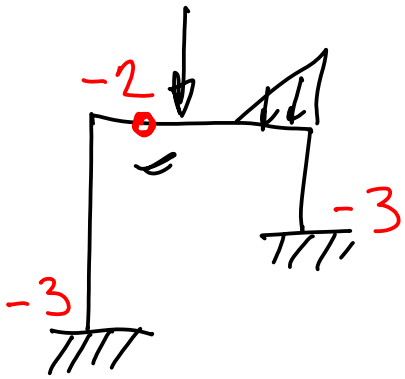
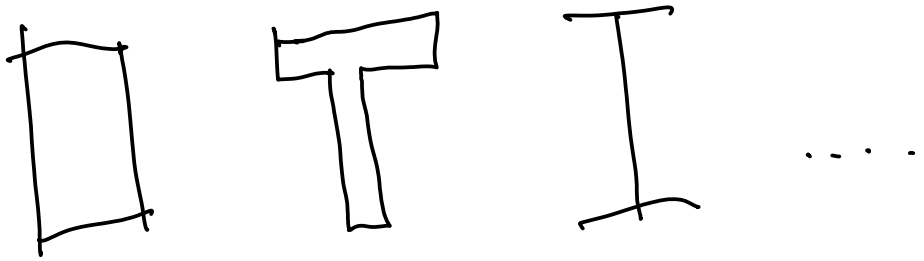
PP analýza průřezu prutu konstrukce (SNK)



PPA průřezu



tah/tl — N
ohyb — M
krut — Mk
(smyk) (T)

