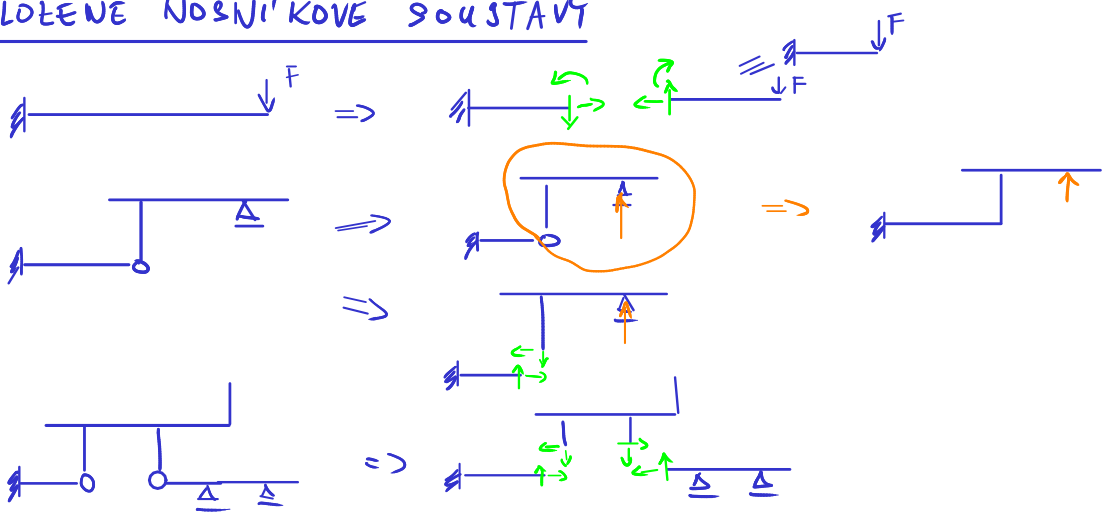
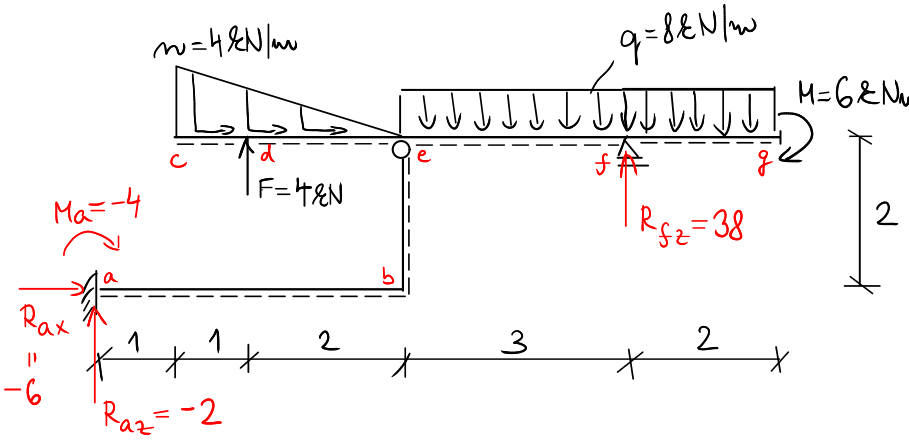
SLOŽENÉ NOSNÍKOVÉ SOUSTAVY





$$\Sigma M^P_{ei} = 0 \ \oplus\circlearrowleft$$

$$-F\cdot 2 - q\cdot 5\cdot\frac{5}{2} + R_{fz}\cdot 3 - M = 0$$

$$R_{fz} = \frac{4\cdot 2 + 8\cdot\frac{25}{2} + 6}{3} = 38\,kN$$

$$\Sigma F_{xi} = 0 \ \oplus\rightarrow$$

$$R_{ax} + \frac{1}{2}w\cdot 3 = 0$$

$$R_{ax} = -\frac{1}{2}4\cdot 3 = -6\,kN$$

$$\Sigma F_{zi} = 0 \ \oplus\uparrow$$

$$R_{az} + R_{fz} + F - q\cdot 5 = 0$$

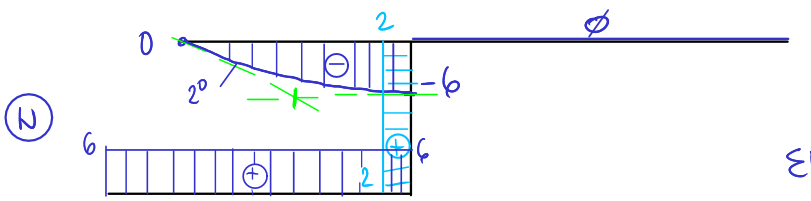
$$R_{az} = -38 - 4 + 8\cdot 5 = -2\,kN$$

