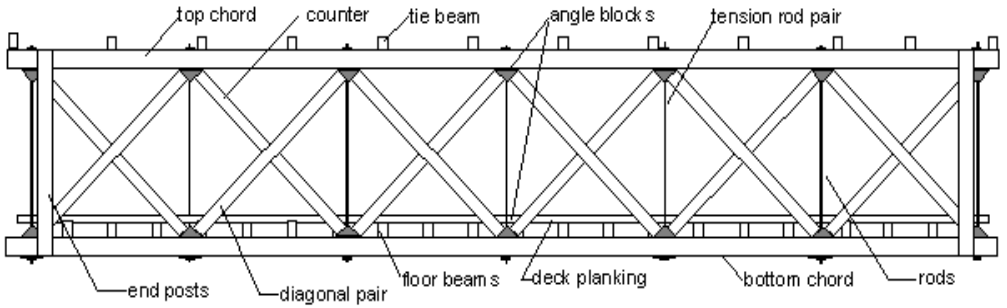
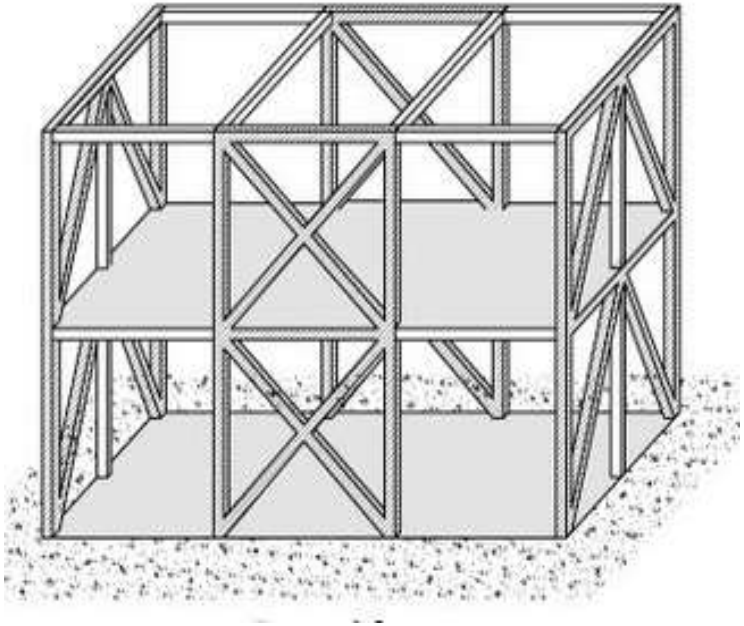
Structural Analysis & Design I

In engineering, a truss is a structure that "consists of two-force members only, where the members are organized so that the assemblage as a whole behaves as a single object".



Structural Analysis & Design I

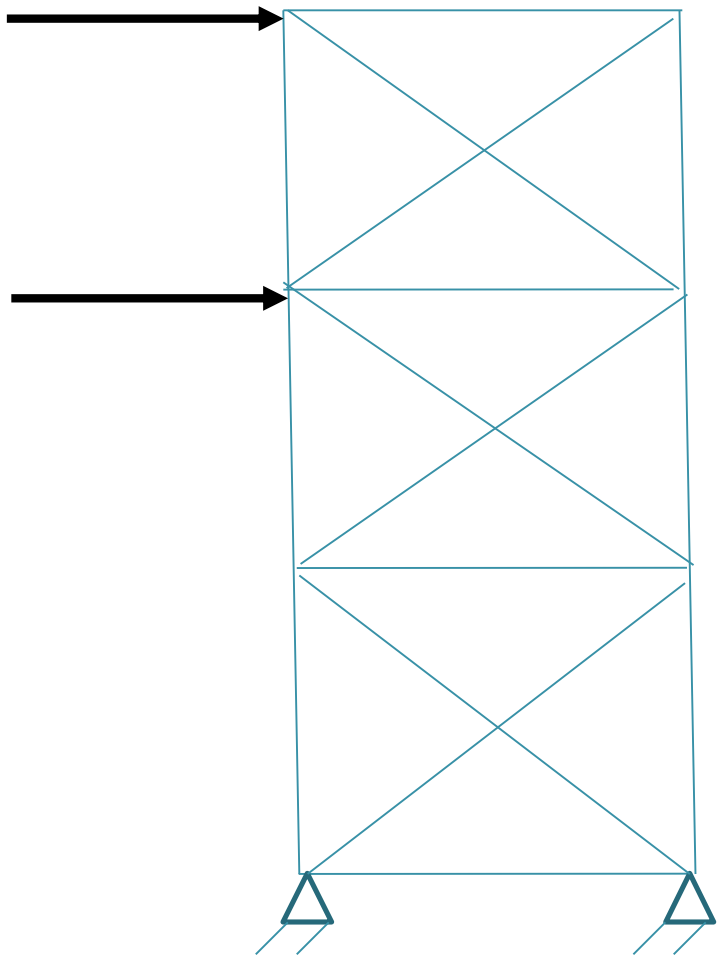






X-Braced Truss

DI = (n + r)-2*j
Here,
n = number of members
R = number of reactions
J = number of joints
DI = (16+3)-2*8 = 3°



Structural Analysis & Design-I

Method - 1 : (Assumptions)

- Diagonal members in panel can carry tension only, no compression

- Full panel shear is carried by diagonal members, carries tension

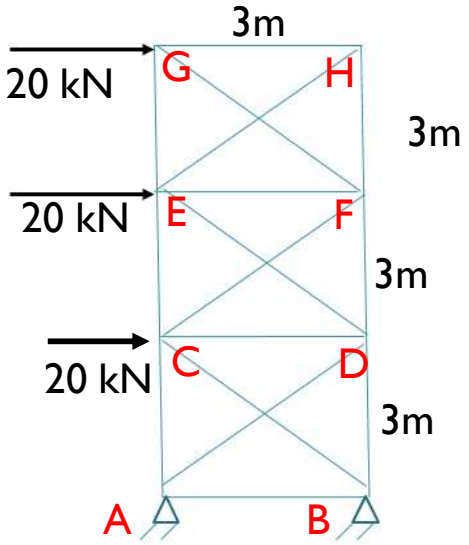
Method - 2 : (Assumptions)

- Diagonal members in the panel can carry both tension and compression

- Full panel shear is equally carried by both diagonal members

Structural Analysis & Design I

Determine the forces of different members of this truss

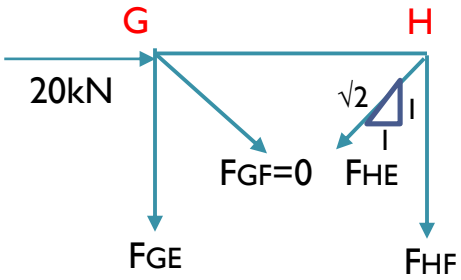


Method 1:

As there is no compression force in diagonals,

$F_{GF}=F_{ED}=F_{CB}=0$

Part 1:



$\sum H=0$

$=>20-F_{HE}*\frac{1}{\sqrt{2}}=0$

$=>F_{HE}=28.28$ kN (T)

At H, $\sum V=F_{HF}+28.28*\frac{1}{\sqrt{2}}=0$

$=>F_{HF}=-20$ kip (C)

At point G,

$\sum V=0$

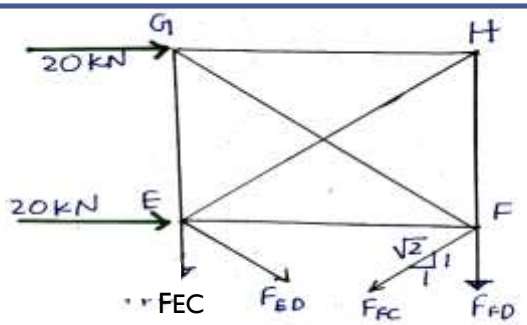
$F_{GE}=0$

Panel 2:

$\sum H=0$

$=>20+20-F_{FC}*\frac{1}{\sqrt{2}}=0$

$=>\mathbf{F_{FC}=40\sqrt{2}\ kN\ (T)}$



$\sum V=0$

$=>F_{EC}+F_{FD}+40*\sqrt{2}*\frac{1}{\sqrt{2}}=0$

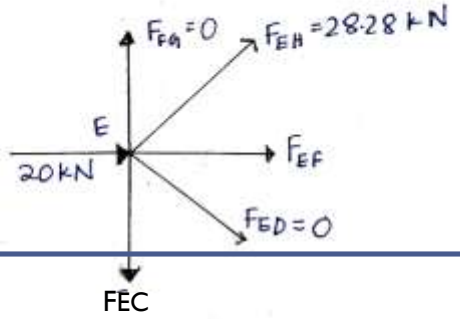
$=>F_{FD}=-60$ kN (C)

At point E,

$\sum H=0$

$=>20+F_{EF}+28.28*\frac{1}{\sqrt{2}}=0$

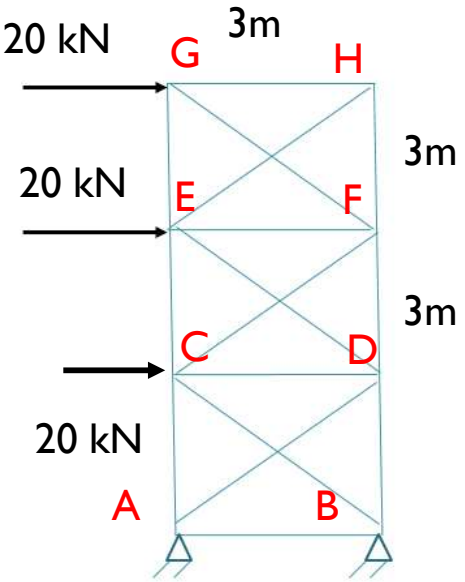
$=>\mathbf{F_{EF}=-40\ kN\ (C)}$



$\sum V=0$

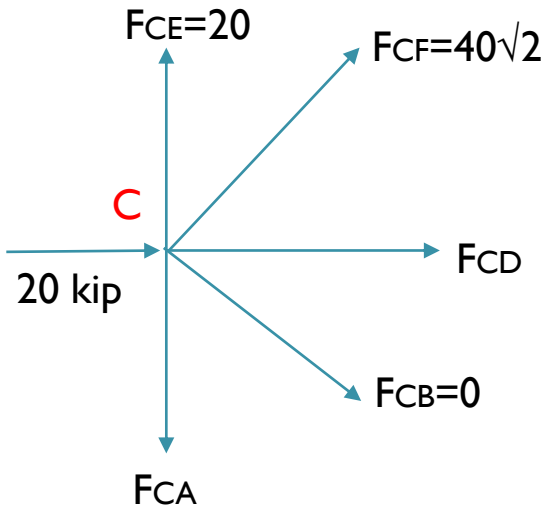
$=>F_{EC}=28.28*\frac{1}{\sqrt{2}}$

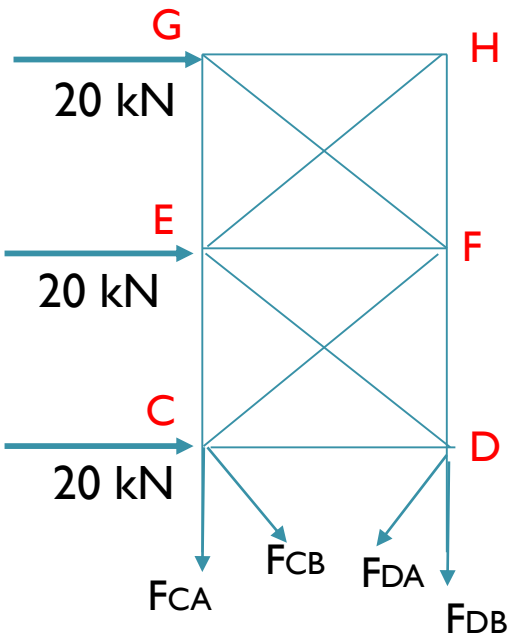
$=>\mathbf{F_{EC}=20\ kN\ (T)}$



Structural Analysis & Design I

Panel 3:





Free body at point C:

$\sum H=0=20+F_{CD}+40\sqrt{2}*\frac{1}{\sqrt{2}}$

=>**F_{CD}=-60 kN (C)**

$\sum V=20+40\sqrt{2}*\frac{1}{\sqrt{2}}-F_{CA}=0$

=>**F_{CA}=60 kN (T)**

Structural Analysis & Design I

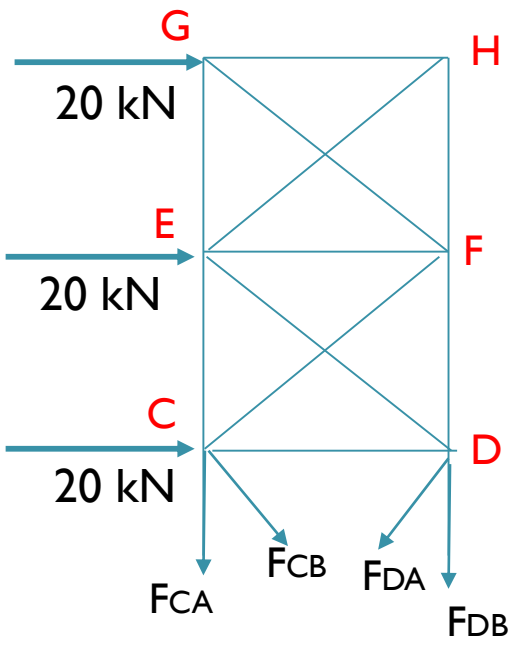
From panel 3:

$\sum H=20+20+20-F_{DA}*\frac{1}{\sqrt{2}}=0$

$\Rightarrow$ **$F_{DA}=60\sqrt{2}$ (kN) (T)**

$\sum V=F_{DB}+F_{CA}+60\sqrt{2}*\frac{1}{\sqrt{2}}=0$

$\Rightarrow F_{DB}=-120$ kN (C)

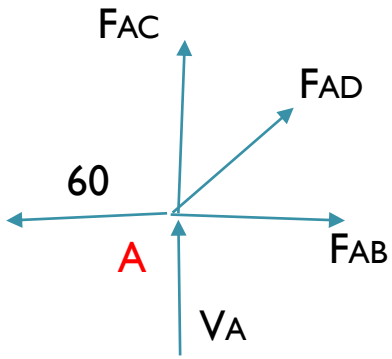


$\sum V=0$

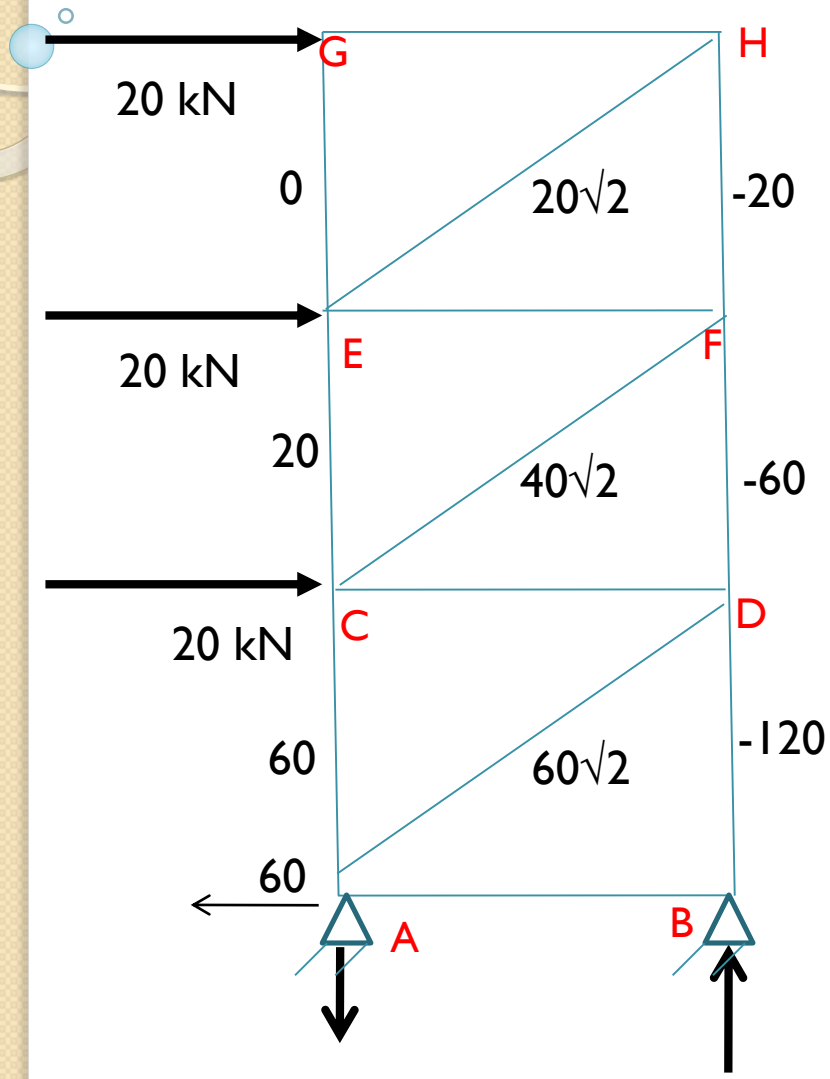
$\Rightarrow V_A+60+60\sqrt{2}*\frac{1}{\sqrt{2}}=0$

