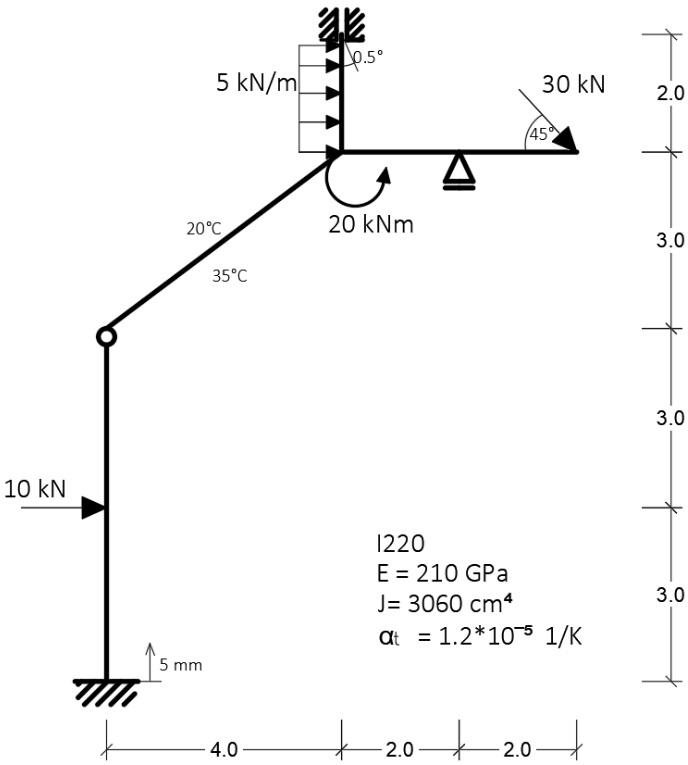
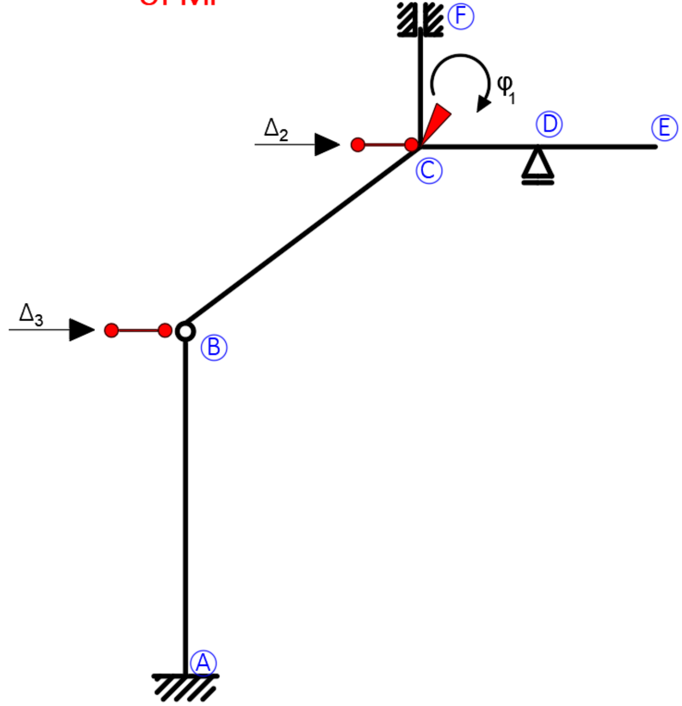
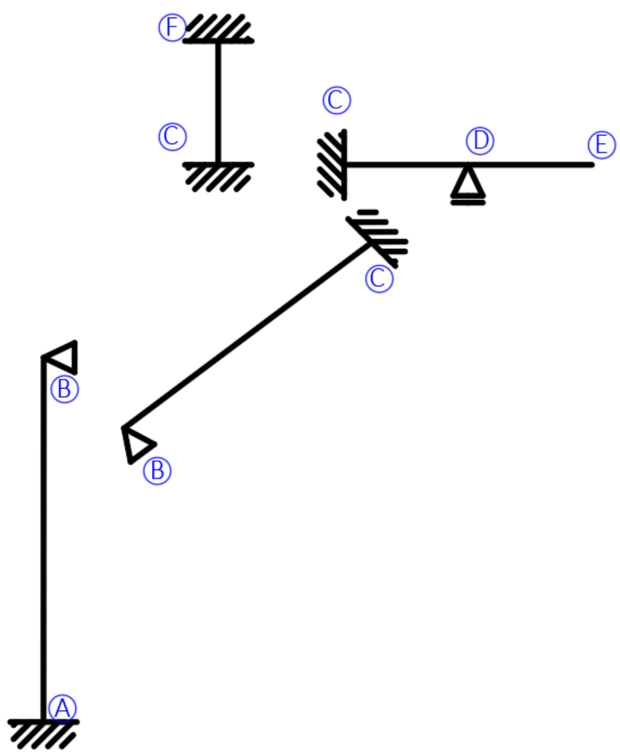


