GRAĐEVNA STATIKA 2

- 2. Program-

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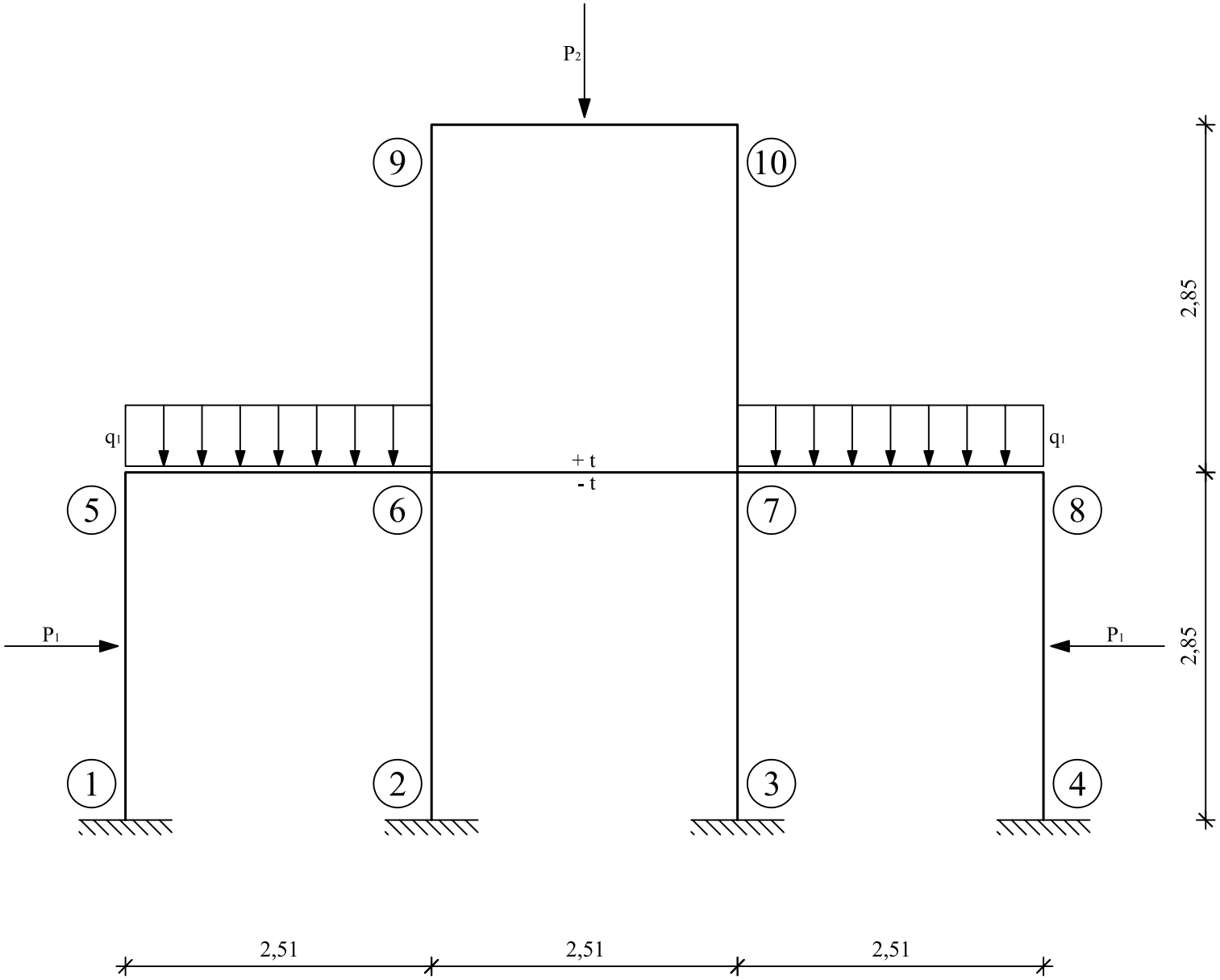

E = $3 \cdot 10^7$ kN/m^2
b/h = 0,5/0,5 m
$\alpha_t = 1 \cdot 10^{-5}$ K^{-1}

$I = \frac{b \cdot h^3}{12} = \frac{0{,}5 \cdot 0{,}5^3}{12} = 5{,}208333 \cdot 10^{-3}\ m^4$
$EI = 3 \cdot 10^7 \cdot 5{,}208333 \cdot 10^{-3} = 156\,250\ kNm^2$

