СТАТИКА КОНСТРУКЦИЈА 2 17.02.2004.

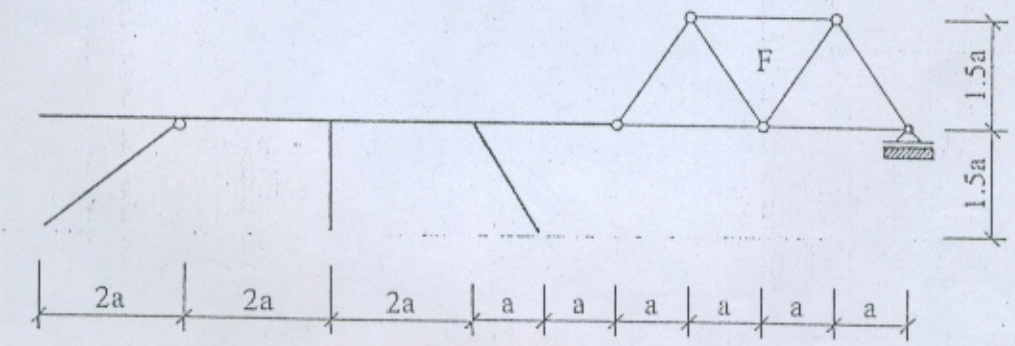
ПРВИ ГРАФИЧКИ РАД

Име и презиме, број индекса: Иван Гркајац 49/01

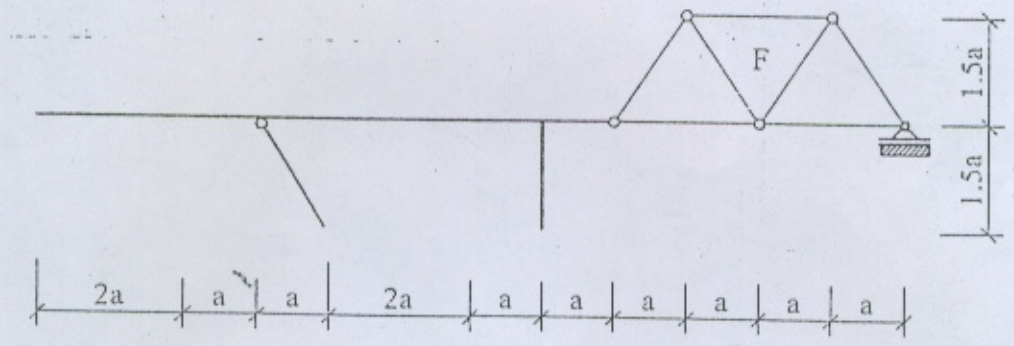
За задати носач:

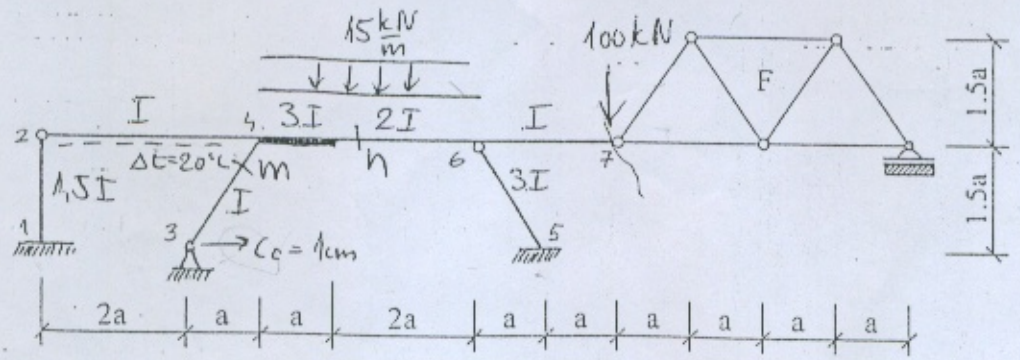
1. а) одредити статичку неодређеност,
   б) срачунати елементе матрице флексибилности δ_{ij}
2. а) срачунати коефицијенте $\delta_{i\omega}$ услед задатог оптерећења и утицаја,
   б) одредити статички неодређене величине,
   в) нацртати дијаграм момената савијања, као и дијаграм трансверзалних сила на означеним штаповима,
3. а) услед задатог оптерећења и утицаја одредити задато генерализано померање, $\sqrt{5}_h$
   б) нацртати утицајну линију за задату статичку величину, T_h
   в) нацртати утицајну линију за задато генерализано померање.

ЗАНЕМАРИТИ УТИЦАЈ НОРМАЛНИХ СИЛА НА ДЕФОРМАЦИЈУ НА ПУНОМ ДЕЛУ НОСАЧА.



I/F=1-за просте штапове
$EI=10^5$ kNm^2
$\alpha_t=10^{-5}$ 1/°C
h=1 m
a= 2 m





(+) 24.5.2004.
В. Радић

Задатак задао Жеравчари К.

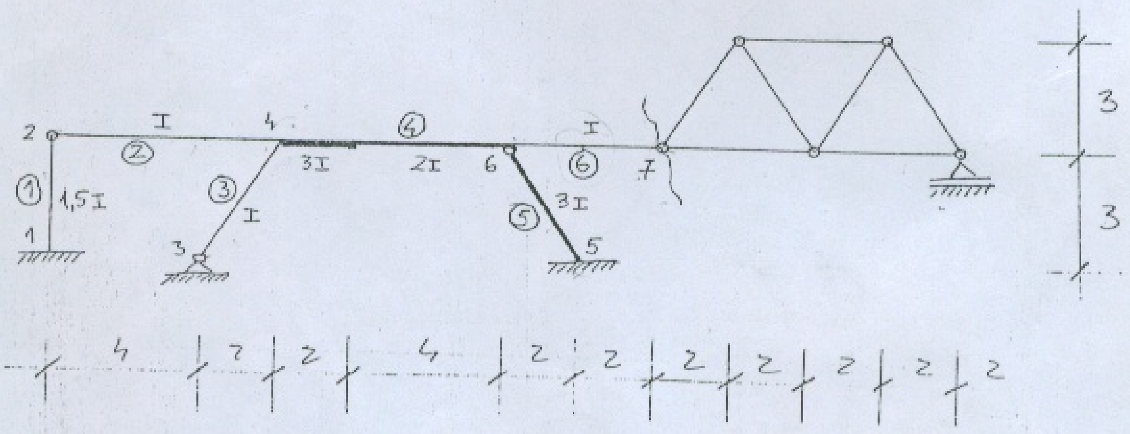
①

а) ОДРЕЂИВАЊЕ СТАТИЧКЕ НЕОДРЕЂЕНОСТИ:

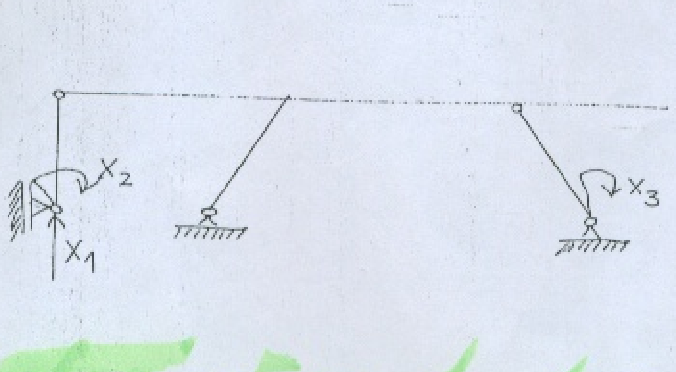
- БРОЈ ОСЛОНАЦА .... $z_o = 6$
- БРОЈ УКЉЕШТЕЊА .... $z_u = 2$
- БРОЈ КРУТИХ УГЛОВА .... $z_k = 3$
- БРОЈ ШТАПОВА .... $z_s = 6$
- БРОЈ ЧВОРОВА .... $K = 7$

$$n = z_o + z_u + z_k + z_s - 2K = 6 + 2 + 3 + 6 - 2 \cdot 7 \Rightarrow$$

$$\Rightarrow \boxed{n = 3}$$

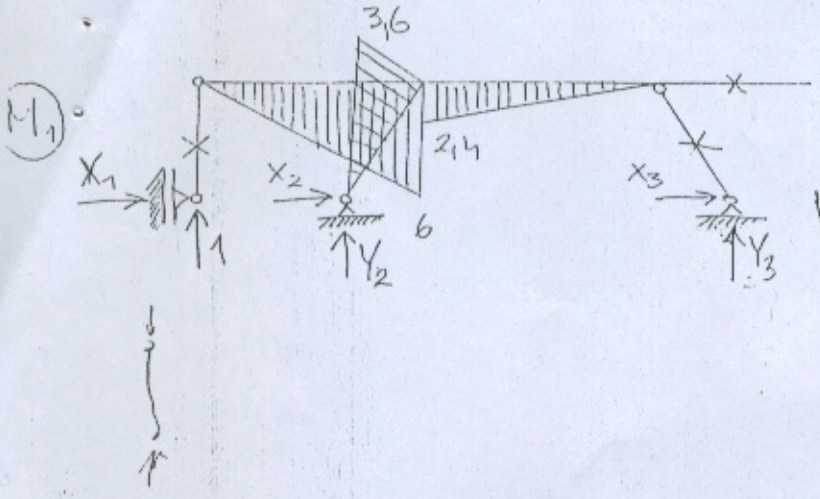


- ОСНОВНИ СИСТЕМ



114/02

Петровић Немања



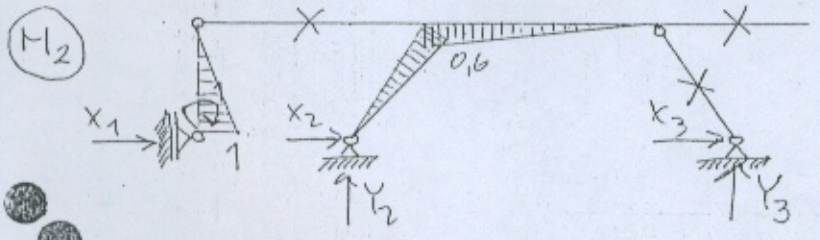
$X_1 = 0 \quad X_2 + X_3 = 0 \Rightarrow \boxed{X_2 = 0,}$

$Y_2 + Y_3 + 1 = 0 \Rightarrow \boxed{Y_3 = 0,4}$

$1 \cdot 1,4 + Y_2 \cdot 10 = 0 \Rightarrow \boxed{Y_2 = -1,}$

$-Y_3 \cdot 1 - X_3 \cdot 3 = 0$

$-0,8 = 3X_3 \Rightarrow \boxed{X_3 = -0,26}$



$\boxed{X_1 = \frac{1}{3}}$

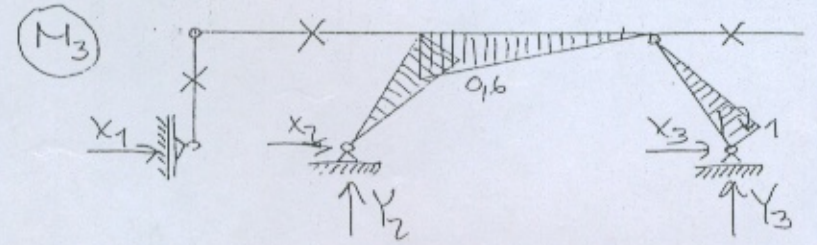
$X_2 + X_3 + \frac{1}{3} = 0 \Rightarrow \boxed{X_2 = \frac{4}{15}}$

