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

Lecture - 06
FBD of Frame Structures

Welcome back to the course mechanics of solids. So, in the last lecture, we are just discussing about the free body diagram of this kind of frame structure.

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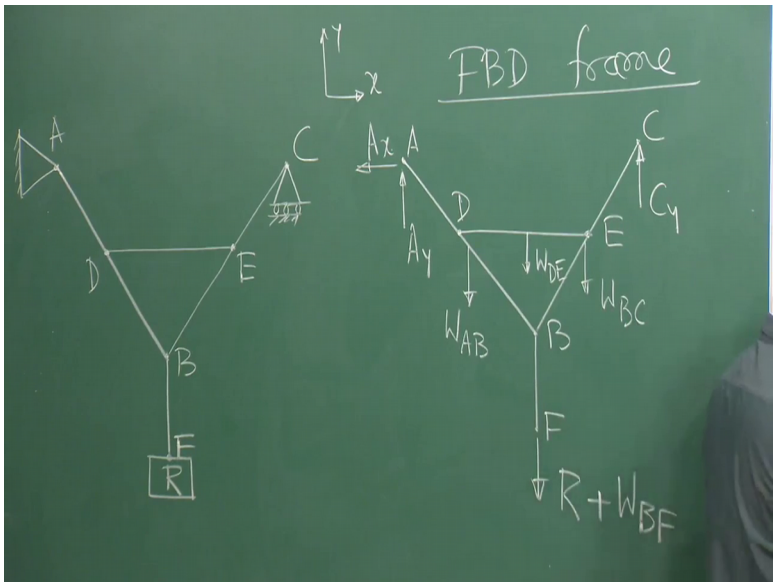

And we have seen that we have 4 members A B B C D E and B F. So, this was the free body diagram of the whole frame by separating out from the supports. So, at A we had in, support and C we had roller support and this was the free body diagram of the whole frame. Now after doing this, we are taking out each individual member from the frame and we are drawing the free body diagram of each individual member.

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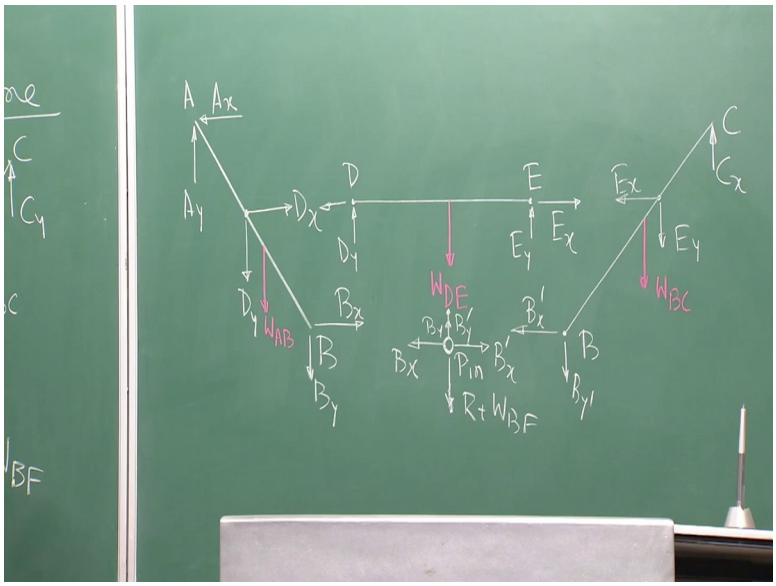

So, in the last lecture we have drawn the free body diagram of A B like this. And free body diagram of D E was like that. Now we can continue with the free body diagram of say B C. So, so this is say B C. So, at C we had already force C x.

Now, this is this was point E. Now already in the last lecture we have seen we have we had chosen the direction of E x from left to right. So, therefore, to satisfy the equilibrium condition, here we should have the direction of E x like this. This is the only thing you need to remember as I told you in the last lecture also.

