Engineering Mechanics
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Module 02
Lecture No 22
Plane trusses IV: Solved examples for calculating forces in a simple truss by method of joints

In the previous lecture, we introduced trusses and solved an example using the method of joints.

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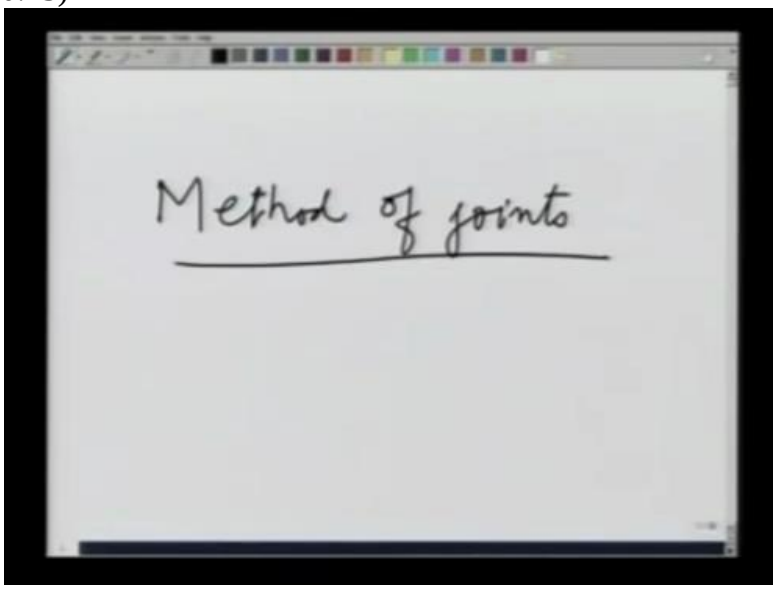
e 

In this lecture, we continue with the method of joints and solve 2 more examples using this method.

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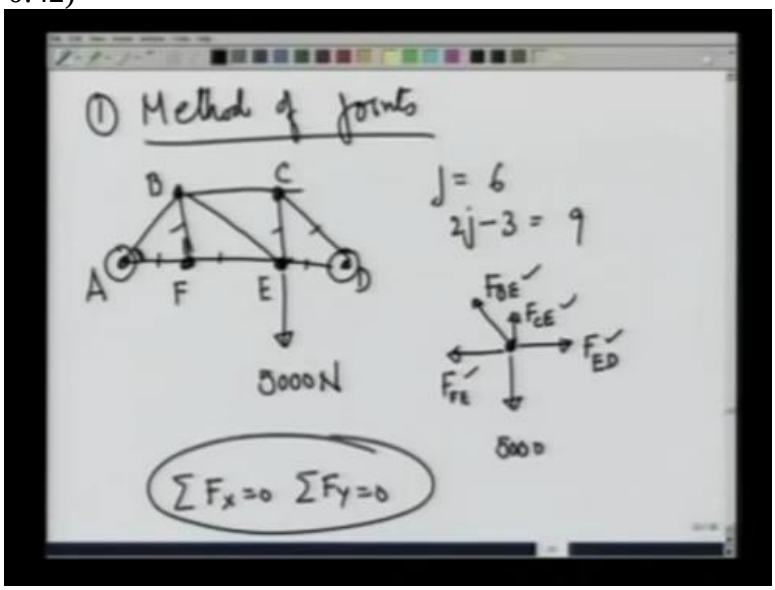

So I will take a simple truss like this, each angle being 45 degrees. These are the joints. You can see, there are 6 joints. So J equals 6. 2J - 3 is 9 and there are 1, 2, 3, 4, 5, 6, 7, 8, 9 members. I am going to name this A, B, C, D, E and F and apply a load of 5000 newtons at E. I want to calculate the force in each member of this truss. So ideally, if I start with this point, I would take point E. The force on point E is 5000 newtons and then a force due to member BE, let me call it FBE, a force due to member FED, a force due to member FCE and a force due to member FE.

