12

СТАТИКА КОНСТРУКЦИЈА 1

Модул: Конструкције

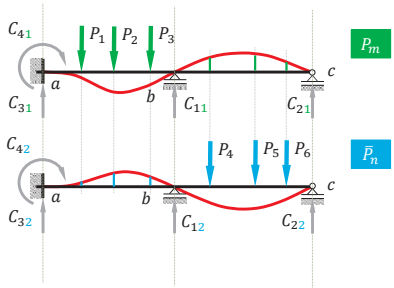
– материјал за вежбе –

2024.

Теореме о узајамности

20 Betti – јева теорема

$$\sum P_m \bar{\delta}_m + \sum C_i \bar{c}_i = \sum \bar{P}_n \delta_n + \sum \bar{C}_i c_i$$



Рад спољашњих сила P_m и C_i **првог** система при померањима која изазива **други** систем једнак је раду спољашњих сила $\bar{P}_n$ и $\bar{C}_i$ **другог** система при померањима који изазива **први** систем утицаја.

21 Maxwell – ова теорема

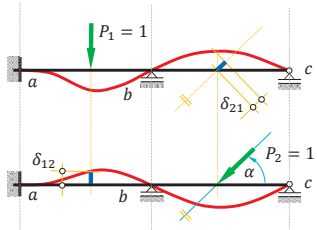
$$\sum P_m \bar{\delta}_m + \sum C_i \bar{c}_i = \sum \bar{P}_n \delta_n + \sum \bar{C}_i c_i$$

$P_m \Rightarrow P_1 = 1 \quad \Rightarrow \quad \delta_n = \delta_{21}$

$\bar{P}_n \Rightarrow P_2 = 1 \quad \Rightarrow \quad \bar{\delta}_m = \delta_{12}$

$$\sum 1 \cdot \bar{\delta}_{12} + \sum C_i \bar{c}_i = \sum 1 \cdot \delta_{21} + \sum \bar{C}_i c_i$$

$$1 \cdot \delta_{12} = 1 \cdot \delta_{21} \qquad \delta_{12} = \delta_{21}$$



Померање нападне тачке силе P_1 у правцу те силе услед силе P_2 једнако је померању нападне тачке силе P_2 у правцу силе P_2 услед силе P_1.

22 прва Rayleigh – јева теорема

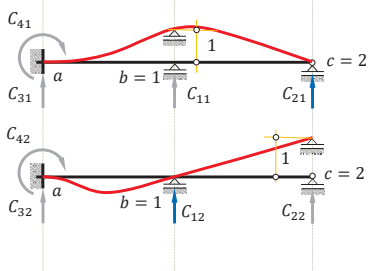
$$\sum P_m \bar{\delta}_m + \sum C_i \bar{c}_i = \sum \bar{P}_n \delta_n + \sum \bar{C}_i c_i$$

$P_m \Rightarrow P_1 = 0 \qquad c_i = c_1 = 1 \quad \Rightarrow \quad C_i = C_{12}$

$\bar{P}_n \Rightarrow P_2 = 0 \qquad \bar{c}_i = c_2 = 1 \quad \Rightarrow \quad \bar{C}_i = C_{21}$

$$\sum 0 \cdot \bar{\delta}_m + \sum C_i \bar{c}_i = \sum 0 \cdot \delta_n + \sum \bar{C}_i c_i$$

$$C_{12} \cdot 1 = C_{21} \cdot 1$$



Реакција ослонца 1 услед јединичног померања ослонца 2 једнака је реакцији ослонца 2 услед јединичног померања ослонца 1.

23 друга Rayleigh – јева теорема

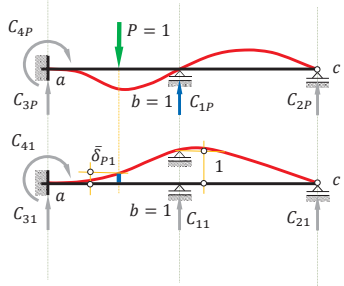
$$\sum P_m \bar{\delta}_m + \sum C_i \bar{c}_i = \sum \bar{P}_n \delta_n + \sum \bar{C}_i c_i$$

$P_m \Rightarrow P = 1 \qquad c_i = 0 \quad \Rightarrow \quad C_{1P}$

$\bar{P}_n \Rightarrow P = 0 \qquad \bar{c}_i = c_1 = 1 \quad \Rightarrow \quad \bar{\delta}_{P1}$

$$\sum 1 \cdot \bar{\delta}_{P1} + \sum C_{1P} \cdot 1 = \sum 0 \cdot \delta_n + \sum \bar{C}_{1P} \cdot 0$$

$$C_{1P} \cdot 1 = -\bar{\delta}_{P1} \cdot 1 \qquad C_{1P} = -\bar{\delta}_{P1}$$



Реакција ослонца **1** услед дејства јединичне силе **P** једнака је негативној вредности померања нападне тачке силе **P** у правцу те силе услед јединичног померања ослонца **1**.

DEFORMACIJA STATIČKI ODREĐENIH NOSAČA

$$\left.\begin{aligned} \varkappa &= \frac{M}{EJ} + \alpha_t \frac{\Delta t}{h} \\ \varepsilon &= \frac{N}{EF} + \alpha_t t^\circ \\ \varphi_T &= k \frac{T}{GF} \end{aligned}\right\} \rightarrow \Delta_{ik}, T_{ik}, T_{ki} \rightarrow C_{oi}, C_{ui} \Rightarrow u_i, v_i$$

- princip virtuelni radova =

Princip: Algebarski zbir radova unutrašnji i spoljašnji jednog mogućeg stanja jeste jednak nuli

$$\underbrace{\Sigma \bar{F}_{ik}}_{\delta} + \Sigma \bar{C}_i a_i = \int_s (\bar{M}\varkappa + \bar{N}\varepsilon + \bar{T}\varphi_T)\, ds$$

$\bar{P}=1$

$\bar{M}=1$

$$\delta = \int_s (\bar{M}\varkappa + \bar{N}\varepsilon + \bar{T}\varphi_T)\, ds - \Sigma \bar{C}_i a_i$$

$$\delta = \int_s \left(\frac{M\bar{M}}{EJ} + \frac{N\bar{N}}{EF} + k\frac{T\bar{T}}{GF} + \bar{M}\alpha_t \frac{\Delta t}{h} + \bar{N}\alpha_t t^\circ \right) ds - \Sigma \bar{C}_i a_i$$

$$\delta_0 = \int_s \frac{M\bar{M}}{EJ} ds + \int_s \frac{N\bar{N}}{EF} ds + k \int_s \frac{T\bar{T}}{GF} ds \quad / EJ_c$$

$$\delta_t = \int_s \bar{M}\alpha_t \frac{\Delta t}{h} ds + \int_s \bar{N}\alpha_t t^\circ ds$$

$$\delta_c = -\Sigma \bar{C}_i a_i \quad \text{pom. oslonca}$$

$$EJ_c \cdot \delta_0 = \int_s M\bar{M} \frac{J_c}{J} ds + \frac{J_c}{F_c} \int_s N\bar{N} \frac{F_c}{F} ds + (2+2\nu) \frac{J_c}{F_c} \int_s T\bar{T} \frac{F_c}{F} ds \qquad \nu = 0{,}10$$

$$ds' = \frac{J_c}{J} ds$$

$$ds'' = \frac{F_c}{F} ds$$

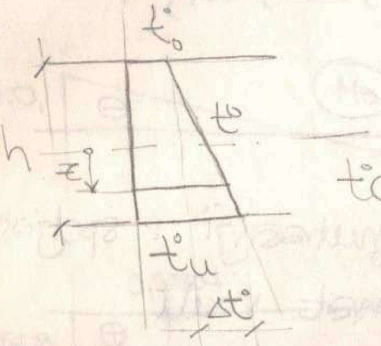
$$ds''' =$$

$$\boxed{EJ_c \delta_0 = \int_s M\bar{M} \frac{J_c}{J} ds + \frac{J_c}{F_c} \int_s N\bar{N} \frac{F_c}{F} ds}$$

usled spoljašnjeg opterećenja

$$EJ_c \cdot \delta_t = EJ_c \int_s \bar{M} \alpha_t \frac{\Delta t}{h} ds + EJ_c \int_s N \alpha_t t^\circ \cdot ds$$

$$EJ_c \delta_c = -\sum C_i c_i$$



$$t^\circ(z) = t^\circ_o + \Delta t \frac{z}{h}$$

$$\Delta t^\circ = t^\circ_u - t^\circ_o$$

$$t^\circ = \frac{t^\circ_u + t^\circ_o}{2}$$

kod rešetki:

$$\delta = \int_s \bar{N} \varepsilon ds - \sum \bar{C}_i c_i$$

$$\delta = \sum_s \int_i^t \bar{N} \varepsilon ds - \sum C_i c_i = \sum_s \bar{S} \Delta l - \sum \bar{C}_i c_i = \sum \frac{S \bar{S}}{EF} l + \sum \bar{S} \cdot \alpha_t t^\circ \cdot l - \sum \bar{C}_i c_i$$