3-3-3 = -3 x SNK

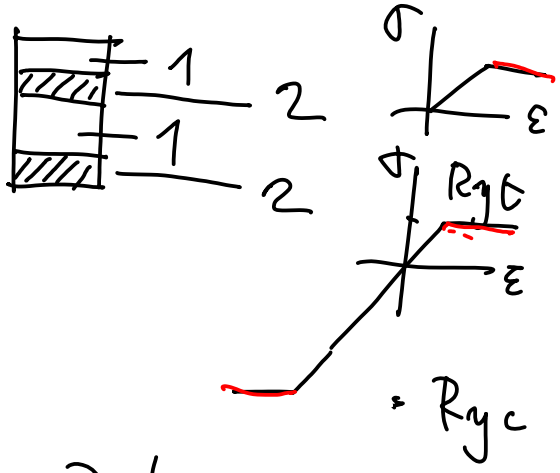
3x2 - 2x3 - 1x2

6-6-2 = -2 x SNK

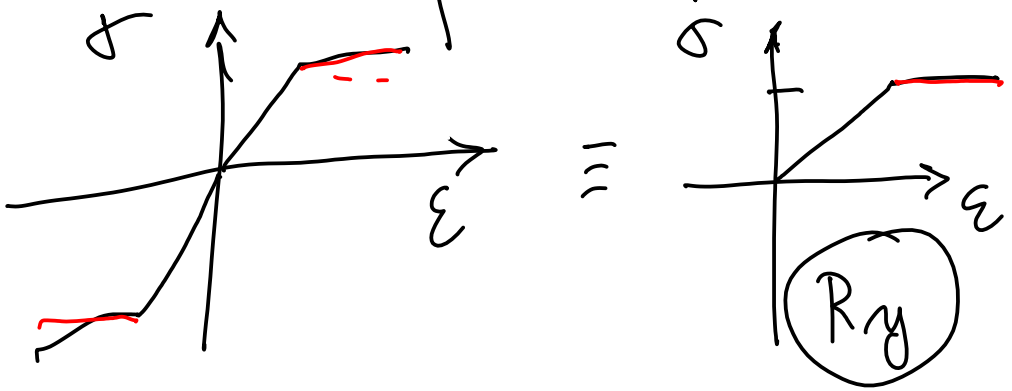
MATERIÁL: homogenní a izotropní

podmínka plasticity

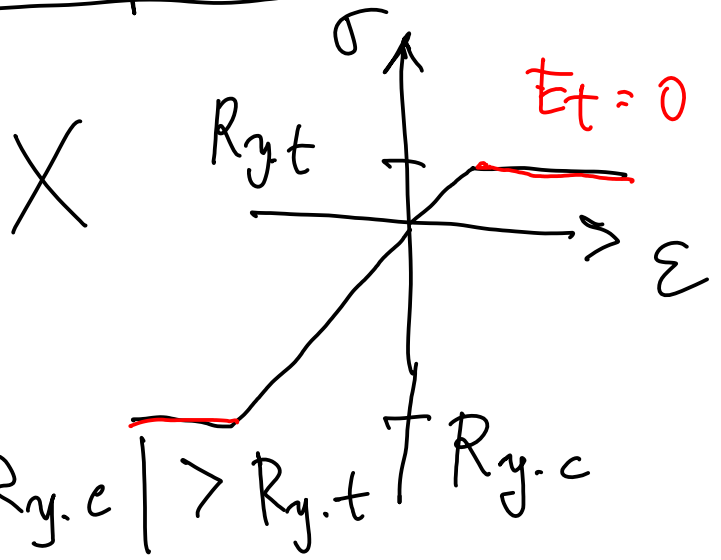
$$|\sigma| = R_y$$



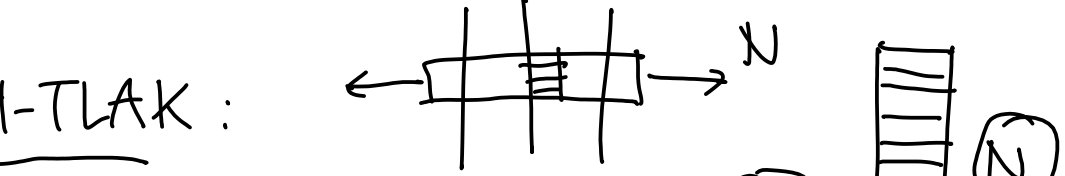
(ideální) pružno-plast mat bez zpevnění!

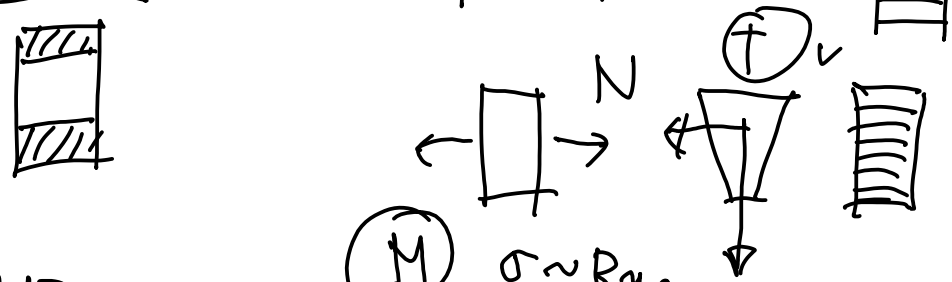


E, $R_y(c,t)$

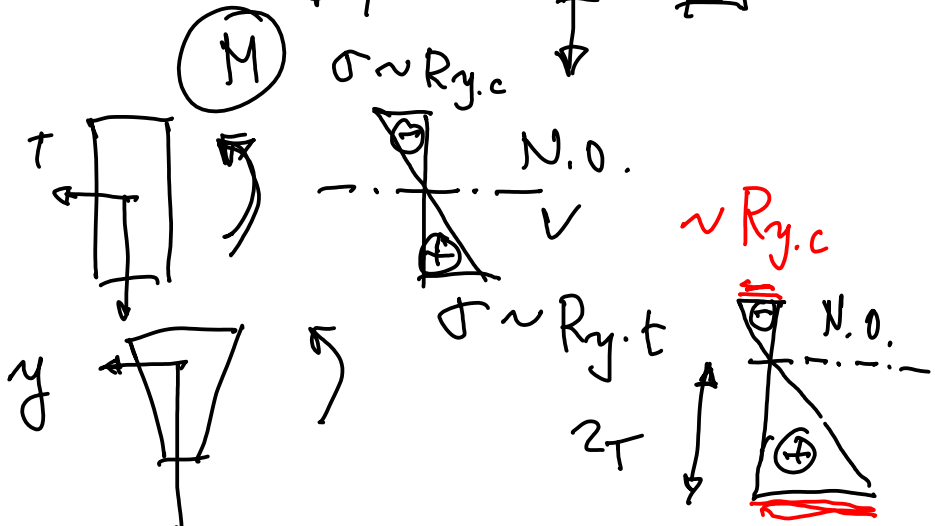


PRŮŘEZ : namáhání : a) TAH-TLAK :

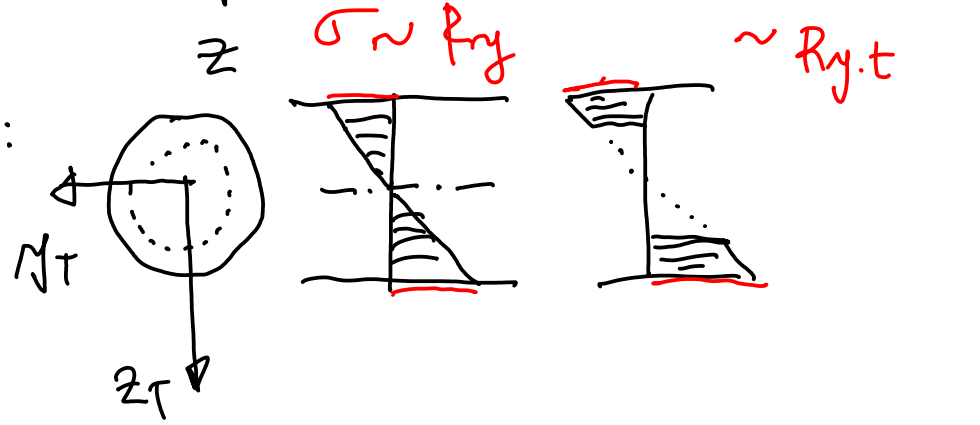




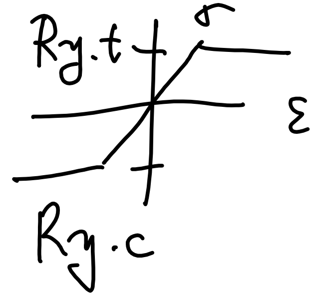
b) OHYB :