Remember, all the forces acting at the same point. Therefore, Torque equation is automatically satisfied. The only equations I have at my disposal are FX equal to 0 and summation and summation FY is equal to 0. And therefore I have only 2 equations that I can apply at this point. However, the number of unknowns is 1, 2, 3, and 4. And therefore I cannot directly apply these 2 equations and get the answers right away. For that, what I should do is get to those points where there are 2 unknowns only.

And those points are A and D. A and D. So 1st thing is to get the forces at A and D and then go to other joints from there onwards. So let us do that.

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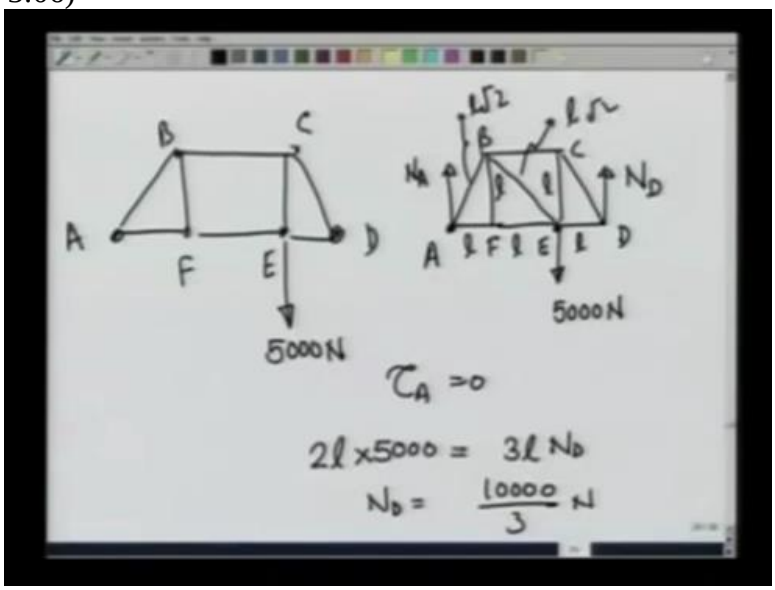

To get the forces at point A and D, let me make this again. A, B, C, D, E, and F. There is a force of 5000 newtons acting downwards. Let me take the entire truss as one unit. Let the normal reaction at D be ND. Let the normal reaction at A be NA and there is this force acting downwards of 5000 newtons. I am not being careful in making this to scale. Let the length of the smallest J rods be L so that this diagonal rod is L root 2. This length is also L root 2.

The 1st thing I want to do is get NA and ND. The simplest thing to do in this case would be to apply the torque equation about this point A. When I apply the torque equation about A and make it 0, I get 2L times 5000 is equal to 3L times ND. And therefore, ND comes out to be 10000 over 3 newtons.

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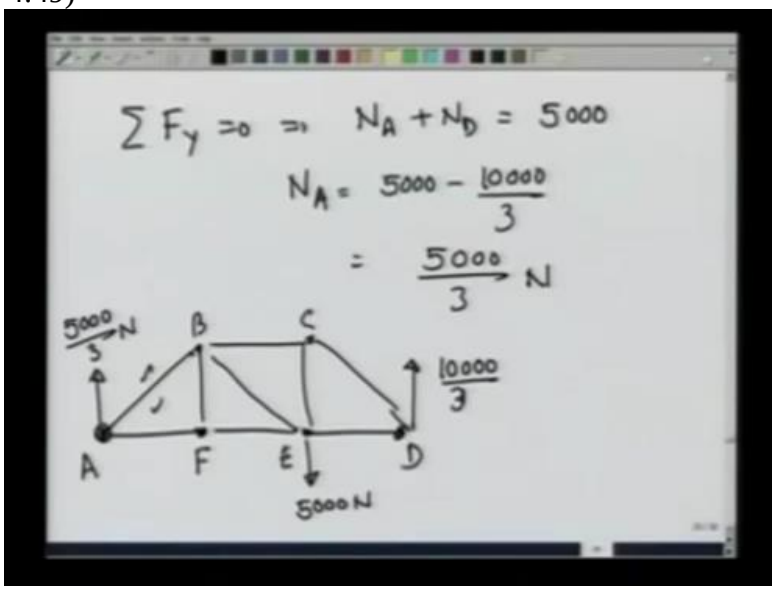