Redak vrijednosti	ℓ_1	ℓ_2	ℓ_3	h_1	h_2	h_3	$\mathbf{P}_1$	$\mathbf{P}_2$	$\mathbf{M}_1$	$\mathbf{q}_1$	φ_t	Δh	t	t_s
5	1,79	2,51	3,54	2,24	2,85	3,79	142	145	60	18,6	0,016	0,004	14	14

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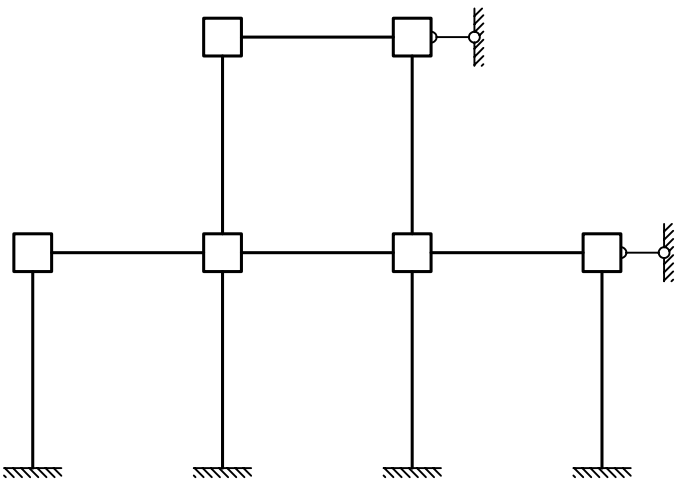
Osnovni sistem:



Momenti upetosti:

$\bar{M}_{15} = \frac{P_1 \cdot l}{8} = \frac{142 \cdot 2{,}85}{8} = 50{,}5875\ kNm$

$\bar{M}_{51} = -\frac{P_1 \cdot l}{8} = -\frac{142 \cdot 2{,}85}{8} = -50{,}5875\ kNm$

$\bar{M}_{48} = -\frac{P_1 \cdot l}{8} = -\frac{142 \cdot 2{,}85}{8} = -50{,}5875\ kNm$

$\bar{M}_{84} = \frac{P_1 \cdot l}{8} = \frac{142 \cdot 2{,}85}{8} = 50{,}5875\ kNm$

$\bar{M}_{9,10} = \frac{P_2 \cdot l}{8} = \frac{145 \cdot 2{,}51}{8} = 45{,}4938\ kNm$

$\bar{M}_{10,9} = -\frac{P_2 \cdot l}{8} = -\frac{145 \cdot 2{,}51}{8} = -45{,}4938\ kNm$

$\bar{M}_{56} = \frac{q_1 \cdot l^2}{12} = \frac{18{,}6 \cdot 2{,}51^2}{12} = 9{,}7652\ kNm$

$\bar{M}_{65} = -\frac{q_1 \cdot l^2}{12} = -\frac{18{,}6 \cdot 2{,}51^2}{12} = -9{,}7652\ kNm$

$\bar{M}_{78} = \frac{q_1 \cdot l^2}{12} = \frac{18{,}6 \cdot 2{,}51^2}{12} = 9{,}7652\ kNm$

$\bar{M}_{87} = -\frac{q_1 \cdot l^2}{12} = -\frac{18{,}6 \cdot 2{,}51^2}{12} = -9{,}7652\ kNm$

$\bar{M}_{67} = -\alpha_t \cdot \frac{EI}{h} \cdot \Delta t = -10^{-5} \cdot \frac{156\,250}{0{,}5} \cdot 28 = -87{,}50\ kNm$

$\bar{M}_{76} = \alpha_t \cdot \frac{EI}{h} \cdot \Delta t = 10^{-5} \cdot \frac{156\,250}{0{,}5} \cdot 28 = 87{,}50\ kNm$

Koeficijenti krutosti:

$$k_{15} = k_{26} = k_{37} = k_{48} = k_{69} = k_{7,10} = \frac{EI}{l} = \frac{156\,250}{2{,}85} = 54824{,}56\ kNm$$

$$k_{56} = k_{67} = k_{78} = k_{9,10} = \frac{EI}{l} = \frac{156\,250}{2{,}51} = 62250{,}00\ kNm$$

$$k_5 = k_{15} + k_{56} = 117074{,}56\ kNm$$

$$k_6 = k_{56} + k_{67} + k_{26} + k_{69} = 234149{,}12\ kNm$$

$$k_7 = k_{67} + k_{78} + k_{37} + k_{7,10} = 234149{,}12\ kNm$$

$$k_8 = k_{78} + k_{48} = 117074{,}56\ kNm$$

$$k_9 = k_{69} + k_{9,10} = 117074{,}56\ kNm$$

$$k_{10} = k_{9,10} + k_{7,10} = 117074{,}56\ kNm$$

Razdjelni koeficijenti:

Čvor 5:

$$\mu_{51} = \frac{k_{51}}{k_5} = \frac{54824{,}56}{117074{,}56} = 0{,}47$$

$$\mu_{56} = \frac{k_{56}}{k_5} = \frac{62250}{117074{,}56} = 0{,}53$$

Čvor 6:

$$\mu_{65} = \frac{k_{65}}{k_6} = \frac{62250}{234149{,}12} = 0{,}26$$

$$\mu_{67} = \frac{k_{67}}{k_6} = \frac{62250}{234149{,}12} = 0{,}26$$

$$\mu_{62} = \frac{k_{62}}{k_6} = \frac{54824{,}56}{234149{,}12} = 0{,}24$$

$$\mu_{69} = \frac{k_{69}}{k_6} = \frac{54824{,}56}{234149{,}12} = 0{,}24$$

Čvor 7:

$$\mu_{76} = \frac{k_{76}}{k_7} = \frac{62250}{234149{,}12} = 0{,}26$$

$$\mu_{78} = \frac{k_{78}}{k_7} = \frac{62250}{234149{,}12} = 0{,}26$$

$$\mu_{73} = \frac{k_{73}}{k_7} = \frac{54824{,}56}{234149{,}12} = 0{,}24$$

$$\mu_{7,10} = \frac{k_{7,10}}{k_7} = \frac{54824{,}56}{234149{,}12} = 0{,}24$$

Čvor 8:

$$\mu_{87} = \frac{k_{87}}{k_8} = \frac{62250}{117074{,}56} = 0{,}53$$

$$\mu_{84} = \frac{k_{84}}{k_8} = \frac{54824{,}56}{117074{,}56} = 0{,}47$$

Čvor 9:

$$\mu_{96} = \frac{k_{96}}{k_9} = \frac{54824{,}56}{117074{,}56} = 0{,}47$$

$$\mu_{9,10} = \frac{k_{9,10}}{k_9} = \frac{62250}{117074{,}56} = 0{,}53$$

Čvor 10:

$$\mu_{10,9} = \frac{k_{10,9}}{k_{10}} = \frac{62250}{117074{,}56} = 0{,}53$$

$$\mu_{10,7} = \frac{k_{10,7}}{k_{10}} = \frac{54824{,}56}{117074{,}56} = 0{,}47$$

Iteracija:

Čvor 6:
-9,7 - 87,5 = -97,2

+97,2 · 0,26 = 25,3
+97,2 · 0,26 = 25,3
+97,2 · 0,24 = 23,3
+97,2 · 0,24 = 23,3

Čvor 7:
87,5 + 12,6 + 9,7 = 109,8

-109,8 · 0,26 = -28,5
-109,8 · 0,26 = -28,5
-109,8 · 0,24 = -26,4
-109,8 · 0,24 = -26,4

