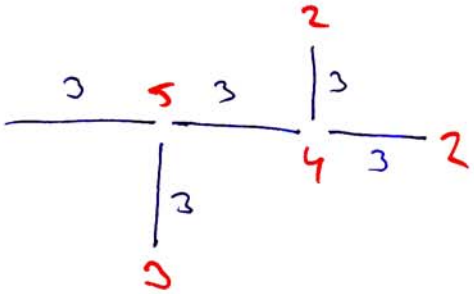
(V)



(M)



SU?



15 SU odstraněno 16 !

~ pro daný způsob podepření je to jedno ...

(Př 2) Kolikrát musím zvýšit zatížení, aby došlo ke kolapsu konstrukce? Uvažujte plasticitu materiálu + ztrátu stability.

$E = 210$ GPa $\quad \sigma_0 = 235$ MPa

---

1. kritérium – plastický kloub nad spodním stojkem

$M_{pl} = \sigma_0 \cdot b_1 \cdot h_1^2 / 4 = 235000 \cdot 0{,}35 \cdot 0{,}4^2 / 4 = 3290$ kNm

$M_{pl} / M = 3290 / 100 = \underline{32{,}9}$

2. kritérium – pevnost (plasticita) v prvcích zatížené stojky

$N_{pl} = \sigma_0 \cdot A = 235000 \cdot 0{,}08^2 = 1504$ kN

$N_{pl} / N = 1504 / 43{,}33 = \underline{34{,}71}$

3. kritérium – Stabilita v prvcích zatížené stojky

$I = \frac{1}{12} \cdot 0{,}08^4 = 3{,}4133 \cdot 10^{-6}$ m^4

$F_{krit_1} = \frac{E I \pi^2}{L^2} = \frac{210 \cdot 10^6 \cdot 3{,}4133 \cdot 10^{-6} \cdot \pi^2}{(0{,}7 \cdot 3)^2} = 1604{,}2$ kN $=$

$= 1{,}6042$ MN

$F_{krit_1} / N_1 = \frac{1604{,}2}{43{,}33} = \underline{37{,}023}$

4. kritérium – Stabilita méně zatížené stojky

$F_{krit_2} = \frac{E I \pi^2}{L^2} = \frac{210 \cdot 10^6 \cdot 3{,}4133 \cdot 10^{-6} \cdot \pi^2}{2{,}6^2} = 1046{,}5$ kN

$F_{krit_2} / N_2 = 1046{,}5 / 33{,}33 = \underline{31{,}39}$

Rozhoduje nejmenší součinitel $\rightarrow 31{,}39$. Pro danou konstrukci je kritická stabilita horní stojky.

(Př 3) Určete takový násobek zatížení, aby celá konstrukce získala pružná

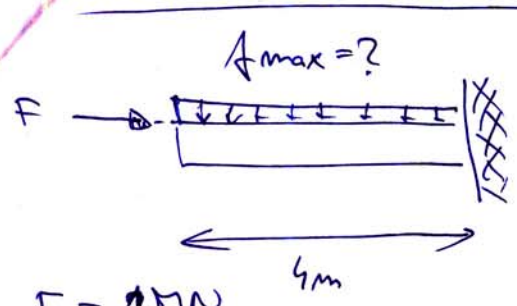
$W_{el_1} = b_1 h_1^2 / 6 = \frac{0{,}35 \cdot 0{,}4^2}{6} = 0{,}009333$ m^3

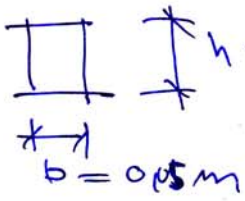
$M_{el} = \sigma_0 \cdot W_{el_1} = 235 \cdot 10^3 \cdot 0{,}009333 = 2193$ kNm

$M_{el} / M_{max} = \frac{2193}{100} = 21{,}93$ Zatížení by se muselo zvýšit 21,93 x.

Určete max. sílu zatížení q_{max}.

