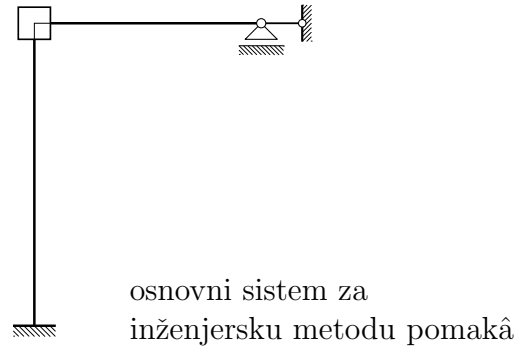
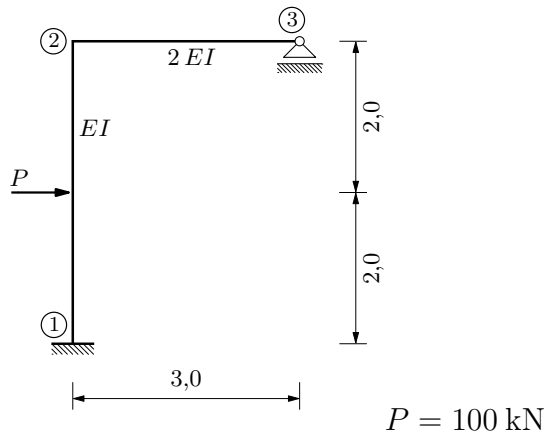
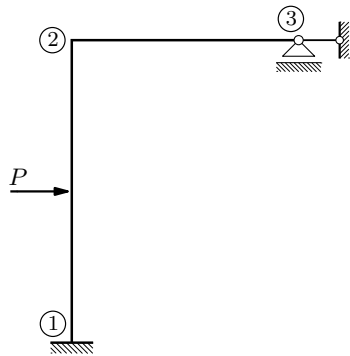


# Relaksacijski postupci

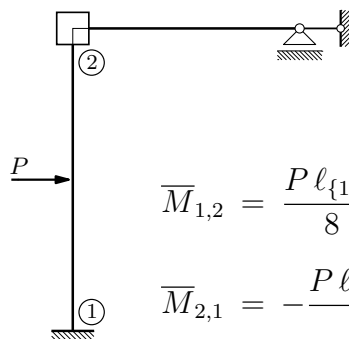
## Još jedan primjer: poluokvir



## Prvi korak: Crossov postupak na nepomičnom sistemu

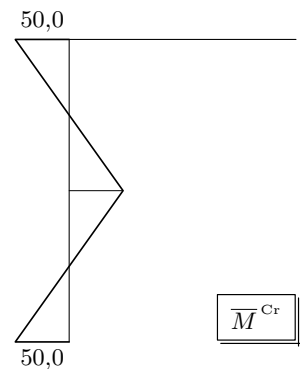


momenti upetosti:



$$\bar{M}_{1,2} = \frac{P l_{\{1,2\}}}{8} = \frac{100,0 \cdot 4,0}{8} = 50,0 \text{ kNm}$$

$$\bar{M}_{2,1} = -\frac{P l_{\{1,2\}}}{8} = -50,0 \text{ kNm}$$



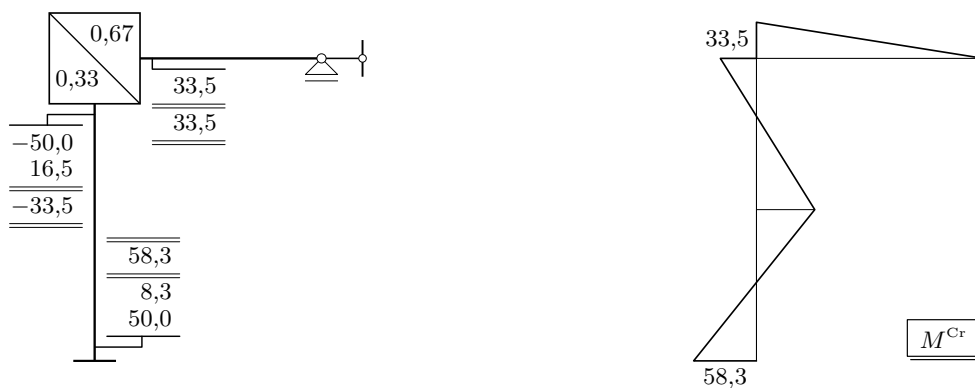
razdjelni koeficijenti:

$$k_2 = 4 k_{\{1,2\}} + 3 k_{\{2,3\}} = 4 \cdot \frac{EI}{4,0} + 3 \cdot \frac{2EI}{3,0} = 3EI$$

