Applied Mechanics

Chapter 7

Analysis of Plane Trusses

Lecture 12 (week 12)

Use of trusses in engineering: Concept of pin joints, Calculation of Member Forces with examples

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Learning Objectives:

- Understand the Basic Concept of Trusses in Engineering
- Comprehend the Concept of Pin Joints in Trusses
- Calculate Member Forces in Trusses
- Work Through Practical Examples

7. Analysis of Plane Trusses

Definition of Truss

A truss is a combination of the structural members that is connected either riveted, bolted or welded in such a way that has only axial forces are induced in the structure and takes only tension or compression and no bending is induced what so ever. The reason behind axial forces is that the external loads are applied in such a way that their effects are in the form of forces applying only on joints.

7.1 Application/ Use of truss in engineering

- Mostly used to cover large spans to provide shelter only.
- Can be used to support the roof of auditoriums, cinema, halls, sports stadiums, railways station etc.
- When spans exceed a certain limit solid beams become heavy and uneconomical, so truss can be used instead of beams.
- Used in industrial buildings in conveyor galleries and large span walkways.

7.1.1 Concept of pin joint

- Pin joints, also known as hinge joints, are connections in trusses that allow the connected members to rotate relative to each other but not translate. This means that the members can pivot around the joint but cannot move linearly.
- Each pin joint provides rotational freedom but restricts translational motion in both horizontal and vertical directions.
- Pin joints are used in trusses to simplify the analysis by assuming that the members only experience axial forces (tension or compression) and no moments (bending).

7.1.2 Characteristics of pin Joints:

- It has Rotational Freedom
- Pin joints do not transfer moments between members
- Forces are assumed to act along the axis of the members
- members only carry axial forces simplifies the analysis of trusses.

7.1.3 Ideal assumption of truss

- Self-weight of the member is not considered.
- Uniform cross – section area throughout the member.
- The application of the load is only at the joint.
- The ends of the member are friction less and hinged.
- Load is transferred on the compression or tension form.
- The centroidal axis of the member passes through a joint.[1]

7.1.4 Stability and Determinacy of structures (Truss) with examples.

Here, M = number of members., R = number of support reactions

j = number of joints in the truss

$M + r = 2j \rightarrow$ perfect truss (rigid truss) so truss is statically determinate and stable.

$M + r > 2j \rightarrow$ over rigid, so it is statically indeterminate

$M + r < 2j \rightarrow$ imperfect truss, truss is unstable and is mechanism.[2]

Total external indeterminacy = $r - 3$

Total internal indeterminacy = $m - (2j - 3)$

Total degree of static indeterminacy = $(r - 3) + m - (2j - 3) = m + r - 2j$

7.2 Analysis Of plane truss (Calculation of Member Forces of Truss)

Method of joints:

The principle behind this method is that all forces acting on a joint must add to zero. If there were a net force the joint would move. The free-body diagram of any joint is a concurrent force system in which the summation of moment will be of no help. Recall that only two equilibrium equations can be written as

$\Sigma F_x=0$ and $\Sigma F_y=0$

So keep in mind, in the method of joint we can only use 2 equilibrium equation so for free body diagram of the joint, we just take a joint in which not more than 2 unknown members are acted.

