

STATIKA KONSTRUKCIJA 1 - VEŽBE

Zadatak: Za istovremeno dejstvo opterećenja i temperature odrediti dijagram pomeranja nosača sa slike u pravcu: a) ose štapa b) upravno na osu štapa c) vertikalno d) horizontalno
 Uticaj transverzalne sile na deformaciju se zanemaruje.

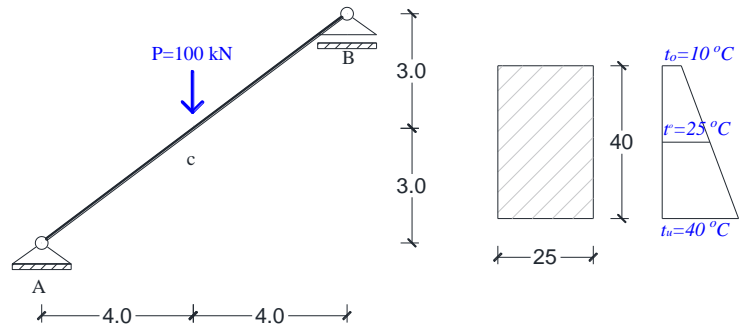
$$E = 3 \cdot 10^7 \text{ kN/m}^2$$

$$\alpha_t = 10^{-5} \text{ 1/}^\circ\text{C}$$

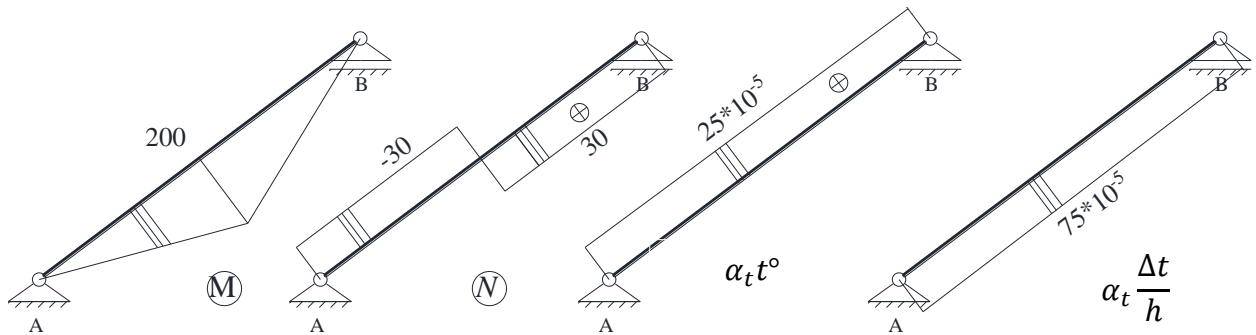
$$t_u = +40^\circ\text{C}, \quad t_o = +10^\circ\text{C}, \quad \rightarrow t^\circ = 25^\circ\text{C}$$

$$EI = 3 \cdot 10^7 \cdot \frac{0,25 \cdot 0,4^3}{12} = 40000 \text{ kNm}^2$$

$$EF = 3 \cdot 10^7 \cdot 0,25 \cdot 0,4 = 3000000 \text{ kN}$$



-Dijagrami presečnih sila i temperaturne promene u nosaču



a) Pomeranje u pravcu ose štapa

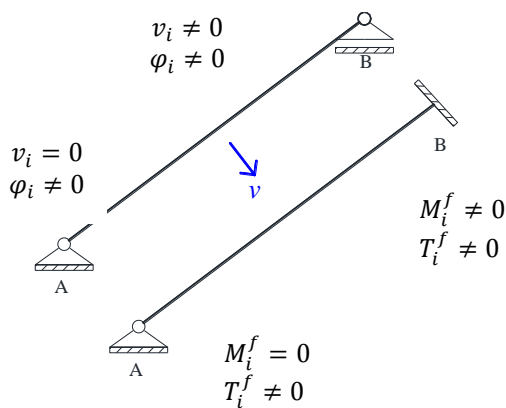
$$\varepsilon = \frac{N}{EF} + \alpha_t t^\circ \rightarrow u_x = \int_0^x \varepsilon_z dz + u_0$$