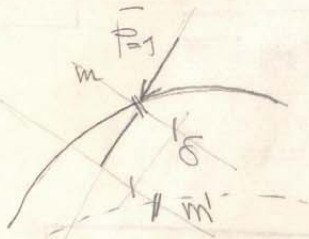
$$\int_i^t \bar{N} \varepsilon ds = \bar{N} \varepsilon \int_i^t ds = \bar{N} \cdot \underbrace{\varepsilon \cdot l}_{\Delta l} = \bar{S} \cdot \Delta l$$

$$\delta_0 = \sum_s \frac{S \bar{S}}{EF} l \Big/ EF_c \rightarrow EF_c \cdot \delta_0 = \sum S \bar{S} \frac{F_c}{F} \cdot l$$

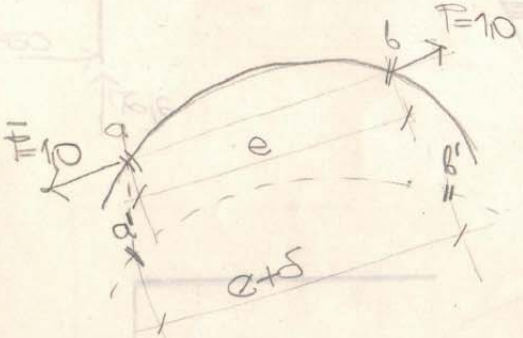
$$\delta_t = \sum_s \bar{S} \alpha_t t^\circ l \Big/ EF_c \rightarrow EF_c \cdot \delta_t = \sum \bar{S} \alpha_t t^\circ l EF_c$$

$$\delta_c = -\sum \bar{C}_i c_i \Big/ EF_c \qquad EF_c \delta_c = -EF_c \sum \bar{C}_i c_i$$

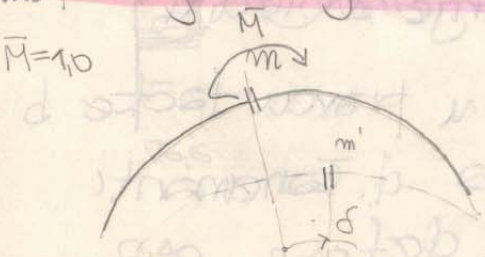
1. Gen. pom. tačke u određenom pravcu



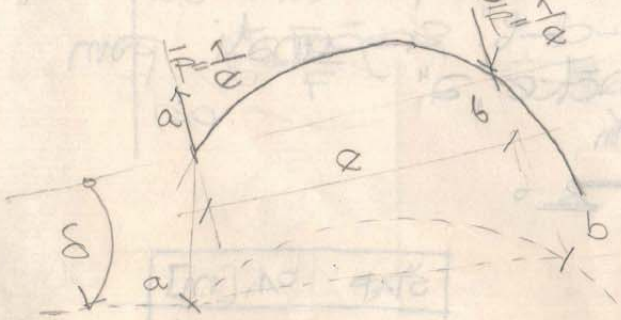
2. Promjena odstojanja između dvije tačke



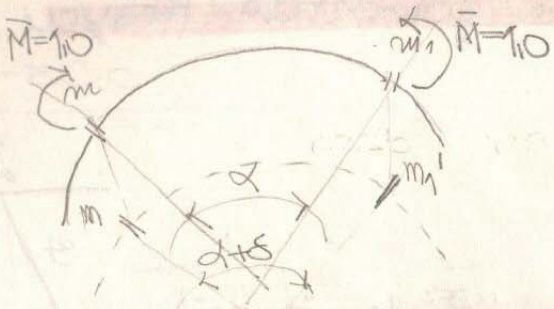
3. Promjena ugla u presjeku



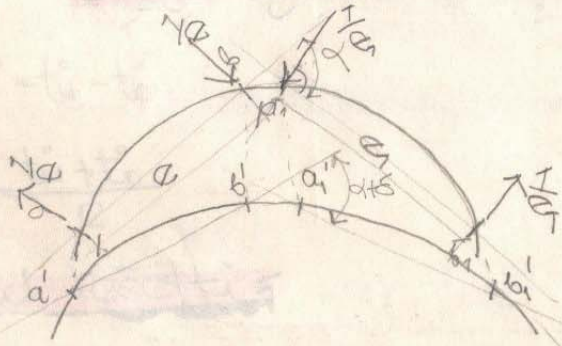
4. Obrtanje prave koja prolazi kroz tačke A i B



5. promjena ugla ramedu presjeka m_i m_1

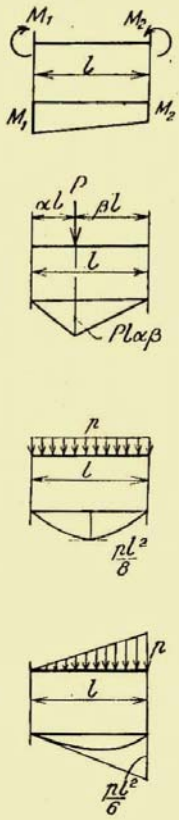


6. promjena ugla ramedu dvije trave

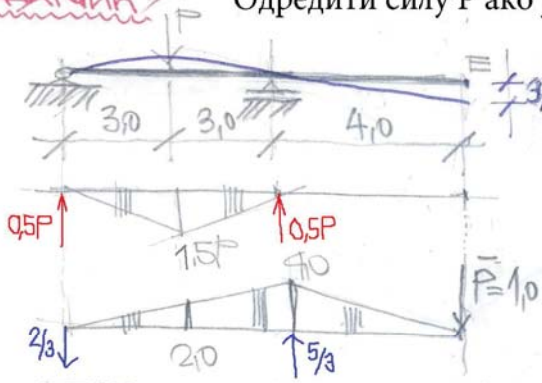


TABLICA 1

$\frac{1}{i}\frac{J_c}{J}\int M\bar{M}ds$	$\bar{i}$	$\bar{k}$	$\bar{i}$ $\bar{k}$	αl βl		$\bar{k}$
i	$i\bar{i}$	$\frac{1}{2}i\bar{k}$	$\frac{1}{2}i(\bar{i}+\bar{k})$	$\frac{1}{2}i\bar{m}$	$\frac{2}{3}i\bar{m}$	$\frac{1}{4}i\bar{k}$
k	$\frac{1}{2}k\bar{i}$	$\frac{1}{3}k\bar{k}$	$\frac{1}{6}k(\bar{i}+2\bar{k})$	$\frac{1}{6}k\bar{m}(1+\alpha)$	$\frac{1}{3}k\bar{m}$	$\frac{2}{15}k\bar{k}$
i	$\frac{1}{2}i\bar{i}$	$\frac{1}{6}i\bar{k}$	$\frac{1}{6}i(2\bar{i}+\bar{k})$	$\frac{1}{6}i\bar{m}(1+\beta)$	$\frac{1}{3}i\bar{m}$	$\frac{7}{60}i\bar{k}$
i k	$\frac{1}{2}(i+k)\bar{i}$	$\frac{1}{6}(i+2k)\bar{k}$	$\frac{1}{6}[i(2\bar{i}+\bar{k})+$ $+k(\bar{i}+2\bar{k})]$	$\frac{1}{6}[i(1+\beta)+$ $+k(1+\alpha)]\bar{m}$	$\frac{1}{3}(i+k)\bar{m}$	$\frac{1}{60}(7i+8k)\bar{k}$
m αl βl	$\frac{1}{2}m\bar{i}$	$\frac{1}{6}m\bar{k}(1+\alpha)$	$\frac{1}{6}m[\bar{i}(1+\beta)+$ $+\bar{k}(1+\alpha)]$	$\frac{1}{3}m\bar{m}$	$\frac{1}{3}m\bar{m}(1+\alpha\beta)$	$\frac{1}{20}m\bar{k}(1+\alpha)\times$ $\times(\frac{7}{3}-\alpha^2)$
m	$\frac{2}{3}m\bar{i}$	$\frac{1}{3}m\bar{k}$	$\frac{1}{3}m(\bar{i}+\bar{k})$	$\frac{1}{3}m\bar{m}(1+\alpha\beta)$	$\frac{8}{15}m\bar{m}$	$\frac{1}{5}m\bar{k}$
k	$\frac{1}{4}k\bar{i}$	$\frac{2}{15}k\bar{k}$	$\frac{1}{60}k(7\bar{i}+8\bar{k})$	$\frac{1}{20}k\bar{m}(1+\alpha)\times$ $\times(\frac{7}{3}-\alpha^2)$	$\frac{1}{5}k\bar{m}$	$\frac{8}{105}k\bar{k}$
i	$\frac{1}{4}i\bar{i}$	$\frac{7}{60}i\bar{k}$	$\frac{1}{60}i(8\bar{i}+7\bar{k})$	$\frac{1}{20}i\bar{m}(1+\beta)\times$ $\times(\frac{7}{3}-\beta^2)$	$\frac{1}{5}i\bar{m}$	$\frac{31}{420}i\bar{k}$



ЗАДАТАК: Одредити силу P ако је вертикално померање тачке "E" 3mm.



