

$$\Sigma X=0$$

$$R_A + R_B + 35\text{kN} - 3 \frac{\text{kN}}{\text{m}} \cdot 7\text{m} - 2 \frac{\text{kN}}{\text{m}} \cdot 2\text{m} - \frac{1}{2} \cdot 2 \frac{\text{kN}}{\text{m}} \cdot 3\text{m} = 0$$

$$\Sigma Y=0$$

$$R_C - 15\text{kN} = 0$$

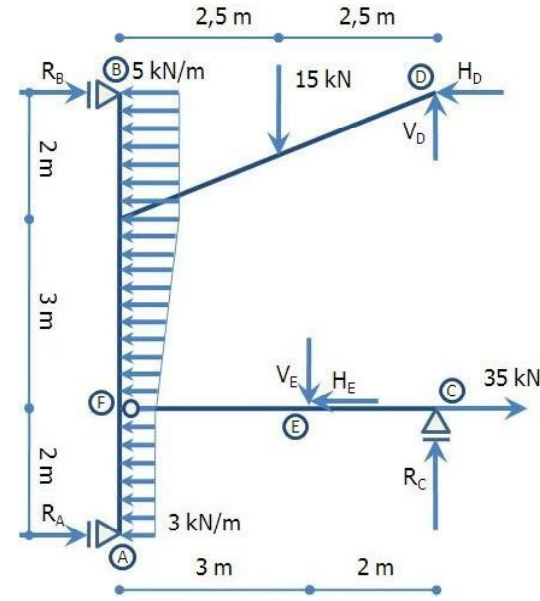
$$\Sigma M_D=0$$

$$20\text{kNm} + 20\text{kNm} + 15\text{kN} \cdot 2.5\text{m} + R_A \cdot 7\text{m} + 35\text{kN} \cdot 5\text{m} - 3 \frac{\text{kN}}{\text{m}} \cdot 7\text{m} \cdot \frac{7\text{m}}{2} - 2 \frac{\text{kN}}{\text{m}} \cdot 2\text{m} \cdot \frac{2\text{m}}{2} - \frac{1}{2} \cdot 2 \frac{\text{kN}}{\text{m}} \cdot 3\text{m} \cdot \left(2\text{m} + \frac{1}{3} \cdot 3\text{m}\right) = 0$$

$$R_A = -23.714\text{ kN}$$

$$R_B = 16.714\text{ kN}$$

$$R_C = 15\text{ kN}$$



$$\Sigma X=0$$

$$H_E + H_D = 0$$

$$\Sigma Y=0$$

$$V_E - V_D = 0$$

$$\Sigma M_D=0$$

$$20\text{kNm} + 20\text{kNm} + H_E \cdot 5\text{m} - V_E \cdot 2\text{m} = 0$$

$$\Sigma M_{Dp}=0$$

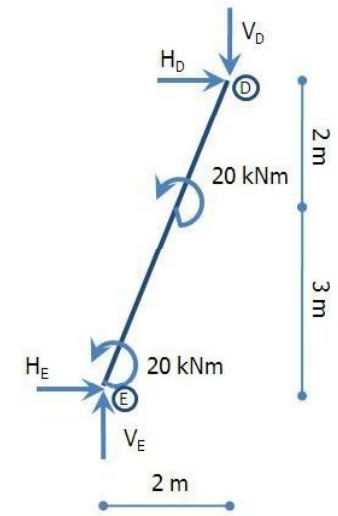
$$V_E \cdot 3\text{m} - R_C \cdot 5\text{m} = 0$$