u_0 - početno pomjeranje
 A podintegralne veličine su konstantne

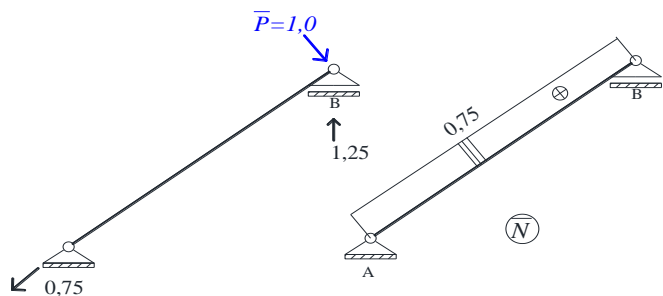
$$u_c = \left(\frac{N}{EF} + \alpha_t t^\circ \right) \cdot 5 = \left(\frac{-30}{3 \cdot 10^6} + 25 \cdot 10^{-5} \right) \cdot 5 = 1,2 \cdot 10^{-3} \text{ m}$$

$$u_B = \left(\frac{N}{EF} + \alpha_t t^\circ \right) \cdot 5 + u_c = \left(\frac{30}{3 \cdot 10^6} + 25 \cdot 10^{-5} \right) \cdot 5 + u_c = 2,5 \cdot 10^{-3} \text{ m}$$

b) Pomeranje upravno na osu štapa



Fiktivni nosač je 1x statički neodređen nosač, a nepoznata (mom. uklještenja) se određuje kao pomjeranje v_b na stvarnom nosaču.



$$v_b = \int \frac{N\bar{N}}{EF} ds + \int \bar{N} \alpha_t t^\circ ds = 25 \cdot 10^{-5} \cdot 0,75 \cdot 10 = 1,875 \cdot 10^{-3} \text{ m}$$

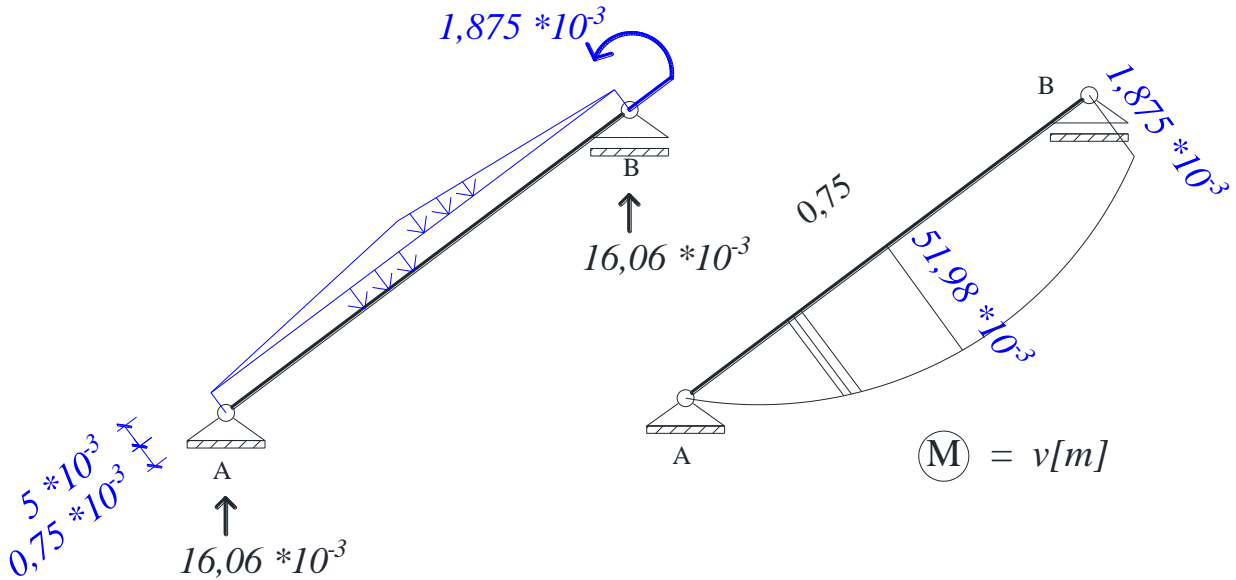
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-Fiktivno opterećenje

$$m^f = \left(\frac{N}{EF} + \alpha_t t^0 \right) \cdot \operatorname{tg} \alpha; \alpha = 0 \rightarrow m^f = 0$$