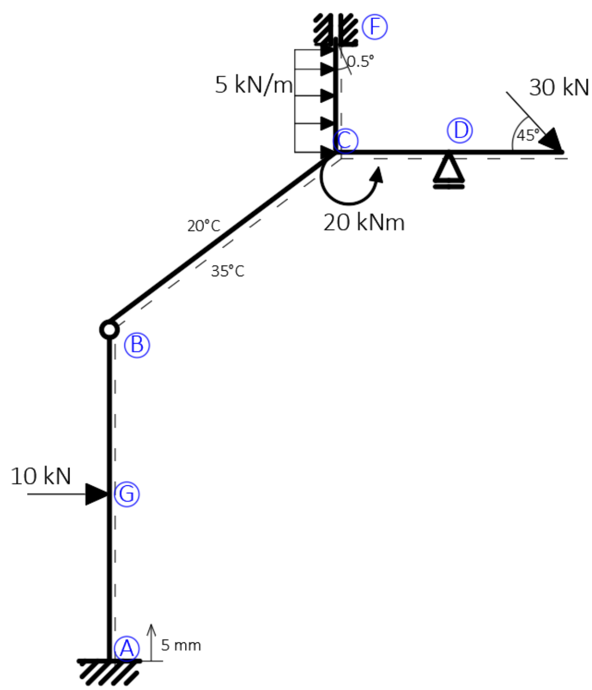
UPMP



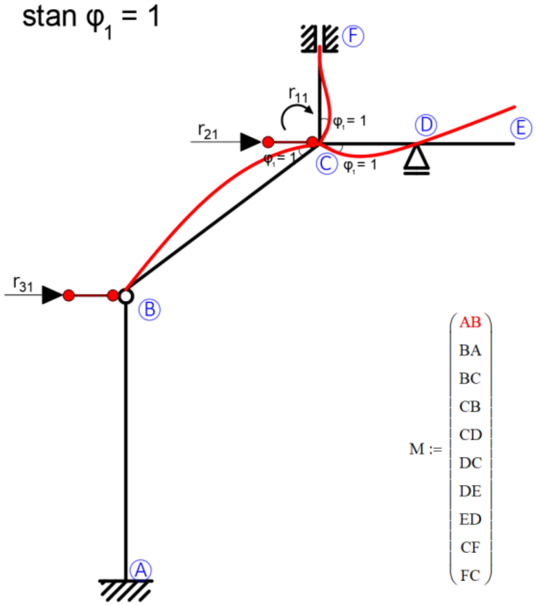
Podział na pręty



Przyjęcie położenia włókien dolnych

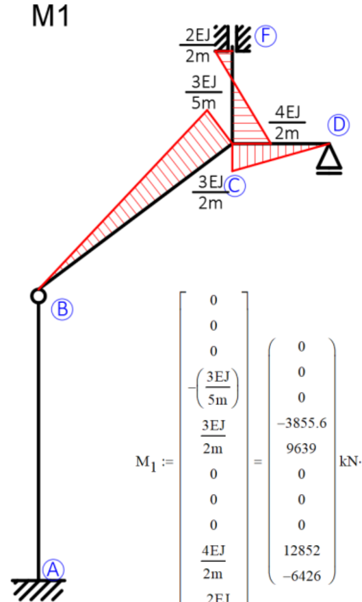


stan $\varphi_1 = 1$



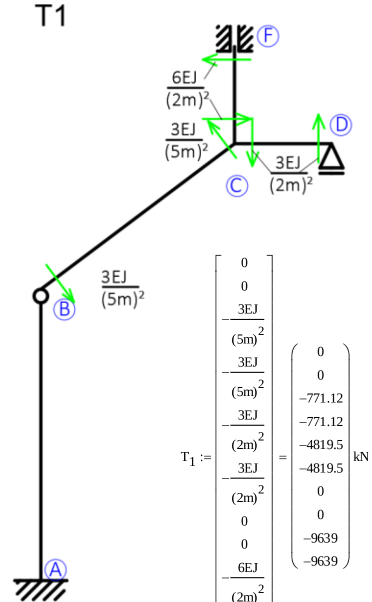
$$M := \begin{pmatrix} AB \\ BA \\ BC \\ CB \\ CD \\ DC \\ DE \\ ED \\ CF \\ FC \end{pmatrix}$$

M1

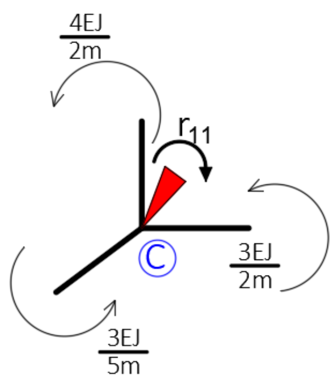


$$M_1 := \begin{bmatrix} 0 \\ 0 \\ 0 \\ -\left(\frac{3EJ}{5m}\right) \\ \frac{3EJ}{2m} \\ 0 \\ 0 \\ 0 \\ \frac{4EJ}{2m} \\ -\frac{2EJ}{2m} \end{bmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ -3855.6 \\ 9639 \\ 0 \\ 0 \\ 0 \\ 12852 \\ -6426 \end{pmatrix} kN\cdot m$$

T1

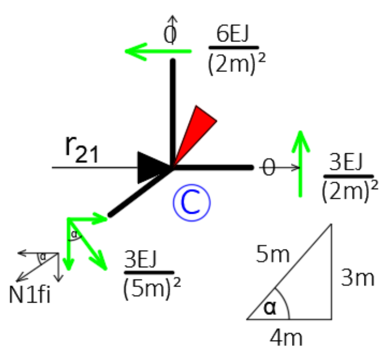


$$T_1 := \begin{bmatrix} 0 \\ 0 \\ -\frac{3EJ}{(5m)^2} \\ -\frac{3EJ}{(5m)^2} \\ -\frac{3EJ}{(2m)^2} \\ -\frac{3EJ}{(2m)^2} \\ 0 \\ 0 \\ -\frac{6EJ}{(2m)^2} \\ -\frac{6EJ}{(2m)^2} \end{bmatrix} = \begin{pmatrix} 0 \\ 0 \\ -771.12 \\ -771.12 \\ -4819.5 \\ -4819.5 \\ 0 \\ 0 \\ -9639 \\ -9639 \end{pmatrix} kN$$



stan φ1=1

$$r_{11} := 3\frac{EJ}{2m} + 4\frac{EJ}{2m} + 3\frac{EJ}{5m} = 26346.6\cdot kN\cdot m$$

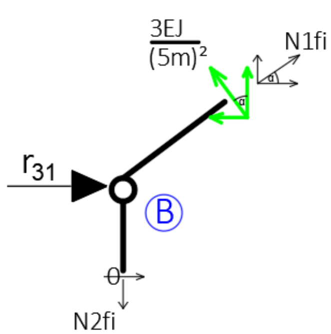


$$\Sigma Y = 0 \quad N1fi\cdot\sin\alpha - 3\frac{EJ}{(2m)^2} + 3\frac{EJ}{(5m)^2}\cdot\cos\alpha = 0$$

$$N1fi := \left[3\frac{EJ}{(2m)^2} - 3\frac{EJ}{(5m)^2}\cdot\cos\alpha\right]\cdot\frac{1}{\sin\alpha} = 7004.34\cdot kN$$

$$\Sigma X = 0 \quad r_{21} - 6\frac{EJ}{(2m)^2} + 3\frac{EJ}{(5m)^2}\cdot\sin\alpha - N1fi\cdot\cos\alpha = 0$$

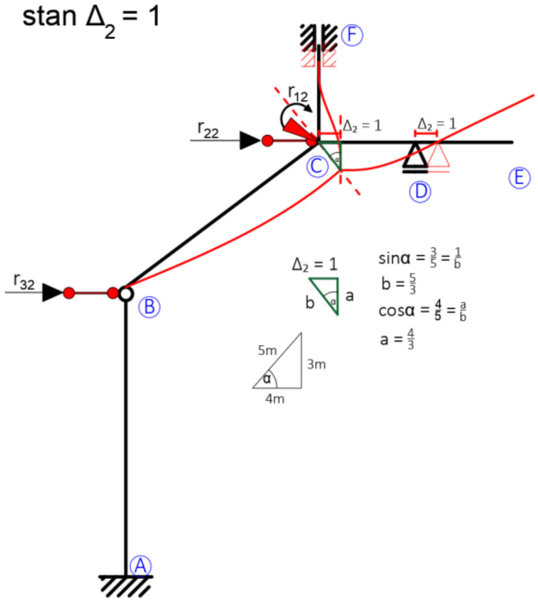
$$r_{21} := 6\frac{EJ}{(2m)^2} - 3\frac{EJ}{(5m)^2}\cdot\sin\alpha + N1fi\cdot\cos\alpha = 14779.8\cdot kN$$



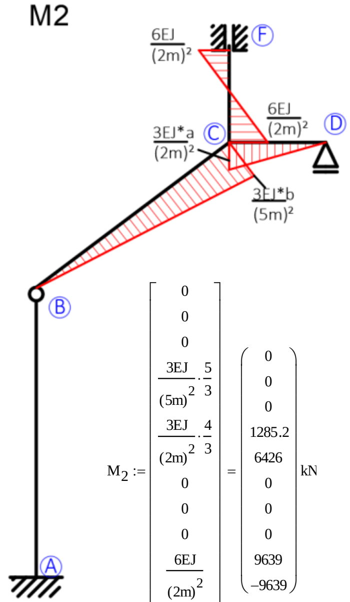
$$\Sigma X = 0 \quad r_{31} + N1fi\cdot\cos\alpha - 3\frac{EJ}{25m^2}\cdot\sin\alpha = 0$$

$$r_{31} := 3\frac{EJ}{25m^2}\cdot\sin\alpha - N1fi\cdot\cos\alpha = -5140.8\cdot kN$$

stan $\Delta_2 = 1$

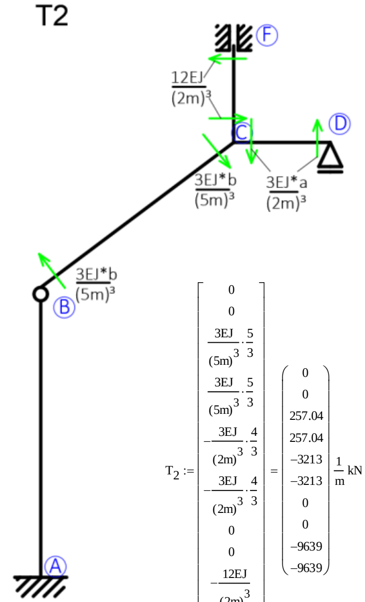


M2

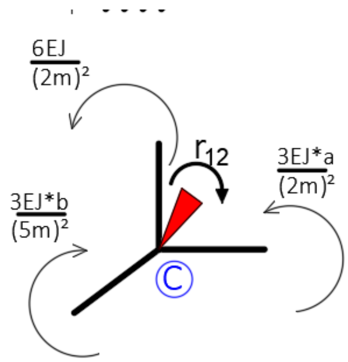


$$M_2 := \begin{pmatrix} 0 \\ 0 \\ 0 \\ \frac{3EJ}{(5m)^2}\cdot\frac{5}{3} \\ \frac{3EJ}{(2m)^2}\cdot\frac{4}{3} \\ 0 \\ 0 \\ 0 \\ \frac{6EJ}{(2m)^2} \\ -\frac{6EJ}{(2m)^2} \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1285.2 \\ 6426 \\ 0 \\ 0 \\ 0 \\ 9639 \\ -9639 \end{pmatrix} kN$$