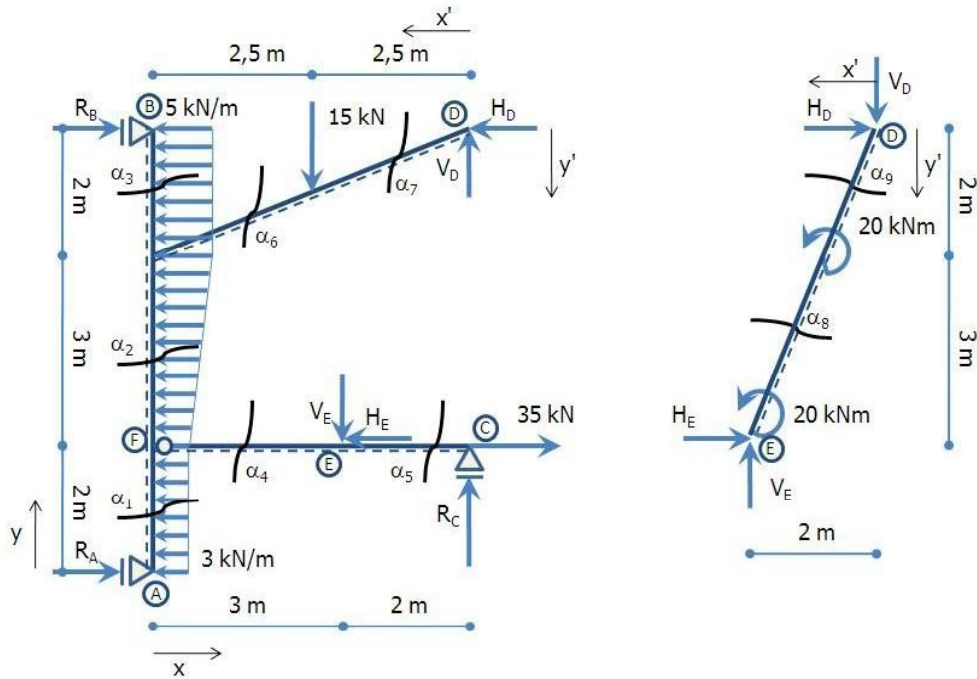
$$V_D = 25\text{ kN}$$

$$H_D = -2\text{ kN}$$

$$V_E = 25\text{ kN}$$

$$H_E = 2\text{ kN}$$





alfa5

$$N_{\alpha 5} = 35 \text{ kN}$$

$$T_{\alpha 5} = -R_C \qquad T_{\alpha 5} = -15 \text{ kN}$$

$$M_{\alpha 5}(x') = R_C \cdot x'$$

$$M_{\alpha 5}(0\text{m}) = 0 \text{ kNm} \qquad M_{\alpha 5}(2\text{m}) = 30 \text{ kNm}$$

alfa4

$$N_{\alpha 4} = 35 \text{ kN} - H_E \qquad N_{\alpha 4} = 33 \text{ kN}$$

$$T_{\alpha 4} = -R_C + V_E \qquad T_{\alpha 4} = 10 \text{ kN}$$

$$M_{\alpha 4}(x') = R_C \cdot x' - V_E \cdot (x' - 2\text{m})$$

$$M_{\alpha 4}(x') \left| \begin{array}{l} \text{expand} \\ \text{float,5} \end{array} \right. = 50.0 \text{ kN} \cdot \text{m} + -10.0 \text{ kN} \cdot x'$$

$$M_{\alpha 4}(2\text{m}) = 30 \text{ kNm} \qquad M_{\alpha 4}(5\text{m}) = 0 \text{ kNm}$$

alfa1

$$N_{\alpha 1} = 0$$

$$T_{\alpha 1}(y) = -R_A + 3 \frac{\text{kN}}{\text{m}} \cdot y \qquad T_{\alpha 1}(0\text{m}) = 23.714 \text{ kN} \qquad T_{\alpha 1}(2\text{m}) = 29.714 \text{ kN}$$

$$M_{\alpha 1}(y) = R_A \cdot y - 3 \frac{\text{kN}}{\text{m}} \cdot y \cdot \frac{y}{2}$$

$$M_{\alpha 1}(x) \left| \begin{array}{l} \text{expand} \\ \text{float,5} \end{array} \right. = -23.714 \text{ kN} \cdot x - \frac{1.5 \text{ kN} \cdot x^2}{\text{m}}$$

