5.3 METHOD OF SECTIONS

When the forces in a few members of a truss are to be determined, then the method of section is mostly used. This method is very quick as it does not involve the solution of other joints of the truss.

In this method, a section line is passed through the members, in which the forces are to be determined. The section line should be drawn in such a way that it does not cut more than three members in which the forces are unknown. The part of the truss on any one side of the section line is treated as free body in equilibrium under the action of external forces on that part and forces in the members cut by the section line. The unknown forces in the members are then determined by using equations of equilibrium as

$\Sigma Fx = 0$, $\Sigma Fy = 0$ and $\Sigma M = 0$,

Example 5.3.1 A truss of span 6 m is loaded as shown in Fig.5.6. Find the reactions and forces in the members of the truss by method of section.

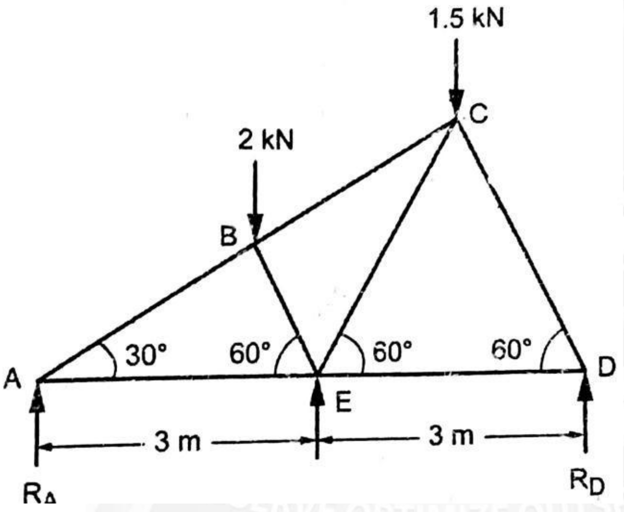

Fig 5.6.a

Solution:

Reaction at $R_C = 1.5$ kN

Reaction at $R_B = 2$ kN

Determine the reactions at A and D (R_A and R_D)

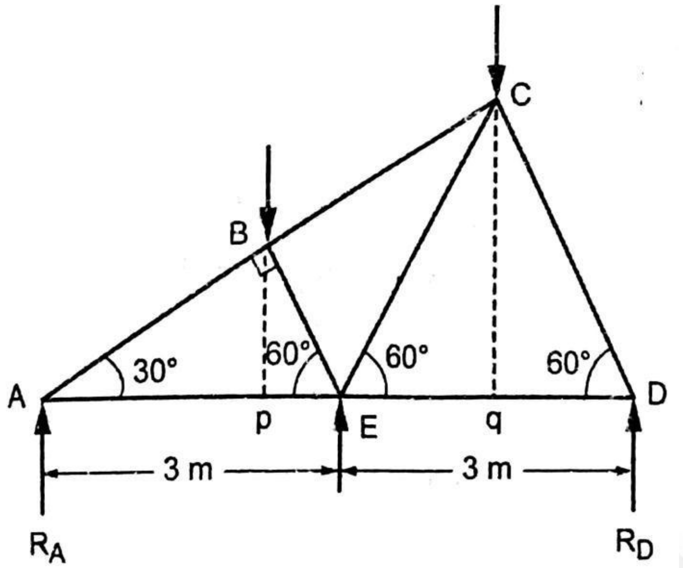

Fig 5.6.b

From ΔCED,

$$Eq = qD = 1.5 \text{ m}$$

From ΔABE,

$$\sin 60° = \frac{AB}{AE}$$

$$AB = AE \times \sin 60° = 3 \times 0.866$$

AB = 2.59 m

From ΔABp,

$$\cos 30° = \frac{Ap}{AB}$$

$$Ap = AB \times \cos 30° = 2.59 \times 0.866$$

Ap = 2.25 m

Taking moment about A:

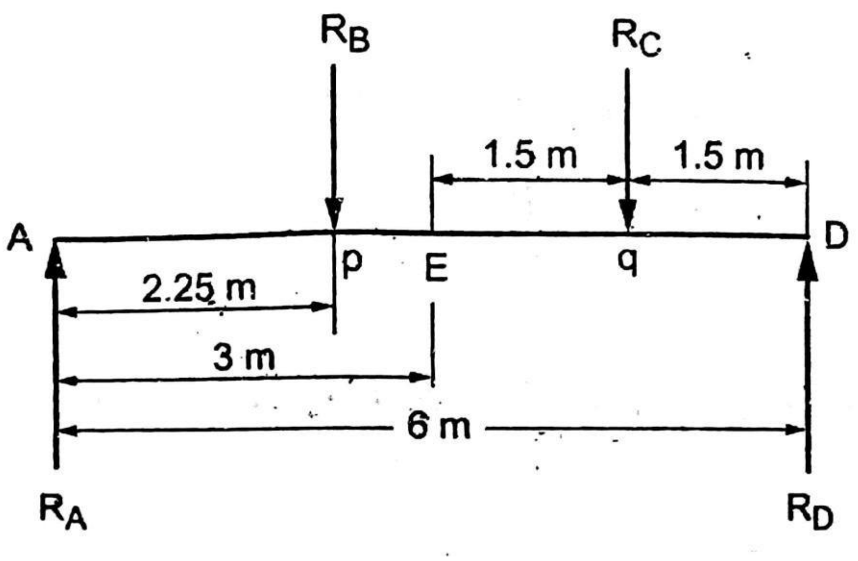

Fig 5.6.c

We know that,

Clockwise moment = Anticlockwise moment

$R_B \times Ap + R_C \times Aq = R_D \times AD$

$R_B \times 2.25 + R_C \times 4.5 = R_D \times 6$

$2 \times 2.25 + 1.5 \times 4.5 = R_D \times 6$

$\mathbf{R_D = 1.875\ KN}$

We know that,

Upward reaction = Downward reaction

$R_A + R_D = R_B + R_C$

RA + 1.875 = 2 + 1.5

$R_A = 1.625$ KN

Draw the section line (1, 1) cutting the members AB and AE

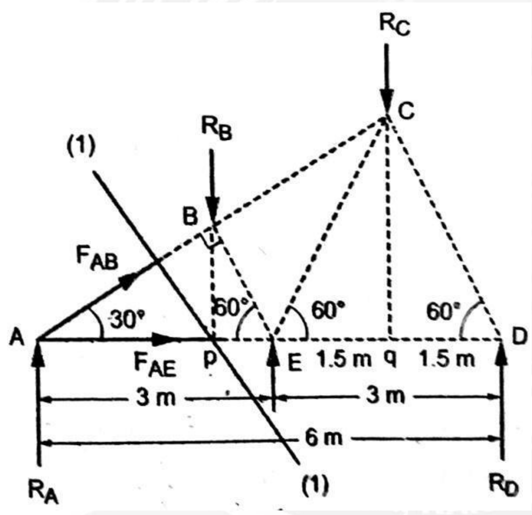

Fig 5.6.d

Now consider the equilibrium of the left part of the truss (since, it is similar than right part).

Taking moments of all forces acting from the left of the section (R_A, F_{AE} and F_{AB}) about point E.

Since force F_{AE} passing through the point E, moment about point E is zero. So, we have to consider R_A and F_{AB} forces only.

We know that,

Sum of Clockwise moment = Sum of Anticlockwise moment

Force (R_A) × perpendicular distance between the force (R_A) and a point E + Force (R_{AB}) × perpendicular distance between the force (R_{AB}) and a point E = 0

(since, there is no anticlockwise moment)

$R_A \times 3 + F_{AB} \times BE = 0$

$$1.625 \times 3 + F_{AB} \times BE = 0 \qquad \ldots(1)$$

From Δ AEB,

$$\sin 30° = \frac{BE}{AE}$$

$$BE = AE \times \sin 30°$$

$$= 3 \times 0.5$$

$$BE = 1.5 \text{ m}$$

$$1.625 \times 3 + F_{AB} \times 1.5 = 0$$

$$F_{AB} = -3.25\text{kN (Compression)}$$

(since, we are assuming all the forces are tensile forces. If we get negative value, the force in that member is compressive.)

Now taking moment of all forces acting to the left of section(R_A,F_{AB} and F_{AE}) about point C.

Since force F_{AB} passing through the point C, the moment about point C is zero. So, we have to consider R_A and F_{AE} force only.

We know that, sum of Clockwise moment = sum of Anticlockwise moment

Or Force (R_A X perpendicular distance between the force R_A and a point C + Force (F_{AE}) X perpendicular distance between the force F_{AE} and a point C =0

Or $$R_A \text{ X } A_q = F_{AE} \text{ X } C_q$$

Or $$1.625 \text{ X } 4.5 = FAE \text{ X } Cq \qquad \ldots(2)$$

From Δ CqD

$$\text{Cos } 60^o = \frac{qD}{CD} = \frac{1.5}{CD}$$

∴ $$CD = 3\text{m}$$

$$\text{in } 60^o = \frac{Cq}{CD}$$

Or $$Cq = CD \text{ X } \sin 60 = 3 \text{ X } 0.866$$

= 2.59m

From equation (2)

$$1.625 \text{ X } 4.5 = F_{AE} \text{ X } 2.59$$

$$F_{AE} = 2.8 \text{ kN (Tension)}$$

Draw a section line (2,2) cutting the members BC, BE and AE.

