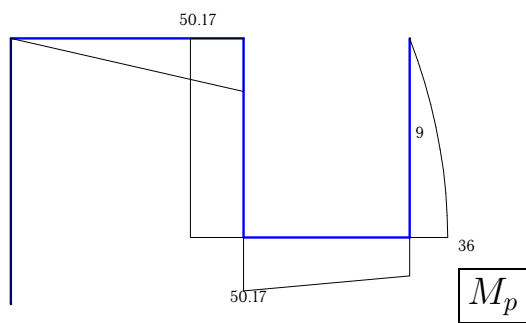
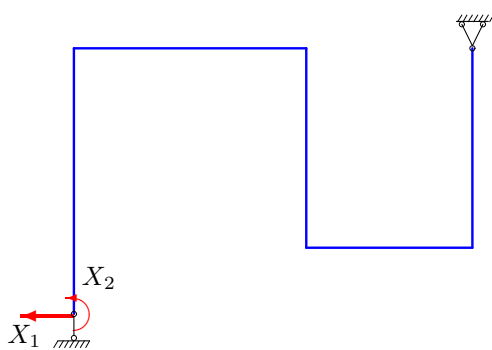
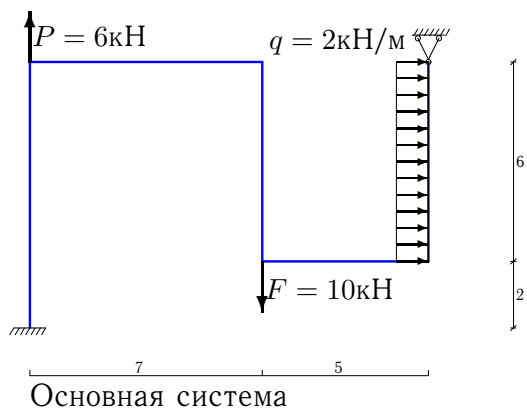
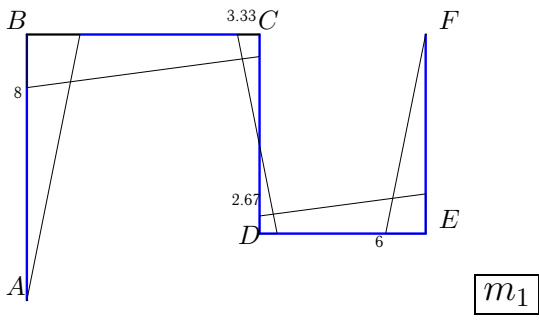
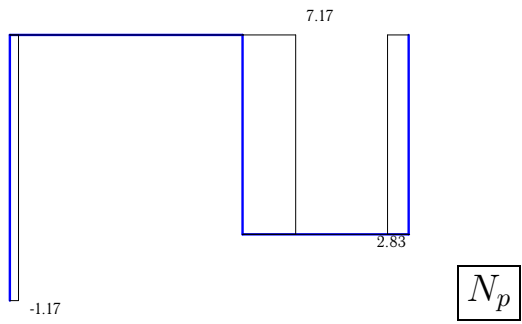
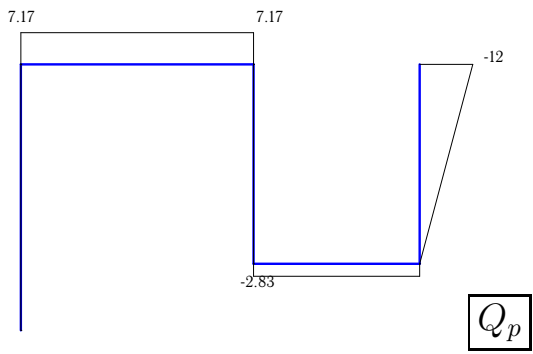
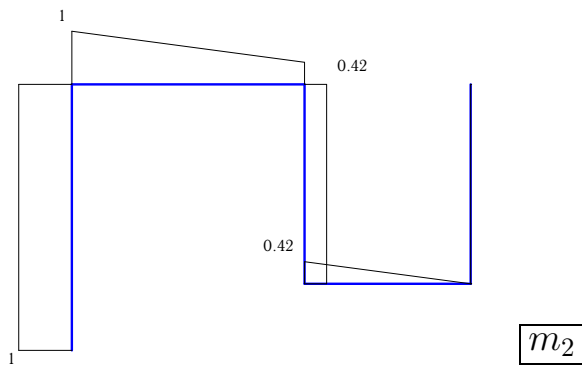


