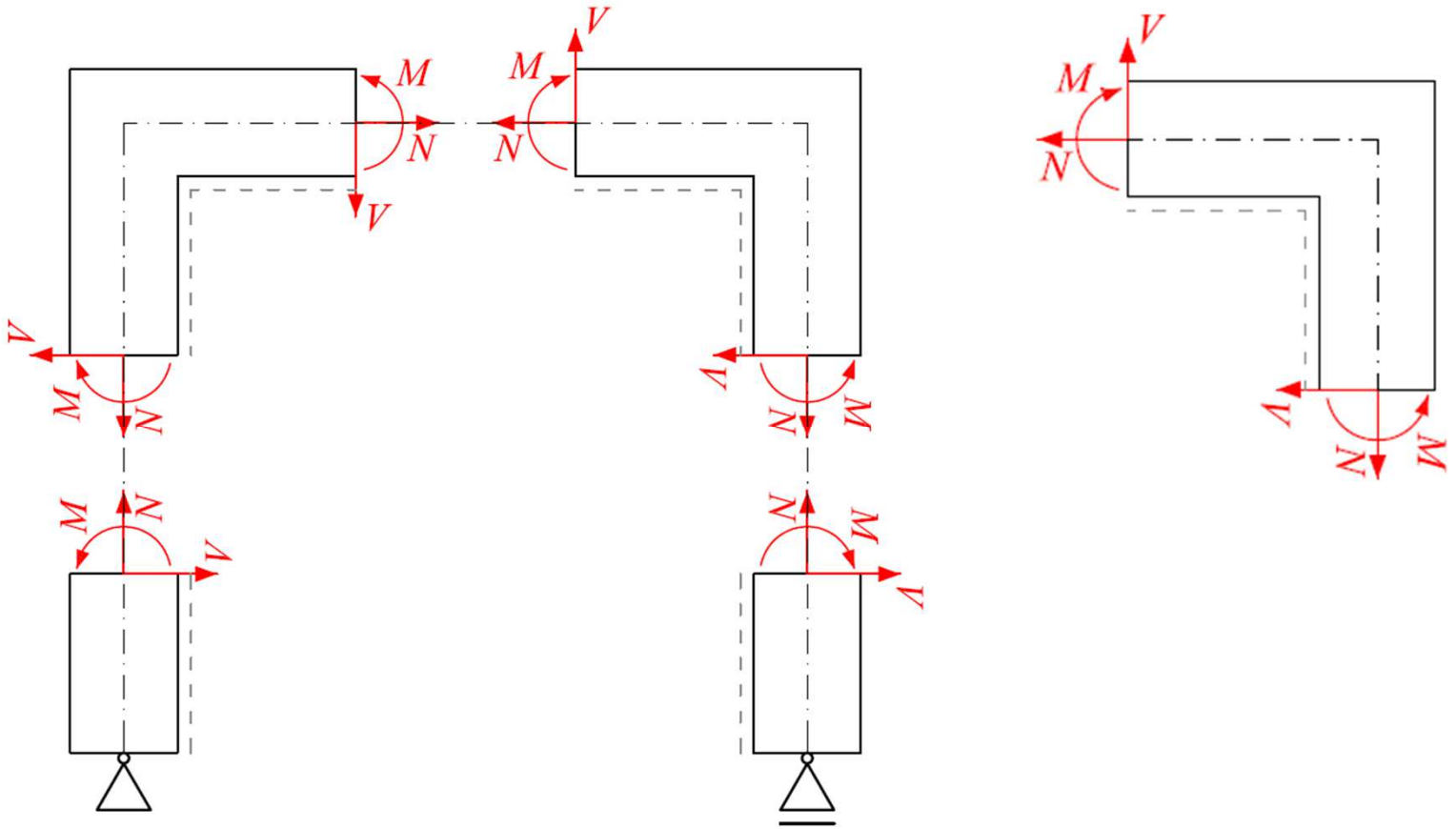
VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ
FAKULTA STAVEBNÍ

BDA015 Stavební mechanika 1
6. přednáška

- Rovinný lomený nosník

doc. Ing. Hana Šimonová, Ph.D. (Hana.Simonova@vut.cz)

