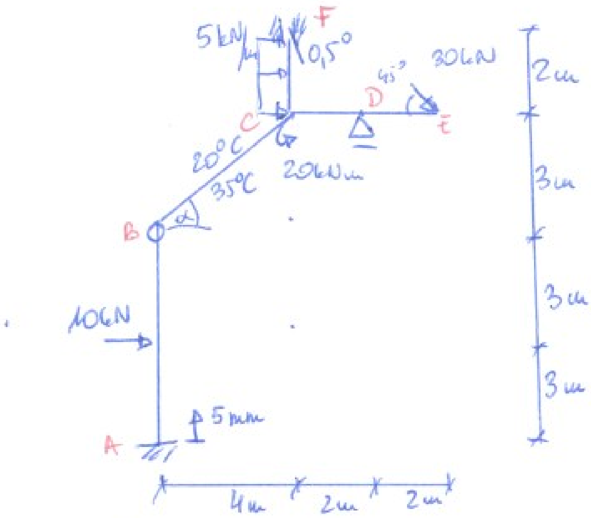


I 220

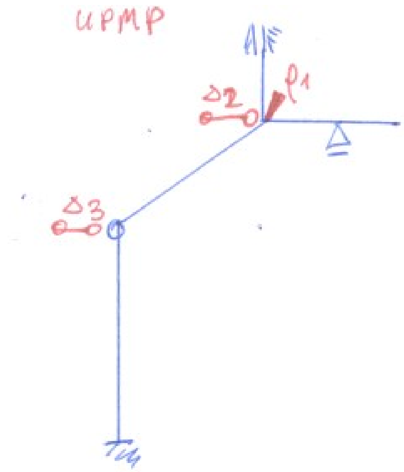
$E = 210\ GPa$

$J = 3060\ cm^4$

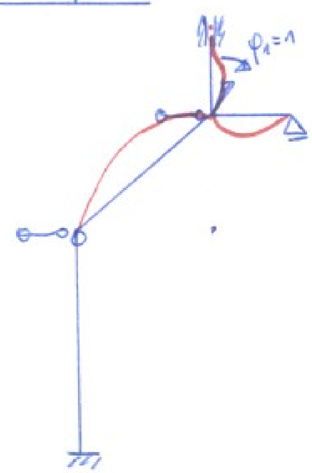
$\sin\alpha = \frac{3}{5}$

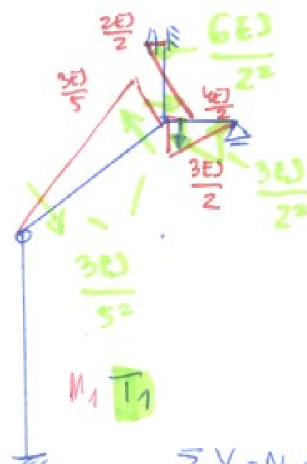
$\cos\alpha = \frac{4}{5}$

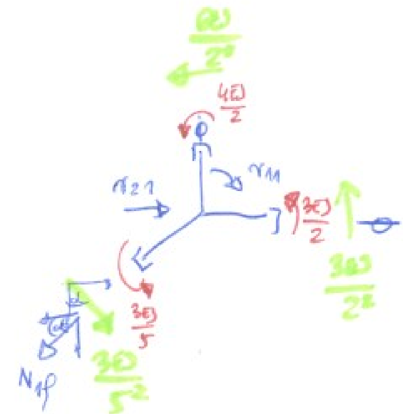
$\alpha_t = 1{,}2\cdot10^{-5}\ \frac{1}{K}$



stan $\varphi_1 = 1$



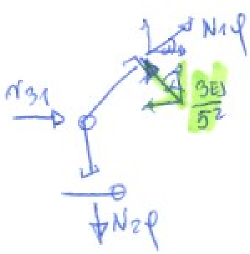




$$r_{11} = \frac{3EJ}{2} + \frac{4EJ}{2} + \frac{3EJ}{5}$$

$$\Sigma Y = N_{1\varphi}\sin\alpha + \frac{3EJ}{5^2}\cos\alpha - \frac{3EJ}{2^2} = 0$$

$$N_{1\varphi} = \left(\frac{3EJ}{2^2} - \frac{3EJ}{5^2}\cdot\cos\alpha\right)\cdot\frac{1}{\sin\alpha}$$



$$\Sigma X = r_{31} + N_{1\varphi}\cdot\cos\alpha - \frac{3EJ}{5^2}\cdot\sin\alpha = 0$$

$$r_{31} = \frac{3EJ}{5^2}\cdot\sin\alpha - N_{1\varphi}\cdot\cos\alpha$$

$$\Sigma X = r_{21} - \frac{6EJ}{2^2} - N_{1\varphi}\cdot\cos\alpha + \frac{3EJ}{5^2}\cdot\sin\alpha = 0$$

$$r_{21} = \frac{6EJ}{2^2} + N_{1\varphi}\cdot\cos\alpha - \frac{3EJ}{5^2}\cdot\sin\alpha$$

stan φ1=1

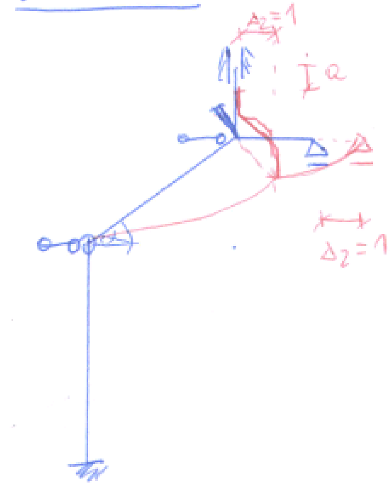
$$r_{11} := 3\frac{EJ}{2m} + 4\frac{EJ}{2m} + 3\frac{EJ}{5m} = 2.635\times10^{4}\,kN\cdot m$$

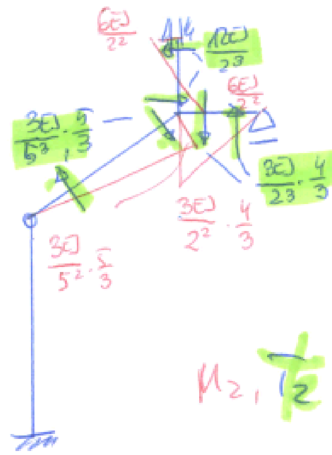
$$N1fi := \left[3\frac{EJ}{(2m)^2} - 3\frac{EJ}{(5m)^2}\cdot\cos\alpha\right]\cdot\frac{1}{\sin\alpha} = 7.004\times10^{6}\,N$$

