Design of Steel Structures.
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Lecture-44.
Design of Column Splice due to Shear.

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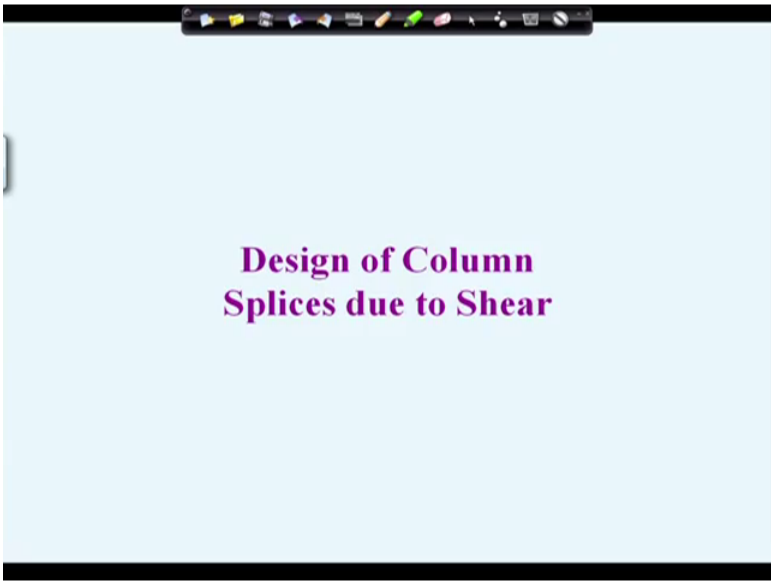

Now I am going to discuss about the design of splice plate due to shear. Today's lecture will be the continuation of previous lecture, in previous lecture we have discussed about the design methodology or design steps for splice plates and a splice plate may undergo due to axial compression then moment and because of moment tension may come and also shear may come into picture. So we have gone through one example and we have shown that how to design the splice plate due to axial compression and moment.

And we have seen that due to axial compression certain compressive force will come into splice plate and due to bending moment also certain amount of force will come into the flange. And because of that we need to design the splice plate because of because of combined action. And the splice plates are designed through the connection through its flange because the bending and compressions are designed in the flange. And shear will be taken care by the weld therefore we will be design a web splice for shear.

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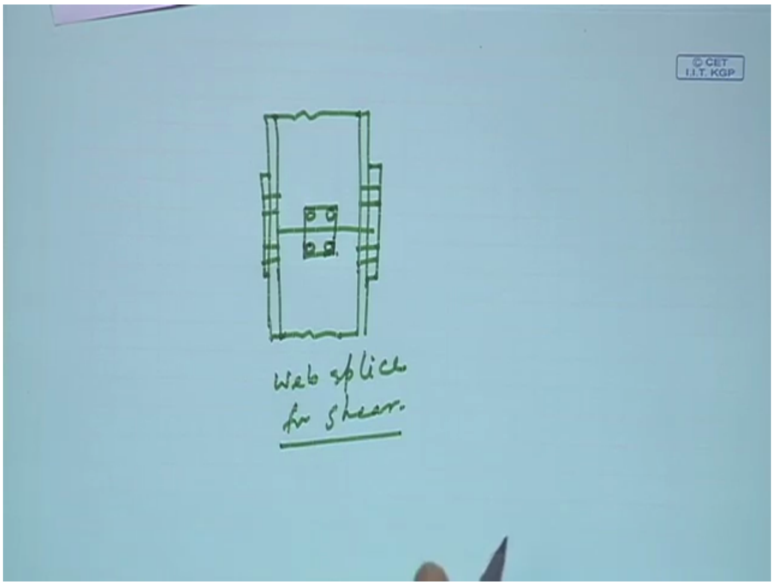

So if we recall the earlier diagram web splice for shear we can see that it is something like this say the columns are spliced by bolt connections, so this is the column flanges which are spliced due to complete bearing. So here we have provided a certain number of bolts to splice them right. So this splice plate can takecare the axial load as well as the moment, but the shear force will be taken by the weld, because we know the shear force is generally taken by the web of the plate.

