B. ARCHITECTURE

MECHANICS OF STRUCTURES – 1 (AR6201)

ANALYSIS OF PLANE TRUSSES

LECTURE - 05

Problem for Simply Supported Truss:

Find the forces in the members AC, AD, BD, BE, ED and CE of the simply supported truss shown below by method of joints. Here we have the truss tolls the span of the 10m it comprise of 5 joints. So no of joints j=5 and it comprise of m=7. Now for perfect frame are statically determinant frame or truss the following equation should be satisfied that is no of members should be m=2j-3. So here m is 7= (2*5)-3 it satisfying the condition and hence this truss statically determinant stress. And hence the unknown member forces can be determine by applying the condition of static equilibrium. Now we will see the solution this is simply supported stress which supports A and B. Now if you seeing the loading on truss external loading acting on the stress or pure vertical forces and hence on two simply supported will be having only vertical reaction components.

So let V_A be the vertical reaction components at support A and V_B be the vertical reaction components at support B. now we have to determine the support reaction components by applying the conditions of equilibrium

$\sum V = 0$

That is algebraic some of all vertical forces equal to zero. Once again we are going to assume all the forces going upward direction is positive. So you have $+V_A+V_B$ the external forces -5-6. So these are the four forces algebraic sum of all these four forces are equated to zero. From this we get

$V_A+V_B= 11$ equation no 1

Now we shall using the next condition of equilibrium that is algebraic sum of moments of all forces $\sum M$ about any support. We are going to consider the support A so $\sum M_A$ algebraic sum of moments of all forces about support A is equated to zero.

$\sum M_A = 0$

Now once again the four forces V_A, V_B. 5 and 6 kilo newton. V_A Passes through A and hence it doesn't have any moment V_B creates an anticlockwise moment about A. Anticlockwise moments are taken negative $-V_B$ perpendicular distance between $-V_B$ and A is 10m

$-V_B*10$

I am extending the line of action 5KN force if you see the triangle ACD it is an equilateral triangle and hence the perpendicular distance between the support Ais and the 5KN force would be half the base width of the equilateral triangle. Now the span distance AD is mentioned as 5m so the perpendicular distance between the 5KN force A would be 2.5m. Now 5KN force creates a clockwise moment about A. so we have put a positive for it.

$-V_B*10+5+2.5$

Now let us consider this 6KN force we shall extent it line of action now the perpendicular distance between the line of action of 6KN force from point D has to be determine we shall denote that distance as x. now let us consider this small triangle that is DE then upto this particular point. We shall take this point as say O right now I am considering the triangle DEO it is right angle triangle. So with respect to 60^0 x is adjacent side so for that triangle DOE.

$\cos60^0=x/DE$

Now the length of the member AC will be 5m because the triangle ACD is an equilateral triangle AD is 5m so AC will also be 5m. Now the distance D will be 2.5m this distance can be applying a similar triangle principle because BD and AD are equal so BD/BA should be equal to DE/AC that is

BD/BA=DE/AC

So from similar triangle principle BD/BA=DE/AC the distance BD is 5m divided by BA is total span of the truss 10m this is equated to DE divided by AC is the member whose length is 5m

5/10=DE/5

Therefore we get

DE=25/10=2.5m

So that distance is written here now let us come to the triangle DOC. In DOC triangle we have applied

$\cos 60^0 = X/DE$

Now this DE distance has been determined as 2.5m therefore

$x = 2.5\cos 60^0 = 1.25m$

So this distance x comes as 1.25m now we are taking moments of all forces about A so the perpendicular distance between 6KN force and the A will be the distance AD+DO which will be 5+1.25. Now 6 KN force creates a clockwise moment so 6*6.25 these are the algebraic sum of all forces about AI am equating into zero. From this we calculated the value of V_B will come as 5KN

$+6*6.25 = 0$

$V_B = 5KN$

Now putting the value of V_B in equation no 1 we can get the value of

$V_A = 6KN$

Now this is the first step in the analysis of truss that we had find out the support reaction components.