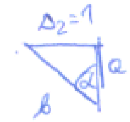
$$r_{21} := 6\frac{EJ}{(2m)^2} - 3\frac{EJ}{(5m)^2}\cdot\sin\alpha + N1fi\cdot\cos\alpha = 1.478\times10^{7}\,N$$

$$r_{31} := 3\frac{EJ}{25m^2}\cdot\sin\alpha - N1fi\cdot\cos\alpha = -5.141\times10^{6}\,N$$

stan $\Delta_2=1$







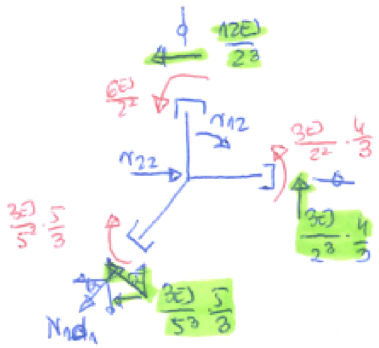
$\sin\alpha=\frac{3}{5}=\frac{1}{b}$

$b=\frac{5}{3}$

$\cos\alpha=\frac{a}{b}=\frac{4}{5}$

$a=\frac{4}{3}$

$M_2,\ T_2$



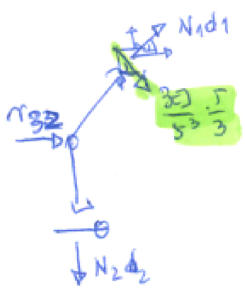
$$r_{12}=\frac{3EJ}{2^2}\cdot\frac{4}{3}+\frac{6EJ}{2^2}-\frac{3EJ}{5^2}\cdot\frac{5}{3}$$

$$\Sigma Y=\frac{3EJ}{2^3}\cdot\frac{4}{3}+\frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\cos\alpha-N_1d_2\cdot\sin\alpha=0$$

$$N_1d_2=\left(\frac{3EJ}{2^3}\cdot\frac{4}{3}+\frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\frac{4}{5}\right)\cdot\frac{1}{\sin\alpha}$$

$$\Sigma X=r_{22}-\frac{12EJ}{2^3}-\frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\sin\alpha-N_1d_2\cos\alpha=0$$

$$r_{22}=\frac{12EJ}{2^3}+\frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\sin\alpha+N_1d_2\cos\alpha$$



$$\Sigma X=N_1d_2\cdot\cos\alpha+\frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\sin\alpha+r_{32}=0$$

$$r_{32}=-N_1d_2\cdot\cos\alpha-\frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\sin\alpha$$

stan Δ2=1

$$r_{12}:=\frac{3EJ}{(2m)^2}\cdot\frac{4}{3}+6\frac{EJ}{(2m)^2}\cdot1-\frac{3EJ}{(5m)^2}\cdot\frac{5}{3}=1.478\times10^{4}kN$$

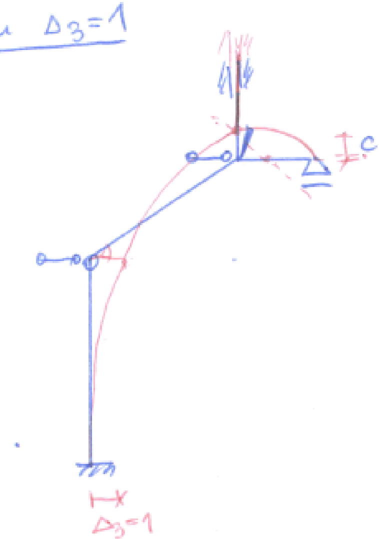
$r_{12}-r_{21}=0N$

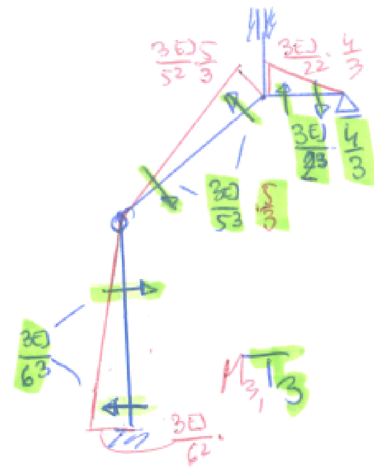
$$N1d2:=\left[\frac{3EJ}{(2m)^3}\cdot\frac{4}{3}+3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\cos\alpha\right]\cdot\frac{1}{\sin\alpha}=5.698\times10^{3}\frac{kN}{m}$$

$$r_{22}:=\frac{12EJ}{(2m)^3}+N1d2\cdot\cos\alpha+3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\sin\alpha=1.435\times10^{4}\frac{kN}{m}$$

$$r_{32}:=-N1d2\cdot\cos\alpha-3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\sin\alpha=-4.712\times10^{3}\frac{kN}{m}$$

stan $\Delta_3=1$



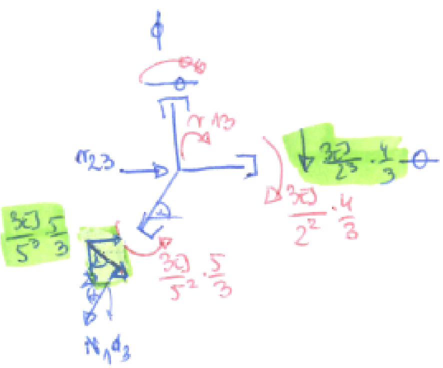


$\sin\alpha = \frac{3}{5} = \frac{1}{d}$

$d = \frac{5}{3}$

$\cos\alpha = \frac{4}{5} = \frac{c}{d}$

$c = \frac{5}{3}\cdot\frac{4}{5} = \frac{4}{3}$



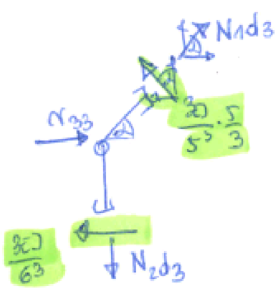
$r_{13} = \frac{3EJ}{5^2}\cdot\frac{5}{3} - \frac{3EJ}{2^2}\cdot\frac{4}{3}$

$\Sigma Y = \frac{3EJ}{2^3}\cdot\frac{4}{3} + \frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\cos\alpha + N_1d_3\cdot\sin\alpha = 0$

$N_1d_3 = \left(\frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\cos\alpha - \frac{3EJ}{2^3}\cdot\frac{4}{3}\right)\cdot\frac{1}{\sin\alpha}$

$\Sigma X = r_{23} + \frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\sin\alpha + N_1d_3\cdot\cos\alpha = 0$

$r_{23} = -\frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\sin\alpha + N_1d_3\cdot\cos\alpha$



$\Sigma X = r_{33} + N_1d_3\cdot\cos\alpha - \frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\sin\alpha - \frac{3EJ}{6^3} = 0$

$r_{33} = \frac{3EJ}{6^3} + \frac{3EJ}{5^3}\cdot\frac{5}{3}\cdot\sin\alpha - N_1d_3\cdot\cos\alpha$

stan Δ3=1

$r_{13} := \frac{3EJ}{(5m)^2}\cdot\frac{5}{3} - \frac{3EJ}{(2m)^2}\cdot\frac{4}{3} = -5.141\times10^3\,kN$