$v_E = 3{,}0\ mm$

$EJ = 3010^3\ kNm^2$

$M\ (kNm)$

$M_1\ (kNm)$

$EJv_E = -9{,}0P$

$3010^3 \cdot 0{,}003 = -9{,}0P$

$P = -10{,}00\ kN$

$EJv_E = -\frac{1}{3} \cdot 1{,}5P \cdot 2 \cdot 3 - \frac{1}{6} 1{,}5P(4+2\cdot 2)\cdot 3 =$

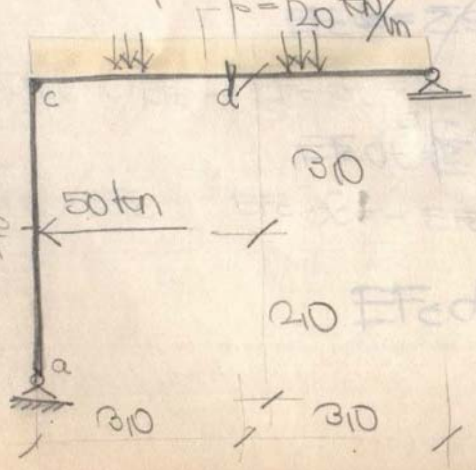
$= -3P - 6P = -9P$

zadatak:

Za dati nosač i opterećenje odrediti:

1. a) pomeranje tačke f u pravcu tačke b
   b) obrtanje preseka d. Zanemariti uticaj transf. sila na def.

2. Pri zadatoj promjeni temperature $t_b = -5°C$, $t_u = 25°C$ duž štapa „c–d–b" sračunati pom. tačke „d" u pravcu tačke „2"



ŠTAP	b/h [m]	J (m⁴)
a–c	0,3/0,4	0,0016
c–b	0,3/0,5	0,003125

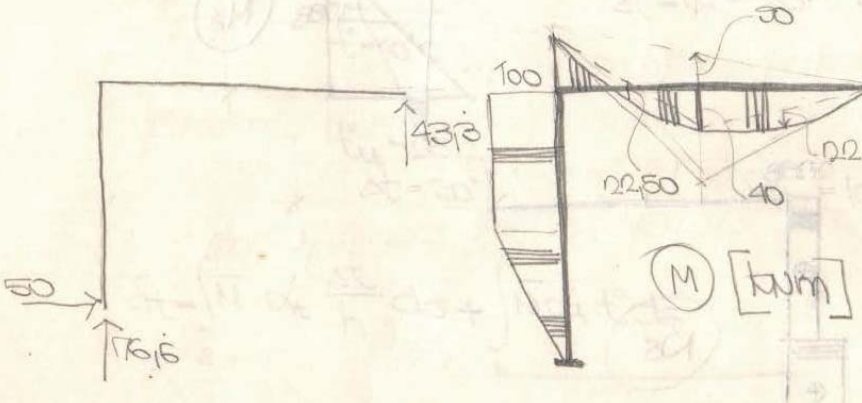
$E = 2 \cdot 10^7\ kN/m^2$

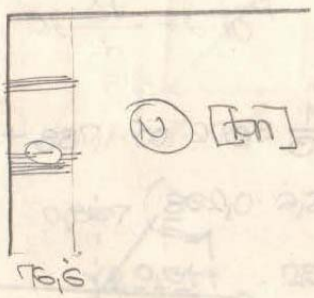
F (m²)
0,12
0,15

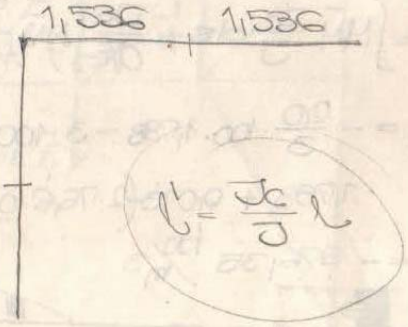
$F_c = 0{,}12\ m^2$ $\quad \frac{J_c}{F_c} = 0{,}0133\ m^2$

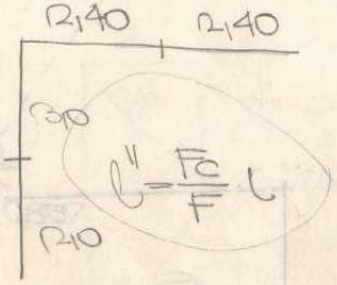
$J_c = 0{,}0016\ m^4$

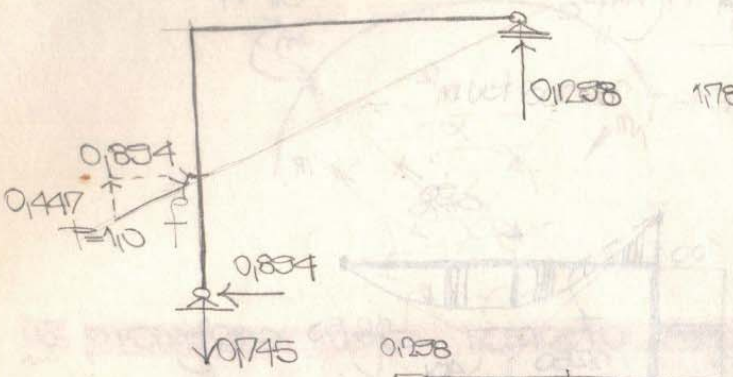
$EJ_c = 2 \cdot 10^7 \cdot 0{,}0016 = 32000\ kN\,m^2$

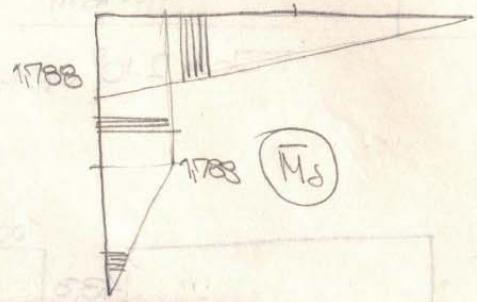


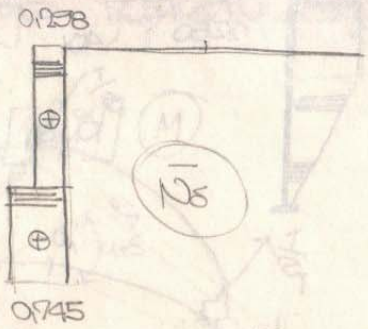












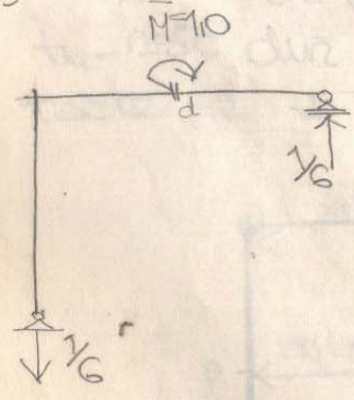
$$EJ_c\delta = \int M\bar{M}\frac{J_c}{J}ds + \frac{J_c}{F_c}\int N\bar{N}\frac{F_c}{F}ds$$