So in case of web splice for shear we need to provide some plate here right. So now I need to know what will be the dimension of the plate what will be the number of bolt required to join to withstand certain shear force. So this is basically web splice for shear. So I will go through one example and that example is nothing but the previous example which we have discussed in earlier lecture. So first part I will just give a brief summary of that, means whatever we have done in earlier class we just go through that very quickly and then to just remind these dimensions and other things right and then I will design a splice plate on the web.

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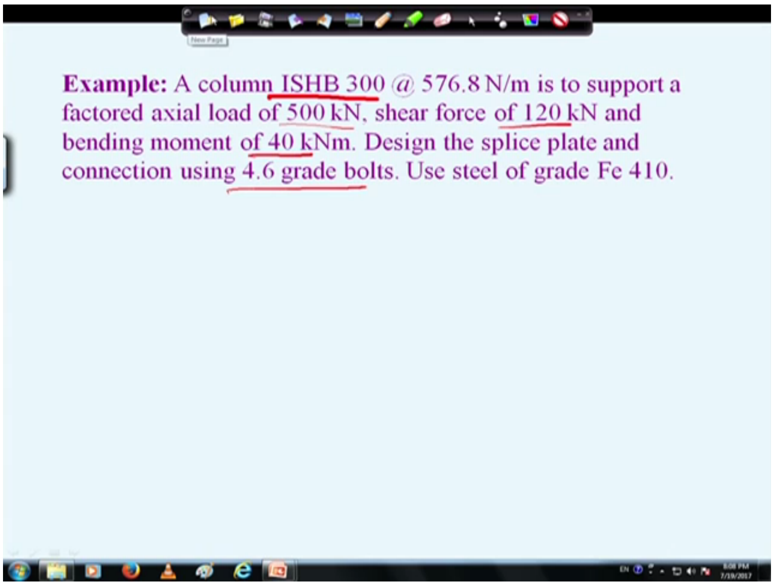

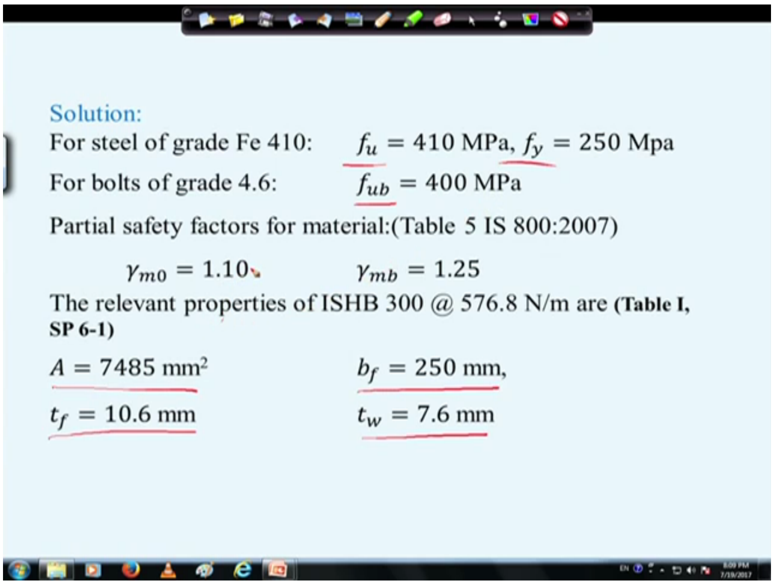

This is the example we can consider which was worked out in last lecture that is the column of ISHB 300 and carrying a load of 500 kilo Newton and shear force of 120 kilo Newton and bending moment of 40 kilo newton and we need to design the splice plate connection using 4.6 grade of bolt right. So for this we have design the splice plate due to bending moment and axial force. And for designing that first what we did we found the cross sectional area, sorry cross sectional area of the column section from table 1 of Sp 6, thickness of the flange, width of the flange and width of the web plate which will be required. And also some material property like fub, fu, fy and their partial safety factors have been noted.