$\Rightarrow V_A=-120$ kN

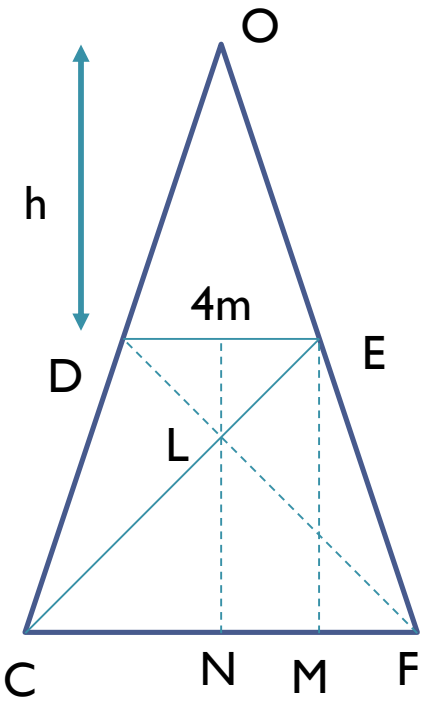
$\Rightarrow H_A=60$ kN( )

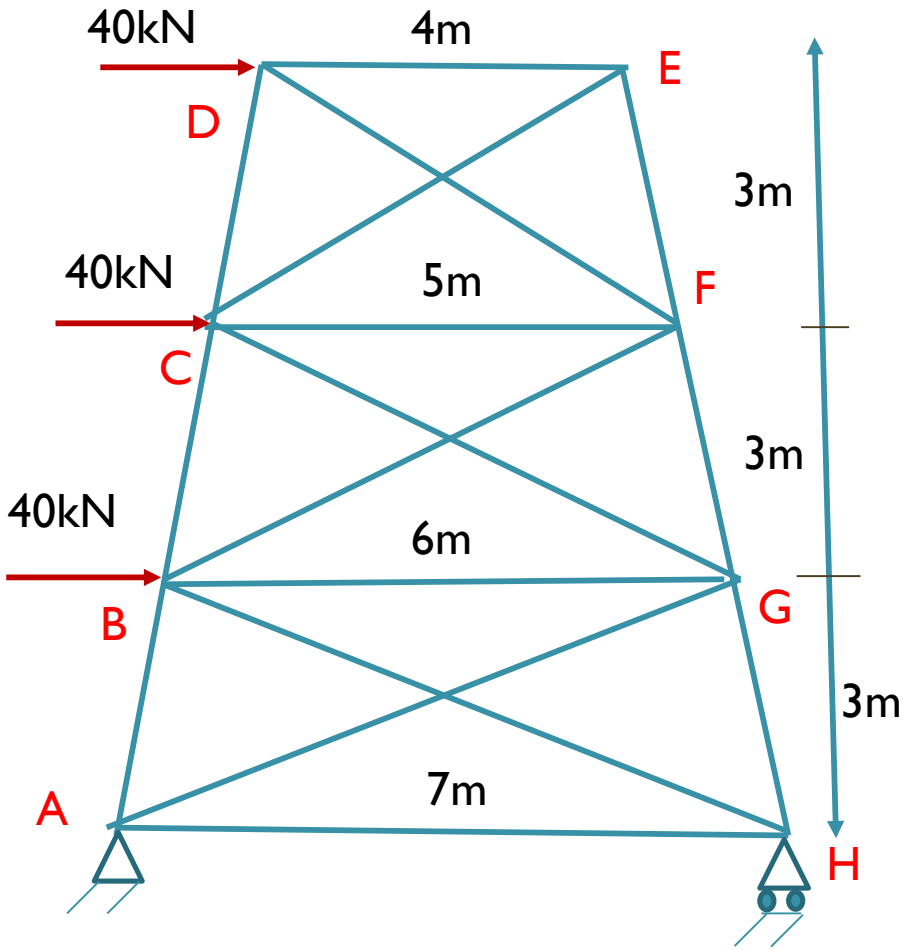


Structural Analysis & Design I



Structural Analysis & Design I





From ΔOCF and ΔODE,

$\frac{h}{4} = \frac{h+3}{5}$

=>h=12m

CN+2.5 m, CM=2.5+(4/2)=4.5m

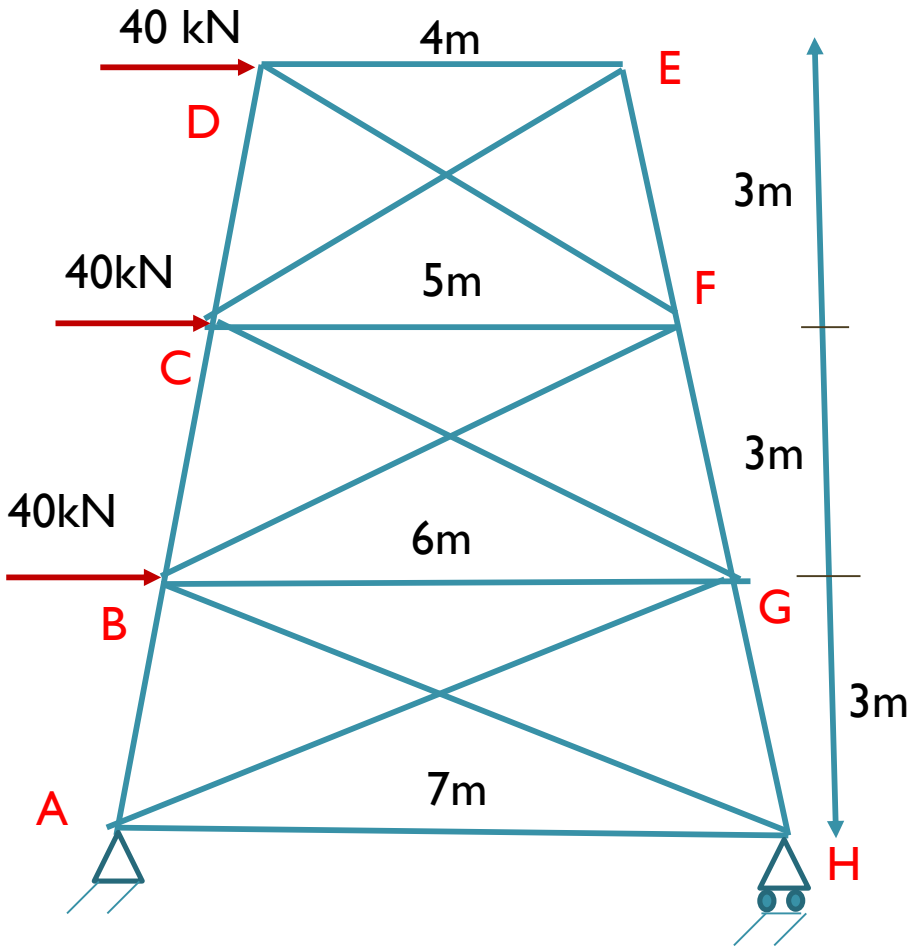
CE^2=3^2 + 4.5^2= 5.41

CD^2=3^2+0.5^2=3.04=EF

Structural Analysis & Design I

Assumptions (Method 1)
According to assumption

FBH =FCG =FDF =0



Structural Analysis & Design I

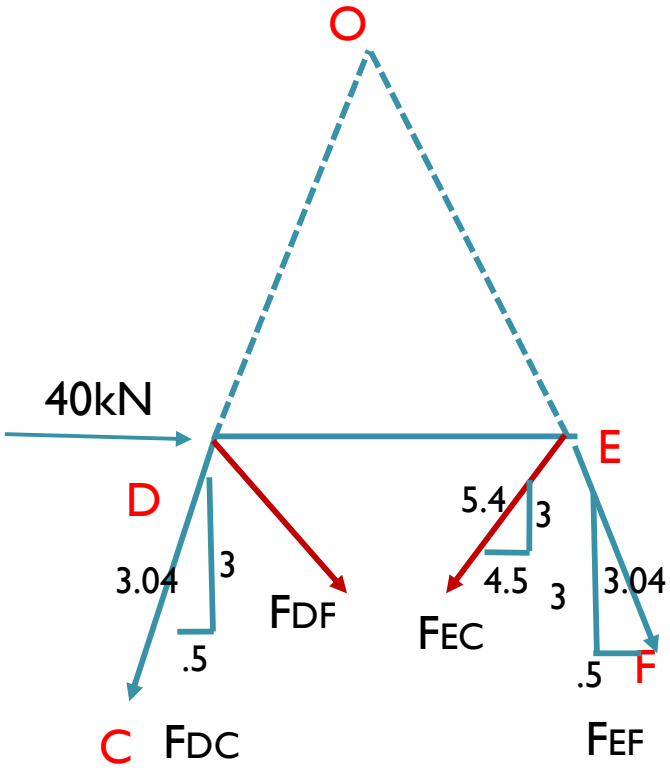
Panel-1:

$+\circlearrowleft \sum M_o = -40*12 + F_{EC}*\frac{4.5}{5.41}*12 + F_{EC}*\frac{3}{5.41}*2 = 0$

