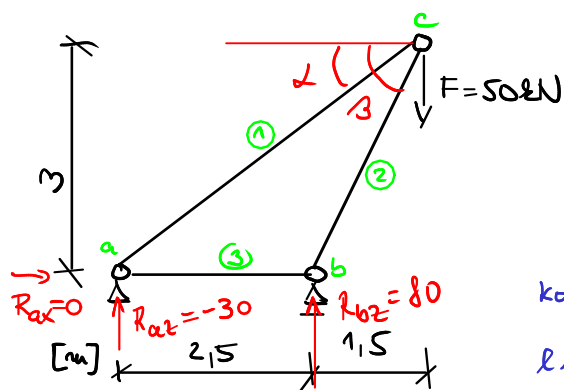




REAKCE:

$$\sum F_{xi} = 0 \Rightarrow R_{ax} = 0$$

$$\sum M_{ai} = 0 \Rightarrow R_{bz} = 80 \text{ kN}$$

$$\sum M_{bi} = 0 \Rightarrow R_{az} = -30 \text{ kN}$$

kontrola: $\sum F_{zi} = 0 \Rightarrow 0 = 0 \checkmark$

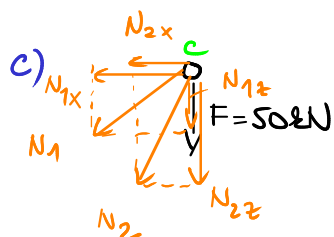
$$l_1 = \sqrt{4^2 + 3^2} = 5 \text{ m} \quad l_2 = \sqrt{1,5^2 + 3^2} = \sqrt{11,25} \text{ m}$$

$$\sin \alpha = \frac{3}{5}$$

$$\cos \alpha = \frac{4}{5}$$

$$\sin \beta = \frac{3}{\sqrt{11,25}}$$

$$\cos \beta = \frac{1,5}{\sqrt{11,25}}$$



$$\sum F_{xi} = 0 \oplus \leftarrow$$

$$N_{1x} + N_{2x} = 0$$

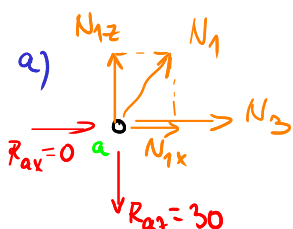
$$\sum F_{zi} = 0 \oplus \downarrow$$

$$N_{1z} + N_{2z} + F = 0$$

$$N_1 \cos \alpha + N_2 \cos \beta = 0$$

$$N_1 \sin \alpha + N_2 \sin \beta + F = 0$$

ŘEŠENÍ NEBO
KONTROLA



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

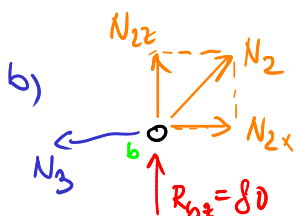
$$N_{1z} - R_{az} = 0 \Rightarrow N_1 \sin \alpha - 30 = 0$$

$$N_1 = \frac{30 \cdot 5}{3} = \underline{\underline{50 \text{ kN}}} \text{ (tah)}$$

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

$$R_{ax} + N_{1x} + N_3 = 0 \Rightarrow N_3 = -N_{1x} = -N_1 \cos \alpha$$

$$N_3 = -50 \cdot \frac{4}{5} = \underline{\underline{-40 \text{ kN}}} \text{ (tlak)}$$



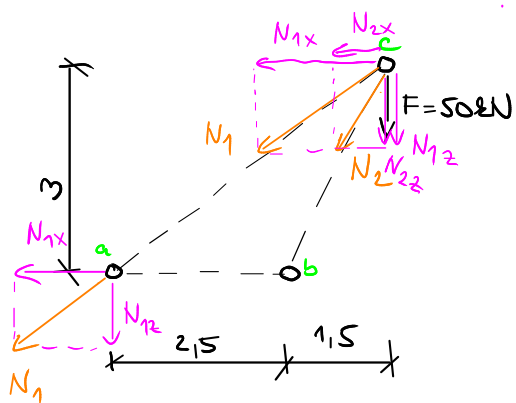
$$\sum F_{zi} = 0 \oplus \uparrow$$

$$R_{bz} + N_{2z} = 0 \Rightarrow N_2 \sin \beta = -R_{bz}$$

$$N_2 = \frac{-80 \sqrt{11,25}}{3} = \underline{\underline{-89,443 \text{ kN}}} \text{ (tlak)}$$

$$\sum F_{xi} = 0 \oplus \leftarrow$$

$$N_3 - N_{2x} = 0 \Rightarrow -40 - (-89,443) \cos \beta = 0 \Rightarrow \underline{\underline{0 = 0}} \checkmark$$