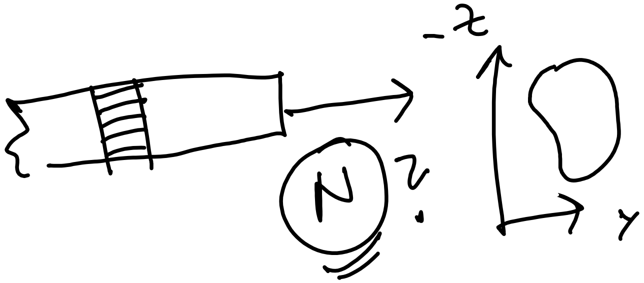
c) KRUT :



PPA průřezu : TAH-TLAK ; izotropní plast. :



$$R_{y.c} = R_{y.t} = R_y$$



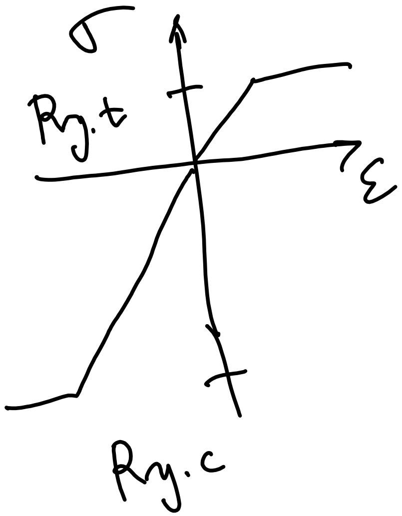
$$|N| = N_{pl}$$

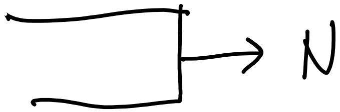
$$N_{pl} = R_y \cdot A$$

$$|N| = R_y \cdot A$$

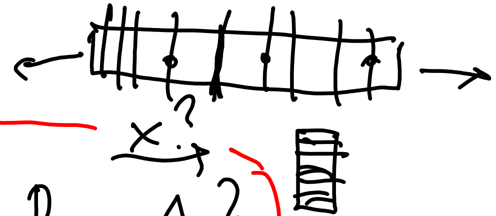
$$\sigma = \frac{F}{A} = \frac{N}{A} \rightarrow N = \sigma \cdot A$$

anizotropní :



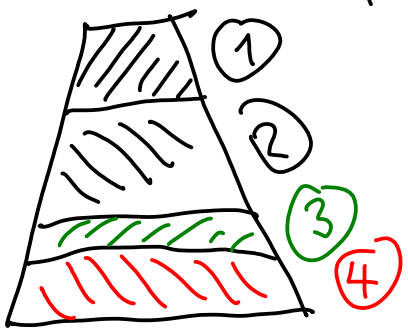


? N_{pl}

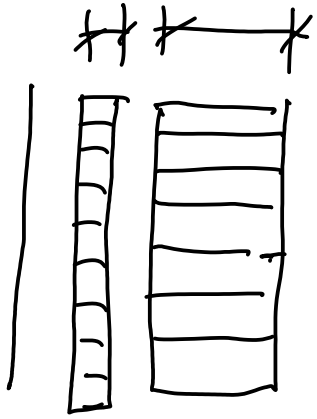


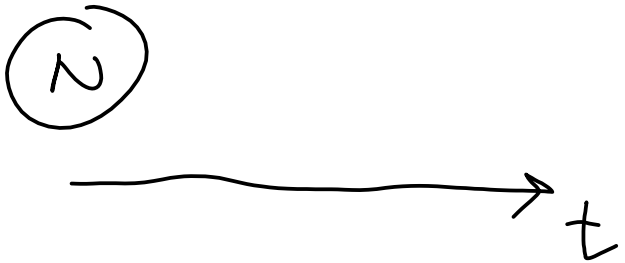
$$N_{pl} = \min\{R_{y.c}\, A\,;\; R_{y.t}\, A\}$$

heterogenní průřez:



$R_{y1}, R_{y2}, R_{y3}, R_{y4}$

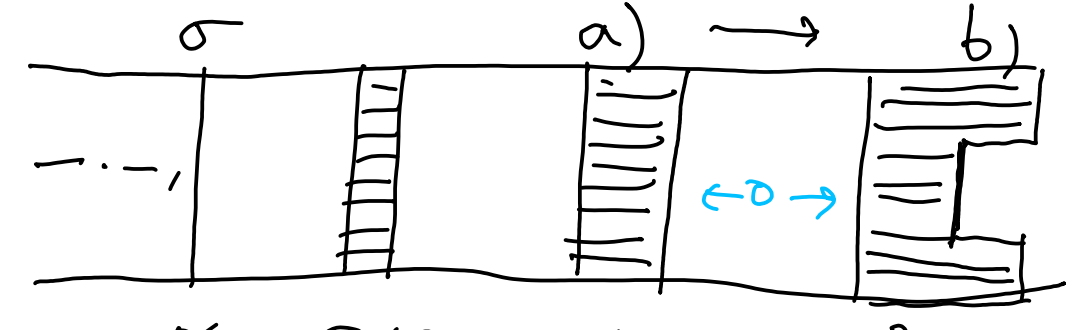




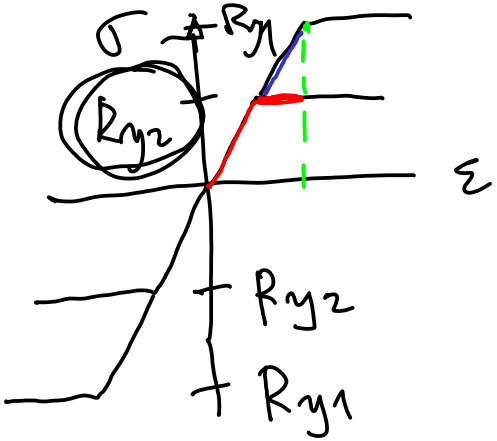
✓ $N_{pl,i} = R_{y,i} \cdot A_i$

$$N_{pl} = \sum_{i=1}^{n} R_{y,i} \cdot A_i$$

Př. A/2, A, A/2 (1, 2, 1)

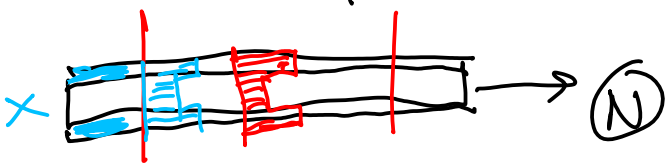


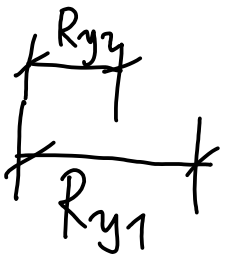
$R_{y1} = 2R_{y2}$



el. stav ✓

mezní pl. stav pro M2

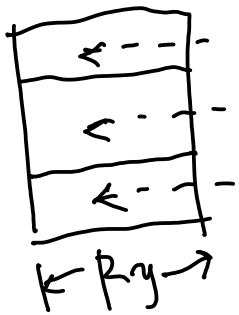




mezní pl. stav pro M1 a celý průřez

a) mez. elast. stav:

$\sigma = \frac{N}{A}$



$^1N_1 = R_y \cdot \frac{A}{2}$

$N_2 = R_y \cdot A$

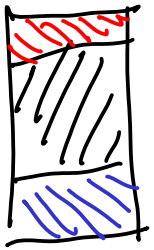
$^2N_1 = R_y \cdot \frac{A}{2}$

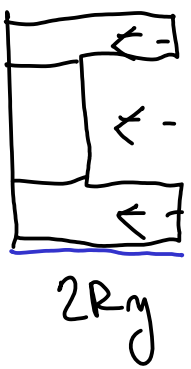
mezní elast. síla:

$N = \sum N_i = {}^1N_1 + N_2 + {}^2N_1 =$

$= R_y \cdot \frac{A}{2} + R_y \cdot A + R_y \frac{A}{2} = (-) \underline{\underline{2R_yA}}$

b) mezní pl. stav:





$^1N_1 = 2R_y \cdot \frac{A}{2}$

$N_2 = R_y \cdot A$

$^2N_1 = 2R_y \cdot \frac{A}{2}$

$N_{pl} = \sum N_i$

$= 2R_y \cdot \frac{A}{2} \cdot 2 + R_y \cdot A$

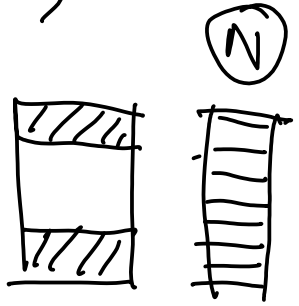
$= 3R_y \cdot A \ (-)$

c) odtížení do nuly

- odtížení je vždy elastické: $N = 0$.

$N_{odt} = \frac{3R_y \cdot A}{2}$

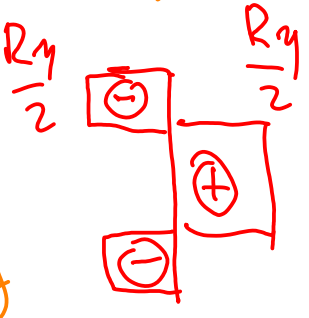
$N_1 = N_2 = \frac{N}{2}$



$N_{1.res} = -2R_y \cdot \frac{A}{2} + \frac{3R_y \cdot A}{2} = -\frac{1}{2} R_y \cdot A$

