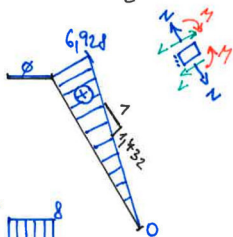
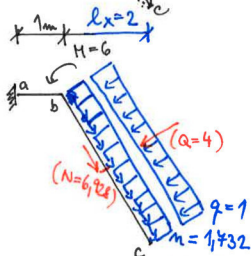
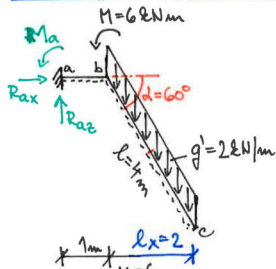
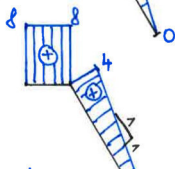


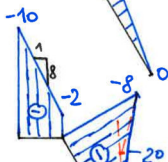
Rovinný lomeň kosmík se šikmými pruty



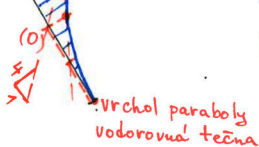
(N)



(V)



(M)



1) rozklad spojitého zatížení

$$q = q' \cos 60^\circ = 2 \cdot \cos 60^\circ = 1 \text{ kN/m}$$

$$m = q' \sin 60^\circ = 2 \cdot \sin 60^\circ = 1,732 \text{ kN/m}$$

$$Q = q \cdot 4 = 4 \text{ kN} \quad G' = q' \cdot 4 = 8 \text{ kN}$$

$$N = m \cdot 4 = 6,928 \text{ kN}$$

2) reakce pro kontrolu

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

$$\oplus \uparrow \sum F_{iz} = 0 \Rightarrow R_{az} = G' = 8 \text{ kN}$$

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

$$M_a + M - G' \cdot 2 = 0 \Rightarrow M_a = 10 \text{ kNm}$$

$$l_x = l \cdot \cos 60^\circ = 2 \text{ m}$$

3) vykreslení vnitřních sil z volného konce

$$N_{cb}^P = 0$$

$$N_{bc}^P = N = 6,928 \text{ kN}$$

$$N_{ba}^P = N_{ab}^P = 0$$

$$V_{cb}^P = 0$$

$$V_{bc}^P = Q = 4 \text{ kN}$$

$$V_{ba}^P = G' = 8 \text{ kN} = V_{ab}$$

$$M_{cb}^P = 0$$

$$M_{bc}^P = -Q \cdot 2 = -G' \cdot 1 = -8 \text{ kNm}$$

$$M_{ba}^P = -Q \cdot 2 + M = -2 \text{ kNm}$$

$$M_{ab}^P = -G' \cdot 2 + M = -10 \text{ kNm}$$

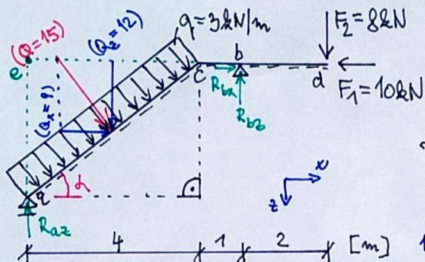
$$M_{qa}^P = 0$$

-zkontroluji reakce
provedu kontrolu

$$N_{ab}^L = 0 \checkmark$$

$$V_{ab}^L = R_{az} = 8 \text{ kN} \checkmark$$

$$M_a^L = -M = -10 \text{ kNm} \checkmark$$



$$l_{ac} = 5\text{m}$$

$$Q = q \cdot l_{ac} = 3 \cdot 5 = 15\text{ kN}$$

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

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

1) reakce

$$Q_x = Q \sin \alpha = 15 \cdot \frac{3}{5} = 9\text{ kN}$$

$$Q_z = Q \cos \alpha = 15 \cdot \frac{4}{5} = 12\text{ kN}$$

$$\Sigma F_{ix} = 0 \quad (+) \rightarrow$$

$$Q_x + R_{bx} - F_1 = 0$$

$$R_{bx} = F_1 - Q_x = 1\text{ kN}$$

$$\Sigma M_{ib} = 0 \quad (+) \downarrow$$

$$R_{az} \cdot 5 - Q_x \cdot 1.5 - Q_z \cdot 3 + F_2 \cdot 2 = 0$$

$$R_{az} = 6.4\text{ kN}$$

$$\Sigma M_{ie} = 0 \quad (+) \uparrow$$

$$Q_x \cdot 1.5 - Q_z \cdot 2 + R_{bz} \cdot 5 - F_2 \cdot 4 = 0$$

$$R_{bz} = 13.3\text{ kN}$$

kontrola:

$$\Sigma F_{iz} = 0 \quad (+) \uparrow$$

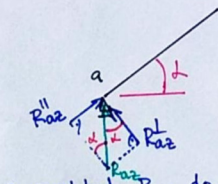
$$R_{az} + R_{bz} - Q_z - F_2 = 0$$

$$0 = 0 \quad \checkmark$$

$$\Sigma M_{ia} = 0 \quad (+) \downarrow$$

$$Q \cdot 2.5 + R_{bx} \cdot 3 - R_{bz} \cdot 5 + F_2 \cdot 4 - F_1 \cdot 3 = 0$$