$\Rightarrow F_{EC} = 43.28$ kN (T)

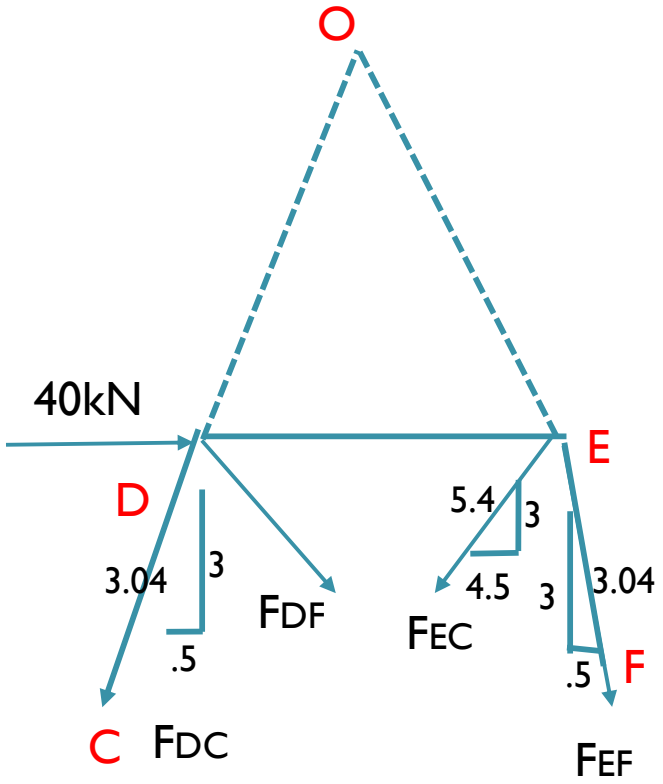
$+\circlearrowleft \sum M_D = 43.28*\frac{3}{5.41}*4 + F_{EF}*\frac{3}{3.04}*4 = 0$

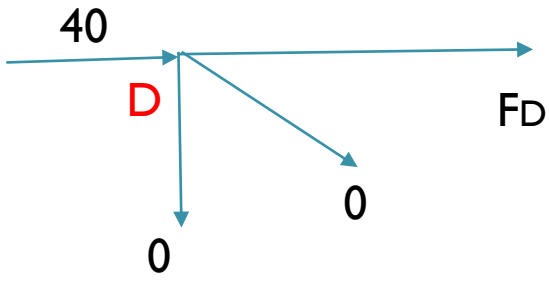
$\Rightarrow F_{EF} = -24.32$ kN (C)



Structural Analysis & Design I

↑ +ve, $\sum V = -F_{DC} * \frac{3}{3.04} -$
$43.28*(3/5.41)+24.32*(3/3.04)=0$
$\Rightarrow F_{DC}=0$





FDE

$\sum H=0$
$\Rightarrow F_{DE}=-40$ kN (C)

Structural Analysis & Design I

Panel 2:

+ $\sum M_o = -40*12 - 40*15 + F_{FB}*(5.5/6.26)*15 + F_{FB}*(3/6.26)*2.5 = 0$

$\Rightarrow$ **$F_{FB} = 75.12$ kN (T)**

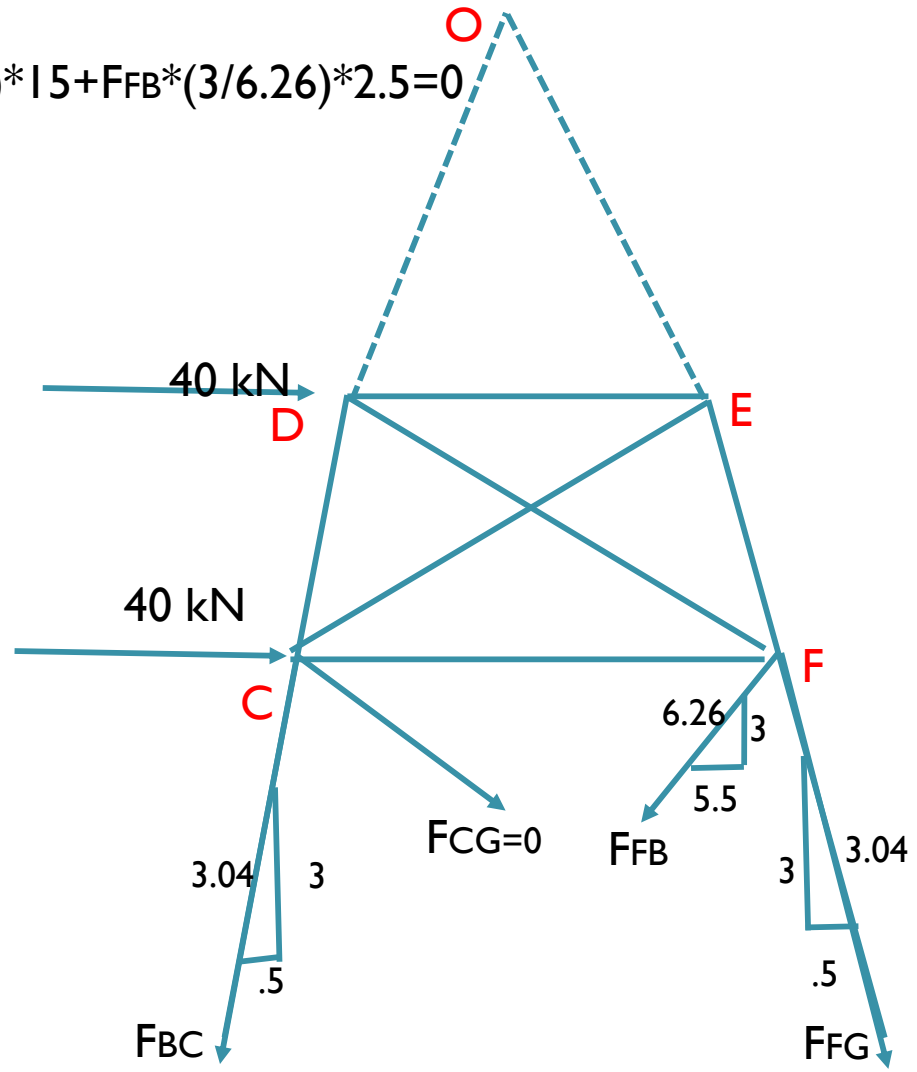
+ $\sum M_c = 40*3 + 75.12*(3/6.26)*5 + F_{FG}*(3/3.04)*5 = 0$