$N_{2.res} = -R_y \cdot A + \frac{3R_y \cdot 2A}{2} = +\frac{1}{2} R_y \cdot A$

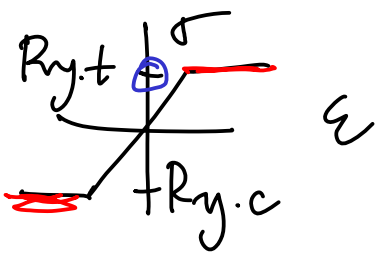
$\sigma = \frac{N}{A}$

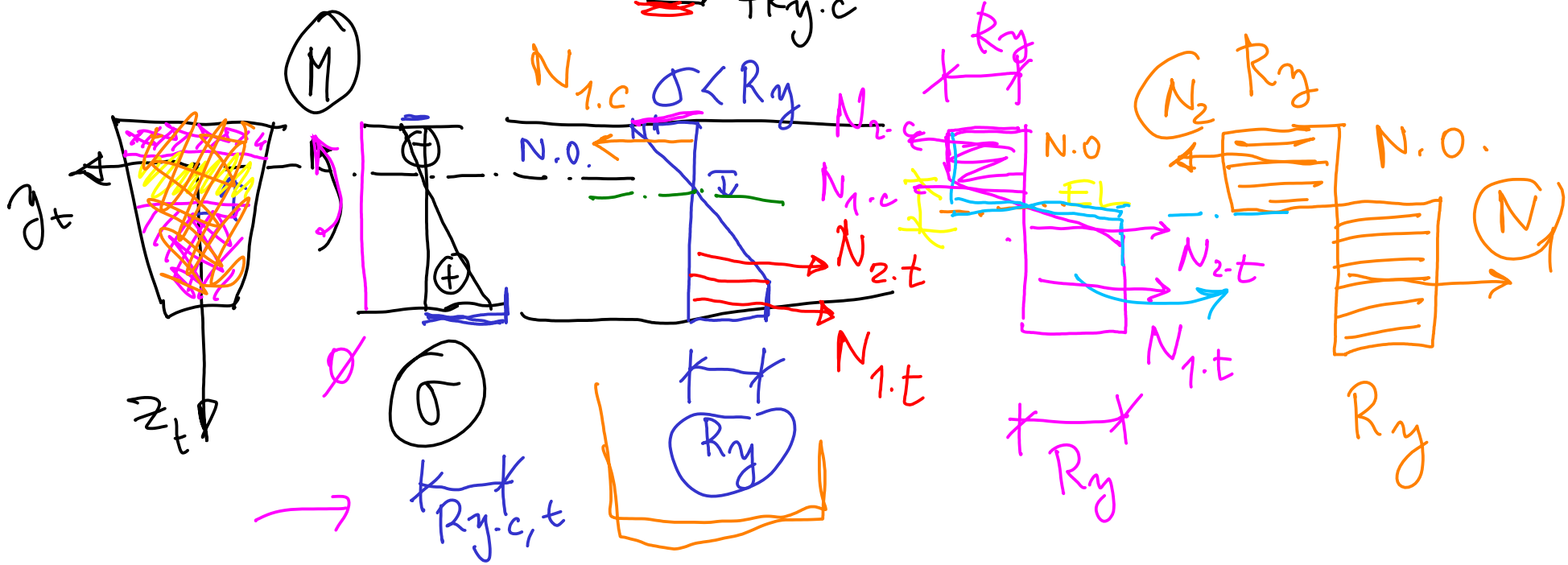


$\sigma_{1.res} = \frac{N_{1.res}}{A} = -\frac{1}{2} R_y$

$\sigma_{2.res} = \frac{N_{2.res}}{A} = \frac{1}{2} R_y$

OHYB & PP stav





$$N_{1.c} = N_{1.t} + N_{2.t}$$

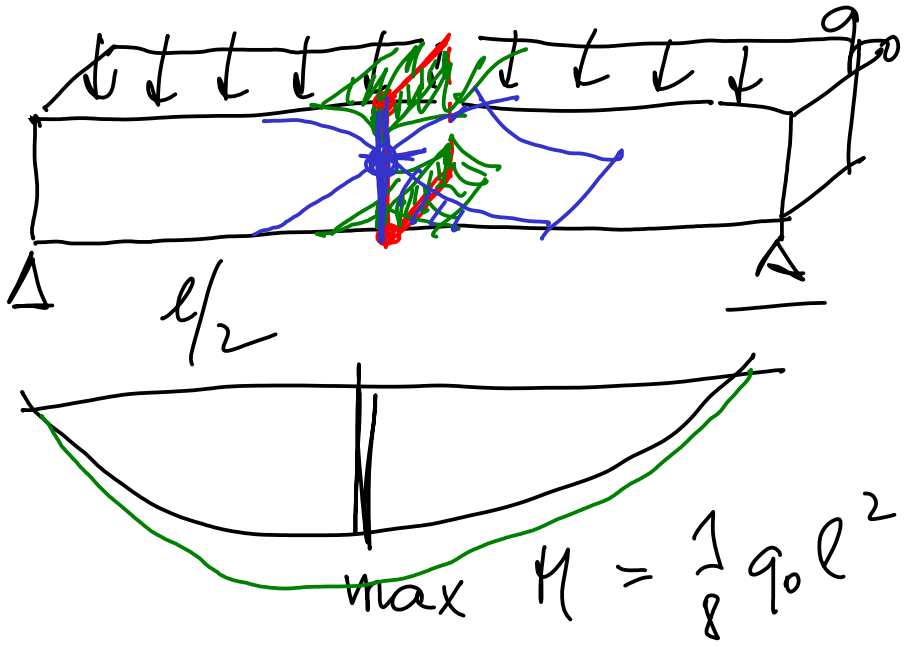
↳ poloha N.O.