$Y_2 + Y_3 = 0 \Rightarrow \boxed{Y_3 = \frac{1}{10}}$

$Y_2 \cdot 10 + \frac{1}{3} \cdot 3 = 0 \Rightarrow \boxed{Y_2 = -\frac{1}{10}}$

$-Y_3 \cdot 2 - X_3 \cdot 3 = 0 \Rightarrow$

$\Rightarrow \boxed{X_3 = -\frac{1}{15}}$



$\boxed{X_1 = 0}$

$X_2 + X_3 = 0 \Rightarrow \boxed{X_2 = -0,26}$

$Y_2 + Y_3 = 0 \Rightarrow \boxed{Y_3 = \frac{1}{10}}$

$Y_2 \cdot 10 + 1 = 0 \Rightarrow \boxed{Y_2 = -\frac{1}{10}}$

$-Y_3 \cdot 2 - X_3 \cdot 3 + 1 = 0 \Rightarrow$

$\Rightarrow \boxed{X_3 = 0,26}$

$\delta_{ij} = \int_S \frac{M_i M_j}{EI} ds \Rightarrow \delta_{ij} EI_c = \frac{I_c}{I} \int M_i M_j ds \qquad I_c = I$

$\delta_{11} EI_c = \frac{I_c}{I} \int_S M_1^2 ds = \frac{6}{3} 6^2 + \frac{\sqrt{13}}{3} 3,6^2 + \frac{1}{2} \frac{4}{3} 1,6^2 + \frac{1}{3} \frac{2}{3} (1,6^2 + 1,6 \cdot 2,4 + 2,4^2) \Rightarrow$

$\boxed{\delta_{11} EI_c = 31,98}$

$\delta_{22} EI_c = \frac{I_c}{I} \int M_2^2 ds = \frac{1}{1,5} \frac{3}{3} 1^2 + \frac{\sqrt{13}}{3} 0,6^2 + \frac{1}{2} \frac{4}{3} 0,4^2 + \frac{1}{3} \cdot \frac{2}{3} (0,4^2 + 0,4 \cdot 0,6 + 0,6^2) =$

$\boxed{\delta_{22} EI_c = 1,37}$

$\delta_{33} EI_c = \frac{I_c}{I} \int M_3^2 ds = \frac{1}{3} \frac{\sqrt{13}}{3} 1^2 + \frac{\sqrt{13}}{3} 0,6^2 + \frac{1}{2} \frac{4}{3} 0,4^2 + \frac{1}{3} \frac{2}{3} (0,4^2 + 0,4 \cdot 0,6 + 0,6^2) =$

$\boxed{\delta_{33} EI_c = 1,11}$

$\delta_{12} EI_c = \frac{I_c}{I} \int M_1 M_2 ds = -\frac{\sqrt{13}}{3} 3,6 \cdot 0,6 + \frac{1}{2} \frac{4}{3} 1,6 \cdot 0,4 + \frac{1}{3} \frac{2}{6} [1,6(2 \cdot 0,4 + 0,6) + 2,4(2 \cdot 0,6$

$\boxed{\delta_{12} EI_c = -1,50}$

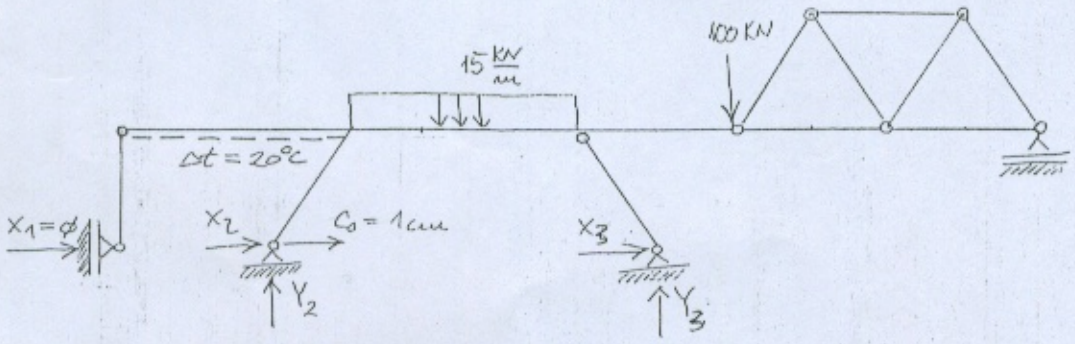
$\delta_{13} EI_c = \frac{I_c}{I} \int M_1 M_3 ds = -\frac{\sqrt{13}}{3} 3,6 \cdot 0,6 + \frac{1}{2} \frac{4}{3} 0,4^2 + \frac{1}{3} \frac{2}{3} (0,4^2 + 0,4 \cdot 0,6 + 0,6^2) \Rightarrow$

$\boxed{\delta_{13} EI_c = -2,32}$

$\delta_{23} EI_c = 0,71$

$$\mathbb{D} = \begin{bmatrix} 91,98 & -1,50 & -2,32 \\ -1,50 & 1,37 & 0,71 \\ -2,32 & 0,71 & 1,11 \end{bmatrix} \frac{1}{EI}$$

(2.)



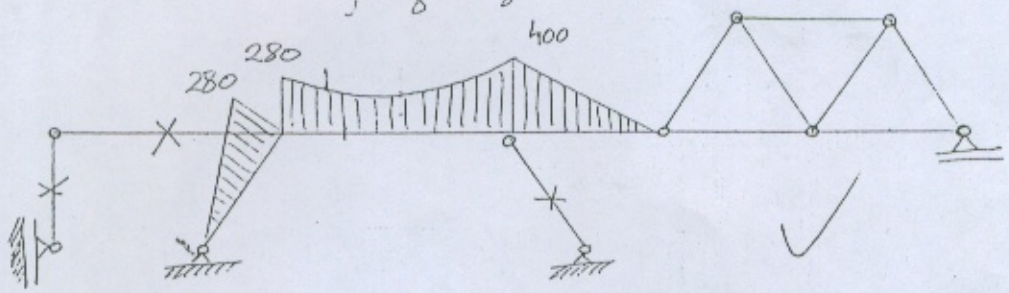
$X_2 + X_3 = 0 \Rightarrow \boxed{X_2 = 110}$

$Y_2 + Y_3 - 100 - 90 = 0 \Rightarrow \boxed{Y_2 = 25}$

$-Y_3 \cdot 10 + 90 \cdot 5 + 100 \cdot 12 = 0 \Rightarrow \boxed{Y_3 = 165}$

$-X_3 \cdot 3 - Y_3 \cdot 2 = 0 \Rightarrow X_3 = -\frac{2}{3} Y_3 \Rightarrow \boxed{X_3 = -110}$