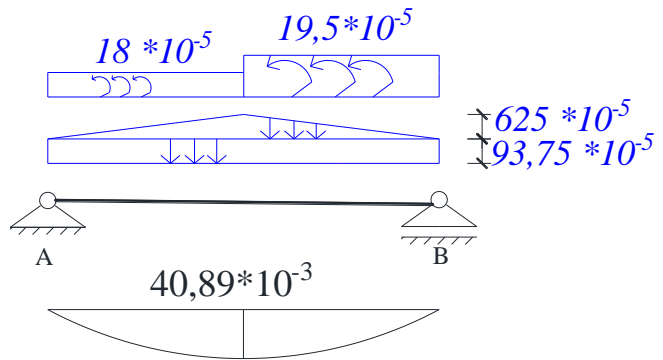
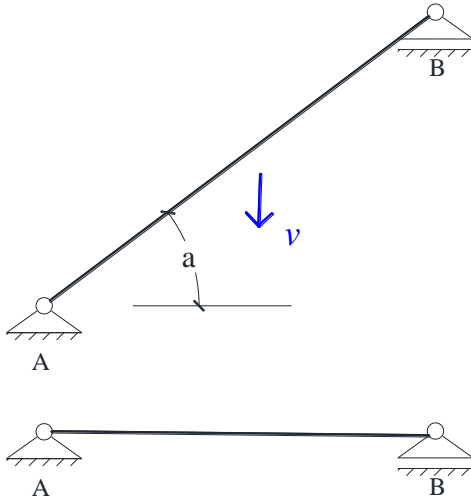
α - ugao između stvarnog i fiktivnog nosača

$$p^f = \left(\frac{M}{EI} + \alpha_t \frac{\Delta t}{h} \right) \frac{1}{\cos \alpha} = \left(\frac{200}{4 \cdot 10^4} + 75 \cdot 10^{-5} \right) \frac{1}{1} = 0,005 + 0,00075$$



α je pozitivan ukoliko ide u smeru kazaljke na satu.

c) Vertikalno pomeranje



$$\arctg \alpha = 6/8 = 36,87^\circ \rightarrow \alpha = -36,87^\circ$$

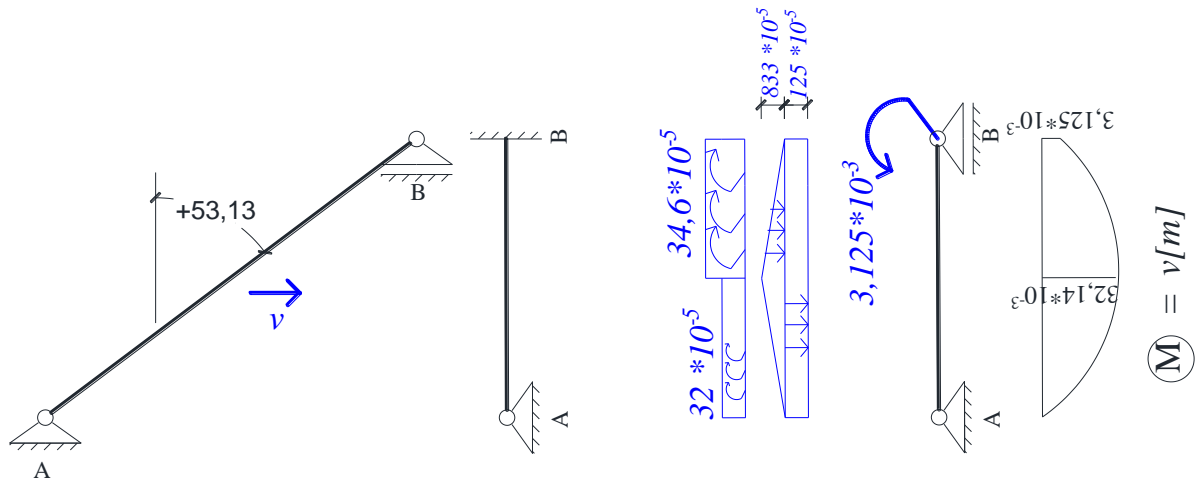
$$p^f = \left(\frac{M}{EI} + \alpha_t \frac{\Delta t}{h} \right) \frac{1}{\cos \alpha} = \left(\frac{200}{4 \cdot 10^4} + 75 \cdot 10^{-5} \right) \frac{1}{0,8} = (625 + 93,75) 10^{-5}$$