T2

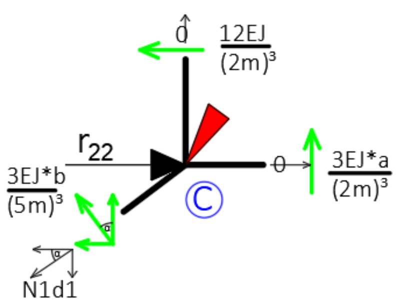


$$T_2 := \begin{pmatrix} 0 \\ 0 \\ \frac{3EJ}{(5m)^3}\cdot\frac{5}{3} \\ \frac{3EJ}{(5m)^3}\cdot\frac{5}{3} \\ -\frac{3EJ}{(2m)^3}\cdot\frac{4}{3} \\ -\frac{3EJ}{(2m)^3}\cdot\frac{4}{3} \\ 0 \\ 0 \\ -\frac{12EJ}{(2m)^3} \\ -\frac{12EJ}{(2m)^3} \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 257.04 \\ 257.04 \\ -3213 \\ -3213 \\ 0 \\ 0 \\ -9639 \\ -9639 \end{pmatrix} \frac{1}{m} kN$$



stan Δ2=1

$$r_{12} := \frac{3EJ}{(2m)^2}\cdot\frac{4}{3} + 6\frac{EJ}{(2m)^2}\cdot 1 - \frac{3EJ}{(5m)^2}\cdot\frac{5}{3} = 14779.8\cdot kN$$

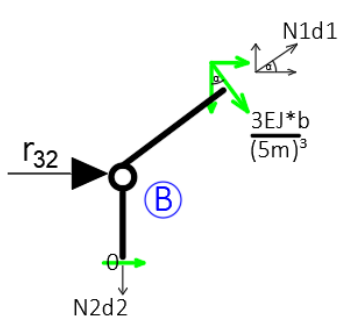


$$\Sigma Y = 0 \qquad \frac{3EJ}{(2m)^3}\cdot\frac{4}{3} + 3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\cos\alpha - N1d2\cdot\sin\alpha = 0$$

$$N1d2 := \left[\frac{3EJ}{(2m)^3}\cdot\frac{4}{3} + 3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\cos\alpha\right]\cdot\frac{1}{\sin\alpha} = 5697.72\cdot\frac{kN}{m}$$

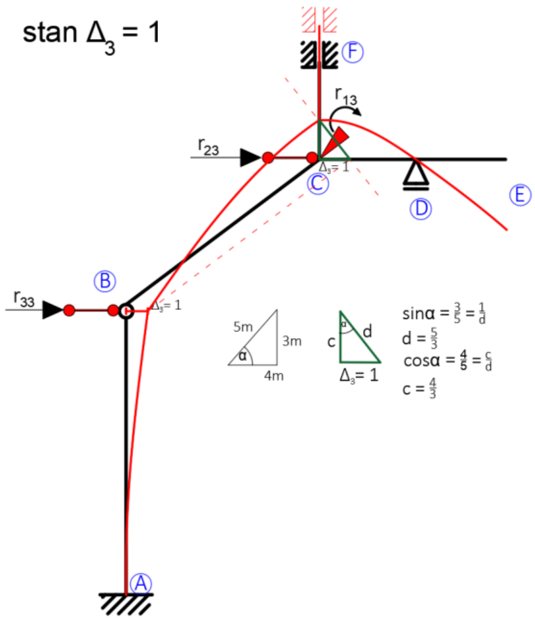
$$\Sigma X = 0 \qquad r_{22} - \frac{12EJ}{(2m)^3} - N1d2\cdot\cos\alpha - 3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\sin\alpha = 0$$

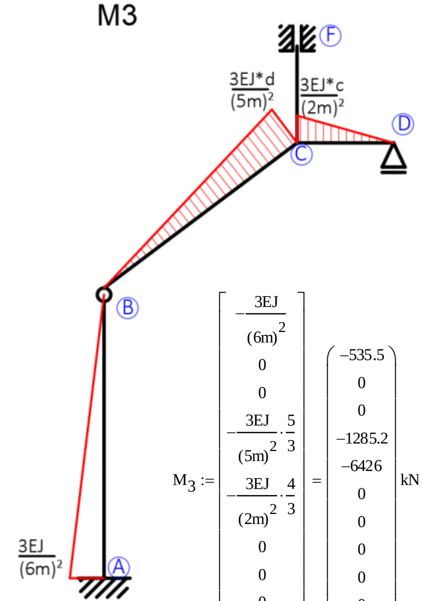
$$r_{22} := \frac{12EJ}{(2m)^3} + N1d2\cdot\cos\alpha + 3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\sin\alpha = 14351.4\cdot\frac{kN}{m}$$



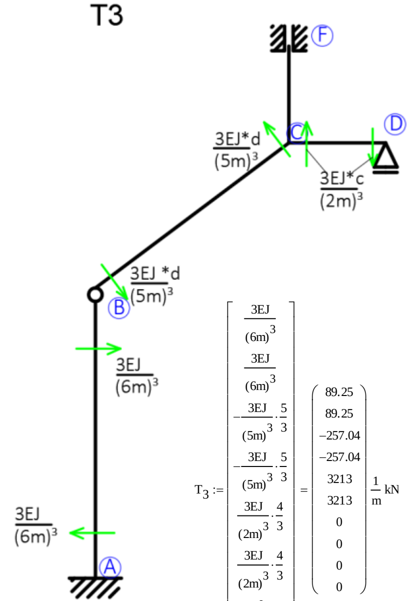
$$\Sigma X = 0 \qquad r_{32} + N1d2\cdot\cos\alpha + 3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\sin\alpha = 0$$

$$r_{32} := -N1d2\cdot\cos\alpha - 3\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\sin\alpha = -4712.4\cdot\frac{kN}{m}$$



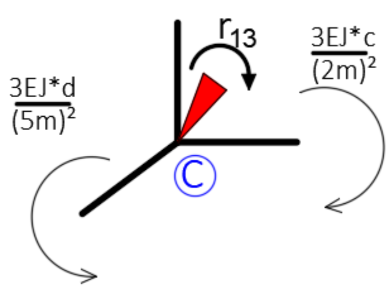


$$M_3 := \begin{bmatrix} -\frac{3EJ}{(6m)^2} \\ 0 \\ 0 \\ -\frac{3EJ}{(5m)^2}\cdot\frac{5}{3} \\ -\frac{3EJ}{(2m)^2}\cdot\frac{4}{3} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{pmatrix} -535.5 \\ 0 \\ 0 \\ -1285.2 \\ -6426 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} kN$$

