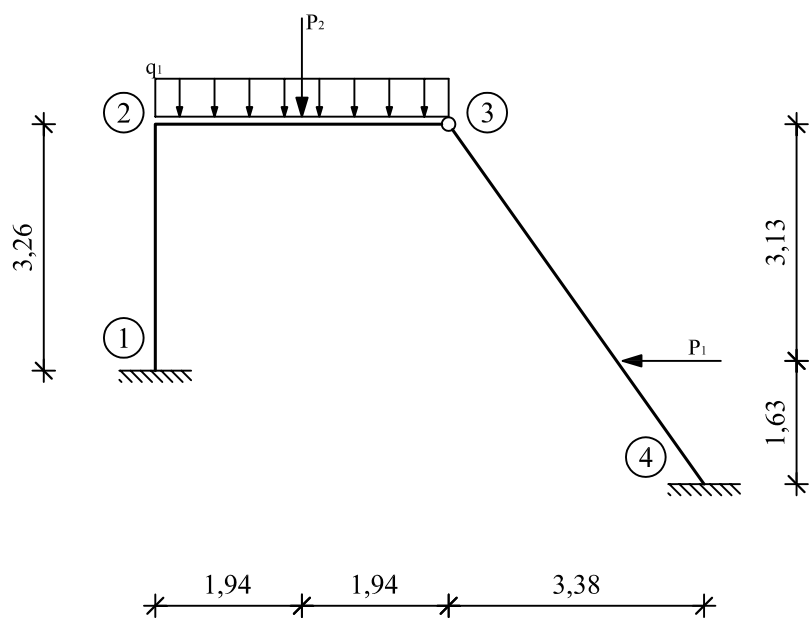


GRAĐEVNA STATIKA 2

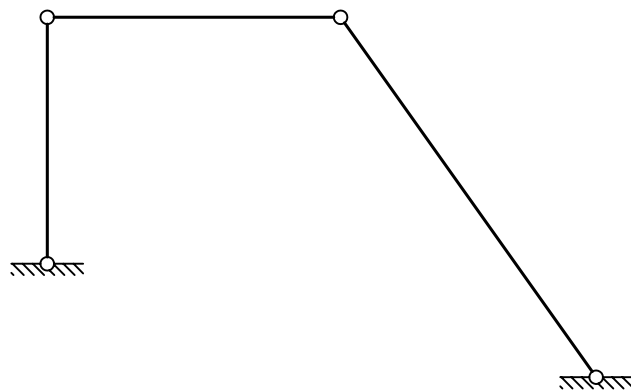
- 1. Program-

Hajdarovac Elis

0082026728

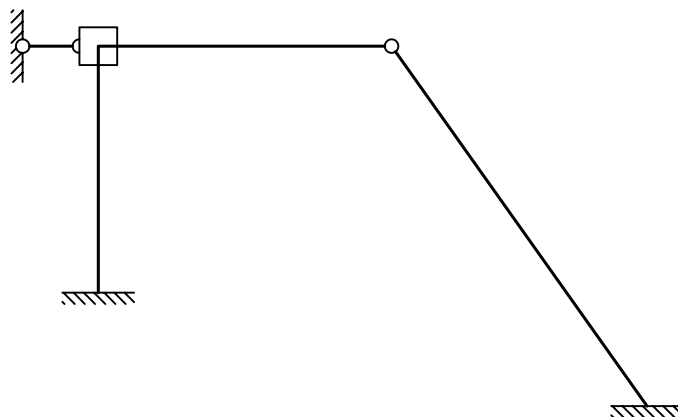


Zglobna shema:



$$S = 2 \cdot 2 - 3 = 1$$

Osnovni sistem:



NEPOZNANICE: u_{23} , φ_2

$$E = 3 \cdot 10^7 \text{ kN/m}^2$$
$$b/h = 50/50 \text{ cm}$$

$$l_{12} = 3,26 \text{ m}$$

$$l_{23} = 3,88 \text{ m}$$

$$l_{34} = \sqrt{3,38^2 + 4,76^2} = 5,83797 \text{ m}$$

$$I = \frac{b \cdot h^3}{12} = \frac{0,5 \cdot 0,5^3}{12} = 5,208333 \cdot 10^{-3} \text{ m}^4$$