$$a-c: m^f = \left(\frac{N}{EF} + \alpha_t t^0 \right) \cdot \operatorname{tg} \alpha = \left(\frac{-30}{3 \cdot 10^6} + 25 \cdot 10^{-5} \right) \cdot (-0,75) = -18 \cdot 10^{-5}$$

$$c-b: m^f = \left(\frac{N}{EF} + \alpha_t t^0 \right) \cdot \operatorname{tg} \alpha = \left(\frac{30}{3 \cdot 10^6} + 25 \cdot 10^{-5} \right) \cdot (-0,75) = -19,5 \cdot 10^{-5}$$

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d) Horizontalno pomjeranje

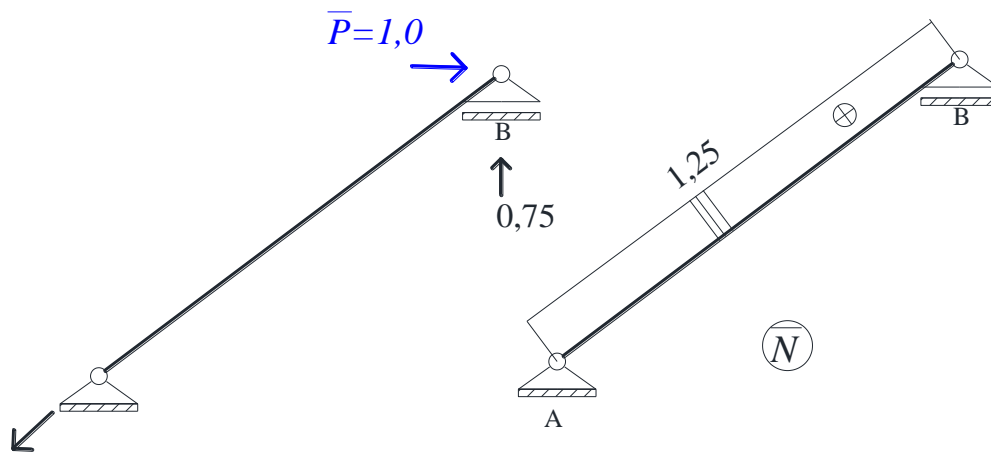


$$\arctg \alpha = 8/6 = 53,13^\circ \rightarrow \alpha = +53,13^\circ$$

$$p^f = \left(\frac{M}{EI} + \alpha_t \frac{\Delta t}{h} \right) \frac{1}{\cos \alpha} = \left(\frac{200}{4 \cdot 10^4} + 75 \cdot 10^{-5} \right) \frac{1}{0,6} = (833,3 + 125) 10^{-5}$$

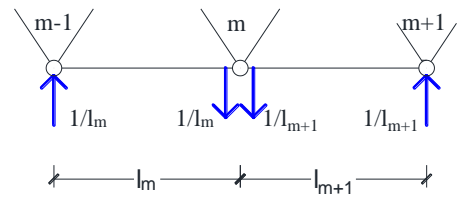
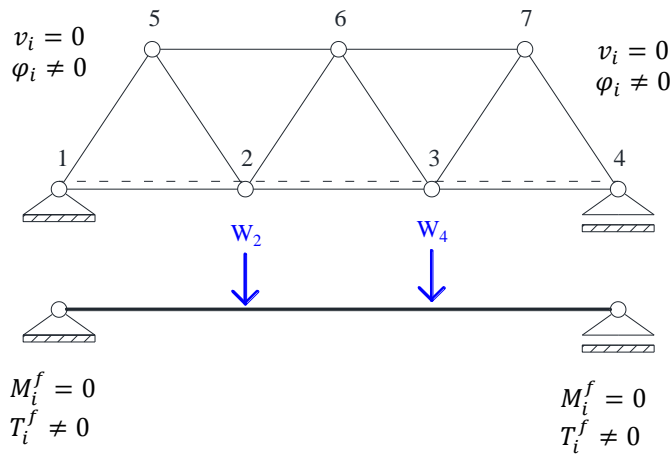
$$a-c: m^f = \left(\frac{N}{EF} + \alpha_t t^\circ \right) \cdot \operatorname{tg} \alpha = \left(\frac{-30}{3 \cdot 10^6} + 25 \cdot 10^{-5} \right) \cdot 1,333 = 32 \cdot 10^{-5}$$