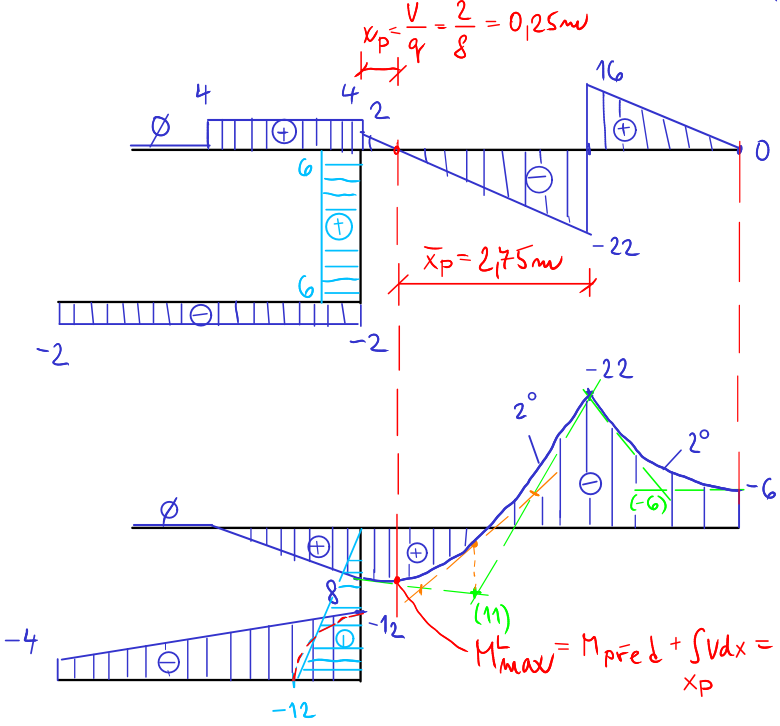
$$\Sigma M_{ai} = 0 \ \oplus\circlearrowleft$$

$$M_a - F\cdot 2 + \frac{1}{2}w\cdot 3\cdot 2 + q\cdot 5\cdot 6{,}5 + M - R_{fz}\cdot 7 = 0$$

$$M_a = 4\cdot 2 - \frac{1}{2}4\cdot 6 - 8\cdot 5\cdot 6{,}5 - 6 + 38\cdot 7 = -4\,kNm$$

(N)

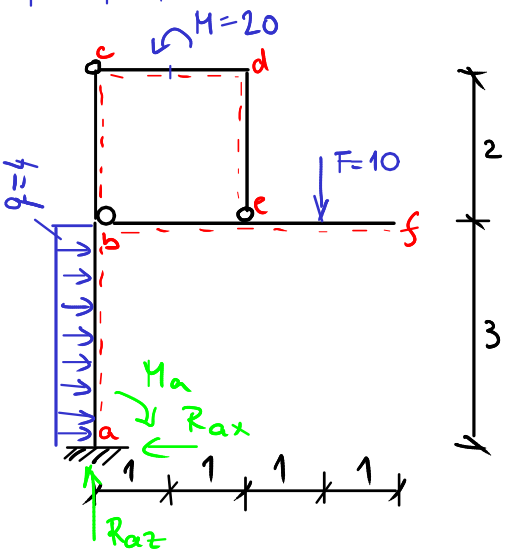




$$M^L_{max} = M_{prec} + \int_{x_p} V\,dx = 8 + \frac{1}{2}\cdot 2\cdot 0{,}25 = 8{,}25\,kNm$$

$$M^P_{max} = -M + R_{fz}\cdot\bar{x}_p - q\cdot\frac{(2+\bar{x}_p)^2}{2} = -6 + 38\cdot 2{,}75 - 8\cdot\frac{(2+2{,}75)^2}{2} = 8{,}25\,kNm$$

[kN, kNm, kN/m, m]



1) reakce

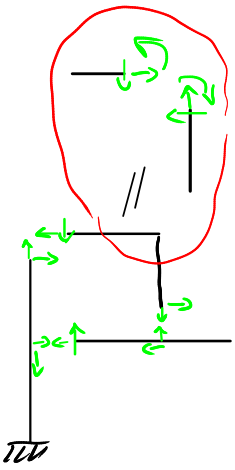
- pro kontrolu, ne vykreslení

$\Sigma F_{xi} = 0 \Rightarrow R_{ax} = 12\,kN$

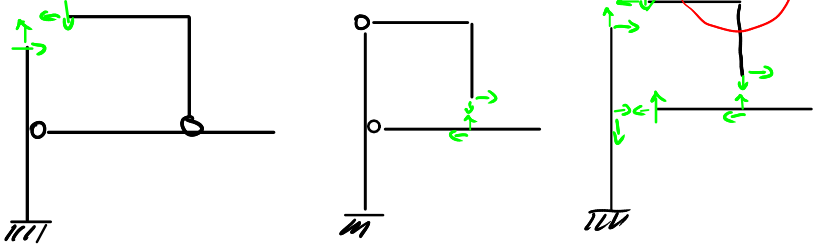
$\Sigma F_{zi} = 0 \Rightarrow R_{az} = 10\,kN$

$\Sigma M_{ai} = 0 \Rightarrow M_a = -28\,kNm$

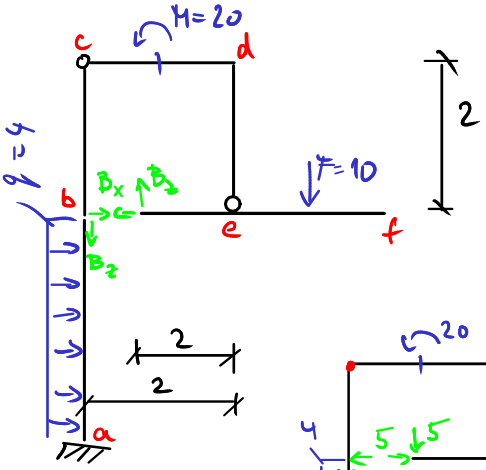
kontrola: $\Sigma M_{fi} = 0$

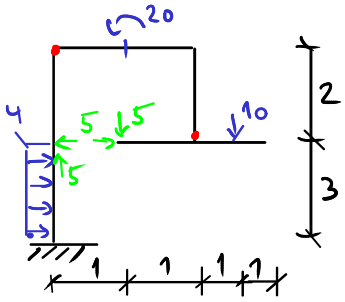


2)



pro vykreslení je nutné otevřít uzavřenou část bcde alespoň v jednom místě
- s výhodou v kloubu (2 interakce)
  ↳ v prutu (3 interakce)