$$M_{\alpha 1}(0\text{m}) = 0 \text{ kNm} \qquad M_{\alpha 1}(2\text{m}) = -53.429 \text{ kNm}$$

alfa2

$$N_{\alpha 2} = -R_C + V_E \qquad N_{\alpha 2} = 10 \text{ kN}$$

$$q'(y) = 2 \frac{\text{kN}}{\text{m}} \cdot \frac{y - 2\text{m}}{3\text{m}}$$

$$T_{\alpha 2}(y) = -R_A + 3 \frac{\text{kN}}{\text{m}} \cdot y + \frac{1}{2} q'(y) \cdot (y - 2\text{m}) + H_E - 35 \text{ kN} \qquad T_{\alpha 2}(2\text{m}) = -3.286 \text{ kN} \qquad T_{\alpha 2}(5\text{m}) = 8.714 \text{ kN}$$

$$T_{\alpha 2}(y) \left| \begin{array}{l} \text{expand} \\ \text{float,5} \end{array} \right. = -7.9524 \text{ kN} + \frac{0.33333 \text{ kN} \cdot y^2}{\text{m}^2} + \frac{1.6667 \text{ kN} \cdot y}{\text{m}}$$

$$y_0 = 3\text{m}$$

$$T_{\alpha 2}(y_0) = 0$$

$$y_0 = 2.987 \text{ m}$$

$$M_{\alpha 2}(y) = R_A \cdot y - 3 \frac{\text{kN}}{\text{m}} \cdot y \cdot \frac{y}{2} - \frac{1}{2} q'(y) \cdot (y - 2\text{m}) \cdot \frac{1}{3} (y - 2\text{m}) - H_E \cdot (y - 2\text{m}) + 35 \text{ kN} \cdot (y - 2\text{m}) + R_C \cdot 5\text{m} - V_E \cdot 3\text{m}$$

$$M_{\alpha 2}(y) \left| \begin{array}{l} \text{expand} \\ \text{float,5} \end{array} \right. = -65.111 \text{ kN} \cdot \text{m} + 7.9524 \text{ kN} \cdot y - \frac{0.83333 \text{ kN} \cdot y^2}{\text{m}} - \frac{0.11111 \text{ kN} \cdot y^3}{\text{m}^2}$$

$$M_{\alpha 2}(2\text{m}) = -53.429 \text{ kNm} \qquad M_{\alpha 2}(5\text{m}) = -60.071 \text{ kNm}$$

$$M_{\alpha 2}(y_0) = -51.754 \text{ kNm}$$

alfa3

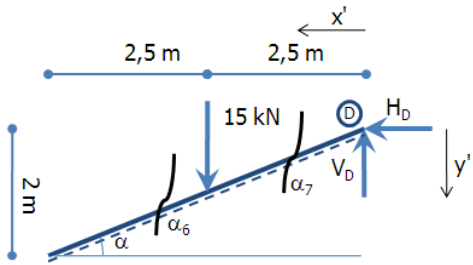
$$N_{\alpha 3} = 0$$

$$T_{\alpha 3}(y') = R_B - 5 \frac{\text{kN}}{\text{m}} \cdot y' \qquad T_{\alpha 3}(0\text{m}) = 16.714 \text{ kN} \qquad T_{\alpha 3}(2\text{m}) = 6.714 \text{ kN}$$

$$M_{\alpha 3}(y') = R_B \cdot y' - 5 \frac{\text{kN}}{\text{m}} \cdot y' \cdot \frac{y'}{2}$$

$$M_{\alpha 3}(x) \left| \begin{array}{l} \text{expand} \\ \text{float,5} \end{array} \right. = 16.714 \text{ kN} \cdot x - \frac{2.5 \text{ kN} \cdot x^2}{\text{m}}$$

$$M_{\alpha 3}(0\text{m}) = 0 \text{ kNm} \qquad M_{\alpha 3}(2\text{m}) = 23.429 \text{ kNm}$$