$f = \frac{ql^2}{8} = \frac{15 \cdot 6^2}{8} = 67{,}5$



M_0

$\delta_{i\phi} = \delta_{i0} + \delta_{it} + \delta_{ic}$

$EI_c \delta_{10} = \frac{I_c}{I} \int M_1 M_0 ds = \frac{\sqrt{13}}{3} 3{,}6 \cdot 280 - \frac{1}{2}\left(\frac{4}{3} 1{,}6 (230 + 400) - \frac{4}{3} 30 \cdot 1{,}6\right) -$

$- \frac{1}{3}\left(\frac{2}{6}\left[2{,}4(280 \cdot 2 + 230) + 1{,}6(2 \cdot 230 + 280)\right] - \frac{2}{3} 7{,}5 \cdot (1{,}6 + 2{,}4)\right) = 209{,}24$

$EI_c \delta_{20} = \frac{I_c}{I} \int M_2 M_0 ds = -\frac{\sqrt{13}}{3} \cdot 0{,}6 \cdot 280 - \frac{1}{2}\left(\frac{4}{3} 0{,}4 (230 + 400) - \frac{4}{3} 30 \cdot 0{,}\right.$

$\left. - \frac{1}{3}\left(\frac{2}{6}\left[0{,}6(2 \cdot 280 + 230) + 0{,}4(2 \cdot 230 + 280)\right] - \frac{2}{3} 7{,}5 (0{,}6 + 0{,}4)\right)\right) =$

$= -553{,}36$

$EI_c \delta_{30} = EI_c \delta_{10} = -553{,}36$

$24 \cdot 0^2 \; 200^4 \cdot$ OK

(40%)

$$EI_c \delta_{2t} = EI_c \int M_2 \alpha_t \frac{\Delta t}{h_c} ds = 10^5 \cdot 10^{-5} \frac{15}{1} \cdot 2 = 270$$

$$EI_c \delta_{3t} = EI_c \int M_3 \alpha_t \frac{\Delta t}{h_c} ds = 10^5 \cdot 10^{-5} \frac{15}{1} \cdot 0 = 0$$

$$EI_c \delta_{1c} = -\sum_j c_{j1} c_j = -10^5 \cdot 0{,}01 \cdot 0{,}26 = -266{,}6$$

$$EI_c \delta_{2c} = -\sum_j c_{j2} c_j = -10^5 \cdot 0{,}01 \cdot 0{,}26 = -266{,}6$$

$$EI_c \delta_{3c} = -\sum_j c_{j3} c_j = -10^5 \cdot 0{,}01 \cdot (-0{,}26) = 266{,}6$$

$$\delta_{1\phi} = 209{,}24 + 270 - 266{,}6 = 212{,}58$$

$$\delta_{2\phi} = -553{,}36 + 0 - 266{,}6 = -820{,}02$$

$$\delta_{3\phi} = -553{,}36 + 0 + 266{,}6 = -286{,}7$$

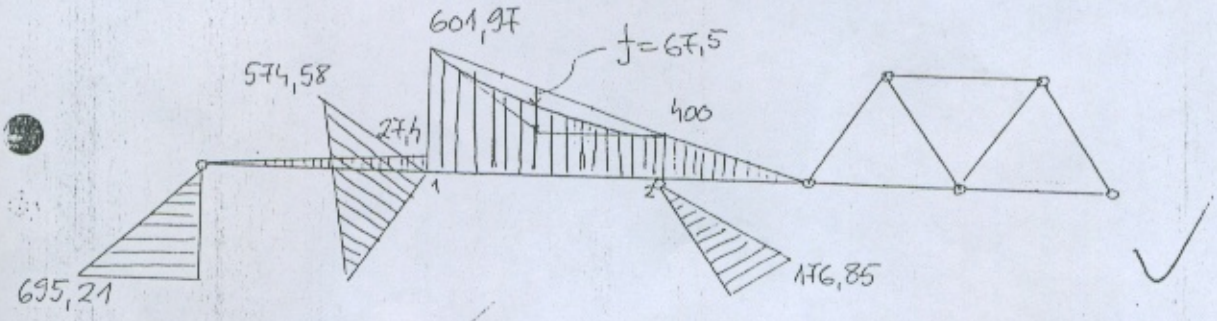
$$\begin{bmatrix} 91{,}98 & -1{,}50 & -2{,}32 \\ -1{,}50 & 1{,}37 & 0{,}71 \\ -2{,}32 & 0{,}71 & 1{,}11 \end{bmatrix} \cdot 10^{-5} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} 212{,}58 \\ -820{,}02 \\ -286{,}7 \end{bmatrix} = 0$$

$$X_1 = -4{,}566$$

$$X_2 = -695{,}206$$

$$X_3 = 176{,}851$$

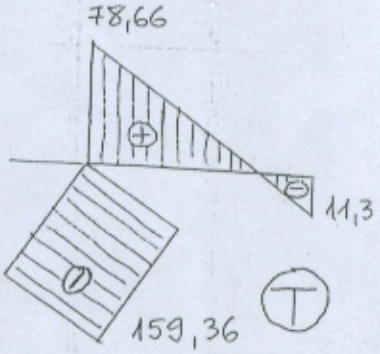
$$M = M_0 + M_1 X_1 + M_2 X_2 + M_3 X_3$$



