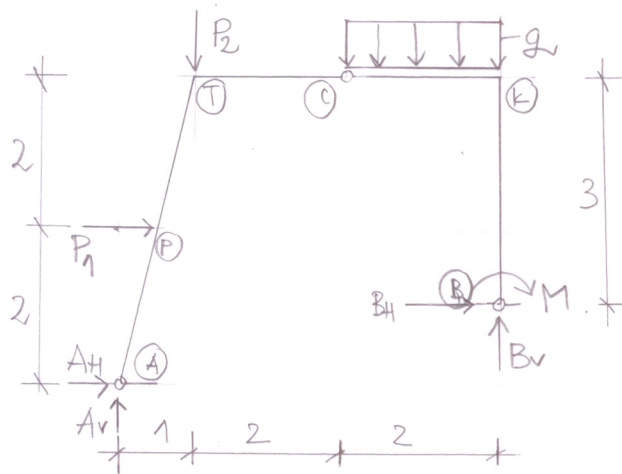


POMOCI TOČKA KONSTRUKCIJE

- ODREDITE VERTIKALNI I HORIZONTALNI POMAK TOČKE (T), TE ZAPDET TOČKE (K)!



$$P_1 = 150 \text{ kN}$$

$$P_2 = 200 \text{ kN}$$

$$q = 55 \text{ kN/m}$$

$$M = 200 \text{ kNm}$$

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

$$\left. \begin{array}{l} b_s/h_s = 30/30 \text{ cm} \\ b_g/h_g = 30/50 \text{ cm} \end{array} \right\} I = \frac{b \cdot h^3}{12}$$

$$E_s I_s = 20250 \text{ kNm}^2$$

$$E_g I_g = 93750 \text{ kNm}^2$$

$$E_s F_s = 2700000 \text{ kN}$$

$$E_g F_g = 4500000 \text{ kN}$$

$$f(M) = \int_s \frac{m_n \cdot M}{EI} ds \dots \text{ utjecaj momenta savijanja na pomak točke konstrukcije}$$

$$f(N) = \int_s \frac{n_n \cdot N}{EF} ds \dots \text{ utjecaj uzdužne sile na pomak točke konstrukcije}$$

$$f(T) = k \int_s \frac{t_n \cdot T}{G \cdot F} ds \dots \text{ utjecaj poprečne sile na pomak točke konstrukcije (zanemarijemo jer je vrlo mali u odnosu na ostale doprinose)}$$

- određivanje dijagrama rezila (M, T, N) iz jednačbi ravnoteže:

$$\sum M(A) = 0 \dots B_v \cdot 5 - B_h \cdot 1 - M - P_1 \cdot 2 - P_2 \cdot 1 - q \cdot 2 \cdot 4 = 0$$

$$\sum M(C) = 0 \dots B_v \cdot 2 + B_h \cdot 3 - M - q \cdot 2 \cdot 1 = 0$$

$$B_v = 219,41 \text{ kN}; B_h = -42,94 \text{ kN}$$

$$\sum M(B) = 0 \dots A_h \cdot 1 - A_v \cdot 5 - P_1 \cdot 1 + P_2 \cdot 4 + q \cdot 2 \cdot 1 - M = 0$$

$$\sum M(C) = 0 \dots A_h \cdot 4 - A_v \cdot 3 + P_1 \cdot 2 + P_2 \cdot 2 = 0$$

$$A_v = 90,59 \text{ kN}; A_h = -107,06 \text{ kN}$$

- izraziti za rezne sile u pojedinim presjecima konstrukcije:



$$M_p = 107,06 \cdot 2 + 90,59 \cdot 0,5 = 259,4 \text{ kNm}$$

$$T_p = -90,59 \cdot \cos \alpha - 107,06 \cdot \sin \alpha = -125,8 \text{ kN}$$

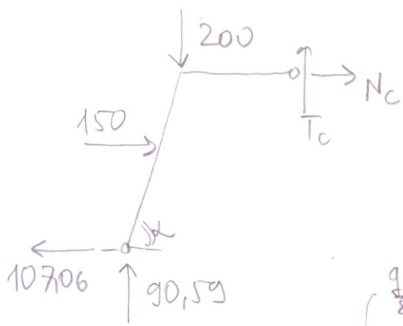
$$N_p = 107,06 \cdot \cos \alpha - 90,59 \cdot \sin \alpha = -61,9 \text{ kN}$$



$$M_t = -150 \cdot 2 + 107,06 \cdot 4 + 90,59 \cdot 1 = 218,83 \text{ kNm}$$

$$T_t = -90,59 \cdot \cos \alpha - 107,06 \cdot \sin \alpha + 150 \cdot \sin \alpha = 19,7 \text{ kN}$$