$$\sin_{\alpha} = \frac{2m}{\sqrt{(2m)^2 + (5m)^2}} \quad \sin_{\alpha} = 0.371$$

$$\cos_{\alpha} = \frac{5m}{\sqrt{(2m)^2 + (5m)^2}} \quad \cos_{\alpha} = 0.928$$

alfa7

$$N_{\alpha 7} = -H_D \cdot \cos_{\alpha} + V_D \cdot \sin_{\alpha} \quad N_{\alpha 7} = 11.142 \cdot \text{kN}$$

$$T_{\alpha 7} = -H_D \cdot \sin_{\alpha} - V_D \cdot \cos_{\alpha} \quad T_{\alpha 7} = -22.469 \cdot \text{kN}$$

$$M_{\alpha 7}(x', y') = V_D \cdot x' + H_D \cdot y'$$

$$M_{\alpha 7}(x', y') \Big|_{\text{float}, 5}^{\text{expand}} = 25.0 \cdot \text{kN} \cdot x' + -2.0 \cdot \text{kN} \cdot y'$$

$$M_{\alpha 7}(0m, 0m) = 0 \cdot \text{kNm} \quad M_{\alpha 7}(2.5m, 1m) = 60.5 \cdot \text{kNm}$$

alfa6

$$N_{\alpha 6} = -H_D \cdot \cos_{\alpha} + V_D \cdot \sin_{\alpha} - 15 \text{kN} \cdot \sin_{\alpha} \quad N_{\alpha 6} = 5.571 \cdot \text{kN}$$

$$T_{\alpha 6} = -H_D \cdot \sin_{\alpha} - V_D \cdot \cos_{\alpha} + 15 \text{kN} \cdot \cos_{\alpha} \quad T_{\alpha 6} = -8.542 \cdot \text{kN}$$

$$M_{\alpha 6}(x', y') = V_D \cdot x' + H_D \cdot y' - 15 \text{kN} \cdot (x' - 2.5m)$$

$$M_{\alpha 6}(x', y') \Big|_{\text{float}, 5}^{\text{expand}} = 37.5 \cdot \text{kN} \cdot m + 10.0 \cdot \text{kN} \cdot x' + -2.0 \cdot \text{kN} \cdot y'$$

$$M_{\alpha 6}(2.5m, 1m) = 60.5 \cdot \text{kNm} \quad M_{\alpha 6}(5m, 2m) = 83.5 \cdot \text{kNm}$$

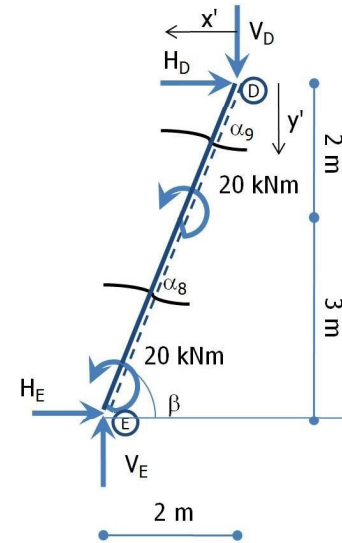
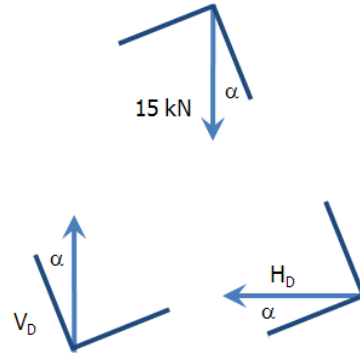
eliminacia y

$$y(x') = x' \cdot \frac{2m}{5m} \quad M_{\alpha 7}(x') = V_D \cdot x' + H_D \cdot \left(x' \cdot \frac{2m}{5m}\right)$$

$$M_{\alpha 7}(x') \Big|_{\text{float}, 5}^{\text{expand}} = 24.2 \cdot \text{kN} \cdot x' \quad M_{\alpha 7}(0m) = 0 \cdot \text{kNm} \quad M_{\alpha 7}(2.5m) = 60.5 \cdot \text{kNm}$$