Method of Sections

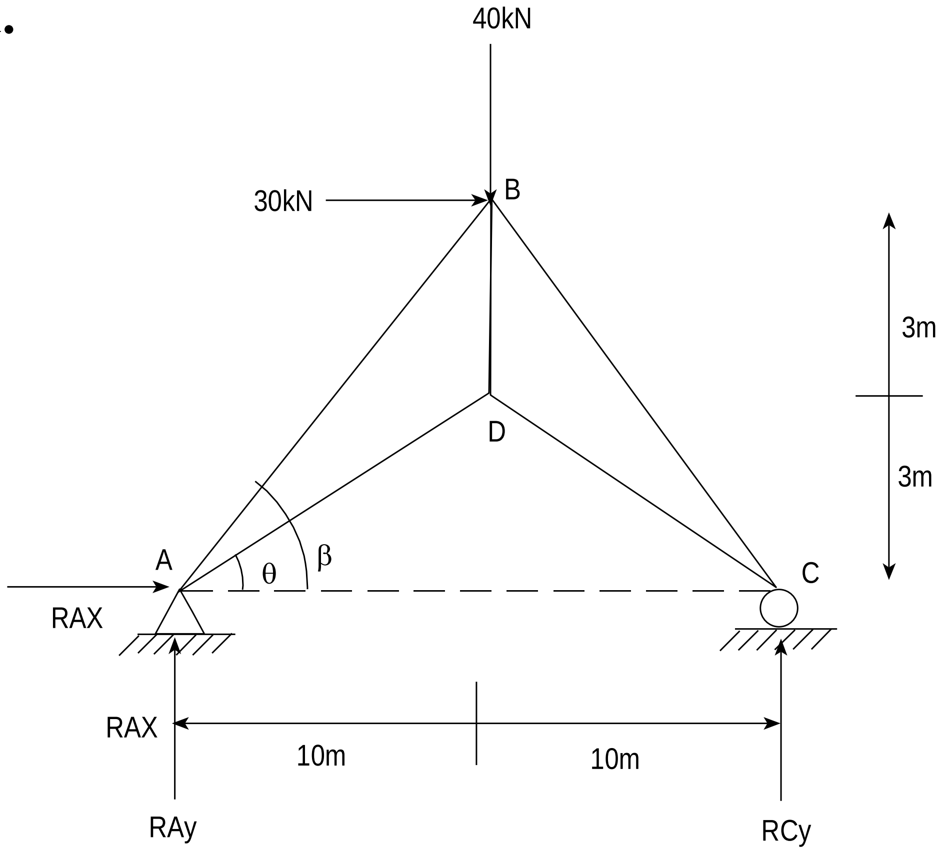
In this method, we will cut the truss into two sections by passing a cutting plane through the members whose internal forces we wish to determine. This method permits us to solve directly any member by analyzing the left or the right section of the cutting plane.

We can use 3 equilibrium equations as

$\Sigma Fx=0$, $\Sigma F_V=0$ and $\Sigma M_{at\ any\ joint}=0$

Because we can only solve up to three unknowns, it is important that not to cut more than three unknown members of the truss. Depending on the type of truss and which members to solve, one may have to repeat Method of Sections more than once to determine all the desired forces.

Q. Calculate the member forces in all members of the truss loaded as shown in figure below by using suitable method.



Solution: For support reactions

(↻+) $\Sigma M_A = 0$

$-R_{Cy} \times 20 + 30 \times 6 + 40 \times 10 = 0$

$[R_{Cy} = 29\ KN\ (\uparrow)]$

(+↑) $\Sigma Fy = 0$

$R_{Ay} + R_{Cy} - 40 = 0$

$[R_{Ay} = 11KN\ (\uparrow)]$

ΣFx (+→) $= 0$

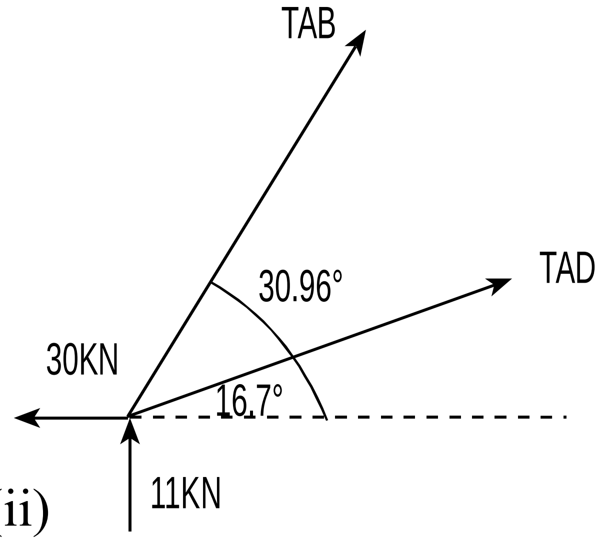
$R_{Ax} + 30 = 0$

RAx = – 30KN

= 30KN (←)

For member forces in all members joint method is suitable so calculation is proceeded by analyzing the F.B.D. of each joint.