But still you may ask me why I have chosen E x here from left to right and here from right to left. I do not have any answer because I do not know actually the direction of E x. You may choose E x here from right to left here from left to right that is up to your up to your choice, but you should be consistent with the direction when you are showing the common point fine. Here we have shown E y in the vertical upward direction. So, here it will be downward direction that is the only thing you need to take care as I told you several times.

Now, coming to B x. So, before going for B x, or B y, here we need to show the free body diagram of joint B. Because joint B is a common point, joint B is a common point for both the members member A B and B C. So, let us draw the free body diagram joint B only. So, that will be that is nothing, but your pin at point B. So, already you have

shown B x in this directions. So, it will be having B x in this direction. So, here there is another thing you need to write. So, that is your W B C that is the weight.

Anyway, for pin B this was the direction this was the force B x because B x we had shown in this directions. So, B x will be in this direction. Similarly, along upward direction you will be having B y we have shown in the downward direction. So, it will be B y, in the vertical upward direction. Now from this if we show the forces say B x prime and B y prime, then you have to be necessarily same. So, I can show B y is downward. So, here B y will be B y prime will be upward B x prime from right to left. So, here it will be left to right and we have we have force r plus WBF.

So, this is the free body diagram of the pin now if I want to draw the free body diagram of the member B f. So, how to look like? So, this is say B F.

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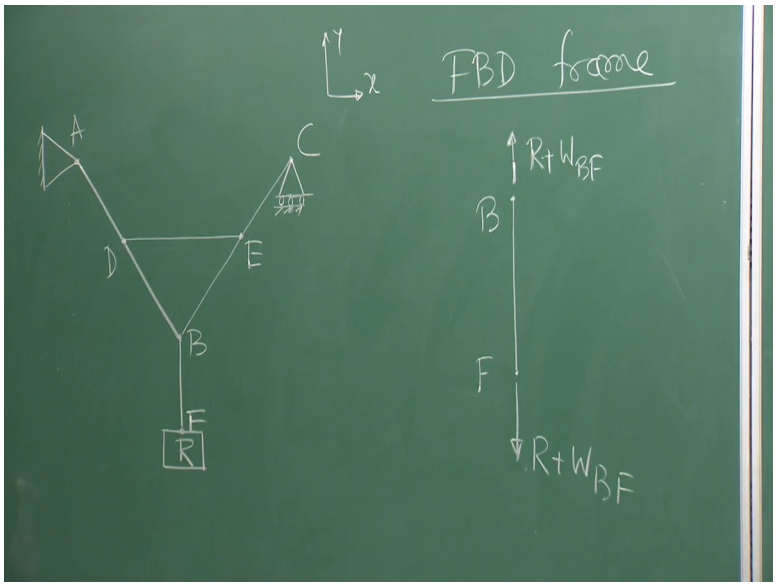

So, at A F already we have seen we r plus WBF is acting, R is the force already applied externally applied force on WBF is the weight of the member B F. So, equal in opposite force will be acting here. So, this will be r plus WBF. So, that is acting at point B. So, this point is nothing, but this pin point. So, you see this is from this this r plus WBF is acting in the upward direction. So, here it was in the downward direction. So, everything is perfect.

So, this is the free body diagram of each and individual member of the frame. Now you can analyze you can take any member and you can analyze the system, but what are the analyze means you need to find out the magnitude of the forces. So, every all the forces can be obtain by exploiting the equations of equilibrium. If the structure is determinant now what is determinant? I do not know.

So, we have need to discuss that thing in the next I mean coming hours right, so this is basically showing you that how we can separate out each and individual component of a particular system and draw the free body diagram. So, this is without now you will appreciate really that without draw in the free body diagram of each and individual component, it is very difficult to analyze the whole system right. So, that is why the free body diagram is really emphasized in the problem of mechanics of solid. So, without drawing free body diagram, do not proceed at all for any kind of problem. So, that is I mean earnest request as well as the advance.