$$c-b: m^f = \left(\frac{N}{EF} + \alpha_t t^\circ \right) \cdot \operatorname{tg} \alpha = \left(\frac{30}{3 \cdot 10^6} + 25 \cdot 10^{-5} \right) \cdot 1,333 = 34,6 \cdot 10^{-5}$$



$$v_b = \int \frac{N \bar{N}}{EF} d_s + \int \bar{N} \alpha_t t^\circ d_s = 25 \cdot 10^{-5} \cdot 1,25 \cdot 10 = 3,125 \cdot 10^{-3} m$$

Dijagram pomeranja rešetkastih nosača



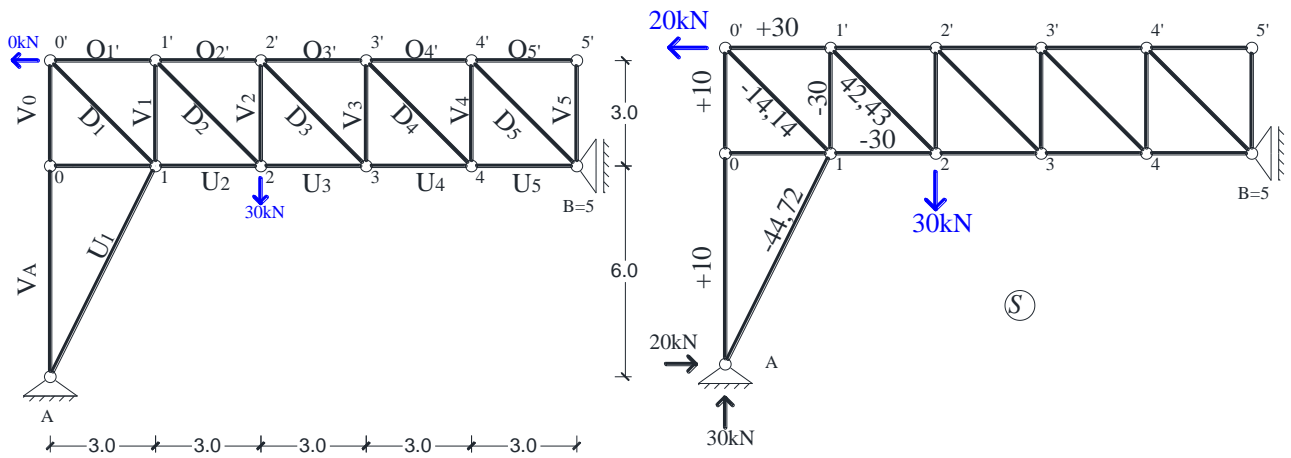
Izraz za elastične težine (razlika obrtanja štapova levo i desno od čvora):

$$W_m = \sum \frac{S \cdot \bar{S}}{EF} l + \sum \bar{S}_m \alpha_T t^\circ l$$

Zadatak: Za rešetkasti nosač sa slike nacrtati dijagram vertikalnog pomeranja gornjeg pojasa usled:

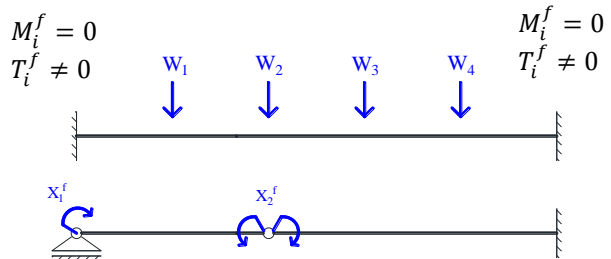
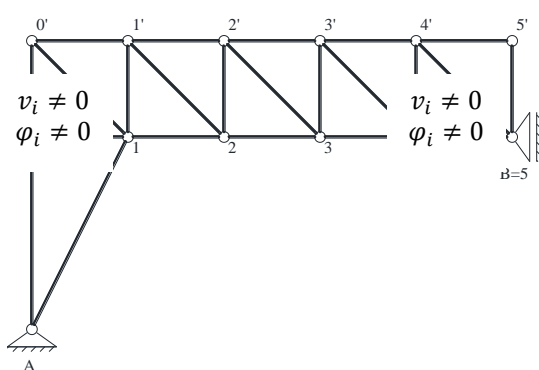
- Zadatog opterećenja sa slike
- Temperaturne promene u osama štapova gornjeg pojasa $t^\circ = +25^\circ\text{C}$
- Pomeranja oslonca „A“ u levo za 3cm