Stýčnick © momentové podmínky

- S výhodou využijeme body a a b ležící na paprscích N_1 a N_2

$$\sum M_{bi} = 0 \oplus \uparrow$$

$$N_{1x} \cdot 3 + N_2 \cdot 0 - F \cdot 1,5 - N_{1z} \cdot 1,5 = 0$$

$$N_1 \cos \alpha \cdot 3 - N_1 \sin \alpha \cdot 1,5 = F \cdot 1,5$$

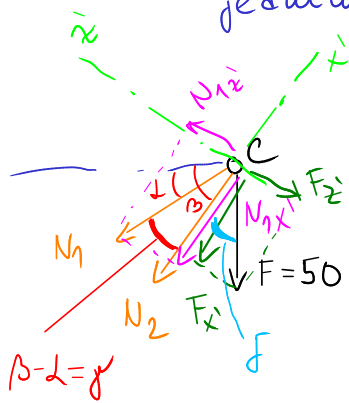
$$N_1 = \frac{50 \cdot 1,5}{3 \cdot \frac{4}{5} - 1,5 \cdot \frac{3}{5}} = \underline{\underline{50 \text{ kN}}}$$

- můžeme využít posunu N_1 po paprsku a ušetřit si 1 rozklad

$$\sum M_{bi} = 0 \oplus \uparrow: N_{1z} \cdot 2,5 + N_{1x} \cdot 0 + N_2 \cdot 0 - F \cdot 1,5 = 0$$

$$N_1 = \frac{F \cdot 1,5}{2,5 \cdot \sin \alpha} = \frac{50 \cdot 1,5}{2,5 \cdot \frac{3}{5}} = \underline{\underline{50 \text{ kN}}}$$

c) rozkladem do souřadného systému procházejícího jedním uznačným prutem N_1 nebo N_2



$$\sum F_{zi} = 0 \quad \oplus \uparrow$$

$$N_{1z} - F_z = 0$$

$$N_1 \sin \gamma = F_z \sin \delta$$

$$N_1 = \frac{F_z \sin \delta}{\sin \gamma} = \underline{\underline{5092 \text{ N (tah)}}}$$

$$\sin(\beta - \alpha) = 0,7138$$

$$\cos(\beta - \alpha) = 0,7004$$

$$\tan \alpha = \frac{3}{4} \Rightarrow \alpha = 36,8699^\circ$$

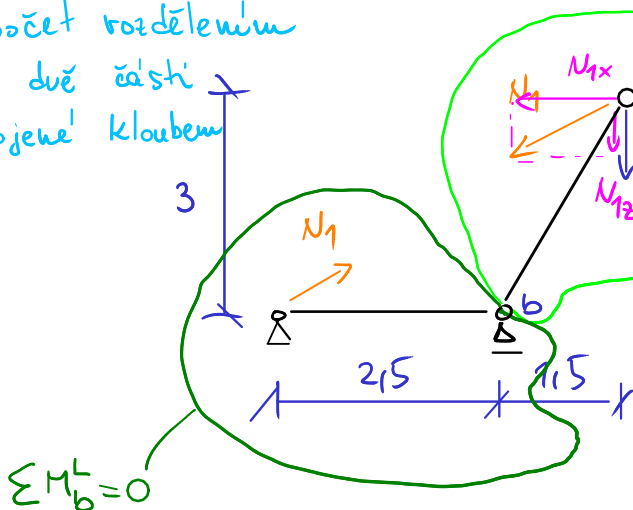
$$\tan \beta = \frac{3}{1,5} \Rightarrow \beta = 63,4349^\circ$$

$$\gamma = \beta - \alpha = 26,5651^\circ$$

$$\delta = 90 - \beta = 26,5651^\circ$$

Odebrání jedné vazby, budeme využívat později (složení konstrukce)