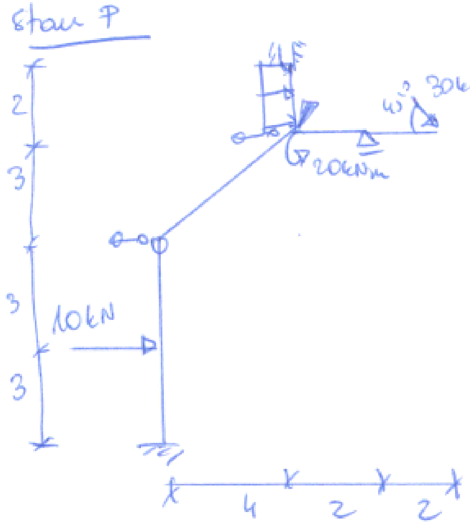
$r_{13} - r_{31} = 0\,N$

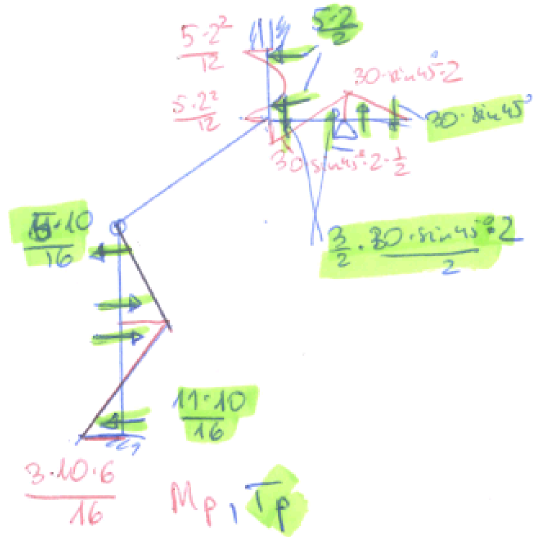
$N1d3 := \left[-\frac{3EJ}{(2m)^3}\cdot\frac{4}{3} - 3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\cos\alpha\right]\cdot\frac{1}{\sin\alpha} = -5.698\times10^3\,\frac{kN}{m}$

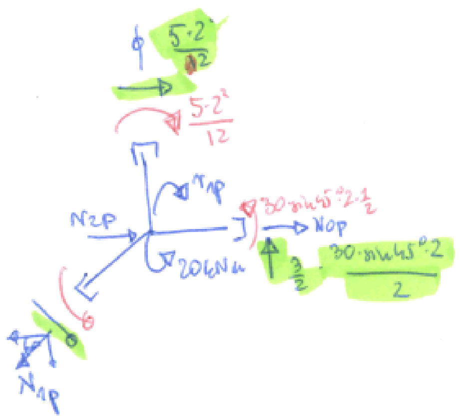
$r_{23} := N1d3\cdot\cos\alpha - 3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\sin\alpha = -4.712\times10^3\,\frac{kN}{m}$

$r_{23} - r_{32} = 0\,\frac{kN}{m}$

$r_{33} := -N1d3\cdot\cos\alpha + 3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\sin\alpha + \frac{3EJ}{(6m)^3} = 4.802\times10^3\,\frac{kN}{m}$







$$r_{1p} = 30\cdot\sin 45°\cdot 2\cdot\frac{1}{2} - \frac{5\cdot 2^2}{12} + 20$$

$$\Sigma X = -N_{0p} + \cos 45°\cdot 30$$

$$N_{0p} = 30\cdot\cos 45°$$

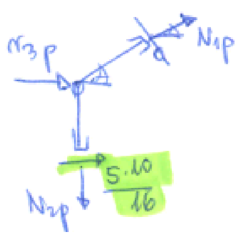
$$\Sigma X = N_{0p} - N_{wp} = 0$$

$$N_{wp} = N_{0p}$$

$$\Sigma Y = \frac{3}{2}\cdot\frac{30\cdot\sin 45°\cdot 2}{2} - N_{1p}\cdot\sin\alpha = 0$$

$$N_{1p} = \left(\frac{3}{2}\cdot\frac{30\cdot\sin 45°\cdot 2}{2}\right)\cdot\frac{1}{\sin\alpha}$$

$$\Sigma X = r_{2p} - N_{1p}\cdot\cos\alpha + \frac{5\cdot 2}{2} + N_{0p}$$



$$\Sigma X = r_{3p} + N_{1p}\cos\alpha + \frac{5\cdot 10}{16} = 0$$

$$r_{3p} = -\frac{5\cdot 10}{16} - N_{1p}\cos\alpha$$

stan P

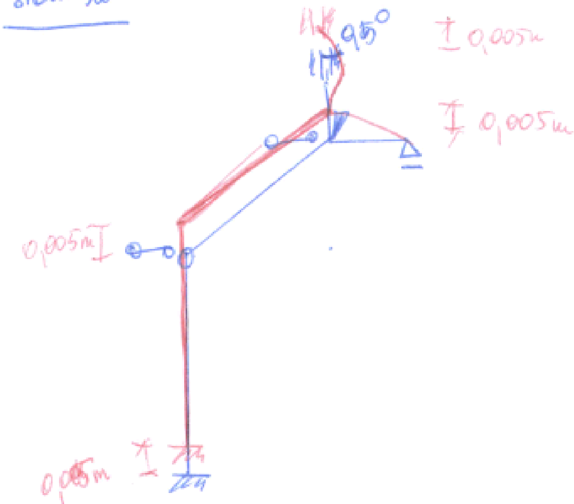
$$r_{1p} := 30kN\cdot\sin(45deg)\cdot 2m\cdot\frac{1}{2} - 5\frac{kN}{m}\cdot\frac{(2m)^2}{12} + 20kN\cdot m = 39.547\,kN\cdot m$$

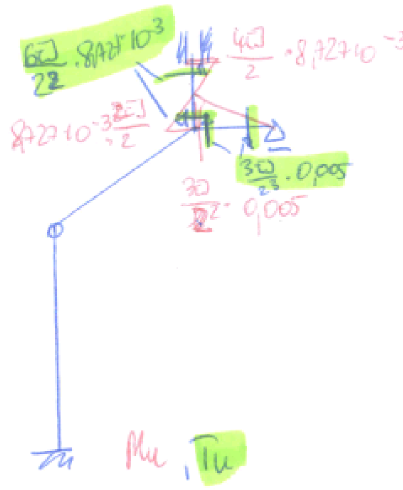
$$N1p := \frac{3}{2}\cdot\frac{30kN\cdot\sin(45deg)\cdot 2m}{2m}\cdot\frac{1}{\sin\alpha} = 53.033\,kN \qquad N0p := 30kN\cdot\cos(45deg) = 21.213\,kN$$

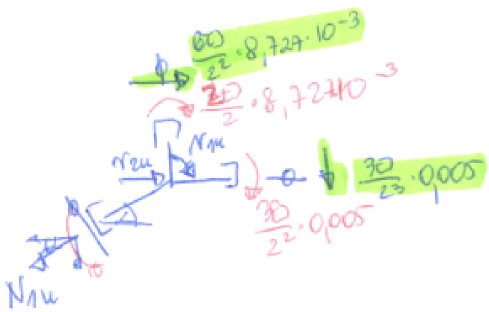
$$r_{2p} := N1p\cdot\cos\alpha - \frac{5\frac{kN}{m}\cdot 2m}{2} - N0p = 16.213\,kN$$

$$r_{3p} := \frac{-5\cdot 10kN}{16} - N1p\cdot\cos\alpha = -45.551\,kN$$

stan u







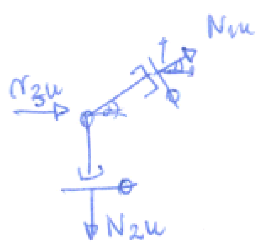
$$\Sigma Y = N_{1u}\cdot\sin\alpha + \frac{3EJ}{2^3}\cdot 0{,}005 = 0$$

$$N_{1u} = \left(-\frac{3EJ}{2^3}\cdot 0{,}005\right)\cdot\frac{1}{\sin\alpha}$$

$$\Sigma X = r_{2u} + \frac{6EJ}{2^2}\cdot 8{,}727\cdot 10^{-3} - N_{1u}\cdot\cos\alpha = 0$$

$$r_{2u} = N_{1u}\cdot\cos\alpha - \frac{6EJ}{2^2}\cdot 8{,}727\cdot 10^{-3}$$

$$r_{1u} = -\frac{3EJ}{2^2}\cdot 0{,}005 - \frac{2EJ}{2}\cdot 8{,}727\cdot 10^{-3}$$



$$\Sigma X = r_{3u} + N_{1u}\cdot\cos\alpha = 0$$

$$r_{3u} = -N_{1u}\cdot\cos\alpha$$

$$0.5\text{deg} = 8.727\times 10^{-3}$$

stan u

$$r_{1u} := -3\,\frac{EJ}{(2m)^2}\cdot 0.005m - \frac{2EJ}{2m}\cdot 8.727\cdot 10^{-3} = -80.177\,kN\cdot m$$

$$N1u := \frac{-3EJ}{(2m)^3}\cdot 0.005m\cdot\frac{1}{\sin\alpha} = -20.081\,kN$$