Příp. cv. 8, str. 3

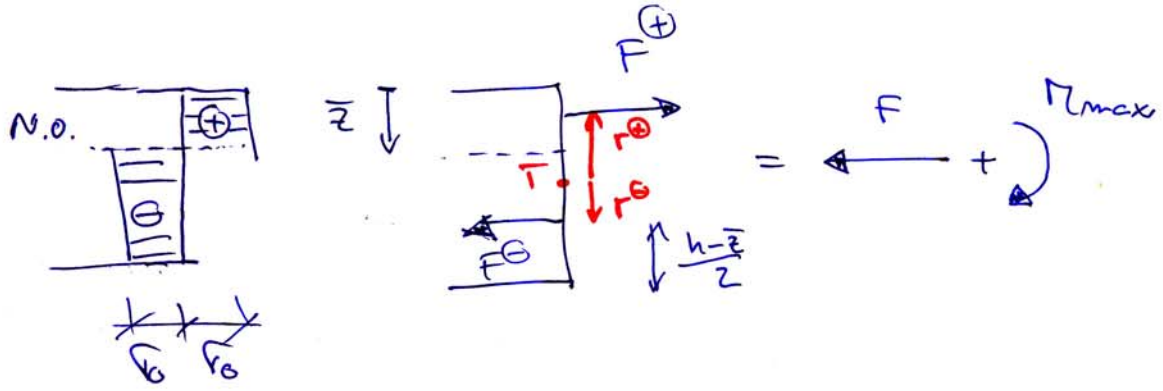




$\sigma_0 = 235$ MPa

$E = 210$ GPa

$F = 1$ MN



Vodorovná podmínka rovnováhy:

$$F^{\oplus} - F^{\ominus} = -F$$

$$\bar{z} b \sigma_0 - (h - \bar{z}) b \sigma_0 = -F \quad \Rightarrow \quad \bar{z} = \frac{-F + hb\sigma_0}{b\sigma_0 + b\sigma_0}$$

$$\bar{z} = \frac{-1 \cdot 10^6 + 0{,}4 \cdot 0{,}05 \cdot 235 \cdot 10^6}{2 \cdot 0{,}05 \cdot 235 \cdot 10^6} = 0{,}1149 \text{ m}$$

$M_{max} = F^{\oplus} r^{\oplus} + F^{\ominus} r^{\ominus}$;

$F^{\oplus} = \bar{z} b \sigma_0 = 0{,}1149 \cdot 0{,}05 \cdot 235 \cdot 10^6 = 1{,}35 \cdot 10^6$ N

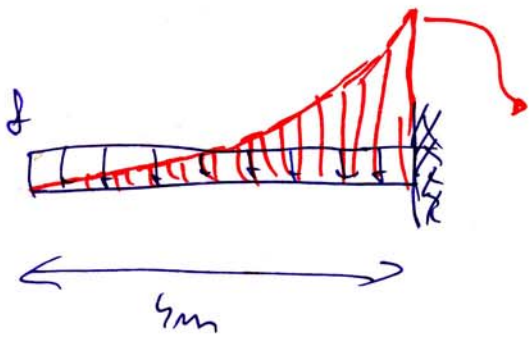
$F^{\ominus} = (h - \bar{z}) b \sigma_0 = (0{,}4 - 0{,}1149) \cdot 0{,}05 \cdot 235 \cdot 10^6 = 3{,}350 \cdot 10^6$ N

$r^{\oplus} = \frac{h}{2} - \frac{\bar{z}}{2} = 0{,}1426$ m

$r^{\ominus} = \frac{(h - \bar{z})}{2} + \frac{h}{2} = \frac{\bar{z}}{2} = 0{,}0574$ m

$M_{max} = 1{,}35 \cdot 10^6 \cdot 0{,}1426 + 3{,}35 \cdot 10^6 \cdot 0{,}0574 \text{ m} = 3{,}8489 \cdot 10^5$ Nm $= 384{,}89$ kNm

$\left(M_{max\,pl} = \sigma_0 \frac{bh^2}{4} = 235 \cdot 10^3 \cdot \frac{0{,}05 \cdot 0{,}4^2}{4} = 470 \text{ kNm} \right)$



$F \cdot \frac{h}{2}$

$M = \frac{1}{2} q L^2 = 384{,}89 + 2 \cdot 10^3 \cdot 0{,}2 = 784{,}89$ kNm

$$\Rightarrow q_{max} = \frac{784{,}89 \cdot 2}{L^2} = \frac{2 \cdot 784{,}89}{16} = 98{,}11 \text{ kN/m}$$

Příp. cv. 8, str. 4

Lze určit max. ohybovou únosnost při působení normálové síly i jinak?