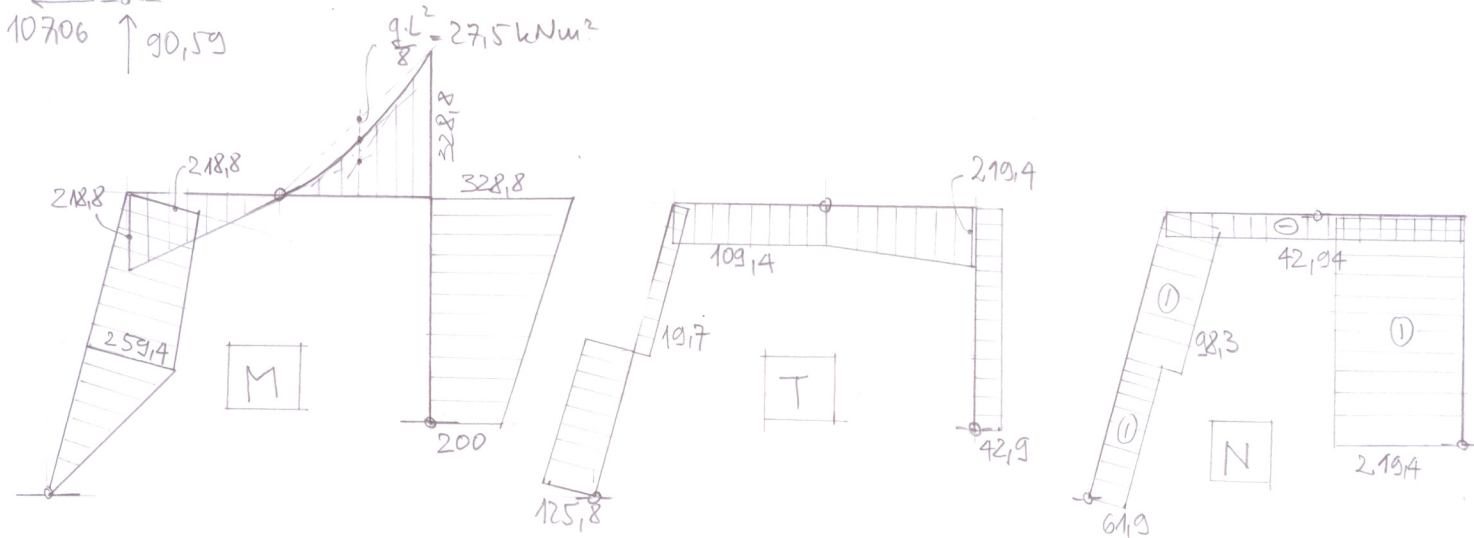
$$N_t = 107,06 \cdot \cos \alpha - 90,59 \cdot \sin \alpha - 150 \cdot \cos \alpha = -98,3 \text{ kN}$$