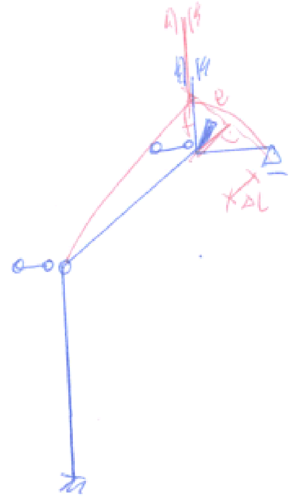
$$r_{2u} := N1u\cdot\cos\alpha - \frac{6EJ}{(2m)^2}\cdot 8.727\cdot 10^{-3} = -100.185\,kN$$

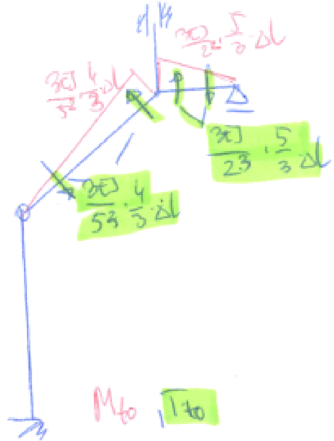
$$r_{3u} := -N1u\cdot\cos\alpha = 16.065\,kN$$

stan t_0

$t_0 = 0{,}5\cdot(t_g + t_d) = 27{,}5$

$\Delta l = \alpha_t \cdot t_0 \cdot l = 1{,}2\cdot 10^{-5}\cdot 27{,}5 \cdot 5 = 1{,}65\cdot 10^{-3}$



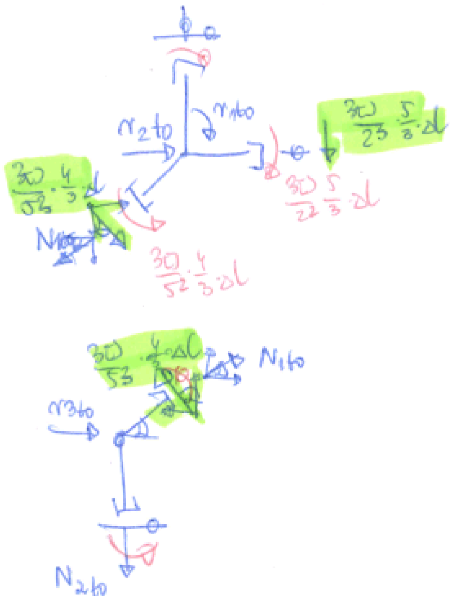


$\sin\alpha = \frac{3}{5} = \frac{\Delta l}{f}$

$f = \Delta l \cdot \frac{5}{3}$

$\cos\alpha = \frac{4}{5} = \frac{e}{f}$

$e = \frac{4}{5} f = \frac{4}{5}\Delta l \cdot \frac{5}{3} = \frac{4}{3}\Delta l$



$r_{1t0} = \frac{3EJ}{5^2}\cdot\frac{4}{3}\cdot\Delta l - \frac{3EJ}{2^2}\cdot\frac{5}{3}\cdot\Delta l$

$\Sigma X = N_{1t0}\cdot\sin\alpha + \frac{3EJ}{5^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\cos\alpha + \frac{3EJ}{2^3}\cdot\frac{5}{3}\cdot\Delta l$

$N_{1t0} = -\frac{3EJ}{5^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\cos\alpha\cdot\frac{1}{\sin\alpha} - \frac{3EJ}{2^3}\cdot\frac{5}{3}\cdot\Delta l\cdot\frac{1}{\sin\alpha}$

$\Sigma X = r_{2t0} - N_{1t0}\cos\alpha + \frac{3EJ}{5^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\sin\alpha = 0$

$r_{2t0} = N_{1t0}\cos\alpha - \frac{3EJ}{5^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\sin\alpha$

$\Sigma X = r_{3t0} + N_{1t0}\cos\alpha - \frac{3EJ}{5^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\sin\alpha = 0$

$r_{3t0} = \frac{3EJ}{5^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\sin\alpha - N_{1t0}\cos\alpha$

stan t_0

$t_g := 20 \qquad t_d := 35 \qquad \alpha_t := 1.2\cdot 10^{-5}$

$t_0 := \frac{t_g + t_d}{2} = 27.5 \qquad \Delta l := \alpha_t t_0 \cdot 5\text{m} = 1.65\times 10^{-3}\,\text{m}$

$r_{1t0} := \frac{3EJ}{(5\text{m})^2}\cdot\frac{4}{3}\cdot\Delta l - \frac{3EJ}{(2\text{m})^2}\cdot\frac{5}{3}\cdot\Delta l = -11.557\,\text{kN}\cdot\text{m}$

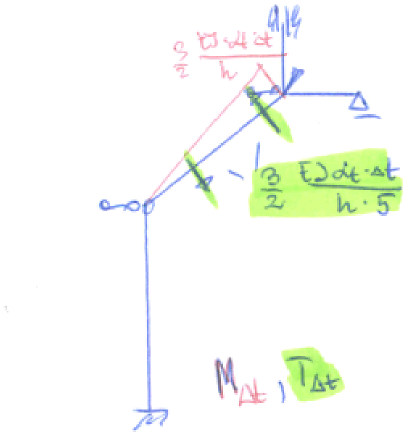
$N1t0 := -\frac{1}{\sin\alpha}\cdot\left[\frac{3EJ}{(5\text{m})^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\cos\alpha + \frac{3EJ}{(2\text{m})^3}\cdot\frac{5}{3}\cdot\Delta l\right] = -11.497\,\text{kN}$

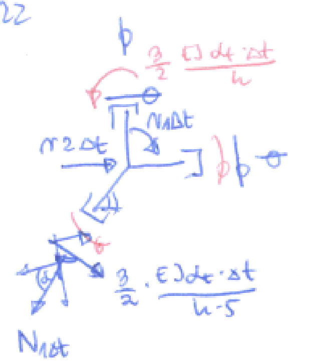
$r_{2t0} := N1t0\cdot\cos\alpha - 3\,\frac{EJ}{(5\text{m})^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\sin\alpha = -9.401\,\text{kN}$

