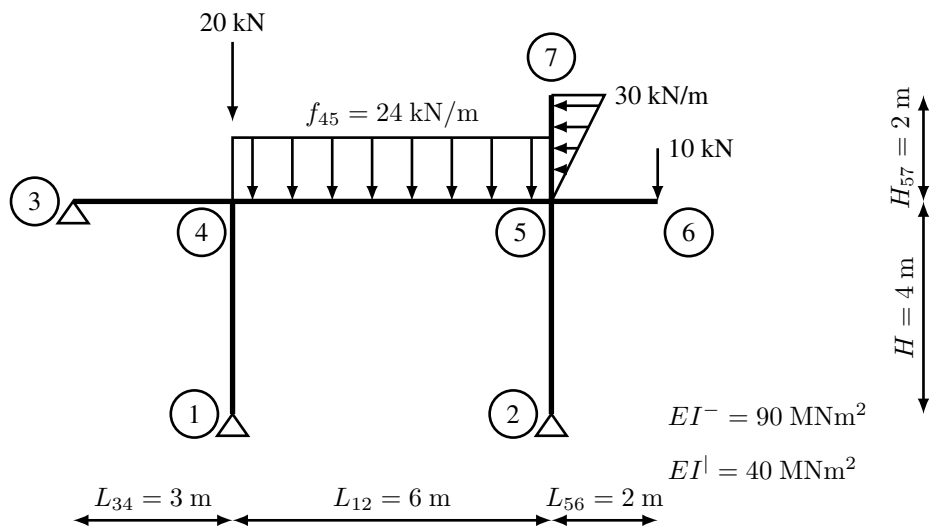
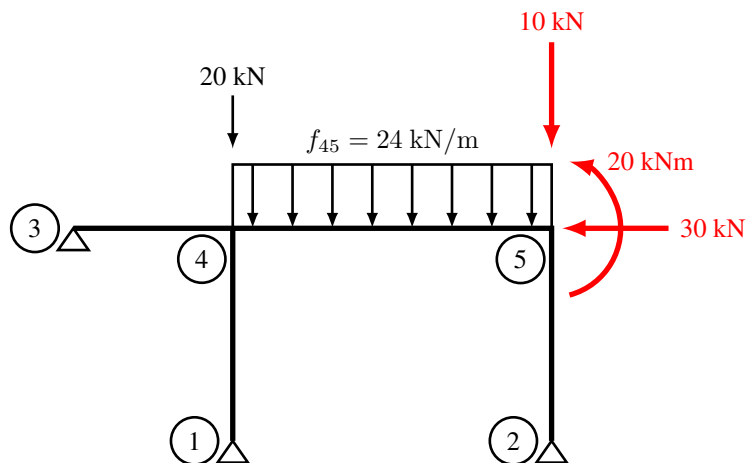


Příklad 1



redukce staticky určitých částí



neznámé φ_4 a φ_5 → podmínky rovnováhy

$$k_{14} = \frac{2 \cdot EI^|}{H} = \frac{2 \cdot 40}{4} = 20 \text{ MNm}$$

$$k_{25} = k_{14} = \frac{2 \cdot EI^|}{H} = \frac{2 \cdot 40}{4} = 20 \text{ MNm} = 20 \text{ MNm}$$

$$k_{34} = \frac{2 \cdot EI^-}{L_{34}} = \frac{2 \cdot 90}{3} = 60 \text{ MNm}$$

$$k_{45} = \frac{2 \cdot EI^-}{L_{12}} = \frac{2 \cdot 90}{6} = 30 \text{ MNm}$$

$$\bar{M}_{45} = \frac{f_{45} \cdot L_{12}^2}{12} = \frac{24 \cdot 6^2}{12} = 72 \text{ kNm}$$

$$\bar{M}_{54} = \frac{(-f_{45} \cdot L_{12}^2)}{12} = \frac{(-24 \cdot 6^2)}{12} = (-72) \text{ kNm}$$