- výpočet interakcí

$\Sigma M^P_{ei} = 0 \quad \oplus\circlearrowleft$

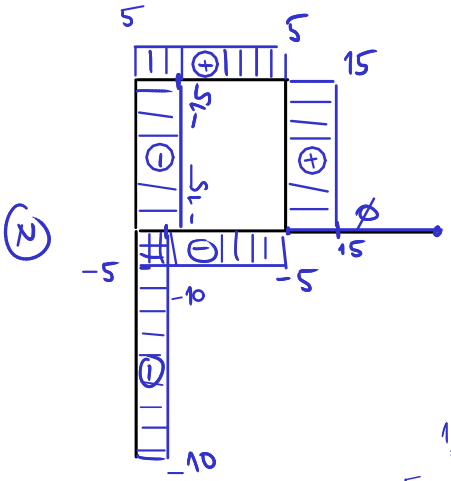
$(B_x \cdot 0) + B_z \cdot 2 + F \cdot 1 = 0$

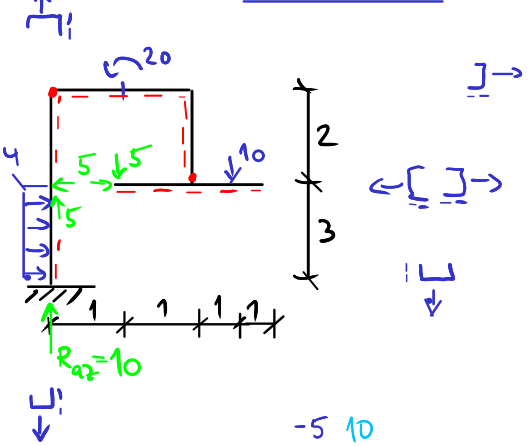
$B_z = -5\,kN$

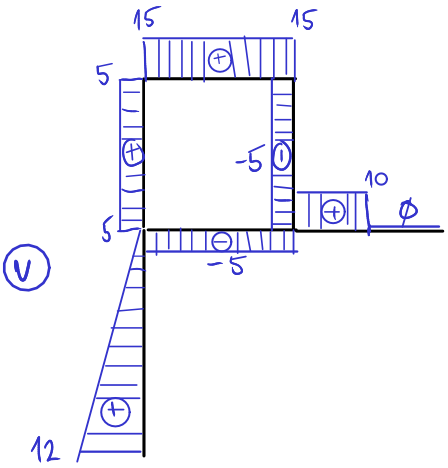
$\Sigma M_{ci} = 0 \quad \oplus\circlearrowleft$

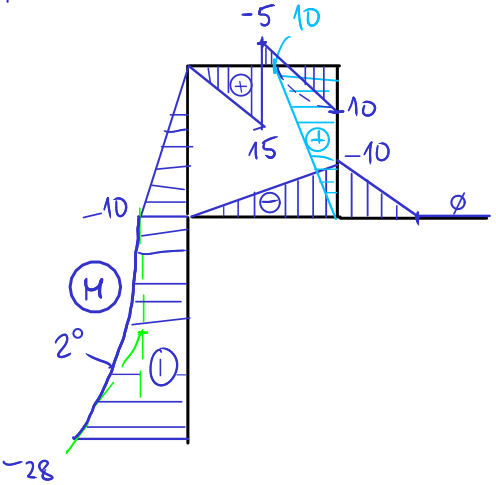
$(B_z \cdot 0) - M + B_x \cdot 2 + F \cdot 3 = 0$

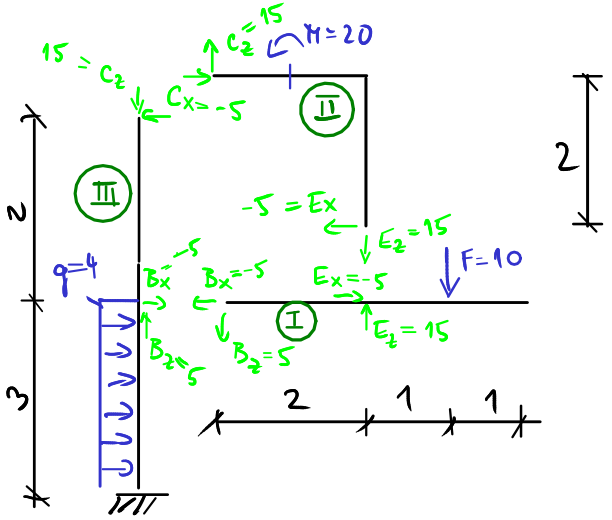
$B_x = -5\,kN$











(I) $\sum M_{Bi} = 0$ ⊕↺

$F \cdot 3 - E_z \cdot 2 = 0 \Rightarrow \underline{E_z = 15\,kN}$

$\sum M_{Ei} = 0$ ⊕↺

$F \cdot 1 - B_z \cdot 2 = 0 \Rightarrow \underline{B_z = 5\,kN}$

kontrola: $\sum F_{zi} = 0$ ⊕↑ $\quad -B_z + E_z - F = 0$

$-5 + 15 - 10 = 0$ ✓

$\sum F_{xi} = 0$ ⊕→

$-B_x + E_x = 0 \Rightarrow B_x = E_x = \underline{-5\,kN}$

(II) $\sum M_{Ci} = 0$ ⊕↺

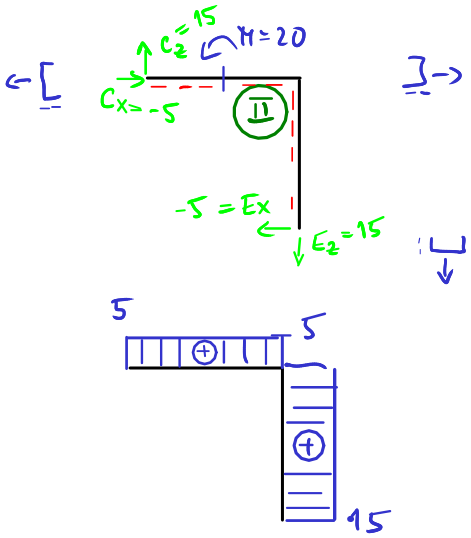
$E_x \cdot 2 + E_z \cdot 2 - M = 0 \rightarrow \underline{E_x = -5\,kN}$