$$M_{\alpha 6}(x') = V_D \cdot x' + H_D \cdot \left(x' \cdot \frac{2m}{5m}\right) - 15 \text{kN} \cdot (x' - 2.5m)$$

$$M_{\alpha 6}(x') \Big|_{\text{float}, 5}^{\text{expand}} = 37.5 \cdot \text{kN} \cdot m + 9.2 \cdot \text{kN} \cdot x' \quad M_{\alpha 6}(2.5m) = 60.5 \cdot \text{kNm} \quad M_{\alpha 6}(5m) = 83.5 \cdot \text{kNm}$$



$$M_{\alpha 8}(x, y) \Big|_{\text{float}, 5}^{\text{expand}} = -91.0 \cdot \text{kN} \cdot m + 25.0 \cdot \text{kN} \cdot x + -2.0 \cdot \text{kN} \cdot y$$

alfa9

$$N_{\alpha 9} = -H_E \cdot \cos_{\beta} - V_E \cdot \sin_{\beta} \quad N_{\alpha 9} = -23.955 \cdot \text{kN}$$

$$T_{\alpha 9} = -H_E \cdot \sin_{\beta} + V_E \cdot \cos_{\beta} \quad T_{\alpha 9} = 7.428 \cdot \text{kN}$$

$$M_{\alpha 9}(x, y) = V_E \cdot (x - 3m) - H_E \cdot (y - 2m) - 20 \text{kNm} - 20 \text{kNm}$$

$$M_{\alpha 9}(x, y) \Big|_{\text{float}, 5}^{\text{expand}} = -111.0 \cdot \text{kN} \cdot m + 25.0 \cdot \text{kN} \cdot x + -2.0 \cdot \text{kN} \cdot y$$

eliminacia x

$$x(y) = (y - 2m) \cdot \frac{2m}{5m} + 3m$$

$$M_{\alpha 8}(y) \Big|_{\text{float}, 5}^{\text{expand}} = -36.0 \cdot \text{kN} \cdot m + 8.0 \cdot \text{kN} \cdot y \quad M_{\alpha 8}(2m) = -20 \cdot \text{kNm} \quad M_{\alpha 8}(5m) = 4 \cdot \text{kNm}$$

$$M_{\alpha 9}(y) = V_E \cdot \left[(y - 2m) \cdot \frac{2m}{5m} + 3m - 3m \right] - H_E \cdot (y - 2m) - 20 \text{kNm} - 20 \text{kNm}$$

$$M_{\alpha 9}(y) \Big|_{\text{float}, 5}^{\text{expand}} = -56.0 \cdot \text{kN} \cdot m + 8.0 \cdot \text{kN} \cdot y$$

$$M_{\alpha 9}(5m) = -16 \cdot \text{kNm} \quad M_{\alpha 9}(7m) = 0 \cdot \text{kNm}$$

$$\sin_{\beta} = \frac{5m}{\sqrt{(2m)^2 + (5m)^2}} \quad \sin_{\beta} = 0.928$$

$$\cos_{\beta} = \frac{2m}{\sqrt{(2m)^2 + (5m)^2}} \quad \cos_{\beta} = 0.371$$

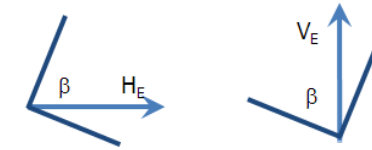
alfa8

$$N_{\alpha 8} = -H_E \cdot \cos_{\beta} - V_E \cdot \sin_{\beta} \quad N_{\alpha 8} = -23.955 \cdot \text{kN}$$