$F_{FG} =$ **-60.8 kN (C)**

+ $\sum M_F = 0$

$\Rightarrow 40*3 - F_{BC}*(3/3.04)*5 = 0$

$\Rightarrow$ **$F_{BC} = 24.32$ kN (T)**



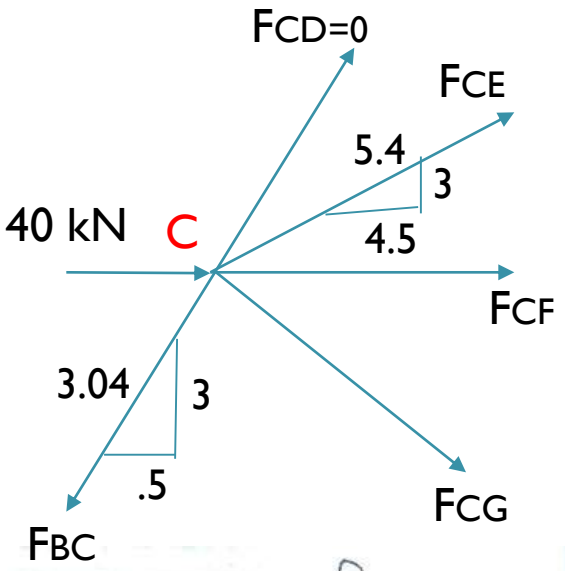
Structural Analysis & Design I

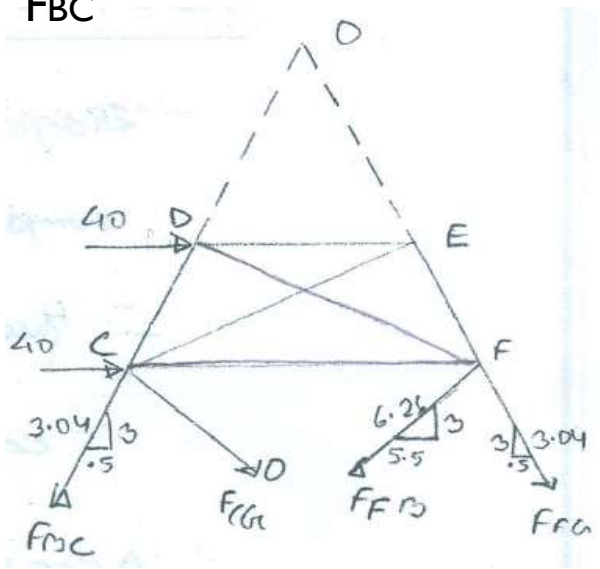
Free body of point C:

$\sum F_x=0$

$\Rightarrow F_{CF}+40+43.28*(4.5/5.41)-24.32*(.5/3.04)=0$

$\Rightarrow F_{CF}=-72$ kN (C)





Structural Analysis & Design I

+ Panel-3:

$\sum M_o = -40*(12+15+18) + F_{AG}*(3/7.16)*3 + F_{AG}*(6.5/7.16)*18 = 0$

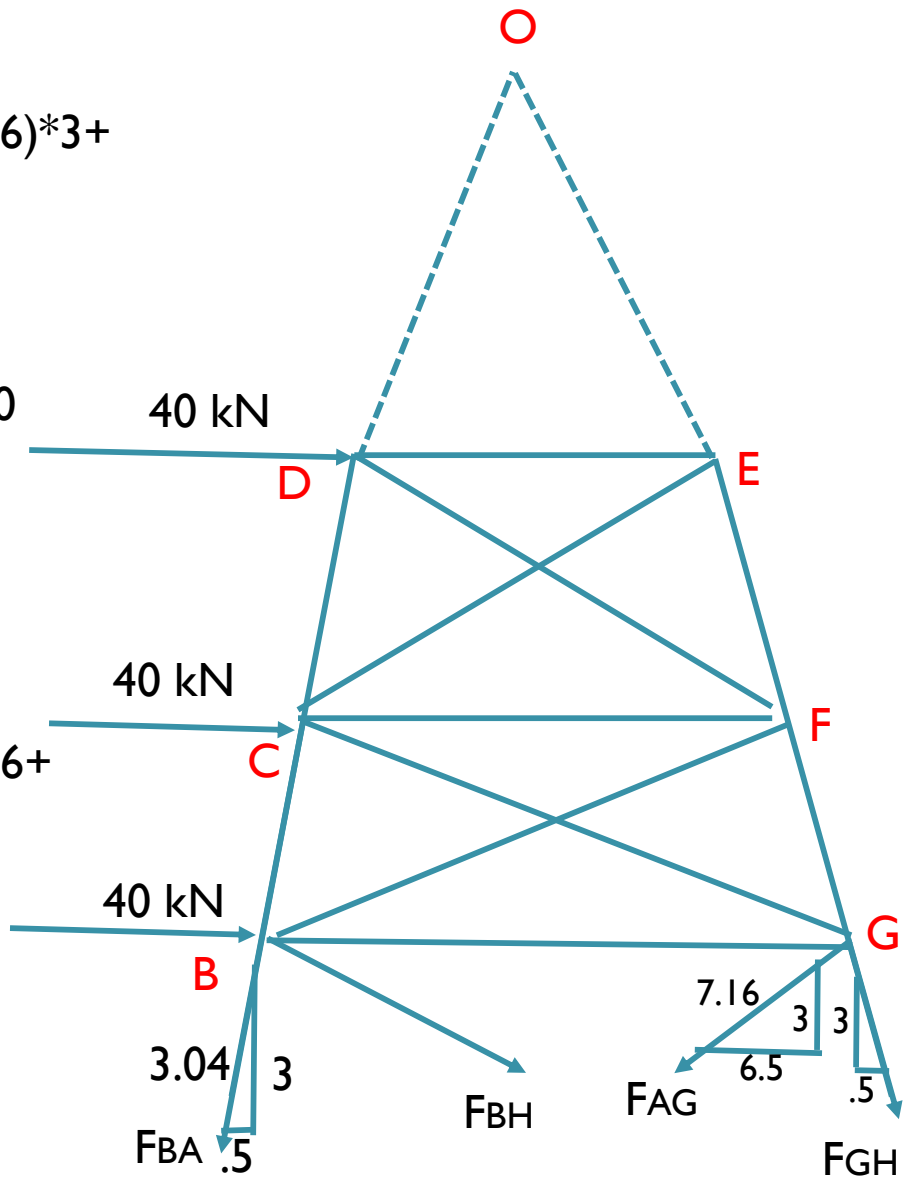
$\Rightarrow F_{AG} = 102.28$ kN(T)

+ $\sum M_G = 40*(6+3) - F_{AB}*(3/3.04)*6 = 0$

$\Rightarrow F_{AB} = 60.8$ kN(T)

+ $\sum M_B = 40*(6+3) + 102.28*(3/7.16)*6 + F_{GH}*(3/3.04)*6 = 0$

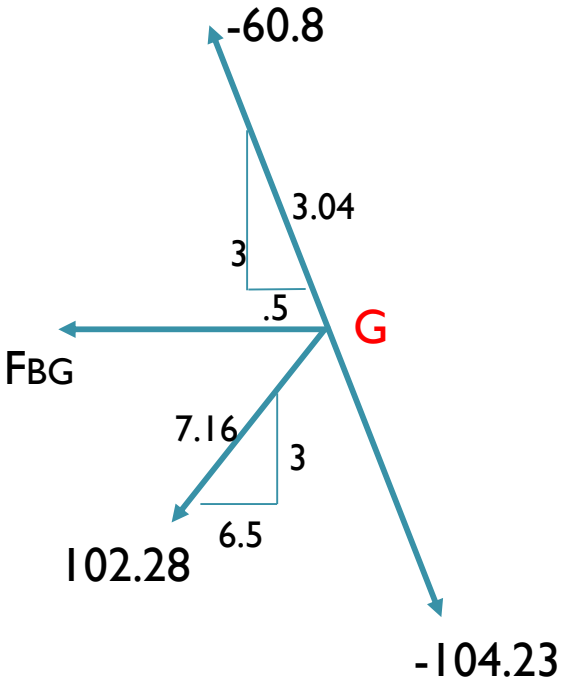
$\Rightarrow F_{GH} = -104.23$ (kN) (C)