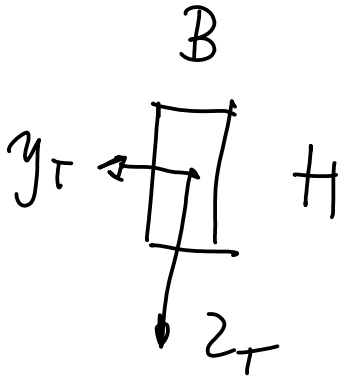
→ zvyšuji M →

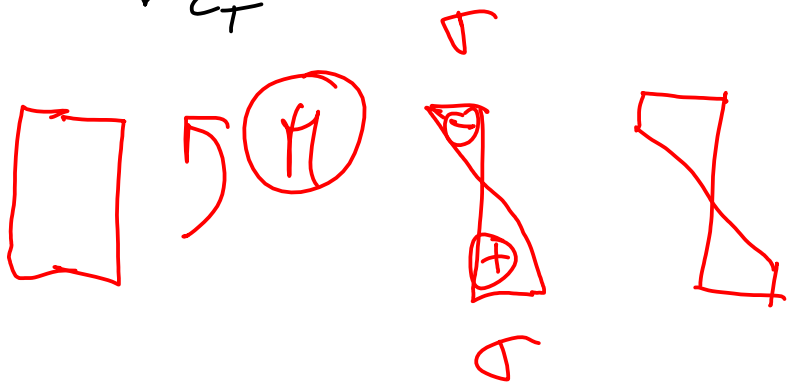
jednostranný mezní el. stav

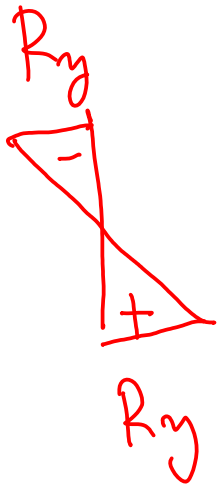
obousm. MES

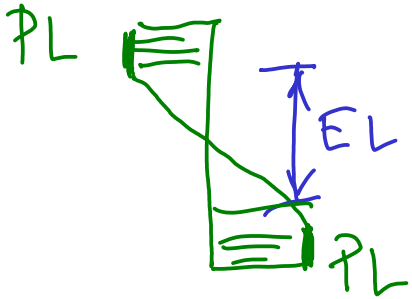
mezní plast. stav

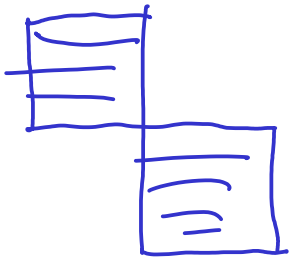


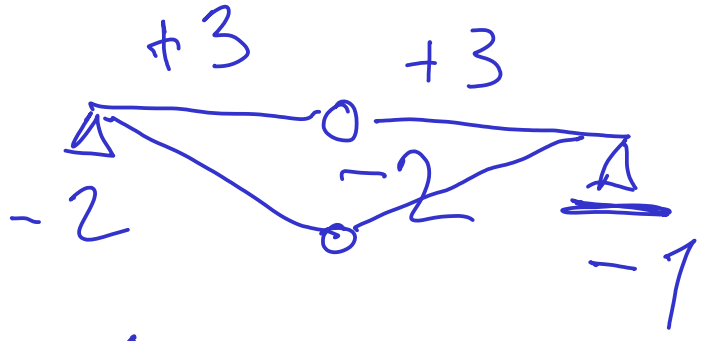


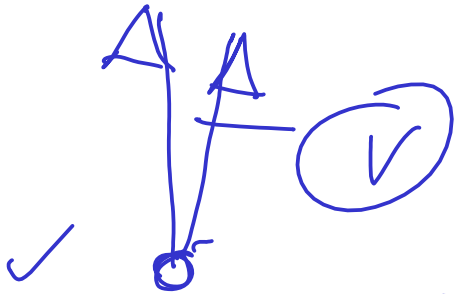








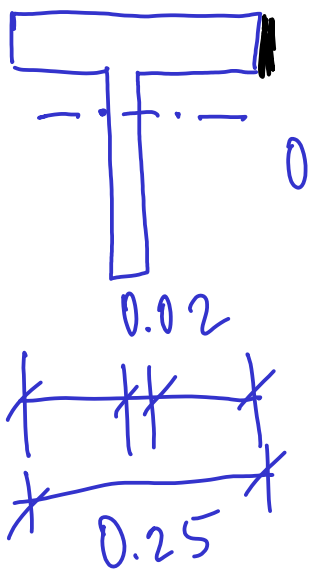


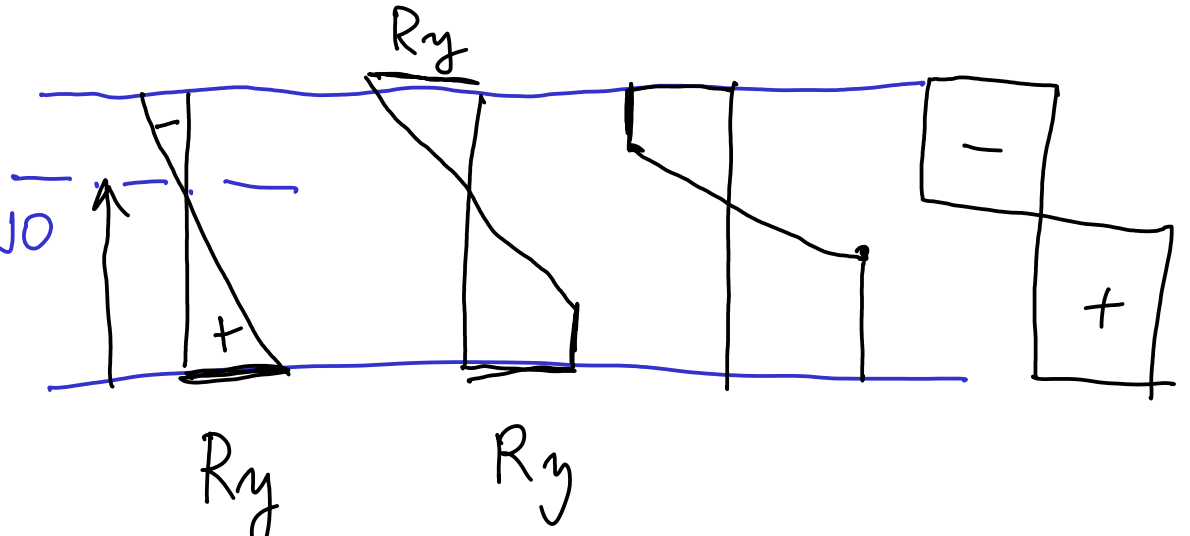


6−5

=+1

1x SPK





$R_y = 250\ MPa$

a) mezní el. stav

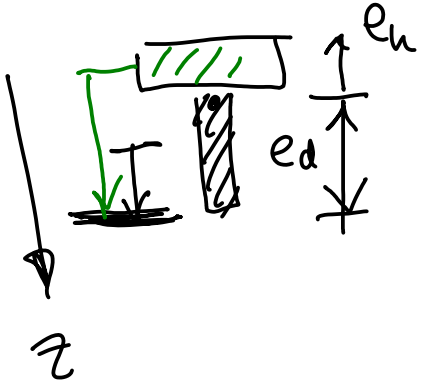
b) 2pl. pásnice

c) mezní pl. stav