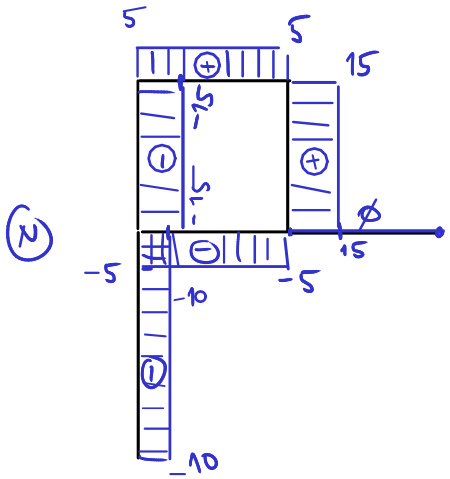
$\sum F_{zi} = 0$ ⊕↑

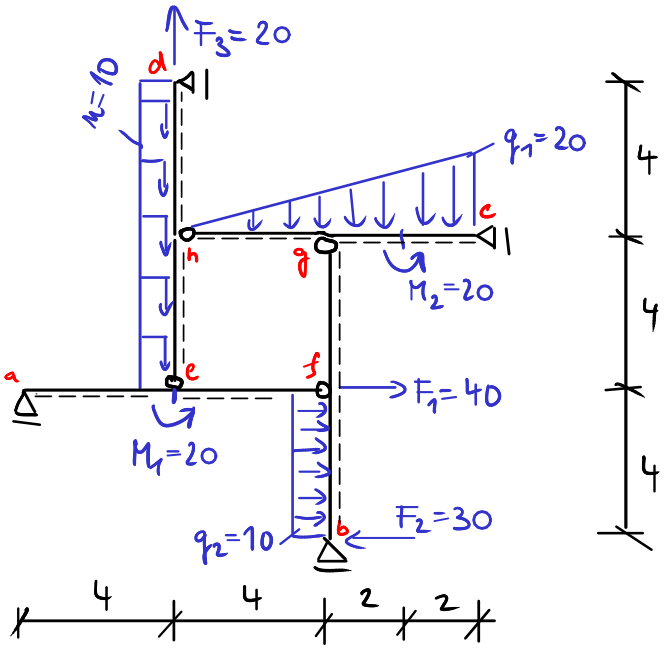
$C_z - E_z = 0 \Rightarrow C_z = E_z = \underline{15\,kN}$

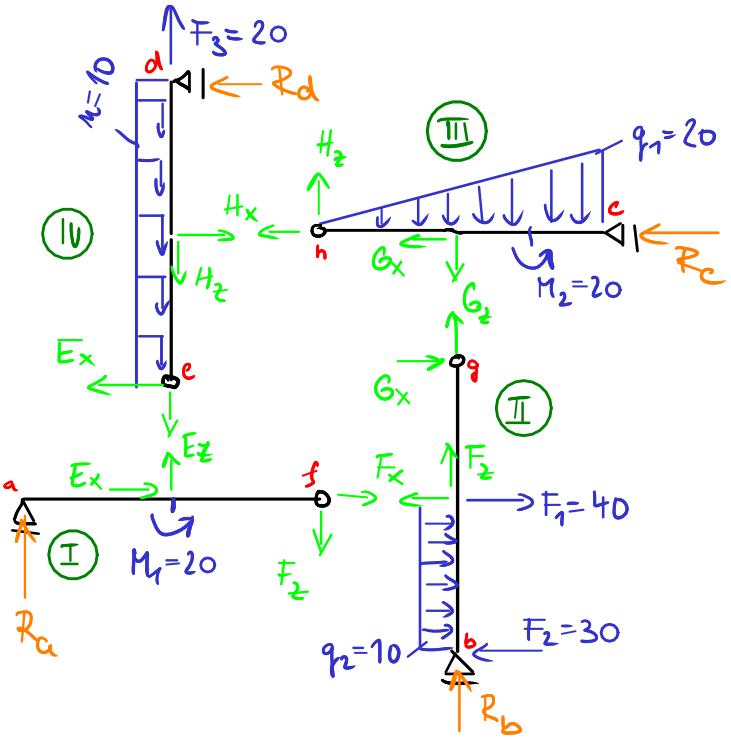
$\sum F_{xi} = 0$ ⊕→

$C_x - E_x = 0 \Rightarrow C_x = E_x = \underline{-5\,kN}$







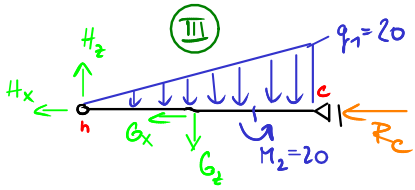


III $\quad \Sigma M_{hi} = 0 \quad \oplus \circlearrowright$

$$G_z \cdot 4 - M_2 + \left(\tfrac{1}{2} q_1 \cdot 8\right) \cdot \left(\tfrac{2}{3} 8\right) = 0 \Rightarrow G_z = -101{,}\overline{6}\ \text{kN}$$