Čvor 8:
-9,7 – 14,2 + 50,6 = 26,7

-26,7 · 0,53 = -14,2
-26,7 · 0,47 = -12,5

Čvor 10:
-45,5 – 13,2 = -58,7

+58,7 · 0,53 = +31,1
+58,7 · 0,47 = +27,6

Čvor 9:
11,6 + 15,6 + 45,5 = 72,7

-72,7 · 0,53 = -38,5
-72,7 · 0,47 = -34,2

Čvor 5:
-50,6 + 9,7 + 12,6 = -28,3

+28,3 · 0,53 = 15,0
+28,3 · 0,47 = 13,3

Čvor 6:
7,5 – 17,1 – 14,2 = -23,8

+23,8 · 0,26 = 6,2
+23,8 · 0,26 = 6,2
+23,8 · 0,24 = 5,7
+23,8 · 0,24 = 5,7

Čvor 7:
13,8 + 3,1 – 7,1 = 9,8

-9,8 · 0,26 = -2,5
-9,8 · 0,26 = -2,5
-9,8 · 0,24 = -2,4
-9,8 · 0,24 = -2,4

Čvor 8:
+1,2 · 0,53 = +0,6
+1,2 · 0,47 = +0,6

Čvor 10:
-19,3 – 1,2 = -20,5

+20,5 · 0,53 = +10,8
+20,5 · 0,47 = +9,7

Čvor 9:
2,8 + 5,4 = 8,2

-8,2 · 0,53 = -4,4
-8,2 · 0,47 = -3,8

Čvor 5:
-3,1 · 0,53 = -1,7
-3,1 · 0,47 = -1,4

Čvor 6:
-0,8 – 1,2 – 1,9 = -3,9

+3,9 · 0,26 = 1,0
+3,9 · 0,26 = 1,1
+3,9 · 0,24 = 0,9
+3,9 · 0,24 = 0,9

Čvor 7:
0,5 + 0,3 + 4,8 = 5,6

-5,6 · 0,26 = -1,5
-5,6 · 0,26 = -1,5
-5,6 · 0,24 = -1,3
-5,6 · 0,24 = -1,3

Čvor 8:
+0,8 · 0,53 = 0,4
+0,8 · 0,47 = 0,4

Čvor 10:
-2,2 - 0,6 = -2,8

+2,8 · 0,53 = 1,5
+2,8 · 0,47 = 1,3

Čvor 9:
0,5 + 0,7 = 1,2

-1,2 · 0,53 = -0,6
-1,2 · 0,47 = -0,6

Čvor 5:
-0,5 · 0,53 = -0,3
-0,5 · 0,47 = -0,2

Čvor 6:
-0,1 - 0,8 – 0,3 = -1,2

+1,2 · 0,26 = 0,3
+1,2 · 0,26 = 0,3
+1,2 · 0,24 = 0,3
+1,2 · 0,24 = 0,3

Čvor 7:
0,1 + 0,2 + 0,7 = 1,0

-1,0 · 0,26 = -0,3
-1,0 · 0,26 = -0,3
-1,0 · 0,24 = -0,2
-1,0 · 0,24 = -0,2

Čvor 10:
-0,3 - 0,1 = -0,4

+0,4 · 0,53 = 0,2
+0,4 · 0,47 = 0,2

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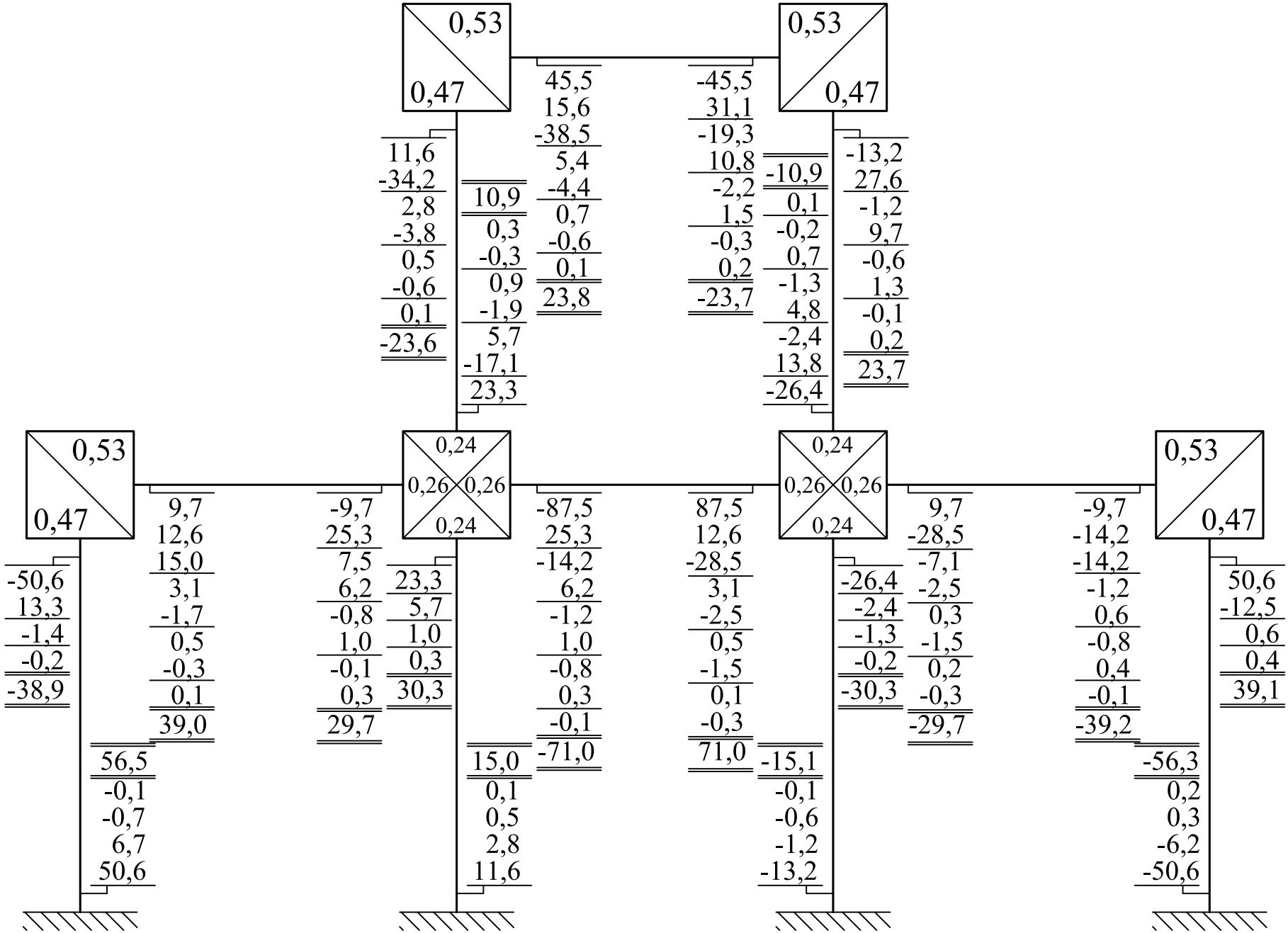

