Mechanics Of Solids
Prof. Priyanka Ghosh
Department of Civil Engineering
Indian Institute of Technology, Kanpur

Lecture - 07
Stability of Truss

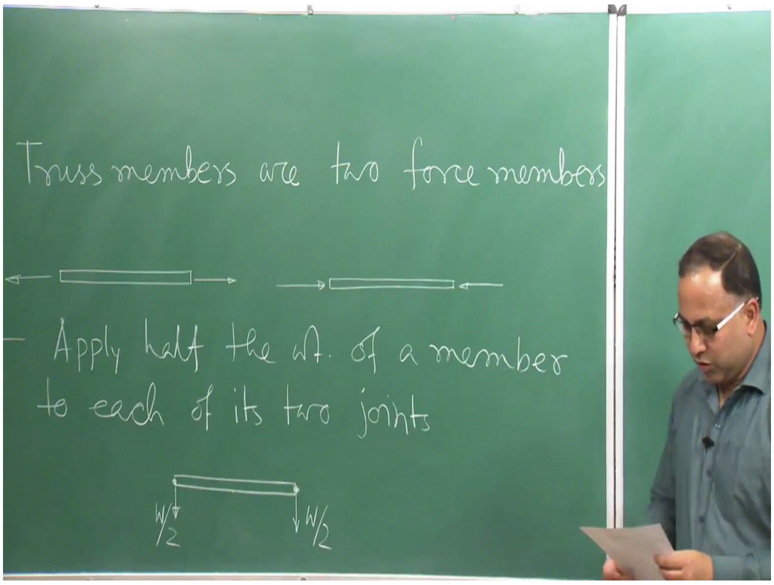
Welcome back to the course mechanics of solids. So, as we have seen in the last lecture we have discussing about the truss plane truss. And we were talking about that how the truss is found and what are the different says specifications or different say details of the truss members. So, anyways so, we are just basically covering this chapter. So, free body diagram with examples on modelling of typical supports and joints conditions for equilibrium in 3D and 2D friction limiting and non limiting cases. So, these are the things we are discussing right now.

So, let us talk about the translates; go back to the discussion, where we left out in the last lecture. So, basically in the last lecture, already we have seen the in the truss right we in in this particular subject we are including all the plane truss as we have decided in the last lecture we are not talking about the space truss.

Now, the external I mean in the last lecture we stopped here the external loads whatever are generally applied on the truss. They are assumed to apply at the joints and we have seen in the last lecture, that how the joints will look like in the real life right. So, whenever you have one member in the truss basically the truss will be having 2 joints, 2 joints means 2 ends right that member will be having 2 ends that is the linear member. So, there will be 2 ends and those 2 ends will be connected to some joints.

So, whenever some external forces are applied on the truss. So, those forces are applied on the joints. So, that is our basic assumption and we will be analysing the truss based on that assumption. So, we are not considering any load any externally applied load which is applied in between the member.

(Refer Slide Time: 02:25)



Now, the next point to be remembered that is truss members are 2 force members. So, truss members are 2 force members. Now already you know from our previous discussion that what is known by 2 force member what is known by 3 force member and all those things right.

So, truss members are 2 force members. So, that is the basic thing we need to remember for any member involve in that truss system. So, when we are considering the member any member is 2 force member, then of course, it could be either tensile member or compressive member. So, now basically this is one member say this is one truss member as you generally see in the real life. So, it could be either tensile member; that means, it is carrying only the tensile force or it could be compressive member like this another compressive forces.

So, and these forces are occurs equal and opposite from the 2 force member say details whatever we have cover in the in the previous lectures right. So, either it could be tensile; that means, this one equal and opposite forces or acting or this could be like this compressive. So, out of apart from these 2 tensile and compressive we cannot have any type of members. Because this is the 2 force member. Then next point is apply half the weight self weight of a member to each of it is 2 joints.