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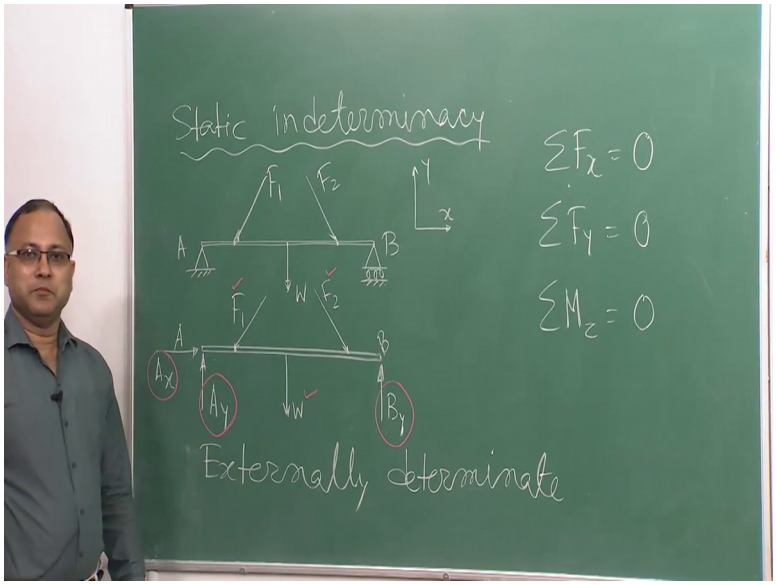

So, now let us talk about determinacy. Because that was just now came out from the discussion. Now what is determine a structure and in determinates, so static indeterminacy. Suppose I have a beam which is having heal support at this end, and roller support at this end. Weight of the beam W is acting here this is the point A this is B. Another force some externally applied concentrated force F 1 is acting like this and F 2 is acting like that. This is the point of application and this is your, this is in x y plane.

Now what is your first job as we have committed. The first job is to draw the free body diagram.

So, let us draw the free body diagram of this beam this is the force F 1 W F 2 and if I want to draw the free body diagram. So, we have to replace all the supports right. So, if I want to replace support A, in basically I should have 2 forces Ay and Ax. Similarly this must replaced with one vertical reaction B y agreed.

So, this is your point B. Now what are the unknowns, could you please tell me what are the unknowns. This is known F 1 because the structure in the actual problem these are the externally applied forces. So, you should know otherwise how will design if you do not know what are the forces are coming on the structure, how will design the structure right. So, the externally applied force must be known to you. So, F 1 is known to you similarly F 2 is known to you. And if you know the dimensions of the beam and material of the beam then W is known to you. So, they are not unknown they are externally applied forces and you are quite familiar to these forces. These are known to you what are the unknowns.

Unknowns are the support reactions; you do not know those right. I mean how much support reactions will be getting developed for the application of these forces, how do you know that you do not know those things you need to analyze. And if I say the beam is under equilibrium condition and by exploiting the equations of equilibrium you can find out those reactions. Now what are the unknowns? Ax is unknown Ay is the unknown because they are not known to you support reactions.

And B y is unknown rest of the things are known to you F 1 F 2 W all are known to you except Ax Ay and B y. These are completely unknown to you. Now if you recall your discussion on the equations of equilibrium right, what was the equations of equilibrium. That is result at of force must be 0 result at on a moment must be 0. Now if you think the structure in x y plane, if you think the structure in x y plane, then basically this this structure will be the (Refer Time: 12:04) structure.

Now, the force all the forces are acting in x y plane with there is no z direction force. So, how many equations of equilibrium available with you? You had 6 equations of equilibrium right, summation of F x equal to 0, summation of F y equal to 0, summation of F z equal to 0, similarly summation of a and x equal to 0, summation of m y equal to

0, summation m z equal to 0, 3 force equation 3 moment equations. If you considered x y z I mean that is the 3 dimensional state of 3 dimensional state of, I mean say force condition right but here your force and everything in x y plane.