$$\sigma = \frac{M}{W} = \frac{M}{I_y} \cdot z \longrightarrow \sigma = R_y$$

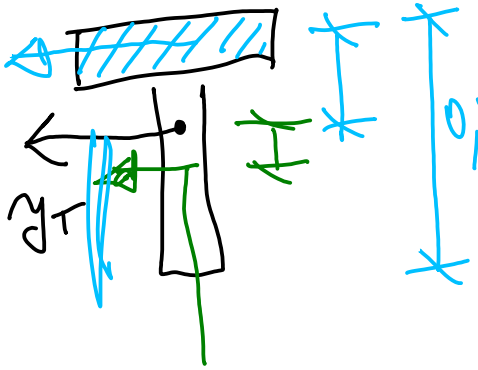
$$M_e = R_y \cdot W_d$$

$$W_d = \frac{I_y}{z_T} = \frac{I_y}{e_d}$$



$$e_d = \frac{\sum A_i \cdot z_i}{\sum A_i} = \frac{t_s \cdot h_s \cdot \frac{h_s}{2} + b_p \cdot t_p \cdot \left(h_s + \frac{t_p}{2}\right)}{t_s h_s + b_p t_p}$$

$$= 0{,}326 \text{ m}$$



$$I_y = \sum I_{y_{T_i}} + A_i \cdot z_i^2 = \frac{1}{12} t_s \cdot h_s^3 + t_s h_s \left(0{,}326 - \frac{0{,}49}{2}\right)^2$$

$$= \frac{1}{12} b_p \cdot t_p^3 + b_p t_p \cdot \left(0{,}49 - 0{,}326\right)^2 =$$