Расчет статически неопределимой рамы методом сил







Система канонических уравнений

$$\begin{aligned} \delta_{11} \cdot X_1 + \delta_{12} \cdot X_2 + \Delta_{P1} &= 0, \\ \delta_{21} \cdot X_1 + \delta_{22} \cdot X_2 + \Delta_{P2} &= 0, \\ 597.33 \cdot X_1 - 58.58 \cdot X_2 &= 495.06; \\ -58.58 \cdot X_1 + 13.04 \cdot X_2 &= 280.06; \end{aligned}$$

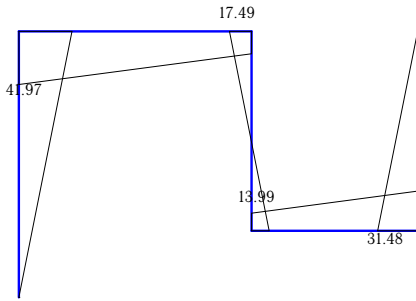
Коэффициенты системы:

$$\begin{aligned} EI \cdot \delta_{11} = \sum_n \int_0^s m_1 m_1 ds &= \left(\frac{1}{2} \cdot 8 \cdot 8 \cdot \frac{2}{3} \cdot 8\right) + \left(\frac{1}{2} \cdot 8 \cdot 7 \cdot \frac{2}{3} \cdot 8 + \frac{1}{2} \cdot 8 \cdot 7 \cdot \frac{1}{3} \cdot 3.33 + \frac{1}{2} \cdot 3.33 \cdot 7 \cdot \frac{2}{3} \cdot 3.33 + \frac{1}{2} \cdot 3.33 \cdot 7 \cdot \frac{1}{3} \cdot 8\right) + \left(\frac{1}{2} \cdot 3.33 \cdot 6 \cdot \frac{2}{3} \cdot 3.33 - \frac{1}{2} \cdot 3.33 \cdot 6 \cdot \frac{1}{3} \cdot 2.67 + \frac{1}{2} \cdot 2.67 \cdot 6 \cdot \frac{2}{3} \cdot 2.67 - \frac{1}{2} \cdot 2.67 \cdot 6 \cdot \frac{1}{3} \cdot 3.33\right) + \left(\frac{1}{2} \cdot 2.67 \cdot 5 \cdot \frac{2}{3} \cdot 2.67 + \frac{1}{2} \cdot 2.67 \cdot 5 \cdot \frac{1}{3} \cdot 6 + \frac{1}{2} \cdot 6 \cdot 5 \cdot \frac{2}{3} \cdot 6 + \frac{1}{2} \cdot 6 \cdot 5 \cdot \frac{1}{3} \cdot 2.67\right) + \left(\frac{1}{2} \cdot 6 \cdot 6 \cdot \frac{2}{3} \cdot 6\right) = 170.67 + 237.48 + 18.67 + 98.52 + 72 = 597.333; \end{aligned}$$

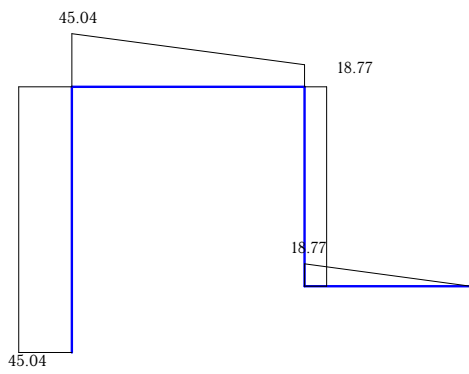
$$\begin{aligned} EI \cdot \delta_{21} = \sum_n \int_0^s m_2 m_1 ds &= \left(-\frac{1}{2} \cdot 8 \cdot 8 \cdot 1\right) + \left(-\frac{1}{2} \cdot 1 \cdot 7 \cdot \frac{2}{3} \cdot 8 - \frac{1}{2} \cdot 1 \cdot 7 \cdot \frac{1}{3} \cdot 3.33 - \frac{1}{2} \cdot 0.42 \cdot 7 \cdot \frac{2}{3} \cdot 3.33 - \frac{1}{2} \cdot 0.42 \cdot 7 \cdot \frac{1}{3} \cdot 8\right) + \left(-\frac{1}{2} \cdot 3.33 \cdot 6 \cdot 0.42 + \frac{1}{2} \cdot 2.67 \cdot 6 \cdot 0.42\right) + \left(\frac{1}{2} \cdot 0.42 \cdot 5 \cdot \frac{2}{3} \cdot 2.67 + \frac{1}{2} \cdot 0.42 \cdot 5 \cdot \frac{1}{3} \cdot 6\right) = -32 - 29.69 - 0.83 + 3.94 = -58.583; \end{aligned}$$