So, how many equations are available with you? 3 that is summation of F x equal to 0, summation of F y equal to 0, and summation of m z equal to 0. Moment with respect to z axis, z axis is normal to the board. Z axis is normal to the board. So, summation of F x means summation of all the forces in x direction must be 0 that is the first equation of equilibrium then summation of F y equal to 0; that means, summation of all the forces in y direction must be 0 and summation of moment with respect to z axis because the forces are acting in x y plane. So, you will be getting the moment with respect to z axis if you if you see right.

So, if the forces in this plane, basically you will be getting the moment with respect to z axis which is normal to the board. So, you have 3 equations of equilibrium available with you to solved this problem all right. Solve this problem means now if you exploit summation of F x equal to 0. So, basically you take Ax, you take x component of F 1 you take x component of F 2 B y will not having any x component, and similarly W will not be having any x component Ay will not be having any x component. So, in that fraction you will be getting one equation.

Similarly, if you consider summation of F y equal to 0 then Ax will not be having any component y direction. So, Ay will be coming in to the picture y component of F 1 will be coming in to the picture, W will be coming in to the picture y component of F 2 will be coming in to the picture and finally, B y. So, that will form a form an equation similarly if you considered m z summation of m z equal to 0, any point you considered any point in the beam you consider. Suppose you consider point A; that means, you are considering moments with respect to z axis at point A. So, that F 1 will be giving sum moment because if you know the pointer application of this. So, you know the distance and from there you can find out the moment, similarly W will be giving you the moment F 2 will be contributing in the moment B y will be contributing in the moment Ax and Ay will not be contributing because you are choosing a point to calculate the moment.

So, in that first time basically you will be getting 3 equations, am I right you will be getting 3 equations how many unknowns are there 3 unknowns. So, mathematically you

can say that you can solve it. You can solve or you can find out all the unknowns Ax Ay and B y by solving these 3 simultaneous equations. So, this kind of structure is known as externally determinate, structure means you can solve the structure; that means, you can solve for the unknowns by using your availably equations of equilibrium, try to understand of the definition. Determinate structure is that structure for which the unknowns can be obtained by using the available equations of equilibrium. That is your definition of the determinate structure. If it is not if you cannot find out, then the structure will be automatically indeterminate structure. So, let us see the indeterminate structure. Now in the same problem in the same problem, what I am doing instead of roller support I am making this support is also hinge support.

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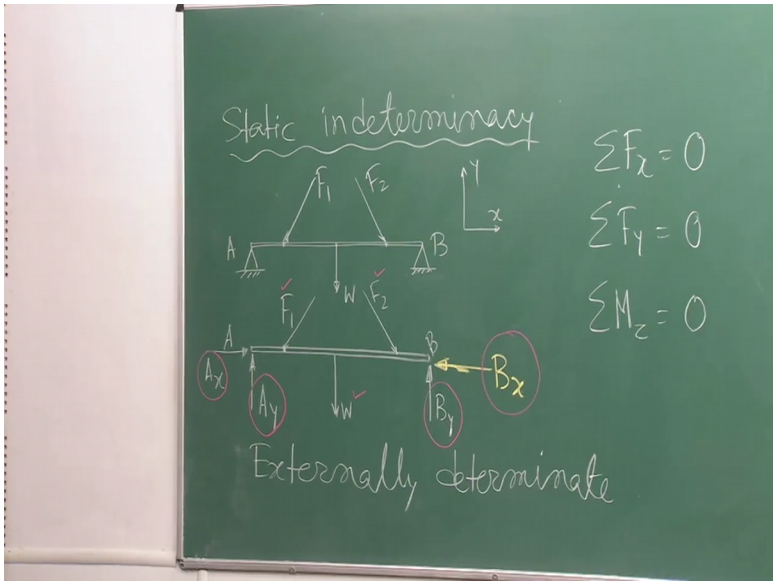

What I am doing instead of making this roller I am putting one hinge support. So, I have 2 hinge support one is at a another one is at B. So, therefore, if I want to draw the free body diagram, so B y will be having one more reactions say B one B one will be having B, B point will be having one more reaction that is B x, now this B x, this B x is known to you or not it is not known to you it is unknown again because of support reactions is unknown. So, how many unknowns are there now you are 4 unknowns Ax, Ay, B x, B y there are 4 unknowns how many equations you have to solve this. Only 3 equations this equations will not be getting changed right. If you changes the support condition because you are dealing with x y plane, these 3 equations are available with you, but you have got one more extra unknown.