Once I know ND then summation FY is equal to 0 gives me NA + ND is equal to 5000. And this gives me NA to be 5000 - 10000 over 3 which gives me 5000 over 3 newtons. So now if I look at this truss if I have to make it to scale, now I know there is a force acting here, 10000 newtons over 3. There is a force acting here downwards of 5000 newtons. There is a force acting upwards here, 5000 over 3 and this is A, B, C, D, E and F.

Now at point A, there are 2 unknowns. Force due to AB member and force due to AF member. Therefore if I bring this pin in equilibrium, I have 2 equations, summation FX equal to 0 and summation FY equal to 0, I can solve for both the forces. So let us do that at point A.

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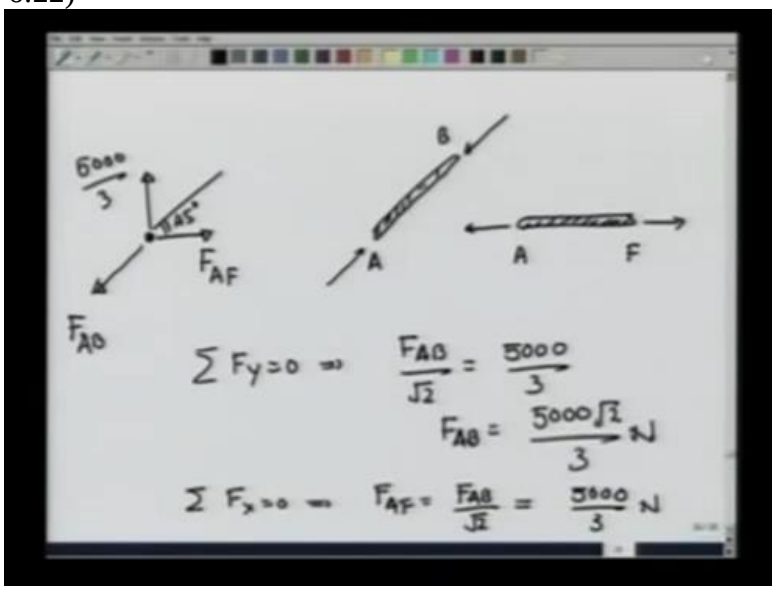

So at point A, the pin at A is in equilibrium under a force which is 5000 over 3 newtons acting of words. To balance this, I need a force on this FAB acting in this direction and to counter the X component of FAB I need a force in this direction which will be FAF. I have already anticipated the directions of these forces. Obviously, the force on member AB due to the pin therefore would be in this direction. So this is a compressive force and force on FAF, this is AB, AF, would be in this direction and this will be a tensile force.

So the member AB is under a compressive force and member AF is under a tensile force. Let us now calculate these forces. This angle is going to be 45 degrees. Summation FY is equal to 0 gives me FAB over root 2 equals 5000 over 3 or FAB he was 5000 root 2 over 3 newtons. Similarly summation FX equal to 0 gives me FAF to be FAB over root 2 which is equal to 5000 over 3 newtons. So now I have gotten forces onto members of the truss, namely AB and AF.