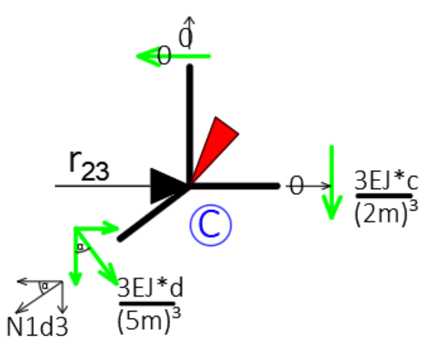


$$T_3 := \begin{bmatrix} \frac{3EJ}{(6m)^3} \\ \frac{3EJ}{(6m)^3} \\ -\frac{3EJ}{(5m)^3}\cdot\frac{5}{3} \\ -\frac{3EJ}{(5m)^3}\cdot\frac{5}{3} \\ \frac{3EJ}{(2m)^3}\cdot\frac{4}{3} \\ \frac{3EJ}{(2m)^3}\cdot\frac{4}{3} \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{pmatrix} 89.25 \\ 89.25 \\ -257.04 \\ -257.04 \\ 3213 \\ 3213 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \frac{1}{m} kN$$

stan Δ3=1



$$r_{13} := \frac{3EJ}{(5m)^2}\cdot\frac{5}{3} - \frac{3EJ}{(2m)^2}\cdot\frac{4}{3} = -5140.8\cdot kN$$

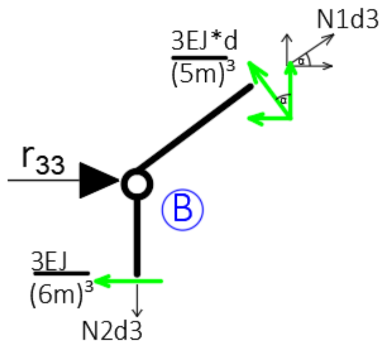


$$\Sigma Y = 0 \qquad N1d3\cdot\sin\alpha + \frac{3EJ}{(2m)^3}\cdot\frac{4}{3} + 3\,\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\cos\alpha = 0$$

$$N1d3 := \left[-\frac{3EJ}{(2m)^3}\cdot\frac{4}{3} - 3\,\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\cos\alpha\right]\cdot\frac{1}{\sin\alpha} = -5697.72\cdot\frac{kN}{m}$$

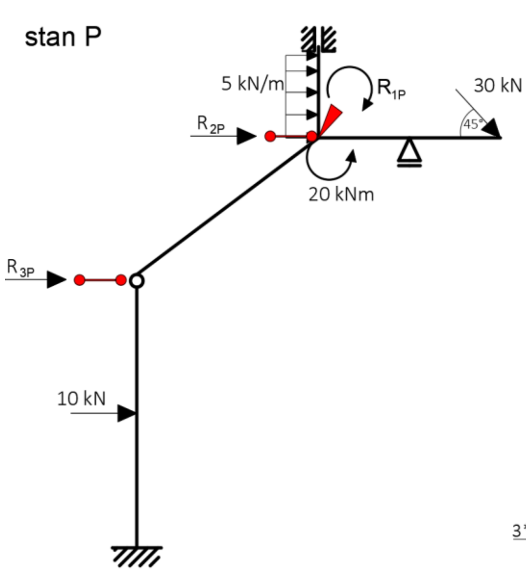
$$\Sigma X = 0 \qquad r_{23} + 3\,\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\sin\alpha - N1d3\cdot\cos\alpha = 0$$

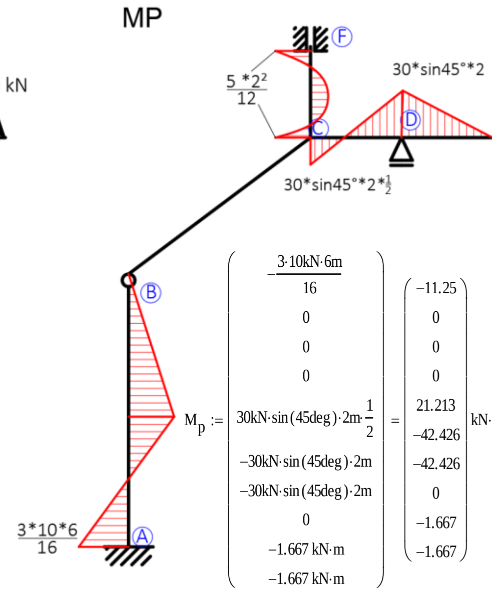
$$r_{23} := N1d3\cdot\cos\alpha - 3\,\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\sin\alpha = -4712.4\cdot\frac{kN}{m}$$



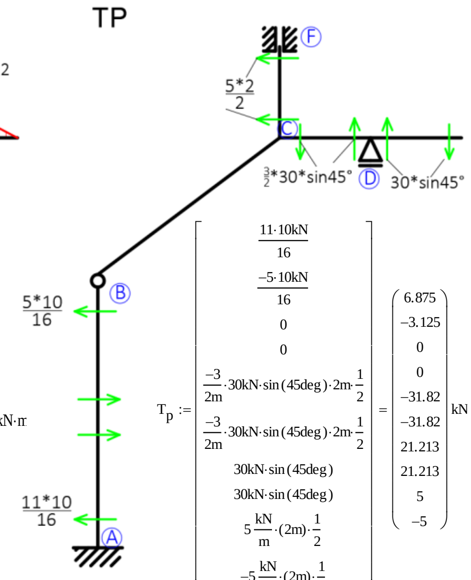
$$\Sigma X = 0 \qquad r_{33} + N1d3\cdot\cos\alpha - 3\,\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\sin\alpha - \frac{3EJ}{(6m)^3} = 0$$

$$r_{33} := -N1d3\cdot\cos\alpha + 3\,\frac{EJ}{(5m)^3}\cdot\frac{5}{3}\cdot\sin\alpha + \frac{3EJ}{(6m)^3} = 4801.65\cdot\frac{kN}{m}$$

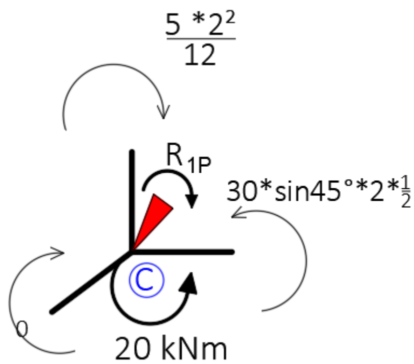




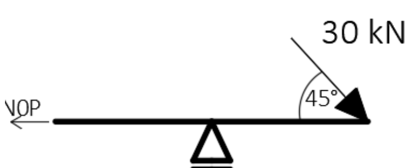
$$M_p := \begin{pmatrix} -\frac{3\cdot 10kN\cdot 6m}{16} \\ 0 \\ 0 \\ 0 \\ 30kN\cdot\sin(45deg)\cdot 2m\cdot\frac{1}{2} \\ -30kN\cdot\sin(45deg)\cdot 2m \\ -30kN\cdot\sin(45deg)\cdot 2m \\ 0 \\ -1.667\,kN\cdot m \\ -1.667\,kN\cdot m \end{pmatrix} = \begin{pmatrix} -11.25 \\ 0 \\ 0 \\ 0 \\ 21.213 \\ -42.426 \\ -42.426 \\ 0 \\ -1.667 \\ -1.667 \end{pmatrix} kN\cdot m$$



$$T_p := \begin{bmatrix} \frac{11\cdot 10kN}{16} \\ \frac{-5\cdot 10kN}{16} \\ 0 \\ 0 \\ \frac{-3}{2m}\cdot 30kN\cdot\sin(45deg)\cdot 2m\cdot\frac{1}{2} \\ \frac{-3}{2m}\cdot 30kN\cdot\sin(45deg)\cdot 2m\cdot\frac{1}{2} \\ 30kN\cdot\sin(45deg) \\ 30kN\cdot\sin(45deg) \\ 5\frac{kN}{m}\cdot(2m)\cdot\frac{1}{2} \\ -5\frac{kN}{m}\cdot(2m)\cdot\frac{1}{2} \end{bmatrix} = \begin{pmatrix} 6.875 \\ -3.125 \\ 0 \\ 0 \\ -31.82 \\ -31.82 \\ 21.213 \\ 21.213 \\ 5 \\ -5 \end{pmatrix} kN$$