$$\frac{|M|}{M_{pl}} + \left(\frac{N}{N_{pl}}\right)^2 = 1 \quad \text{... interakční diagram pro plasticitu a } \square \text{ průřez}$$

$$\rightarrow M = \left[1 - \left(\frac{N}{N_{pl}}\right)^2\right] M_{pl}$$

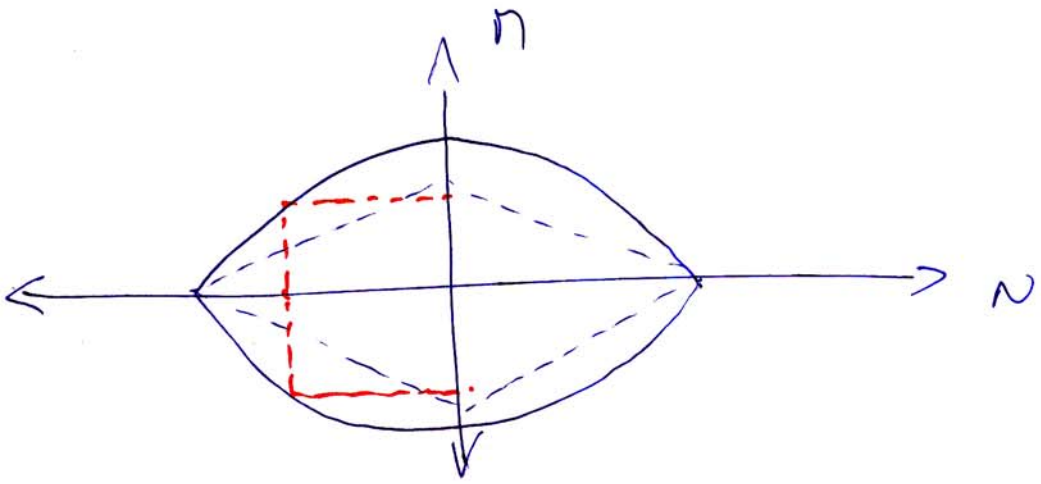
pro naše zadání $N = -2\,MN$

$N_{pl} = A \cdot f_0 = 0{,}05 \cdot 0{,}4 \cdot 235 \cdot 10^6 =$

$= 4{,}7 \cdot 10^6\,N = 4{,}7\,MN$

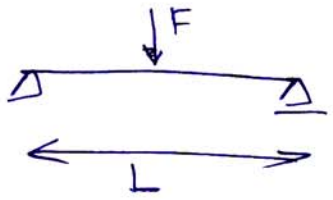
$M_{pl} = 470\,kNm$

$$M = \left[1 - \left(\frac{-2}{4{,}7}\right)^2\right] \cdot 470 = 384{,}89\,kNm$$



Určete maximální přípustnou velikost síly F! Pepe cv. 8, str. 5

Př. 5



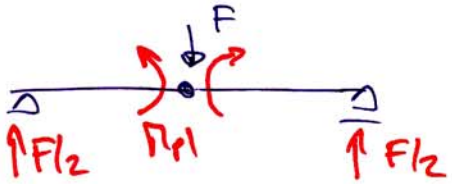
$L = 8\,m$

I $b = 0{,}1\,m \quad h = 0{,}4\,m$

$\sigma_0 = 235\,MPa$

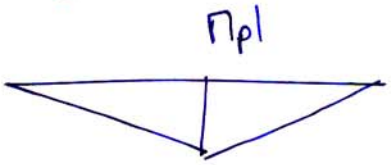
$M_{pl} = \sigma_0 \frac{bh^2}{4} = 235 \cdot \frac{0{,}1 \cdot 0{,}4^2}{4} = 0{,}94\,MN\,m$

Pro kolapsovou konstrukci, která je N-krát staticky neurčitá musí vznikat N+1 plastických kloubů

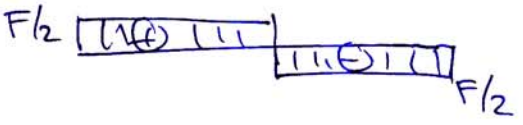


$M_{pl} = \frac{F}{2} \cdot \frac{L}{2} \rightarrow F = \frac{4M_{pl}}{L} = \frac{4 \cdot 0{,}94}{8} = 0{,}47\,MN$

Průběhy vn. sil:

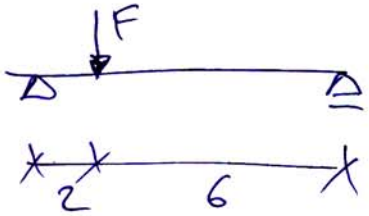


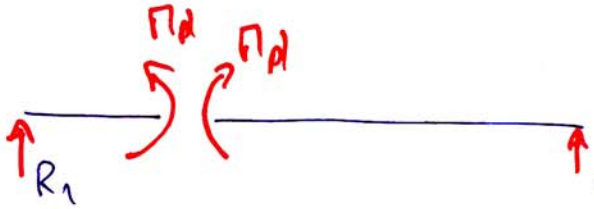
M



V

Př. 6

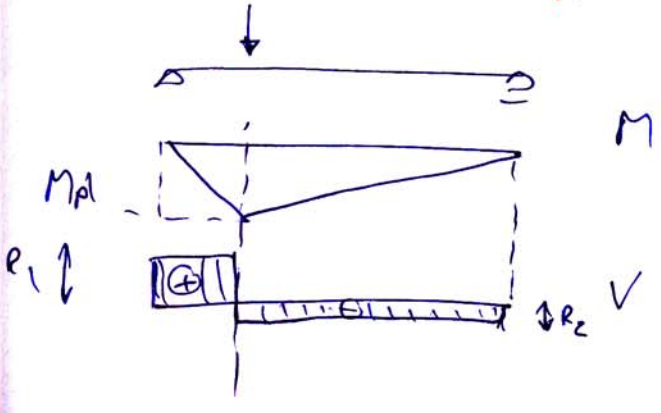




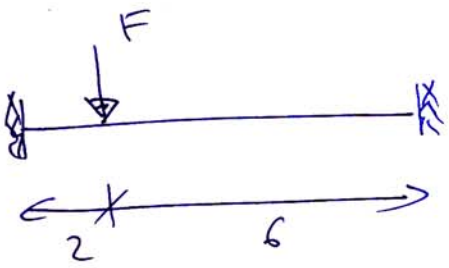
$M_{pl} = R_1 \cdot 2 \rightarrow R_1 = \frac{M_{pl}}{2} = 0{,}47\,MN$

$M_{pl} = R_2 \cdot 6 \Rightarrow R_2 = \frac{M_{pl}}{6} = 0{,}15667\,MN$

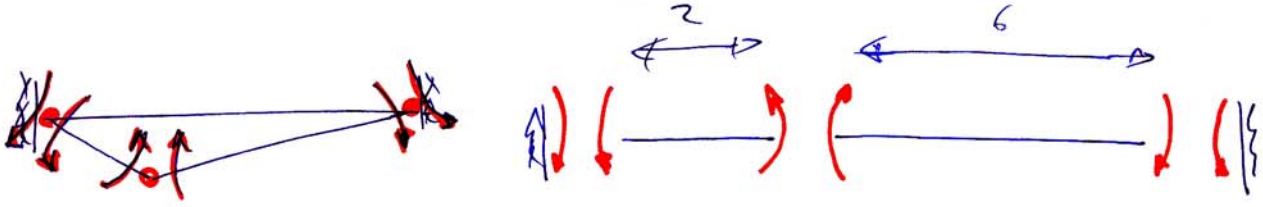
$\Rightarrow F = R_1 + R_2 = 0{,}62667\,MN$

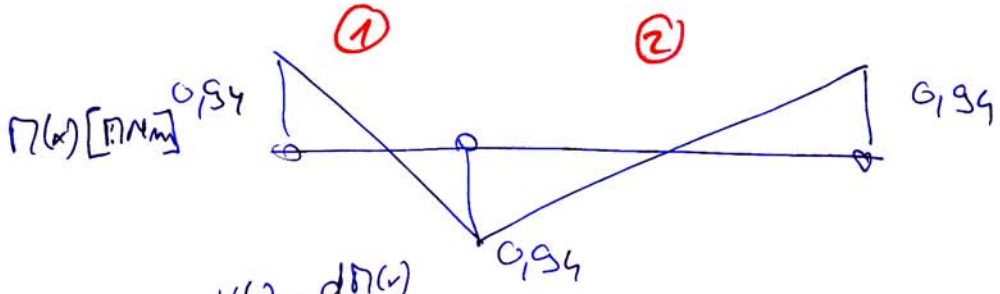


R7



$\Rightarrow$ 2x SN $\rightarrow$ N+1 = 3 plast. klouby

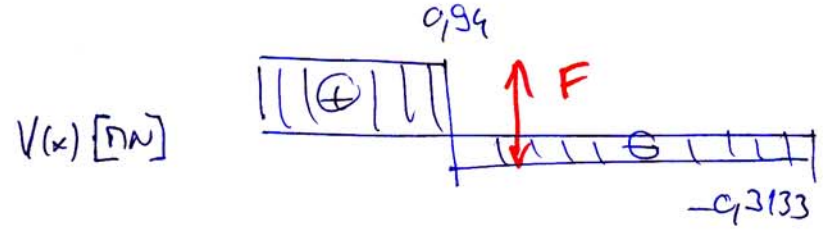




$$V(x) = \frac{dM(x)}{dx}$$

$$V_1 = \frac{2M_{pl}}{2m} = \underline{0,94\ MN}$$

$$V_2 = \frac{-2M_{pl}}{6m} = -\frac{0,94}{3} = \underline{-0,3133\ MN}$$



$$F = |V_1| + |V_2| = \underline{1,2533\ MN}$$