$r_{3t0} := -N1t0\cdot\cos\alpha + 3\,\frac{EJ}{(5\text{m})^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\sin\alpha = 9.401\,\text{kN}$

stan Δt

$\Delta t = |t_d - t_g| = 15$ $\qquad h = 0{,}22$





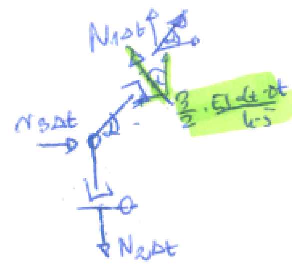
$$r_{1\Delta t} = \frac{3}{2}\frac{EJ\alpha_t\cdot\Delta t}{h}$$

$$\Sigma X = r_{2\Delta t} + \frac{3}{2}\cdot\frac{EJ\alpha_t\cdot\Delta t}{0{,}22\cdot 5}\cdot\sin\alpha - N_{1\Delta t}\cdot\cos\alpha = 0$$

$$r_{2\Delta t} = -\frac{3}{2}\cdot\frac{EJ\alpha_t\cdot\Delta t}{0{,}22\cdot 5}\cdot\sin\alpha + N_{1\Delta t}\cdot\cos\alpha$$

$$\Sigma Y = N_{1\Delta t}\cdot\sin\alpha + \frac{3}{2}\cdot\frac{EJ\alpha_t\cdot\Delta t}{0{,}22\cdot 5}\cdot\cos\alpha = 0$$

$$N_{1\Delta t} = -\frac{3}{2}\cdot\frac{EJ\alpha_t\Delta t}{0{,}22\cdot 5}\cdot\cos\alpha\cdot\frac{1}{\sin\alpha}$$



$$\Sigma X = r_{3\Delta t} + N_{1\Delta t}\cdot\cos\alpha - \frac{3}{2}\frac{EJ\alpha_t\Delta t}{h\cdot 5}\cdot\sin\alpha$$

$$r_{3\Delta t} = -N_{1\Delta t}\cdot\cos\alpha + \frac{3}{2}\frac{EJ\alpha_t\Delta t}{h\cdot 5}\cdot\sin\alpha$$

stan Δt

$\Delta t := t_d - t_g = 15$ $\qquad h := 0.22m$

$$r_{1\Delta t} := \frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h} = 7.886\,kN\cdot m$$

$$N1\Delta t := -\frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h\cdot 5m}\cdot\cos\alpha\cdot\frac{1}{\sin\alpha} = -2.103\,kN$$

$$r_{2\Delta t} := -\frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h\cdot 5m}\cdot\sin\alpha + N1\Delta t\cdot\cos\alpha = -2.629\,kN$$

$$r_{3\Delta t} := -N1\Delta t\cdot\cos\alpha + \frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h\cdot 5m}\cdot\sin\alpha = 2.629\,kN$$

Układ równań kanonicznych

$$\begin{cases} r_{11}\cdot\varphi_1 + r_{12}\Delta_2 + r_{13}\cdot\Delta_3 + r_{1p} + r_{1u} + r_1\Delta t + r_1 t_0 = 0 \\ r_{21}\varphi_1 + r_{22}\Delta_2 + r_{23}\cdot\Delta_3 + r_{2p} + r_{2u} + r_2\Delta t + r_2 t_0 = 0 \\ r_{31}\varphi_1 + r_{32}\cdot\Delta_2 + r_{33}\cdot\Delta_3 + r_{3p} + r_{3u} + r_3\Delta t + r_3 t_0 = 0 \end{cases}$$

$$A := \begin{pmatrix} \frac{r_{11}}{kN\cdot m} & \frac{r_{12}}{kN} & \frac{r_{13}}{kN} \\ \frac{r_{21}}{kN} & \frac{r_{22}}{\frac{kN}{m}} & \frac{r_{23}}{\frac{kN}{m}} \\ \frac{r_{31}}{kN} & \frac{r_{32}}{\frac{kN}{m}} & \frac{r_{33}}{\frac{kN}{m}} \end{pmatrix} \qquad C := \begin{bmatrix} \frac{-(r_{1p} + r_{1u} + r_{1t0} + r_{1\Delta t})}{kN\cdot m} \\ \frac{-(r_{2p} + r_{2u} + r_{2t0} + r_{2\Delta t})}{kN} \\ \frac{-(r_{3p} + r_{3u} + r_{3t0} + r_{3\Delta t})}{kN} \end{bmatrix}$$

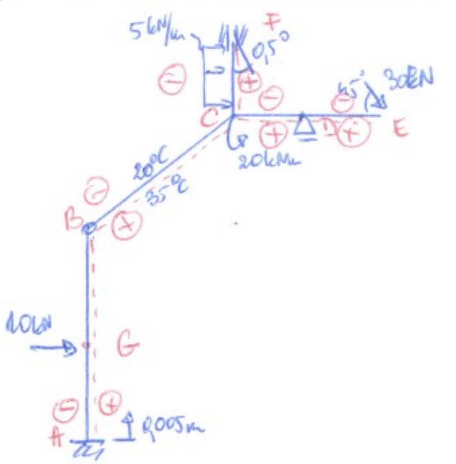
$$B := A^{-1}\cdot C = \begin{pmatrix} -4.526\times 10^{-3} \\ 0.016 \\ 0.015 \end{pmatrix}$$

$$\varphi_1 := B_0 = -4.526\times 10^{-3}$$

$$\Delta_2 := B_1\cdot m = 16.161\times 10^{-3}\,m$$

$$\Delta_3 := B_2\cdot m = 14.650\times 10^{-3}\,m$$

Wyznaczenie momentów ostatecznych i tnących ostatecznych



Określenie położenia włókien dolnych (oznakowanie Momentów)

Dla każdego punktu:

$$M_{ost} = M_1\cdot\varphi_1 + M_2\cdot\Delta_2 + M_3\cdot\Delta_3 + M_p + M_u + M_{t0} + M_{\Delta t}$$

$$T_{ost} = T_1\cdot\varphi_1 + T_2\cdot\Delta_2 + T_3\cdot\Delta_3 + T_p + T_u + T_{t0} + T_{\Delta t}$$

$M_{1AB} := 0$ $\quad M_{2AB} := 0$ $\quad M_{3AB} := -\frac{3EJ}{(6m)^2}$ $\quad M_{pAB} := -\frac{3\cdot 10kN\cdot 6m}{16}$

$M_{1BA} := 0$ $\quad M_{2BA} := 0$ $\quad M_{3BA} := 0$ $\quad M_{pBA} := 0$

$M_{1BC} := 0$ $\quad M_{2BC} := 0$ $\quad M_{3BC} := 0$ $\quad M_{pBC} := 0$

$M_{1CB} := -\frac{3EJ}{5m}$ $\quad M_{2CB} := \frac{3EJ}{(5m)^2}\cdot\frac{5}{3}$ $\quad M_{3CB} := -\frac{3EJ}{(5m)^2}\cdot\frac{5}{3}$ $\quad M_{pCB} := 0$

$M_{1CD} := \frac{3EJ}{2m}$ $\quad M_{2CD} := \frac{3EJ}{(2m)^2}\cdot\frac{4}{3}$ $\quad M_{3CD} := -\frac{3EJ}{(2m)^2}\cdot\frac{4}{3}$ $\quad M_{pCD} := 30kN\cdot\sin(45deg)\cdot 2m\cdot\frac{1}{2}$

$M_{1DC} := 0$ $\quad M_{2DC} := 0$ $\quad M_{3DC} := 0$ $\quad M_{pDC} := -30kN\cdot\sin(45deg)\cdot 2m$

$M_{1DE} := 0$ $\quad M_{2DE} := 0$ $\quad M_{3DE} := 0$ $\quad M_{pDE} := -30kN\cdot\sin(45deg)\cdot 2m$