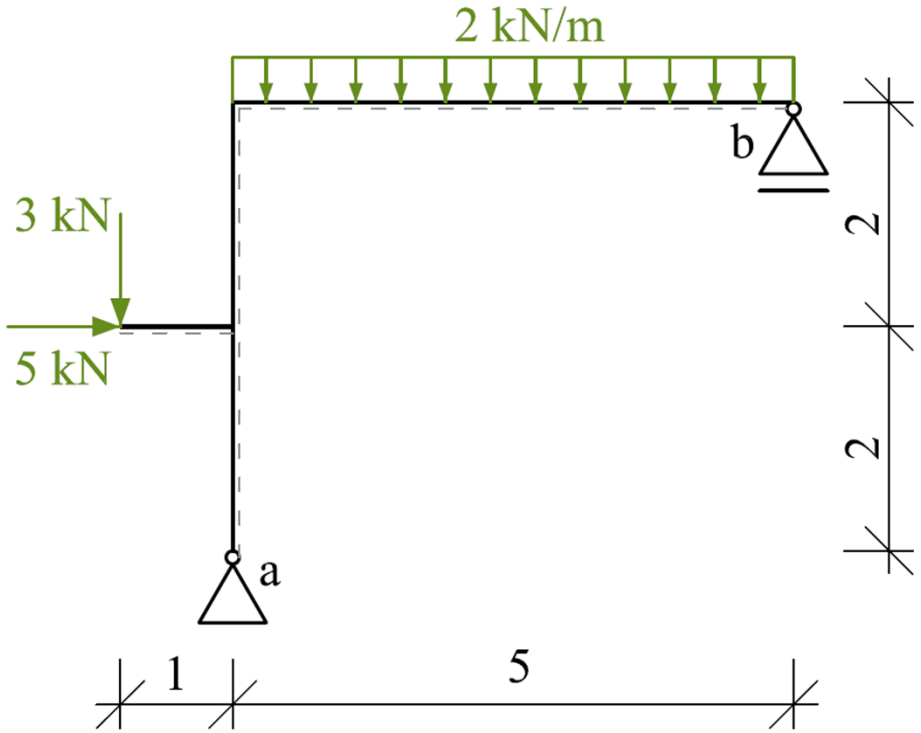
PRAVOÚHLE LOMENÝ NOSNÍK



- ZVOLENÁ SPODNÍ VLÁKNA → KLADNÁ KONVENCE VNITŘNÍCH SIL
- KONTROLA ROVNOVÁHY VE STYČNÍKU

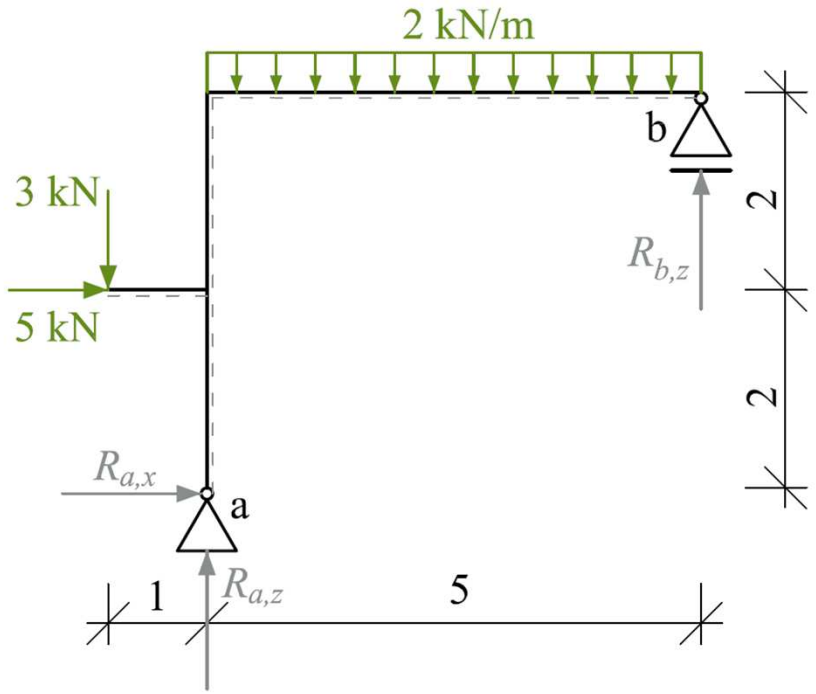
PRAVOÚHLE LOMENÝ NOSNÍK

Vykreslete průběhy vnitřních sil



PRAVOÚHLE LOMENÝ NOSNÍK

1) Výpočet reakcí



- $\sum F_{i,x} = 0$ ⊕ →

  $R_{a,x} + 5 = 0$

  $R_{a,x} = -5\ \text{kN}$

- $\sum M_{i,a} = 0$ ⊕

  $-5 \cdot 2 + 3 \cdot 1 - 2 \cdot 5 \cdot 2{,}5 + R_{b,z} \cdot 5 = 0$

  $R_{b,z} = 6{,}4\ \text{kN}$

- $\sum M_{i,b} = 0$

  $-R_{a,z} \cdot 5 + (-5) \cdot 4 + 5 \cdot 2 + 3 \cdot 6 + 2 \cdot 5 \cdot 2{,}5 = 0$

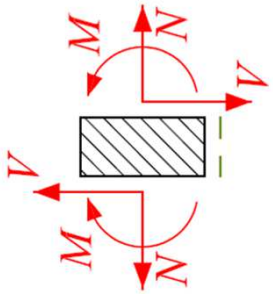
  $R_{a,z} = 6{,}6\ \text{kN}$

- $\sum F_{i,z} = 0;\ 3 + 2 \cdot 5 - R_{a,z} - R_{b,z} = 0$ ⊕ ↓

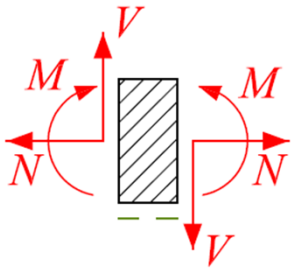
  $0 = 0 \rightarrow \text{VYHOVÍ}$

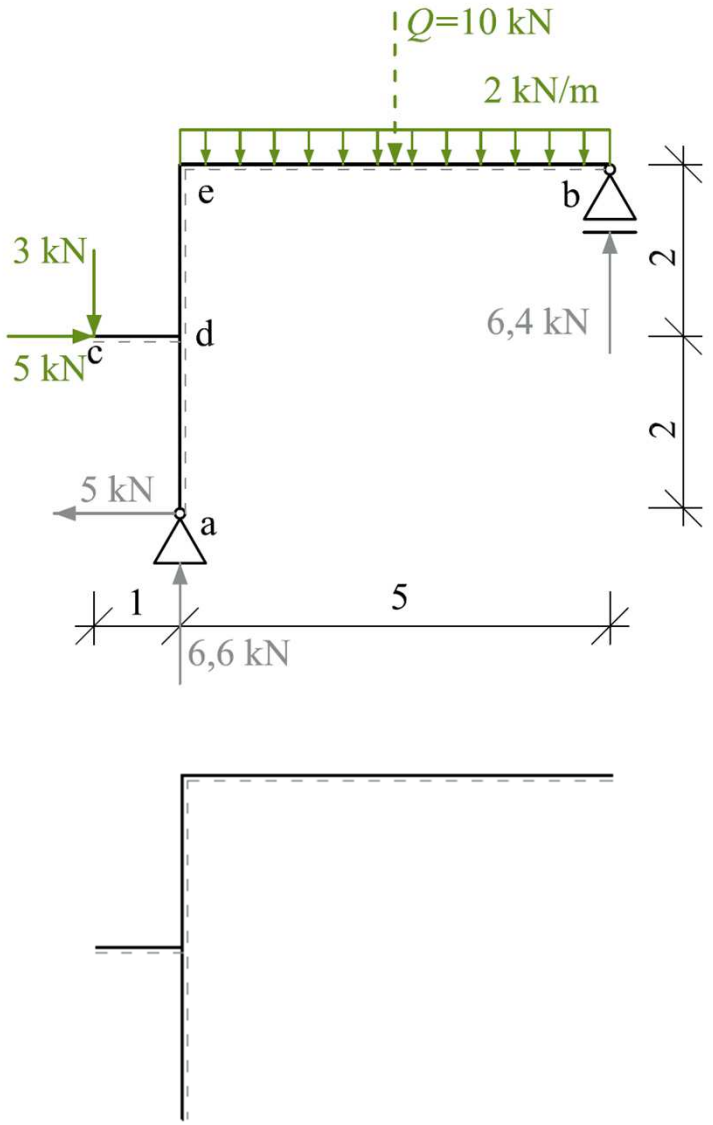
PRAVOÚHLE LOMENÝ NOSNÍK

2) Normálové síly



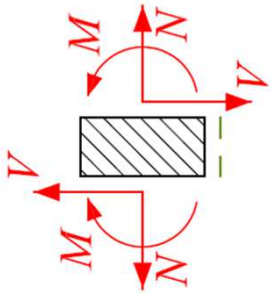
- $N_a^L = -6{,}6$ kN
- $N_{da}^L = -6{,}6$ kN
- $N_{de}^L = -6{,}6 + 3 = -3{,}6$ kN
- $N_{ed}^L = -6{,}6 + 3 = -3{,}6$ kN
- $N_c^L = -5 = -5$ kN
- $N_{dc}^L = -5 = -5$ kN
- $N_e^L = 5 - 5 = 0$ kN
- $N_b^P = 0$