$$\begin{aligned} EI \cdot \Delta_{P1} = \sum_n \int_0^s M_p m_1 ds &= \left(\frac{1}{2} \cdot 50.17 \cdot 7 \cdot \frac{2}{3} \cdot 3.33 + \frac{1}{2} \cdot 50.17 \cdot 7 \cdot \frac{1}{3} \cdot 8\right) + \left(\frac{1}{2} \cdot 3.33 \cdot 6 \cdot 50.17 - \frac{1}{2} \cdot 2.67 \cdot 6 \cdot 50.17\right) + \left(-\frac{1}{2} \cdot 50.17 \cdot 5 \cdot \frac{2}{3} \cdot 2.67 - \frac{1}{2} \cdot 50.17 \cdot 5 \cdot \frac{1}{3} \cdot 6 - \frac{1}{2} \cdot 36 \cdot 5 \cdot \frac{2}{3} \cdot 6 - \frac{1}{2} \cdot 36 \cdot 5 \cdot \frac{1}{3} \cdot 2.67\right) + \left(-\frac{1}{2} \cdot 36 \cdot 6 \cdot \frac{2}{3} \cdot 6\right) - 12 \cdot 9 = +858.4 + 100.33 - 913.8 - 432 - 108 = -495.056; \end{aligned}$$

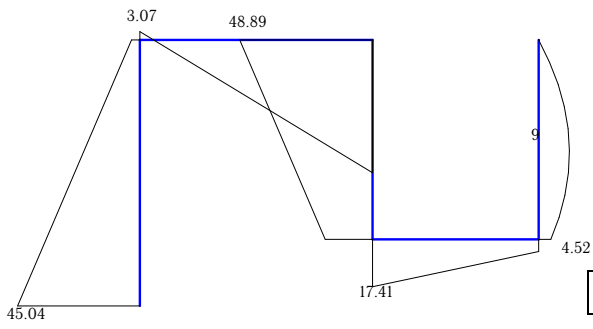
$$\begin{aligned} EI \cdot \delta_{22} = \sum_n \int_0^s m_2 m_2 ds &= 1 \cdot 1 \cdot 8 + \left(\frac{1}{2} \cdot 1 \cdot 7 \cdot \frac{2}{3} \cdot 1 + \frac{1}{2} \cdot 1 \cdot 7 \cdot \frac{1}{3} \cdot 0.42 + \frac{1}{2} \cdot 0.42 \cdot 7 \cdot \frac{2}{3} \cdot 0.42 + \frac{1}{2} \cdot 0.42 \cdot 7 \cdot \frac{1}{3} \cdot 1\right) + 0.42 \cdot 0.42 \cdot 6 + \left(\frac{1}{2} \cdot 0.42 \cdot 5 \cdot \frac{2}{3} \cdot 0.42\right) = 8 + 3.71 + 1.04 + 0.29 = 13.042; \end{aligned}$$