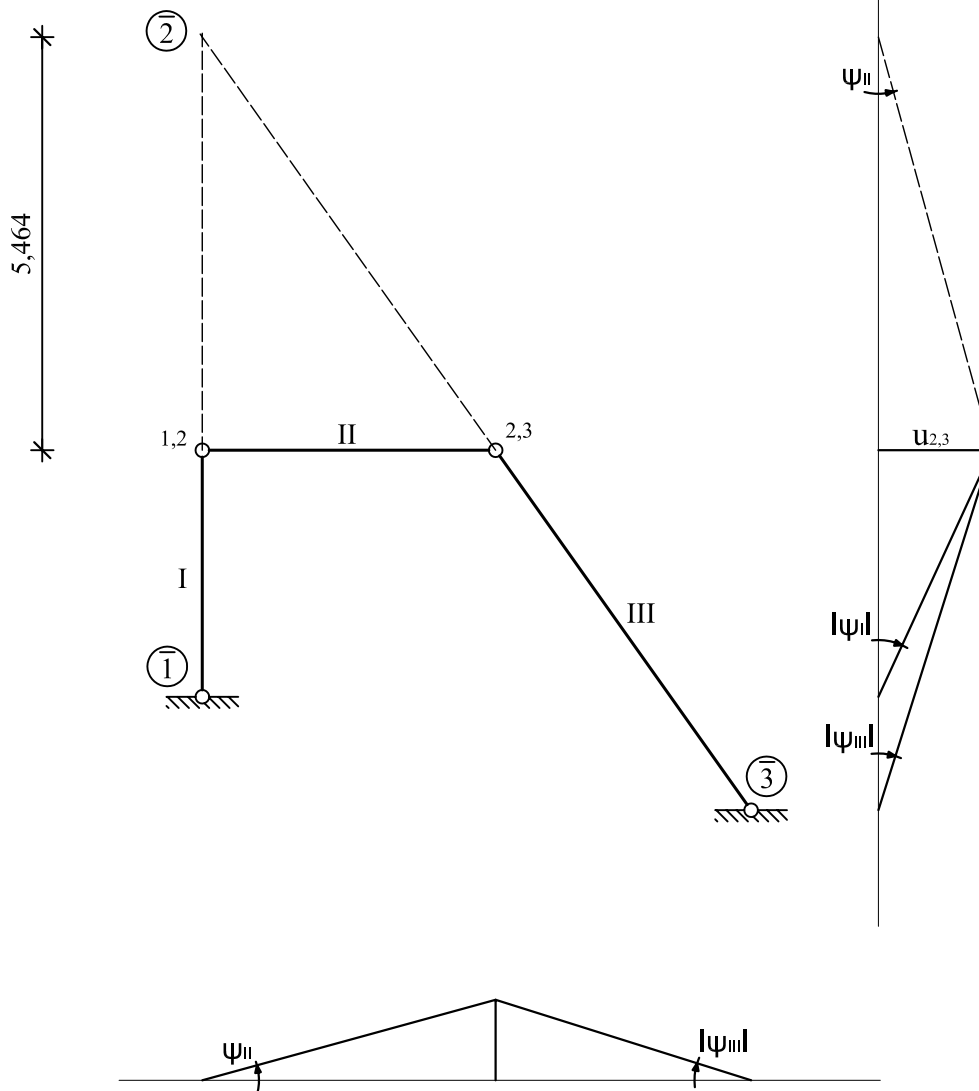
$$EI = 3 \cdot 10^7 \cdot 5,208333 \cdot 10^{-3} = 156\,250 \text{ kNm}^2$$

$$k_{12} = EI / l_{12} = 47929,44785 \text{ kNm}$$

$$k_{23} = EI / l_{23} = 40270,61856 \text{ kNm}$$

$$k_{34} = EI / l_{34} = 26764,44038 \text{ kNm}$$

Plan pomaka:



$$\Psi_I = \Psi_{12} = -\frac{u_{23}}{3,26}$$

$$\Psi_{II} = \Psi_{23} = \frac{u_{23}}{5,46}$$

$$\Psi_{III} = \Psi_{34} = -\frac{u_{23}}{4,76}$$

-Element 1-2 (obostrano upeta greda)

$$M_{12} = 2 \cdot k_{12} \cdot \varphi_2 - 6 \cdot k_{12} \cdot \Psi_{12}$$

$$M_{21} = 4 \cdot k_{12} \cdot \varphi_2 - 6 \cdot k_{12} \cdot \Psi_{12}$$

-Element 2-3 (jednostrano upeta greda)