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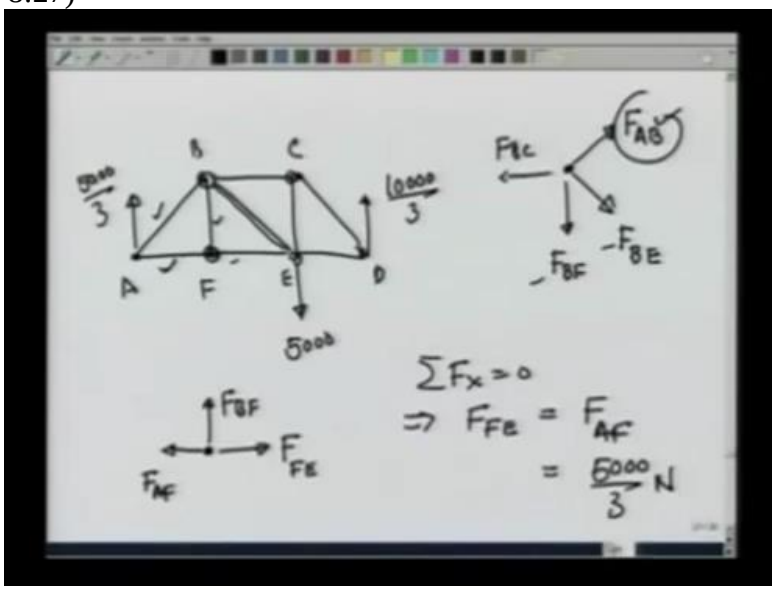

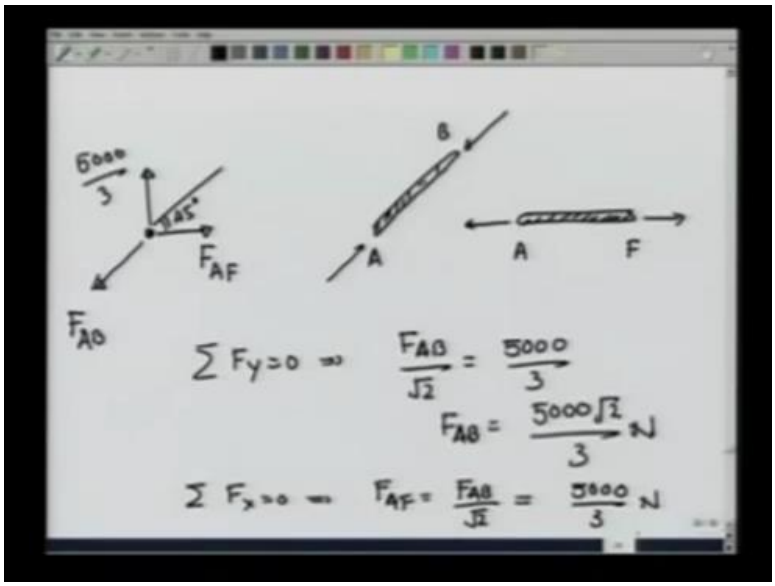

If I make it again, I know the force here, it is 5000 over 3, force here is 10,000 over 3, force here is 5000. I know the force in this member and in this member. Now if I go to point F, A, B, C, D, E or point B I have 2, of the 3 forces I have 1 force which is known. And therefore I can calculate the other 2 forces. Let us go to point B.

The pin at B is under equilibrium due to a force on AB which is compressive, so it pushes the pin in this way. There is a rod like this and there is a force BF. Let us call it FBF. There is a force

FBE and there is a force FBC. Sorry, I said earlier that at point B, I can solve but now, I have one known and 3 unknowns. Equations are only 2. So for point B, I cannot solve.

But certainly point F, I can solve because point F, there is one more force FAF and FAF we had determined it to be a force which is tensile and therefore it pulls the pin at F in this direction. There is a force FFE and there is a force FBF. From summation FX equal to 0, we get that FFE is equal to FAF which is equal to 5000 over 3 newtons.

Let me just check whether this force was really tensile or not. This was tensile. So it pulls the pin in. So summation FY is equal to 0 gives you right away that FBF is equal to 0. The moment I know FBF, I know this force and I know this force. There are only 2 unknowns at point B. I can solve for forces FBE as well as FBC. Let us do that.