$M_{1ED} := 0$ $\quad M_{2ED} := 0$ $\quad M_{3ED} := 0$ $\quad M_{pED} := 0$

$M_{1CF} := \frac{4EJ}{2m}$ $\quad M_{2CF} := \frac{6EJ}{(2m)^2}$ $\quad M_{3CF} := 0$ $\quad M_{pCF} := -5\frac{kN}{m}\cdot(2m)^2\cdot\frac{1}{12}$

$M_{1FC} := -\frac{2EJ}{2m}$ $\quad M_{2FC} := -\frac{6EJ}{(2m)^2}$ $\quad M_{3FC} := 0$ $\quad M_{pFC} := -5\frac{kN}{m}\cdot(2m)^2\cdot\frac{1}{12}$

$M_{uAB} := 0$ $\quad M_{t0AB} := 0$ $\quad M_{\Delta tAB} := 0$

$M_{uBA} := 0$ $\quad M_{t0BA} := 0$ $\quad M_{\Delta tBA} := 0$

$M_{uBC} := 0$ $\quad M_{t0BC} := 0$ $\quad M_{\Delta tBC} := 0$

$M_{uCB} := 0$ $\quad M_{t0CB} := -\frac{3EJ}{(5m)^2}\cdot\frac{4}{3}\cdot\Delta 1$ $\quad M_{\Delta tCB} := -\frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h}$

$M_{uCD} := -\frac{3EJ}{(2m)^2}\cdot 0.005m$ $\quad M_{t0CD} := -\frac{3EJ}{(2m)^2}\cdot\frac{5}{3}\cdot\Delta 1$ $\quad M_{\Delta tCD} := 0$

$M_{uDC} := 0$ $\quad M_{t0DC} := 0$ $\quad M_{\Delta tDC} := 0$

$M_{uDE} := 0$ $\quad M_{t0DE} := 0$ $\quad M_{\Delta tDE} := 0$

$M_{uED} := 0$ $\quad M_{t0ED} := 0$ $\quad M_{\Delta tED} := 0$

$M_{uCF} := -\frac{2EJ}{2m}\cdot 8.727\times 10^{-3}$ $\quad M_{t0CF} := 0$ $\quad M_{\Delta tCF} := 0$

$M_{uFC} := \frac{4EJ}{2m}\cdot 8.727\times 10^{-3}$ $\quad M_{t0FC} := 0$ $\quad M_{\Delta tFC} := 0$

$$T_{1AB} := 0 \qquad T_{2AB} := 0 \qquad T_{3AB} := \frac{3EJ}{(6m)^3} \qquad T_{pAB} := \frac{11 \cdot 10kN}{16}$$

$$T_{1BA} := 0 \qquad T_{2BA} := 0 \qquad T_{3BA} := \frac{3EJ}{(6m)^3} \qquad T_{pBA} := \frac{-5 \cdot 10kN}{16}$$

$$T_{1BC} := -\frac{3EJ}{(5m)^2} \qquad T_{2BC} := \frac{3EJ}{(5m)^3} \cdot \frac{5}{3} \qquad T_{3BC} := -\frac{3EJ}{(5m)^3} \cdot \frac{5}{3} \qquad T_{pBC} := 0$$

$$T_{1CB} := -\frac{3EJ}{(5m)^2} \qquad T_{2CB} := \frac{3EJ}{(5m)^3} \cdot \frac{5}{3} \qquad T_{3CB} := -\frac{3EJ}{(5m)^3} \cdot \frac{5}{3} \qquad T_{pCB} := 0$$

$$T_{1CD} := -\frac{3EJ}{(2m)^2} \qquad T_{2CD} := -\frac{3EJ}{(2m)^3} \cdot \frac{4}{3} \qquad T_{3CD} := \frac{3EJ}{(2m)^3} \cdot \frac{4}{3} \qquad T_{pCD} := \frac{-3}{2m} \cdot 30kN \cdot \sin(45deg) \cdot 2m \cdot \frac{1}{2}$$

$$T_{1DC} := -\frac{3EJ}{(2m)^2} \qquad T_{2DC} := -\frac{3EJ}{(2m)^3} \cdot \frac{4}{3} \qquad T_{3DC} := \frac{3EJ}{(2m)^3} \cdot \frac{4}{3} \qquad T_{pDC} := \frac{-3}{2m} \cdot 30kN \cdot \sin(45deg) \cdot 2m \cdot \frac{1}{2}$$

$$T_{1DE} := 0 \qquad T_{2DE} := 0 \qquad T_{3DE} := 0 \qquad T_{pDE} := 30kN \cdot \sin(45deg)$$

$$T_{1ED} := 0 \qquad T_{2ED} := 0 \qquad T_{3ED} := 0 \qquad T_{pED} := 30kN \cdot \sin(45deg)$$

$$T_{1CF} := -\frac{6EJ}{(2m)^2} \qquad T_{2CF} := -\frac{12EJ}{(2m)^3} \qquad T_{3CF} := 0 \qquad T_{pCF} := 5\frac{kN}{m} \cdot (2m) \cdot \frac{1}{2}$$

$$T_{1FC} := -\frac{6EJ}{(2m)^2} \qquad T_{2FC} := -\frac{12EJ}{(2m)^3} \qquad T_{3FC} := 0 \qquad T_{pFC} := -5\frac{kN}{m} \cdot (2m) \cdot \frac{1}{2}$$

$$T_{uAB} := 0 \qquad T_{t0AB} := 0 \qquad T_{\Delta tAB} := 0$$

$$T_{uBA} := 0 \qquad T_{t0BA} := 0 \qquad T_{\Delta tBA} := 0$$

$$T_{uBC} := 0 \qquad T_{t0BC} := -\frac{3EJ}{(5m)^3} \cdot \frac{4}{3} \cdot \Delta 1 \qquad T_{\Delta tBC} := -\frac{3}{2} \cdot \frac{EJ \cdot \alpha_t \cdot \Delta t}{h \cdot 5m}$$

$$T_{uCB} := 0 \qquad T_{t0CB} := -\frac{3EJ}{(5m)^3} \cdot \frac{4}{3} \cdot \Delta 1 \qquad T_{\Delta tCB} := -\frac{3}{2} \cdot \frac{EJ \cdot \alpha_t \cdot \Delta t}{h \cdot 5m}$$

$$T_{uCD} := \frac{3EJ}{(2m)^3} \cdot 0.005m \qquad T_{t0CD} := \frac{3EJ}{(2m)^3} \cdot \frac{5}{3} \cdot \Delta 1 \qquad T_{\Delta tCD} := 0$$

$$T_{uDC} := \frac{3EJ}{(2m)^3} \cdot 0.005m \qquad T_{t0DC} := \frac{3EJ}{(2m)^3} \cdot \frac{5}{3} \cdot \Delta 1 \qquad T_{\Delta tDC} := 0$$

$$T_{uDE} := 0 \qquad T_{t0DE} := 0 \qquad T_{\Delta tDE} := 0$$

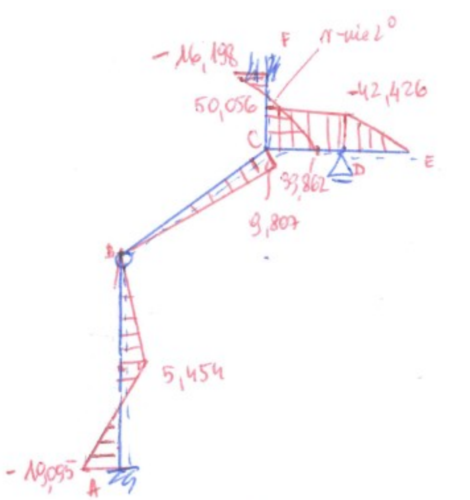
$$T_{uED} := 0 \qquad T_{t0ED} := 0 \qquad T_{\Delta tED} := 0$$

$$T_{uCF} := \frac{6EJ}{(2m)^2} \cdot 8.727 \times 10^{-3} \qquad T_{t0CF} := 0 \qquad T_{\Delta tCF} := 0$$