For joint A



$\sum F_x \overset{+}{\rightarrow} = 0$

$-30 + T_{AD} \cos 16.7° + T_{AB} \cos 30.96° = 0$....(i)

$(+\uparrow) \sum F_y = 0$

$11 + T_{AD} \sin 16.7° + T_{AB} \sin 30.96° = 0$ ....(ii)

on solving (i) and (ii)

$T_{AD} = 100.94$KN (T)

[$T_{AB} = -77.77$KN = 77.77KN (C)]

$$\theta = \tan^{-1}\left(\frac{3}{10}\right) = 16.7°$$

$$\beta = \tan^{-1}\left(\frac{6}{10}\right) = 30.96°$$

For joint D

$\sum F_x \xrightarrow{+} = 0$

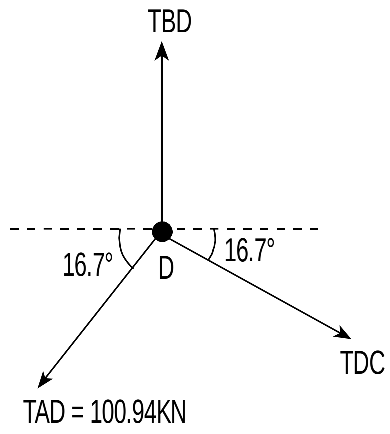
$-100.94 \cos 16.7° + T_{DC} \cos 16.7° = 0$

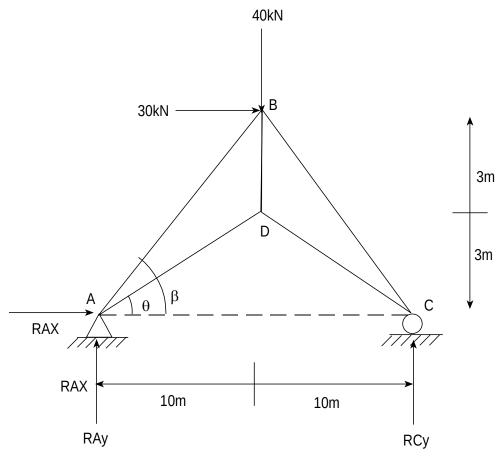
$[T_{DC} = 100.94KN\ (T)]$

$(+\uparrow)\sum F_y = 0$

$-100.94\sin 16.7° - T_{DC} \sin 16.7° + T_{BD} = 0$

$[T_{BD} = 58.01\ KN\ (T)]$

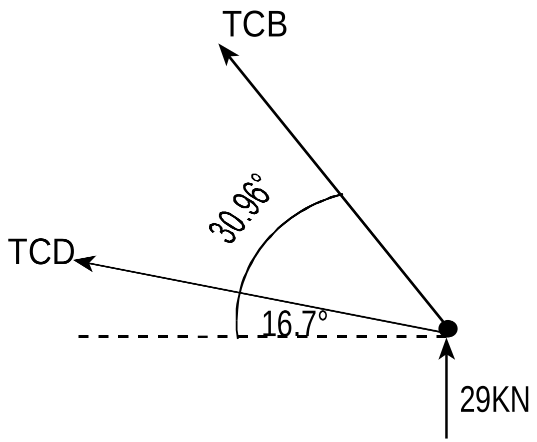




For joint C

$\sum F_x \overset{+}{\rightarrow} = 0$

$-T_{CD} \cos 16.7 - T_{CB} \cos 30.96° = 0$ ….(i)



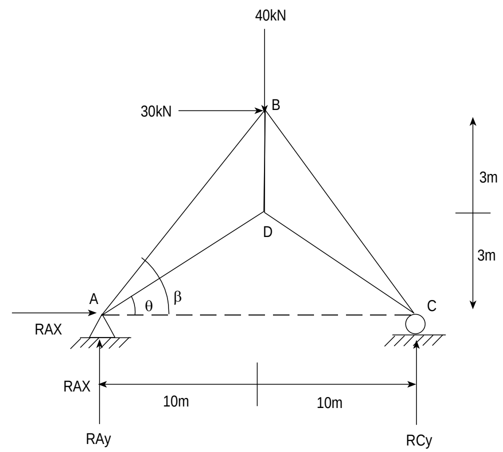
$(+\uparrow) \sum F_y = 0$

$T_{CD} \sin 16.7° + T_{CB} \sin 30.96° + 29 = 0$…………..(ii)

on solving (i) and (ii)

$T_{CD} = 100.94$KN (T)

$T_{CB} = -112.76 = 112.76$ KN (C)



(Our calculation is ok because

T_{CD} is already calculated by opening joint D

And has a same result.)

References

[1] Kumar, D. (2019). *Engineering Mechanics.* New delhi: S.K Kataria and Sons.

[2] M.N. SHESHA PRAKASH, G. B. (August, 2014). *ELEMENTS OF CIVIL ENGINEERING AND ENGINEERING MECHANICS.* Rimjhim House, 111, Patparganj, Delhi: PHI Learning Private Limited.

Thank You!!!