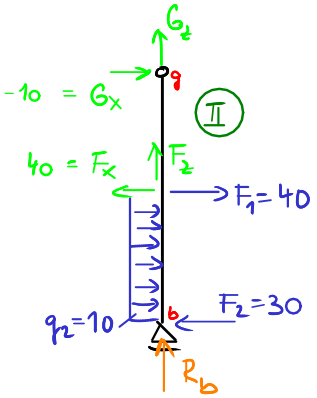
$\Sigma M_{gi} = 0 \quad \oplus \circlearrowright$

$$H_z \cdot 4 - M_2 + \left(\tfrac{1}{2} q_1 \cdot 8\right) \cdot \left(\tfrac{2}{3} 8 - 4\right) = 0 \Rightarrow H_z = -21{,}\overline{6}\ \text{kN}$$



kontrola: $\Sigma F_{zi} = 0 \quad \oplus \uparrow$

$$H_z - G_z - \tfrac{1}{2} q_1 \cdot 8 = 0 \quad \checkmark$$



II $\quad \Sigma M_{gi} = 0 \quad \oplus \circlearrowleft$

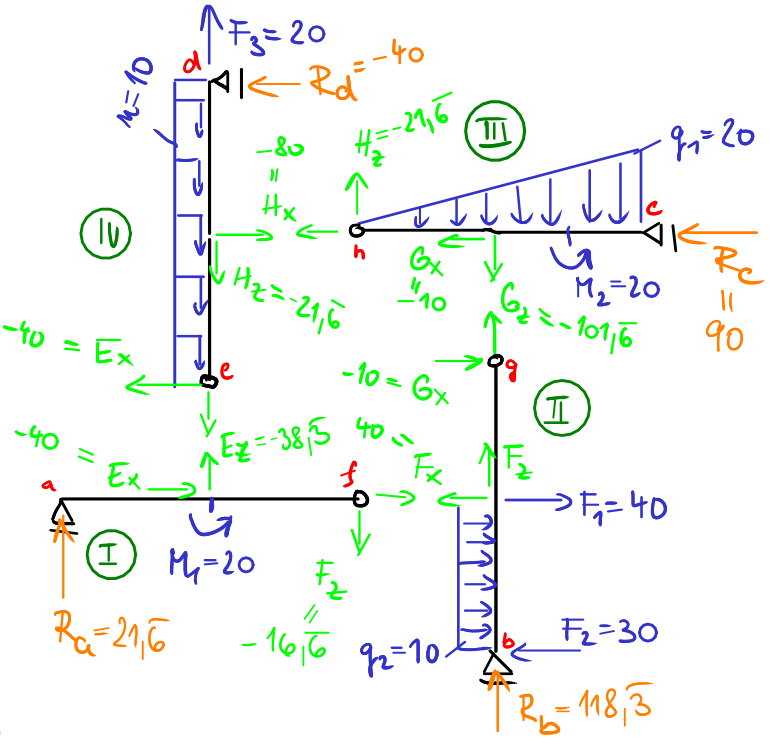
$$F_1 \cdot 4 - F_2 \cdot 8 - F_x \cdot 4 + (q_2 \cdot 4) \cdot \left(4 + \tfrac{1}{2} 4\right) = 0 \Rightarrow F_x = 40\ \text{kN}$$

$\Sigma M_{fi} = 0 \quad \oplus \circlearrowright$

$$G_x \cdot 4 - (q_2 \cdot 4) \cdot \left(\tfrac{1}{2} 4\right) + F_2 \cdot 4 = 0 \Rightarrow G_x = -10\ \text{kN}$$