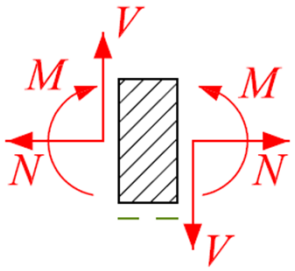


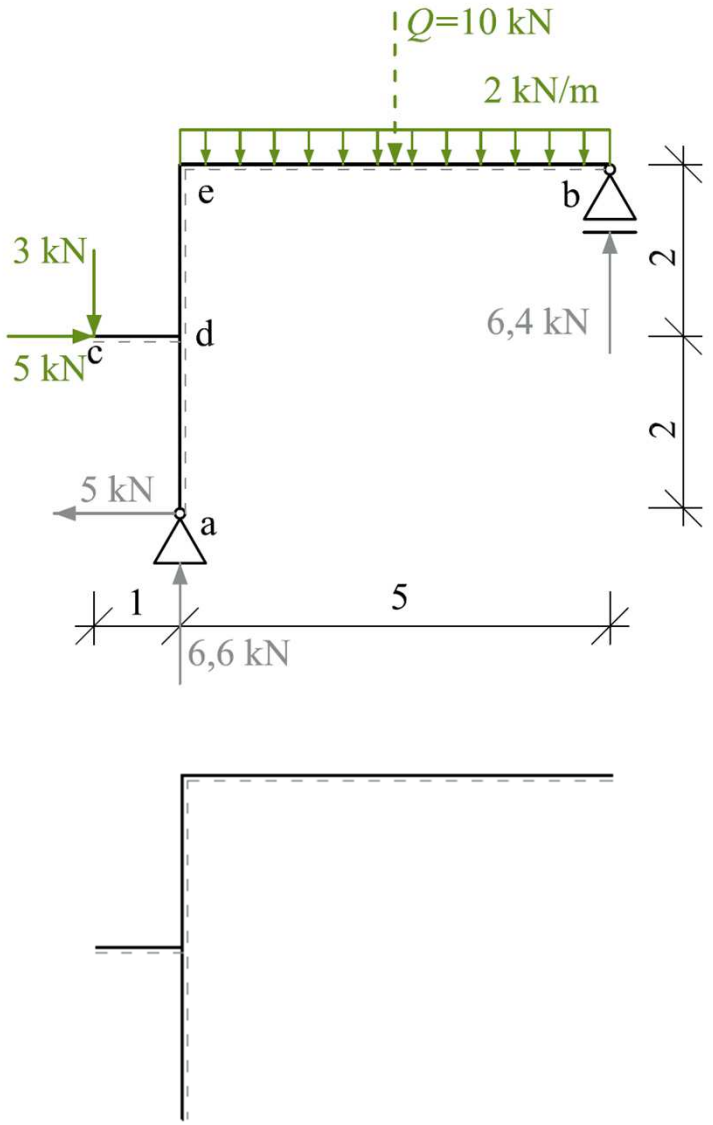
PRAVOÚHLE LOMENÝ NOSNÍK

3) Posouvající síly



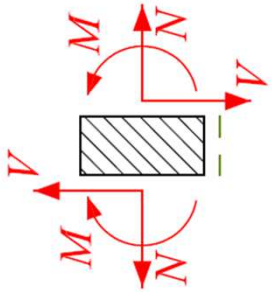
- $V_a^L = -5$ kN
- $V_{da}^L = -5$ kN
- $V_{de}^L = 5 - 5 = 0$
- $V_{ed}^L = 5 - 5 = 0$
- $V_c^L = -3 = -3$ kN
- $V_{dc}^L = -3 = -3$ kN
- $V_e^L = 6{,}6 - 3 = 3{,}6$ kN
- $V_b^P = -\ 6{,}4$kN
- $V_{x_p}^L = V_e^L - 2 \cdot x_p = 0; \rightarrow x_p = 1{,}8$ m



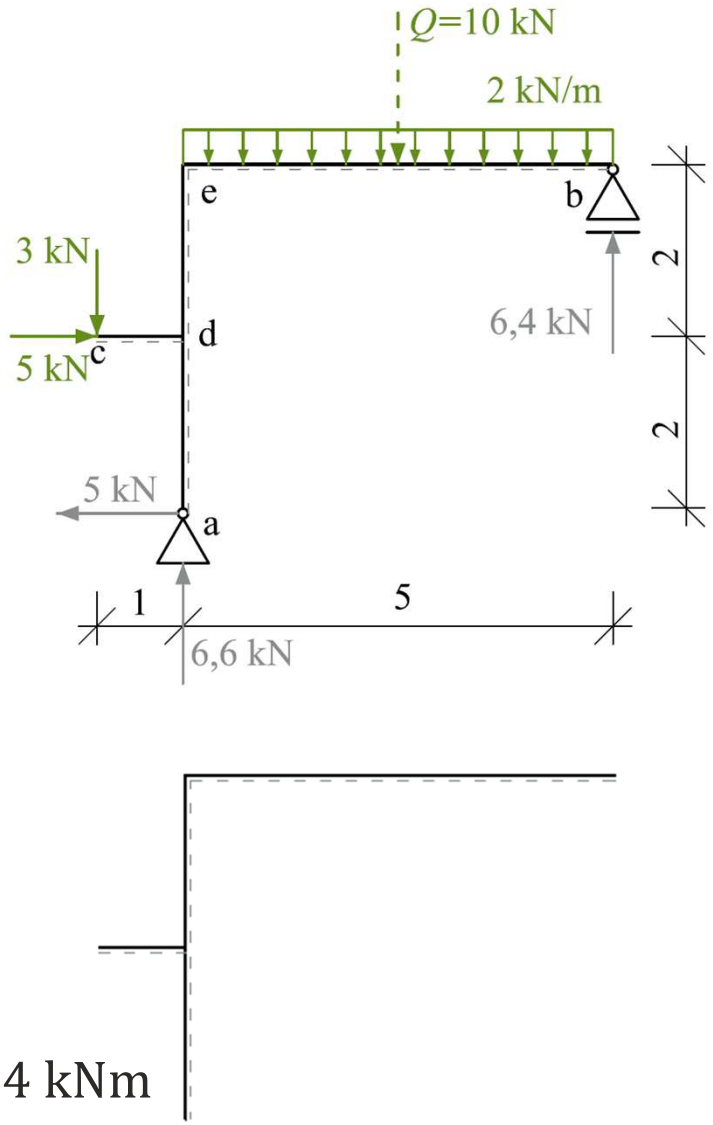


PRAVOÚHLE LOMENÝ NOSNÍK

4) Ohybové momenty



- $M_a^L = 0$
- $M_{da}^L = 5 \cdot 2 = 10\ \text{kNm}$
- $M_{de}^L = 5 \cdot 2 - 3 \cdot 1 = 7\ \text{kNm}$
- $M_{ed}^L = 5 \cdot 4 - 3 \cdot 1 - 5 \cdot 2 = 7\ \text{kNm}$
- $M_c^L = 0$
- $M_{dc}^L = -3 \cdot 1 = -3\ \text{kNm}$
- $M_e^L = -5 \cdot 4 - 3 \cdot 1 - 5 \cdot 2 = 7\ \text{kNm}$
- $M_b^P = 0$
- $M_{x_p}^L = M_e^L + \int_e^{x_p} V\,\text{dx} = 7 + \frac{1}{2} \cdot 3{,}6 \cdot 1{,}8 = 10{,}24\ \text{kNm}$

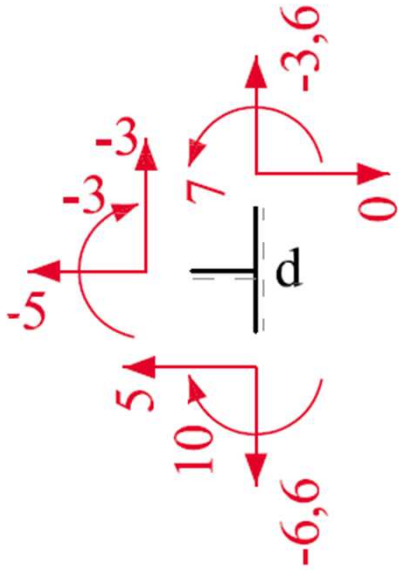


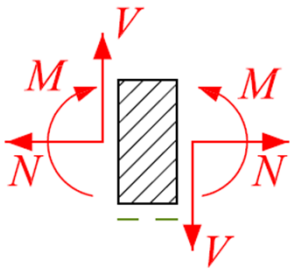
PRAVOÚHLE LOMENÝ NOSNÍK

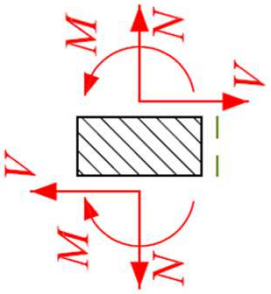
5) Rovnováha ve styčníku

styčník „d"