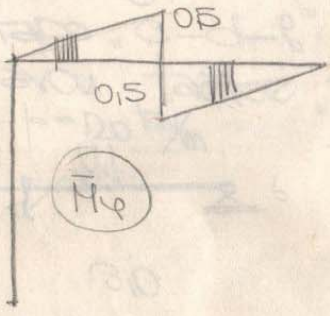
$$EJ_c\cdot\delta = -\frac{2,0}{3}\cdot 100\cdot 1,788 - 3\cdot 100\cdot 1,788 - \frac{1}{3}3,072\cdot 100\cdot 1,788 + \frac{1}{3}3,072\cdot 30\cdot$$
$$\cdot 1,788 + 0,013(2\cdot 76,6\cdot 0,745 - 3\cdot 76,6\cdot 0,298)$$

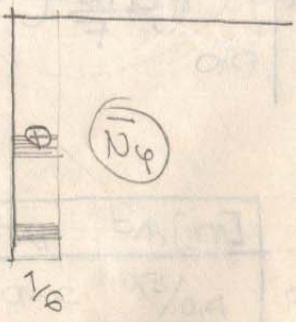
$$EJ_c\cdot\delta = -676,35\ \text{tm}^3$$

$$\delta = -0,021\ m = -2,1\ cm$$

b)



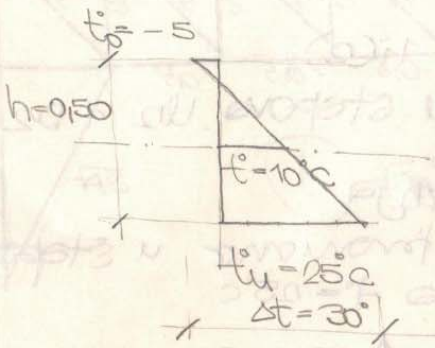




$$EJ_c\varphi = -\frac{1}{6}1,536\cdot 0,50(2\cdot 40 - 100) - \frac{1}{3}1,536\cdot 0,50\cdot 22,50 + \frac{1}{3}1,536\cdot 40\cdot 0,50 -$$
$$+\frac{1}{3}1,536\cdot 22,50\cdot 0,50 + 0,013\left(-50\cdot 76,6\cdot\frac{1}{6}\right) = 101,55\ \text{tm}^2$$

$\varphi = 0{,}00032$ rad.

(12.)

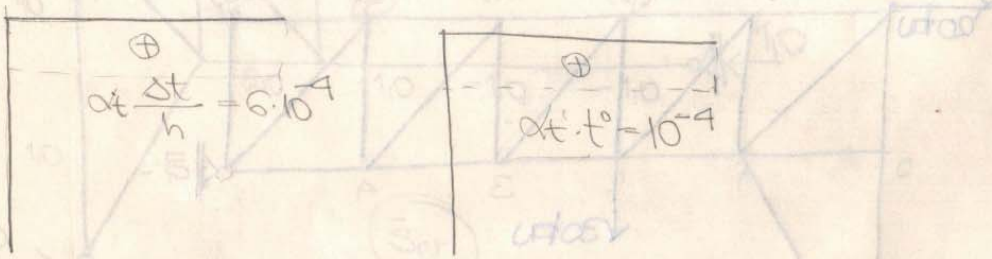


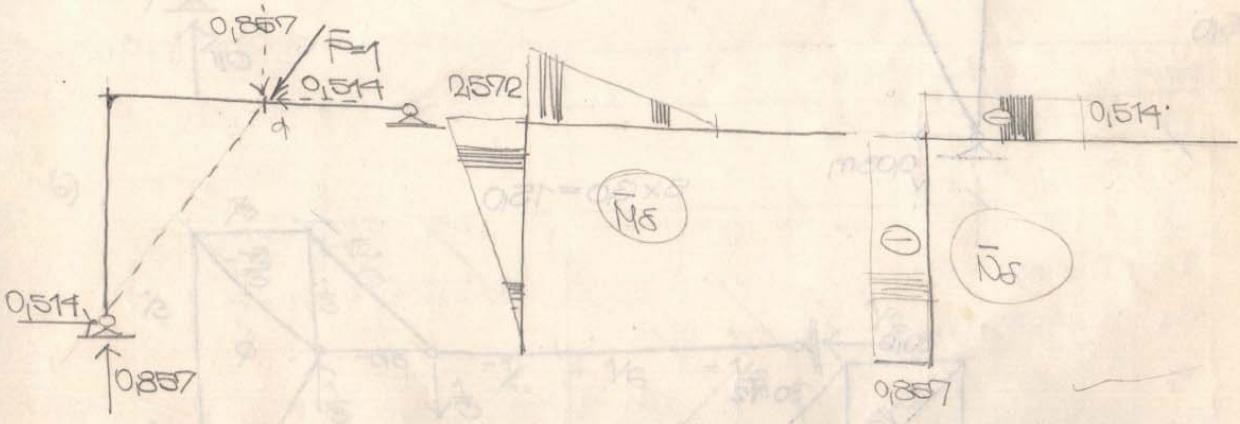
$$t° = \frac{t_u + t_b}{2} = 10°C$$

$$\Delta t = t_u - t_b = 30°C$$

$\alpha_t = 10^{-5}/°C$ - za beton

$$\delta_t = \int_s \bar{M} \cdot \alpha_t \frac{\Delta t}{h} ds + \int_s \bar{N} \alpha_t \cdot t° ds$$



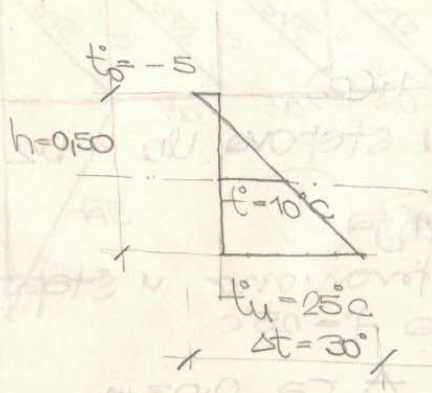


$$E \cdot c \cdot \delta_t = \left(-\frac{1}{2} \cdot 3{,}0 \cdot 2{,}572 \cdot 6 \cdot 10^{-4} - 3 \cdot 0{,}514 \cdot 10^{-4}\right) \cdot E \cdot c$$

$$\delta_t = -2{,}161 \cdot 10^{-3}\ m \rightarrow \delta = -2{,}16\ mm$$

$\varphi = 0{,}00032$ rad.

(12.)

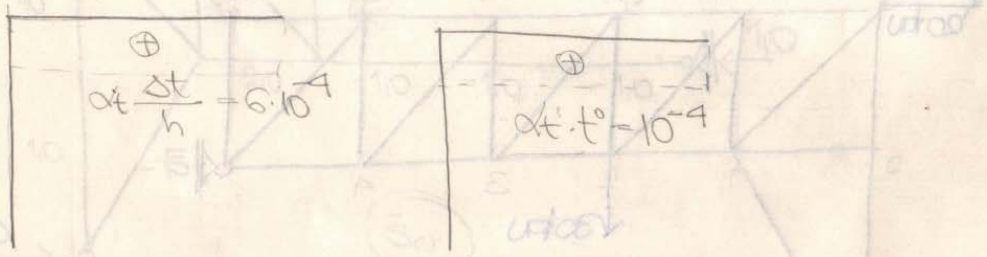


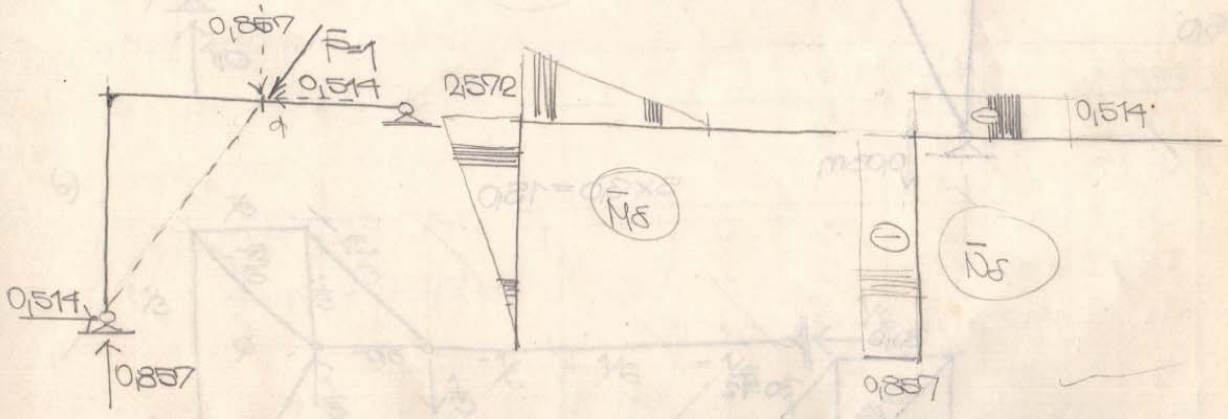
$$t° = \frac{t_u + t_b}{2} = 10°C$$

$$\Delta t = t_u - t_b = 30°C$$

$\alpha_t = 10^{-5}/°C$ - za beton

$$\delta_t = \int_s \bar{M} \cdot \alpha_t \frac{\Delta t}{h} ds + \int_s \bar{N} \alpha_t \cdot t° ds$$





$$\sum E J_c \delta_t = \left(-\frac{1}{2} \cdot 3{,}0 \cdot 2{,}572 \cdot 6 \cdot 10^{-4} - 3 \cdot 0{,}514 \cdot 10^{-4}\right) \cdot \sum E J_c$$

