Truss

Data

Node List

Node	x	y
	m	m
1	0	0
2	2	0
3	4	0
4	2	2
5	0	2

Element List

Element	Node 1	Node 2	Area	Elasticity
			m^2	kN/m^2
1	1	2	150.00×10^{-5}	200000000
2	2	3	150.00×10^{-5}	200000000
3	3	4	150.00×10^{-5}	200000000
4	2	4	150.00×10^{-5}	200000000
5	1	4	150.00×10^{-5}	200000000
6	4	5	150.00×10^{-5}	200000000

Displacement Boundary Condition

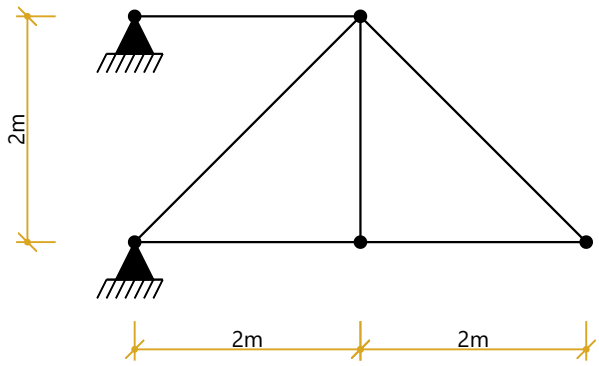
Node	x	y	Angle	S_x	S_y
			°	m	m
1	1	1	0	0.0000	0.0000
5	1	1	0	0.0000	0.0000

Forces Boundary Condition

Node	x	y
	kN	kN
1	0	0
3	0	-30

Geometry of Structure

$scale_{xy,coord} = 50$



Stiffness Matrix ▲

Transformation matrix T_{skew} for global to nodal transformation ▲

Node 1

Skew angle of support, $\alpha = 0$ °

$\cos(0) = 1$, $\sin(0) = 0$, $-\sin(0) = 0$, $\cos(0) = 1$

$$t_{skew} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Node 5

Skew angle of support, $\alpha = 0$ °

$\cos(0) = 1$, $\sin(0) = 0$, $-\sin(0) = 0$, $\cos(0) = 1$

$$t_{skew} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Transformation T_{skew} matrix for Structure

$$T_{skew} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Element stiffness matrix ▲

Element 1

Start node : 1 , End node: 2

Area of Element, $A_{ei} = 0.0015\ \mathrm{m}^2$

Modulus of Elasticity, $E_{ei} = 200000000\ \frac{\mathrm{kN}}{\mathrm{m}^2}$

$(x_1, y_1) = (0, 0)$

$(x_2, y_2) = (2, 0)$

Length of Element, $L_{ei} = \sqrt{(2-0)^2 + (0-0)^2} = 2\ \mathrm{m}$

$\mathrm{Cos}(\theta) = \lambda_x = \frac{x_2 - x_1}{Lei} = \frac{2-0}{2} = 1$

$\mathrm{Sin}(\theta) = \lambda_y = \frac{y_2 - y_1}{Lei} = \frac{0-0}{2} = 0$

$k_{e,local,11} = \frac{Aei \cdot Eei}{Lei} = \frac{0.0015 \cdot 200000000}{2} = 150000\ \frac{\mathrm{kN}}{\mathrm{m}}$

$$k_{e,global} = \begin{bmatrix} 150000 & 0 & -150000 & 0 \\ 0 & 0 & 0 & 0 \\ -150000 & 0 & 150000 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$gatherOp = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$K_{struc} = K_{struc} + T_{skew} \cdot \mathbf{transp}(gatherOp) \cdot k_{e,global} \cdot gatherOp \cdot \mathbf{transp}(T_{skew}) =$

$$\begin{bmatrix} 150000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -150000 & 0 & 150000 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Element 2

Start node : 2 , End node: 3

Area of Element, $A_{ei} = 0.0015\ \mathrm{m}^2$

Modulus of Elasticity, $E_{ei} = 200000000\ \frac{\mathrm{kN}}{\mathrm{m}^2}$

$(x_1, y_1) = (2, 0)$

$(x_2, y_2) = (4, 0)$

Length of Element, $L_{ei} = \sqrt{(4-2)^2 + (0-0)^2} = 2\ \mathrm{m}$

$\mathrm{Cos}(\theta) = \lambda_x = \frac{x_2 - x_1}{Lei} = \frac{4-2}{2} = 1$

$\mathrm{Sin}(\theta) = \lambda_y = \frac{y_2 - y_1}{Lei} = \frac{0-0}{2} = 0$

$$k_{e,local,11} = \frac{Aei \cdot Eei}{Lei} = \frac{0.0015 \cdot 200000000}{2} = 150000 \ \frac{kN}{m}$$

$$k_{e,global} = \begin{bmatrix} 150000 & 0 & -150000 & 0 \\ 0 & 0 & 0 & 0 \\ -150000 & 0 & 150000 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$gatherOp = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$K_{struc} = K_{struc} + T_{skew} \cdot \mathbf{transp}(gatherOp) \cdot k_{e,global} \cdot gatherOp \cdot \mathbf{transp}(T_{skew}) =$$

$$\begin{bmatrix} 150000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -150000 & 0 & 300000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -150000 & 0 & 150000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Element 3

