B. ARCHITECTURE

MECHANICS OF STRUCTURE – 1 (AR6201)

ANALYSIS OF PLANE TRUSSES

Lecture - 6

Cantilever Truss of Joint A:

We have a cantilever truss, a cantilever truss is the one in which one end of the truss is fixed actually the ends D and E that is the joint D and E are fixed and the other end that is end A is free and hence this truss is a cantilever truss. At the free end A we have a force of 10 MN acting in the downward direction. Total span of the truss is 8m we are asked to find the forces in all the members of this cantilever truss by method of joints.

So this is cantilever truss has 3 members. We have to determine the forces in all these 6 members by method of joints. Unlike simply supported beans there is no need to calculate any support reactions for a cantilever truss. Now first of all we shall consider the free end or the joint which is at the right hand end that is at the free end. So we are considering the free body diagram of joint A first. At joint A we have a downward force of 10 MN acting. We have the member C A meeting at joint A. Let F_{CA} or F_{AC} be the force in that particular member. We shall tensile force for that particular member, so the arrow head should point away from join A, also there is another member B A coming in joint A let the force in that particular member F be compressive Force for this particular member so that should point towards this right now for this trust in relation between the members are not given from the dimensions of the trust given Visual calculate the angles the angle BAC that is this particular angle will work out to be 23.56 degrees 2 degrees angle will be 63.44 degree angle 63.44 degrees 3.44 degrees now we shall apply the conditions of equilibrium for getting the two unknown member forces F_{BA}

and F_{AC} first of all we shall apply the conditions Sigma V will be equal to zero algebraic sum of all vertical forces at joint A is zero this 10MN forces acting in the downward direction and hence we have minus sign so -10. Now let us consider F_{BA} the force F_{BA} goes in this particular direction that is it starts here and it ends up at joint A, it starts here and it ends up here. To travel along this path horizontally we have to move towards right and reach this particular point and then vertically we have to go upwards, so if you see the vertical component, vertical component of F_{BA} goes in the upward direction so its sign will be plus now this particular angle is 63.44 degrees so with respect to the 63.44 degree vertical component of F_{BA} is the adjacent side of a right angled triangle so the vertical component will be,

$V = +\cos 63.44 \text{ degree} \times F_{BA}$

$-10 + F_{BA}\cos 63.44 \text{ degree} = 0$

Now the next forces is F_{AC}, F_{AC} is a horizontal force and hence it does not have any vertical component, so these are the algebraic sum of all vertical component of forces and equating it to zero, now solving this equation we will be getting

$F_{BA} = 22.36\text{MN}$

F_{BA} comes as positive which means that our assumed nature of force in the member BA which is compression is right so F_{BA} will be 22.36MN compressive. Now let us apply the second equilibrium equation that is equilibrium condition which is algebraic sum of all horizontal forces at joint A is zero this 10MN force is vertical force It does not have any horizontal component F_{AC} it is a horizontal force it goes towards left so we should put a negative sign for it so - F_{AC}. Now let us get the value of horizontal component of F_{BA} now this is a horizontal component of F_{BA}, horizontal component of F_{BA} goes towards right so it should have a positive sign with respect to this 63.44 degree horizontal component H is opposite side of the right angled triangle and hence horizontal component will be

$H = +F_{BA}$ sin63.44 degrees

$-F_{AC} + F_{BA}$ sin63.44 degrees = 0

Already we have found the value of F_{BA} which is 22.36MN compressive, using that value in this equation we get,

F_{AC} = 20MN

Once again sign convention is positive hear that is it is +20MN which means that our assumed nature of force for the member AC our assumed nature of force is tensile is also right so F_{AC} is 20MN tensile. So by considering joint A, we have found out two unknown member forces which are F_{BA} which is 22.36MN compressive and F_{AC} which is 20MN tensile.

Cantilever Truss of Joint B:

Now we shall go for the next joint, the next joint that will be considered here will be joint B we cannot consider joint C because there are totally 4 members meeting at joint C in which we have only one member in which we are found out the force so in the remaining three members we don't know the value of forces and hence we should not consider joint C. Now we shall consider joint B let me draw the free body diagram of joint B, 3 member forces at joint B are F_{AB} ,F_{AC} and F_{BE} already we have found out the magnitude of the force F_{AB} which is compressive the nature of force in the member AB is compressive hence arrow head should point towards the joint B, now I am assuming that the force in member B is also compressive in nature, so the arrowhead once again for FB is pointing towards joint B similarly F_{BC} is also assumed to be compressive so arrow heads points towards the joint B the angle between the members BC and AB will be 63.44 degrees. Now let us apply the conditions of equilibrium the first one is Sigma V is equal to zero. F_{BC} is a vertical force it goes in the downward direction so negative sign should come for F_{BC} so $-F_{BC}$, F_{BE} is a horizontal force hence it does not have any vertical reaction component. Now we shall find out the vertical component of the force F_{AB}, F_{AB} goes like this that is it starts here and it ends up at joint B, so to travel along this particular path horizontally we have to move towards left till this particular point and then vertically we have to come down so this is the horizontal component H of F_{AB} and this is a vertical component of F_{AB}, since the vertical component of F_{AB} goes in the downward direction this angle is 63.44 degrees. Now vertical component of F_{AB} goes in the downward direction so it should have a minus sign with respect to this angle 63.44 degree vertical component is the adjacent side of the right angle triangle so the vertical component would be

$V = -F_{AB} \cos 63.44$ degree

Now let us come to the horizontal component of F_{AB}, horizontal component of F_{AB} moves towards left so according to our sign convention we are putting a minus sign with respect to 63.44 degree this horizontal component is opposite side of the right angled triangle so the horizontal component maybe

