		DOC No:	
		JOB No:	REV:
CLIENT:		BY:	DATE:
PROJECT:		CHK:	DATE:
SUBJECT:		SHEET:	OF:

INPUT DATA

Enter node and bar data in the fields below:

Setting of nodes features							
	Coordinates		Constraints			Nodal action	
Num	X (m)	Y (m)	v_X	v_Y	r_Z	F_X (kN)	F_Y (kN)
1	0.000	0.000	1	1	1		
2	5.000	10.000					-90
3	10.000	20.000					
4	30.000	20.000	1	1	1		

Input_N := *excel* "Sheet1!B4:H7"

Setting of bars features							
	Nodes		A	I	E	Uniform action	
Num	First	Second	(cm^2)	(cm^4)	(GPa)	w_X (kN/m)	w_Y (kN/m)
1	1	2	80	31000	200	0	0
2	2	3	80	31000	200	0	0
3	3	4	80	31000	200	0	-1.5

Input_B := *excel* "Sheet1!B4:H6"

PROCESSING INPUT DATA

Initialisation coordinates in horizontal and vertical directions, $x := 1$ and $y := 2$

Number of nodes, $n_n := \text{rows}(\text{Input\_N})$

Number of bar elements, $n_b := \text{rows}(\text{Input\_B})$

Coordinates of nodes, $N := \text{submatrix}(\text{Input\_N}, 1, n_n, 1, 2) \cdot \mathbf{m}$

End nodes of the bars, $T := \text{submatrix}(\text{Input\_B}, 1, n_b, 1, 2)$

Cross-sectional area of bars, $A := \text{submatrix}(\text{Input\_B}, 1, n_b, 3, 3) \cdot \mathbf{cm}^2$

Second moment of area of bars, $I := \text{submatrix}(\text{Input\_B}, 1, n_b, 4, 4) \cdot \mathbf{cm}^4$

Elastic modulus of bars, $E := \text{submatrix}(\text{Input\_B}, 1, n_b, 5, 5) \cdot \mathbf{GPa}$

Nodal constraints, $v := \text{submatrix}(\text{Input\_N}, 1, n_n, 3, 5)$

Nodal forces, $F := \text{submatrix}(\text{Input\_N}, 1, n_n, 6, 7) \cdot \mathbf{kN}$

Uniform bar forces, $W := \text{submatrix}(\text{Input\_B}, 1, n_b, 6, 7) \cdot \mathbf{kN} \cdot \mathbf{m}^{-1}$

PLOT OF THE STRUCTURE

Undeformed frame, UDF :=

```
for i ∈ 1 .. n_b
    n_i ← T_{i,x}
    n_f ← T_{i,y}
    v_{x,i} ← N_{n_i,x} + N_{n_i,y} · 1i
    v_{y,i} ← N_{n_f,x} + N_{n_f,y} · 1i
v
```

Nodal constraints, NC :=

```
j ← 0
for i ∈ 1 .. n_n
    if v_{i,x} ≠ 0 ∨ v_{i,y} ≠ 0
        j ← j + 1
        s_j ← N_{i,x} + N_{i,y} · 1i
s
```

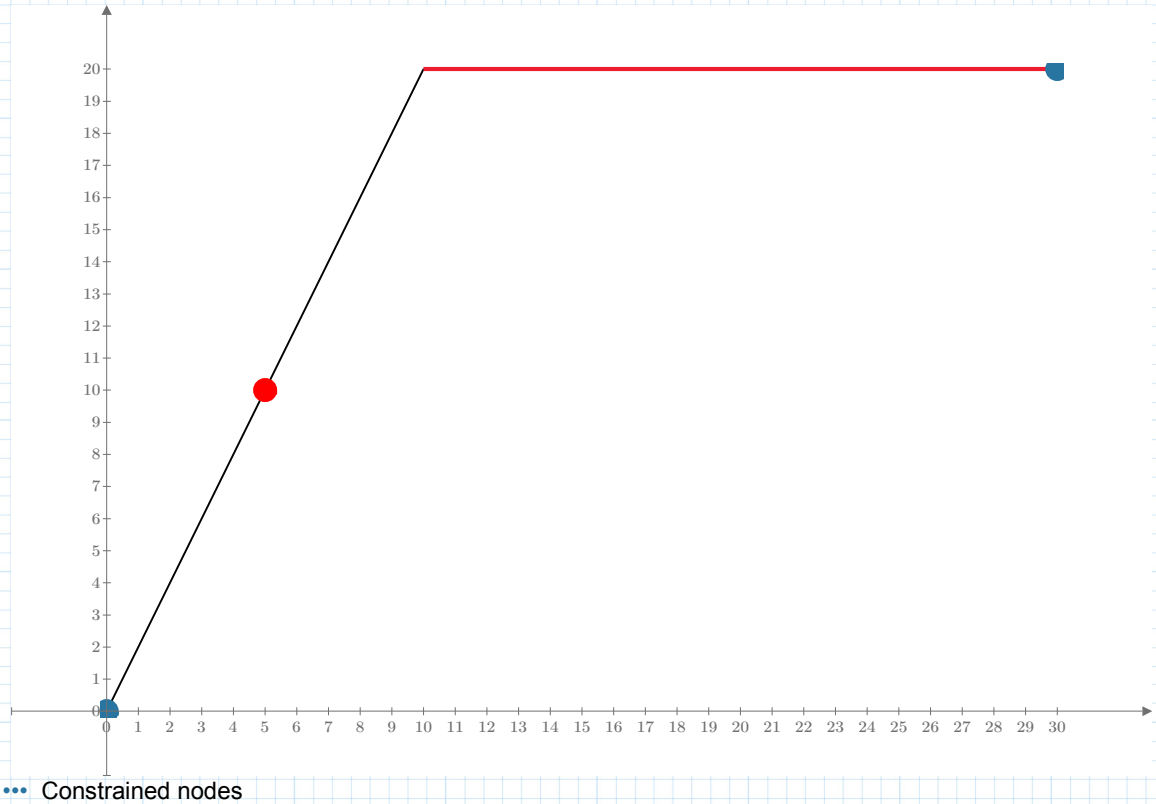
DOC No:
JOB No: REV:
CLIENT: BY: DATE:
PROJECT: CHK: DATE:
SUBJECT: SHEET: OF:

Nodal loads, $NL :=$

```
j ← 0
for i ∈ 1 .. n_n
    if F_{i,x} ≠ 0 ∨ F_{i,y} ≠ 0
        j ← j + 1
        s_j ← N_{i,x} + N_{i,y} · 1i
s
```

Uniform bar loads, $BL :=$

```
for i ∈ 1 .. n_b
    if W_{i,x} ≠ 0 ∨ W_{i,y} ≠ 0
        n_i ← T_{i,x}
        n_f ← T_{i,y}
        v_{x,i} ← N_{n_i,x} + N_{n_i,y} · 1i
        v_{y,i} ← N_{n_f,x} + N_{n_f,y} · 1i
v
```



••• Constrained nodes

••• Loaded nodes

---- Loaded bars

---- Undeformed structure

DOC No:
JOB No: REV:
CLIENT: BY: DATE:
PROJECT: CHK: DATE:
SUBJECT: SHEET: OF:

STRUCTURE SOLVING

Range of elements that define the structure, $i := 1 .. n_b$

Length of a bar element, $L_i := \sqrt{\left(N_{T_{i,1},x} - N_{T_{i,2},x}\right)^2 + \left(N_{T_{i,1},y} - N_{T_{i,2},y}\right)^2}$

Cosine of a bar element, $c_i := \dfrac{N_{T_{i,2},x} - N_{T_{i,1},x}}{L_i} = \begin{bmatrix} 0.447 \\ 0.447 \\ 1 \end{bmatrix}$

Sine of a bar element, $s_i := \dfrac{N_{T_{i,2},y} - N_{T_{i,1},y}}{L_i} = \begin{bmatrix} 0.894 \\ 0.894 \\ 0 \end{bmatrix}$

Stiffness matrix of a bar element,

$$K_i := \frac{E_i \cdot I_i}{L_i^3} \cdot \begin{bmatrix} \left(\frac{A_i \cdot L_i^2}{I_i} \cdot c_i^2 + 12 \cdot s_i^2\right) & \left(\frac{A_i \cdot L_i^2}{I_i} - 12\right) \cdot c_i \cdot s_i & -6 \cdot L_i \cdot s_i & -\left(\frac{A_i \cdot L_i^2}{I_i} \cdot c_i^2 + 12 \cdot s_i^2\right) & -\left(\frac{A_i \cdot L_i^2}{I_i} - 12\right) \cdot c_i \cdot s_i & -6 \cdot L_i \cdot s_i \\ \left(\frac{A_i \cdot L_i^2}{I_i} - 12\right) \cdot c_i \cdot s_i & \frac{A_i \cdot L_i^2}{I_i} \cdot s_i^2 + 12 \cdot c_i^2 & 6 \cdot L_i \cdot c_i & -\left(\frac{A_i \cdot L_i^2}{I_i} - 12\right) \cdot c_i \cdot s_i & -\left(\frac{A_i \cdot L_i^2}{I_i} \cdot s_i^2 + 12 \cdot c_i^2\right) & 6 \cdot L_i \cdot c_i \\ -6 \cdot L_i \cdot s_i & 6 \cdot L_i \cdot c_i & 4 \cdot L_i^2 & 6 \cdot L_i \cdot s_i & -6 \cdot L_i \cdot c_i & 2 \cdot L_i^2 \\ -\left(\frac{A_i \cdot L_i^2}{I_i} \cdot c_i^2 + 12 \cdot s_i^2\right) & -\left(\frac{A_i \cdot L_i^2}{I_i} - 12\right) \cdot c_i \cdot s_i & 6 \cdot L_i \cdot s_i & \frac{A_i \cdot L_i^2}{I_i} \cdot c_i^2 + 12 \cdot s_i^2 & \left(\frac{A_i \cdot L_i^2}{I_i} - 12\right) \cdot c_i \cdot s_i & 6 \cdot L_i \cdot s_i \\ -\left(\frac{A_i \cdot L_i^2}{I_i} - 12\right) \cdot c_i \cdot s_i & -\left(\frac{A_i \cdot L_i^2}{I_i} \cdot s_i^2 + 12 \cdot c_i^2\right) & -6 \cdot L_i \cdot c_i & \left(\frac{A_i \cdot L_i^2}{I_i} - 12\right) \cdot c_i \cdot s_i & \frac{A_i \cdot L_i^2}{I_i} \cdot s_i^2 + 12 \cdot c_i^2 & -6 \cdot L_i \cdot c_i \\ -6 \cdot L_i \cdot s_i & 6 \cdot L_i \cdot c_i & 2 \cdot L_i^2 & 6 \cdot L_i \cdot s_i & -6 \cdot L_i \cdot c_i & 4 \cdot L_i^2 \end{bmatrix}$$