Equilibrium of Joints Separately:

Now let us consider the equilibrium of joints separately we known that joint that is to be consider should not have more than two unknown member forces now initially consider joint A. I am drawing the free body diagram of joint A so we have the reaction V_A at this particular point joint A. then we have the horizontal member which is F_{AB} similarly we also have the member AC let F_{AC} be the force in the member AC. Inclination between these two member AC and AB is given as 60^0.

Now as general rule always the bottom card member will be subjected to tensile forces. So in order to indicate tensile force the arrow head should away from joint A. so we have assumed force in member AB tensile in nature. Now we shall assume force in member AC to be compress in nature compressive force should have arrow head pointing towards joint. After assuming this nature of force for the two members AC and AB which are all apply the condition of equilibrium. The first condition of equilibrium will be

$\sum V = 0$

F_{AC} goes like this and this is force in member AC and this is joint A. now F_{AC} moves from this particular point and it reaches here to travel from this particular point to reach here vertically we have to go in the downward direction till this particular point and then horizontally we have go towards left. So this is the vertical component of F_{AC}. We know this particular angle which is 60^0 so is the vertical component of F_{AC}

$V = F_{AC} \sin 60^0$

If you see the direction of vertical component it is in the downward direction hence we have to put a negative sign

$-F_{AC} \sin 60^0$

Also joint A we have the vertical reaction component since it is vertical force we will be putting positive sign for it $+V_A$. Now the vertical component of F_{AB} will be zero these are all algebraic sum of vertical component forces

$+V_A = 0$

$F_{AC} \sin 60° = V_A$

$F_{AC} \sin 60° = 6$

From this we get the value of

$F_{AC} = \frac{6}{\sin 60°} = 6.93KN$

If you see sign for F_{AC} it comes us positive which means that our assumed nature force for member AC that is compressive is correct. So F_{AC} compression is correct so we have determine the force in the member AC. For determining the force in the member AB we shall apply the second condition equilibrium which algebraic sum of all horizontal forces

$\Sigma H = 0$

Now V_A is vertical force it doesn't have any horizontal component F_{AB} it assume to be acting towards right so the sign convention will be $+F_{AB}$. Now we need to find the horizontal component of F_{AC} in this above triangle the horizontal component of F_{AC} is H which will be given by

$H = F_{AC} \cos 60°$

If you see the horizontal component of H it move towards left so

$F_{AB} - F_{AC} \cos 60°$

These are the algebraic sum of all horizontal component of forces I am equating into zero

$F_{AB} - F_{AC} \cos 60° = 0$

Already we have determine the value of F_{AC}has 6.93KN subsisting in the value of F_{AC}in the above equation we can get the value of F_{AB}

F_{AB} = 3.46KN

Once you can see the sign for F_{AB} it comes as positive which means that our assumed nature of force for the member AB which is tensile which is also correct. So F_{AB} is 3.46KN in magnitude and the nature of this force tensile in nature. Now we will consider the equilibrium of joint B the bottom horizontal member of joint B is BD. Let force in that member F_{BD} we will assume tensile force for the particular member hence the arrow head should point away from this joint B. the other inclined member is B in F_{BE} force in that particular member which will assume compressive force for that member the inclination member between BD and BE given as the angle is 30°. The vertical component at B that is $V_B$has been already determine which is 5KN. Now let us applying the two condition equilibrium the 1st will be

∑V = 0

Algebraic sum of all vertical component of forces first we considered V_B it acts in upward direction so it is +5KN. F_{BD} In the horizontal force it doesn't have any vertical component so the vertical component of F_{BD} is zero. Now let us considered F_{BE} is act like this it starts here and end up joint B in order to travel along this direction we go vertically upto this point from downward direction from this particular point will be reaching point B in the horizontal direction so this inclination is 30°. So vertical component ofF_{BE} denoted as V and horizontal component F_{BE} is denoted as H.