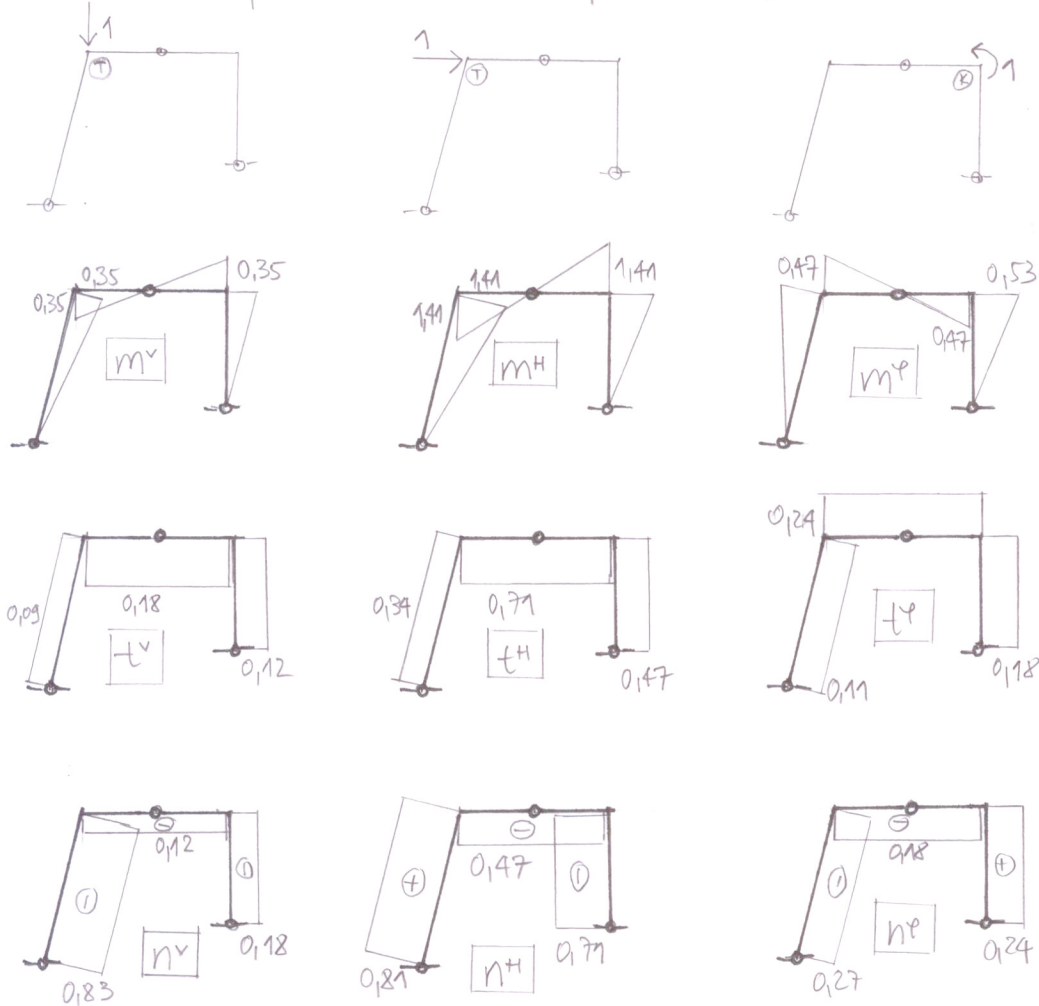
$$T_c = 200 - 90,59 = 109,4 \text{ kN}$$

$$N_c = 107,06 - 150 = -42,94 \text{ kN}$$

itd...



- dijagrami reznih sila od jediničnog opterećenja na mjestu i u smjeru traženih pomaka:



- proračun traženih pomaka (zanemaruje se utjecaj poprečnih sila) pomoću Veresćaginovog teorema:

VERTIKALAN POMAK TOČKE (T)

$$\begin{aligned}
 w_T = & \frac{1}{E_s I_s} \left[\frac{259,4 \cdot \sqrt{4,25}}{2} \cdot \frac{0,35 \cdot 2}{2 \cdot 3} + \frac{259,4 \cdot \sqrt{4,25}}{2} \cdot \left(\frac{2}{3} \cdot \frac{0,35}{2} + \frac{1}{3} \cdot 0,35 \right) + \right. \\
 & + \frac{218,8 \cdot \sqrt{4,25}}{2} \cdot \left(\frac{1}{3} \cdot \frac{0,35}{2} + \frac{2}{3} \cdot 0,35 \right) + \frac{200 \cdot 3}{2} \cdot \frac{1}{3} \cdot 0,35 + \left. \frac{328,8 \cdot 3}{2} \cdot \frac{2}{3} \cdot 0,35 \right] + \\
 & + \frac{1}{E_g I_g} \left[\frac{218,8 \cdot 2}{2} \cdot \frac{2}{3} \cdot 0,35 + \frac{328,8 \cdot 2}{2} \cdot \frac{2}{3} \cdot 0,35 - \frac{2}{3} \cdot 275 \cdot 2 \cdot \frac{0,35}{2} \right] + \\
 & + \frac{1}{E_s F_s} \left[61,9 \cdot \sqrt{4,25} \cdot 0,83 + 98,3 \cdot \sqrt{4,25} \cdot 0,83 + 219,4 \cdot 3 \cdot 0,18 \right] + \\
 & + \frac{1}{E_g F_g} \left[42,94 \cdot 4 \cdot 0,12 \right] = \underbrace{0,016575}_{\text{od momenata savijanja (99,1\%)}} + \underbrace{0,00014999}_{\text{od uzdužnih sila (0,9\%)}} = 1,67 \text{ cm}
 \end{aligned}$$