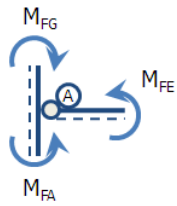
$$T_{\alpha 8} = -H_E \cdot \sin_{\beta} + V_E \cdot \cos_{\beta} \quad T_{\alpha 8} = 7.428 \cdot \text{kN}$$

$$M_{\alpha 8}(x, y) = V_E \cdot (x - 3m) - H_E \cdot (y - 2m) - 20 \text{kNm}$$

$$M_{\alpha 8}(3m, 2m) = -20 \cdot \text{kNm} \quad M_{\alpha 8}\left(2m \cdot \frac{3m}{5m} + 3m, 5m\right) = 4 \cdot \text{kNm}$$



Sprawdzenie równowagi w węzłach

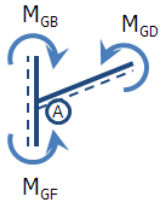


$$M_{FE} = M_{\alpha 4}(5m) \quad M_{FE} = 0 \cdot \text{kNm}$$

$$M_{FG} = M_{\alpha 2}(2m) \quad M_{FG} = -53.429 \cdot \text{kNm}$$

$$M_{FA} = M_{\alpha 1}(2m) \quad M_{FA} = -53.429 \cdot \text{kNm}$$

$$-M_{FA} + M_{FE} + M_{FG} = 0 \cdot \text{kNm}$$

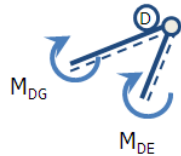


$$M_{GB} = M_{\alpha 3}(2m) \quad M_{GB} = 23.429 \cdot \text{kNm}$$

$$M_{GF} = M_{\alpha 2}(5m) \quad M_{GF} = -60.071 \cdot \text{kNm}$$

$$M_{GD} = M_{\alpha 6}(5m) \quad M_{GD} = 83.5 \cdot \text{kNm}$$

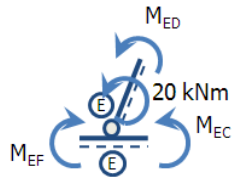
$$M_{GF} + M_{GD} - M_{GB} = -7.276 \times 10^{-15} \cdot \text{kNm}$$



$$M_{DG} = M_{\alpha 7}(0m) \quad M_{DG} = 0 \cdot \text{kNm}$$

$$M_{DE} = M_{\alpha 9}(7m) \quad M_{DE} = 0 \cdot \text{kNm}$$

$$-M_{DE} - M_{DG} = 0 \cdot \text{kNm}$$

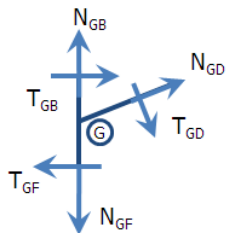


$$M_{EF} = M_{\alpha 4}(2m) \quad M_{EF} = 30 \cdot \text{kNm}$$

$$M_{ED} = M_{\alpha 8}(2m) \quad M_{ED} = -20 \cdot \text{kNm}$$

$$M_{EC} = M_{\alpha 5}(2m) \quad M_{EC} = 30 \cdot \text{kNm}$$

$$-M_{EF} + M_{EC} + M_{ED} + 20 \text{kNm} = 0 \cdot \text{kNm}$$



$$N_{GB} = N_{\alpha 3} \quad N_{GB} = 0 \cdot \text{kN}$$

$$N_{GF} = N_{\alpha 2} \quad N_{GF} = 10 \cdot \text{kN}$$

$$N_{GD} = N_{\alpha 6} \quad N_{GD} = 5.571 \cdot \text{kN}$$

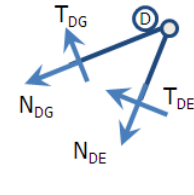
$$T_{GB} = T_{\alpha 3}(2m) \quad T_{GB} = 6.714 \cdot \text{kN}$$

$$T_{GF} = T_{\alpha 2}(5m) \quad T_{GF} = 8.714 \cdot \text{kN}$$

$$T_{GD} = T_{\alpha 6} \quad T_{GD} = -8.542 \cdot \text{kN}$$

$$\Sigma X \quad N_{GD} \cdot \cos_{\alpha} + T_{GD} \cdot \sin_{\alpha} + T_{GB} - T_{GF} = 1.819 \times 10^{-15} \cdot \text{kN}$$