kontrola: $\Sigma F_{xi} = 0 \quad \oplus \rightarrow$

$$G_x - F_x + F_1 - F_2 + q_2 4 = 0 \quad \checkmark$$



(I) $\Sigma F_{xi} = 0$ $\oplus\rightarrow$

$E_x + F_x = 0$

$E_x = -F_x = -40\,kN$

(IV) $\Sigma M_{ai} = 0$ $\oplus\circlearrowleft$

$E_x \cdot 4 - R_d \cdot 4 = 0 \Rightarrow R_d = E_x = -40\,kN$

$\Sigma M_{di} = 0$ $\oplus\uparrow$

$H_x \cdot 4 - E_x \cdot 8 = 0 \Rightarrow H_x = 2E_x = -80\,kN$

kontrola: $\Sigma F_{xi} = 0$ $\oplus\rightarrow$

$-R_d + H_x - E_x = 0$ ✓

$\Sigma F_{zi} = 0$ $\oplus\uparrow$

$F_3 - H_z - E_z - m \cdot 8 = 0 \Rightarrow E_z = -38,\overline{3}\,kN$

(I) $\Sigma M_{ai} = 0$ $\oplus\circlearrowleft$

$E_z \cdot 4 + M_1 - F_z \cdot 8 = 0 \Rightarrow F_z = -16,\overline{6}\,kN$

$\Sigma M_{fi} = 0$ $\oplus\circlearrowleft$

$-R_a \cdot 8 - E_z \cdot 4 + M_1 = 0 \Rightarrow R_a = 21,\overline{6}\,kN$

kontrola: $\Sigma F_{zi} = 0$ $\oplus\uparrow$

$R_a + E_z - F_z = 0$ ✓

(II) $\Sigma F_{zi} = 0$ $\oplus\uparrow$

$R_b + F_z + G_z = 0 \Rightarrow R_b = 118,\overline{3}\,kN$

(III) $\Sigma F_{xi} = 0$ $\oplus\leftarrow$

$H_x + G_x + R_c = 0 \Rightarrow R_c = 90\,kN$

kontrola na celé konstrukci

$\Sigma F_{xi} = 0$ $\oplus\rightarrow$

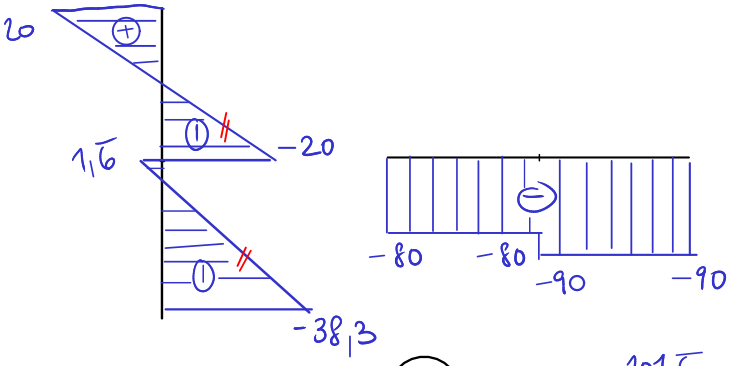
$-R_d - R_c + q_2 \cdot 4 + F_1 - F_2 = 0$ ✓

$\Sigma F_{zi} = 0$ $\oplus\uparrow$

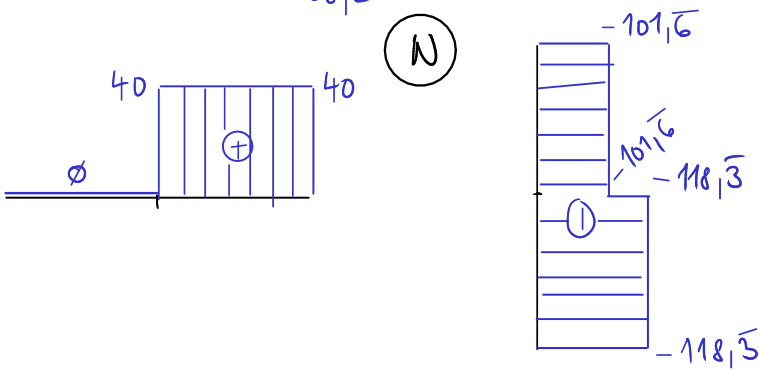
$F_3 - m \cdot 8 + R_a + R_b - \frac{1}{2} q_1 \cdot 8 = 0$ ✓

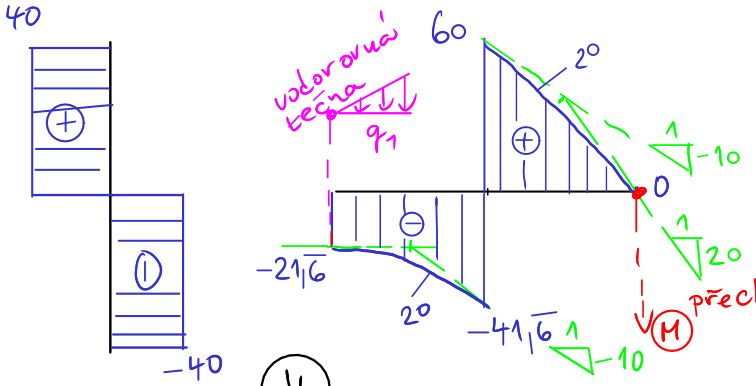
$\Sigma M_{ai} = 0$ $\oplus\circlearrowleft$

$M_1 + M_2 + F_3 \cdot 4 + R_d \cdot 8 - (m \cdot 8) \cdot 4 + R_c \cdot 4 + (q_2 \cdot 4) \cdot 2 + R_b \cdot 8 - F_2 \cdot 4 - \frac{1}{2} q_1 \cdot 8 \cdot \left(4 + \frac{2}{3} 8\right) = 0$ ✓