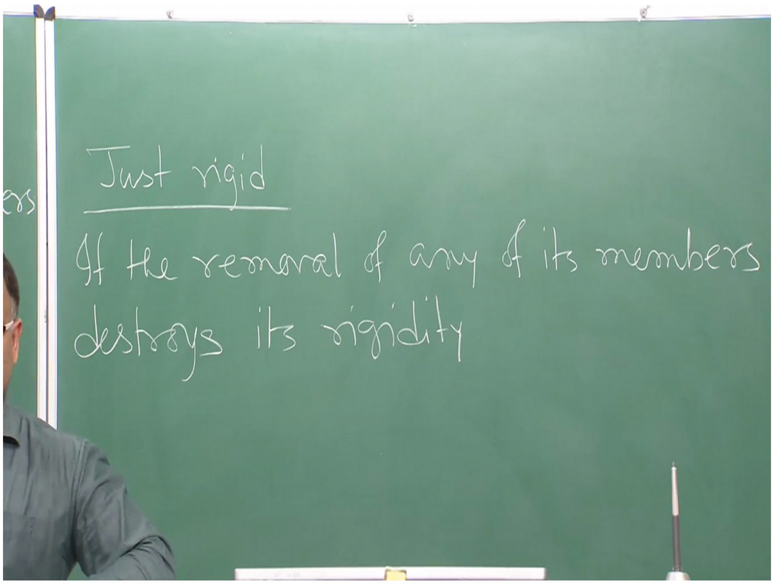
Now, we need some discussion for this. Suppose every member or whatever members are there in the truss. So, every member is has got some self weight. Right, but generally truss is design to carry a load such that the self weight of individual member is very negligible as compare to the externally applied load.

So, therefore, most of the times we will see that most of the times we generally neglect the self weight because that is as compare to the externally applied load is very negligible. So, that is why we generally do not consider, but frankly speaking if you want to analyse the system, in the right say direction. So, basically you need to consider the self weight of the member also which is applied as a external force on the member.

So, when you have this kind of situation. So, this is your member. So, these member is having 2 ends of course, 2 ends will be corrected to 2 joints basically, when it will be forming a truss now the self weight W if you have generally we can assume this self weight is acting at the centre of gravity of the member, but as we have already resided that no force will be applied in between the member. So, we will just distribute this force half of W at each end. So, this is our idealization you can say if you consider the self weight of the member, but most of the time. So, we will not consider the self weight of the member unless until it is mentioned. You also do not consider the self weight of the member as I told you that self weight of the member as compare to the external applied load is very negligible, if you think of the truss bridge for the railway track.

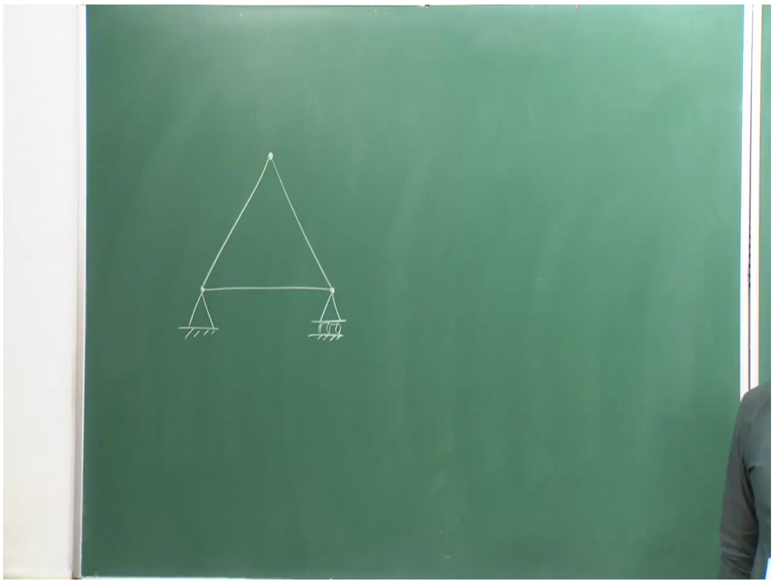
Now, the load of the railway I mean rail or the load of the train is much more higher than the self weight of the member. So, therefore, we can neglect. So, for the for the idealization purpose we can neglect, but if you want to do the proper design or the proper analysis you need to calculate or need to consider the self weight of the member and that can be consider in this way.