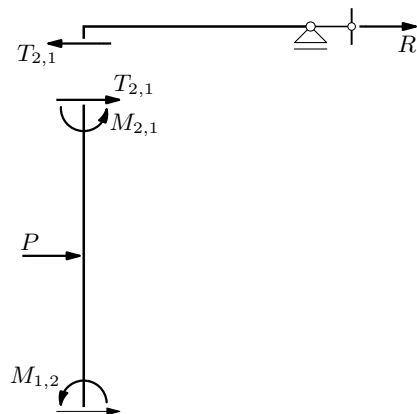
$$\mu_{2,1} = \frac{4 k_{\{1,2\}}}{k_2} = \frac{4 \cdot \frac{EI}{4,0}}{3EI} = \frac{1}{3} = 0,33$$

$$\mu_{2,3} = \frac{3 k_{\{2,3\}}}{k_2} = \frac{3 \cdot \frac{2EI}{3,0}}{3EI} = \frac{2}{3} = 0,67$$

raspodjela momenata:



reakcija u zamišljenom spoju:



$$-T_{2,1} + R = 0$$

$$R = T_{2,1}$$

$$-\ell_{\{1,2\}} \cdot T_{2,1} + M_{2,1} + M_{1,2} - \frac{\ell_{\{1,2\}}}{2} \cdot P = 0$$

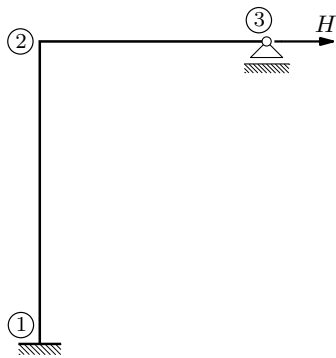
$$T_{2,1} = \frac{1}{\ell_{\{1,2\}}} (M_{2,1} + M_{1,2}) - \frac{1}{2} P$$

$$= \frac{1}{4,0} (-33,5 + 58,3) - \frac{1}{2} 100$$

$$= -43,8 \text{ kN}$$

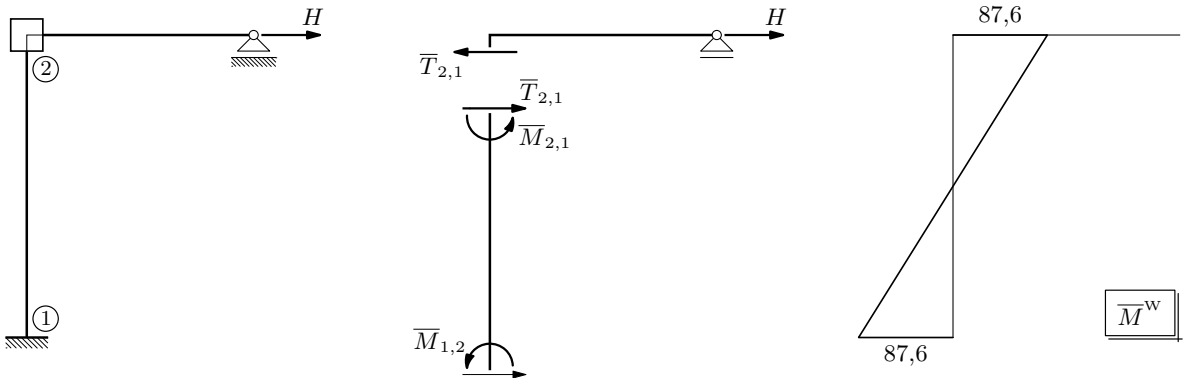
$$R = -43,8 \text{ kN}$$

## Drugi korak: postupak Wernera i Csonke



$$H = -R = 43,8 \text{ kN}$$

momenti upetosti:



$$-\ell_{\{1,2\}} \cdot \bar{T}_{2,1} + \bar{M}_{2,1} + \bar{M}_{1,2} = 0$$

$$-\bar{T}_{2,1} + H = 0$$

$$\bar{M}_{1,2} = \bar{M}_{2,1} = \frac{1}{2} \bar{T}_{2,1} \ell_{\{1,2\}}$$

$$\bar{T}_{2,1} = H = 43,8 \text{ kN}$$

$$\bar{M}_{1,2} = \bar{M}_{2,1} = \frac{1}{2} \cdot 43,8 \cdot 4,0 = 87,6 \text{ kNm}$$