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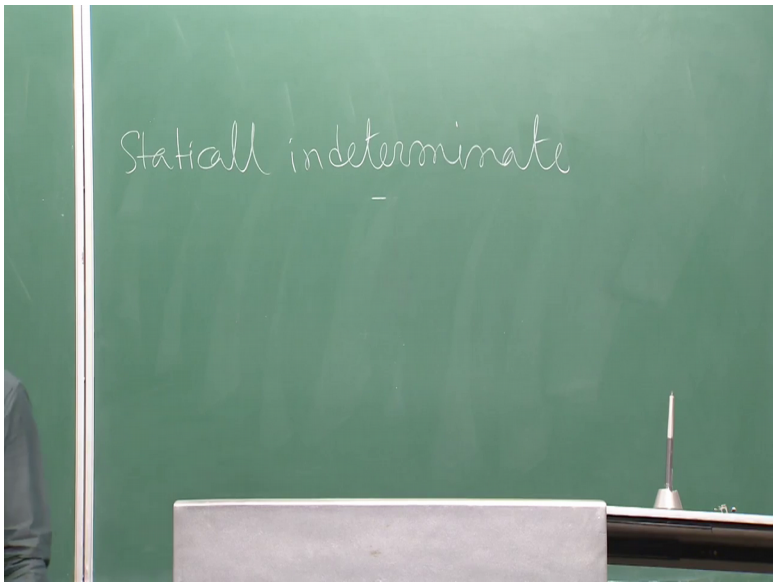

So, 4 unknowns 3 equations can you solve it no you cannot solve it. So, this structure is known as statically indeterminate. To solve this kind of structure we need to impose some condition.

So, those things will be coming later on when will be discussing about the next chapter. So, at this moment what type of problems will be taking in this chapter basically will be taking the problem related to determinate structure. In determinate structure can be solve, but you have to do some extra exercise to solve it. So, is it clear to you? So, what is determinate and indeterminate it is very important. So, whenever you are getting some problem immediately you draw the free body diagram in then you check whether it is determinate and indeterminate. If it is determinate find you can solve it by using your equations of equilibrium alone if it is not determinate if it is indeterminate then you have to in includes some more conditions. Apart from your equations of equilibrium you have to impose some extra condition. So, now we are coming to a new topic that is plane truss.

So, you might have seen this kind of structure several times in your life whenever you travel by some railway bridge which is having you might have seen this kind of structure.

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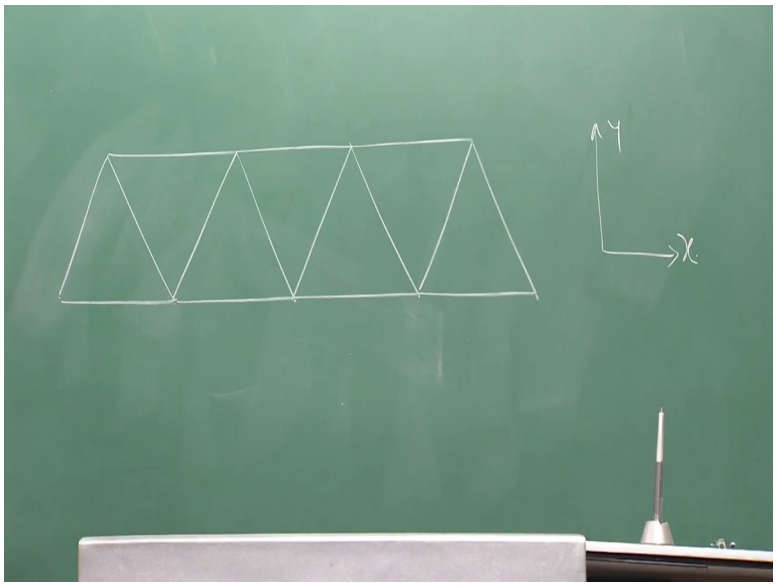