(Refer Slide Time: 07:59)



Now, we will be talking about a concept just rigid concept. So, it says if the removal of any of it is members destroys it is rigidity. Now what do you mean by rigidity. So, when I am saying a truss is I mean fairly rigid, what do you mean by that rigid means stable.

(Refer Slide Time: 08:58).



Now, if you look at this truss, if you look at this truss which is made of 3 members and there are 3 joints say this is your hinge support this is your roller support; that means, it will form the simple support right. So, if you considered these elementary truss made of

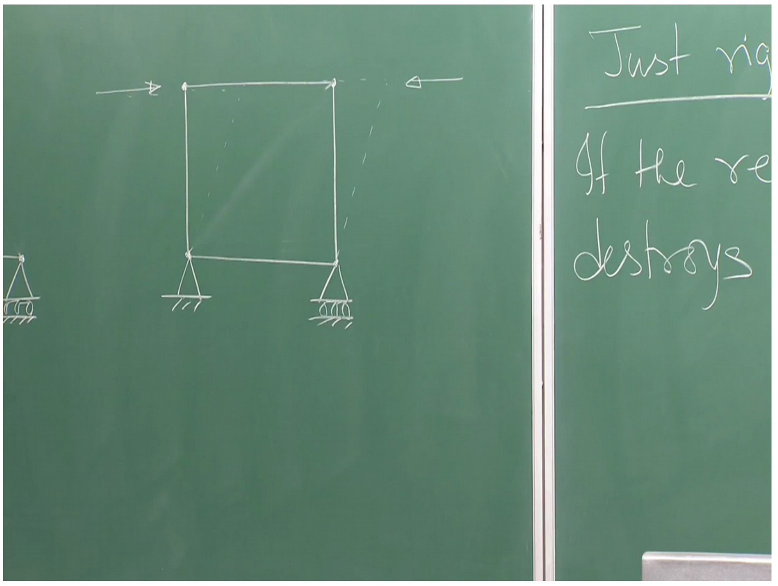
3 members with 3 joints you see this truss I can say these truss is just rigid structure. These truss is just rigid structure. Why?

Now, if you apply a load here it can carry the load without disturbing the stability of the structure. Instead of having the vertical load you may have some horizontal load. Still the truss will carried that horizontal load and of course, these loads are well below the strength of the truss actual truss. So, if you have the horizontal force is acting still the truss will carried the load right. So, it will carry the load without disturbing the stability of the actual structure.

Now, if I remove one member, if I remove one member now what will happen is it a rigid structure; that means, is it a stable structure of course, not. So, under the action of these load these member will try to rotate under the action of these load or the horizontal load from this side this number will try to rotate. So, the stability of the system will be getting disturbed by the application of the external loads. So, this structure we cannot say it is a rigid structure.

So, now I mean earlier when you had the member when you had the just rigid structure; that means, another member was there at the time if you apply the load there will be no rotation or there will be no instability in the structure, but as we have removed one member from this immediately the instabilities coming to the system and rigidity is getting disturbed. So, this kind of system is known as just rigid structure. So, it says that if the removal of any of it is members, I have removed only one member and that basically disturbs the stability right. So, if you remove any of it is members and it if it destroys the rigidity then that is known as just rigid structure.

(Refer Slide Time: 11:57).