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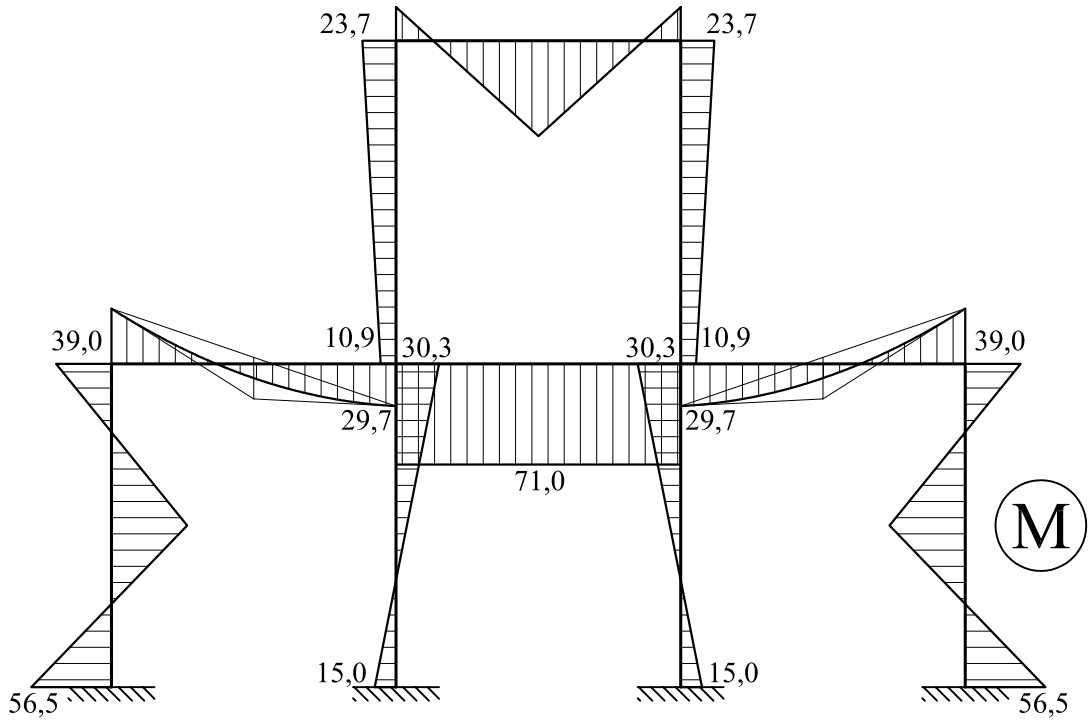

