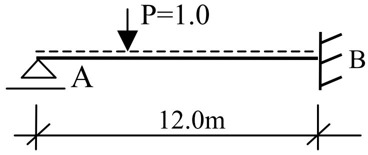
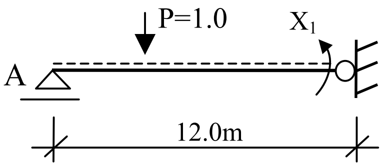
Zad.2. **Wyznaczyć linie wpływu momentu podporowego M_B dla belki (EI=const):**

Schemat belki:



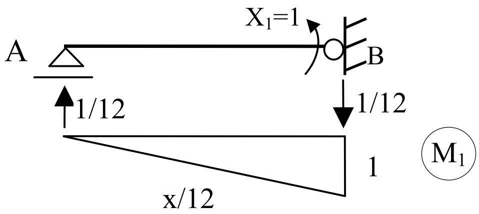
SSN=1

Układ podstawowy:



$$LwM_B = LwX_1$$

Stan $X_1=1$



$$\delta_{11} LwX_1 + \delta_{1P}(x) = 0$$

$$\delta_{11} = \frac{1}{EI}\left(\frac{1}{2}\cdot 12\cdot 1\cdot \frac{2}{3}\cdot 1\right) = \frac{4}{EI}$$

$$\delta_{1P}(x) = \delta_{P1}(x)$$

$$M(x) = \frac{x}{12}$$

$$EI\frac{d^2y}{dx^2} = -\frac{x}{12}$$

$$EI\frac{dy}{dx} = -\frac{x^2}{24} + C$$

$$EIy = -\frac{x^3}{72} + Cx + D$$

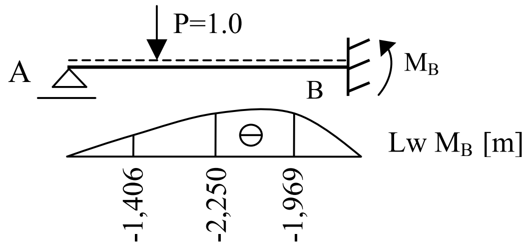
$war.brzeg.$:

$$x = 0 \rightarrow y = 0 \Rightarrow D = 0$$

$$x = 12 \rightarrow y = 0 \Rightarrow C = 2$$

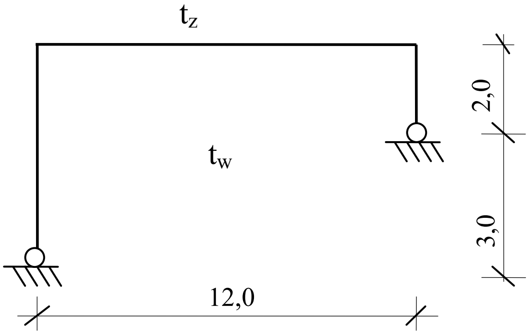
$$\delta_{P1}(x) = y = \frac{1}{EI}\left(-\frac{x^3}{72} + 2x\right)$$

$$LwM_B = LwX_1 = -\frac{\delta_{P1}(x)}{\delta_{11}} = \frac{x^3}{288} - \frac{x}{2}$$



Zad.3. Korzystając z metody sił wyznaczyć wykres momentów zginających wywołanych równomiernym ogrzaniem ramy o t_0 oraz nierównomiernym o Δt:

Schemat układu:



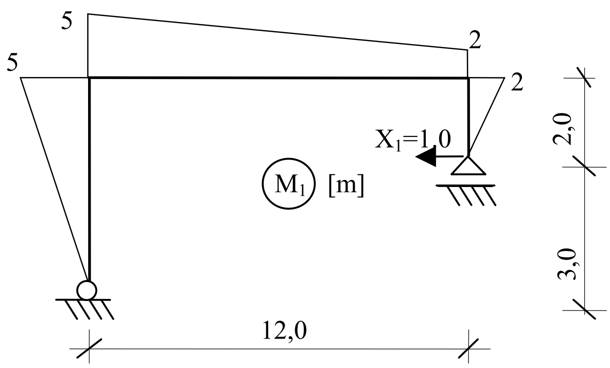
SSN=1

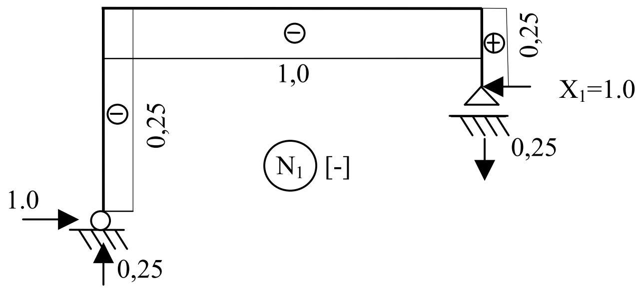
EI=const
t_0=20°C
$\Delta t = t_w - t_z$=15°C => $t_w > t_z$
I260: I_x=5740 cm^4
E=205 GPa
$\alpha_\tau = 1,2 \cdot 10^{-5}$ 1/°C

EI=11767 kNm

Układ podstawowy:

Stan X_1=1





$$\delta_{11} X_1 + \delta_{1t} = 0$$

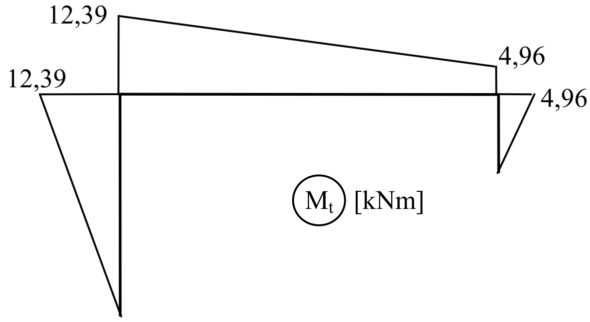
$$\delta_{11} = \Sigma \int_s \frac{M_1^2}{EI} ds = \frac{1}{EI}\left[\frac{1}{2} 2 \cdot 2 \cdot \frac{2}{3} \cdot 2 + \frac{12}{6}\left(2 \cdot 5 \cdot 5 + 2 \cdot 2 \cdot 2 + 2 \cdot 5 \cdot 2\right) + \frac{1}{2} \cdot 5 \cdot 5 \cdot \frac{2}{3} \cdot 5\right] = \frac{200,3333}{EI}$$

$$\delta_{1t} = \Sigma \int_s M_1 \alpha_t \frac{\Delta t}{h} ds + \Sigma \int_s N_1 \alpha_t t_0 ds =$$

$$= -\alpha_t \frac{15}{0,26}\left(\frac{1}{2} \cdot 2 \cdot 2 + 7 \cdot 12 \cdot \frac{1}{2} + \frac{1}{2} \cdot 5 \cdot 5\right) + \alpha_t \cdot 20\left(2 \cdot 0,25 - 12 \cdot 1 - 5 \cdot 0,25\right) =$$

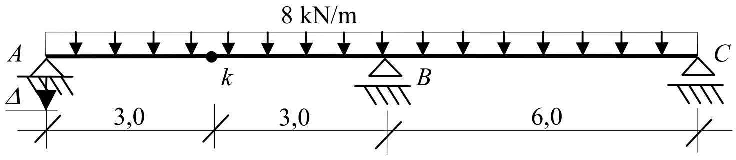
$$= \alpha_t (-3259,615 - 255) = -3514,615 \alpha_t = -0,04217$$

$$X_1 = -\frac{\delta_{1t}}{\delta_{11}} = \frac{0,04217 EI}{200,3333} = 2,48 kN$$

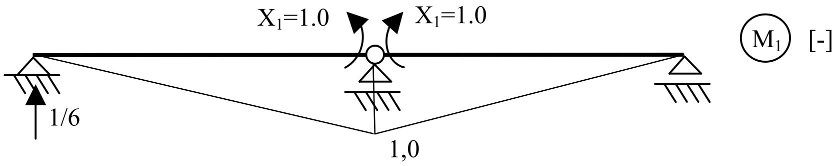


Zad.1. Korzystając z metody sił wyznaczyć przemieszczenie pionowe pktu *k* wywołane działaniem zadanego obciążenia zewnętrznego oraz osiadaniem podpory *A* o Δ=0,06m:

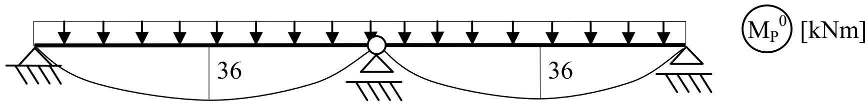
SSN=1



Stan X_1=1.0:



Stan „P”:

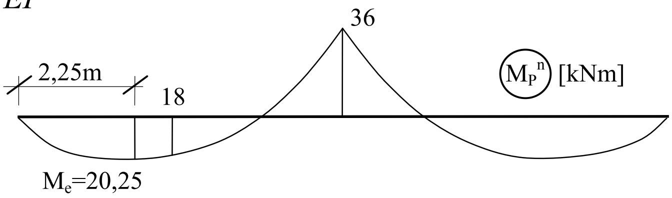


$$\delta_{11}X_1 + \delta_{1P} = 0$$

$$\delta_{11} = \Sigma\int_s \frac{M_1 M_1}{EI}ds = \frac{1}{EI}\left[\frac{1}{2}\cdot 6\cdot 1\cdot\frac{2}{3}\cdot 1\cdot 2\right] = \frac{4{,}00}{EI} \qquad \left[\frac{1}{kNm}\right]$$

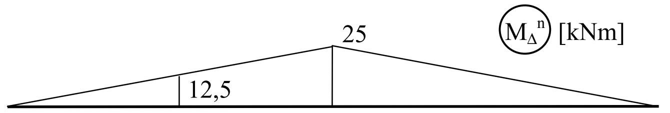
$$\delta_{1P} = \Sigma\int_s \frac{M_1 M_P}{EI}ds = \frac{1}{EI}\left[\frac{2}{3}\cdot 6\cdot\frac{8\cdot 6^2}{8}\cdot\frac{1}{2}\cdot 1\cdot 2\right] = \frac{144}{EI} \qquad [-]$$

$$X_1 = -\frac{\delta_{1P}}{\delta_{11}} = -\frac{144}{EI}\cdot\frac{EI}{4} = -36{,}0\ kNm$$



$$\delta_{11}X_1 + \delta_{1\Delta} = 0$$

$$\delta_{1\Delta} = -R_1\cdot\Delta = -\left(-\frac{1}{6}\cdot 0{,}06\right) = 0{,}01 \quad [-]$$



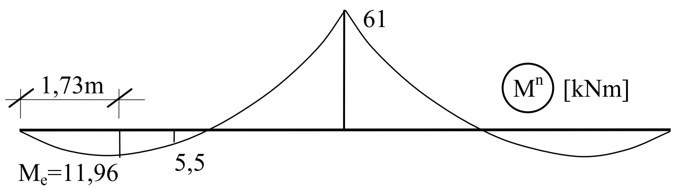
$$X_1 = -\frac{\delta_{1\Delta}}{\delta_{11}} = -0{,}01\cdot\frac{EI}{4} = -25{,}0\ kNm$$

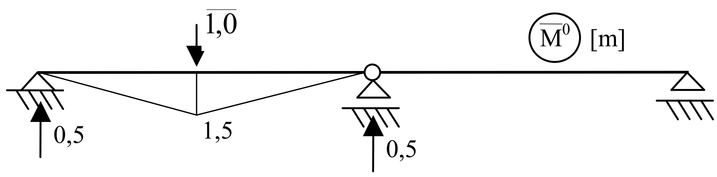
lub:

$$\delta_{1(P+\Delta)} = \delta_{1P} + \delta_{1\Delta} = \frac{144}{EI} + 0{,}01 =$$

$$= 0{,}0144 + 0{,}01 = 0{,}0244 \quad [-]$$

$$X_1 = -\frac{\delta_{1(P+\Delta)}}{\delta_{11}} = -0{,}0244\cdot\frac{EI}{4} = -61{,}0\ kNm$$





$$\upsilon_k = \Sigma\int_s \frac{\overline{M}\cdot M^n_{P+\Delta}}{EI}ds - \Sigma\overline{R}\cdot\Delta =$$

$$= \frac{1}{EI}\left[\frac{1}{2}\cdot 3\cdot\frac{3}{2}\cdot\frac{2}{3}\cdot 5{,}5 + \frac{2}{3}\cdot\frac{8\cdot 3^2}{8}\cdot 3\cdot\frac{1}{2}\cdot\frac{3}{2}\cdot 2 + \frac{1}{2}\cdot 3\cdot\frac{3}{2}\left(\frac{2}{3}\cdot 5{,}5 - \frac{1}{3}\cdot 61\right)\right] - \left(-0{,}5\cdot 0{,}06\right) =$$

$$= \frac{-2{,}25}{EI} + 0{,}03 = 0{,}02977m = 2{,}98cm$$