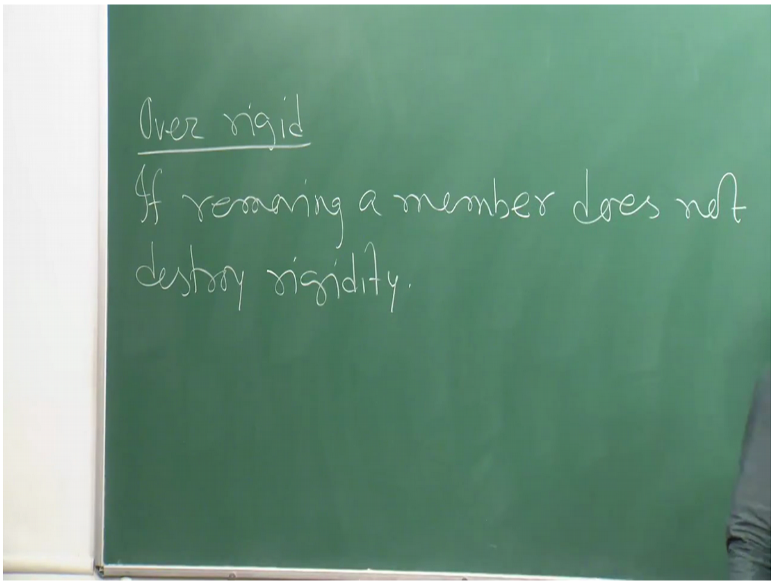


Suppose for example, if you consider tetras like that some square shape or a rectangular shape whatever these are all joints, can you say this is a rigid structure. Yes, or no? Of course, not this is not the rigid structure suppose what will happen, if I apply load in these direction this will this will try to rotate this will try to. So, a in this way or if you apply a load in this direction it will try to. So, A in this direction right?

So, this under the action of the apply I mean externally applied load basically these will not mistable. So, that is why this may this system is not a rigid system right, but for the sake of completeness of the discussion if I add one member here, now what will happen? If I add one member here what will happen? It will be rigid structure right. So, how many members are there 5 members now. So, 5 members are making this system as a rigid system. Immediately we remove this this member as it was there earlier the stability gets disturbed and it becomes unstable right. So, rigidity is getting disturbed by removing only one member. So, if you connect this that structure was just rigid structure and now after removal of your rigidity gets disturbed.

So, similarly we will be having another kind of. So, it is not necessary that all the times we will be getting just rigid structure; that means, if you remove one member immediately the system will be going to the instability.

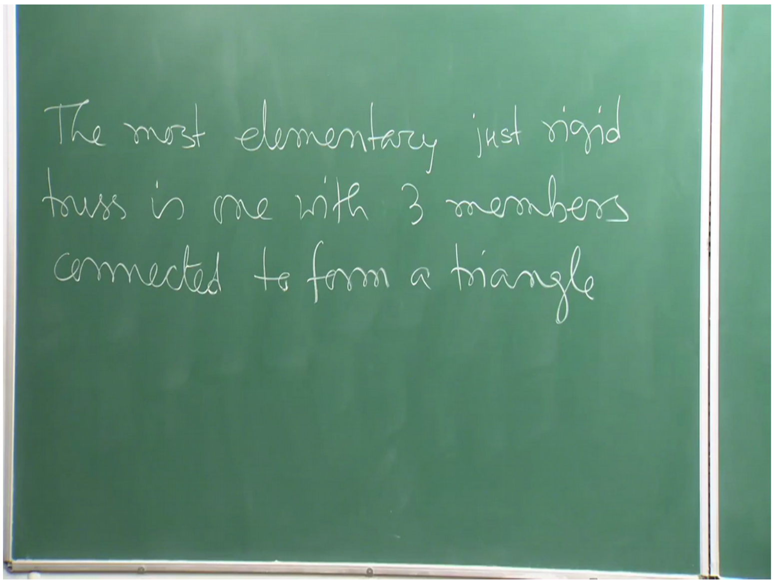
(Refer Slide Time: 14:25).



So, most of the times it is not the case. So, most of the times we will be getting over rigid structure. So, if removing a member does not destroy rigidity if it does not destroy the rigidity by removing a member if you remove a member if it does not destroy the rigidity then basically the structure is known as over rigid structure.