$$M_{23} = 3 \cdot k_{23} \cdot \varphi_2 - 3 \cdot k_{23} \cdot \Psi_{23} + \bar{M}_{23}^c$$

$$\bar{M}_{23}^c(P_2) = \bar{M}_{23}(P_2) - \frac{1}{2} \bar{M}_{32}(P_2) = 60,3825 \text{ kNm}$$

$$\bar{M}_{23}^c(q) = \bar{M}_{23}(q) - \frac{1}{2} \bar{M}_{32}(q) = 30,86152 \text{ kNm}$$

$$\bar{M}_{23}^c = \bar{M}_{23}^c(P_2) + \bar{M}_{23}^c(q) = 91,24402 \text{ kNm}$$

$$M_{32} = 0$$

-Element 3-4 (jednostrano upeta greda)

$$M_{43} = -3 \cdot k_{43} \cdot \Psi_{43} + \bar{M}_{43}^c$$

$$P_p = P \cdot \cos \alpha = 92,13462558 \text{ kN}$$

$$\bar{M}_{43}^c = -P_p \cdot \frac{a \cdot (L^2 - a^2)}{2 \cdot L^2} = -100,378898 \text{ kNm}$$

$$M_{34} = 0$$

JEDNADŽBA RAVNOTEŽE ČVORA 2

$$\Sigma M_2 = 0$$

$$-M_{21} - M_{23} = 0$$

$$M_{21} + M_{23} = 0$$

$$4 \cdot k_{12} \cdot \varphi_2 - 6 \cdot k_{12} \cdot \Psi_{12} + 3 \cdot k_{23} \cdot \varphi_2 - 3 \cdot k_{23} \cdot \Psi_{23} + \bar{M}_{23}^c = 0$$

$$191717,7914 \cdot \varphi_2 + 88213,707699 \cdot u_{23} + 120811,85568 \cdot \varphi_2 - \\ - 22126,713495 \cdot u_{23} + 91,24402 = 0$$

$$312529,647079 \cdot \varphi_2 + 66086,994205 \cdot u_{23} = -91,24402 \quad (1)$$

VIRTUALNI RAD

$$\Sigma W = 0$$

$$M_{12} \cdot \delta \psi_{12} + M_{21} \cdot \delta \psi_{12} + M_{23} \cdot \delta \psi_{23} + M_{43} \cdot \delta \psi_{34} + P_1 \cdot \left(-\frac{1,63}{4,76}\right) + P_2 \cdot \left(-\frac{169}{476}\right) + Q \cdot \left(-\frac{169}{476}\right) = 0$$

$$M_{12} \cdot \delta \psi_{12} + M_{21} \cdot \delta \psi_{12} + M_{23} \cdot \delta \psi_{23} + M_{43} \cdot \delta \psi_{34} + 113 \cdot \left(-\frac{1,63}{4,76}\right) + 83 \cdot \left(-\frac{169}{476}\right) + 63,632 \cdot \left(-\frac{169}{476}\right) = 0$$

$$\begin{aligned} & (2 \cdot k_{12} \cdot \varphi_2 - 6 \cdot k_{12} \cdot \Psi_{12}) \cdot \left(-\frac{1}{3,26}\right) + (4 \cdot k_{12} \cdot \varphi_2 - 6 \cdot k_{12} \cdot \Psi_{12}) \cdot \left(-\frac{1}{3,26}\right) + \\ & + (3 \cdot k_{23} \cdot \varphi_2 - 3 \cdot k_{23} \cdot \Psi_{23} + \bar{M}_{23}^c) \cdot \left(\frac{1}{5,46}\right) + (-3 \cdot k_{43} \cdot \Psi_{43} + \bar{M}_{43}^c) \cdot \left(-\frac{1}{4,76}\right) = 90,755899 \end{aligned}$$

$$\begin{aligned} & -29404,569233 \cdot \varphi_2 - 27059,419539 \cdot u_{23} - 58809,138466 \cdot \varphi_2 - 27059,419539 \cdot u_{23} + \\ & + 22126,713495 \cdot \varphi_2 - 4052,511629 \cdot u_{23} + 16,711359 - 3543,769911 \cdot u_{23} + 21,088004 = 90,755899 \end{aligned}$$

$$-66086,994205 \cdot \varphi_2 - 61715,12056 \cdot u_{23} = 52,956536 \quad (2)$$