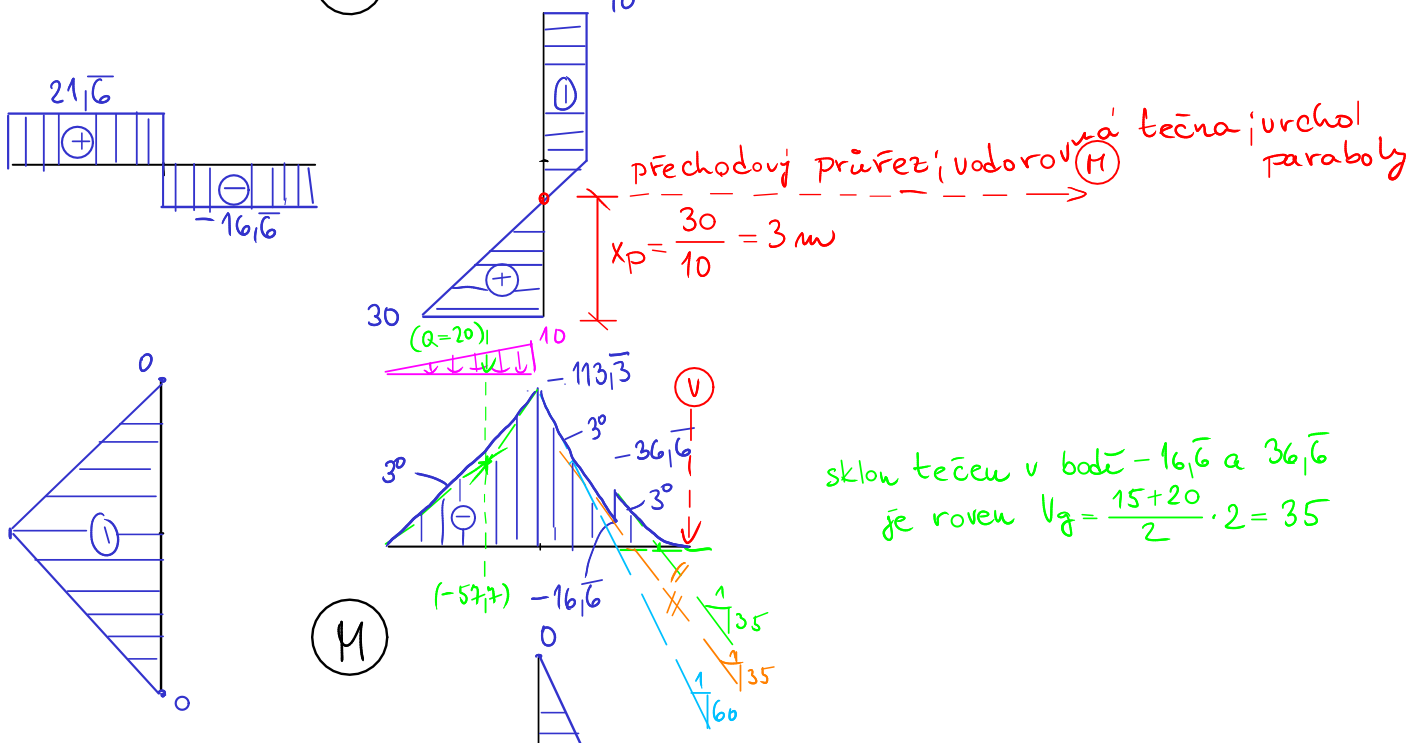


N

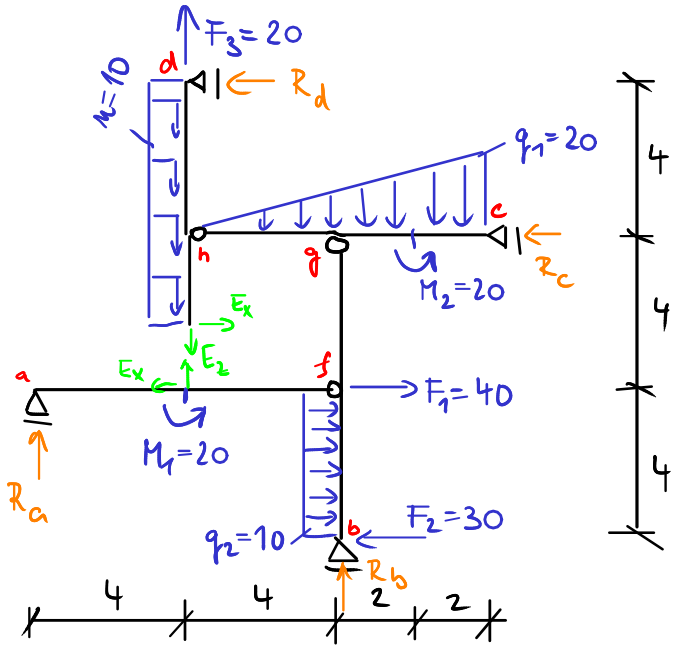




V



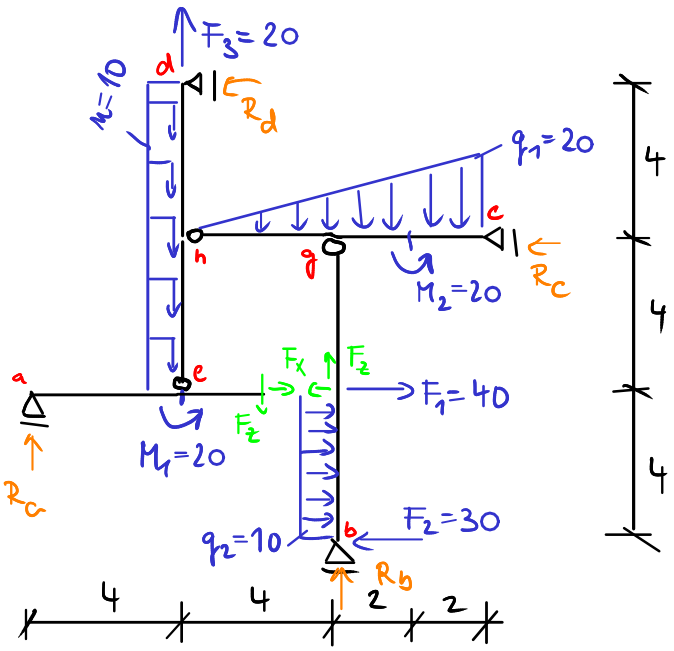
sklon tečen v bodě $-16,\overline{6}$ a $36,\overline{6}$ je roven $V_g = \frac{15+20}{2} \cdot 2 = 35$



$\Sigma M^{L}_{fi} = 0 \oplus \circlearrowleft$

VEDE NA

SOUSTAVU ROVNIC

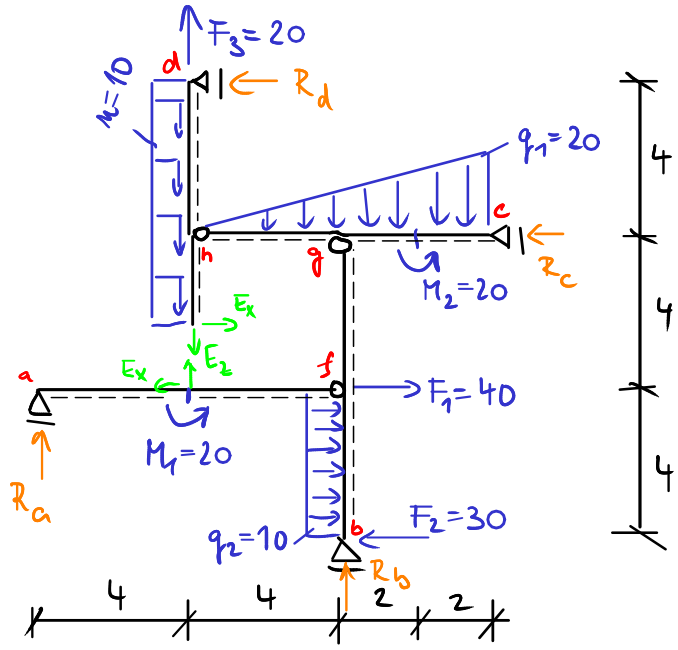


$\Sigma M^{P}_{gi} = 0 \oplus \circlearrowright$

$F_x \cdot 4 - F_1 \cdot 4 + F_2 \cdot 8 - (q_2 \cdot 4)\left(4 + \frac{1}{2}4\right)$