$EF = \text{const.}$



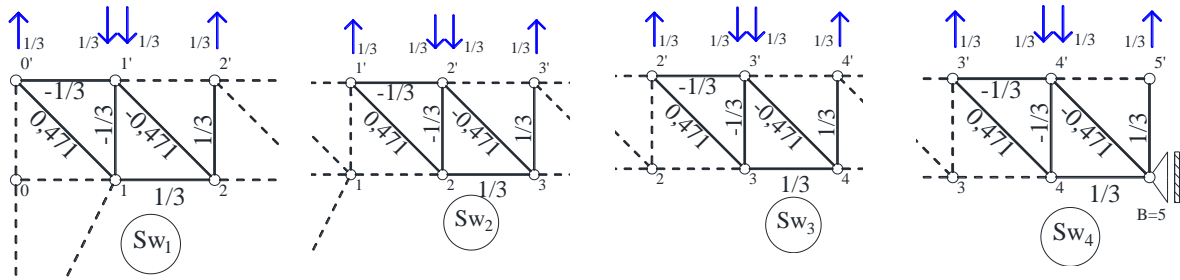
Redukovane dužine zbog $EF = \text{const.}$ su iste kao i stvarne dužine nosača $l'' = \frac{F_c}{F} d_s = l$.

-Fiktivni nosač i elastične težine



Osnovni sistem fiktivnog statički neodređenog nosača.

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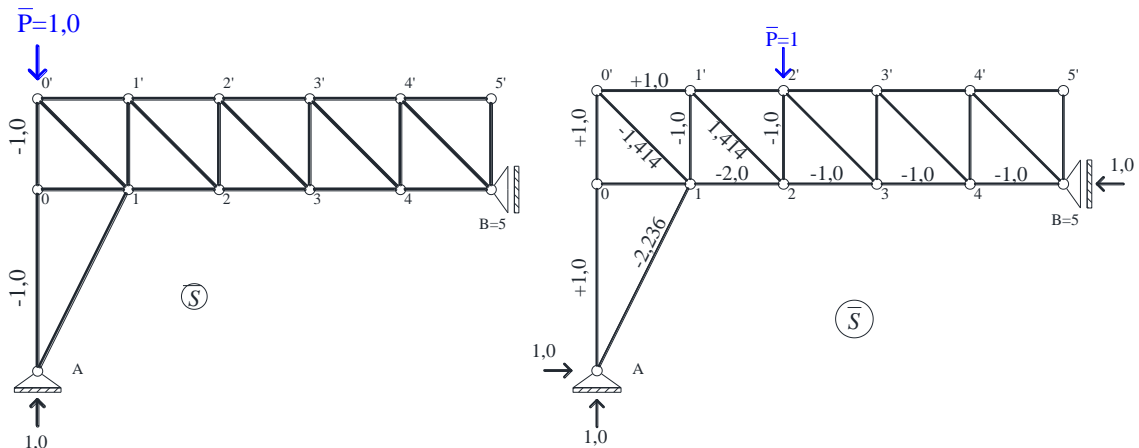


a) Usled zadatog opterećenja

$$\begin{aligned}
 EFW_1 &= \sum S \cdot \bar{S} \cdot l \\
 &= 30 \cdot (-1/3) \cdot 3 + (-30) \cdot 1/3 \cdot 3 + (-30) \cdot (-1/3) \cdot 3 + (-14,14) \cdot 0,471 \\
 &\quad \cdot 4,243 + 42,43 \cdot (-0,471) \cdot 4,243 = -143,05 \\
 EFW_2 &= \sum S \cdot \bar{S} \cdot l = 42,43 \cdot 0,471 \cdot 4,243 = 84,79 \\
 EFW_3 &= EFW_4 = 0
 \end{aligned}$$