Výpočet rozdělení
na dvě části
spojené kloubem



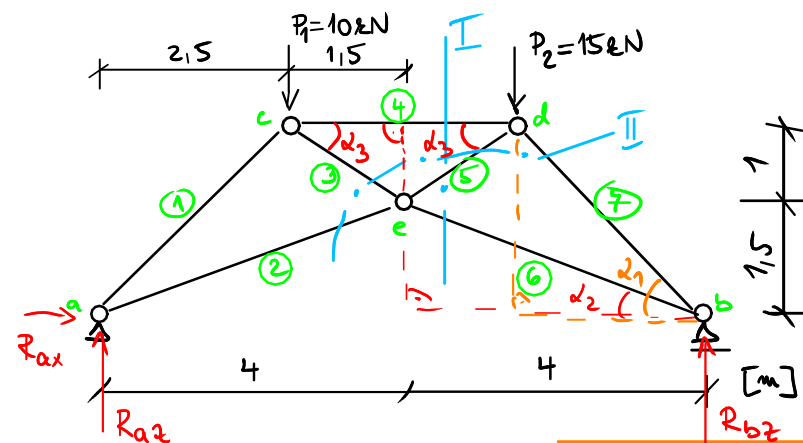
$$\sum M_b^L = 0$$

$$\sum M_b^P = 0 \quad \oplus \downarrow$$

$$-N_{1x} \cdot 3 + N_{1z} \cdot 1,5 + F \cdot 1,5 = 0$$

$$-N_1 \cos \alpha \cdot 3 + N_1 \sin \alpha \cdot 1,5 + F \cdot 1,5 = 0$$

$$N_1 = \frac{-F \cdot 1,5}{1,5 \cdot \sin \alpha - 3 \cos \alpha} = \underline{\underline{5092 \text{ N}}}$$



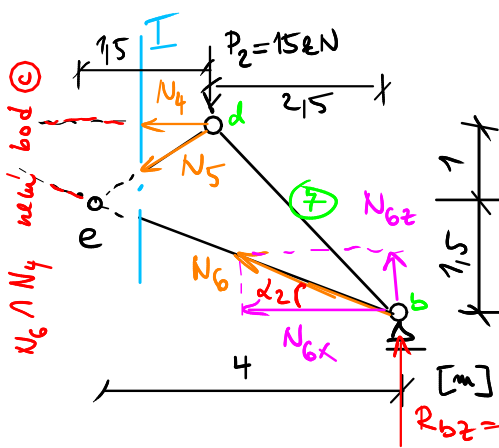
REAKCE

$$\sum F_{xi} = 0 \Rightarrow R_{ax} = 0 \text{ kN}$$

$$\sum M_{ai} = 0 \Rightarrow R_{bz} = \frac{13,4375 \text{ kN}}$$

$$\sum M_{bi} = 0 \Rightarrow R_{az} = \frac{11,5625 \text{ kN}}$$

$$\text{kontrola } \sum F_{zi} = 0 \Rightarrow 0 = 0 \checkmark$$



$$l_2 = l_6 = \sqrt{1,5^2 + 2,5^2} = \sqrt{18,25}$$

$$\sin \alpha_2 = \frac{1,5}{\sqrt{18,25}} \quad \cos \alpha_2 = \frac{2,5}{\sqrt{18,25}}$$

$$\sum M_{di} = 0 \quad (+ \curvearrowright)$$

$$N_{6z} \cdot 2,5 + R_{bz} \cdot 2,5 - N_{6x} \cdot 2,5 = 0$$

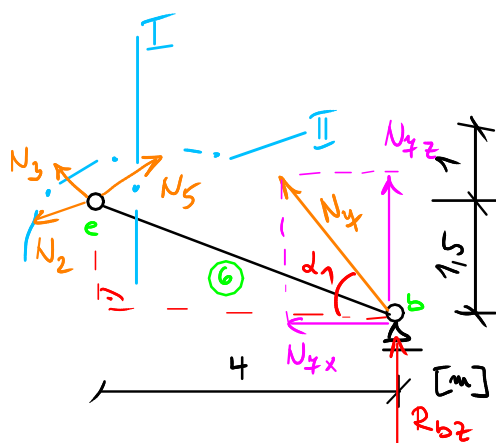
$$N_6 \sin \alpha_2 \cdot 2,5 + R_{bz} \cdot 2,5 - N_6 \cos \alpha_2 \cdot 2,5 = 0 \quad (\text{tak})$$

$$N_6 = \frac{-R_{bz} \cdot 2,5}{2,5 \cdot \sin \alpha_2 - 2,5 \cdot \cos \alpha_2} = \underline{\underline{22,962 \text{ kN}}}$$

$$\sum M_{ei} = 0 \quad (+ \curvearrowright)$$

$$N_4 \cdot 1 - P_2 \cdot 1,5 + R_{bz} \cdot 4 = 0$$

$$N_4 = 1,5 P_2 - 4 R_{bz} = \underline{\underline{-31,25 \text{ kN}}} \quad (\text{tlak})$$