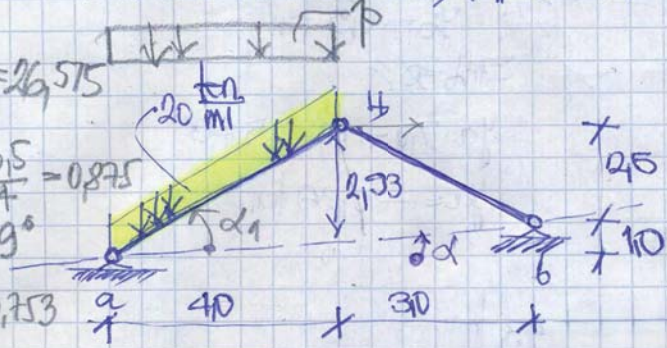
$$\delta_t = -2{,}161 \cdot 10^{-3}\ m \rightarrow \delta = -2{,}16\ mm$$

ЗАДАЧА:

ЗА НОСАЧ НА СЛИКИ УСЛЕД ЗАДАНОГ ОПТЕРЕЋЕЊА ОДРЕДИТИ:

1° – ПРОМЕНУ УГЛА У „Ц"

2° – ХОРИЗОНТАЛНО ПОМЕРАЊЕ ЧВОРА „Ц" УСЛЕД ВЕРТИКАЛНОГ ПОМЕРЕЊА ОСЛОНЦА „a" ЗА ОРОЈ n



$p = \frac{20}{\cos\alpha_1} = 26,575$

$\operatorname{tg}\alpha_1 = \frac{3,5}{4} = 0,875$

$\alpha_1 = 41,19°$

$\cos\alpha_1 = 0,753$

$E = 2 \cdot 10^7 \text{ kNm}^2$

$J = 0,0072 \text{ m}^4$

$\operatorname{tg}\alpha = \frac{1}{7} = 0,14285 = 0,14$

$\alpha = 8,13°$

$\sum M_a = 0 \Rightarrow y_b \cdot 7,0 - 106,30 \cdot 2,10 = 0 \Rightarrow y_b = 30,37$ kN

$\sum M_b = 0 \Rightarrow -y_a \cdot 7,0 + 106,30 \cdot 5,10 = 0 \Rightarrow y_a = 75,93$ kN

$H_a = \frac{1}{2,93}(75,93 \cdot 4,0 - 106,30 \cdot 2,10) \Rightarrow H_a = 31,10$ kN

$H_b = \frac{1}{2,93}(30,37 \cdot 3,0) \Rightarrow H_b = 31,10$ kN

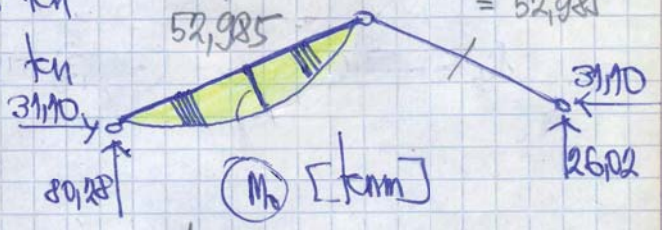
$V_a = 75,93 + 31,10 \cdot 0,14 = 80,28$ kN

$V_B = 30,37 - 31,10 \cdot 0,14 = 26,02$ kN

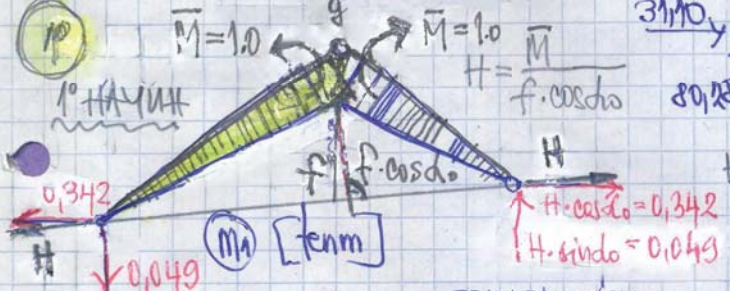
(p)

$M = 80,28 \cdot 2 - 31,1 \cdot 0,5 \cdot 3,5 - 26,575 \cdot 2 \cdot 1 =$

$= 52,985$



(p) 1° НАЧИН



$H = \frac{1}{2,93 \cdot 0,9899} = 0,345$ t/kN

$EI \cdot \delta_{11} = \int_S \frac{M_1 M_0}{EJ} ds + \int_S \frac{N_1 N_0}{EF} ds + \int_S \frac{T_1 T_0}{GF} ds$ (занемарујем)

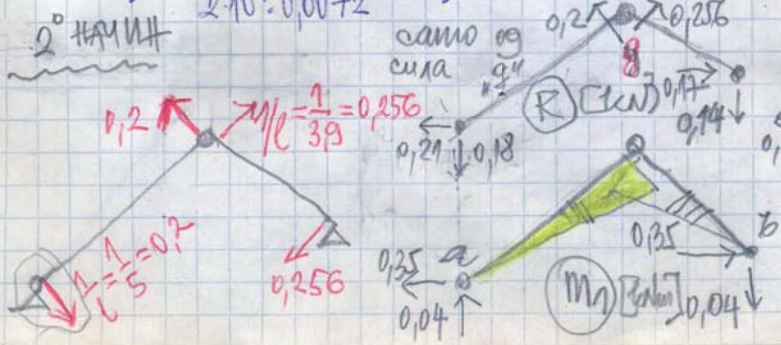
$EI \cdot \delta_{11} = -\frac{1}{3} \cdot 1 \cdot 52,985 \cdot 5 + 0 = 88,417$

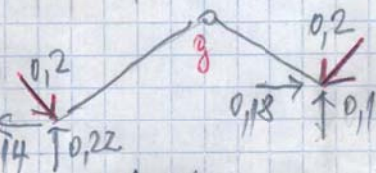
$\delta_{11} = -\frac{88,417}{2 \cdot 10^7 \cdot 0,0072}$

$d_{11} = 0,000614$ rad.

→ ПРОВЕРА СА 2° НАЧИНОМ.

2° НАЧИН

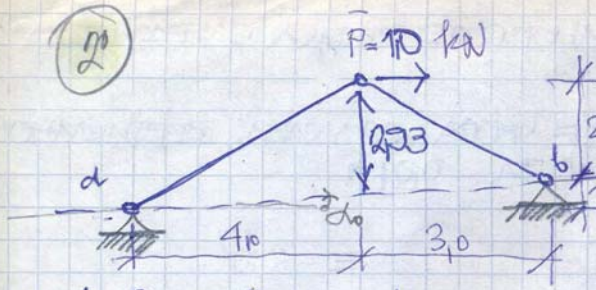




$EI \delta_{11} = \frac{1}{3} \cdot 1 \cdot 52,985 \cdot 5 + 0 = 88,417$

$\delta_{11} = 0,000614$ rad.