$$T_{M1} = \frac{-400 + 601{,}97}{6} + \frac{15 \cdot 6}{2} = 78{,}66$$

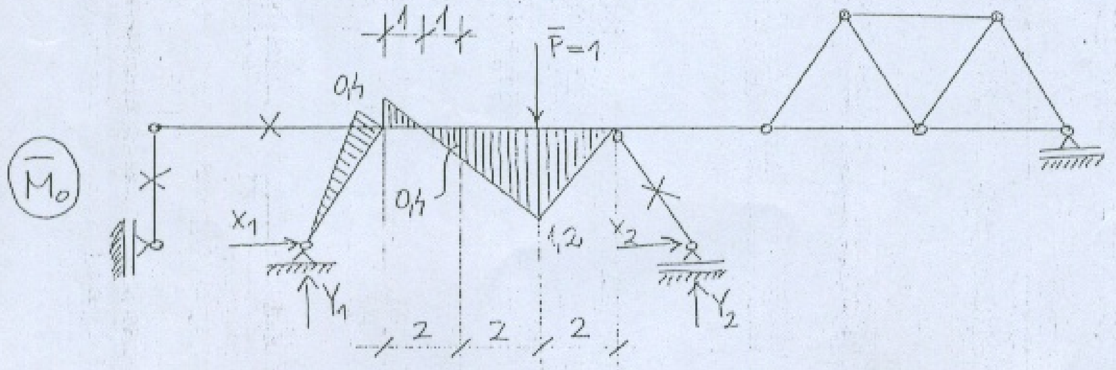
$$T_{M2} = \frac{-400 + 601{,}97}{6} - \frac{15 \cdot 6}{2} = -11{,}34$$

$$T_M = \frac{-574{,}58 + 0}{\sqrt{13}} = -159{,}36$$



(5.)

a) $\vartheta_u = \int \frac{M\bar{M}_0}{EI}ds + \int \frac{N\bar{N}_0}{EF}ds + \int M_0\,\alpha_t \frac{\Delta t}{h}ds + \int \bar{N}_0\,\alpha_t\, t^0 ds - \sum_j \bar{C}_{j0}\, c_j$



$X_1 + X_2 = 0 \Rightarrow \boxed{X_1 = 0{,}4}$

$Y_1 + Y_2 - 1 = 0 \Rightarrow \boxed{Y_2 = 0{,}6}$

$Y_1 \cdot 10 - 1\cdot 4 = 0 \Rightarrow \boxed{Y_1 = 0{,}4}$

$-Y_2 \cdot 2 - X_2 \cdot 3 = 0 \Rightarrow \boxed{X_2 = -0{,}4}$

$$EI_c\vartheta_u = \frac{I_c}{I}\int M\bar{M}_0 ds - \sum_j \bar{C}_{j0} c_j EI_c = \frac{\sqrt{13}}{3}574{,}58\cdot 0{,}4 + \frac{1}{3}\Big(\frac{2}{6}\big[0{,}4(2\cdot 601{,}97 + 474{,}64) - 0{,}4(2\cdot 474{,}64 + 601{,}97)\big] - \frac{2}{3}7{,}5\,(0{,}4-0{,}4)\Big) +$$
$$+ \frac{1}{2}\Big(\frac{2}{6}\big[-0{,}4(2\cdot 474{,}64 + 392{,}32) - 1{,}2(2\cdot 392{,}32 + 474{,}64)\big] -$$
$$- \frac{2}{3}7{,}5(-0{,}4-1{,}2)\Big) + \frac{1}{2}\Big(\frac{2}{6}\big[-1{,}2(2\cdot 392{,}32 + 400) + 0\big] -$$
$$- \frac{2}{3}7{,}5(-1{,}2)\Big) - 10^5\cdot 0{,}4\cdot 0{,}01 = -778{,}72$$

б)

$$EI_c\delta_{10} = \frac{\sqrt{13}}{3}3{,}6\cdot 0{,}4 + \frac{1}{3}\Big(\frac{2}{6}\big(2{,}4(2\cdot(-0{,}4)+0{,}4) + 1{,}6\cdot(2\cdot 0{,}4 - 0{,}4)\big)\Big) +$$
$$+ \frac{1}{2}\frac{2}{6}\big(1{,}6(2\cdot 0{,}4 + 1{,}2) + 0{,}8(2\cdot 1{,}2 + 0{,}4)\big) + \frac{1}{2}\frac{2}{3}0{,}8\cdot 1{,}2 =$$
$$= 2{,}92$$

$$EI_c\delta_{20} = EI_c\delta_{30} = -\frac{\sqrt{13}}{3}0{,}6\cdot 0{,}4 + \frac{1}{3}\frac{2}{6}\big(0{,}6(2\cdot(-0{,}4)+0{,}4) + 0{,}4(2\cdot 0{,}4 - 0{,}4\big)$$
$$+ \frac{1}{2}\frac{2}{6}\big(0{,}4(2\cdot 0{,}4 + 1{,}2) + 0{,}2(2\cdot 1{,}2 + 0{,}4)\big) + \frac{1}{2}\frac{2}{3}0{,}2\cdot 1{,}2 =$$
$$= 0{,}00934$$

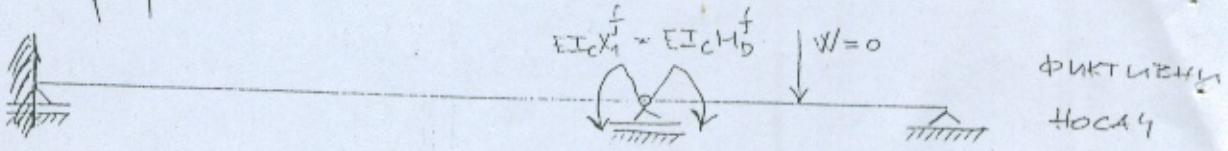
$EI_c\delta_{1\phi} = 2{,}92 - 266{,}\dot{6} + 270 = 6{,}32$