SUSTAV JEDNADŽBI :

$$312529,647079 \cdot \varphi_2 + 66086,994205 \cdot u_{23} = -91,24402 \quad (1)$$

$$66086,994205 \cdot \varphi_2 + 61715,12056 \cdot u_{23} = -52,956536 \quad (2)$$

KONAČNA RJEŠENJA NEPOZNANICA

$$u_{23} = -7,051087 \cdot 10^{-4} \text{ m}$$

$$\varphi_2 = -1,428520 \cdot 10^{-4} \text{ rad}$$

-Element 1-2 (obostrano upeta greda)

$$\begin{aligned}M_{12} &= 2 \cdot k_{12} \cdot \varphi_2 - 6 \cdot k_{12} \cdot \Psi_{12} = \\&= 2 \cdot 47929,44785 \cdot (-0,000142852) - 6 \cdot 47929,44785 \cdot \left(-\frac{-0,000705108}{3,26}\right) = \\&= -75,893 \text{ kNm}\end{aligned}$$

$$\begin{aligned}M_{21} &= 4 \cdot k_{12} \cdot \varphi_2 - 6 \cdot k_{12} \cdot \Psi_{12} = \\&= 4 \cdot 47929,44785 \cdot (-0,000142852) - 6 \cdot 47929,44785 \cdot \left(-\frac{-0,000705108}{3,26}\right) = \\&= -89,587 \text{ kNm}\end{aligned}$$

-Element 2-3 (jednostrano upeta greda)

$$\begin{aligned}M_{23} &= 3 \cdot k_{23} \cdot \varphi_2 - 3 \cdot k_{23} \cdot \Psi_{23} + \bar{M}_{23}^c = \\&= 3 \cdot 40270,61856 \cdot (-0,000142852) - 3 \cdot 40270,61856 \cdot \left(\frac{-0,000705108}{5,46}\right) + 91,24402 = \\&= 89,587 \text{ kNm}\end{aligned}$$

$$M_{32} = 0$$

-Element 3-4 (jednostrano upeta greda)

$$\begin{aligned}M_{43} &= -3 \cdot k_{43} \cdot \Psi_{43} + \bar{M}_{43}^c = -3 \cdot 26764,44038 \cdot \left(-\frac{-0,000705108}{4,76}\right) - 100,378898 \text{ kNm} = \\&= -112,272 \text{ kNm}\end{aligned}$$