$$\Sigma Y \quad N_{GD} \cdot \sin_{\alpha} - T_{GD} \cdot \cos_{\alpha} + N_{GB} - N_{GF} = 1.819 \times 10^{-15} \cdot \text{kN}$$



$$N_{DG} = N_{\alpha 7} \quad N_{DG} = 11.142 \cdot \text{kN}$$

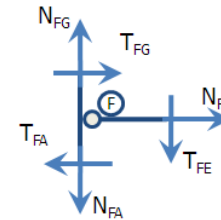
$$N_{DE} = N_{\alpha 9} \quad N_{DE} = -23.955 \cdot \text{kN}$$

$$T_{DG} = T_{\alpha 7} \quad T_{DG} = -22.469 \cdot \text{kN}$$

$$T_{DE} = T_{\alpha 9} \quad T_{DE} = 7.428 \frac{1}{m} \cdot \text{kNm}$$

$$\Sigma X \quad -N_{DG} \cdot \cos_{\alpha} - T_{DG} \cdot \sin_{\alpha} - T_{DE} \cdot \sin_{\beta} - N_{DE} \cdot \cos_{\beta} = 1.819 \times 10^{-15} \cdot \text{kN}$$

$$\Sigma Y \quad -N_{DG} \cdot \sin_{\alpha} + T_{DG} \cdot \cos_{\alpha} + T_{DE} \cdot \cos_{\beta} - N_{DE} \cdot \sin_{\beta} = 0 \cdot \text{kN}$$



$$N_{FE} = N_{\alpha 4} \quad N_{FE} = 33 \cdot \text{kN}$$

$$N_{FG} = N_{\alpha 2} \quad N_{FG} = 10 \cdot \text{kN}$$

$$N_{FA} = N_{\alpha 1} \quad N_{FA} = 0 \cdot \text{kN}$$

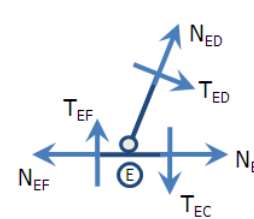
$$T_{FE} = T_{\alpha 4} \quad T_{FE} = 10 \cdot \text{kN}$$

$$T_{FG} = T_{\alpha 2}(2m) \quad T_{FG} = -3.286 \cdot \text{kN}$$

$$T_{FA} = T_{\alpha 1}(2m) \quad T_{FA} = 29.714 \cdot \text{kN}$$

$$\Sigma X \quad N_{FE} + T_{FG} - T_{FA} = 0 \cdot \text{kN}$$

$$\Sigma Y \quad -T_{FE} + N_{FG} - N_{FA} = 0 \cdot \text{kN}$$



$$N_{ED} = N_{\alpha 8} \quad N_{ED} = -23.955 \cdot \text{kN}$$

$$N_{EC} = N_{\alpha 5} \quad N_{EC} = 35 \cdot \text{kN}$$

$$N_{EF} = N_{\alpha 4} \quad N_{EF} = 33 \cdot \text{kN}$$

$$T_{ED} = T_{\alpha 8} \quad T_{ED} = 7.428 \cdot \text{kN}$$

$$T_{EC} = T_{\alpha 5} \quad T_{EC} = -15 \cdot \text{kN}$$

$$T_{EF} = T_{\alpha 4} \quad T_{EF} = 10 \cdot \text{kN}$$

$$\Sigma X \quad N_{EC} - N_{EF} + T_{ED} \cdot \sin_{\beta} + N_{ED} \cdot \cos_{\beta} = 0 \cdot \text{kN}$$

$$\Sigma Y \quad -T_{EC} + T_{EF} - T_{ED} \cdot \cos_{\beta} + N_{ED} \cdot \sin_{\beta} = -7.276 \times 10^{-15} \cdot \text{kN}$$