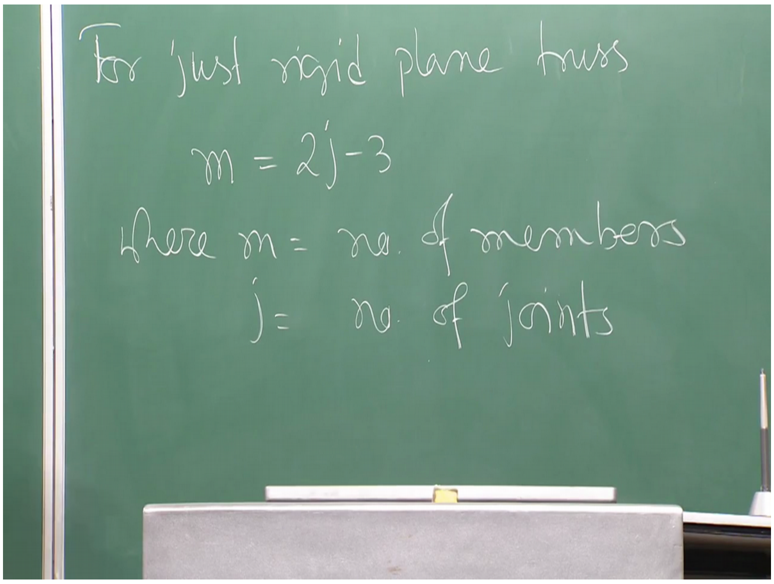
So, now the obvious discussion, what is coming from this part is that, that what is by basic structure which will tell me this is the rigid structure right. So, what is our basic structure or elementary structure which will be the rigid structure?

(Refer Slide Time: 15:48)



So, for that, we can simply write the most elementary just rigid truss is one with 3 members connected to form a triangle the most elementary already. You have seen that with 2 members, if you look at the previous example with 2 members it was not rigid it was not stable right. Immediately you connect one more member which will form a triangle that was giving me the just rigid structure. So, that is basically the elementary structure, which will be the just rigid; that means, for getting just rigid structure the minimum number of members should be 3, which will be making a triangular pattern that is will be your elementary truss.

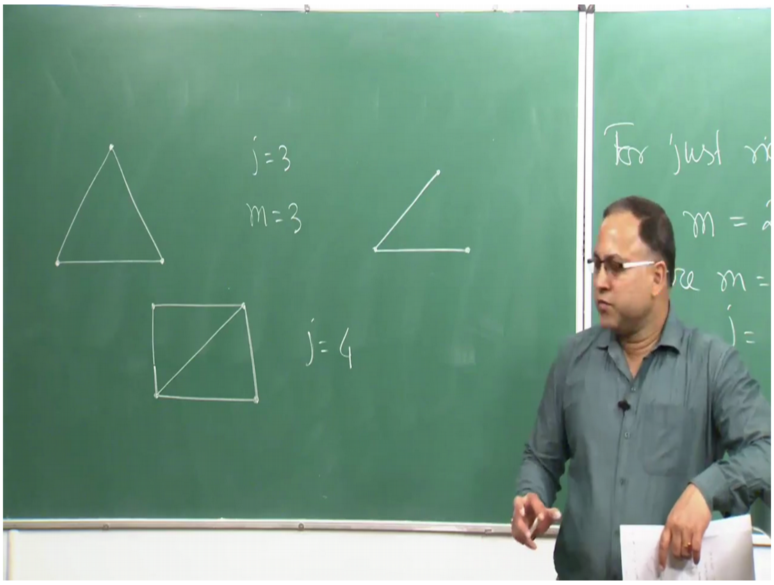
(Refer Slide Time: 17:23)



Now, for how we will identify that whether it is just rigid or not. So, there is some law. So, for just rigid plane truss your m equal to twice j minus 3 where m equal to number of members and j equal to number of joints. So, if this equation or this relation is getting satisfied, then you can say this is my just rigid structure.

Now, let us check with the 3 member system which will be making a triangle. I am not showing the supports it is quite understood that occurs support is there. So, this is your elementary just rigid structure already we have decided.