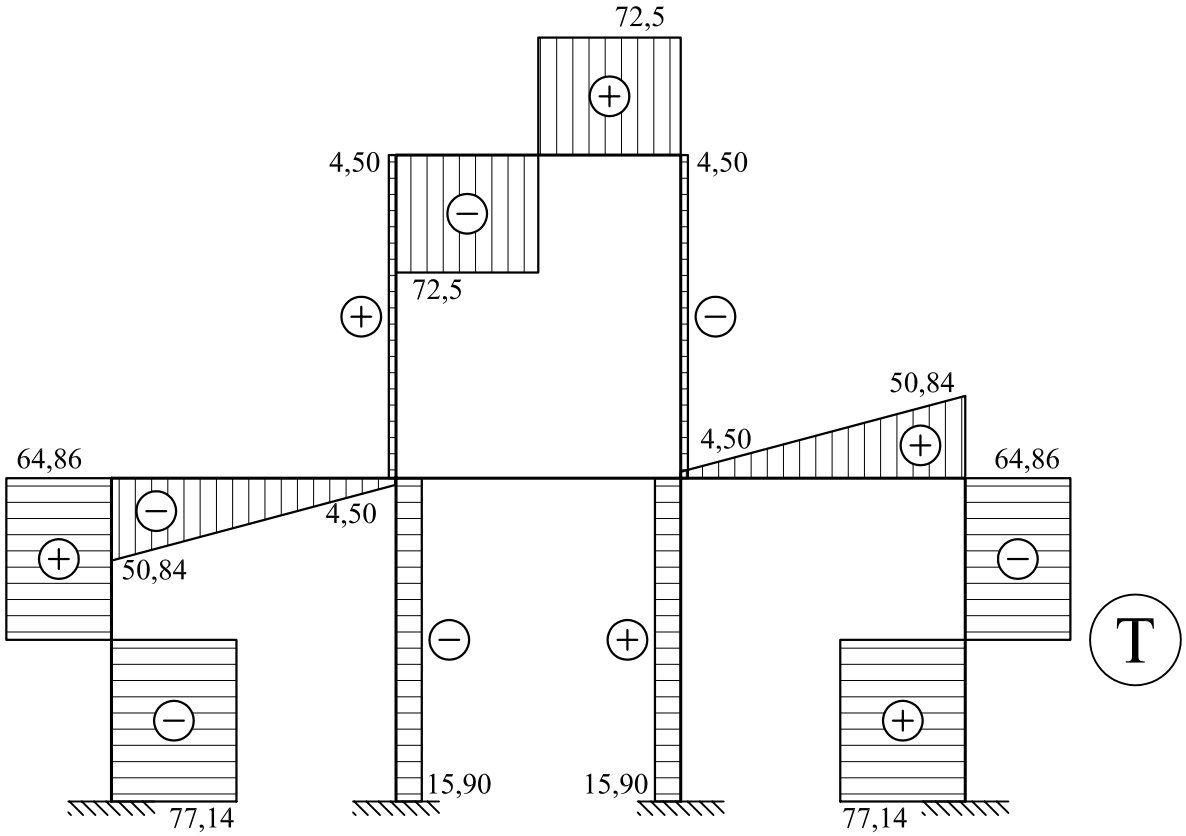

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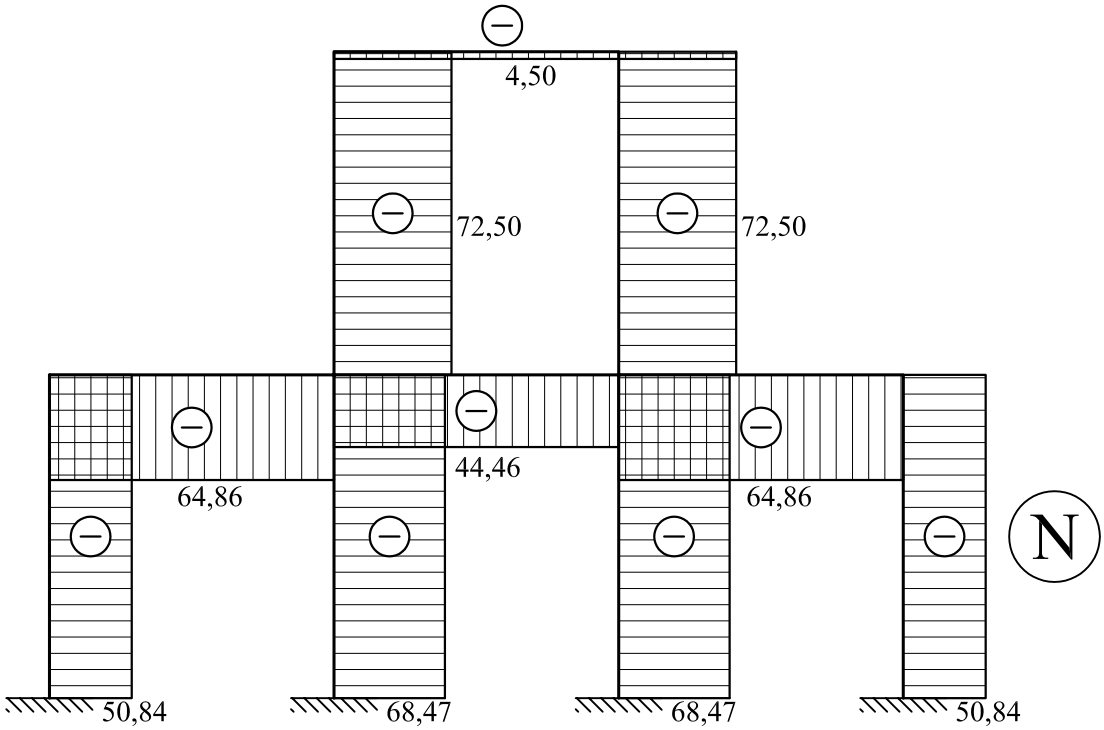