V = $F_{BE} \sin 30°$

Similarly the horizontal component F_{BE} is

H =$F_{BE} \cos 30°$

Now we are using the condition

∑V = 0

So $+V_B$ the vertical component of F_{BE} if you see the direction of vertical component of F_{BE} it is in the downward direction so we have to put minus sign

5 - $F_{BE} \sin 30°$ = 0

From this we can get the value of F_{BE}

$F_{BE} = 10$KN

If you see sign for this force once again it is positive which means that our assumed nature of force for member BE compression is right. So F_{BE} will be 10KN than compressive.

Now shall we apply the second condition equilibrium

$\sum H = 0$

$V_B$is a vertical force its horizontal component will be zero F_{BD} is a horizontal force it goes towards left and hence we had to put a negative sign for it -F_{BD}. Then horizontal component of F_{BE} is here which is $F_{BE} \cos 30°$ if you see the direction of horizontal component it move towards right and hence we had put a positive sign

$F_{BD} + \quad F_{BE} \cos 30°$

So this is algebraic sum of all horizontal force at joint B I am equating to zero.

$F_{BD} + \quad F_{BE} \cos 30° = 0$

Already we have found out the value of

$F_{BE} = 10$KN (compressive)

From which we can get the value of

F_{BD} = 8.66KN

Which means our assumed nature of forces for the member BD is right. We have assumed tensile force for the member BD and hence

F_{BD} = 8.66KN (tensile)

So now this is the joint E there are four forces 6KN force acting in the downward direction then we have F_{BE} F_{DE} and finally F_{CE}. F_{BE} Has already found out the nature of force in the member BE is compressive so we have the arrow head pointing towards the joint. F_{DE} Is assumed to be tensile in nature so arrow head away from the joint and F_{CE} is assume to be compressive arrow head points towards the joint. We are applying the 1st condition equilibrium

$\sum V = 0$

6KN force act in the down direction so -6 the vertical component of F_{BE} will go in the upward direction it will be

-6 + $F_{BE} \sin 30°$

F_{DE} Acts from this point and reaches here so the vertical component of F_{DE} will be

$F_{DE} \sin 60°$

Since it goes in the down ward direction will be putting a negative sign

- $F_{DE} \sin 60°$

The final force will be the vertical component of F_{CE} will be

$F_{CE} \sin 30°$

It direction will be downward direction so we have to put a negative sign

- $F_{CE} \sin 30° = 0$

Simplifying this equation we get

0.5 F_{CE} + 0.866 F_{DE} = -1

Now we apply the second condition equilibrium

∑H = 0

Applying this condition we get 6KN force vertical force so it horizontal component will be zero. Horizontal component of F_{BE}

- $F_{BE} \cos 30°$

If you see the horizontal component of F_{CE} it goes towards right its magnitude will be

$F_{CE} \cos 30°$

The final forces F_{DE} its horizontal component is here moving towards to left magnitude of the horizontal component will be

$F_{DE} \cos 60°$

The horizontal component of F_{DE} move towards left so we have to put a negative sign for it

- $F_{DE} \cos 60°$

So these are the algebraic sum of horizontal forces we shall equates zero

- $F_{BE} \cos 30°$ + $F_{CE} \cos 30°$- $F_{DE} \cos 60° = 0$

Simplifying this equation getting

0.866 F_{CE} – 0.5 F_{DE} = 8.66 equation 2

Already we got a another equation by a applying the condition

∑V = 0equation 1

Now we have two equation in which the unknown quantities are F_{CE} and F_{DE} solving these two simultaneous equation we can get this

F_{CE} = 7KN

F_{CE} Comes as positive which means that our assumed nature of force for member CE compressive is wright

F_{CE} = 7KN (compressive)

If we calculated the value of F_{DE}

F_{DE} = -5.2 KN

Since minus sign is coming for F_{DE} our assumed nature of force for F_{DE} that is tensile is wrong so it has to be compressive. So therefore

F_{DE} = 5.2KN (compressive)

By this way we have determine the required unknown member forces by method of joints.