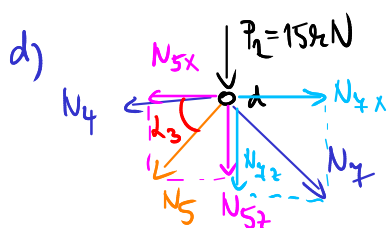
$$l_1 = l_7 = \sqrt{2,5^2 + 2,5^2} = \sqrt{12,5} \quad (\alpha_1 = 45^\circ)$$

$$\sin \alpha_1 = \cos \alpha_1 = \frac{2,5}{\sqrt{12,5}} = \frac{\sqrt{2}}{2}$$

$$\sum M_{ei} = 0 \quad (+ \curvearrowright)$$

$$R_{bz} \cdot 4 + N_{7z} \cdot 4 - N_{7x} \cdot 1,5 = 0$$

$$N_7 = \frac{-4 R_{bz}}{4 \sin \alpha_1 - 1,5 \cos \alpha_1} = \underline{\underline{-30,406 \text{ kN}}} \quad (\text{tlak})$$



$$l_3 = l_5 = \sqrt{1^2 + 1,5^2} = \sqrt{3,25}$$

$$\sin \alpha_3 = \frac{1}{\sqrt{3,25}} \quad \cos \alpha_3 = \frac{1,5}{\sqrt{3,25}}$$

$$\sum F_{zi} = 0 \quad (+ \downarrow)$$

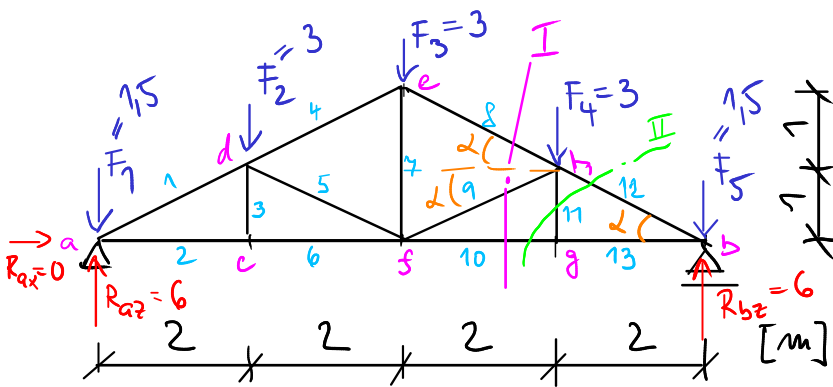
$$P_1 + N_{5z} + N_{7z} = 0$$

$$N_5 \sin \alpha_3 = -P_1 - N_7 \sin \alpha_1$$

$$N_5 = \frac{-15 - (-30,406) \cdot \frac{\sqrt{2}}{2}}{\frac{1}{\sqrt{3,25}}} = \underline{\underline{11,419 \text{ kN}}} \quad (\text{tak})$$

$$\text{kontrola: } \sum F_{xi} = 0$$

$$\left\{ N_2 = 19,758 \text{ kN} \quad N_3 = 15,324 \text{ kN} \quad N_1 = -26,163 \text{ kN} \right\}$$



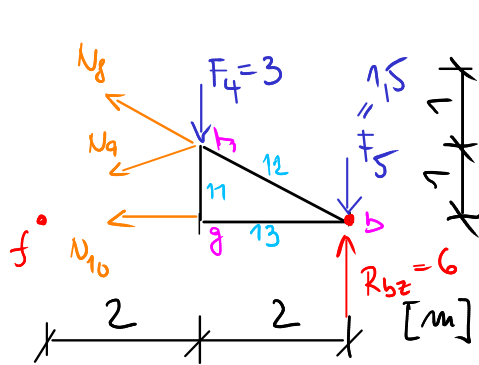
$$\sum F_{xi} = 0 \Rightarrow R_{ax} = 0$$

$$\sum M_{ai} = 0 \Rightarrow R_{bz} = 6 \text{ kN}$$

$$\sum M_{bi} = 0 \Rightarrow R_{az} = 6 \text{ kN}$$

$$\text{kontrola: } \sum F_{zi} = 0 \checkmark$$

$$\text{hebo ze symetrie } R_{az} = R_{bz} = \frac{\sum F_{zi}}{2} = \underline{\underline{6 \text{ kN}}}$$