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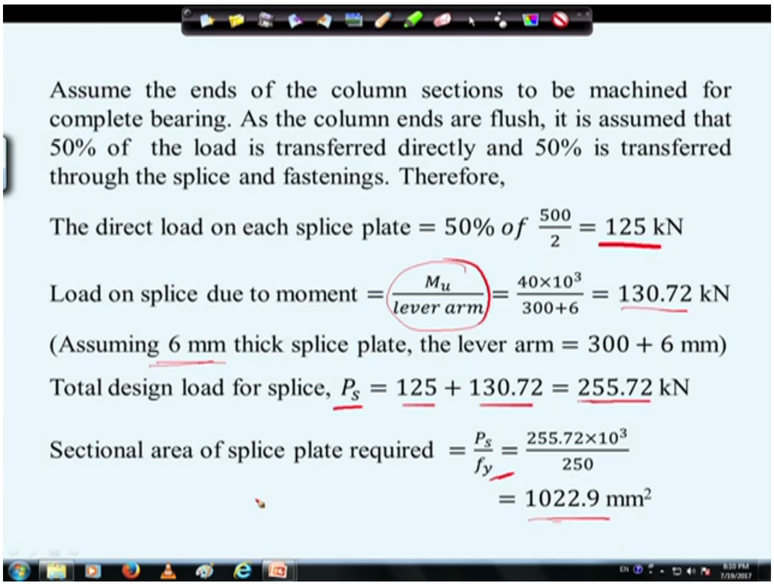

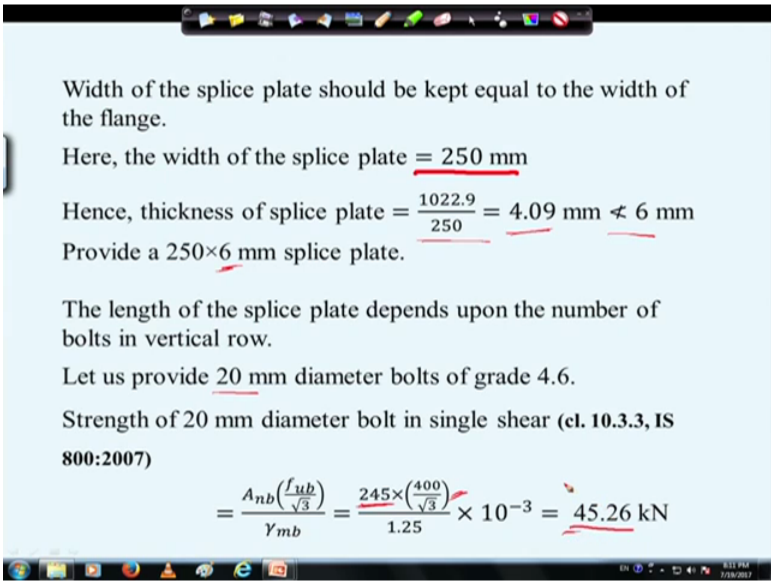

So after that what we did is that we have assumed it as a complete bearing and from that we found the direct force as 125 kilo Newton that is P by 4 basically and the moment Mu by force due to moment as Mu by lever arm and that we found as 130.72 kilo Newton and where we have where we have assumed splice plate thickness as 6 mm. so the design load for splice we could calculate that is Pu1 + Pu2 which is coming 255.72 kilo Newton and from that we can find out the sectional area required which is Ps by fy which is coming 1022.9 millimetre square.

So once we find the sectional area we can find the thickness of the splice plate because the width can be considered as 250 millimetre which is the width of flange so flange width of the member is 250. So that we can consider as the width of splice plate keeping same. So the thickness of the splice plate we can find out simply by cross sectional by width which is coming 4.09 millimetre and it should not be less than 6 mm so we can provide at least 6 mm splice plate.

And also for finding out the number of bolts we have to assume certain diameter of bolts so in this case we have assumed 20 millimetre diameter of bolts and for that we can find out the strength of the bolt due to single shear which is coming 45.26 kilo Newton, where Anb is 244 which is.78584d square and fub is 400 so from this we can find out. So again we can, we need to find out the strength due to bearing.