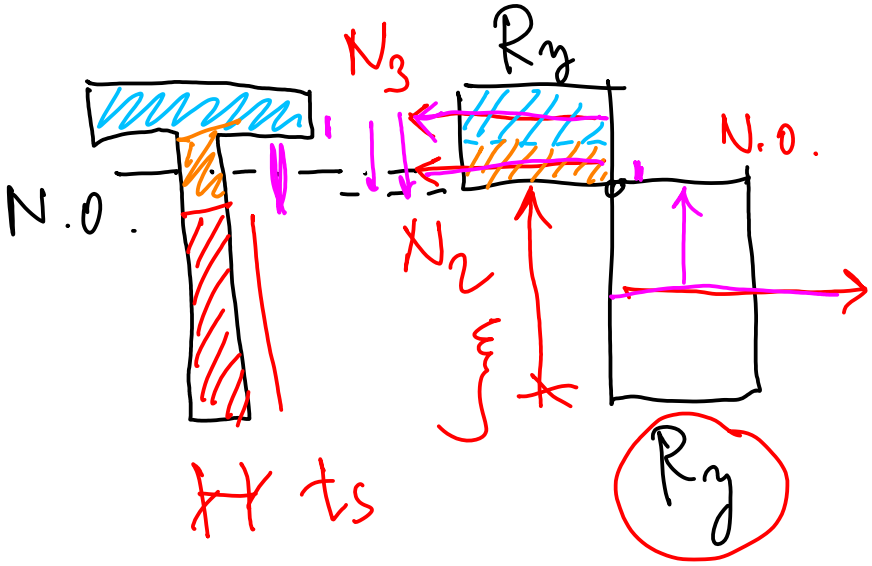
$$= 0{,}390 \cdot 10^{-3} \text{ m}^4$$

$$\sigma = \frac{M}{W}$$

$$W_d = \frac{I_y}{e_d} = \frac{0{,}390 \cdot 10^{-3}}{0{,}326} = 1{,}198 \cdot 10^{-3} \text{ m}^3$$

$$M_e = R_y \cdot W_d = 250 \cdot 10^3 \cdot 1{,}198 \cdot 10^{-3} = 299{,}5 \text{ kNm}$$

Mpl



$N_3 = R_y \cdot t_p \cdot b_p$

$N_2 = R_y \cdot (h_s - \xi)$

$N_1 = R_y \cdot \xi \, t_s$

Mpl

$\rightarrow \quad N_1 - N_2 - N_3 = 0$

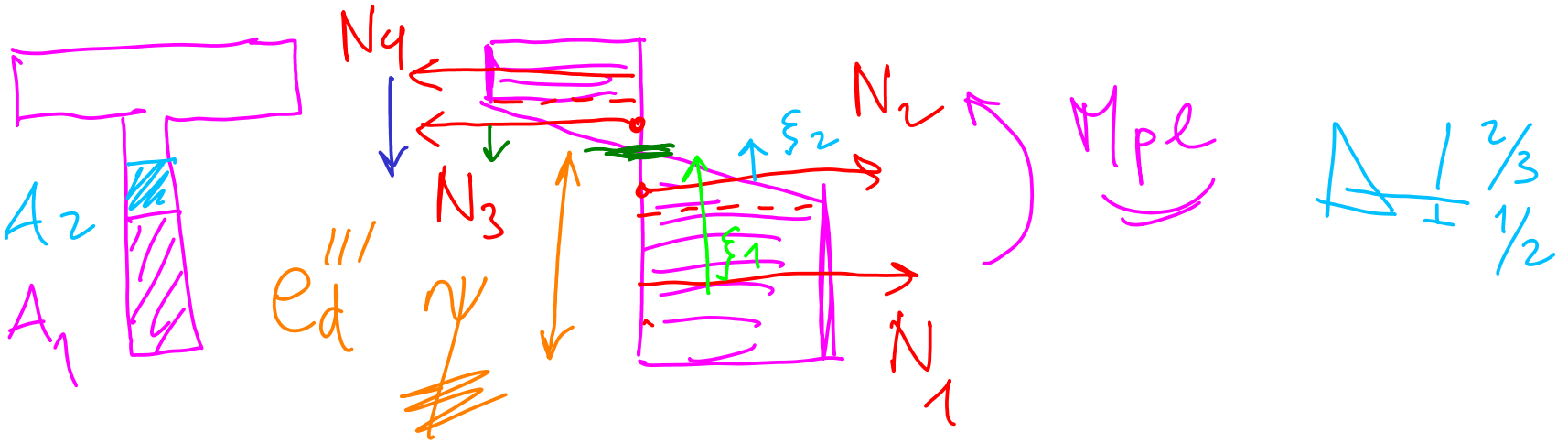
$$R_y \, \xi \, t_s - R_y \, (h_s - \xi) - R_y \cdot t_p \cdot b_p = 0$$

$$\xi = 0{,}365 \text{ m}$$

$$M_{pl} = N_1 \cdot \frac{\xi}{2} + N_2 \cdot \frac{h_s - \xi}{2} + N_3 \left(h_s - \xi + \frac{b_p}{2} \right)$$

$$= 5224 \text{ kNm}$$

c)



$$M_{pl} = N_1 \cdot \xi_1 + N_2 \xi_2 + N_3 \xi_3 + N_4 \xi_4$$

$$\psi: \rightarrow \quad N_1 + N_2 - N_3 - N_4 = 0$$

$$N_1 = R_y \cdot A_1 + R_3 \cdot A_2$$