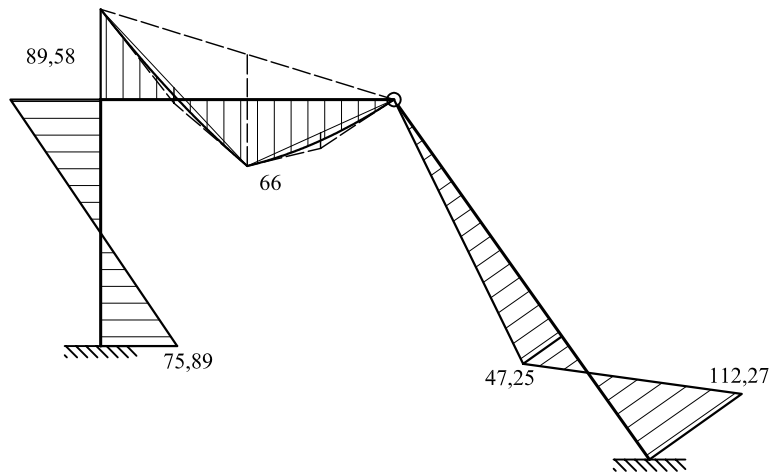
$$M_{34} = 0$$

$$M_{12} = -75,893 \text{ kNm}$$

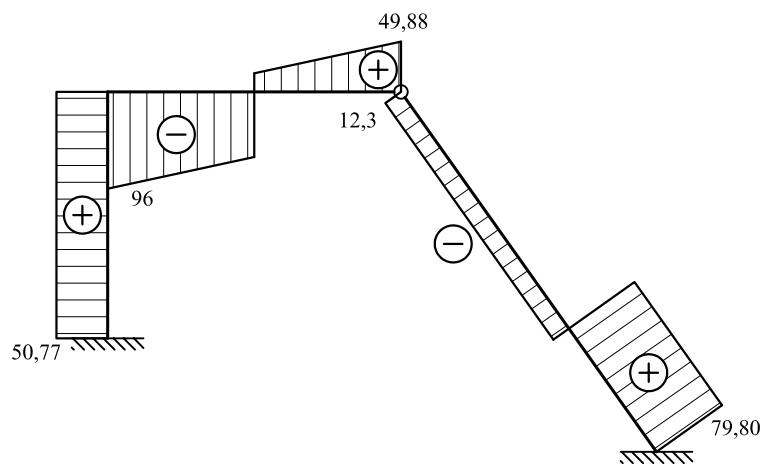
$$M_{21} = -89,587 \text{ kNm}$$

$$M_{23} = 89,587 \text{ kNm}$$

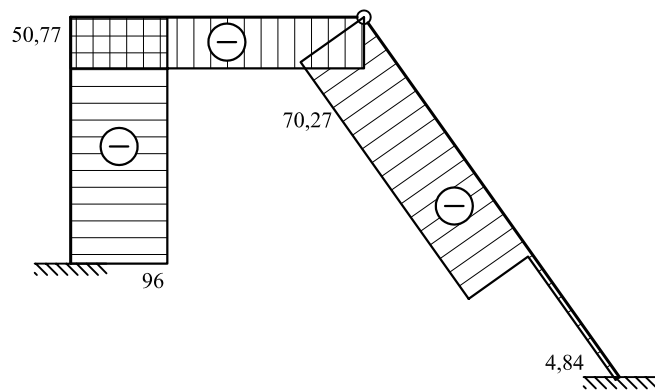
$$M_{43} = -112,272 \text{ kNm}$$



M



T



N

DiM (Displacement Method - Metoda pomaka)

Analysis Nodes Supports Elements Characteristics Loads

Degrees of Freedom: 5

Nodal displacements:

nd	u _i	v _i	phi _i
1:	0	0	0
2:	-0.000696153	-4.19036e-05	-0.00014694
3:	-0.000722349	-0.000558627	0
4:	0	0	0

Element end forces:

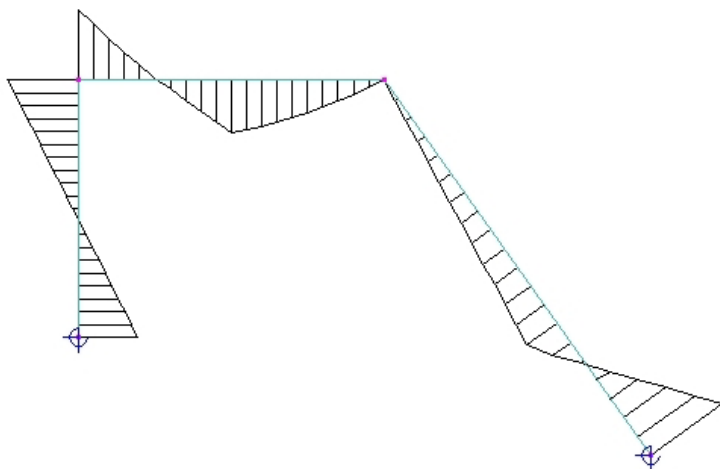
el	H _{ij}	T _{ij}	M _{ij}	H _{ji}	T _{ji}	M _{ji}
1:	96.4039	-50.6371	-75.4957	-96.4039	50.6371	-89.5812
2:	50.6371	96.4039	89.5812	-50.6371	50.2281	0
3:	70.2707	12.2066	0	-4.84738	79.9281	-112.928

Reactions:

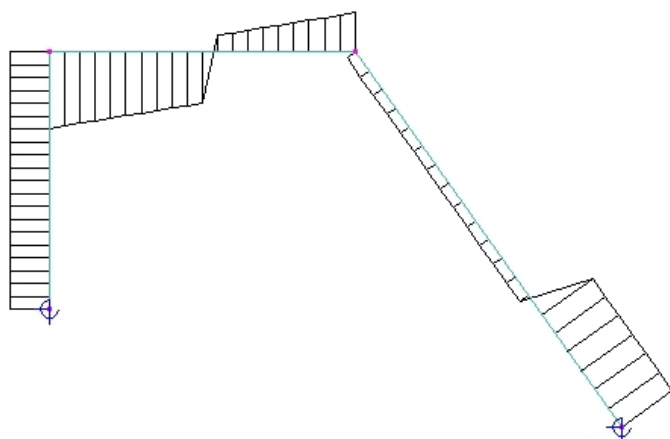
nd	R _x	R _y	M
1:	50.6371	96.4039	-75.4957
4:	62.3629	50.2281	-112.928

DiM

M-dijagram



T-dijagram



N-dijagram