2)



$\Sigma M_a = 0 =$

$2,5\ y_b \cdot 7,0 - 1,0 \cdot 3,5 = 0$

$y_b = 0,5$ tf

$\Sigma M_b = 0 =$

$y_a \cdot 7,0 + 1,0 \cdot 2,5 = 0$

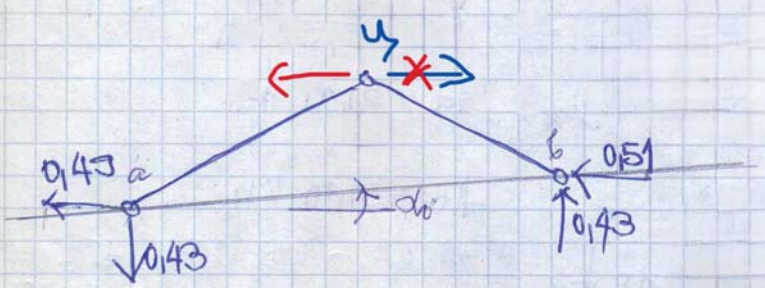
$y_a = -0,36$ tf

$H_b = \frac{1}{2,93}(0,5 \cdot 3,0) = 0,51$ tf

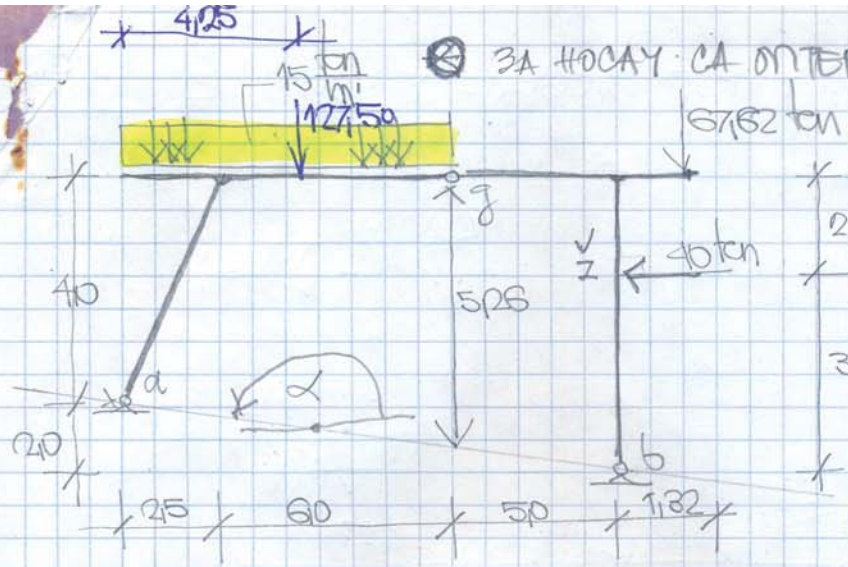
$H_a = \frac{1}{2,93}(-0,36 \cdot 4,0) = -0,49$ tf

$y_a = -0,36 + (-0,49) \cdot 0,14 = -0,43$ tf

$V_b = 0,5 - 0,51 \cdot 0,14 = 0,43$



$\delta_y = -\Sigma \bar{C}_i \cdot c_i = -(0,43) \cdot 0,01 = -0,0043\ m = -4,3\ mm$



ЗА НОСАЧ СА ОПТЕРЕЋЕЊЕМ НА СЛИЦИ

1° СРАЧУНАТИ И НАЦРТАТИ ДИЈАГРАМЕ ПРЕСЕЧНИХ СИЛА.

2° ОДРЕДИТИ ПРЕСЕКА „у" ИЗВОРУ „2".

$E = 2 \cdot 10^7 \ kN/m^2$

$b/h = 0{,}2/0{,}4 \ m.$

$\sum M_a = 0:$ $\quad y_b \cdot 13{,}5 + 40 \cdot 1{,}8 - 67{,}62 \cdot 14{,}82 - 127{,}5 \cdot 4{,}25 = 0$

$$y_b = \frac{-40 \cdot 1{,}8 + 67{,}62 \cdot 14{,}82 + 127 \cdot 4{,}25}{13{,}5}$$

$y_b = 108{,}71 \ kN$

$\sum M_b = 0:$

$$-y_a \cdot 13{,}5 + 127{,}5 \cdot 9{,}25 + 40 \cdot 3{,}8 - 67{,}62 \cdot 1{,}32$$

$$y_a = \frac{127{,}5 \cdot 9{,}25 + 40 \cdot 3{,}8 - 67{,}62 \cdot 1{,}32}{13{,}5}$$

$y_a = 92{,}00 \ kN.$

$\sum M_1' = 0:$

$$-y_a \cdot 8{,}5 + 127{,}5 \cdot 4{,}25 + H_a \cdot 5{,}26 = 0$$

$$H_a = \frac{92{,}0 \cdot 8{,}5 - 127{,}5 \cdot 4{,}25}{5{,}26}$$

$H_a = 45{,}65 \ kN$

$\sum M_{5-5} = 0:$

$$H_b \cdot 5{,}26 - y_b \cdot 5{,}0 + 40 \cdot 2{,}2 + 67{,}62 \cdot 6{,}32 = 0$$

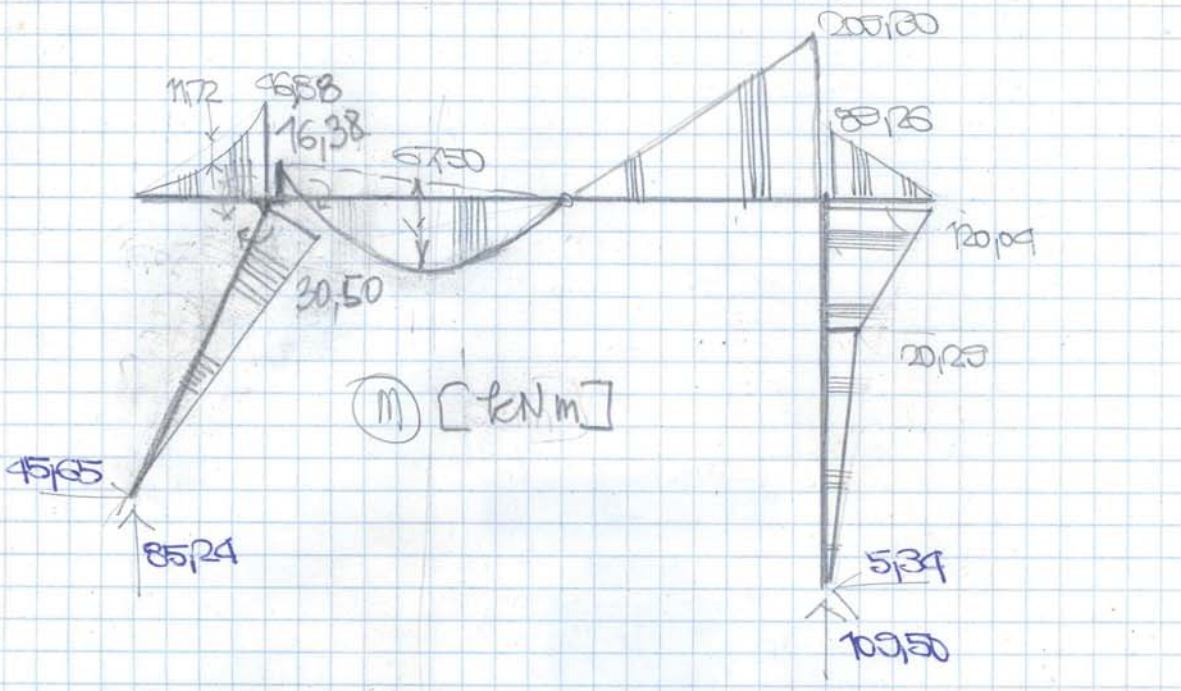
$$H_b = \frac{108{,}71 \cdot 5{,}0 - 40 \cdot 2{,}2 - 67{,}62 \cdot 6{,}32}{5{,}26}$$

