The system shown in the figure is made up of a beam connected on its right end to a truss.

Data:

$L_{EF} = L_{FG} = L_{EG} = 4\ m$

$D_{EF} = D_{FG} = D_{EG} = 0{,}04\ m$ (diameter)

$L_{AB} = L_{BC} = L_{DE} = 1\ m;\ L_{CD} = 2\ m$

Young modulus = 210 GPA

Determine:

a) DSI of the truss and its possible implications.

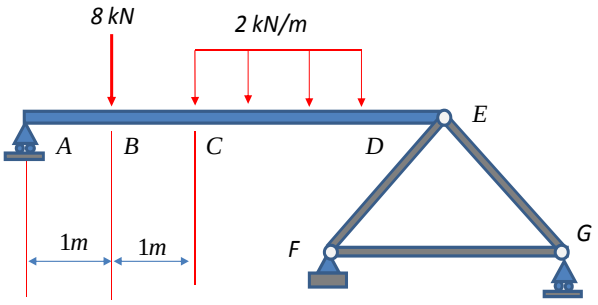
b) Reaction forces in supports A and E.

c) Reaction forces in supports F and G.

d) Using the **method of the joints**, the axial forces in all members of the structure indicating if they are tensile or compressive.

e) Using the **method of the sections**, the axial forces in bars FE and FG.

f) Normal stress in member EF.



Solution:

In order to solve the exercise, we will separate both structures and add the corresponding internal forces as it is shown in the drawings.

1. DSI Isolated truss

$EDSI = R - EDOF = 3 - 3 = 0$

$IL = 3.2.(2-1) = 6$

$IDOF = 3.(3-1) = 6$

$IDSI = IL - IDOF = 0$

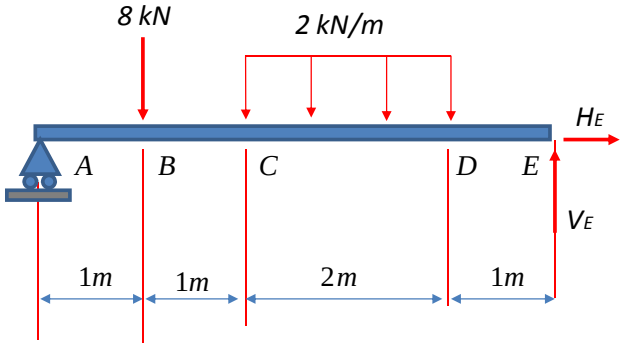
$DSI = EDSI + IDSI = 0$

Alternatively

$DSI = r + m - 2j = 3 + 3 - 2.6 = 0$

Thus, structure is entirely linked and the reactions exerted by the supports can be determined using equilibrium conditions.

2. Reaction forces beam



$\sum M_E = 0 \rightarrow 5V_A - 4.8 - 2.2.2 = 0$

$\boldsymbol{V_A = 8\ kN}$

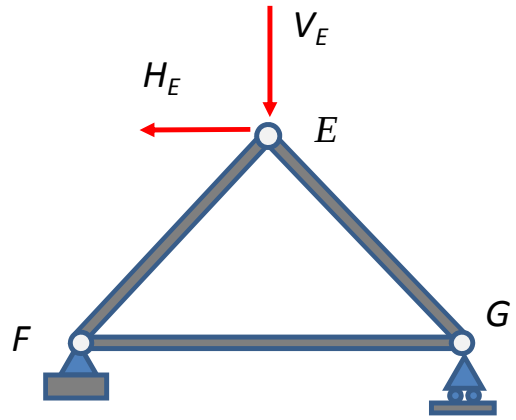
$\sum F_y = 0 \rightarrow V_E = 2.2 + 12 - 8$

$\boldsymbol{V_E = 4\ kN}$

$\sum F_x = 0 \rightarrow \boldsymbol{H_E = 0\ kN}$

3. Reaction forces in the truss

Isolating the system:



$$\sum M_G = 0 \rightarrow 4V_F - 2.4 = 0$$

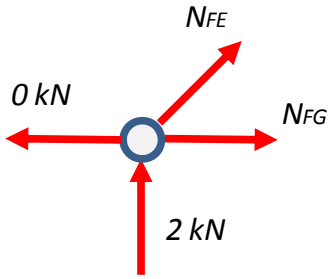
$$\boldsymbol{V_F = 2\ kN}$$

$$\sum F_y = 0 \rightarrow V_G = 4 - 2 \rightarrow \boldsymbol{V_G = 2\ kN}$$

$$\sum F_x = 0 \rightarrow \boldsymbol{H_F = 0\ kN}$$

4. Internal forces (using the method of the nodes)

Node F



$$\sum F_y = 0 \rightarrow 2 + N_{FE}.\sin 60 = 0$$

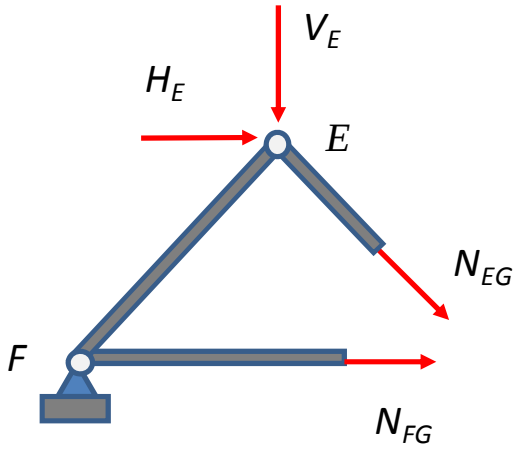
$$\boldsymbol{N_{FE} = \frac{4}{3}\sqrt{3}\ kN\ (C)}$$

$$\boldsymbol{N_{GE} = \frac{4}{3}\sqrt{3}\ kN\ (C)(simmetry)}$$

$$\sum F_x = 0 \rightarrow N_{FE}.\cos 60 + N_{FG} = 0$$

$$\boldsymbol{N_{FG} = \frac{2\sqrt{3}}{3}\ kN\ (T)}$$

5. Internal forces (using the method of sections)



$$\tan 60° = \frac{h}{2} \rightarrow h = 2\sqrt{3}\ m$$

$$\sum M_E = 0 \rightarrow 2.V_F - N_{FG}.2\sqrt{3} = 0$$

$$\boldsymbol{N_{FG} = \frac{2\sqrt{3}}{3}\ kN\ (T)}$$

$$\sum F_y = 0 \rightarrow V_F - V_E - N_{EG}.\cos 30 = 0$$

$$\boldsymbol{N_{FE} = \frac{4}{3}\sqrt{3}\ kN\ (C)}$$

6. Calculation of the normal stress in EF.

$$\sigma = \frac{N}{A} = E.\varepsilon = E.\frac{\Delta l}{l} \rightarrow \Delta l = \frac{Nl}{EA}$$

$$\Delta l_{EF} = \frac{\frac{4}{3}\sqrt{3}\ 10^3 N\ .4\ m}{210.10^9 Pa.\pi.0{,}02^2 m^2} = \boldsymbol{0{,}035\ mm}$$