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Statička analiza:

Nodal displacements:

nd	u_i	v_i	phi_i
1:	0	0	0
2:	0	0	0
3:	0	0	0
4:	0	0	0
5:	2.85195e-05	-1.92079e-05	4.19687e-05
6:	7.15233e-06	-2.60828e-05	0.000135368
7:	-7.15233e-06	-2.60828e-05	-0.000135368
8:	-2.85195e-05	-1.92079e-05	-4.19687e-05
9:	8.19853e-07	-5.36328e-05	-0.000173373
10:	-8.19853e-07	-5.36328e-05	0.000173373

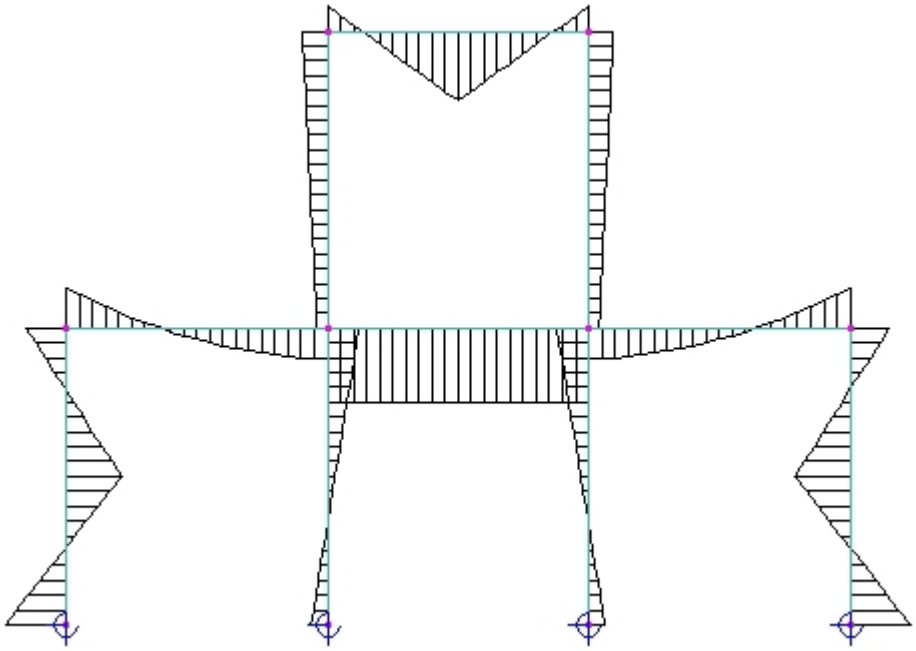
Element end forces:

el	N_ij	T_ij	M_ij	N_ji	T_ji	M_ji
1:	50.5471	78.154	58.481	-50.5471	63.846	-38.0921
2:	68.6389	16.2035	15.6685	-68.6389	-16.2035	30.5114
3:	68.6389	-16.2035	-15.6685	-68.6389	16.2035	-30.5114
4:	50.5471	-78.154	-58.481	-50.5471	-63.846	38.0921
5:	63.846	50.5471	38.0921	-63.846	-3.8611	30.1902
6:	42.743	0	-70.6464	-42.743	0	70.6464
7:	63.846	-3.8611	-30.1902	-63.846	50.5471	-38.0921
8:	72.5	-4.89952	9.94478	-72.5	4.89952	-23.9084
9:	72.5	4.89952	-9.94478	-72.5	-4.89952	23.9084
10:	4.89952	72.5	23.9084	-4.89952	72.5	-23.9084