Start node : 3 , End node: 4

Area of Element, $A_{ei} = 0.0015 \ m^2$

Modulus of Elasticity, $E_{ei} = 200000000 \ \frac{kN}{m^2}$

$(x_1, y_1) = (4 , 0)$

$(x_2, y_2) = (2 , 2)$

Length of Element, $L_{ei} = \sqrt{(2-4)^2 + (2-0)^2} = 2.83 \ m$

Cos(θ) = $\lambda_x = \frac{x_2 - x_1}{Lei} = \frac{2-4}{2.83} = -0.707$

Sin(θ) = $\lambda_y = \frac{y_2 - y_1}{Lei} = \frac{2-0}{2.83} = 0.707$

$$k_{e,local,11} = \frac{Aei \cdot Eei}{Lei} = \frac{0.0015 \cdot 200000000}{2.83} = 106066 \ \frac{kN}{m}$$

$$k_{e,global} = \begin{bmatrix} 53033 & -53033 & -53033 & 53033 \\ -53033 & 53033 & 53033 & -53033 \\ -53033 & 53033 & 53033 & -53033 \\ 53033 & -53033 & -53033 & 53033 \end{bmatrix}$$

$$gatherOp = \begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

$$K_{struc} = K_{struc} + T_{skew} \cdot \text{transp}(gatherOp) \cdot k_{e,global} \cdot gatherOp \cdot \text{transp}(T_{skew}) =$$

$$\begin{bmatrix} 150000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -150000 & 0 & 300000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -150000 & 0 & 203033 & -53033 & -53033 & 53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & -53033 & 53033 & 53033 & -53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & -53033 & 53033 & 53033 & -53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & 53033 & -53033 & -53033 & 53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Element 4

Start node : 2 , End node: 4

Area of Element, $A_{ei} = 0.0015\ \text{m}^2$

Modulus of Elasticity, $E_{ei} = 200000000\ \frac{\text{kN}}{\text{m}^2}$

$(x_1, y_1) = (2, 0)$

$(x_2, y_2) = (2, 2)$

Length of Element, $L_{ei} = \sqrt{(2-2)^2 + (2-0)^2} = 2\ \text{m}$

$\text{Cos}(\theta) = \lambda_x = \frac{x_2 - x_1}{Lei} = \frac{2-2}{2} = 0$

$\text{Sin}(\theta) = \lambda_y = \frac{y_2 - y_1}{Lei} = \frac{2-0}{2} = 1$

$k_{e,local,11} = \frac{Aei \cdot Eei}{Lei} = \frac{0.0015 \cdot 200000000}{2} = 150000\ \frac{\text{kN}}{\text{m}}$

$$k_{e,global} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 150000 & 0 & -150000 \\ 0 & 0 & 0 & 0 \\ 0 & -150000 & 0 & 150000 \end{bmatrix}$$

$$gatherOp = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

$$K_{struc} = K_{struc} + T_{skew} \cdot \text{transp}(gatherOp) \cdot k_{e,global} \cdot gatherOp \cdot \text{transp}(T_{skew}) =$$

$$\begin{bmatrix} 150000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -150000 & 0 & 300000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 150000 & 0 & 0 & 0 & -150000 & 0 & 0 \\ 0 & 0 & -150000 & 0 & 203033 & -53033 & -53033 & 53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & -53033 & 53033 & 53033 & -53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & -53033 & 53033 & 53033 & -53033 & 0 & 0 \\ 0 & 0 & 0 & -150000 & 53033 & -53033 & -53033 & 203033 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Element 5