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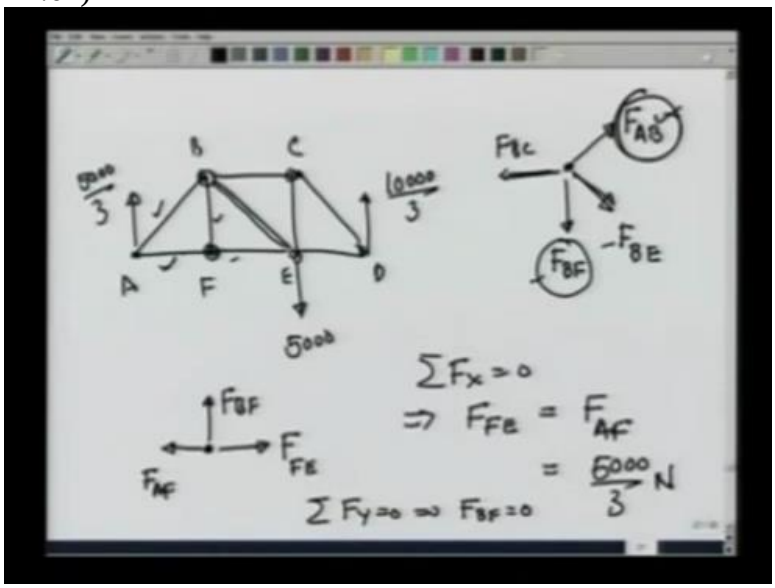

So let us 1st write the forces that we have determined so far. We have determined FAB and FAB was a compressive force, compressive and its magnitude was 5000 root 2 over 3 newtons. We have determined FAF which is tensile which is equal to 5000 over 3 newtons. We have determined FFE which is also tensile and its magnitude is 5000 over 3 newtons. We have determined FBF to be 0. We are now ready to analyse point B. Let us see, point B has a force pushing it this way.

Because FAB is compressive, it pushes by newton's 3rd law, the pin out. There is no force in BF direction. There is a force FBE in this direction and there is a force, let us assume now to balance the force FBC in this direction. These are at 45 degrees each. Right away, you see that this is FAB. Then FBE must be equal to FAB.

This comes from summation FY equal to 0 and therefore FBE and the direction also comes out to be right. It should be equal to 5000 over 3 newtons. The X component FBC balances the X component of FAB as well as FBE and therefore I can write right away that FBC must be twice of the X component of FAB or F this is FAB is 5000 times **2** root 2 newtons. Twice the X component of FAB or FBE. Let us do that now.

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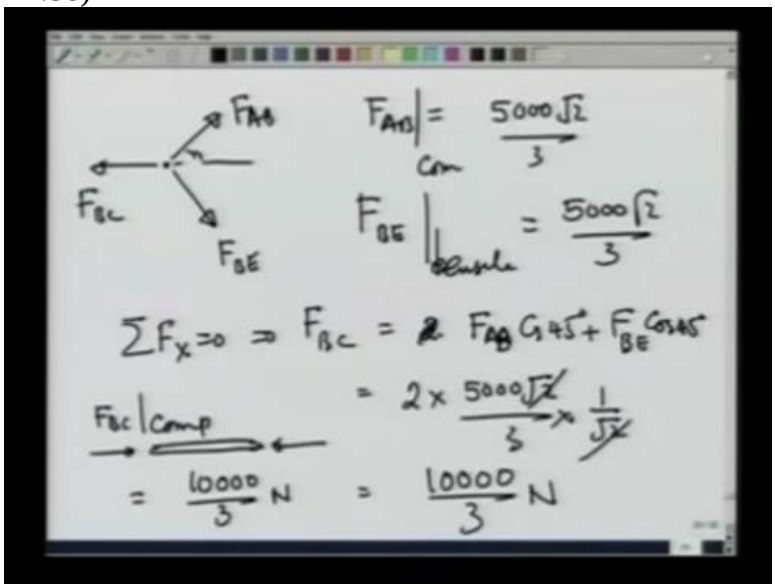

So at point B there is a force FAB working this way, FBE working this way and SBC working this way. FAB is pushing the pin out. So this is compressive. It is 5000 root 2 over 3. FBE we have just determined but FBE just pulls the pin in. Therefore by newton's 3rd law, pin pulls it out, this is tensile but its magnitude is 5000 root 2 over 3. And FBC from summation FX equal to 0 would come out to be 2 times the X component of FAB or FBE, it is the same thing.