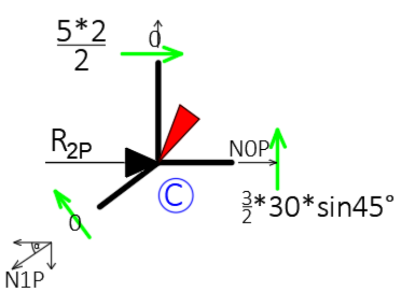


$$R_{1P} := 30kN\cdot\sin(45deg)\cdot 2m\cdot\frac{1}{2} - 5\,\frac{kN}{m}\cdot\frac{(2m)^2}{12} + 20kN\cdot m = 39.547\cdot kN\cdot m$$



$$\Sigma X = 0 \qquad N0P - 30kN\cdot\cos(45deg) = 0$$

$$N0P := 30kN\cdot\cos(45deg) = 21.213\cdot kN$$

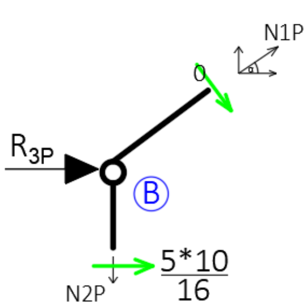


$$\Sigma Y = 0 \qquad N1P\cdot\sin\alpha - \frac{3}{2}\cdot\frac{30kN\cdot\sin(45deg)\cdot 2m}{2m} = 0$$

$$N1P := \frac{3}{2}\cdot\frac{30kN\cdot\sin(45deg)\cdot 2m}{2m}\cdot\frac{1}{\sin\alpha} = 53.033\cdot kN$$

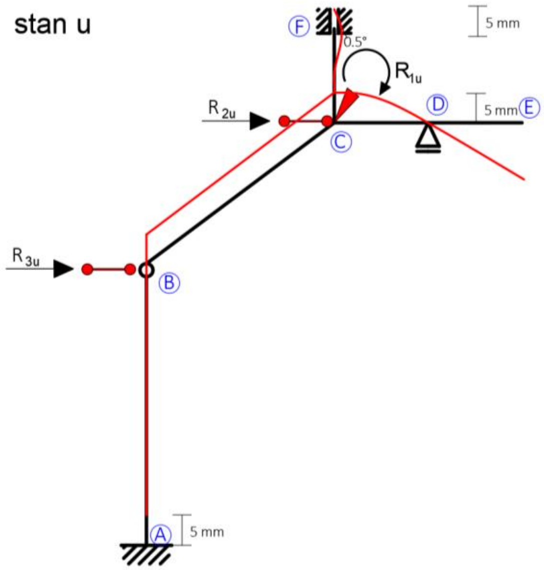
$$\Sigma X = 0 \qquad R_{2P} - N1P\cdot\cos\alpha + \frac{5\,\frac{kN}{m}\cdot 2m}{2} + N0P = 0$$

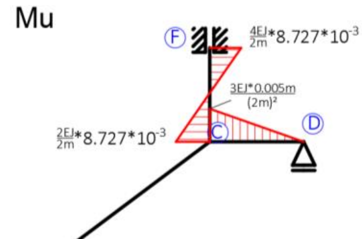
$$R_{2P} := N1P\cdot\cos\alpha - \frac{5\,\frac{kN}{m}\cdot 2m}{2} - N0P = 16.213\cdot kN$$



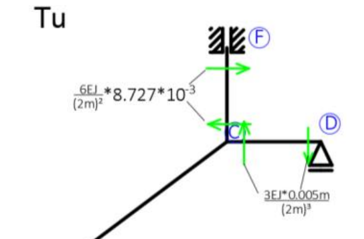
$$\Sigma X = 0 \qquad R_{3P} + \frac{5\cdot 10kN}{16} + N1P\cdot\cos\alpha = 0$$

$$R_{3P} := \frac{-5\cdot 10kN}{16} - N1P\cdot\cos\alpha = -45.551\cdot kN$$

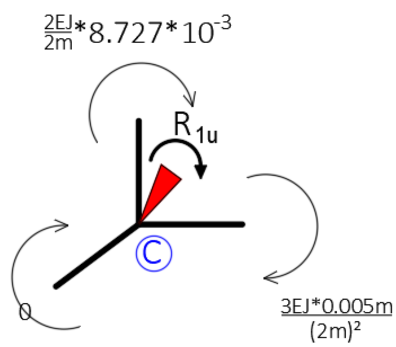




$$M_u := \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ -\frac{3EJ}{(2m)^2}\cdot 0.005m \\ 0 \\ 0 \\ 0 \\ -\frac{2EJ}{2m}\cdot 8.727\times 10^{-3} \\ \frac{4EJ}{2m}\cdot 8.727\times 10^{-3} \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ -24.098 \\ 0 \\ 0 \\ 0 \\ -56.08 \\ 112.159 \end{pmatrix} kN\cdot m$$

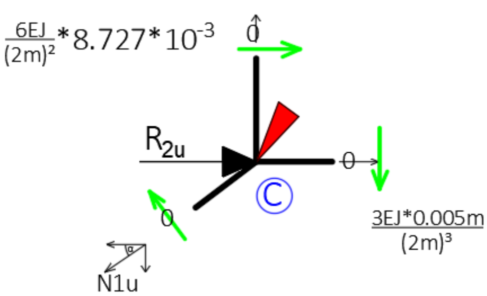


$$T_u := \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ \frac{3EJ}{(2m)^3}\cdot 0.005m \\ \frac{3EJ}{(2m)^3}\cdot 0.005m \\ 0 \\ 0 \\ \frac{6EJ}{(2m)^2}\cdot 8.727\times 10^{-3} \\ \frac{6EJ}{(2m)^2}\cdot 8.727\times 10^{-3} \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 12.049 \\ 12.049 \\ 0 \\ 0 \\ 84.12 \\ 84.12 \end{pmatrix} kN$$



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

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

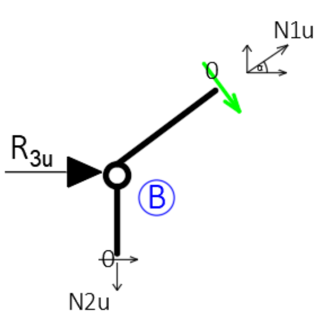


$$\Sigma Y = 0 \qquad N1u := \frac{-3EJ}{(2m)^3}\cdot 0.005m\cdot\frac{1}{\sin\alpha} = -20.081\cdot kN$$

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

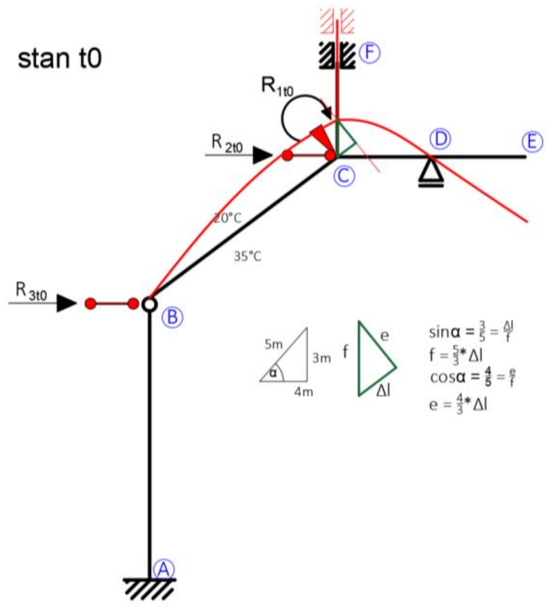
$$\Sigma X = 0 \qquad R_{2u} - N1u\cdot\cos\alpha + \frac{6EJ}{(2m)^2}\cdot 8.727\cdot 10^{-3} = 0$$