Start node : 1 , End node: 4

Area of Element, $A_{ei} = 0.0015\ \mathrm{m}^2$

Modulus of Elasticity, $E_{ei} = 200000000\ \frac{\mathrm{kN}}{\mathrm{m}^2}$

$(x_1, y_1) = (0, 0)$

$(x_2, y_2) = (2, 2)$

Length of Element, $L_{ei} = \sqrt{(2-0)^2 + (2-0)^2} = 2.83\ \mathrm{m}$

Cos(θ) = $\lambda_x = \frac{x_2 - x_1}{Lei} = \frac{2-0}{2.83} = 0.707$

Sin(θ) = $\lambda_y = \frac{y_2 - y_1}{Lei} = \frac{2-0}{2.83} = 0.707$

$k_{e,local,11} = \frac{Aei \cdot Eei}{Lei} = \frac{0.0015 \cdot 200000000}{2.83} = 106066\ \frac{\mathrm{kN}}{\mathrm{m}}$

$$k_{e,global} = \begin{bmatrix} 53033 & 53033 & -53033 & -53033 \\ 53033 & 53033 & -53033 & -53033 \\ -53033 & -53033 & 53033 & 53033 \\ -53033 & -53033 & 53033 & 53033 \end{bmatrix}$$

$$gatherOp = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

$K_{struc} = K_{struc} + T_{skew} \cdot \mathrm{transp}(gatherOp) \cdot k_{e,global} \cdot gatherOp \cdot \mathrm{transp}(T_{skew}) =$

$$\begin{bmatrix} 203033 & 53033 & -150000 & 0 & 0 & 0 & -53033 & -53033 & 0 & 0 \\ 53033 & 53033 & 0 & 0 & 0 & 0 & -53033 & -53033 & 0 & 0 \\ -150000 & 0 & 300000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 150000 & 0 & 0 & 0 & -150000 & 0 & 0 \\ 0 & 0 & -150000 & 0 & 203033 & -53033 & -53033 & 53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & -53033 & 53033 & 53033 & -53033 & 0 & 0 \\ -53033 & -53033 & 0 & 0 & -53033 & 53033 & 106066 & 0 & 0 & 0 \\ -53033 & -53033 & 0 & -150000 & 53033 & -53033 & 0 & 256066 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Element 6

Start node : 4 , End node: 5

Area of Element, $A_{ei} = 0.0015\ \mathrm{m}^2$

Modulus of Elasticity, $E_{ei} = 200000000\ \frac{\mathrm{kN}}{\mathrm{m}^2}$

$(x_1, y_1) = (2, 2)$

$(x_2, y_2) = (0, 2)$

Length of Element, $L_{ei} = \sqrt{(0-2)^2 + (2-2)^2} = 2\ \mathrm{m}$

$$\text{Cos}(\theta) = \lambda_x = \frac{x_2 - x_1}{Lei} = \frac{0 - 2}{2} = -1$$

$$\text{Sin}(\theta) = \lambda_y = \frac{y_2 - y_1}{Lei} = \frac{2 - 2}{2} = 0$$

$$k_{e,local,11} = \frac{Aei \cdot Eei}{Lei} = \frac{0.0015 \cdot 200000000}{2} = 150000 \ \frac{\text{kN}}{\text{m}}$$

$$k_{e,global} = \begin{bmatrix} 150000 & 0 & -150000 & 0 \\ 0 & 0 & 0 & 0 \\ -150000 & 0 & 150000 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$gatherOp = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$K_{struc} = K_{struc} + T_{skew} \cdot \text{transp}(gatherOp) \cdot k_{e,global} \cdot gatherOp \cdot \text{transp}(T_{skew}) =$$

$$\begin{bmatrix} 203033 & 53033 & -150000 & 0 & 0 & 0 & -53033 & -53033 & 0 & 0 \\ 53033 & 53033 & 0 & 0 & 0 & 0 & -53033 & -53033 & 0 & 0 \\ -150000 & 0 & 300000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 150000 & 0 & 0 & 0 & -150000 & 0 & 0 \\ 0 & 0 & -150000 & 0 & 203033 & -53033 & -53033 & 53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & -53033 & 53033 & 53033 & -53033 & 0 & 0 \\ -53033 & -53033 & 0 & 0 & -53033 & 53033 & 256066 & 0 & -150000 & 0 \\ -53033 & -53033 & 0 & -150000 & 53033 & -53033 & 0 & 256066 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -150000 & 0 & 150000 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Global Structure Stiffness Matrix

$$K_{struc} = \begin{bmatrix} 203033 & 53033 & -150000 & 0 & 0 & 0 & -53033 & -53033 & 0 & 0 \\ 53033 & 53033 & 0 & 0 & 0 & 0 & -53033 & -53033 & 0 & 0 \\ -150000 & 0 & 300000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 150000 & 0 & 0 & 0 & -150000 & 0 & 0 \\ 0 & 0 & -150000 & 0 & 203033 & -53033 & -53033 & 53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & -53033 & 53033 & 53033 & -53033 & 0 & 0 \\ -53033 & -53033 & 0 & 0 & -53033 & 53033 & 256066 & 0 & -150000 & 0 \\ -53033 & -53033 & 0 & -150000 & 53033 & -53033 & 0 & 256066 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -150000 & 0 & 150000 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Displacement vector ▲

$$\vec{U}_{nodal} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Force vector ▲

$$\vec{F}_{nodal} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -30 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Deletion approach ▲