HORIZONTALAN POMAK TOČKE (T)

$$\begin{aligned}
 w_T = & \frac{1}{E_s I_s} \left[\frac{259,4 \cdot \sqrt{4,25}}{2} \cdot \frac{1,41 \cdot 2}{2 \cdot 3} + \frac{259,4 \cdot \sqrt{4,25}}{2} \cdot \left(\frac{2}{3} \cdot \frac{1,41}{2} + \frac{1}{3} \cdot 1,41 \right) + \right. \\
 & + \frac{218,8 \cdot \sqrt{4,25}}{2} \cdot \left(\frac{1}{3} \cdot \frac{1,41}{2} + \frac{2}{3} \cdot 1,41 \right) + \frac{200 \cdot 3}{2} \cdot \frac{1}{3} \cdot 1,41 + \left. \frac{328,8 \cdot 3}{2} \cdot \frac{2}{3} \cdot 1,41 \right] + \\
 & + \frac{1}{E_g I_g} \left[\frac{218,8 \cdot 2}{2} \cdot \frac{2}{3} \cdot 1,41 + \frac{328,8 \cdot 2}{2} \cdot \frac{2}{3} \cdot 1,41 - \frac{2}{3} \cdot 275 \cdot 2 \cdot \frac{1,41}{2} \right] + \\
 & + \frac{1}{E_s F_s} \left[-61,9 \cdot \sqrt{4,25} \cdot 0,81 - 98,3 \cdot \sqrt{4,25} \cdot 0,81 + 219,4 \cdot 3 \cdot 0,171 \right] + \\
 & + \frac{1}{E_g F_g} \left[42,94 \cdot 4 \cdot 0,47 \right] = \underbrace{0,06678}_{\text{od momenata savijanja (99,9\%)}} + \underbrace{0,00009194}_{\text{od uzdužnih sila (0,1\%)}} = 0,06687 \text{ m} \\
 & \qquad \qquad \qquad w_T = 6,687 \text{ cm}
 \end{aligned}$$

ZAKRET TOČKE (K)

$$\begin{aligned}
 \varphi_K = & \frac{1}{E_s I_s} \left[-\frac{259,4 \cdot \sqrt{4,25}}{2} \cdot \frac{0,47 \cdot 2}{2 \cdot 3} - \frac{259,4 \cdot \sqrt{4,25}}{2} \cdot \left(\frac{2}{3} \cdot \frac{0,47}{2} + \frac{1}{3} \cdot 0,47 \right) - \right. \\
 & - \frac{218,8 \cdot \sqrt{4,25}}{2} \cdot \left(\frac{1}{3} \cdot \frac{0,47}{2} + \frac{2}{3} \cdot 0,47 \right) + \frac{200 \cdot 3}{2} \cdot \frac{1}{3} \cdot 0,153 + \left. \frac{328,8 \cdot 3}{2} \cdot \frac{2}{3} \cdot 0,153 \right] + \\
 & + \frac{1}{E_g I_g} \left[-\frac{218,8 \cdot 2}{2} \cdot \frac{2}{3} \cdot 0,47 - \frac{328,8 \cdot 2}{2} \cdot \frac{2}{3} \cdot 0,47 + \frac{2}{3} \cdot 275 \cdot 2 \cdot \frac{0,47}{2} \right] + \\
 & + \frac{1}{E_s F_s} \left[61,9 \cdot \sqrt{4,25} \cdot 0,27 + 98,3 \cdot \sqrt{4,25} \cdot 0,27 - 219,4 \cdot 3 \cdot 0,124 \right] + \\
 & + \frac{1}{E_g F_g} \left[42,94 \cdot 4 \cdot 0,18 \right] = \underbrace{-0,0010835}_{\text{od momenata savijanja (98,3\%)}} - \underbrace{0,00001861}_{\text{od uzdužnih sila (1,7\%)}} = -0,001102 \text{ rad}
 \end{aligned}$$