$$\sum M_{hi} = 0 \oplus \downarrow$$

$$F_5 \cdot 2 - R_{bz} \cdot 2 + N_{10} \cdot 1 = 0$$

$$N_{10} = 2R_{bz} - 2F_5 = \underline{\underline{9 \text{ kN}}} \text{ (tah)}$$

$$l_1 = l_5 = l_4 = l_8 = l_9 = l_{12} = \sqrt{2^2 + 1^2} = \sqrt{5}$$

$$\sin \alpha = \frac{1}{\sqrt{5}} \quad \cos \alpha = \frac{2}{\sqrt{5}}$$

$$\sum M_{bi} = 0 \oplus \uparrow$$

$$F_4 \cdot 2 + N_{9x} \cdot 1 + N_{9z} \cdot 2 = 0$$

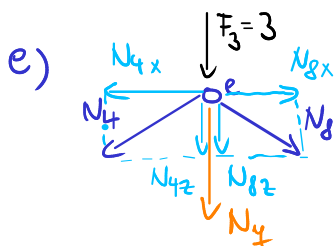
$$1 \cdot N_9 \cos \alpha + 2 N_9 \sin \alpha = -2F_4$$

$$N_9 = \frac{-2F_4}{1 \cos \alpha + 2 \sin \alpha} = \underline{\underline{-3,354 \text{ kN}}} \text{ (tlak)}$$

$$\sum M_{fi} = 0 \oplus \uparrow$$

$$-F_4 \cdot 2 - F_5 \cdot 4 + R_{bz} \cdot 4 + N_{8x} \cdot 1 + N_{8z} \cdot 2 = 0$$

$$N_8 = \frac{2F_4 + 4F_5 - 4R_{bz}}{1 \cos \alpha + 2 \sin \alpha} = \underline{\underline{-6,708 \text{ kN}}} \text{ (tlak)}$$



$$\sum F_{zi} = 0 \oplus \downarrow$$

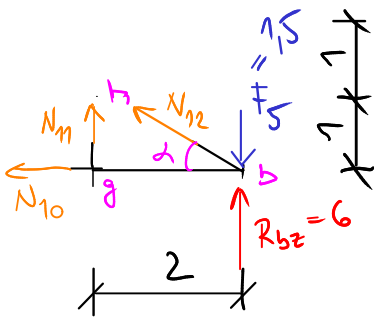
$$F_3 + N_7 + N_{4z} + N_{8z} = 0$$

$$2 \cdot N_{4z} = 2N_{8z}$$

$$N_7 = -F_3 - 2N_8 \cdot \sin \alpha = -3 - 2 \cdot (-6,708) \cdot \frac{1}{\sqrt{5}}$$

$$\underline{\underline{N_7 = 3 \text{ kN}}} \text{ (tah)}$$

$$\begin{aligned} N_1 &= N_{12} = -10,0623 \text{ kN} \\ N_2 &= N_{13} = 9 \text{ kN} \\ N_3 &= N_{14} = 0 \\ N_4 &= N_8 = -6,708 \text{ kN} \\ N_5 &= N_9 = -3,354 \text{ kN} \\ N_6 &= N_{10} = 9 \text{ kN} \\ N_7 &= 3 \text{ kN} \end{aligned}$$



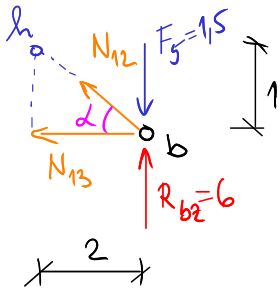
$$\sum M_{bi} = 0 \oplus \curvearrowright$$

$$N_{11} \cdot 2 = 0 \Rightarrow \underline{N_{11} = 0 \text{ kN}}$$

$$\sum M_{gi} = 0 \oplus \curvearrowright$$

$$N_{12z} \cdot 2 - F_5 \cdot 2 + R_{bz} \cdot 2 = 0 \quad |:2$$

$$N_{12} = \frac{F_5 - R_{bz}}{\sin \alpha} = \frac{1,5 - 6}{1} \sqrt{5} = \underline{\underline{-10,0623 \text{ kN}}}$$



$$\sum F_{xi} = 0 \oplus \leftarrow$$

$$N_{13} + N_{12x} = 0 \quad N_{13} = -N_{12x} = -N_{12} \cos \alpha = -(-10,0623) \cdot \frac{2}{\sqrt{5}} = \underline{\underline{9 \text{ kN}}}$$

nebo

$$\sum M_{hi} = 0 \oplus \curvearrowright$$

$$N_{13} \cdot 1 - R_{bz} \cdot 2 + F_5 \cdot 2 = 0$$

$$N_{13} = +6 \cdot 2 - 1,5 \cdot 2 = \underline{\underline{9 \text{ kN}}} \checkmark$$