So, you might have seen this kind of structure on some railway bridge or some highway bridge right, this kind of structure made of steel. So, this is known as plane truss. The classical example of this plane truss is your how the bridge.

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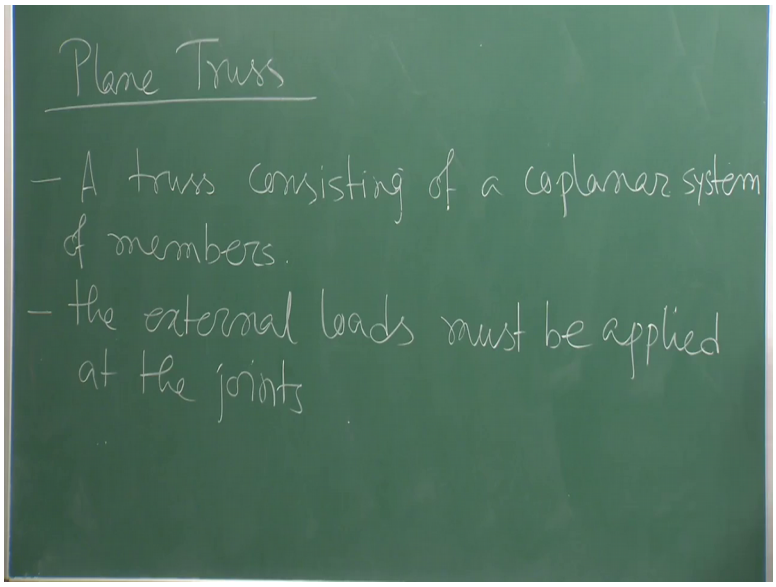

As I told you classical example of plane truss is your how the bridge. Even if you are Eifel tower is an example of truss, but that is not the plane truss. So, you are not going to discuss about that thing that is your space truss. So, that is not including in your syllabus so, but that is also a truss member those members are truss members. Now there are few

things you need to know for the plane truss. What is truss? A truss consisting of a coplanar system of members a truss consisting of a coplanar system of members, when I am talking plane truss basically the truss is made in one plane.

So, if you look at this truss, and if I say this is my x y coordinate system. So, basically in x y plane the truss is having the members. So, all the members are connected in such a way that it is expanding in x y plane. So, there is no z direction component or z direction members. So, if you have the z direction members then basically that will be known as space truss as I told you. So, that is not including in your syllabus. Then the external loads must be applied at the joints. So, what does it mean? So, if you have the truss like this, suppose this is one truss, this is the support, simple support.

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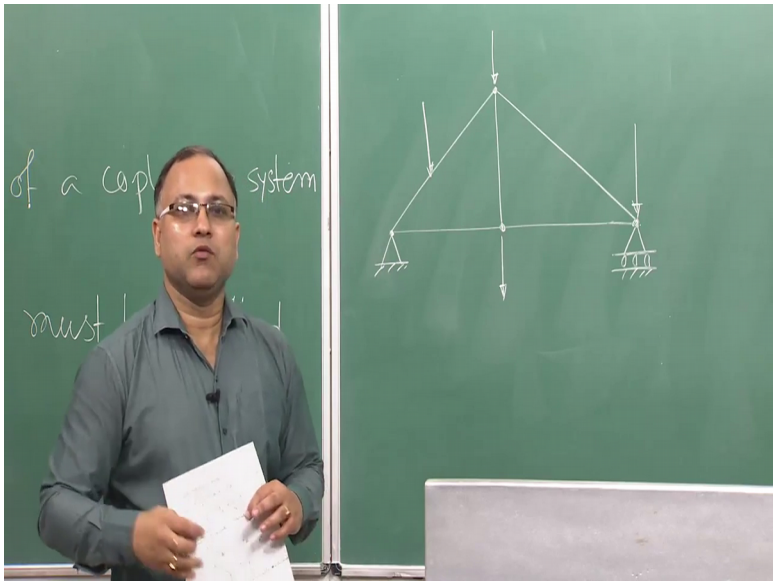