$H = -F_{AB} \sin 63.44$ degree

Now here we are applying the equilibrium equation Sigma V equal to zero for joint B

$- F_{BC} - F_{AB} \cos 63.44$ degree $= 0$

Putting the value of F_{AB} in the above equation we can get the value of F_{BC},

$F_{BC} = - 10MN$

Minus sign indicates that our assumed the nature of force for the member BC our assumption is that it is compressive in nature is wrong and hence F_{BC} should be tensile in nature, so therefore

$F_{BC} = - 10MN$ (Compressive)

F_{BC}= 10MN(Tensile)

Now let us apply the second equilibrium equation which is Sigma H equal to zero F_{BC} is a vertical force It does not have any horizontal component F_{BE} already horizontal force It moves towards right so we should have a positive sign for it

$+ F_{BE} – F_{AB} \sin 63.44$ degree = 0

F_{BE} = 20MN

If you see the sign it is positive which means that our assumed nature of the member force for the member AB that is compression is right so F_{BE} is 20MNcompressive.

Cantilever Truss of Joint C:

Now let us move on to the next joint which will be joint C. I am drawing the free body diagram of joint C here. Joint C is acted upon by 4 forces which are F_{CA} F_{CB} F_{EC} and F_{DC} already we have found out the direction as well as magnitude of the two forces F_{CA} and F_{CB} F_{CA} is 20MN tensile, since it is tensile in nature the arrow head should point away from the joint, F_{CB} is 10MN once again it is tensile so arrowhead should point way from the joint. Now for F_{BC} I am assuming compressive force so arrow head is pointing towards the joint and for F_{CE} I am assuming tensile force so are ahead points away from the joint after assuming suitable nature of force for all the members we shall apply the equilibrium equations conditions of equilibrium the first condition will be Sigma V equal to zero algebraic sum of all vertical forces equal to zero, F_{CA} is a horizontal force It does not have any vertical component F_{CB} goes in the download direction so it is minus F_{CB} let us consider the force $F_{DC}F_{DC}$ acts like this it starts from this particular point and it ends up at joint C that is it starts here and it ends up here to move along this particular path vertically we have to come down till this particular point and horizontally we have to move towards left this angle is known to us which is 23.56 degrees so this is a vertical component V and this is a horizontal component H with respect to 23.56 degrees vertical component is opposite side also the vertical component goes in the download direction so we should have a negative sign for it so vertical component V will be

$V = -F_{DC} \sin 23.56$ degree

Horizontal component of F_{DC} moves towards right since it is moving in right hand side direction we should have a positive sign for it, so magnitude of H will be

$H = +F_{DC} \cos 23.56$ degree

Now we are applying the condition Sigma V is equal to zero we need the vertical component of F_{DC} which is $-F_{DC}$ sin23. 56 degree, so we have considered a F_{CB} we have found out the vertical component of F_{DC} now she'll come to the force F_{EC}, the force F_{EC} goes like this is F_{EC} it starts from the joint C this is our joint C and it ends up here, to travel along with particular direction horizontally we have to move towards left till this particular point and vertically we have to come down so this particular angle is 23.56 degree so this is the horizontal component of F_{CE} and this is the vertical component of F_{CE}, horizontal component of F_{CE} moves towards left so it should have a negative sign, horizontal component will be F_{CE} into cos of 23.56 degree, similarly vertical component of F_{CE} vertical component goes in the downward direction it also has a negative sign vertical component V with respect to 23.56 degree is the opposite side of the right angled triangle so we will have $-F_{CE}$ into sin of 23.56 degree. Now we need only the vertical component of F_{CE} which is $-F_{CE}$ into sign of 23.56 degree so now you have found out the algebraic sum of all vertical components of forces I am equating it to zero. Already we have found out the force in the member CB note the value of F_{CB} so upon simplifying this equation we get

$F_{CE} + F_{DC} = -22.36$

Name the above equation as equation 1. The equation 1 is obtained by applying the condition sigma V equal to zero. Now we shall apply the second equilibrium condition sigma H is equal to zero algebraic sum of all horizontal forces acting at joint C is zero F_{CB} is a vertical force hence it does not have any horizontal components F_{CA} moves towards right it is a horizontal force and it is going towards right so we should have a positive sign for it plus F_{CA}. Now let us get the horizontal component of the force F_{DC}, now in this triangle horizontal component of the force F_{DC} is

$H = + F_{DC} \cos 23.56$ degree

Next we need a horizontal component of the force F_{CE} which is horizontal component of F_{CE} is - F_{CE} into cos of 23.56 degree we are equating this to zero. Already we know the value of F_{CA}.

$+F_{CA} + F_{DC} \cos 23.56$ degree $- F_{CE} \cos 23.56$ degree $= 0$

So simplifying this equation we will get

$F_{DC} - F_{CE} = - 22.36$

Consider the above equation as equation number 2, now we have equation one here and this is the second equation there are two equations with two unknowns solving the simultaneous equations we can get the value of F_{CE} and F_{DC} to get that we shall add equation 1 and 2 equation 1 added with equation 2 will be getting

$2F_{DC} = -44.72$

$F_{DC} = -22.36$MN

Negative sign indicates here the assumed nature of force for the member DC that is compressive is wrong it is in correct and hence it should be tensile so therefore F_{DC} is,

$F_{DC} = -22.36$MN (Tensile)

Now you can use this value of F_{DC} in equation 1 or equation 2 in order to get the value of F_{CE} now we shall put this value in equation 2 so,

$F_{CE} - 22.36 = -22.36$

$F_{CE} = 0$

Which means that there is no force acting in this member EC, so member EC is devoid of any force only in the rest of the members we have forces acting.