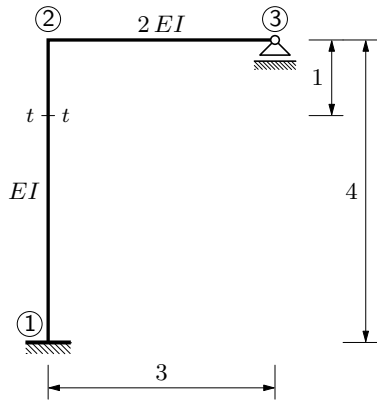


Utjecajne funkcije i utjecajne linije

Poluokvir

(Primjena teorema Müller–Breslaua)

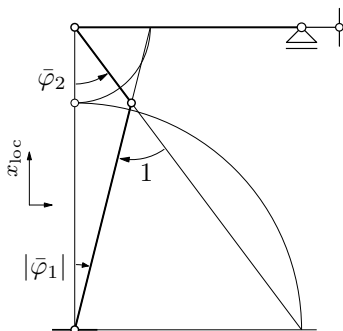


$$\eta_{M_{t-t}}$$

nepoznanice u metodi pomakâ: $\varphi_2, u_{\{2,3\}}$

$$k_{\{1,2\}} = \frac{EI}{4}$$

$$k_{\{2,3\}} = \frac{2EI}{3}$$



$$\bar{\varphi}_1 = -\frac{1}{4}, \quad \bar{\varphi}_2 = \frac{3}{4}$$

$$\bar{M}_{1,2} = -4 k_{\{1,2\}} \bar{\varphi}_1 - 2 k_{\{1,2\}} \bar{\varphi}_2$$

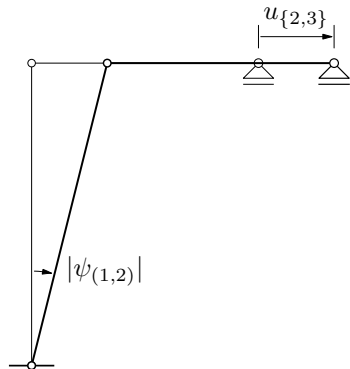
$$= -4 \cdot \frac{EI}{4} \cdot \left(-\frac{1}{4}\right) - 2 \cdot \frac{EI}{4} \cdot \frac{3}{4} = -\frac{EI}{8}$$

$$\bar{M}_{2,1} = -4 k_{\{1,2\}} \bar{\varphi}_2 - 2 k_{\{1,2\}} \bar{\varphi}_1$$

$$= -4 \cdot \frac{EI}{4} \cdot \frac{3}{4} - 2 \cdot \frac{EI}{4} \cdot \left(-\frac{1}{4}\right) = -\frac{5EI}{8}$$

$$\bar{M}_{2,3} = 0$$

inženjerska metoda pomakâ:



$$\psi_{\{1,2\}} = -\frac{u_{\{2,3\}}}{4}, \quad \delta\psi_{\{1,2\}} = -\frac{\delta u_{\{2,3\}}}{4}$$

$$M_{1,2} = 2 k_{\{1,2\}} \varphi_2 - 6 k_{\{1,2\}} \psi_{\{1,2\}} + \bar{M}_{1,2}$$

$$= \frac{EI}{2} \varphi_2 + \frac{3EI}{8} u_{\{2,3\}} + \bar{M}_{1,2}$$

$$M_{2,1} = 4 k_{\{1,2\}} \varphi_2 - 6 k_{\{1,2\}} \psi_{\{1,2\}} + \bar{M}_{2,1}$$

$$= EI \varphi_2 + \frac{3EI}{8} u_{\{2,3\}} + \bar{M}_{2,1}$$

$$M_{2,3} = 3 k_{\{2,3\}} \varphi_2 = 2 EI \varphi_2$$

$$(1) \quad \sum_j M_{2,j} = 0; \quad M_{2,1} + M_{2,3} = 0$$

$$\left[EI \varphi_2 + \frac{3EI}{8} u_{\{2,3\}} - \frac{5EI}{8} \right] + 2 EI \varphi_2 = 0 \quad \implies \quad 3 \varphi_2 + \frac{3}{8} u_{\{2,3\}} = \frac{5}{8}$$