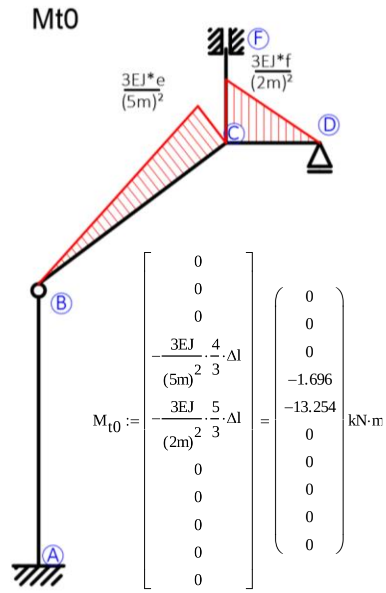
$$R_{2u} := N1u\cdot\cos\alpha - \frac{6EJ}{(2m)^2}\cdot 8.727\cdot 10^{-3} = -100.185\cdot kN$$



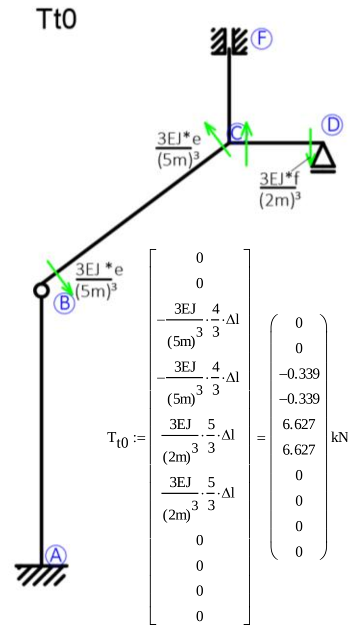
$$\Sigma X = 0 \qquad R_{3u} + N1u\cdot\cos\alpha = 0$$

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

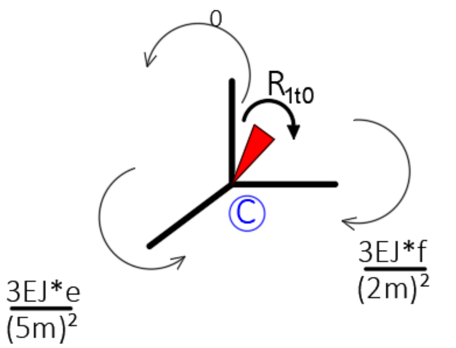




$$M_{t0} := \begin{pmatrix} 0 \\ 0 \\ 0 \\ -\frac{3EJ}{(5m)^2}\cdot\frac{4}{3}\cdot\Delta l \\ -\frac{3EJ}{(2m)^2}\cdot\frac{5}{3}\cdot\Delta l \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ -1.696 \\ -13.254 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} kN\cdot m$$



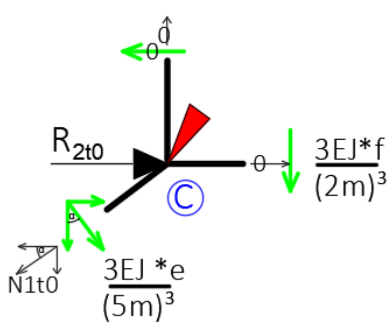
$$T_{t0} := \begin{pmatrix} 0 \\ 0 \\ -\frac{3EJ}{(5m)^3}\cdot\frac{4}{3}\cdot\Delta l \\ -\frac{3EJ}{(5m)^3}\cdot\frac{4}{3}\cdot\Delta l \\ \frac{3EJ}{(2m)^3}\cdot\frac{5}{3}\cdot\Delta l \\ \frac{3EJ}{(2m)^3}\cdot\frac{5}{3}\cdot\Delta l \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ -0.339 \\ -0.339 \\ 6.627 \\ 6.627 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} kN$$



$t_g := 20$ $\quad t_d := 35$ $\quad \alpha_t := 1.2\cdot10^{-5}$

$$t_0 := \frac{t_g + t_d}{2} = 27.5 \qquad \Delta l := \alpha_t\, t_0\cdot 5m = 1.65\times10^{-3}\, m$$

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

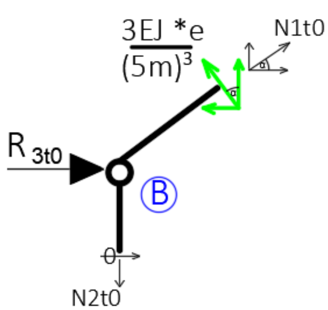


$$\Sigma Y = 0 \quad N1t0\cdot\sin\alpha + \frac{3EJ}{(5m)^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\cos\alpha + \frac{3EJ}{(2m)^3}\cdot\frac{5}{3}\cdot\Delta l = 0$$

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

$$\Sigma X = 0 \quad R_{2t0} - N1t0\cdot\cos\alpha + 3\,\frac{EJ}{(5m)^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\sin\alpha = 0$$

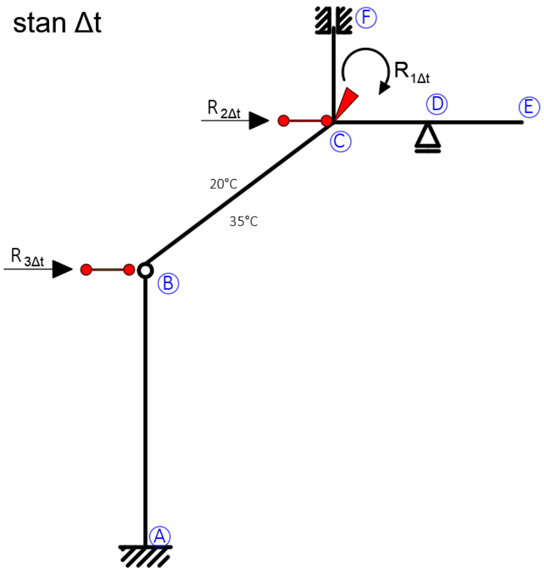
$$R_{2t0} := N1t0\cdot\cos\alpha - 3\,\frac{EJ}{(5m)^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\sin\alpha = -9.401\cdot kN$$



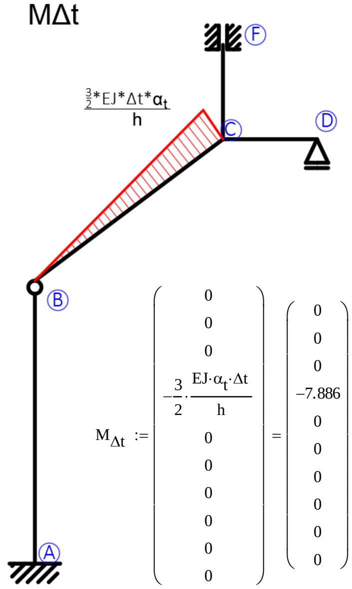
$$\Sigma X = 0 \quad R_{3t0} + N1t0\cdot\cos\alpha - 3\,\frac{EJ}{(5m)^3}\cdot\frac{4}{3}\cdot\Delta l\cdot\sin\alpha = 0$$

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

stan Δt

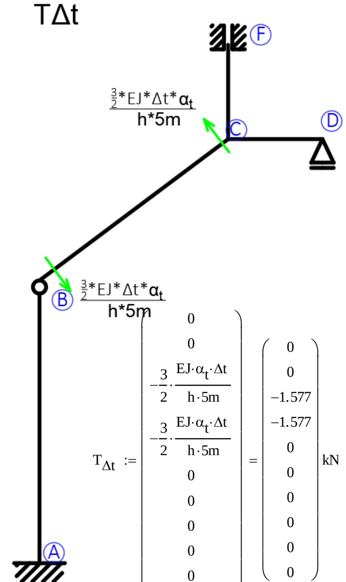


MΔt



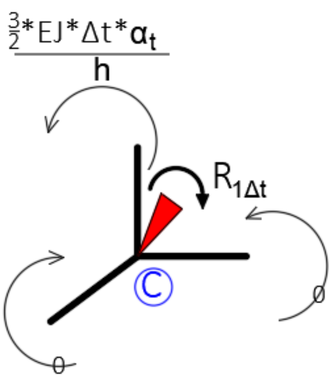
$$M_{\Delta t} := \begin{pmatrix} 0 \\ 0 \\ 0 \\ -\frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ -7.886 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} kN\cdot m$$