- $\sum F_{i,x} = 0$ $\xrightarrow{\oplus}$
  $-(-5) + 0 - 5 = 0$
- $\sum F_{i,z} = 0$ $\downarrow\oplus$
  $-(-3) - (-3{,}6) + (-6{,}6) = 0$
- $\sum M_i = 0$ $\circlearrowright\oplus$
  $(-3) + 7 - 10 = 0$

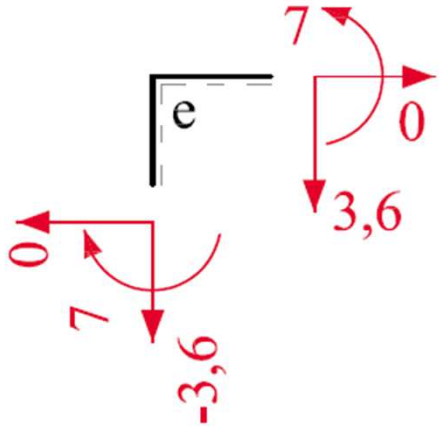






styčník „e"

- $\sum F_{i,x} = 0$ $\xrightarrow{\oplus}$
  $-0 + 0 = 0$
- $\sum F_{i,z} = 0$ $\downarrow\oplus$
  $(-3{,}6) + 3{,}6 = 0$
- $\sum M_i = 0$ $\circlearrowright\oplus$
  $-7 + 7 = 0$

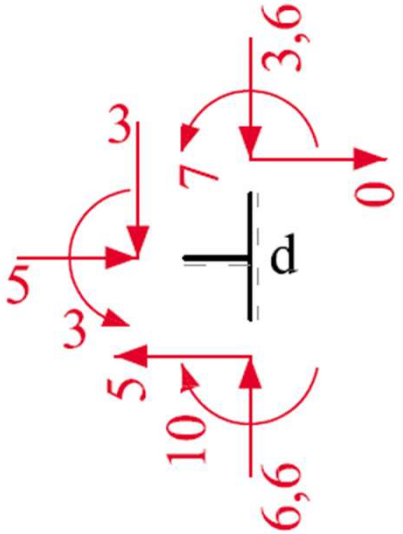


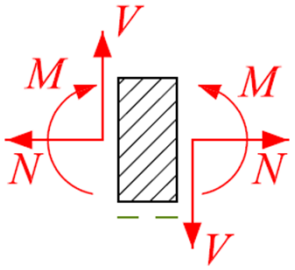
PRAVOÚHLE LOMENÝ NOSNÍK

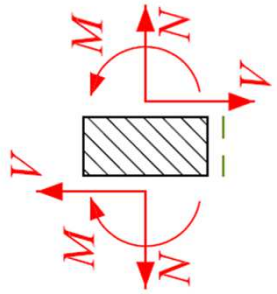
5) Rovnováha ve styčníku

styčník „d“

- $\sum F_{i,x} = 0$ ⊕→
  $5 + 0 - 5 = 0$
- $\sum F_{i,z} = 0$ ⊕↓
  $3 + 3{,}6 - 6{,}6 = 0$
- $\sum M_i = 0$ ⊕↺
  $3 + 7 - 10 = 0$

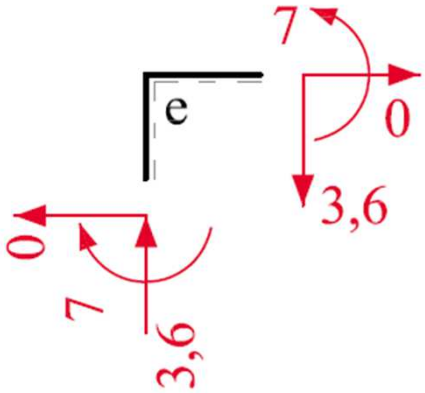






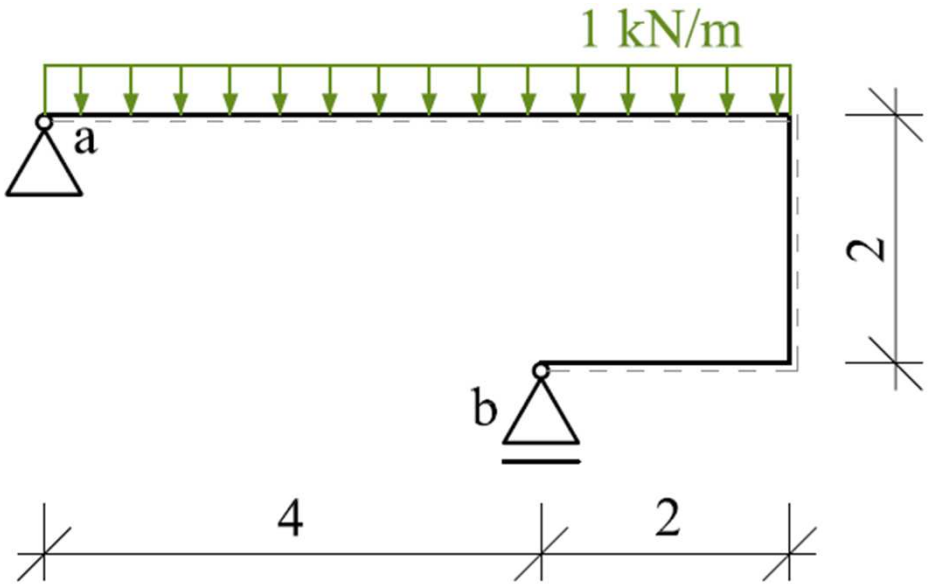
styčník „e“

- $\sum F_{i,x} = 0$ ⊕→
  $-0 + 0 = 0$
  $\sum F_{i,z} = 0$ ⊕↓
  $-3{,}6 + 3{,}6 = 0$
- $\sum M_i = 0$ ⊕↺
  $-7 + 7 = 0$