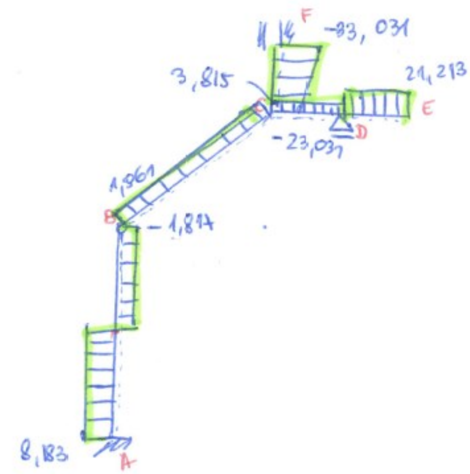
$$T_{uFC} := \frac{6EJ}{(2m)^2} \cdot 8.727 \times 10^{-3} \qquad T_{t0FC} := 0 \qquad T_{\Delta tFC} := 0$$

$$M_{ostAB} := M_{1AB}\cdot\varphi_1 + M_{2AB}\cdot\Delta_2 + M_{3AB}\cdot\Delta_3 + M_{pAB} + M_{uAB} + M_{t0AB} + M_{\Delta tAB} = -19.095\,\text{kN}\cdot\text{m}$$
$$M_{ostBA} := M_{1BA}\cdot\varphi_1 + M_{2BA}\cdot\Delta_2 + M_{3BA}\cdot\Delta_3 + M_{pBA} + M_{uBA} + M_{t0BA} + M_{\Delta tBA} = 0\,\text{kN}\cdot\text{m}$$
$$M_{ostBC} := M_{1BC}\cdot\varphi_1 + M_{2BC}\cdot\Delta_2 + M_{3BC}\cdot\Delta_3 + M_{pBC} + M_{uBC} + M_{t0BC} + M_{\Delta tBC} = 0\,\text{kN}\cdot\text{m}$$
$$M_{ostCB} := M_{1CB}\cdot\varphi_1 + M_{2CB}\cdot\Delta_2 + M_{3CB}\cdot\Delta_3 + M_{pCB} + M_{uCB} + M_{t0CB} + M_{\Delta tCB} = 9.807\,\text{kN}\cdot\text{m}$$
$$M_{ostCD} := M_{1CD}\cdot\varphi_1 + M_{2CD}\cdot\Delta_2 + M_{3CD}\cdot\Delta_3 + M_{pCD} + M_{uCD} + M_{t0CD} + M_{\Delta tCD} = -50.056\,\text{kN}\cdot\text{m}$$
$$M_{ostDC} := M_{1DC}\cdot\varphi_1 + M_{2DC}\cdot\Delta_2 + M_{3DC}\cdot\Delta_3 + M_{pDC} + M_{uDC} + M_{t0DC} + M_{\Delta tDC} = -42.426\,\text{kN}\cdot\text{m}$$
$$M_{ostDE} := M_{1DE}\cdot\varphi_1 + M_{2DE}\cdot\Delta_2 + M_{3DE}\cdot\Delta_3 + M_{pDE} + M_{uDE} + M_{t0DE} + M_{\Delta tDE} = -42.426\,\text{kN}\cdot\text{m}$$
$$M_{ostED} := M_{1ED}\cdot\varphi_1 + M_{2ED}\cdot\Delta_2 + M_{3ED}\cdot\Delta_3 + M_{pED} + M_{uED} + M_{t0ED} + M_{\Delta tED} = 0\,\text{kN}\cdot\text{m}$$
$$M_{ostCF} := M_{1CF}\cdot\varphi_1 + M_{2CF}\cdot\Delta_2 + M_{3CF}\cdot\Delta_3 + M_{pCF} + M_{uCF} + M_{t0CF} + M_{\Delta tCF} = 39.863\,\text{kN}\cdot\text{m}$$
$$M_{ostFC} := M_{1FC}\cdot\varphi_1 + M_{2FC}\cdot\Delta_2 + M_{3FC}\cdot\Delta_3 + M_{pFC} + M_{uFC} + M_{t0FC} + M_{\Delta tFC} = -16.198\,\text{kN}\cdot\text{m}$$

$$T_{ostAB} := T_{1AB}\cdot\varphi_1 + T_{2AB}\cdot\Delta_2 + T_{3AB}\cdot\Delta_3 + T_{pAB} + T_{uAB} + T_{t0AB} + T_{\Delta tAB} = 8.183\,\text{kN}$$
$$T_{ostBA} := T_{1BA}\cdot\varphi_1 + T_{2BA}\cdot\Delta_2 + T_{3BA}\cdot\Delta_3 + T_{pBA} + T_{uBA} + T_{t0BA} + T_{\Delta tBA} = -1.817\,\text{kN}$$
$$T_{ostBC} := T_{1BC}\cdot\varphi_1 + T_{2BC}\cdot\Delta_2 + T_{3BC}\cdot\Delta_3 + T_{pBC} + T_{uBC} + T_{t0BC} + T_{\Delta tBC} = 1.961\,\text{kN}$$
$$T_{ostCB} := T_{1CB}\cdot\varphi_1 + T_{2CB}\cdot\Delta_2 + T_{3CB}\cdot\Delta_3 + T_{pCB} + T_{uCB} + T_{t0CB} + T_{\Delta tCB} = 1.961\,\text{kN}$$
$$T_{ostCD} := T_{1CD}\cdot\varphi_1 + T_{2CD}\cdot\Delta_2 + T_{3CD}\cdot\Delta_3 + T_{pCD} + T_{uCD} + T_{t0CD} + T_{\Delta tCD} = 3.815\,\text{kN}$$
$$T_{ostDC} := T_{1DC}\cdot\varphi_1 + T_{2DC}\cdot\Delta_2 + T_{3DC}\cdot\Delta_3 + T_{pDC} + T_{uDC} + T_{t0DC} + T_{\Delta tDC} = 3.815\,\text{kN}$$
$$T_{ostDE} := T_{1DE}\cdot\varphi_1 + T_{2DE}\cdot\Delta_2 + T_{3DE}\cdot\Delta_3 + T_{pDE} + T_{uDE} + T_{t0DE} + T_{\Delta tDE} = 21.213\,\text{kN}$$
$$T_{ostED} := T_{1ED}\cdot\varphi_1 + T_{2ED}\cdot\Delta_2 + T_{3ED}\cdot\Delta_3 + T_{pED} + T_{uED} + T_{t0ED} + T_{\Delta tED} = 21.213\,\text{kN}$$
$$T_{ostCF} := T_{1CF}\cdot\varphi_1 + T_{2CF}\cdot\Delta_2 + T_{3CF}\cdot\Delta_3 + T_{pCF} + T_{uCF} + T_{t0CF} + T_{\Delta tCF} = -23.031\,\text{kN}$$
$$T_{ostFC} := T_{1FC}\cdot\varphi_1 + T_{2FC}\cdot\Delta_2 + T_{3FC}\cdot\Delta_3 + T_{pFC} + T_{uFC} + T_{t0FC} + T_{\Delta tFC} = -33.031\,\text{kN}$$