TΔt



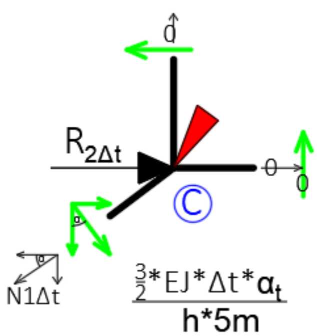
$$T_{\Delta t} := \begin{pmatrix} 0 \\ 0 \\ -\frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h\cdot 5m} \\ -\frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h\cdot 5m} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ -1.577 \\ -1.577 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} kN$$

$$h := 0.22m$$



$$\Delta t := t_d - t_g = 15$$

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

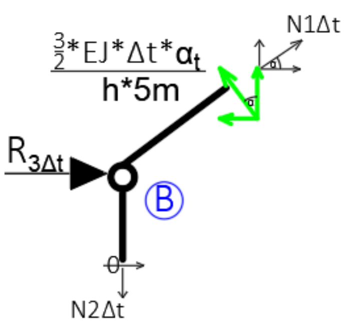


$$\Sigma Y = 0 \qquad N1\Delta t\cdot\sin\alpha + \frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h\cdot 5m}\cdot\cos\alpha = 0$$

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

$$\Sigma X = 0 \qquad R_{2\Delta t} + \frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h\cdot 5m}\cdot\sin\alpha - N1\Delta t\cdot\cos\alpha = 0$$

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



$$\Sigma X = 0 \qquad R_{3\Delta t} + N1\Delta t\cdot\cos\alpha - \frac{3}{2}\cdot\frac{EJ\cdot\alpha_t\cdot\Delta t}{h\cdot 5m}\cdot\sin\alpha = 0$$

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

Układ równań kanonicznych

$$\begin{cases} r_{11}\cdot\varphi_1 + r_{12}\cdot\Delta_2 + r_{13}\cdot\Delta_3 + R_{1P} + R_{1u} + R_{1t0} + R_{1\Delta t} = 0 \\ r_{21}\cdot\varphi_1 + r_{22}\cdot\Delta_2 + r_{23}\cdot\Delta_3 + R_{2P} + R_{2u} + R_{2t0} + R_{2\Delta t} = 0 \\ r_{31}\cdot\varphi_1 + r_{32}\cdot\Delta_2 + r_{33}\cdot\Delta_3 + R_{3P} + R_{3u} + R_{3t0} + R_{3\Delta t} = 0 \end{cases}$$

Rozwiązanie układu

(reakcje podzielono przez jednostki aby uzyskać układ bez jednostek, następnie wartości przesunięć przemnożono przez metry, a kąt pozostaje w radianach)

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

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

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

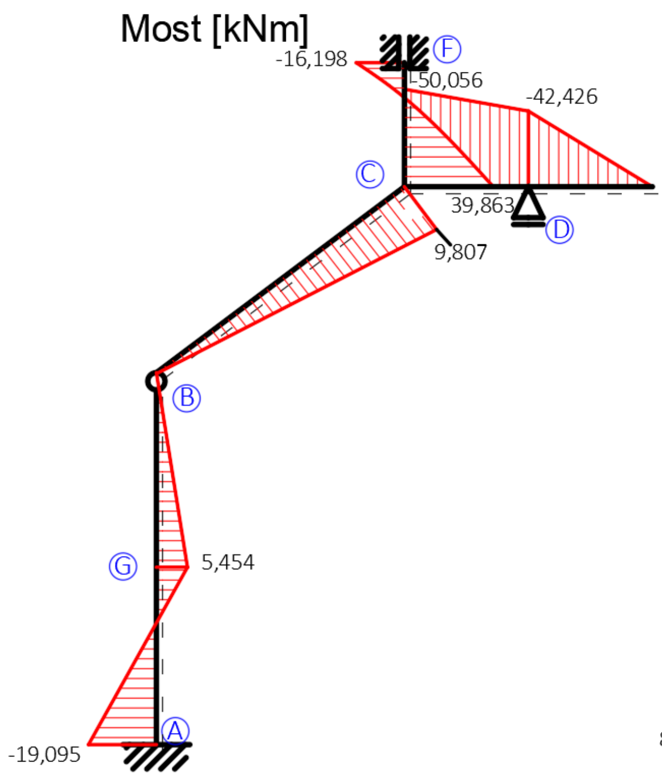
$$\Delta_2 := B_1\cdot m = 16.161\times 10^{-3}\,m$$

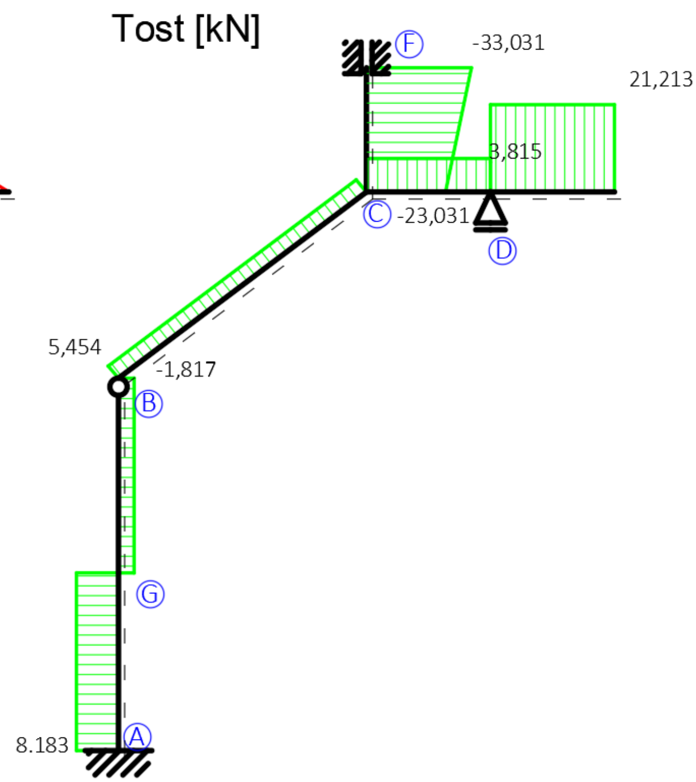
$$\Delta_3 := B_2\cdot m = 14.650\times 10^{-3}\,m$$

Wyznaczenie Momentów i Tnących ostatecznych

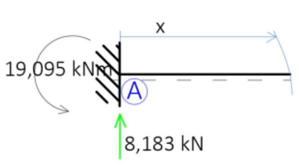
$$M_{ost} := M_1 \cdot \varphi_1 + M_2 \cdot \Delta_2 + M_3 \cdot \Delta_3 + M_p + M_u + M_{t0} + M_{\Delta t} \qquad T_{ost} := T_1 \cdot \varphi_1 + T_2 \cdot \Delta_2 + T_3 \cdot \Delta_3 + T_p + T_u + T_{t0} + T_{\Delta t}$$

$$M_{ost} = \begin{pmatrix} -19.095 \\ 0 \\ 0 \\ 9.807 \\ -50.056 \\ -42.426 \\ -42.426 \\ 0 \\ 39.863 \\ -16.199 \end{pmatrix} kN \cdot m \qquad \begin{pmatrix} AB \\ BA \\ BC \\ CB \\ CD \\ DC \\ DE \\ ED \\ CF \\ FC \end{pmatrix} \qquad T_{ost} = \begin{pmatrix} 8.183 \\ -1.817 \\ 1.961 \\ 1.961 \\ 3.815 \\ 3.815 \\ 21.213 \\ 21.213 \\ -23.031 \\ -33.031 \end{pmatrix} kN$$