So I can write this as actually FAB cosine 45 + FBE cosine of 45 which comes out to be too times 5000 root 2 over 3 times 1 over root 2 which comes out to be 10,000 over 3 newtons. And since the pin is being pushed out, the pin will push the rod in and therefore on the rod the force

FBC is compressive and this is of the magnitude 10,000 over 3 newtons. So now we have found forces.

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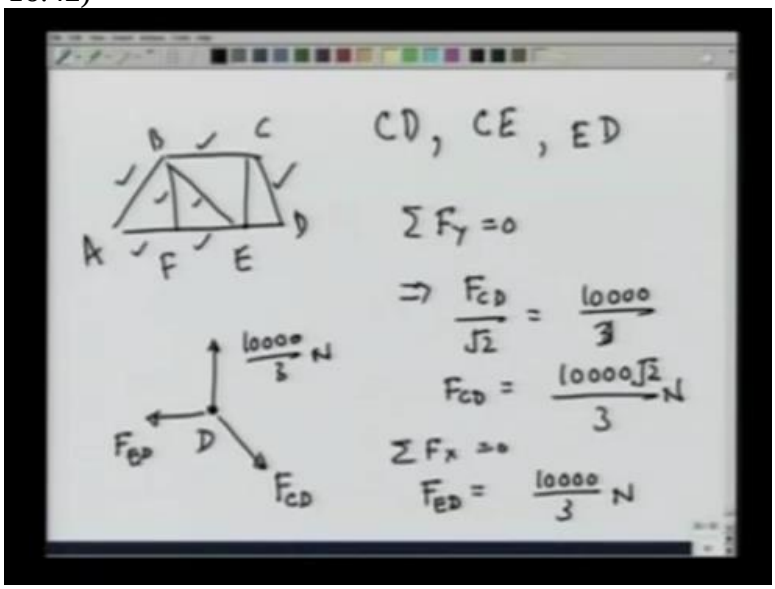

Let us make this truss again. In this member, in this member, in this member, this member, this member, and this member. Only members which are left are A, B, C, D, E, F, the members CD, CE and ED. One can keep going from B onwards to C and D and E or work from D backwards. For example at point D we have already calculated that there is a force of 10,000 over 3 newtons working upwards.

Due to the CD, there will be a force FCD acting this way. This would give an X component and to balance that, I should have a force FED acting this way. So this is point D. Summation FY is equal to 0 gives me that FCD over root 2 should be 10,000 over 3. Or FCD is equal to 10,000 root 2 over 3 newtons. And therefore, again by summation Fx is equal to 0, I will get that FED is makeover to 10,000 over 3 newtons.

So immediately we have found the force in this member as well as this member. The only member now left is FCE.

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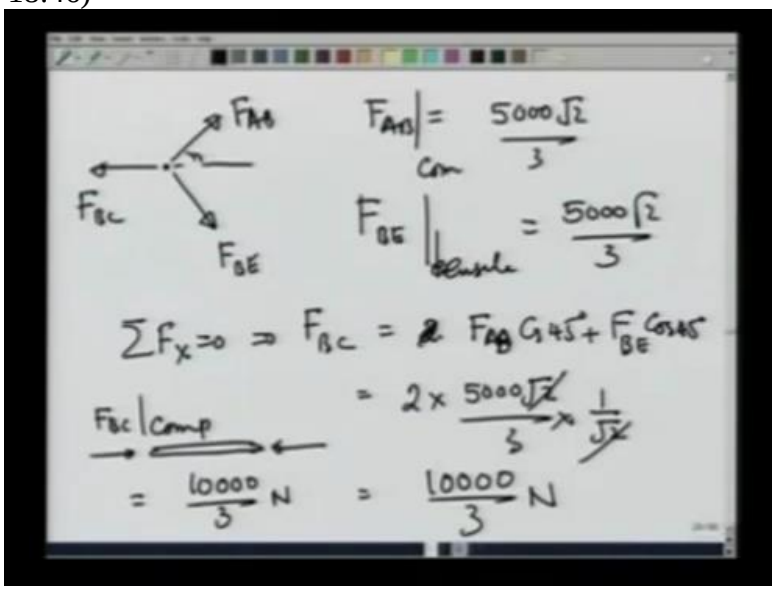