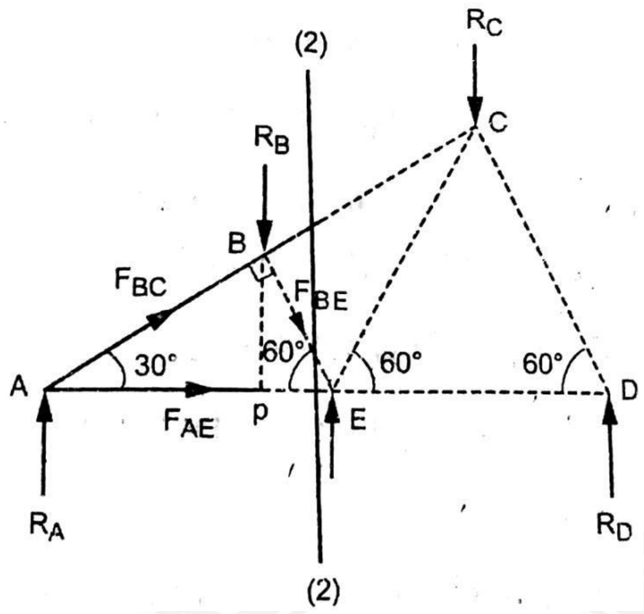

Fig 5.6.e

(only two unknown forces are permitted while considering a section. Here, BC,BE – unknown forces AE – known Force)

Now taking moment of all forces acting to the left of section (R_A, F_{AE}, F_{BC}, R_B and F_{BE}) about point A.

Consider R_B and F_{BE} forces only.

(Since R_A, F_{AE} and F_{BC} passing through a point A)

We know that,

Sum of Clockwise moment = Sum of Anticlockwise moment

Or Force (F_{BE}) X perpendicular distance between the force (F_{BE}) and a point A + Force R_B X perpendicular distance between the force R_B and a point A = 0

Or F_{BE} X AB + R_B X A_p = 0

Or F_{BE} X 2.59 +2 X 2.25 = 0

F_{BE} = -1.73kN Compression

(Since F_{BE} and F_{AE} passing through a point E.)

We know that,

Sum of Clockwise moment = Sum of Anticlockwise moment

Force R_A X Perpendicular distance between the force R_A and a point E + Force F_{BC} X Perpendicular distance between the force F_{BC} and a point E = Force(R_B) X Perpendicular distance between R_B and a point E

Or R_A X AE + F_{BC} X BE = R_B X pE

Or 1.625 X 3 + F_{BC} X 1.5 = R_B X pE

Or 1.625 X 3 + F_{BC} X 1.5 = 2 X 0.75

(AP = 2.25, AE = 3m and pE = 3-2.25 = 0.75m)

F_{BC} = -2.25 kN Compression

Draw a section line (3,3) cutting the members BC, CE and ED. (Only two unknown forces are permitted while considering a section. Here, BC is known force, CE and ED are unknown forces).

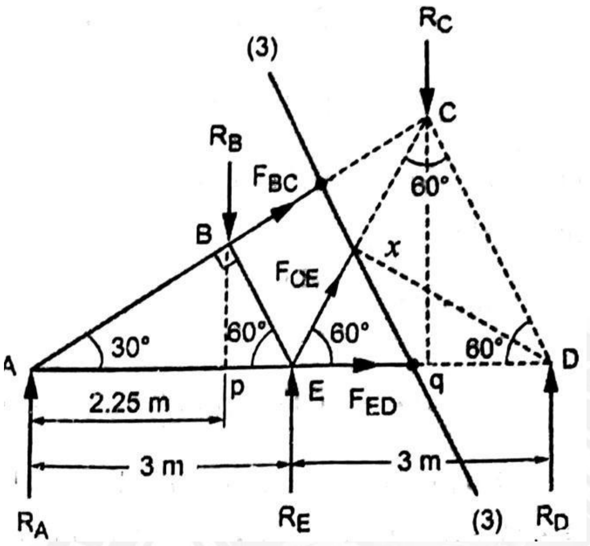

Fig 5.6.f

Taking moment of all forces acting from the left of section (R_A,R_B,F_{BC}, F_{CE} and F_{ED}) about point D.

Consider R_A, R_B , F_{BC}, F_{CE} forces only.