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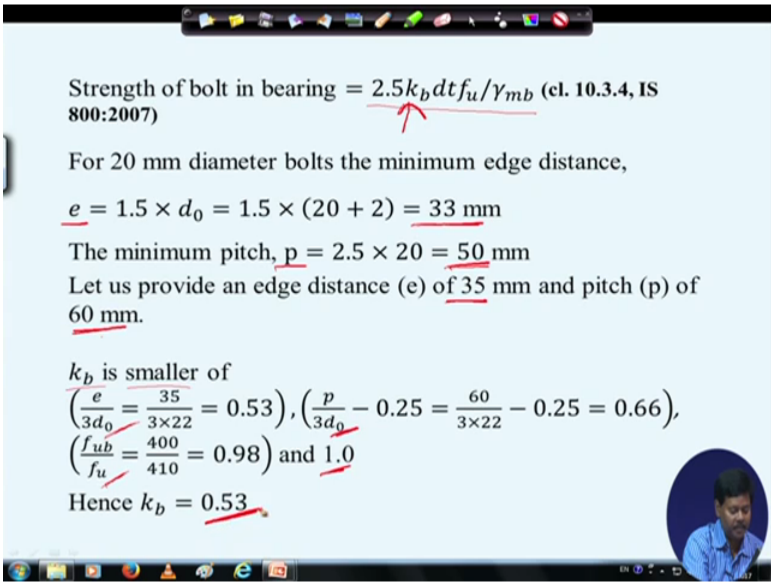

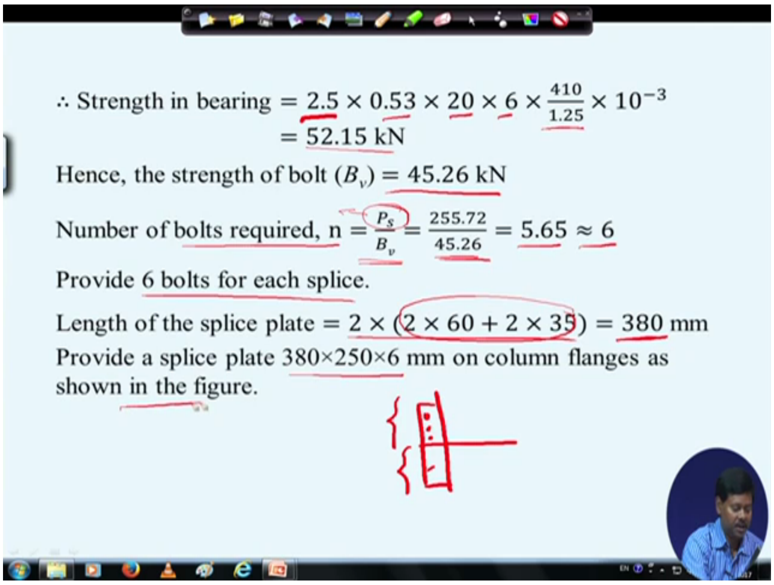

So that also we can find out from this formulae 2.5 kb dt fu by gamma mb, so for that first we have to find out the value of kb and to find out the value of kb we need to know what is the edge distance and what is the pitch distance. So as per the codal provision at least the edge distance has to be 33 and pitch distance has to be 50 and we have provided as 35 mm edge distance and 60 mm pitch distance.

So then we can find out the value of kb which should be smaller of e by 3d0 and P by 3d0 - 0.25 fub by fu and 1. So from this calculation we could see that the value of kb is becoming 0.53 which is the smallest one. So once we find out the value of kb we can find out the strength of bolt in bearing. So strength of bolt in bearing I can find out by providing the necessary values of the parameters like 2.5 kb dt into fu by gamma mb ok.

So from this we can find out the value of strength in bearing as 52.15 kilo Newton. So so strength of the bolt will become the smaller of this two, one is strength in sharing and strength in bearing and smaller of these two we could find as 45.26 kilo Newton. So if the strength of bolt is 45.26 kilo Newton, then the number of bolts required can be found. So that can be found from this formulae that Is the total load in the splice divided by bolt value. Total load within a splice means total compressive load or axial load I should say.