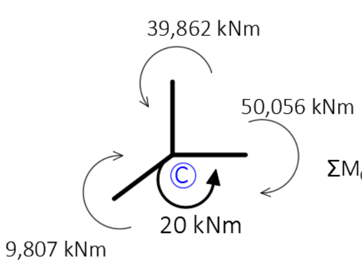
Moment i Tnąca w punkcie G



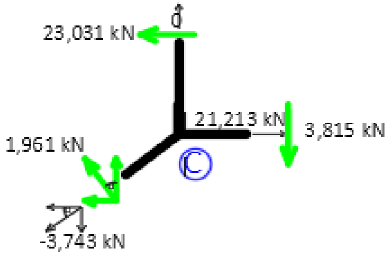
M(x=3m)=8,183 kN *3 m - 19,095 kNm = 5,454 kNm

T(x=3m)=8,183 kN

Sprawdzenie równowagi momentów w węźle



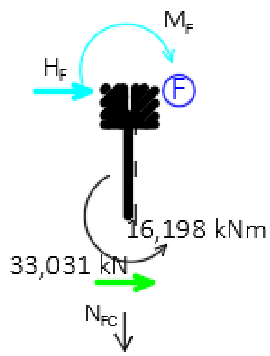
ΣM_C = 50,056 kNm + 9,807 kNm - 39,862 kNm - 20 kNm = 0,001 kNm



$$\Sigma X = -23{,}031\ kN + 21{,}213\ kN - 1{,}961\ kN*\sin\alpha - (-3{,}743\ kN*\cos\alpha) = 0$$

$$\Sigma Y = 1{,}961\ kN*\cos\alpha - (-3{,}743\ kN*\sin\alpha) - 3{,}815\ kN = 0$$

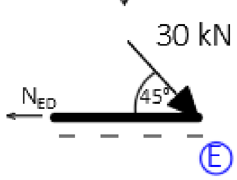
Wyznaczenie sił normalnych i reakcji w podporach z równowagi węzłów



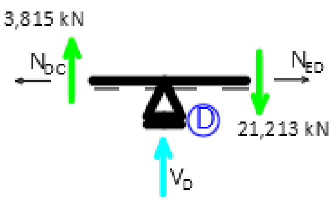
$$\Sigma X = H_F + 33{,}031\ kN = 0 \qquad H_F = -33{,}031\ kN$$

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

$$\Sigma M = M_F - 16{,}198\ kN = 0 \qquad M_F = 16{,}198\ kN$$

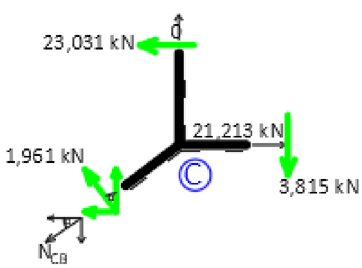


$$\Sigma X = N_{ED} - 30\ kN * \cos 45° = 0 \qquad N_{ED} = 21{,}213\ kN$$

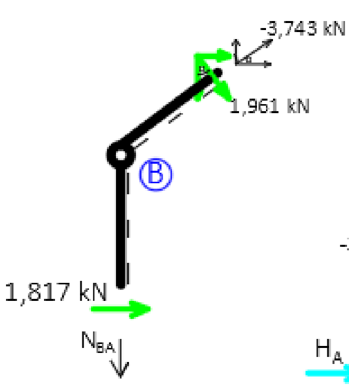


$$\Sigma X = N_{ED} - N_{DC} = 0 \qquad N_{DC} = N_{ED} = 21{,}213\ kN$$

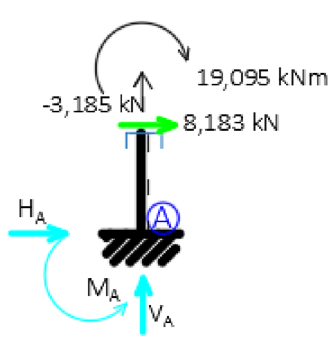
$$\Sigma Y = V_D + 3{,}815\ kN - 21{,}213\ kN = 0 \qquad V_D = 17{,}398\ kN$$



$$\Sigma X = -23{,}031\ kN + 21{,}213\ kN - 1{,}961\ kN*\sin\alpha - N_{CB}*\cos\alpha = 0 \qquad N_{CB} = -3{,}743\ kN$$



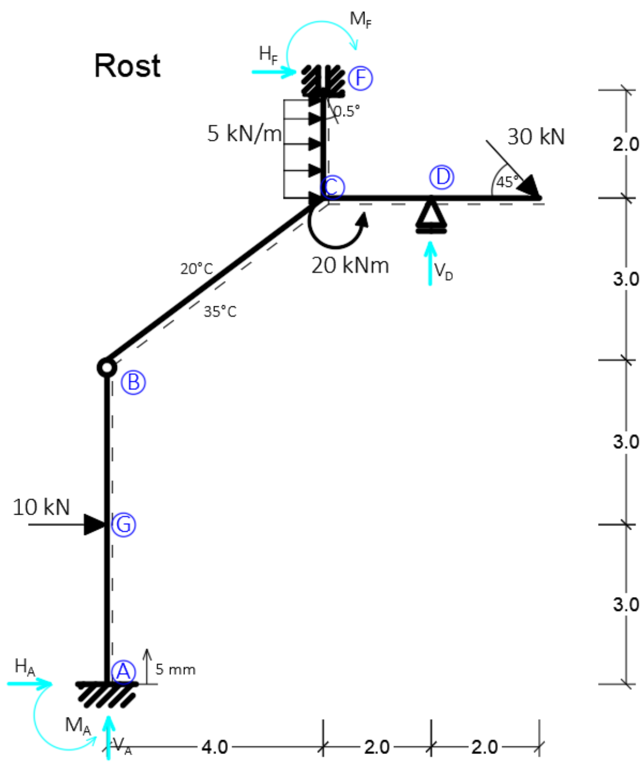
$$\Sigma Y = N_{BA} + 1{,}961*\cos\alpha - 3{,}743\ kN*\sin\alpha = 0 \qquad N_{BA} = -3{,}815\ kN$$

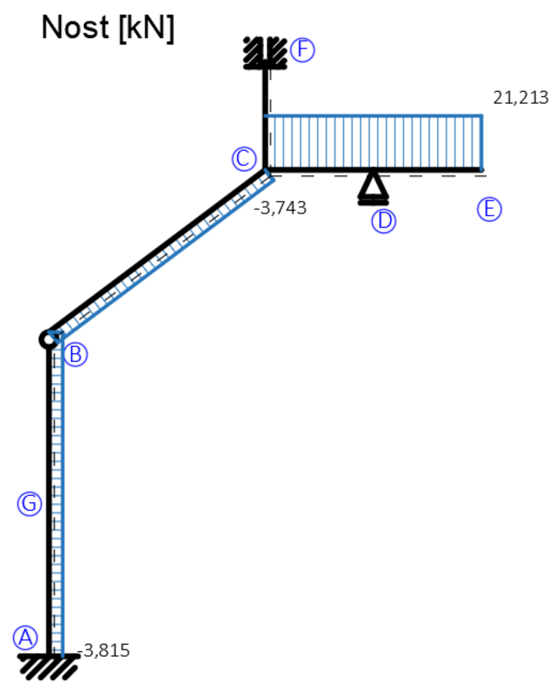


$$\Sigma X = H_A + 8{,}183\ kN = 0 \qquad H_A = -8{,}183\ kN$$

$$\Sigma Y = V_A - 3{,}185\ KN = 0 \qquad V_A = 3{,}185\ kN$$

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





Sprawdzenie reakcji

$$\Sigma X = H_F + H_A - 10\ kN + 30\ kN*\sin 45° + 5\ \tfrac{kN}{m}*2m = 0$$

$$\Sigma Y = V_A + V_D - 30\ kN*\sin 45° = 0$$

$$\Sigma M_E = M_F - M_A - 20\ kNm + V_D*2\ m + H_F*2\ m + V_A*8\ m - H_A*9\ m + 5\ \tfrac{kN}{m}*2\ m*1\ m - 10\ kN*6\ m = 0$$