So, this hinge and roller supports together is known as simply supported structure or the simple supports. So, these supports are known as in mechanics I mean subsequently I will be using this term simple supported structure. So, simple supported means it is supported on hinge and roller support something like that fine.

So, this is one truss. These are all joints. These are all joints. Now the next statement is said the external loads must be applied at the joints. So, whatever external forces are coming any external force, they will be act that is assumption and that is fair enough or fair good assumption, all external forces if I apply some external force if I apply some external force, if I apply some external force all external forces are applied at the joints.

The how this joints will look like. So, let us look at this problem lo look at this figure. So, this is one typical joint. Joint does not mean that it will be simple pin joint or something like that it may have several members emerging from the joint.

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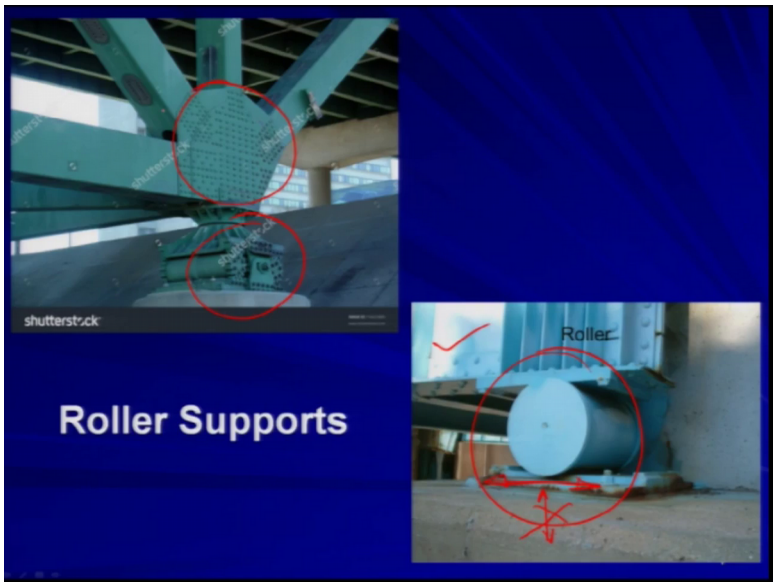

So, this is one member this is another member this is a truss structure another member this is another member. So, 4 members are coming out like this joints if you considered 3 members are coming out. 1 2 and 3 how many members are there in this truss 1 2 3 4 5 there are 5 members they are connected by joints.

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The joints may be welded; joints may be riveted like this or joints may be bolted whatever there are joints.

If you look at this figure, these are all joints, this is joint, this is one joint something like that. So, the next assumption is that is the second assumption that is the external loads must be applied at the joints. So, we are not going to consider any force which are applied in between the (Refer Time: 26:11). That is our assumption or rather you should say that is our idealization of the problem we need to idealize the system well. So, I will stop here today. So, in the next class will continue with this truss and how to analyze this truss will see. And will learnt you methods by which you can solve the truss solve means these member forces basically what is the idea. If you want to design a truss you want to design a truss, now first thing is that you should know what are the support reactions.

That will be getting as I told you by using your equations of equilibrium, then once you know the support reactions under the application of the external forces, what are the different member forces member forces means. There are 5 members in the truss. So, those 5 members how much forces they are carried. So, based on those forces basically you can design the member that is the idea. So, you need to analyze the truss to get the member forces well.

So, I will stop here today. So, in the next class will continue with the truss analysis.

Thank you very much.