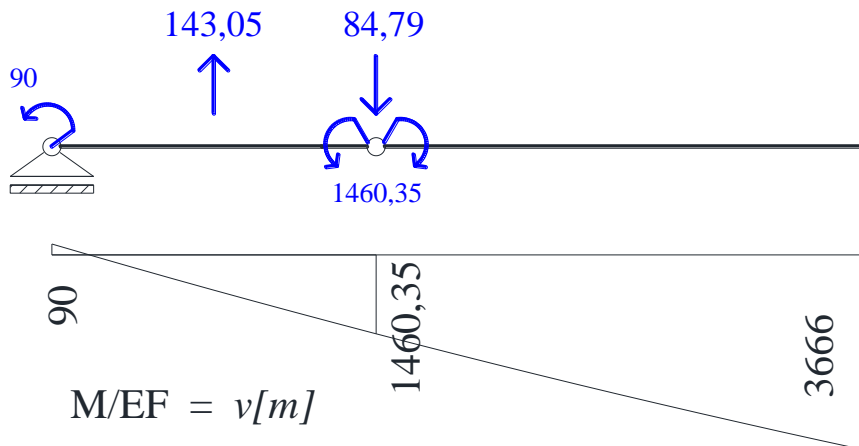
-fiktivne nepoznate

*Stanje $X_1^f = 1$



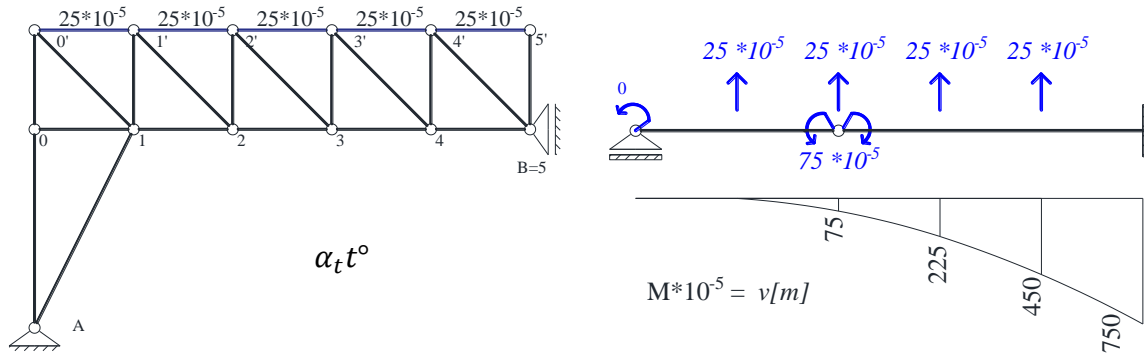
$$X_1^f = EFv_0 = 10 \cdot (-1) \cdot 3 + 10 \cdot (-1) \cdot 6 = -90$$

$$\begin{aligned}
 X_2^f &= EFv_2 = 10 \cdot 1 \cdot 6 + 10 \cdot 1 \cdot 3 + 30 \cdot 1 \cdot 3 + (-14,14) \cdot (-1,414) \cdot 4,243 + (-44,72) \cdot (-2,236) \\
 &\quad \cdot 6,708 + (-30) \cdot (-1) \cdot 3 + 42,43 \cdot 1,414 \cdot 4,243 + (-30) \cdot (-2) \cdot 3 = 1460,2
 \end{aligned}$$



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b) Usled temperaturne promene u osi štapova gornjeg pojasa



$$W_1 = W_2 = W_3 = W_4 = \sum \alpha_t t^o \cdot \bar{s} \cdot L = -25 \cdot 10^{-5} \cdot \frac{1}{3} \cdot 3 = -25 \cdot 10^{-5}$$

$$X_1^f = EFv_0 = 0$$

$$X_2^f = EFv_2 = 25 \cdot 10^{-5} \cdot 1 \cdot 3 = 75 \cdot 10^{-5}$$

c) Usled pomeranja oslonca „A“ za 3cm u levo

Sve elastične težine su jednake 0 zbog toga što pomeranje oslonaca ne izaziva sile u štapovima.

$$X_1^f = v_0 = 0$$

$$X_2^f = v_2 = - \sum \bar{c}_i \bar{c}_i 25 = -(-1) \cdot 0,03 = 0,03$$