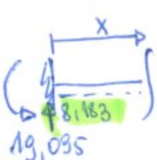


Most [kNm]



Tost [kN]

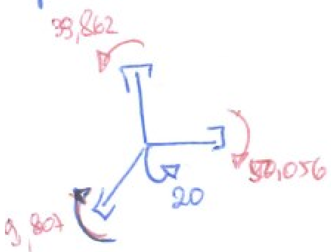
Moment i Tnąca w punkcie G



$M(x=3m) = 8{,}183 \cdot 3 - 19{,}095 = 5{,}454$

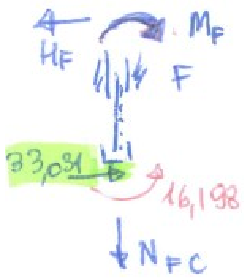
$T(x=3m) = 8{,}183$

sprawdzenie



$$\Sigma M = 50{,}056 + 9{,}807 - 39{,}862 - 20 = -0{,}006 \approx \underline{\underline{0}}$$

Wyznaczenie sił Normalnych i Reakcji w podporach

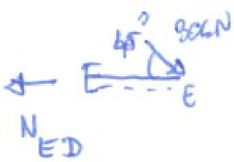


$M_F = 16{,}198$ [kNm]

$\Sigma X = 33{,}031 - H_F = 0$

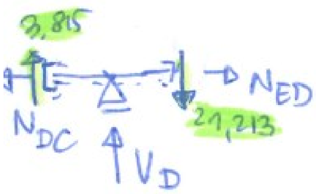
$H_F = 33{,}031$ [kN]

$\Sigma Y = N_{FC} = 0$



$\Sigma X = -N_{ED} + 30\,kN \cdot \cos 45° = 0$

$N_{ED} = 21{,}213$ [kN]

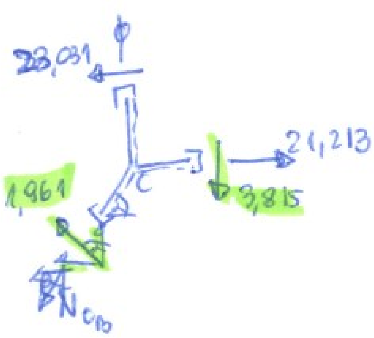


$\Sigma X = N_{DC} - N_{ED} = 0$

$N_{DC} = N_{ED} = 21{,}213$ [kN]

$\Sigma Y = -V_D + 21{,}213 - 3{,}815 = 0$

$V_D = 21{,}213 - 3{,}815 = 17{,}398$ [kN]

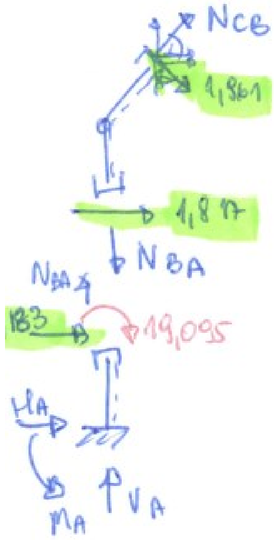


$\Sigma X = 33{,}031 - 21{,}213 + 1{,}961 \cdot \sin\alpha + N_{CB} \cdot \cos\alpha = 0$

$N_{CB} = -3{,}743$ [kN]

spr:

$\Sigma Y = N_{CB} \cdot \sin\alpha + 3{,}815 - 1{,}961 \cdot \cos\alpha = \underline{\underline{0}}$



$$\Sigma Y = N_{BA} + 1{,}861 \cdot \cos\alpha - N_{CB} \cdot \sin\alpha = 0$$

$$N_{BA} = -3{,}815\ [kN]$$

spr

$$\Sigma X = 1{,}817 + N_{CB} \cdot \cos\alpha + 1{,}861 \cdot \sin\alpha = 0$$

$$\Sigma X = 8{,}183 + H_A = 0$$

$$H_A = -8{,}183\ [kN]$$

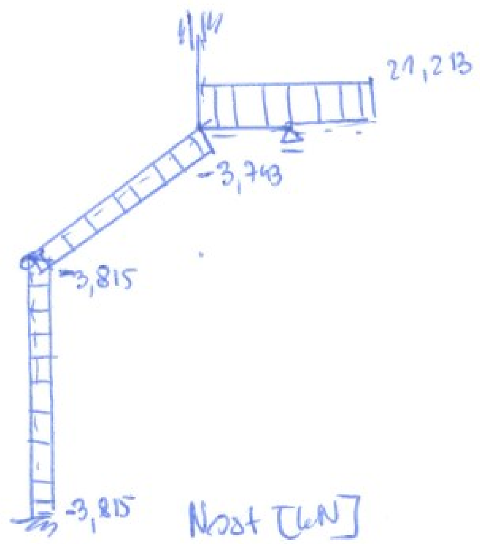
$$\Sigma Y = V_A + N_{BA} = 0$$

$$N_{BA} = 3{,}815\ [kN]$$

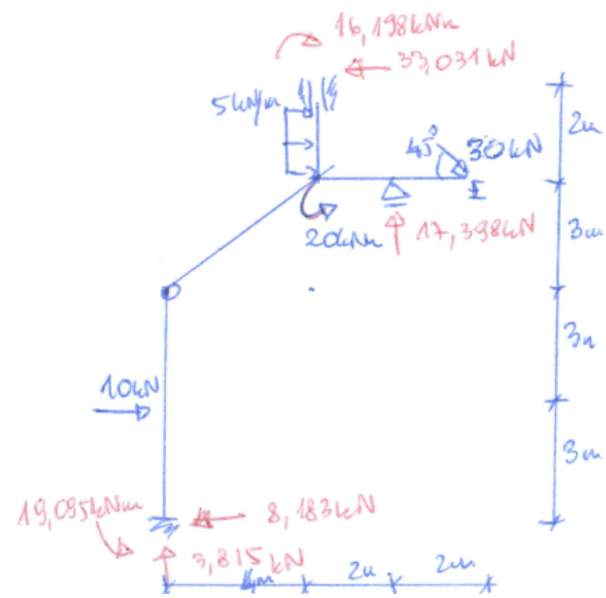
$$\Sigma M = M_A - 19{,}095 = 0$$

$$M_A = 19{,}095\ [kNm]$$

Normalne ostatecznie



N_{ost} [kN]



Sprawdzenie reakcji

$$\Sigma X = 10 + 5 \cdot 2 + 30 \cdot \cos 45° + (-8{,}183) + (-33{,}031) = -0{,}004 \approx 0$$

$$\Sigma Y = 3{,}815 + 17{,}398 - 30 \cdot \sin 45° = 0{,}003 \approx 0$$

$$\Sigma M_E = 16{,}198 - 19{,}095 + 3{,}815 \cdot 8 + 8{,}183 \cdot 9 - 10 \cdot 6 + 17{,}398 \cdot 2 - 33{,}031 \cdot 2 + 5 \cdot 2 \cdot 1 - 20 = 0{,}004 \approx 0$$