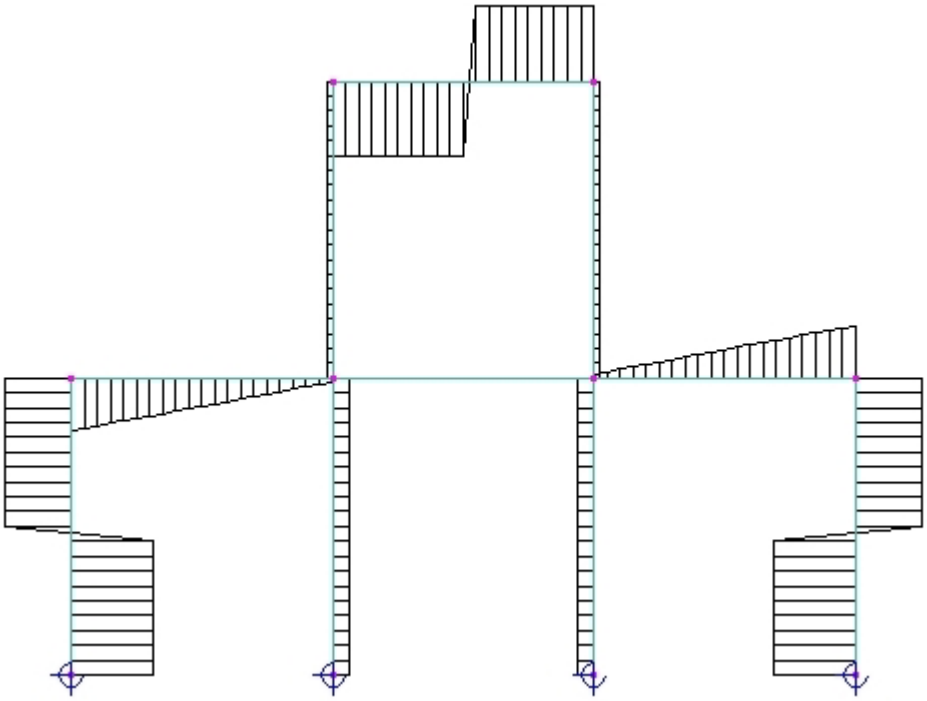
Reactions:

nd	R_x	R_y	M
1:	-78.154	50.5471	58.481
2:	-16.2035	68.6389	15.6685
3:	16.2035	68.6389	-15.6685
4:	78.154	50.5471	-58.481

M - dijagram



T - dijagram



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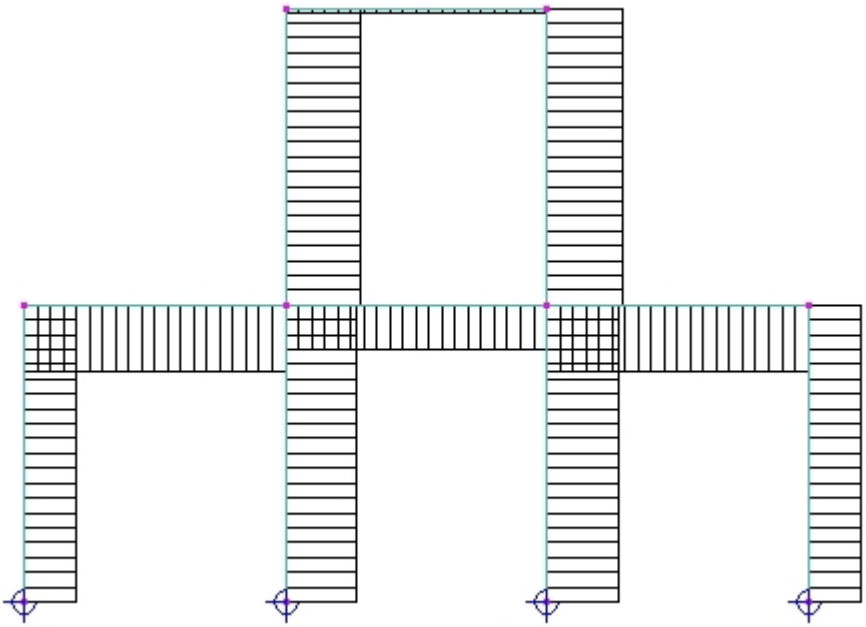
N – dijagram



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