Structural Analysis & Design I

$\sum F_X = -F_{BG} - 102.28*(6.5/7.16) + 60.8*(.5/3.04) - 104.23*(.5/3.04) = 0$

$\Rightarrow \mathbf{F_{BG} = -99.99kN(C)}$



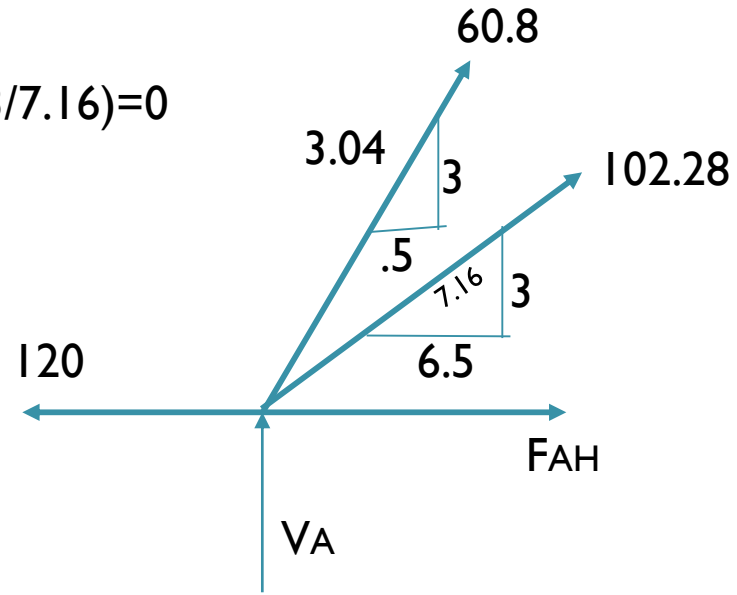
Structural Analysis & Design I

+ve $\sum V = V_A + 60.8*(3/3.04) + 102.28*(3/7.16) = 0$

$\Rightarrow V_A = 102.85$ kN (C)

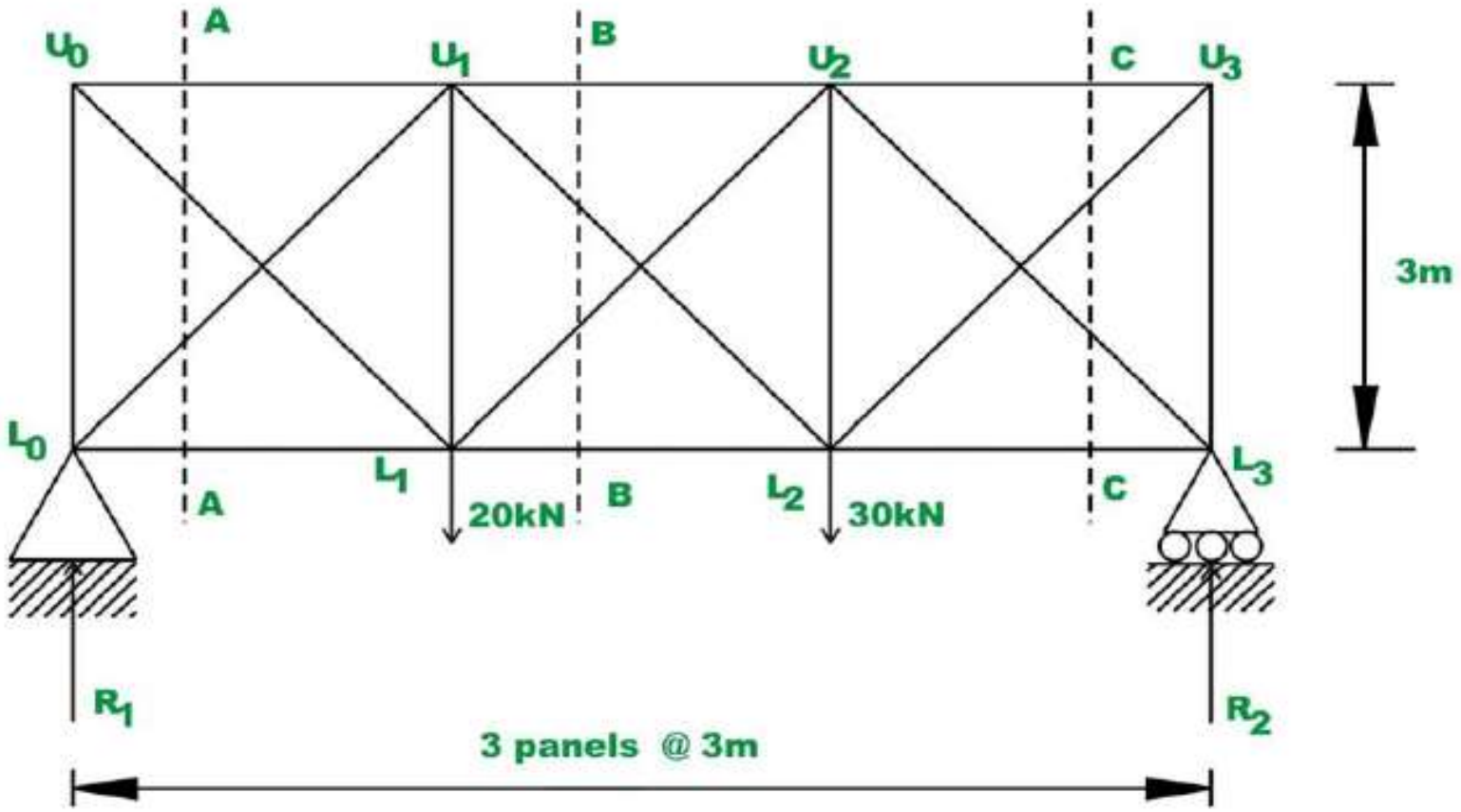
$\sum H = F_{AH} + 102.29*(6.5/7.16) + 60.8*(.5/3.04) - 120 = 0$

$\Rightarrow F_{AH} = 17.13$ kN (T)



Structural Analysis & Design I

Evaluate approximately forces in the truss members shown in Fig. 35.2a, assuming that the diagonals are to be designed such that they are equally capable of carrying compressive and tensile forces.

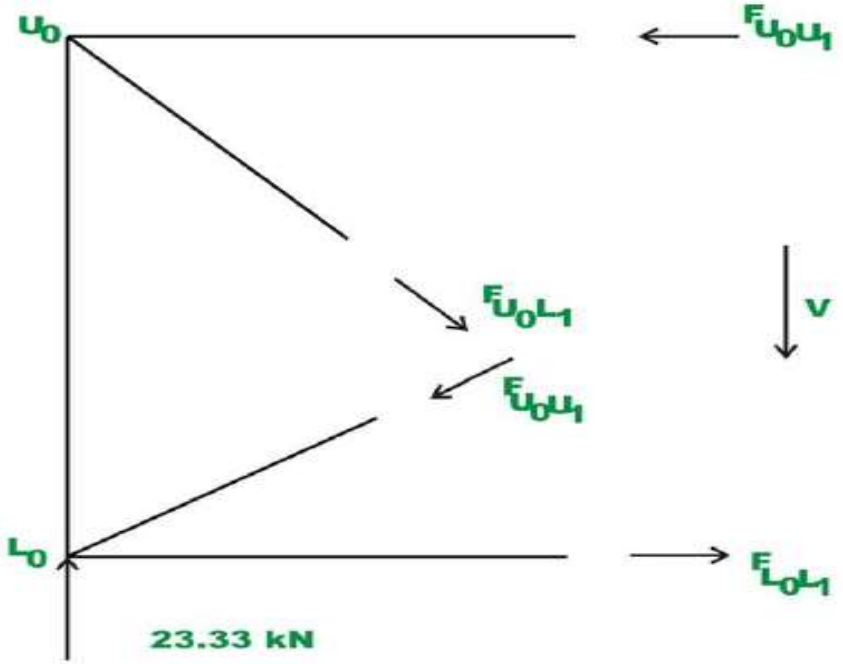


Solution:

The given frame is externally determinate and internally indeterminate to order 3. Hence reactions can be evaluated by equations of statics only. Thus,

$$R_1 = 23.33 \quad \text{kN} \quad (\uparrow)$$
$$R_2 = 26.67 \quad \text{kN} \quad (\uparrow) \qquad (1)$$

Now it is required to make three independent assumptions to evaluate all bar forces. Based on the given information, it is assumed that, panel shear is equally resisted by both the diagonals. Hence, compressive and tensile forces in diagonals of each panel are numerically equal. Now consider the equilibrium of free body diagram of the truss shown left of $A-A$. This is shown in Fig. 35.2b.