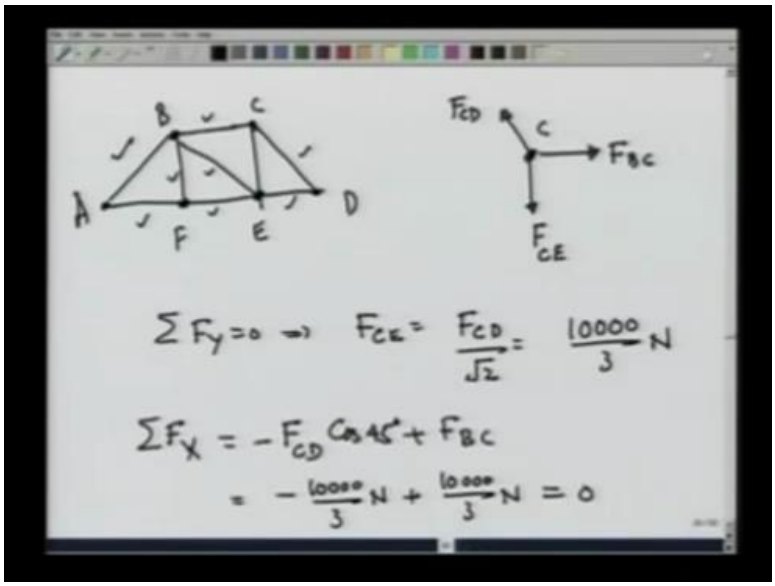

Let us now calculate the force on the member that is now left that is FCE. This we have calculated, this we have calculated, the only member left is FCE. Let me read this again A, B, C, D, E, F. For this, I will take point C which is in equilibrium under the forces of FCD. We have already calculated FCD to be of compressive nature and therefore it pushes C out.

Then there is a force FBC which we have calculated earlier, let me just have a look at that. FBC was calculated to be FBC was to be 10,000 over 3 newtons and it was compressive. So FBC was compressive and therefore it will push point C in this manner. FCE is what we want to calculate

and these are the 3 forces under which the system is in equilibrium. Right away, you can see that summation FY equal to 0 would give me FCE to be equal to FCD over root 2.

And we have already calculated FCD to be 10,000 over 3 times root 2 newtons. And therefore we get this to be 10,000 over 3 newtons. At this point, we can also make a consistency check because at this point, if I have done my calculations correctly, the X component must vanish automatically. And that it does we can see because this is FCD with a negative sign cosine of 45 degrees + FBC. FCD was calculated to be 10,000 over 3 root 2.

So this comes out to be - 10,000 over 3 newtons + FBC was calculated to be, you can see that from the previous slides, FBC was calculated to be 10,000 over 3 newtons. So this comes out to be 10,000 over 3 newtons which is 0. So we are consistent in our calculations. Let us now tabulate all the forces that we have calculated.