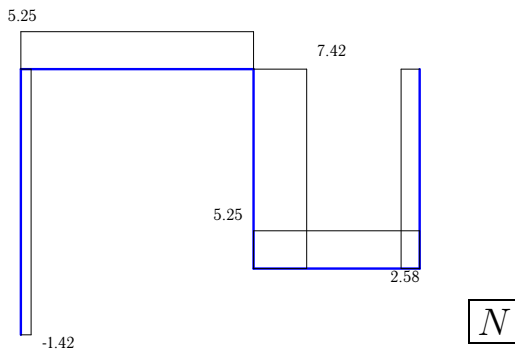
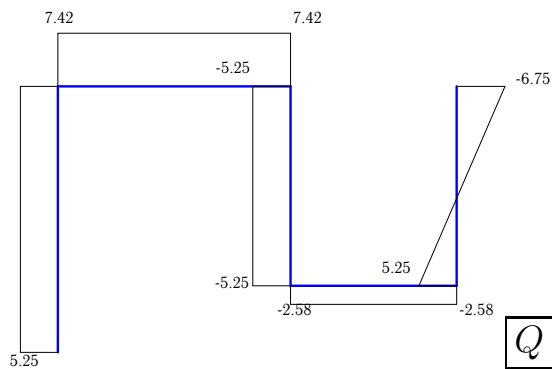
$$m_1 \cdot x_1$$



$$m_2 \cdot x_2$$



$$M$$



Кинематическая проверка

$$\sum_n \int_0^s M m_1 ds = \left(-\frac{1}{2} \cdot 45.04 \cdot 8 \cdot \frac{1}{3} \cdot 8 - \frac{1}{2} \cdot 3.07 \cdot 8 \cdot \frac{2}{3} \cdot 8 \right) + \left(-\frac{1}{2} \cdot 3.07 \cdot 7 \cdot \frac{2}{3} \cdot 8 - \frac{1}{2} \cdot 3.07 \cdot 7 \cdot \frac{1}{3} \cdot 3.33 + \frac{1}{2} \cdot 48.89 \cdot 7 \cdot \frac{2}{3} \cdot 3.33 + \frac{1}{2} \cdot 48.89 \cdot 7 \cdot \frac{1}{3} \cdot 8 \right) + \left(\frac{1}{2} \cdot 48.89 \cdot 6 \cdot \frac{2}{3} \cdot 3.33 - \frac{1}{2} \cdot 48.89 \cdot 6 \cdot \frac{1}{3} \cdot 2.67 - \frac{1}{2} \cdot 17.41 \cdot 6 \cdot \frac{2}{3} \cdot 2.67 + \frac{1}{2} \cdot 17.41 \cdot 6 \cdot \frac{1}{3} \cdot 3.33 \right) + \left(-\frac{1}{2} \cdot 17.41 \cdot 5 \cdot \frac{2}{3} \cdot 2.67 - \frac{1}{2} \cdot 17.41 \cdot 5 \cdot \frac{1}{3} \cdot 6 - \frac{1}{2} \cdot 4.52 \cdot 5 \cdot \frac{2}{3} \cdot 6 - \frac{1}{2} \cdot 4.52 \cdot 5 \cdot \frac{1}{3} \cdot 2.67 \right) + \left(-\frac{1}{2} \cdot 4.52 \cdot 6 \cdot \frac{2}{3} \cdot 6 \right) - 12 \cdot 9 = -545.93 + 767.24 + 160.73 - 219.74 - 54.3 - 108 = 0;$$

$$\sum_n \int_0^s M m_2 ds = \left(\frac{1}{2} \cdot 45.04 \cdot 8 \cdot 1 + \frac{1}{2} \cdot 3.07 \cdot 8 \cdot 1 \right) + \left(\frac{1}{2} \cdot 3.07 \cdot 7 \cdot \frac{2}{3} \cdot 1 + \frac{1}{2} \cdot 3.07 \cdot 7 \cdot \frac{1}{3} \cdot 0.42 - \frac{1}{2} \cdot 48.89 \cdot 7 \cdot \frac{2}{3} \cdot 0.42 - \frac{1}{2} \cdot 48.89 \cdot 7 \cdot \frac{1}{3} \cdot 1 \right) + \left(-\frac{1}{2} \cdot 48.89 \cdot 6 \cdot 0.42 - \frac{1}{2} \cdot 17.41 \cdot 6 \cdot 0.42 \right) + \left(-\frac{1}{2} \cdot 17.41 \cdot 5 \cdot \frac{2}{3} \cdot 0.42 - \frac{1}{2} \cdot 4.52 \cdot 5 \cdot \frac{1}{3} \cdot 0.42 \right) = 192.44 - 95.9 - 82.87 - 13.66 = 0;$$