$$(2) \quad \sum W = 0; \quad (M_{1,2} + M_{2,1}) \delta\psi_{\{1,2\}} = 0$$

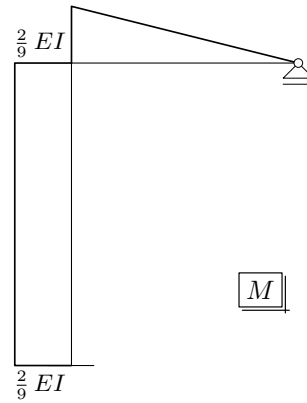
$$\left(\frac{3EI}{2} \varphi_2 + \frac{3EI}{4} u_{\{2,3\}} - \frac{3EI}{4} \right) \left(-\frac{\delta u_{\{2,3\}}}{4} \right) = 0 \quad \implies \quad \frac{3}{8} \varphi_2 + \frac{3}{16} u_{\{2,3\}} = \frac{3}{16}$$

$$(1) \ \& \ (2) \ \implies \ \varphi_2 = 1/9, \ u_{\{2,3\}} = 7/9$$

$$M_{1,2} = \frac{EI}{2} \cdot \frac{1}{9} + \frac{3EI}{8} \cdot \frac{7}{9} - \frac{EI}{8} = \frac{2}{9} EI$$

$$M_{2,1} = EI \cdot \frac{1}{9} + \frac{3EI}{8} \cdot \frac{7}{9} - \frac{5EI}{8} = -\frac{2}{9} EI$$

$$M_{2,3} = 2EI \cdot \frac{1}{9} = \frac{2}{9} EI$$



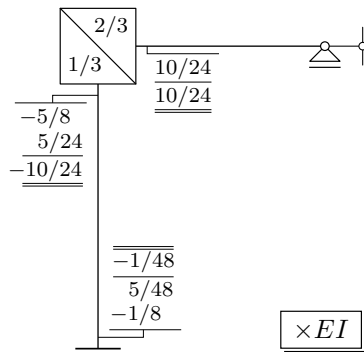
iteracijski postupak:

1. Cross:

$$k_2 = k_{\{1,2\}} + \frac{3}{4} k_{\{2,3\}} = \frac{3}{4}$$

$$\mu_{2,1} = \frac{k_{\{1,2\}}}{k_2} = \frac{1}{3}$$

$$\mu_{2,3} = \frac{3}{4} \frac{k_{\{2,3\}}}{k_2} = \frac{2}{3}$$



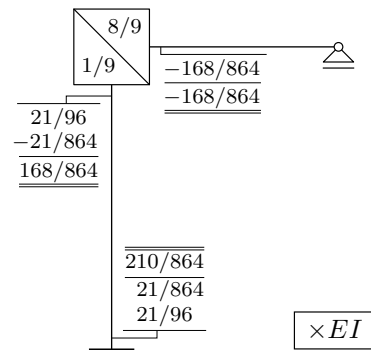
2. Werner-Csonka:

$$\bar{T}_{2,1} = -T_{2,1} = \frac{1}{4} \cdot \frac{21}{48} \cdot EI$$

$$\bar{M}_{1,2} = \bar{M}_{2,1} = \frac{1}{2} \cdot \bar{T}_{2,1} \cdot 4 = \frac{21}{96} EI$$

$$k_2^W = k_{\{1,2\}} + 3 k_{\{2,3\}} = \frac{9}{4}$$

$$\mu_{2,1} = \frac{k_{\{1,2\}}}{k_2^W} = \frac{1}{9}, \quad \mu_{2,3} = \frac{3 k_{\{2,3\}}}{k_2^W} = \frac{3 \cdot 2/3}{3/4} = \frac{8}{9}$$



$$T_{2,1} = \frac{1}{4} (M_{2,1} + M_{1,2})$$

$$= \frac{1}{4} \cdot \left(-\frac{10}{24} - \frac{1}{48}\right) \cdot EI$$

$$= -\frac{1}{4} \cdot \frac{21}{48} \cdot EI$$

$$M_{2,3} = M_{2,3}^{Cr} + M_{2,3}^W = \left(\frac{10}{24} - \frac{168}{864}\right) EI = \frac{192}{864} EI = \frac{2}{9} EI$$

$$M_{2,1} = M_{2,1}^{Cr} + M_{2,1}^W = \left(-\frac{10}{24} + \frac{168}{864}\right) EI = -\frac{192}{864} EI = -\frac{2}{9} EI$$

$$M_{1,2} = M_{1,2}^{Cr} + M_{1,2}^W = \left(-\frac{1}{48} + \frac{210}{864}\right) EI = \frac{192}{864} EI = \frac{2}{9} EI$$

crtanje utjecajne linije:

mjerilo duljina: 1 [cm] :: 1 [m]

$$\bar{\varphi}_1 = 3 \cdot \frac{2}{9} = 6/9$$

$$\tilde{\varphi}_1 = 3 \text{ cm}$$

$$\bar{\varphi}_2 = 1 \cdot \frac{2}{9} = 2/9$$

$$\tilde{\varphi}_2 = 1 \text{ cm}$$

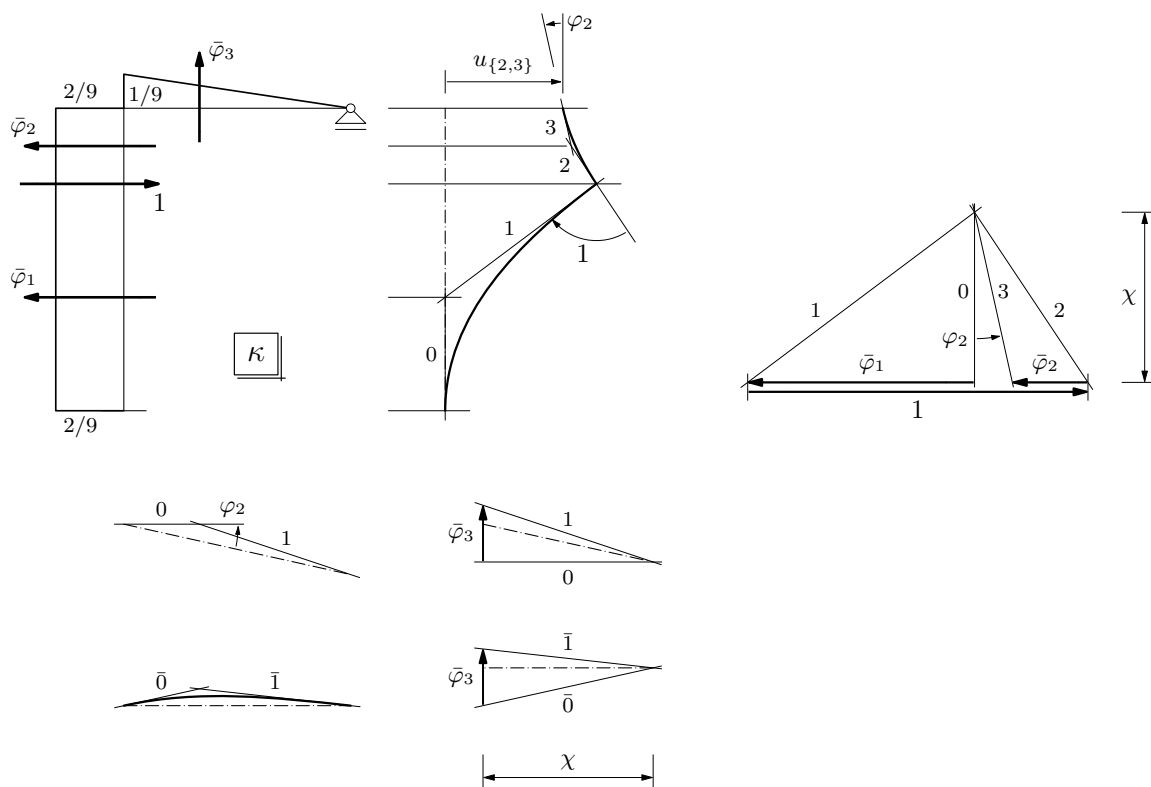
$$\bar{\varphi}_3 = \frac{1}{2} \cdot 3 \cdot \frac{1}{9} = 1/6$$

$$\tilde{\varphi}_3 = 0,75 \text{ cm}$$

mjerilo kutova: 1 [cm] :: 2/9

$$\tilde{\bar{I}} = 4,5 \text{ cm}$$

$$\tilde{\chi} = 2,25 \text{ cm} \Rightarrow \chi = 1/2, n = 2$$



$$\eta = \frac{m}{n} \tilde{\eta} = \frac{1}{2} \tilde{\eta}$$

$$\tilde{u}_{\{2,3\}} = 15,5 \text{ mm} = 1,55 \text{ cm} \Rightarrow u_{\{2,3\}} = \frac{1}{2} \tilde{u}_{\{2,3\}} = 0,775 \approx 7/9$$

$$\varphi_2 = 1 - (\bar{\varphi}_1 + \bar{\varphi}_2) = 1 - (6/9 + 2/9) = 1/9$$