PRAVOÚHLE LOMENÝ NOSNÍK

Vykreslete průběhy vnitřních sil



PRAVOÚHLE LOMENÝ NOSNÍK

1) Výpočet reakcí

- $\sum F_{i,x} = 0$ ⊕ →

  $R_{a,x} = 0$

- $\sum M_{i,a} = 0$ ⊕

  $-6 \cdot 3 + R_{b,z} \cdot 4 = 0$

  $R_{b,z} = 4{,}5\ \text{kN}$

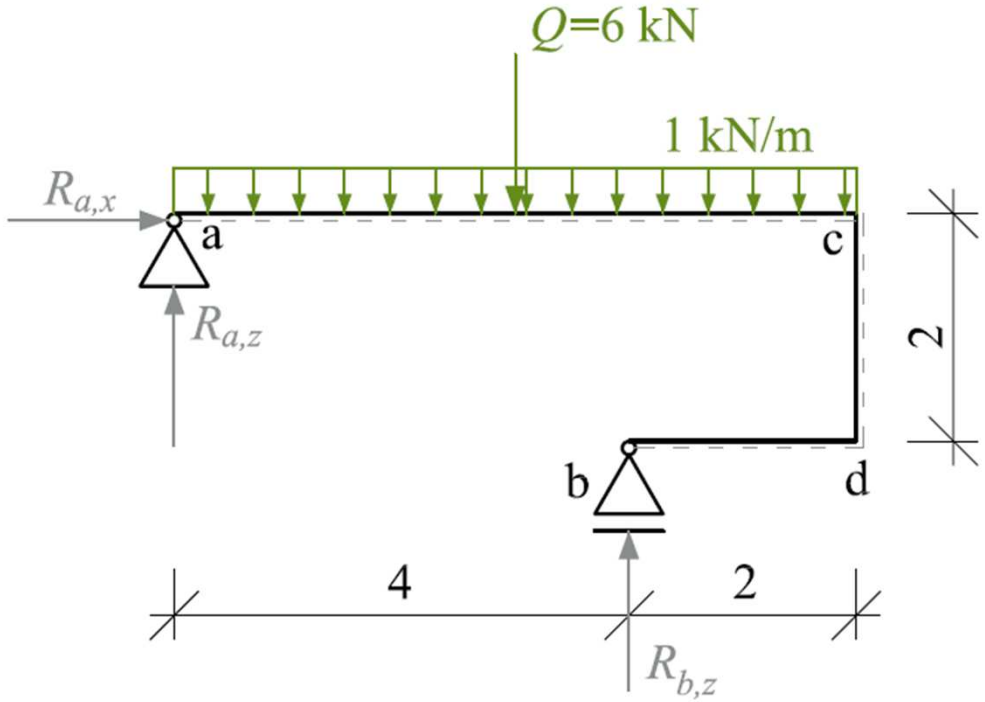
- $\sum M_{i,b} = 0$

  $-R_{a,z} \cdot 4 + 6 \cdot 1 = 0$

  $R_{a,z} = 1{,}5\ \text{kN}$

- $\sum F_{i,z} = 0;\ 6 - R_{a,z} - R_{b,z} = 0$ ⊕ ↓

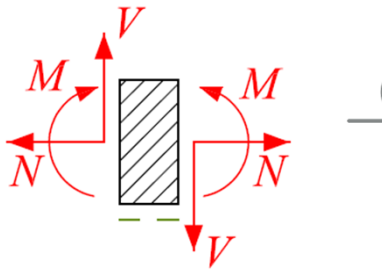
  $0 = 0 \rightarrow$ VYHOVÍ

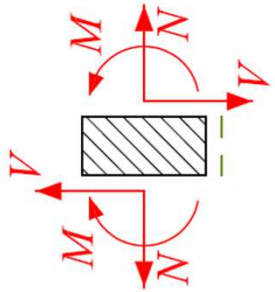


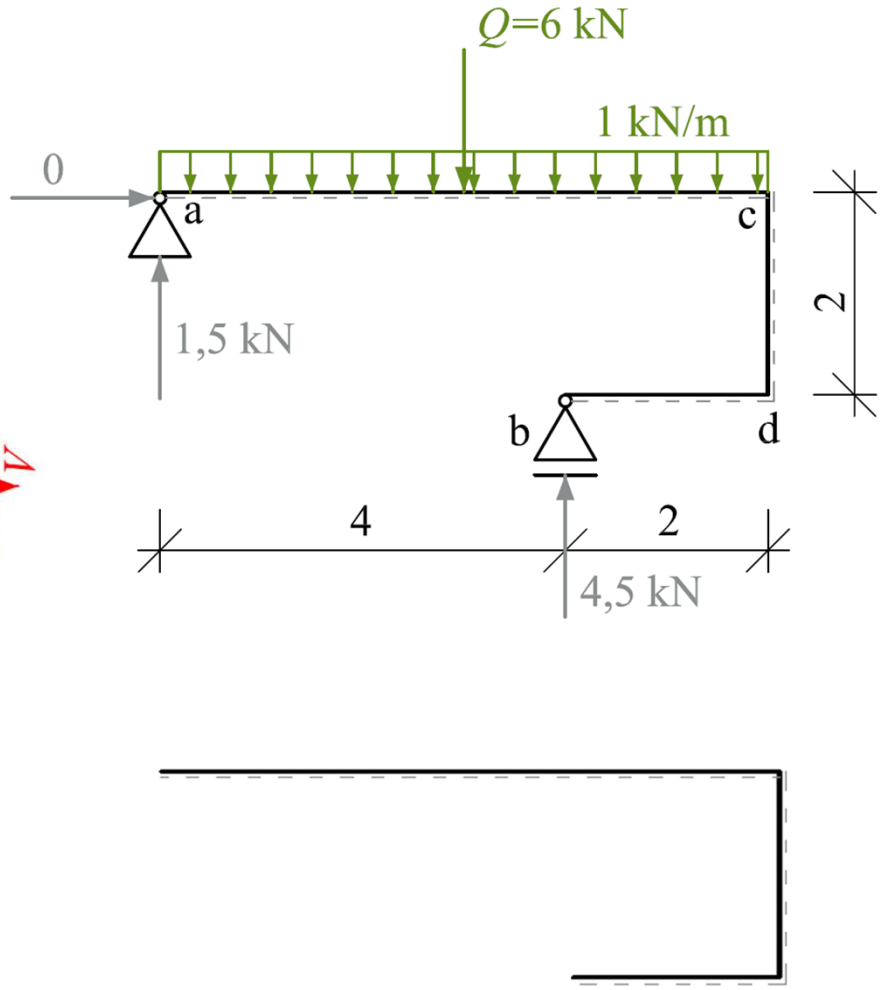
PRAVOÚHLE LOMENÝ NOSNÍK

2) Normálové síly

- $N_a^L = 0$
- $N_{ca}^L = 0$
- $N_{cd}^P = 1{,}5 - 6 = -4{,}5\ \text{kN}$
- $N_{dc}^P = 1{,}5 - 6 = -4{,}5\ \text{kN}$
- $N_{dc}^L = -4{,}5\ \text{kN}$
- $N_b^L = 0$
- $N_{db}^L = 0$