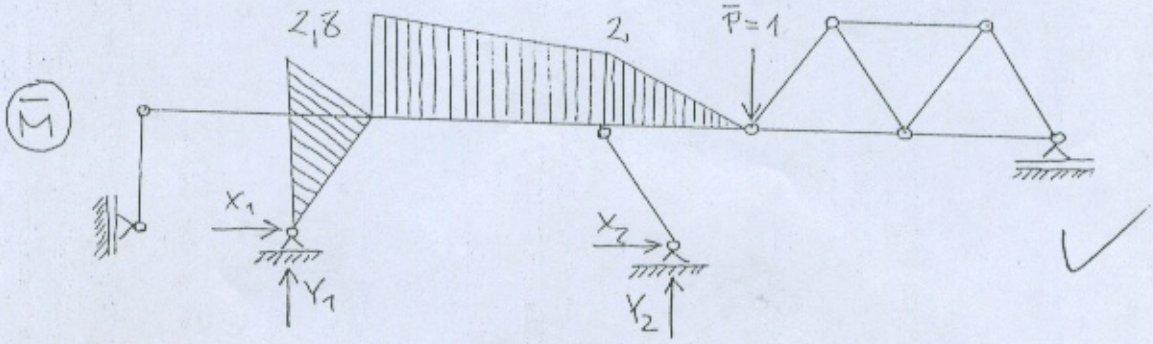
$EI_c\delta_{2\phi} = 0{,}00934 - 266{,}\dot{6} = -266{,}59$

$EI_c\delta_{3\phi} = 0{,}00934 + 266{,}6 = 266{,}61$

$\delta_{11} = \delta_{10} + \delta_{11} X_1 + \delta_{12} X_2 + \delta_{13} X_3$

popravi





$X_1 + X_2 = 0 \Rightarrow \boxed{X_1 = 0{,}8}$

$Y_1 + Y_2 - 1 = 0 \Rightarrow \boxed{Y_2 = 1{,}2}$

$-2Y_2 - X_2 \cdot 3 = 0 \Rightarrow \boxed{X_2 = -0{,}8}$

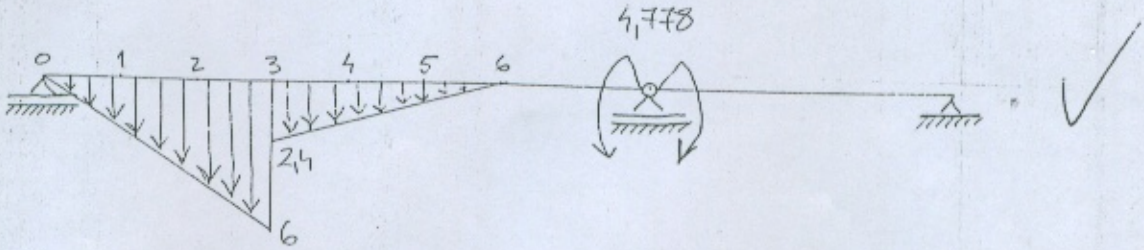
$Y_1 \cdot 10 + 1 \cdot 2 = 0 \Rightarrow \boxed{Y_1 = -0{,}2}$

$$EI_c M_D^f = \frac{I_c}{I} \int M_1 \bar{M} ds = \frac{\sqrt{13}}{3} 2{,}8 \cdot 3{,}6 - \left(\frac{2}{6} \left[2{,}8 \left(2 \cdot 2{,}4 + 1{,}6 \right) + 2{,}5\dot{3} \left(2 \cdot 1{,}6 + 2{,}4 \right) \right] \frac{1}{3} + \frac{4}{6} \left[1{,}6 \left(2 \cdot 2{,}5\dot{3} + 2 \right) + 0 \right] \frac{1}{2} \right) = 4{,}778 \quad (\text{за } X_1 = 1)$$

$$EI_c M_D^f = \frac{I_c}{I} \int M_2 \bar{M} ds = -\frac{\sqrt{13}}{3} 0{,}6 \cdot 2{,}8 - \left(\frac{2}{6} \left[2{,}8 \left(2 \cdot 0{,}6 + 0{,}4 \right) + 2{,}5\dot{3} \left(2 \cdot 0{,}4 + 0{,}6 \right) \right] \frac{1}{3} + \frac{4}{6} \left[0{,}4 \left(2 \cdot 2{,}5\dot{3} + 2 \right) + 0 \right] \frac{1}{2} \right) = -3{,}853 \quad (\text{за } X_2 =$$

$$EI_c M_D^f = \frac{I_c}{I} \int M_3 \bar{M} ds = -3{,}853 \quad (\text{за } X_3 = 1)$$

СТАНЕ $X_1 = 1$



$P_0 = \frac{2}{6}(2 \cdot 0 + 2) = 0{,}6$

$P_1 = \frac{2}{6}(0 + 4 \cdot 2 + 4) = 4$

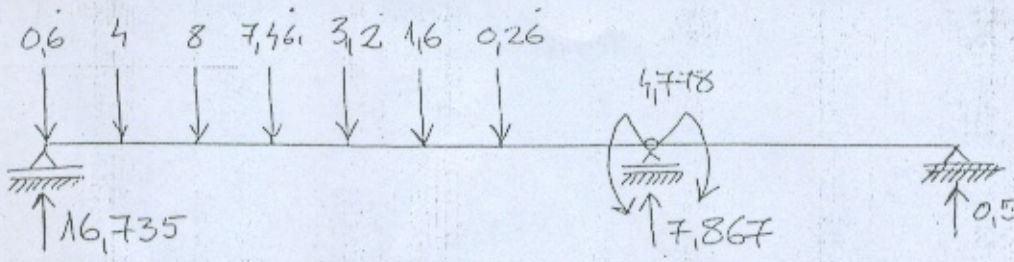
$P_2 = \frac{2}{6}(2 + 4 \cdot 4 + 6) = 8$

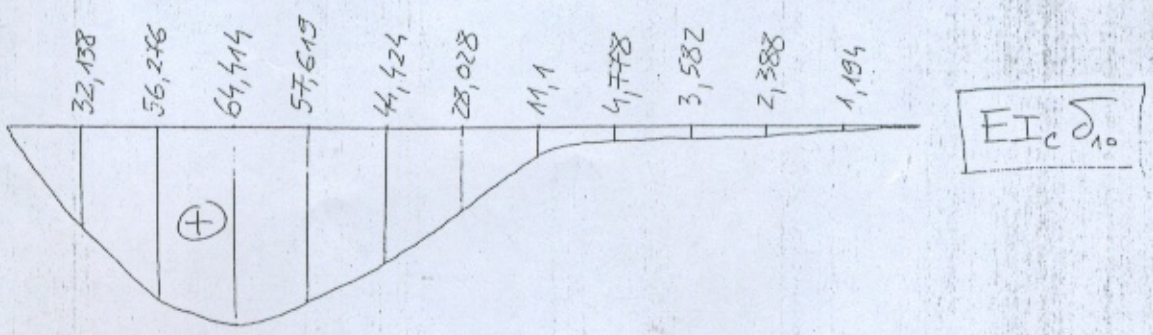
$P_3 = \frac{2}{6}(4 + 2 \cdot 6) + \frac{2}{6}(2 \cdot 2{,}4 + 1{,}6) = 7{,}46$