$$\bar{M}_{43} = 0 \text{ kNm}$$

$$\bar{M}_{41} = 0 \text{ kNm}$$

$$\bar{M}_{52} = 0 \text{ kNm}$$

$$M_{45}^{\varphi} = k_{45} \cdot (2 \cdot \varphi_4 + \varphi_5)$$

$$M_{54}^{\varphi} = k_{45} \cdot (\varphi_4 + 2 \cdot \varphi_5)$$

$$M_{43}^{\varphi} = \frac{3 \cdot k_{34}}{2} \cdot \varphi_4$$

$$M_{41}^{\varphi} = \frac{3 \cdot k_{14}}{2} \cdot \varphi_4$$

$$M_{52}^{\varphi} = \frac{3 \cdot k_{25}}{2} \cdot \varphi_5$$

$$M_{45} = \overline{M}_{45} + M_{45}^{\varphi}$$

$$M_{54} = \overline{M}_{54} + M_{54}^{\varphi}$$

$$M_{43} = \overline{M}_{43} + M_{43}^{\varphi}$$

$$M_{41} = \overline{M}_{41} + M_{41}^{\varphi}$$

$$M_{52} = \overline{M}_{52} + M_{52}^{\varphi}$$

$$M_{41} + M_{43} + M_{45} = 0$$

$$M_{54} + M_{52} = 20$$

$$0 + \frac{3 \cdot 20}{2} \cdot \varphi_4 + 0 + \frac{3 \cdot 60}{2} \cdot \varphi_4 + 72 + 30 \cdot (2 \cdot \varphi_4 + \varphi_5) = 0$$

$$(-72) + 30 \cdot (\varphi_4 + 2 \cdot \varphi_5) + 0 + \frac{3 \cdot 20}{2} \cdot \varphi_5 = 20$$

$$72 + 30 \cdot \varphi_5 + 180 \cdot \varphi_4 = 0$$

$$(-72) + 30 \cdot \varphi_4 + 90 \cdot \varphi_5 = 20$$

$$\varphi_4 = (-0.6039) \text{ mrad}$$

$$\varphi_5 = 1.224 \text{ mrad}$$

$$M_{45}^{\varphi} = k_{45} \cdot (2 \cdot \varphi_4 + \varphi_5) = 30 \cdot (2 \cdot (-0.6039) + 1.224) = 0.4706 \text{ kNm}$$

$$M_{54}^{\varphi} = k_{45} \cdot (\varphi_4 + 2 \cdot \varphi_5) = 30 \cdot ((-0.6039) + 2 \cdot 1.224) = 55.29 \text{ kNm}$$

$$M_{43}^{\varphi} = \frac{3 \cdot k_{34}}{2} \cdot \varphi_4 = \frac{3 \cdot 60}{2} \cdot (-0.6039) = (-54.35) \text{ kNm}$$

$$M_{41}^{\varphi} = \frac{3 \cdot k_{14}}{2} \cdot \varphi_4 = \frac{3 \cdot 20}{2} \cdot (-0.6039) = (-18.12) \text{ kNm}$$

$$M_{52}^{\varphi} = \frac{3 \cdot k_{25}}{2} \cdot \varphi_5 = \frac{3 \cdot 20}{2} \cdot 1.224 = 36.71 \text{ kNm}$$

$$M_{45} = \overline{M}_{45} + M_{45}^{\varphi} = 72 + 0.4706 = 72.47$$

$$M_{54} = \overline{M}_{54} + M_{54}^{\varphi} = (-72) + 55.29 = (-16.71)$$

$$M_{43} = \overline{M}_{43} + M_{43}^{\varphi} = 0 + (-54.35) = (-54.35)$$

$$M_{41} = \overline{M}_{41} + M_{41}^{\varphi} = 0 + (-18.12) = (-18.12)$$

$$M_{52} = \overline{M}_{52} + M_{52}^{\varphi} = 0 + 36.71 = 36.71$$

$$Z_{45}^l = \left(-\frac{f_{45} \cdot L_{12}}{2} \right) - \frac{3 \cdot k_{45}}{2 \cdot L_{34}} \cdot (\varphi_4 + \varphi_5) = \left(-\frac{24 \cdot 6}{2} \right) - \frac{3 \cdot 30}{2 \cdot 3} \cdot ((-0.6039) + 1.224) = (-81.29) \text{ kNm}$$

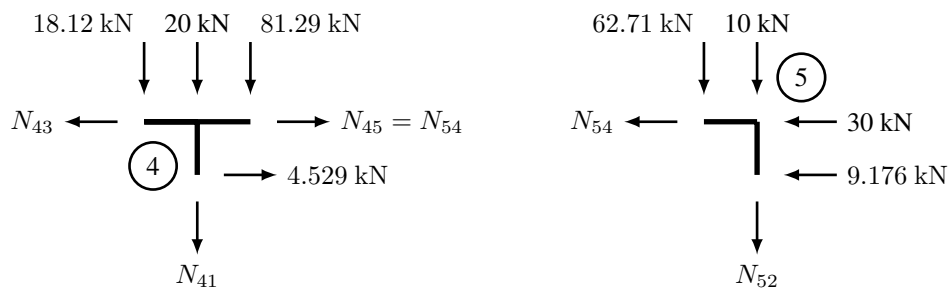
$$Z_{54}^l = \left(-\frac{f_{45} \cdot L_{12}}{2} \right) + \frac{3 \cdot k_{45}}{2 \cdot L_{34}} \cdot (\varphi_4 + \varphi_5) = \left(-\frac{24 \cdot 6}{2} \right) + \frac{3 \cdot 30}{2 \cdot 3} \cdot ((-0.6039) + 1.224) = (-62.71) \text{ kNm}$$