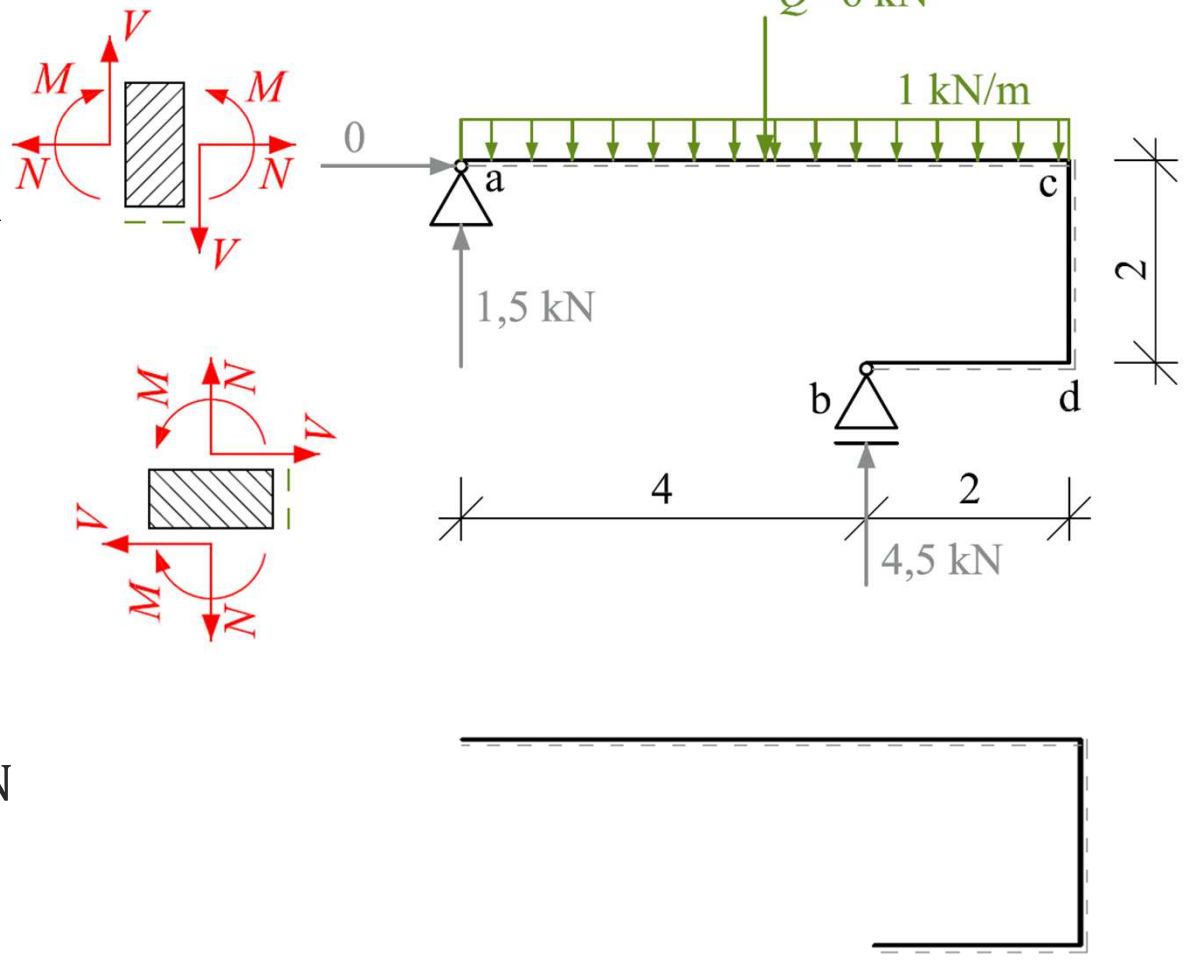




PRAVOÚHLE LOMENÝ NOSNÍK

3) Posouvající síly

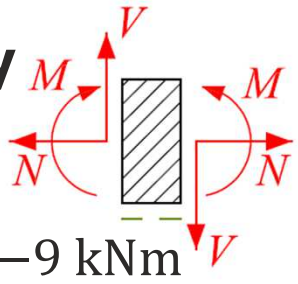
- $V_a^L = 1{,}5$ kN
- $V_{ca}^L = 1{,}5 - 6 = -4{,}5$ kN
- $V_{cd}^P = 0$
- $V_{dc}^P = 0$
- $V_b^L = 4{,}5$ kN
- $V_{db}^L = 4{,}5$ kN
- $V_{db}^P = -1{,}5 + 6 = 4{,}5$ kN

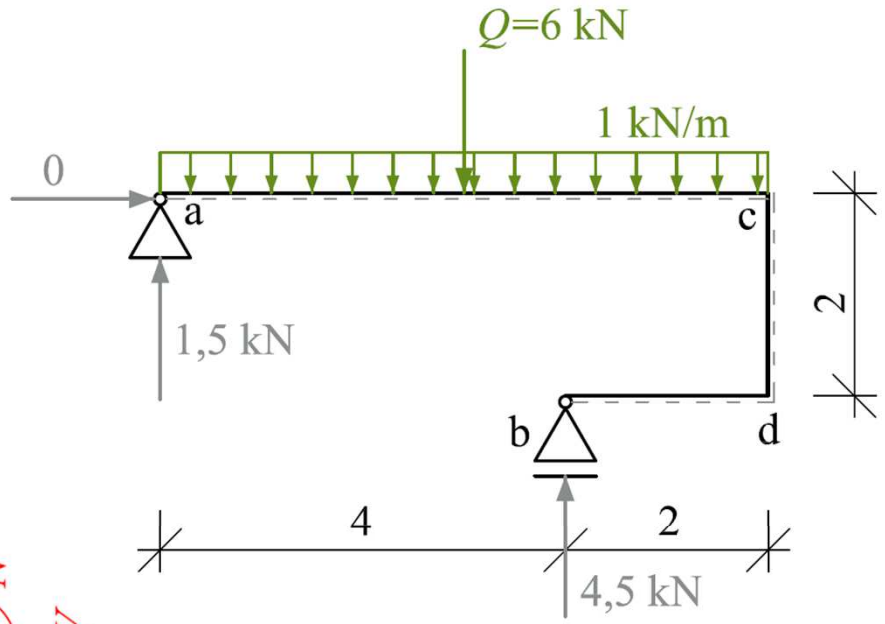


- $V_{x_p}^L = V_a^L - 1 \cdot x_p = 0; \rightarrow x_p = 1{,}5$ m

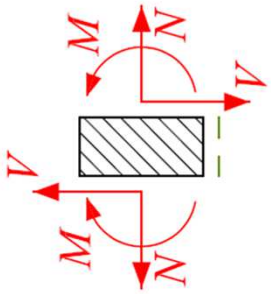
PRAVOÚHLE LOMENÝ NOSNÍK

4) Ohybové momenty





- $M_a^L = 0$
- $M_{ca}^L = 1{,}5 \cdot 6 - 6 \cdot 3 = -9\ \text{kNm}$
- $M_{cd}^P = -1{,}5 \cdot 6 + 6 \cdot 3 = 9\ \text{kNm}$
- $M_{dc}^P = -1{,}5 \cdot 6 + 6 \cdot 3 = 9\ \text{kNm}$
- $M_b^L = 0$
- $M_b^P = -1{,}5 \cdot 4 + 6 \cdot 1 = 0$
- $M_{db}^L = 4{,}5 \cdot 2 = 9\ \text{kNm}$



- $M_{x_p}^L = M_a^L + \frac{1}{2} \cdot 1{,}5 \cdot 1{,}5 = 1{,}125\ \text{kNm}$

PRAVOÚHLE LOMENÝ NOSNÍK

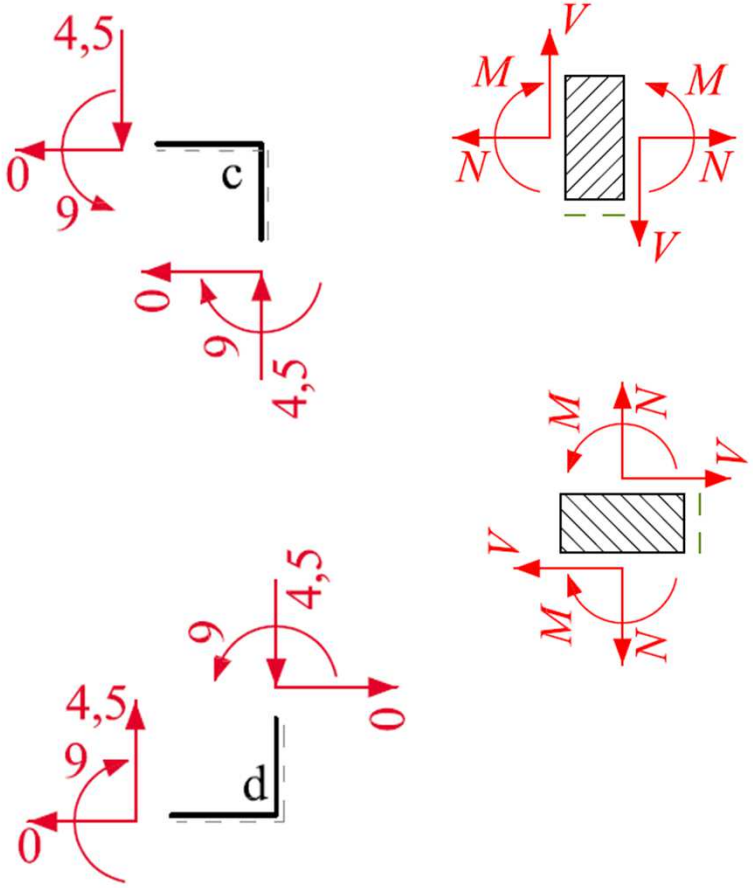
5) Rovnováha ve styčníku

styčník „c“

- $\sum F_{i,x} = 0$
- $\sum F_{i,z} = 0$
  $4{,}5 - 4{,}5 = 0$
- $\sum M_i = 0$
  $9 - 9 = 0$