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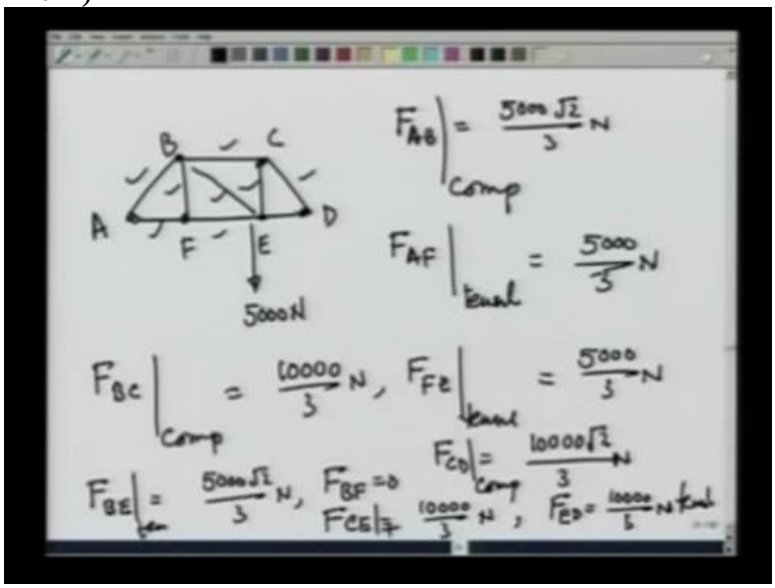

All the forces that we have calculated are A, B, C, D, E, F. When this truss is loaded with a 5000 newton load at point E, FAB which came out to be 5000 root 2 over 3 newtons and this was compressive, then FAF which was tensile and it came out to be 5000 over 3 newtons, then FBC which came out to be compressive and its value was 10,000 over 3 newtons. Then FFE which came out to be tensile again and its value was 5000 over 3 newtons. 1, 2, BC, FE I have done. 1, 2, 3, 4 members.

Then FBE came out to be tensile and its value was 5000 root 2 over 3 newtons. FBF came out to be 0. So we have done BF, we have done BE. FCD came out to be 10,000 root 2 over 3 newtons and this was compressive. FCD we have done. FCE came out to be we just calculated this, 10,000 over 3 newtons tensile and FED came out to be 10,000 over 3 newtons tensile. You can go back and check these answers yourself

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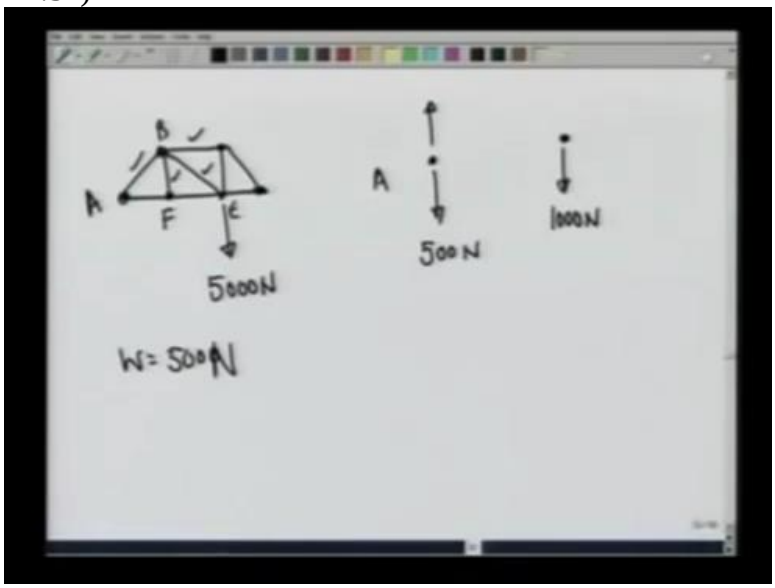

Next question is, what happens if each of these members in addition to this load had weightt themselves. So here is a load of 5000 N and each member let us say had a weight of 500 newtons. In that case, as I remarked earlier, what we would do is divide this way equally at each point. + pin A would carry weight of member AB which is 250 and member AF which is 250 additional weight of 500 newtons, the reaction would change correspondingly.

Point B would carry the weight of AB, BF, BE, and BC. So it will carry an additional weight ease, half of each, so 250 times 4, 1000 newtons in addition to whatever else is being done. I would leave this exercise for you to complete as to how the forces in each member would now change when I put this additional load due to the weight of each member onto these pins.