$F_x = 40\,kN$

SOUSTAVA ROVNIC



$\Sigma M^L_{fi} = 0 \oplus\circlearrowleft$

$\Sigma M^L_{hi} = 0 \overset{\oplus\circlearrowleft}{:}\quad R_d \cdot 4 + E_x \cdot 4 = 0$

$\Sigma M^P_{gi} = 0 \overset{\oplus\circlearrowleft}{:}\quad M_2 - \frac{1}{2} q_1 \cdot 8 \cdot \left(\frac{2}{3}8 - 4\right) + R_d \cdot 4 - F_3 \cdot 4 + m \cdot 8 \cdot 4 + E_x \cdot 4 + E_z \cdot 4 = 0$

$\Sigma M^L_{fi} = 0 \overset{\oplus\circlearrowright}{:}\quad R_a \cdot 8 - M_1 + E_z \cdot 4 = 0$

$\Sigma M^L_{gi} = 0 \overset{\oplus\circlearrowright}{:}\quad R_a \cdot 8 + E_x \cdot 4 + E_z \cdot 4 - M_1 + F_2 \cdot 8 - F_1 \cdot 4 - q_2 \cdot 4 \cdot 6 = 0$

$\Sigma F_{zi} = 0 \overset{\oplus\uparrow}{:}\quad R_a + R_b - \frac{1}{2} q_1 \cdot 8 - m \cdot 8 + F_3 = 0$

$\Sigma F_{xi} = 0 \overset{\oplus\rightarrow}{:}\quad F_1 - F_2 + q_2 \cdot 4 - R_c - R_d = 0$

$4R_d + 4E_x = 0$

$4R_d + 4E_x + 4E_z + 20 - \frac{1}{2} 20 \cdot 8 \left(\frac{2}{3}8 - 4\right) - 20 \cdot 4 + 10 \cdot 8 \cdot 4 = 0$

$8R_a + 4E_z - 20 = 0$

$8R_a + 4E_x + 4E_z - 20 + 30 \cdot 8 - 40 \cdot 4 - 10 \cdot 4 \cdot 6 = 0$

$R_a + R_b - \frac{1}{2} 20 \cdot 8 - 10 \cdot 8 + 20 = 0$

$R_c + R_d - 40 + 30 - 10 \cdot 4 = 0$

$4R_d + 4E_x = 0$

$4R_d + 4E_x + 4E_z + 153{,}\overline{3} = 0$

$8R_a + 4E_z - 20 = 0$

$8R_a + 4E_x + 4E_z - 180 = 0$

$R_a + R_b - 140 = 0$

$R_c + R_d - 50 = 0$

$$\begin{bmatrix} 0 & 0 & 0 & 4 & 4 & 0 \\ 0 & 0 & 0 & 4 & 4 & 4 \\ 8 & 0 & 0 & 0 & 0 & 4 \\ 8 & 0 & 0 & 0 & 4 & 4 \\ 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \end{bmatrix} \begin{Bmatrix} R_a \\ R_b \\ R_c \\ R_d \\ E_x \\ E_z \end{Bmatrix} = \begin{Bmatrix} 0 \\ -153{,}\overline{3} \\ 20 \\ 180 \\ 140 \\ 50 \end{Bmatrix}$$

$$\begin{bmatrix} 8 & 0 & 0 & 0 & 0 & 4 & | & 20 \\ 1 & 1 & 0 & 0 & 0 & 0 & | & 140 \\ 0 & 0 & 1 & 1 & 0 & 0 & | & 50 \\ 0 & 0 & 0 & 4 & 4 & 4 & | & -153{,}\overline{3} \\ 8 & 0 & 0 & 0 & 4 & 4 & | & 180 \\ 0 & 0 & 0 & 4 & 4 & 0 & | & 0 \end{bmatrix} \overset{\begin{matrix} \cdot(-8) \\ \cdot(-1) \\ \cdot(-1) \end{matrix}}{\sim} \begin{bmatrix} 8 & 0 & 0 & 0 & 0 & 4 & | & 20 \\ 0 & -8 & 0 & 0 & 0 & 4 & | & -1100 \\ 0 & 0 & 1 & 1 & 0 & 0 & | & 50 \\ 0 & 0 & 0 & 4 & 4 & 4 & | & -153{,}\overline{3} \\ 0 & 0 & 0 & 0 & -4 & 0 & | & -160 \\ 0 & 0 & 0 & 0 & 0 & 4 & | & -153{,}\overline{3} \end{bmatrix}$$

$\Rightarrow R_a = 21{,}\overline{6}\ \text{kN}$

$\Rightarrow R_b = 118{,}\overline{3}\ \text{kN}$

$\Rightarrow R_c = 90\ \text{kN}$

$\Rightarrow R_d = -40\ \text{kN}$

$\Rightarrow E_x = 40\ \text{kN}$

$\Rightarrow E_z = -38{,}\overline{3}\ \text{kN}$