(Refer Slide Time: 18:26)



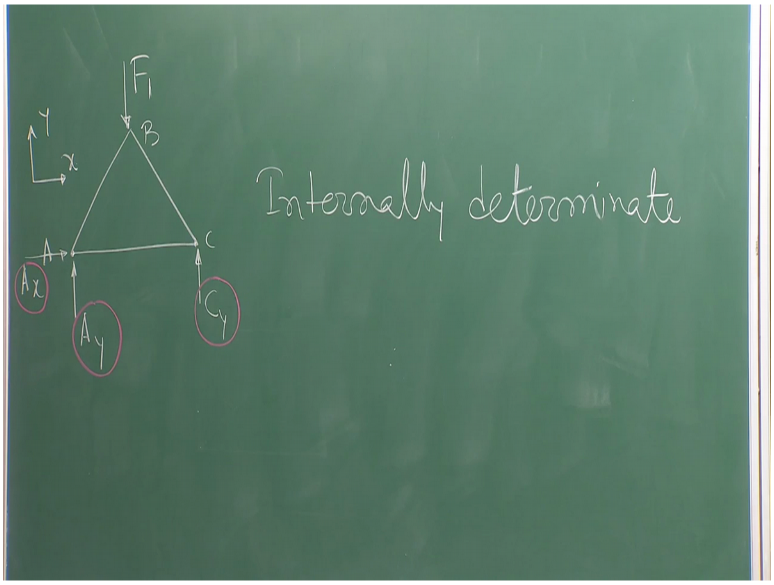
Now, let us talk about or let us see that why that this equation is getting satisfied from this elementary truss or not. How many joints are there j equal to 3? So, in this equation if you come in this, from this equation what I get. So, j equal to 3; that means, number of members must be 3 right. So, in this triangular say truss basically your m is also 3. So, it is satisfying this expression or the equation therefore, we can say this is the just rigid structure.

Now, let us talk about 2 members this is one member this is another member, how many joints are there 3 if you put in this equation, then how many members you should get 3, but you have only 2 members. So, therefore, it cannot be the rigid structure. So, this is a check by which you can check the rigidity of the structure.

Now, talk about that this kind of truss square or rectangular orientation, how many joints are there 4 you have 4 joints 4 coroner means 4 joints. So, if you put in this equation then basically how many members, you should get to get the rigid structure 2 into 4 8 minus 3 is 5. So, minimum 5 members you need to get the just rigid structure, but how many members are there 4 therefore, it is not the rigid structure and already, you have seen that already you have proved the this is not the rigid structure. So, if you connect one member then it will become the just rigid structure understood fine.

So, with this discussion, now we are going to find out determinant truss statically determinate truss or indeterminate truss. So, let us talk about that first. Already you have seen in the last lecture that what is statically determinate member and what is statically indeterminate member. And now we are going to see that thing from the truss.

(Refer Slide Time: 21:35).



So, suppose this is one truss you have load here say F 1, ABC. One thing is already you from the from the previous discussion one thing is very clear this this truss is rigid truss, but whether it is statically determinate or indeterminate that also we have to look at otherwise how we can solve the support reactions.

Now, if you remove the supports, if you want to draw the free body diagram just removed the supports. So, you will be getting Ax, Ay if it is your x y is a plane and you will be getting Cy.

So, these 3 are your are your unknowns, unknowns support reactions. So, you have 3 equations of equilibrium you have 3 unknowns. So, you can solve this. So, this is your determinate externally determinate structure right, as well as if you look at the members, I mean say support if you if you come to this joint, basically if you want to draw the free body diagram of this joint. So, from the equations of equilibrium you have got the magnitude of Ax Ay and Cy. So, now, they are known to you they are not unknown.