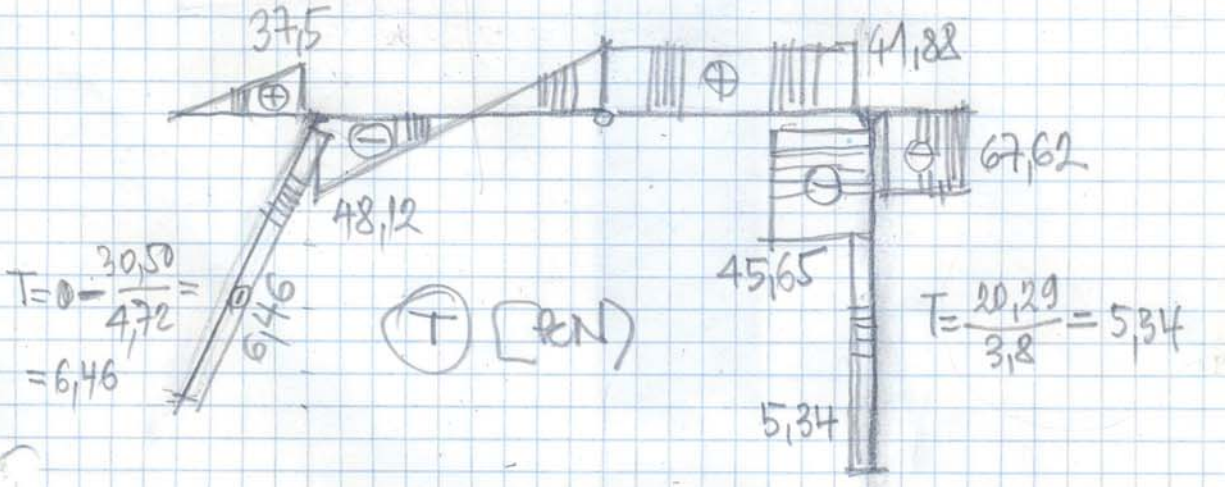
$H_b = 5{,}34 \ kN$

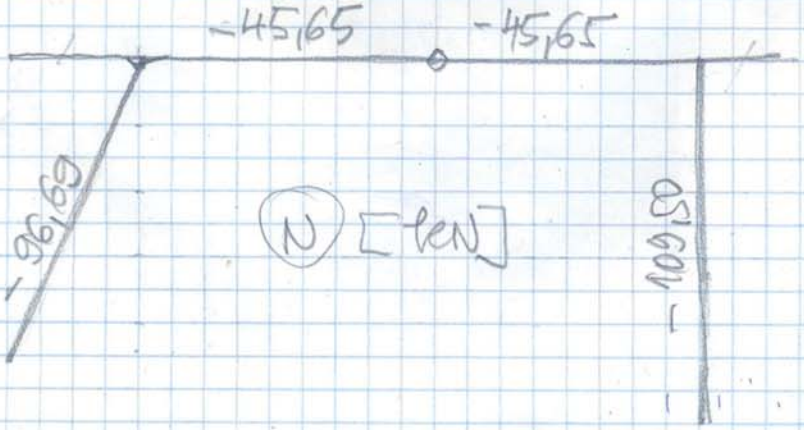
$\operatorname{tg}\alpha_0 = -0{,}148$

$A = 92{,}00 + 45{,}65(-0{,}148) = 85{,}24 \ kN$

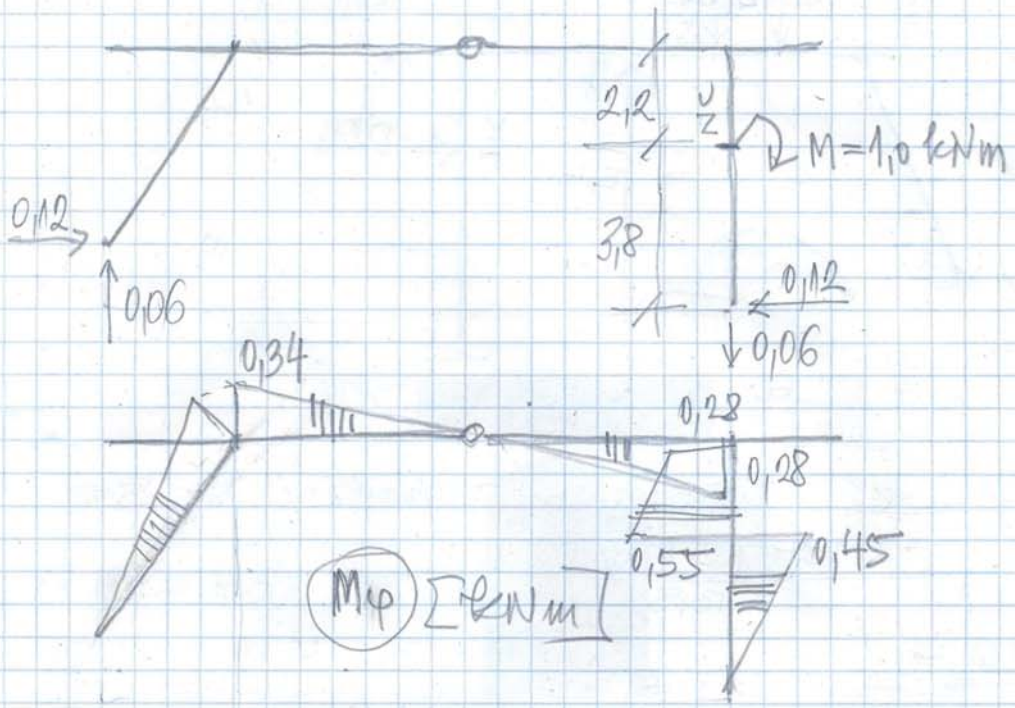
$B = 108{,}71 + 5{,}34 \cdot 0{,}148 = 109{,}50 \ kN.$


200,00
89,26
120,04
20,29
5,34
109,50
11,72
46,58
16,38
6,150
30,50
45,65
85,24
M [kN m]


37,5
41,88
67,62
48,12
45,65
5,34
T=0-30,50/4,72=
=6,46
6,46
T=20,29/3,8=5,34
T [kN]


-45,65
-45,65
-96,69
-109,50
N [kN]

*ОБРТАЊЕ ПОПРЕЧНОГ ПРЕСЕКА У ЧВОРУ „Z"



$$EI\delta_\varphi = \int_S M \cdot M_\varphi \, ds =$$

$$= -\frac{1}{3} 30,9 \cdot 0,34 \cdot 4,72 \cdot +$$

$$+ \frac{1}{3} 0,34 \cdot 16,38 \cdot 6 - \frac{1}{3} \cdot 0,34 \cdot 67,5 \cdot 6 -$$

$$- \frac{1}{3} 209,30 \cdot 0,28 \cdot 5 -$$

$$- \frac{1}{6} [0,55 \cdot (2 \cdot 20,29 + 120,04) + 928 (20,29 + 2 \cdot 120,04) \cdot 2,2 +$$

$$+ \frac{1}{3} 0,45 \cdot 20,29 \cdot 3,8 = -196,308$$

$$EI\delta_\varphi = -196,308$$

$$\delta_\varphi = -\frac{196,308}{3 \cdot 10^7 \cdot \frac{0,2 \cdot 0,4^3}{12}} = -\frac{196,308}{3,2 \cdot 10^4} =$$

$$\delta_\varphi = -0,006135 \text{ rad.}$$

ZADATAK: Za rešetku na slici izračunati

a) vertikalno pom. čvora (2)

b) obrtanje štapa U2

c) razmicanje čvorova 1 i (2)