$P_4 = \frac{2}{6}(2{,}4 + 4 \cdot 1{,}6 + 0{,}8) = 2{,}$

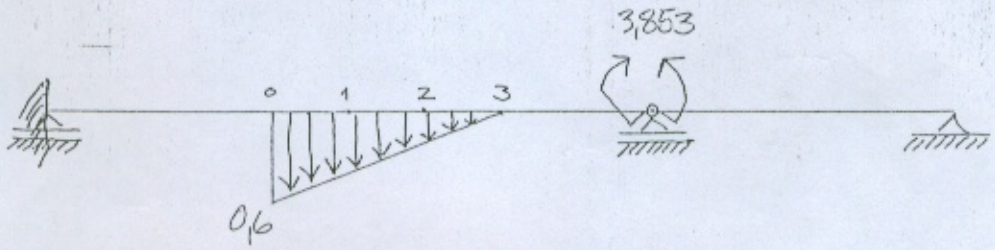
$P_5 = \frac{2}{6}(1{,}6 + 4 \cdot 0{,}8 + 0) = 1{,}$

$P_6 = \frac{2}{6}(0{,}8 + 0) = 0{,}26$





СТАВЕ $X_2 = 1$ и $X_3 = 1$

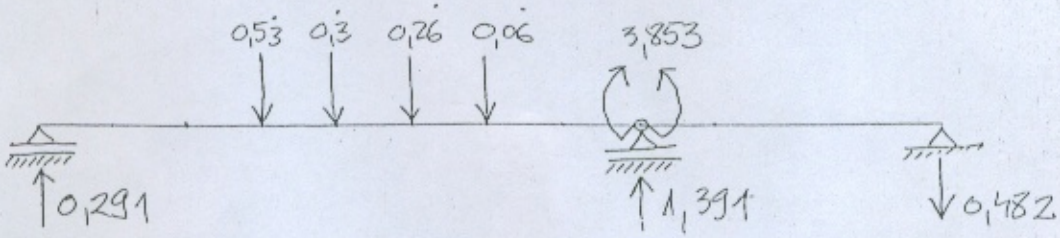


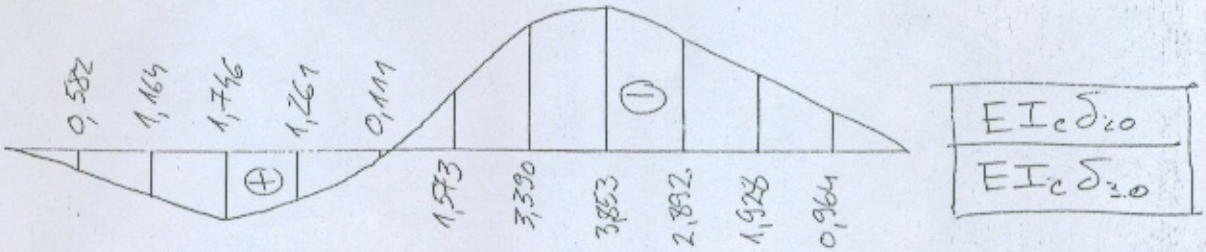
$$P_0 = \frac{2}{6}(2 \cdot 0{,}6 + 0{,}4) = 0{,}5\dot{3}$$

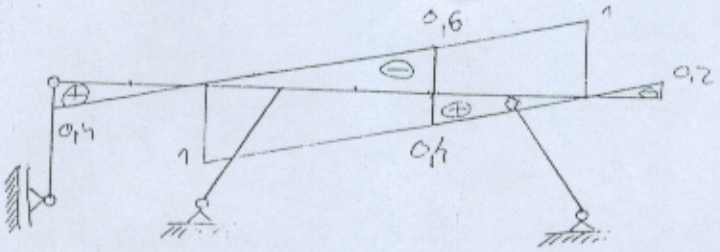
$$P_1 = \frac{2}{6}(0 + 2 \cdot 0{,}4 + 0{,}2) = 0{,}\dot{3}$$

$$P_2 = \frac{2}{6}(0{,}4 + 2 \cdot 0{,}2 + 0) = 0{,}2\dot{6}$$

$$P_3 = \frac{2}{6}(0{,}2 + 0) = 0{,}0\dot{6}$$







T_{M0}

$T_{M1} = -0,4 \quad T_{M2} = -0,1 \quad T_{M3} = -0,1$

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = -\begin{bmatrix} 0,0148 & 0,000295 & 0,0239 \\ 0,000295 & 1,692 & -0,698 \\ 0,0239 & -0,698 & 1,397 \end{bmatrix} \begin{bmatrix} EI_c\delta_{10} = \delta_{10}^* \\ EI_c\delta_{20} = \delta_{20}^* \\ EI_c\delta_{30} = \delta_{30}^* \end{bmatrix}$$

$$T_M = T_{M0} - 0,4\left(-0,0148\,\delta_{10}^* - 0,000295\,\delta_{20}^* - 0,0239\,\delta_{30}^*\right) -$$
$$- 0,1\left(-0,000295\,\delta_{10}^* - 1,092\,\delta_{20}^* + 0,698\,\delta_{30}^*\right) -$$
$$- 0,1\left(-0,0239\,\delta_{10}^* + 0,698\,\delta_{20}^* - 1,397\,\delta_{30}^*\right)$$

$$\boxed{T_{M_i} = T_{M0} + 0,00834\,\delta_{10}^* + 0,040\,\delta_{20}^* + 0,795\,\delta_{30}^*}$$

i	0	1	2	3	4	5	6	7	8
T_{M0}	0,4	0,2	0	-0,2	-0,4	-0,6	0,2	0	-0,2
δ_{10}^*	0	32,138	56,276	64,414	57,619	44,424	28,028	11,1	4,778
δ_{20}^*	0	0,582	1,164	1,746	1,261	0,111	-1,573	-3,390	-3,853
δ_{30}^*	0	0,582	1,164	1,746	1,261	0,111	-1,573	-3,390	-3,853
T_M	0,4	0,954	1,441	1,795	1,133	-0,137	-0,880	-2,738	-3,377