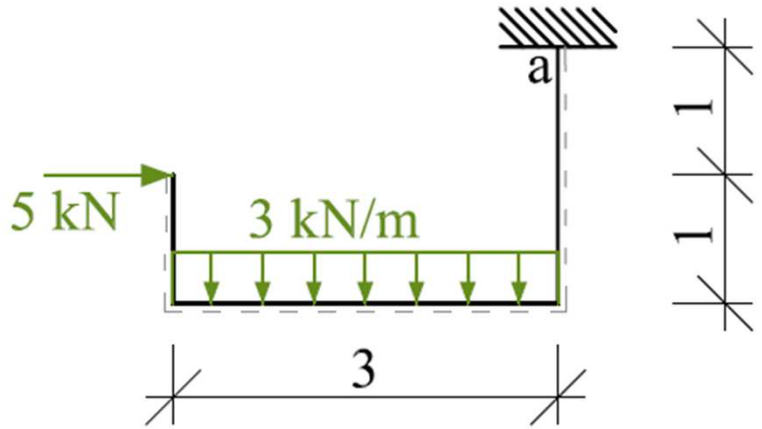
styčník „d“

- $\sum F_{i,x} = 0$
- $\sum F_{i,z} = 0$
  $-4{,}5 + 4{,}5 = 0$
- $\sum M_i = 0$
  $-9 + 9 = 0$



PRAVOÚHLE LOMENÁ KONZOLA

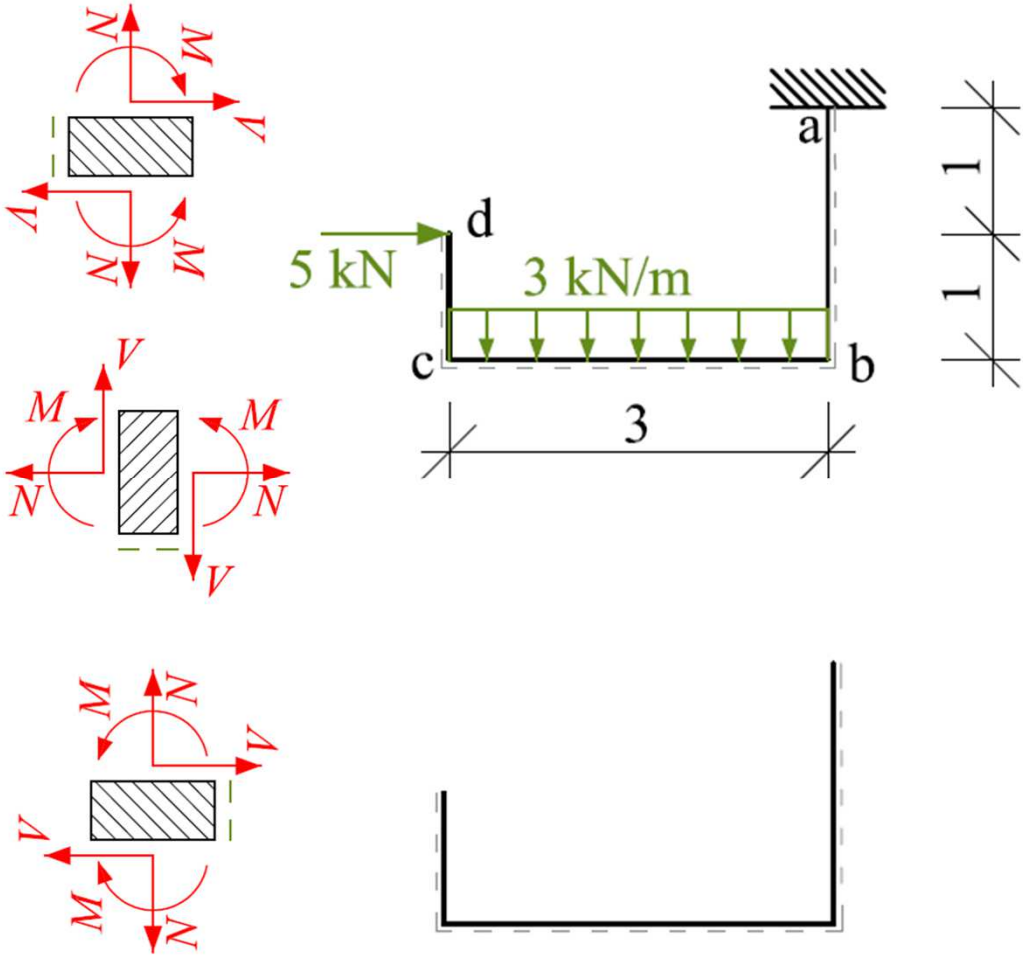
Vykreslete průběhy vnitřních sil



PRAVOÚHLE LOMENÁ KONZOLA

1) Normálové síly

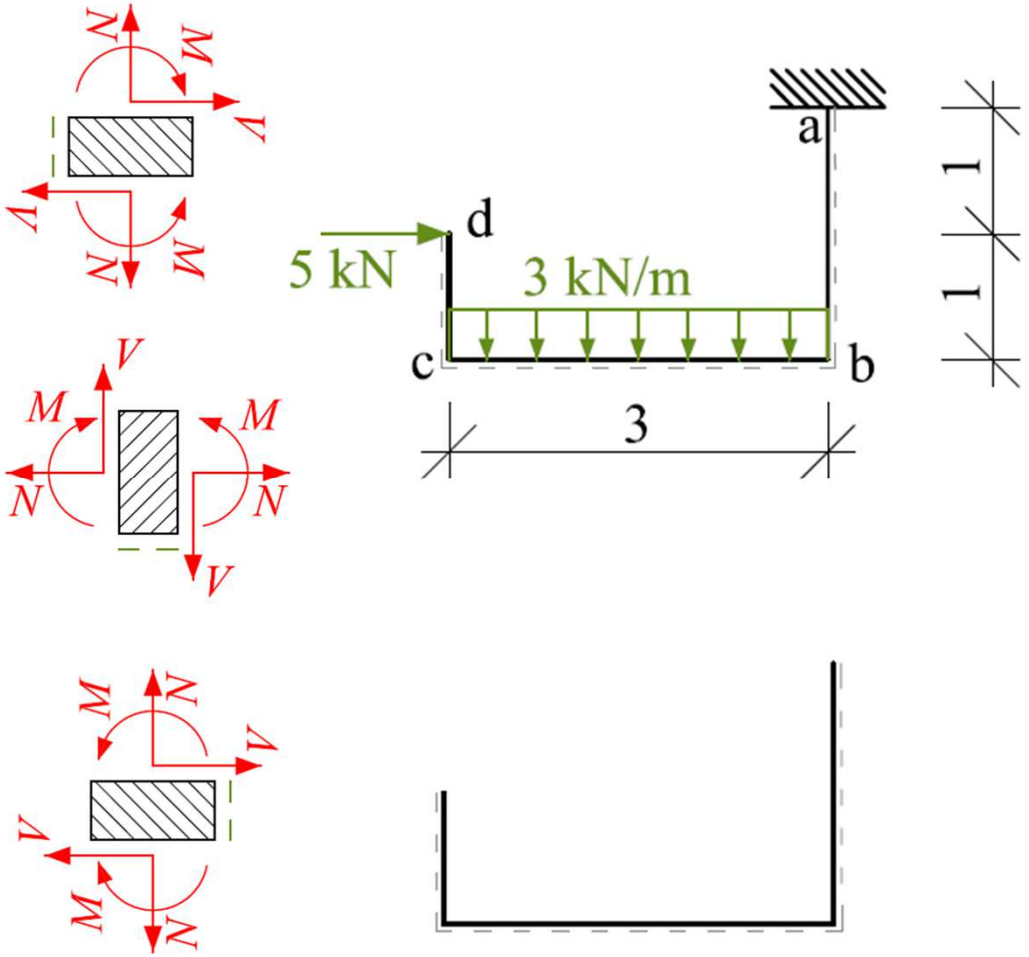
- $N_d^L = 0$
- $N_{cd}^L = 0$
- $N_{cb}^L = -5\ \mathrm{kN}$
- $N_{bc}^L = -5\ \mathrm{kN}$
- $N_{ba}^L = 3 \cdot 3 = 9\ \mathrm{kN}$
- $N_{ab}^L = 3 \cdot 3 = 9\ \mathrm{kN}$