(Since F_{ED} passing through a point D)

We know that, Sum of Clockwise moment = Sum of Anticlockwise moment

Force R_A X perpendicular distance between the force R_A and a point D + Force F_{BC} X perpendicular distance between the force F_{BC} and a point D + Force F_{CE} X perpendicular distance between F_{CE} and a point D = Force R_B X Perpendicular distance between R_B and a point D

Or R_A X AD + F_{BC} X CD + F_{CE} X xD = R_B X pD or

1.625 X 6 + -2.25 X 3 + F_{CE} X xD = 2 X 3.75

(ED = CE = CD = 3m)

ED =3m, Ap = 2.25m,pD = 3+0.75 = 3.75m

From Δ CxD,

$$\text{Sin } 60^o = \frac{xD}{CE}$$

xD = CD X Sin 60^o = 3 X Sin 60^o or 1.625 X 6 - 2.25 X 3 + F_{CE} X xD = 2 X 3.75 or 1.625 X 6 -2.25 X 3 + F_{CE} X 3 X Sin 60^o = 2 X 3.75

$\therefore$ F_{CE} = 0.96 kN (Tension)

Now taking moment of all the forces acting from the left of the section (R_A, R_B, F_{BC}, F_{CE} and F_{ED}) about point C.

Consider R_A, R_B, F_{ED} forces only.

(since F_{BC}, F_{CE} passing through a point C)

Force R_A X Perpendicular distance between R_A and a point C = Force R_B X Perpendicular distance between R_B and a point C + Force F_{ED} X perpendicular distance between F_{ED} and a point C

Or $$R_A \times A_q = R_B \times Pq + F_{ED} \times Cq$$

Or $$1.625 \times 4.5 = 2 \times 2.25 + F_{ED} \times 3 \times \sin 60^o$$

∴ $$F_{ED} = 1.08 \text{ kN (Tension)}$$

We know that From fig (iii),

$$Aq = 4.5m$$
$$Ap = 2.25$$
$$(PE = 3-2.25 = 0.75m$$
$$Pq = PE + Eq = 0.75+1.5 = 2.25m$$
$$Cq = xD = 3 \times \sin 60^o)$$

Consider a section line (4,4) cutting the members CD and ED.

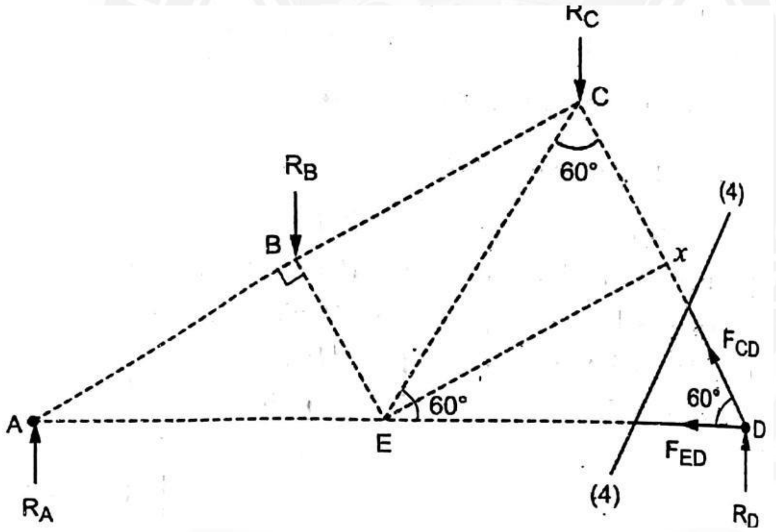

Fig 5.6.g

Consider the equilibrium of the right part of truss (since It is smaller than left part). Now taking moment of all forces acting from the right of the section (R_D,F_{CD} and F_{CE}) about point E.

We know that, Sum of Clockwise moment = Sum of Anticlockwise moment

Or Force R_D X perpendicular distance between the force R_D and a point E + Force F_{CD} X perpendicular distance beteen the force F_{CD} and a point E. = 0

Or $$R_D \times DE + F_{CD} \times xE = 0$$

Or $$1.875 \times 3 + F_{CD} \times 3 \times \sin 60^o = 0$$

From Δ CEx, $$\sin 60^o = \frac{xE}{CE}$$

Or $$xE = CE \times \sin 60^o = 3 \times \sin 60^o$$

$\therefore F_{CD} = -2.16$ kN Compression **Result:**

Sl.No.	Member	Force (kN)	Nature of force
1	AB	-3.25	Compression
2	AE	2.8	Tension
3	BE	-1.73	Compression
4	BC	-2.25	Compression
5	CE	0.96	Tension
6	ED	1.08	Tension
7	CD	-2.16	Compression