So from this we can find out the value as 5.65 that means 6, so we need to provide 6 number of bolts for each splice. So for each splice if we provide 6 number of bolts that means if we see that 6 number of bolts means 3 number of bolts in this position and 3 number of bolts in this position. So we can provide 3 number of bolts so according to that we can find out the length of the splice plate. So length of the splice plate to accommodate three number of bolts this and then into 2 so 380 millimetre.

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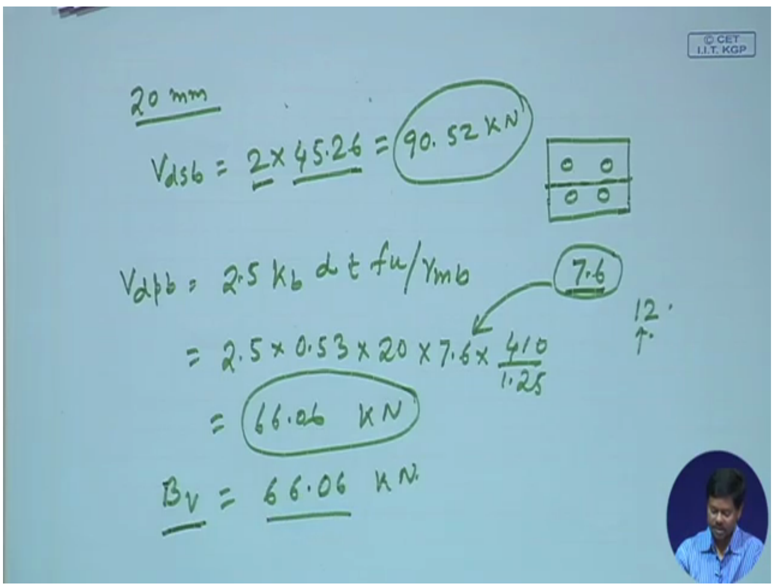

So finally we can provide a splice plate of 380 by 250 by 6 mm on column flange as shown in the figure, figure I will show at the end of this lecture. Now splice plate for shear will see how to find out the splice plate dimension due to shear. So let us calculate step by step for splice plate due to shear. So if we use 20 mm diameter of bolt then the strength of bolt in double shear it will be that means Vdsb double shear will be 2 into 45.26 kilo Newton. This 45.26 kilo newton we have calculated earlier due to strength of bolt due to single shear right.

And here as bolt means plate should be provided in two side of the web right. So if we provide like this so plate will be provided in two sides so it will be double shear. Therefore the strength of bolt will be calculated due to double shear and which would become 90.52 kilo Newton. And similarly strength of bolt due to bearing that we can find out Vdpb. So that also can be found out as 2.5 kb dt fu by gamma mb right. So now kb we have calculated earlier because we are providing same pitch and edge distance.

If we consider same pitch and edge distance then we can provide kb as 0.53 as we calculated earlier d is 20 mm diameter bolt and t is the thickness of the plate. Here thickness of the plate will be the thickness of the smaller plate that means here web thickness is 7.6 right. So the smaller one is 7.6, so 7.6 into 410 by 1.25 right. So that will become 66.06 smaller means here actually, if we provide two splice then its thickness will be total 12 mm and thickness of the web will be 7.6, therefore we can consider the smaller one right, considering 6 mm thickness of splice plate. So we are getting 66.06 kilo Newton as strength in bearing.

So we can find out the strength of 20 mm bolt is becoming lesser of these two strength due shear, double shear and strength due to bearing. So we can find out as 66.06 kilo Newton. So the strength of bolt finally we found as 66.06 kilo Newton.