Structural Analysis & Design I

For the first panel, the panel shear is 23.33 kN. Now in this panel, we have

$$F_{U_0L_1} = F_{L_0U_1} = F \qquad (2)$$

Considering the vertical equilibrium of forces, yields

$$-F_{L_0U_1}\sin\theta - F_{L_0U_1}\sin\theta + 23.33 = 0 \qquad (3)$$

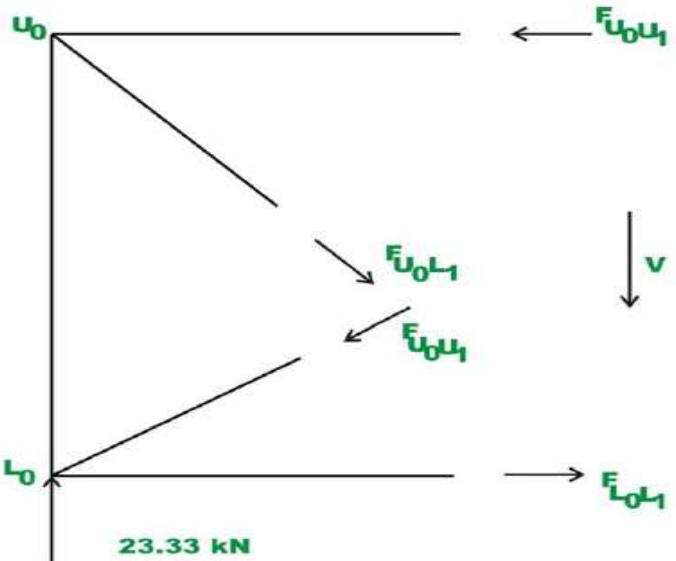
$$2F\sin\theta = 23.33 \qquad \sin\theta = \frac{1}{\sqrt{2}}$$

$$F = \frac{23.33}{\sqrt{2}} \cong 16.50 \text{ kN} \qquad (4)$$

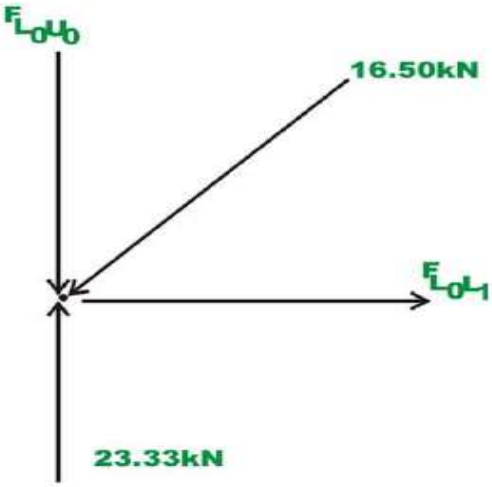
Thus,

$$F_{U_0L_1} = 16.50 \text{ kN} \ (Tension)$$

$$F_{L_0U_1} = 16.50 \text{ kN} \ (Compression)$$



Considering the joint L_0.



$$\sum F_y = 0 \Rightarrow \quad -F_{L_0U_0} - 16.50\sin 45 + 23.33 = 0$$

$$F_{L_0U_0} = 11.67 \ \text{kN}(Comp.) \qquad (5)$$

$$\sum F_x = 0 \Rightarrow \quad -16.50\cos 45 + F_{L_0L_1} = 0$$

$$F_{L_0L_1} = 11.67 \ \text{kN}(Tension) \qquad (6)$$

Similarly, $F_{U_0U_1} = 11.67 \ \text{kN}(comp.)$

In this panel, the shear is 3.33 kN. Considering the vertical equilibrium of the free body diagram,

$$\sum F_y = 0 \Rightarrow \quad -F_{L_1U_2}\sin 45 - F_{U_1L_2}\sin 45 + 23.33 - 20 = 0 \qquad (7)$$

It is given that $F_{L_1U_2} = F_{U_1L_2} = F$

$$2F\sin\theta = 3.33$$

$$F = \frac{3.33}{\sqrt{2}} \cong 2.36 \text{ kN}$$

Thus,

$$F_{U_1L_2} = 2.36 \text{ kN} \quad (Tension)$$

$$F_{L_1U_2} = 2.36 \text{ kN} \quad (Compression)$$

Taking moment about U_1 of all the forces,

$$-F_{L_1L_2} \times 3 + 2.36\left(\frac{1}{\sqrt{2}}\right) \times 3 + 23.33 \times 3 = 0$$

$$F_{L_1L_2} = 25 \text{ kN} (Tension)$$

Taking moment about L_1 of all the forces,

$$F_{U_1U_2} = 25 \text{ kN} (Comp.)$$

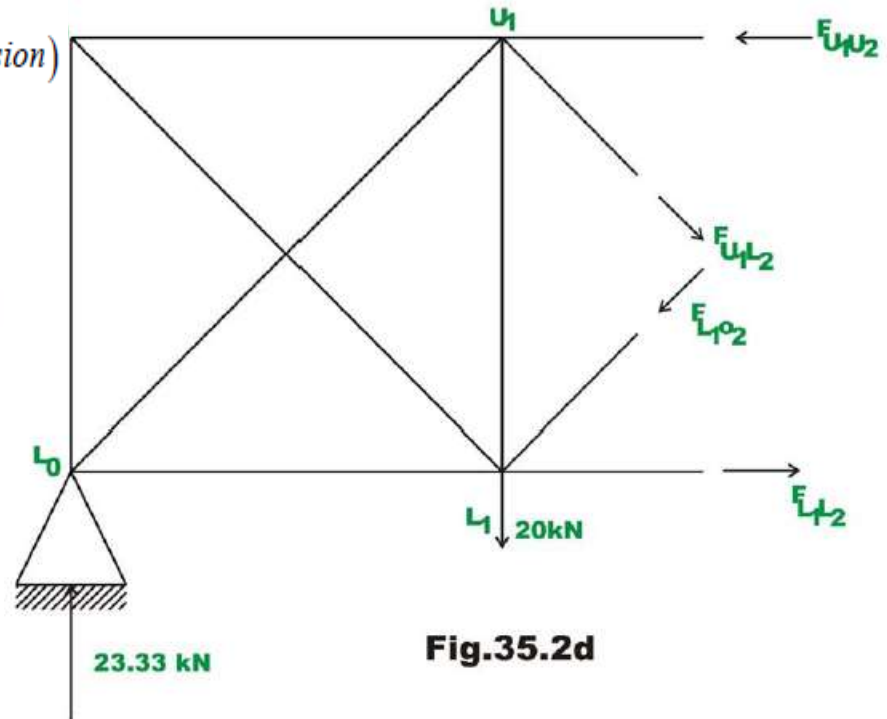


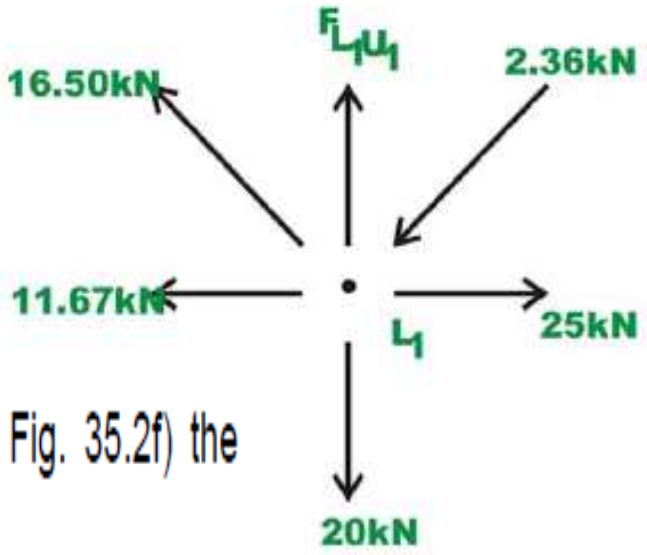
Fig.35.2d

Structural Analysis & Design I

- Considering the joint equilibrium of L_1

$$\sum F_y = 0 \Rightarrow \quad F_{L_4U_1} + 16.50\sin 45 - 2.36\sin 45 - 20 = 0$$

$$F_{L_4U_1} = 10 \ \text{kN}(Tension)$$



Consider the equilibrium of right side of the section $B-B$ (ref. Fig. 35.2f) the forces in the 3^{rd} panel are evaluated.