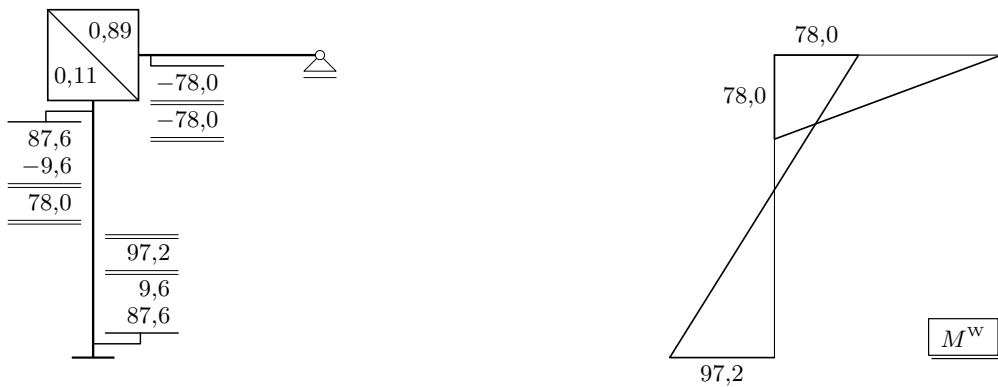
razdjelni koeficijenti:

$$k_2^w = k_{\{1,2\}} + 3 k_{\{2,3\}} = \frac{EI}{4,0} + 3 \cdot \frac{2EI}{3,0} = \frac{9EI}{4}$$

$$\mu_{2,1}^w = \frac{k_{\{1,2\}}}{k_2^w} = \frac{\frac{EI}{4,0}}{\frac{9EI}{4}} = \frac{1}{9} = 0,11$$

$$\mu_{2,3}^w = \frac{3 k_{\{2,3\}}}{k_2^w} = \frac{3 \cdot \frac{2EI}{3,0}}{\frac{9EI}{4}} = \frac{8}{9} = 0,89$$

raspodjela momenata:

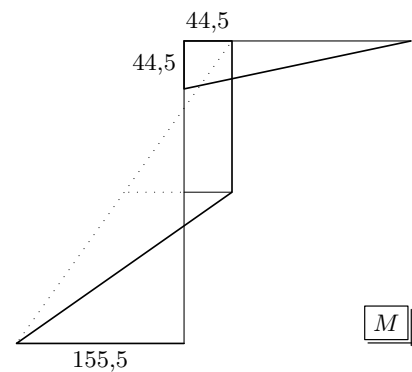


konačne vrijednosti momenata:  $M = M^{Cr} + M^w$

$$M_{1,2} = M_{1,2}^{Cr} + M_{1,2}^w = 58,3 + 97,2 = 155,5 \text{ kNm}$$

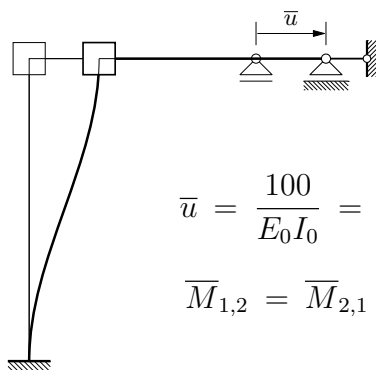
$$M_{2,1} = M_{2,1}^{Cr} + M_{2,1}^w = -33,5 + 78,0 = 44,5 \text{ kNm}$$

$$M_{2,3} = M_{2,3}^{Cr} + M_{2,3}^w = 33,5 - 78,0 = -44,5 \text{ kNm}$$



Ili, kao drugi korak: proširenje Crossova postupka

momenti upetosti:

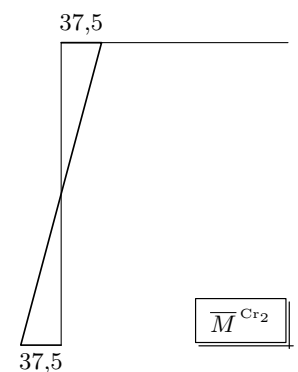


$$\bar{u} = \frac{100}{E_0 I_0} = \frac{100}{EI}$$

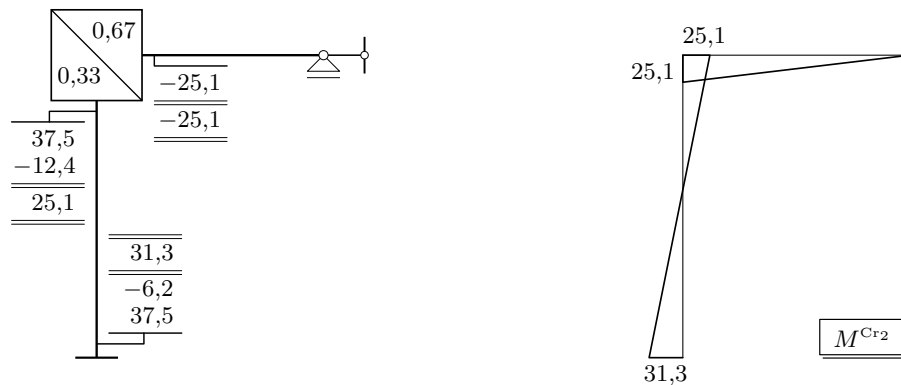
$$\bar{M}_{1,2} = \bar{M}_{2,1} = -6 k_{\{1,2\}} \bar{\psi}_{\{1,2\}}$$

$$= -6 \frac{EI}{\ell_{\{1,2\}}} \left( -\frac{\bar{u}}{\ell_{\{1,2\}}} \right)$$

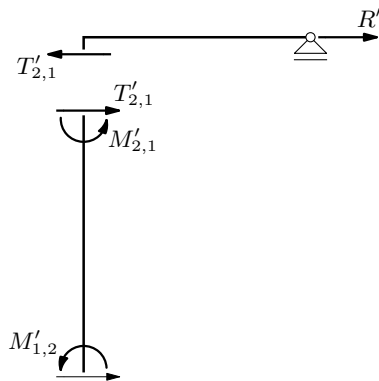
$$= 6 \cdot \frac{EI}{4,0} \cdot \frac{100}{4,0} = 37,5 \text{ kNm}$$



raspodjela momenata:



reakcija u zamišljenoj vezi:



$$R' = T'_{2,1}$$

$$T'_{2,1} = \frac{1}{\ell_{\{1,2\}}} (M'_{1,2} + M'_{2,1})$$

$$= \frac{1}{4,0} (31,3 + 25,1)$$

$$= 14,1 \text{ kN}$$

$$R + \varrho R' = 0 \quad \Rightarrow \quad \varrho = -\frac{R}{R'} = -\frac{-43,8}{14,1} = \frac{43,8}{14,1} = 3,106$$

konačne vrijednosti momenata:  $\mathbf{M} = \mathbf{M}^{\text{Cr}} + \varrho \mathbf{M}^{\text{Cr}_2}$

$$M_{1,2} = M_{1,2}^{\text{Cr}} + \varrho M_{1,2}^{\text{Cr}_2} = 58,3 + 3,106 \cdot 31,3 = 58,3 + 97,2 = 155,6 \text{ kNm}$$

$$M_{2,1} = M_{2,1}^{\text{Cr}} + \varrho M_{2,1}^{\text{Cr}_2} = -33,5 + 3,106 \cdot 25,1 = -33,5 + 78,0 = 44,5 \text{ kNm}$$

$$M_{2,3} = M_{2,3}^{\text{Cr}} + \varrho M_{2,3}^{\text{Cr}_2} = 33,5 - 3,106 \cdot 25,1 = 33,5 - 78,0 = -44,5 \text{ kNm}$$

duljina translacijskoga pomaka:

$$u = u_{2,3} = \varrho \bar{u} = 3,106 \cdot \frac{100}{EI} = 3,106 \cdot \frac{100}{3 \cdot 10^7 \cdot 0,0054} = 0,00192 \text{ m}$$