$$D_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$D_1 = \mathbf{identity}_{hp}(N_{g,dof}) - D_2 = \mathbf{identity}_{hp}(10) - D_2 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\vec{F}_{nodal,D1} = \mathbf{vector}(N_{g,dof}) + \vec{F}_{nodal} + \vec{U}_{nodal} = \mathbf{vector}(10) + \vec{F}_{nodal} + \vec{U}_{nodal} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -30 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$K_{struct,11} = D_1 \cdot K_{struc} \cdot D_1 + D_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 300000 & 0 & -150000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 150000 & 0 & 0 & 0 & -150000 & 0 & 0 \\ 0 & 0 & -150000 & 0 & 203033 & -53033 & -53033 & 53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & -53033 & 53033 & 53033 & -53033 & 0 & 0 \\ 0 & 0 & 0 & 0 & -53033 & 53033 & 256066 & 0 & 0 & 0 \\ 0 & 0 & 0 & -150000 & 53033 & -53033 & 0 & 256066 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$K_{struct,12} = K_{struc} \cdot D_2 - D_2 \cdot K_{struc} \cdot D_2 + D_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -150000 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -53033 & -53033 & 0 & 0 & 0 & 0 & 0 & 0 & -150000 & 0 \\ -53033 & -53033 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Displacement and Reactions

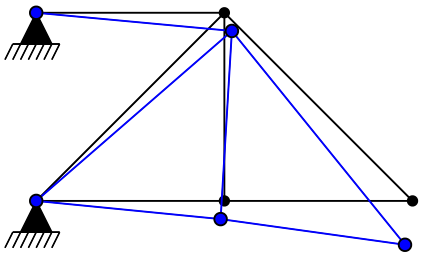
Displacement

$\vec{U}_{nodal} = \text{lsolve}(K_{struct,11};\ \vec{F}_{nodal,D1} - K_{struct,12} \cdot \vec{U}_{nodal}) + \vec{U}_{nodal} = [0$

$0\ \ -0.0002\ \ -0.000966\ \ -0.0004\ \ -0.00233\ \ 0.0004\ \ -0.000966\ \ 0\ \ 0]$

$\vec{U}_{global} = \text{transp}(T_{skew}) \cdot \vec{U}_{nodal} = [0\ \ 0\ \ -0.0002\ \ -0.000966\ \ -0.0004\ \ -0.00233\ \ 0.0004\ \ -0.000966\ \ 0\ \ 0]$

$scale_{deflecShape} = 200$

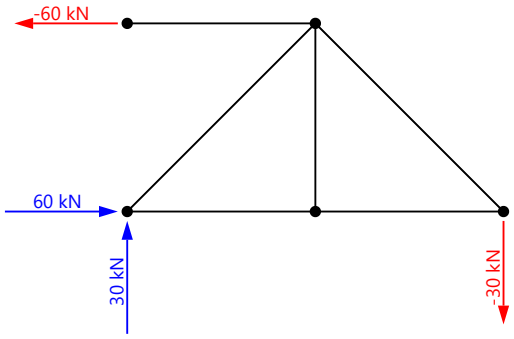


Nodal Displacement

Node	$U_{x,nodal}$	$U_{y,nodal}$
	m	m
1	0	0
2	-0.0002	-0.000966
3	-0.0004	-0.00233
4	0.0004	-0.000966
5	0	0

Reaction

$\vec{F}_{nodal} = K_{struc} \cdot \vec{U}_{nodal} = [60\ \ 30\ \ 0\ \ 0\ \ 0\ \ -30\ \ 0\ \ 0\ \ -60\ \ 0]$



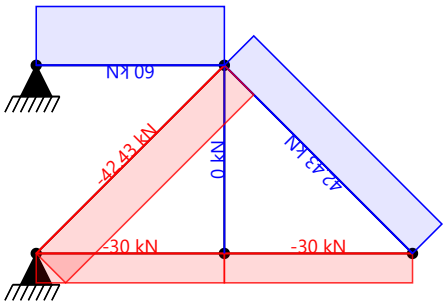
Nodal Reaction/Force

Node	$F_{x,nodal}$	$F_{y,nodal}$
	kN	kN

Node	$F_{x,nodal}$	$F_{y,nodal}$
	kN	kN
1	60	30
2	0	0
3	-7.11×10^{-15}	-30
4	0	0
5	-60	0

Element Node Reactions ... ▼

$scale_{AFD}$ = 2.5



Element End Reaction, r

Element	Node 1		Node 2	
	r_x	r_y	r_x	r_y
	kN	kN	kN	kN
1	30	0	-30	0
2	30	0	-30	0
3	-42.43	0	42.43	0
4	0	0	0	0
5	42.43	0	-42.43	0
6	-60	0	60	0