Consider the equilibrium of right side of the section $B-B$ (ref. Fig. 35.2f) the forces in the 3^{rd} panel are evaluated.

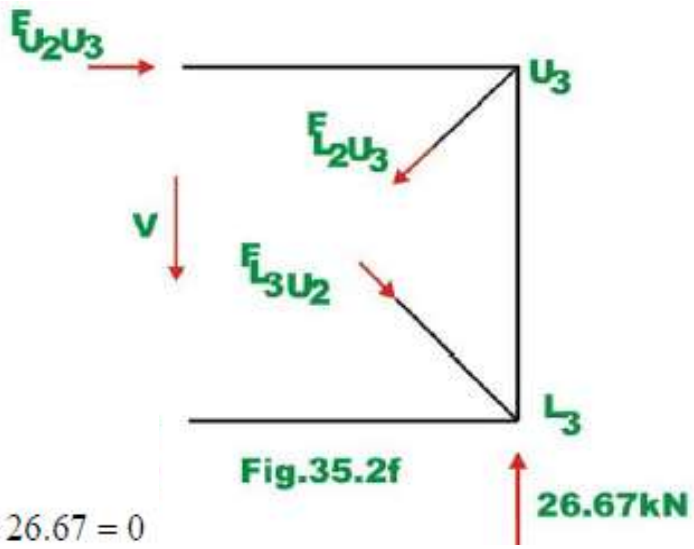


Fig.35.2f

We know that, $F_{L_3U_2} = F_{L_2U_3} = F$

$$\sum F_y = 0 \Rightarrow \quad -F_{L_3U_2} \sin 45 + F_{L_2U_3} \sin 45 + 26.67 = 0$$

$$F = \frac{26.67}{\sqrt{2}} \cong 18.86 \quad \text{kN}$$

$$F_{L_3U_2} = 18.86 \quad \text{kN} \quad (Comp.)$$

$$F_{L_2U_3} = 18.86 \quad \text{kN} \quad (Tension)$$

Considering the joint equilibrium of L_3 (ref. Fig. 35.2g), yields

Structural Analysis & Design I

Considering the joint equilibrium of L_3 (ref. Fig. 35.2g), yields

$$\sum F_x = 0 \Rightarrow \quad -18.86\cos 45 + F_{L_2L_3} = 0$$

$$F_{L_2L_3} = 13.34 \ \text{kN}(Tension)$$

$$\sum F_y = 0 \Rightarrow \quad F_{L_3U_3} = 13.33 \ \text{kN}(Comp.)$$

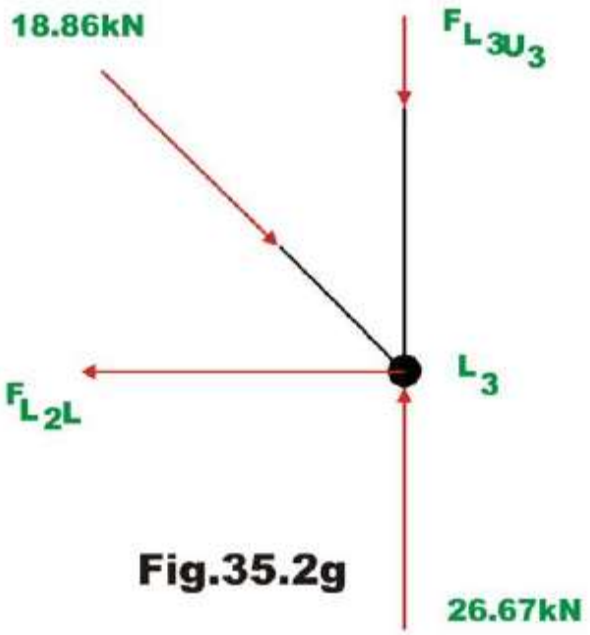
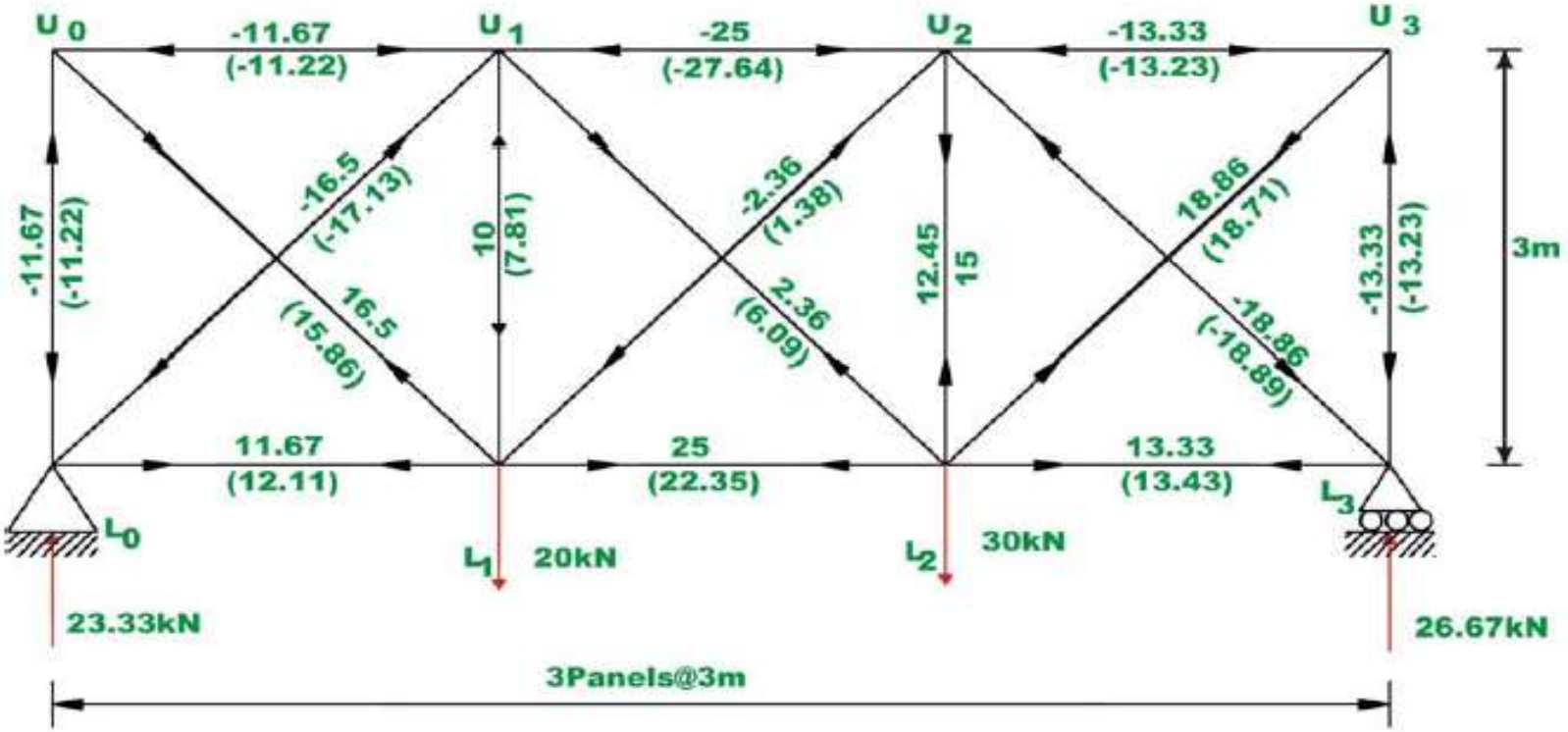


Fig.35.2g

Structural Analysis & Design I

The bar forces in all the members of the truss are shown in Fig. 35.2h. Also in the diagram, bar forces obtained by exact method are shown in brackets.



Structural Analysis & Design I