PRAVOÚHLE LOMENÁ KONZOLA

2) Posouvající síly

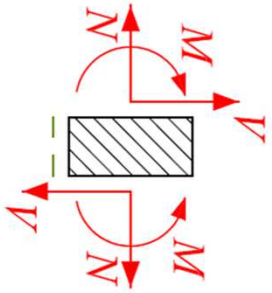
- $V_d^L = 5$ kN
- $V_{cd}^L = 5$ kN
- $V_{cb}^L = 0$
- $V_{bc}^L = -3 \cdot 3 = -9$ kN
- $V_{ba}^L = -5$ kN
- $V_{ab}^L = -5$ kN

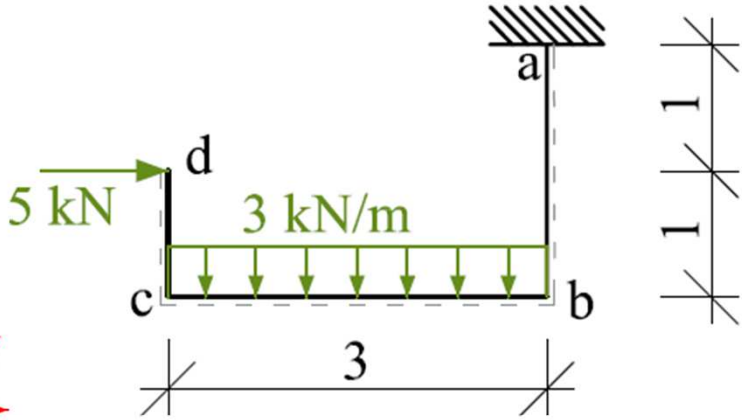


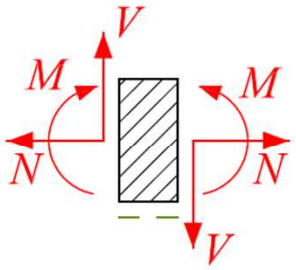
PRAVOÚHLE LOMENÁ KONZOLA

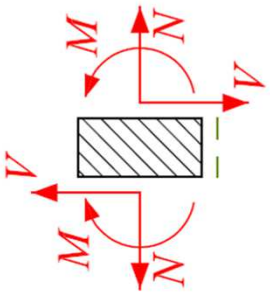
3) Ohybové momenty

- $M_d^L = 0$
- $M_{cd}^L = 5 \cdot 1 = 5\ \text{kNm}$
- $M_{cb}^L = 5 \cdot 1 = 5\ \text{kNm}$
- $M_{bc}^L = 5 \cdot 1 - 3 \cdot 3 \cdot 1{,}5 =$
  $= -8{,}5\ \text{kNm}$
- $M_{ba}^L = 5 \cdot 1 - 3 \cdot 3 \cdot 1{,}5 =$
  $= -8{,}5\ \text{kNm}$
- $M_{ab}^L = -5 \cdot 1 - 3 \cdot 3 \cdot 1{,}5 =$
  $= -18{,}5\ \text{kNm}$









PRAVOÚHLE LOMENÁ KONZOLA

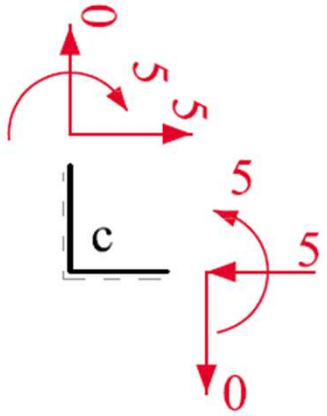
4) Rovnováha ve styčníku

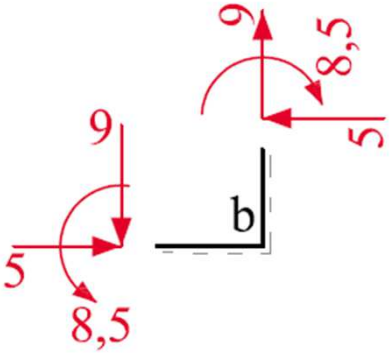
styčník „c"

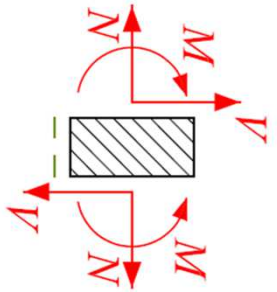
- $\sum F_{i,x} = 0$
  $5 - 5 = 0$
- $\sum F_{i,z} = 0$
- $\sum M_i = 0$
  $-5 + 5 = 0$

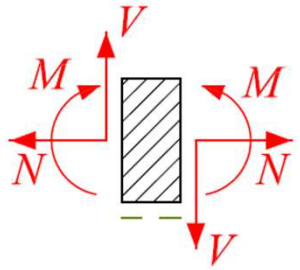
styčník „b"

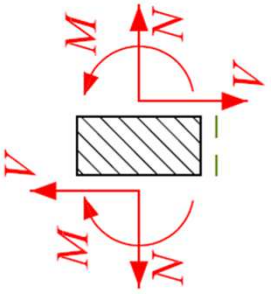
- $\sum F_{i,x} = 0$
  $5 - 5 = 0$
- $\sum F_{i,z} = 0$
  $9 - 9 = 0$
- $\sum M_i = 0$
  $8{,}5 - 8{,}5 = 0$











PRAVOÚHLE LOMENÁ KONZOLA

5) Rovnováha ve styčníku – výpočet reakcí

styčník „a“

- $\sum F_{i,x} = 0$

  $-R_{a,x} + 5 = 0$

  $R_{a,x} = 5\ \mathrm{kN}$

- $\sum F_{i,z} = 0$

  $-R_{a,z} + 9 = 0$

  $R_{a,z} = 9\ \mathrm{kN}$

- $\sum M_i = 0$

  $M_a + 18{,}5 = 0$

  $M_a = -18{,}5\ \mathrm{kNm}$