$$Z_{43}^l = \frac{3 \cdot k_{34}}{2 \cdot L_{34}} \cdot \varphi_4 = \frac{3 \cdot 60}{2 \cdot 3} \cdot (-0.6039) = (-18.12) \text{ kNm}$$

$$Z_{41}^l = \frac{3 \cdot k_{14}}{2 \cdot H} \cdot \varphi_4 = \frac{3 \cdot 20}{2 \cdot 4} \cdot (-0.6039) = (-4.529) \text{ kNm}$$

$$Z_{52}^l = \frac{3 \cdot k_{25}}{2 \cdot H} \cdot \varphi_5 = \frac{3 \cdot 20}{2 \cdot 4} \cdot 1.224 = 9.176 \text{ kNm}$$

normálové síly ze silových podmínek rovnováhy na styčnicích 4 a 5

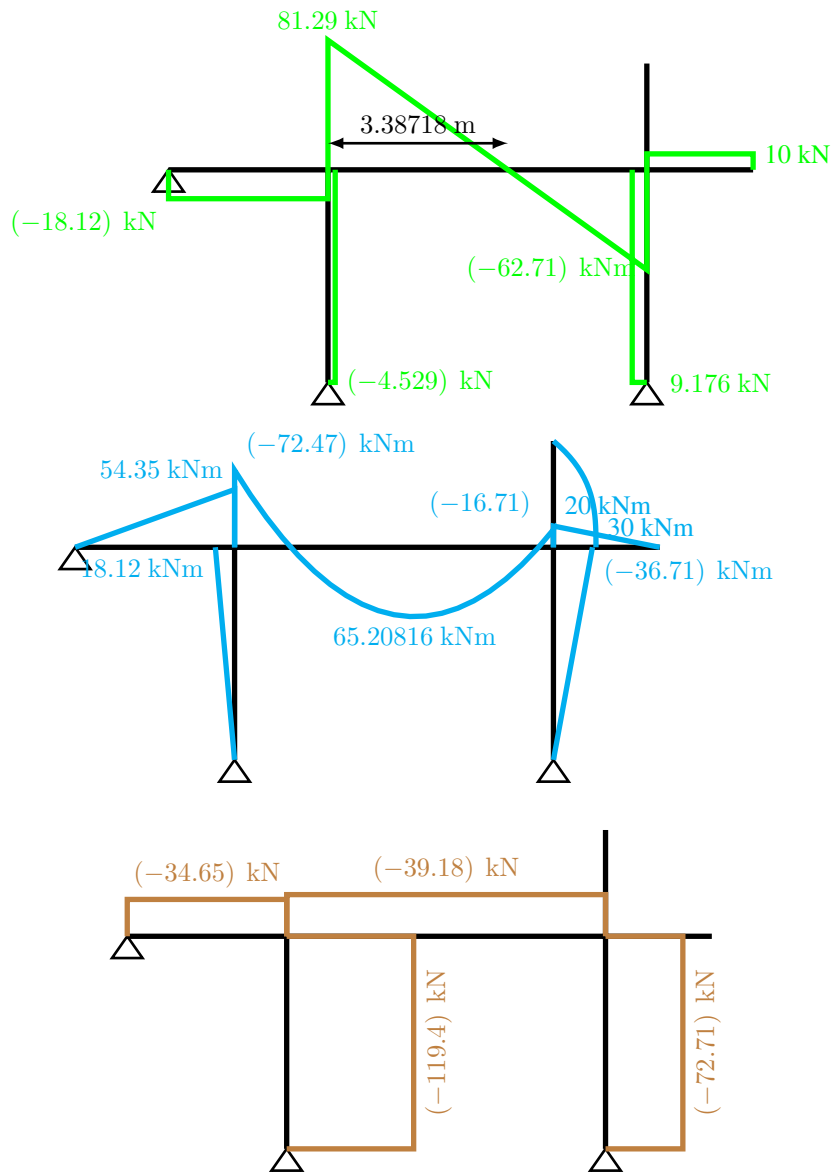


$$N_{54} = -30 - Z_{52}^l = (-30) - 9.176 = (-39.18) \text{ kN}$$

$$N_{52} = -10 + Z_{54}^l = (-10) + (-62.71) = (-72.71) \text{ kN}$$

$$N_{41} = -20 + Z_{43}^l + Z_{45}^l = (-20) + (-18.12) + (-81.29) = (-119.4) \text{ kN}$$

$$N_{43} = N_{45} - Z_{41}^l = (-39.18) - (-4.529) = (-34.65) \text{ kN}$$



V případě nalezení chyb, nejasností či dotazů mi prosím napište na jan.stransky@fsv.cvut.cz
verze 01, 2.3.2015