$$0 = 0 \quad \checkmark$$



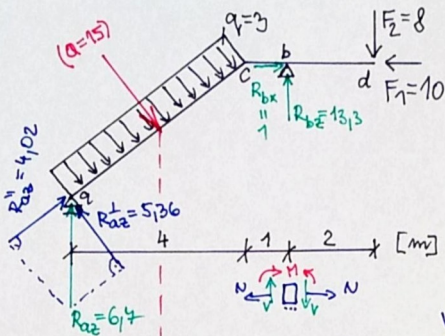
2) rozklad R_{az} do složek $\perp$ a $\parallel$ sprutem (ac)

$$R_{az}^{\parallel} = R_{az} \sin \alpha = 4.02\text{ kN}$$

$$R_{az}^{\perp} = R_{az} \cos \alpha = 5.36\text{ kN}$$

- pro kontrolu zprava můžeme udělat rozklad i pro síly R_{bx} , R_{bz} , F_1 a F_2 nebo jejich výslednici $\rightarrow$ viz kontrola rovnováhy ve styčném bodě (na konci)

$\rightarrow$ pro vykreslení vnitřních sil na šikmém prutu zleva



3) vykreslení vnitřních sil

- zleva a zprava do bodu ©

$$N_{ac}^L = -R_{az}'' = -4.02 \text{ kN} = N_{ca}$$

$$N_{db}^P = N_{bd}^P = -F_1 = -10 \text{ kN}$$

$$N_{bc}^P = N_{cb}^P = -F_1 + R_{bx} = -9 \text{ kN}$$

$$V_{ac}^L = R_{az}^L = 5.36 \text{ kN}$$

$$V_{ca}^L = R_{az}^L - Q = -9.64 \text{ kN}$$

$$V_{db}^P = V_{bd}^P = F_2 = 8 \text{ kN}$$

$$V_{bc}^P = V_{cb}^P = F_2 - R_{bz} = -5.3 \text{ kN}$$

$$M_a^L = 0$$

$$M_c^L = R_{az} \cdot 4 - Q \cdot 2.5 = (\text{nebo}) = R_{az}^L \cdot 5 - Q \cdot 2.5 = -10.4 \text{ kNm}$$

$$M_d^P = 0$$

$$M_b^P = -F_2 \cdot 2 = -16 \text{ kNm}$$

$$M_c^P = -F_2 \cdot 3 + R_{bz} \cdot 1 = -10.4 \text{ kNm} = M_c^L \checkmark$$

$$M_Q^L = (\text{pod } Q \text{ bez } q) = R_{az} \cdot 2 = 13.14 \text{ kNm}$$

$$M_{\text{max}}^L = R_{az}^L \cdot x_p - q \cdot \frac{x_p^2}{2} = 4.78826 \text{ kNm}$$

$$x_p = \frac{V_{ab}}{q} = \frac{5.36}{3} = 1.786 \text{ m}$$

kontrolu v bodě © můžeme provést zleva s využitím sil R_{az}, Q_x, Q_z

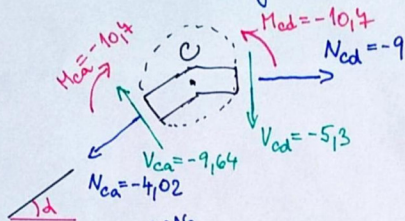
$$M_{cb}^L = (\text{kontrolu jsme již provedli}) = R_{az} \cdot 4 - Q \cdot 2.5$$

$$V_{cb}^L = R_{az} - Q_z = 6.4 - 12 = -5.3 \text{ kN} \checkmark$$

$$N_{cb}^L = -Q_x = -9 \text{ kN} \checkmark$$

$$N_{ax} = N_{ca} \cos \alpha =$$

kontrola rovnováhy sil v bodě ©



$$N_{ca,x} = -3,216$$

$$N_{ca,x} = N_{ca} \cdot \cos \alpha = -3,216 \text{ kN}$$

$$N_{ca,z} = -2,412$$

$$N_{ca,z} = N_{ca} \cdot \sin \alpha = -2,412 \text{ kN}$$

$$V_{ca,x} = -5,784$$

$$V_{ca,x} = V_{ca} \cdot \sin \alpha = -5,784 \text{ kN}$$

$$V_{ca,z} = -4,712$$

$$V_{ca,z} = V_{ca} \cdot \cos \alpha = -4,712 \text{ kN}$$

$$\begin{aligned} \textcircled{+} \sum M_c &= 0 \Rightarrow M_{ca} - M_{cd} = 0 \\ (-10,7) - (-10,7) &= 0 \\ 0 &= 0 \checkmark \end{aligned}$$

$$\begin{aligned} \textcircled{+} \sum F_{ix} &= 0 \Rightarrow -N_{ca,x} - V_{ca,x} + N_{cd} = 0 \\ -(-3,216) - (-5,784) + (-9) &= 0 \\ 0 &= 0 \checkmark \end{aligned}$$

$$\begin{aligned} \textcircled{+} \sum F_{iz} &= 0 \Rightarrow -N_{ca,z} + V_{ca,z} - V_{cd} = 0 \\ -(-2,412) + (-4,712) - (-5,3) &= 0 \\ 0 &= 0 \checkmark \end{aligned}$$