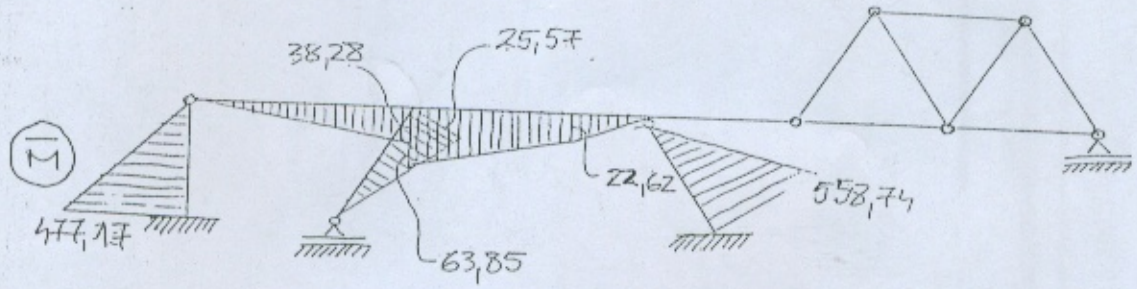
$$\begin{bmatrix} -1,5 & 1,37 & 0,71 \\ -2,32 & 0,71 & 1,11 \end{bmatrix} \begin{bmatrix} \bar{X}_1 \\ \bar{X}_2 \\ \bar{X}_3 \end{bmatrix} = \begin{bmatrix} \\ -266,59 \\ 266,61 \end{bmatrix}$$

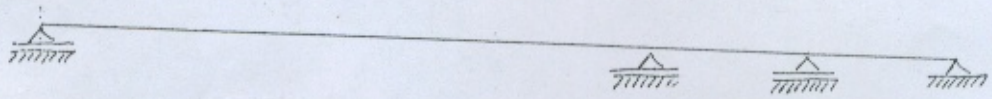
$\bar{X}_1 = 6,38$

$\bar{X}_2 = -477,17$

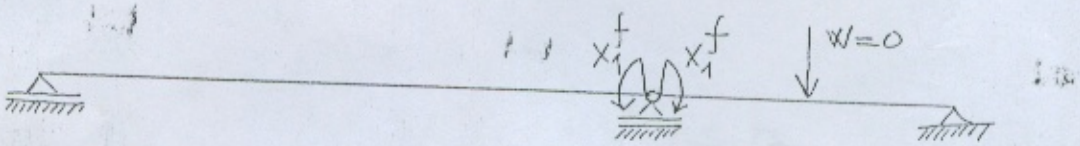
$\bar{X}_3 = 558,74$

$$\bar{M} = \bar{M}_0 + M_1\bar{X}_1 + M_2\bar{X}_2 + M_3\bar{X}_3$$

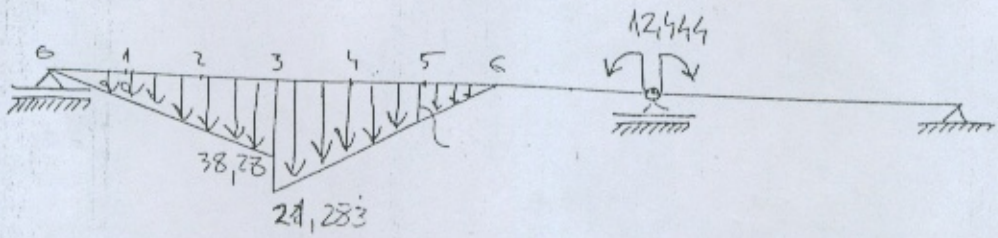


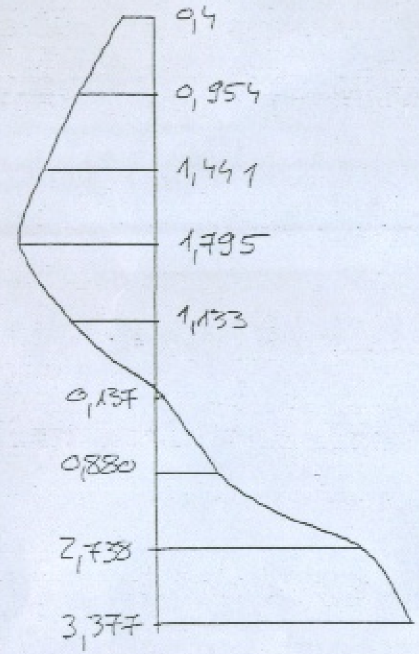


ФИКТИВНИ НОСАЧ



$$X_1^f = \frac{I_c}{I}\int \bar{M}_0\bar{M}\,ds = -\frac{\sqrt{13}}{3}25,57\cdot 0,7 + \frac{1}{3}\frac{2}{6}\left[0,4\left(2\cdot(-63,85)-43,235\right)\right.$$
$$+(-0,4)\left(2\cdot(-43,235)-63,85\right)] + \frac{1}{3}\frac{2}{6}\left[-0,4\left(2\cdot(-43,235)-22,62\right)\right.$$
$$+(-1,2)\left(2\cdot(-22,62)-43,235\right)] + \frac{1}{2}\frac{2}{6}\left[-1,2\left(2\cdot(-22,62)+0\right)\right]$$
$$= 12,444$$





Tu

Popravi!