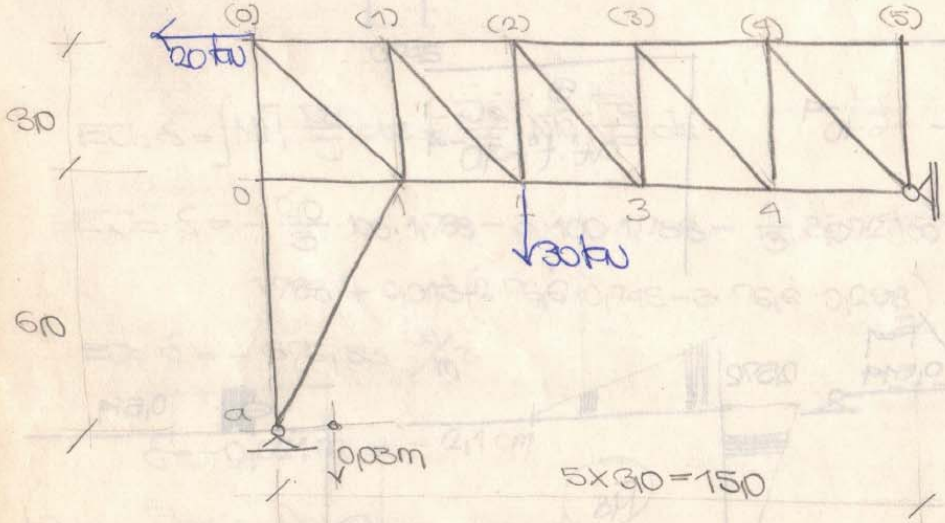
d) promena ugla između štapova U2 i D2

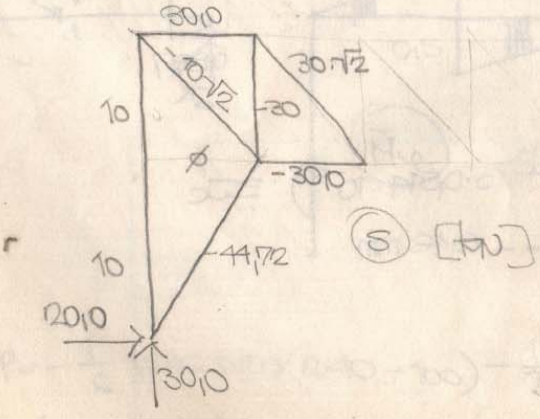
usled

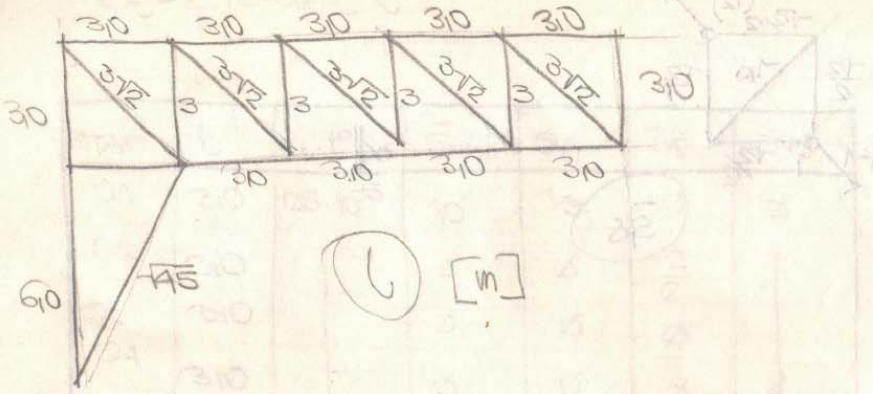
A - datog opterećenja

B - temperaturne promene u štapovima donjeg pojasa $t° = 25°C$

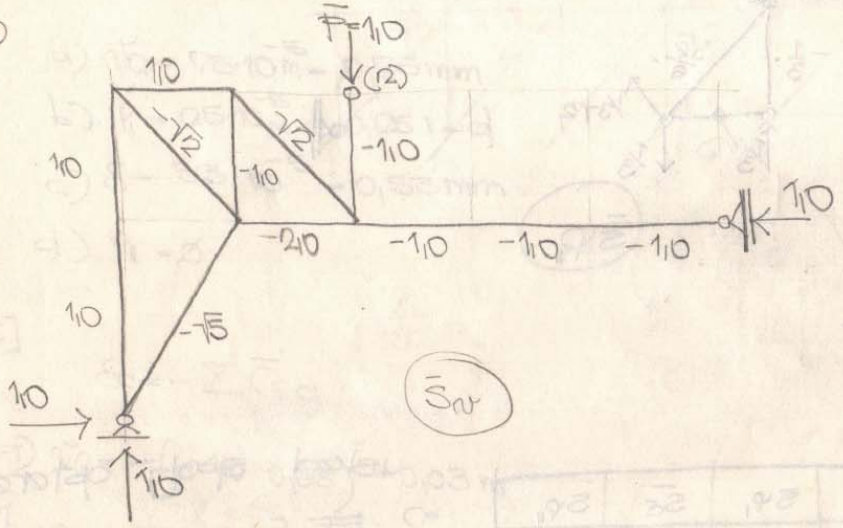
C - pom. oslonca A za 0,03m.



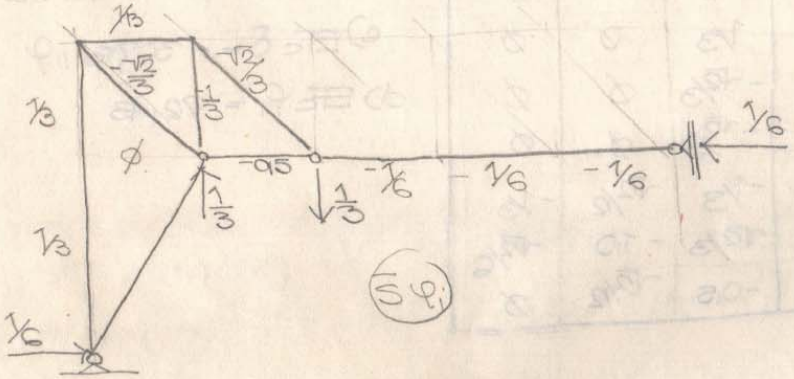



3,0
3,0
3,0
3,0
3,0
3√2
3
3√2
3
3√2
3
3√2
3
3√2
3,0
3,0
3,0
3,0
3,0
6,0
-√45
(1)
[m]

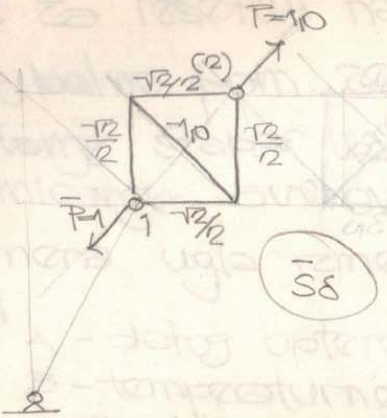
a)


F=1,0
(2)
1,0
1,0
-√2
√2
-1,0
-1,0
-2,0
-1,0
-1,0
-1,0
1,0
1,0
-√5
1,0
1,0
S̄ik

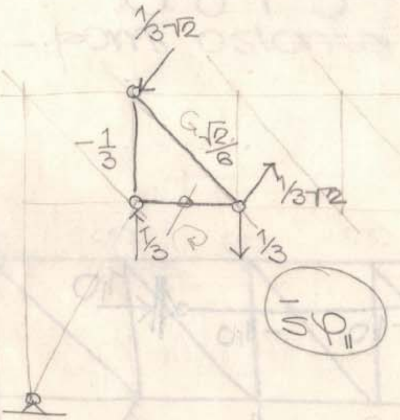
b)


1/3
-√2/3
√2/3
1/3
1/3
φ
-0,5
1/3
1/3
-1/6
-1/6
-1/6
1/6
1/3
1/6
S̄φi

c)



d)



A]

STAP	l	S	$\bar{S}_\nu$	$\bar{S}\varphi_1$	$\bar{S}\delta$	$\bar{S}\varphi_{11}$
V_a	6	10	1	$1/3$	∅	∅
V_0	3	10	1	$1/3$	∅	∅
O_1	3	30	1	$1/3$	∅	∅
D_1	$3\sqrt{2}$	$-10\sqrt{2}$	$-\sqrt{2}$	$-\sqrt{2}/3$	∅	∅
U_1	3	$-44{,}7\sqrt{2}$	$-\sqrt{5}$	$-\sqrt{2}/6$	∅	∅
V_1	3	-30	-1	$-1/3$	$\sqrt{2}/12$	$-1/3$
D_2	$3\sqrt{2}$	$-30\sqrt{2}$	$-\sqrt{2}$	$\sqrt{2}/3$	$-1{,}0$	$\sqrt{2}/6$
U_2	3	-30	-2	$-0{,}5$	$-\sqrt{2}/12$	∅
$EF_c\delta$						

usled spolj. opterećenja,

a) $EF_c\delta = 1460{,}20$

b) $EF_c\varphi_1 = 359{,}94$

c) $EF_c\delta = -307{,}3$

d) $EF_c\varphi_{11} = 72{,}43$

B] $\delta_t = \sum_s \bar{S} \cdot \alpha_t \cdot t^\circ \cdot l$

STAF	l	$\alpha_t \cdot t^\circ$	$\bar{S}_V$	$S\varphi_I$	$\bar{S}_S$	$S\varphi_{II}$
01	310	$125 \cdot 10^{-5}$	1,0	1/3	Ø	Ø
02	310	↓	Ø	Ø	$\frac{\sqrt{2}}{2}$	↓
03	310		Ø	Ø	Ø	
04	310		Ø	Ø	Ø	
05	310		Ø	Ø	Ø	

a) $v_2 = 175 \cdot 10^{-5}\,m = 0{,}175\,mm$

b) $\varphi_I = 25 \cdot 10^{-5}\,m - 0{,}25\,rad$

c) $\delta = 53 \cdot 10^{-5} = 0{,}53\,mm$

d) $\varphi_{II} = \emptyset$

C] $\delta_c = -\sum \bar{C}_i \cdot c_i$

a) $v_2 = -(-1{,}0 \cdot 0{,}03) = 0{,}03\,m$

b) $\varphi_I = \emptyset$

c) $\delta = \emptyset$

d) $\varphi_{II} = \emptyset$