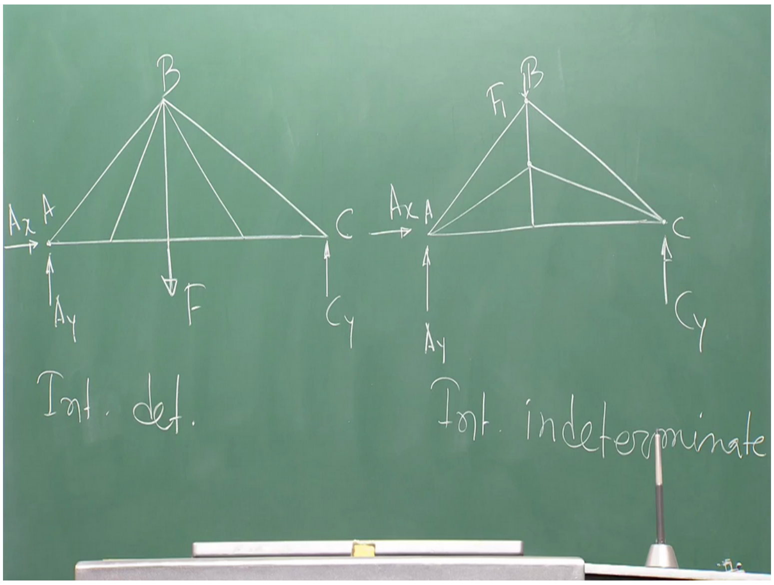
So, if you come to this joint a. So, you have because AB is the 2 force member AC all members are 2 force members it could be either tensile or compressive. So, if you consider the free body diagram of these particular joint what are the forces are acting on that particular joint Ax is acting Ay is acting member force AB is acting member force AC is acting. So, member force AB and AC both are unknown to you. You do not know what are the things known to you know Ax and Ay. So, at this joint basically how many equations of equilibrium available with you because at that point if you consider a point your moment equilibrium is not coming because that anyway if you consider the equation moment equilibrium condition here, it will be giving to the trivial solution right. So, that I do not want I want some non trivial solution.

So, at that joint basically you have only 2 equations of equilibrium available with you what are those summation of F x equal to 0, summation of F y equal to 0 right summation of F x equal to 0 summation of F y equal to 0. So, these 2 equations of equilibrium are available with you at that particular joint. So, 2 equations of equilibrium are available with you and there are 2 unknowns. So, you can solve it.

Similarly, if you come to this point joint C. How many unknowns are there 2 member forces member AC and member B C the forces in those 2 members are unknown to you say, for example, Cy is known to you how many equations of equilibrium available with you 2 summation of F x equal to 0 summation of F y equal to 0. So, therefore, conceptually, I can get the values of member force AC as well as member for BC. So, based on this discussion we will come to the solution procedure for any particular truss.

Now, similarly if you consider. So, so if you consider point joint A you have got member force in AB member force in AC similarly if you consider joint C you have got member force B C and member force AC is already obtained. So, all the forces in individual member have been obtained. So, by just exploiting the equations of equilibrium. So, by exploiting or by satisfying the equations of equilibrium, if you can solve all the member forces. So, that is known as internally determinate internally determinate truss right.

(Refer Slide Time: 27:12)



Similarly, if you look at these truss, let me draw it you have support reactions Ax Ay, this was hinge. So, and you have roller support here. So, only Cy. This is AB and C and you have. So, how many members are there 1 2 3 4 5 6 7 8 9. So, there are 9 members and if you just follow whatever we have discussed now, you will see that all the or the forces in all the members cannot be obtained by just satisfying the equations of equilibrium this kind of structure is known as oh of course, of course, I will for this for this structure we can find out. So, for this structure you cannot find out. So, this is also statically or internally determinate this is also internally determinate. So, you can see that you can check it internally, determinate this is also internally determinate. So, if you apply any force here say suppose, this is a one force F is applied here and another action of these forces you can find out the forces in all the members. So, therefore, these structure is also internally determinate like this.

Though it is it looks like very complicate, but you can solve it and we should know and we will be coming to that part right. Now that how we can solve this force member forces now if you have this kind of say truss here also you have say Ax, Ay, this is point a this is point joint B this is joint C, you have Cy and a force is applied here F one at joint B.

If you look at this structure you will find out that you cannot get all the member forces by using your simple equations of equilibrium. So, therefore, it is known as internally indeterminate, now why I am using internally and externally why this word is coming out say if I can find out all the support reactions then that is the externally determinate and if I can find out the member forces by just simply using the equations of equilibrium then that is known as internally determinate. So, externally determinate means if you can manage to get all the support reactions internally determinate means if you manage to get all the member forces.

Similarly, this structure is also externally determinate as well as internally determinate this structure is externally determinate, but internally indeterminate because you can find out all the support reactions, but you cannot find out all the member forces well. So, I will stop here today. So, in the next lecture, we will be talking about how to solve or how to analyse the truss system.

Thank you very much.