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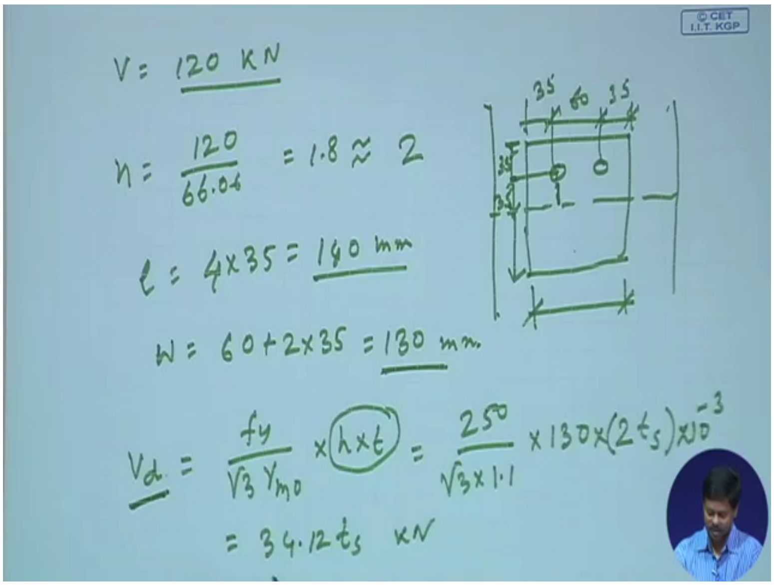

Now the shear force was given as 120 kilo Newton so if the shear force Is this then I can find out number of bolts required will be 120 by 66.06, so 1.8 that means two number of bolts. So two number of bolts if we provide on each side of the splice then we can find out length of the splice plate, so if we draw two number of bolts. So if this is a splice plate and this is the column, this the web of the column and then if we provide two numbers of bolts in each side, then the we can find out length. Length will be this will be 35 because the edge distance is 35, so this is 35 and this is 35.

So total will be 35 into 270 and again 70 right. So finally length will become 4 into 35 so 140 mm so length of the splice plate will become 140 mm. Similarly width I can find out, width will become this will be 60 and this is 35 and this is 35. So finally width will become say W as 60 + 2 into 35, so that is 130 right. So length and width of splice plate can be found as 140 by 130, now I have to find out the design shear strength of the splice plate because I have to see whether the design shear strength of the splice plate can be, the splice plates can take that much shear which is applied externally.

And by equating that means from with design shear strength with the external shear we can find out the thickness of the splice plate. So first we can find out the design shear strength if that is Vd we can write fy by root 3 gamma m0 into h into t where h into t is the area cross sectional. So here if we put the value 250 by root 3 into gamma m0 Is 1.1 into h is 130, so this W we could find out here is 130 and t is a thickness of the splice plate.

So here two splice plates are provided in two side so I can provide 2 into ts, ts is the thickness of the splice plate right so if we make we can find out 34.12 into ts kilo Newton. If we make kilo Newton I have to multiply 10 to the - 3. So Vd the design shear strength can be found as 34.12 into ts where ts is the thickness of the splice plate. So with respect to thickness of the splice plate the design shear strength of the same has been calculated.

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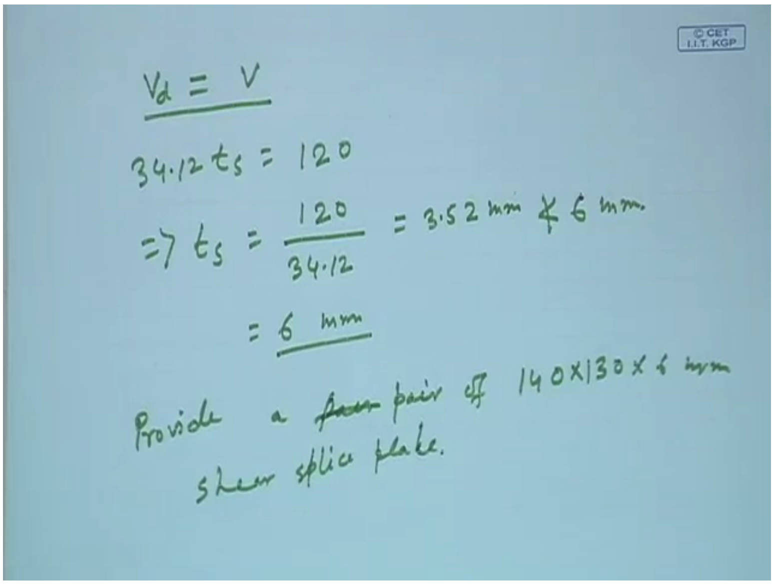

Now we can make equal Vd equal V so that I can find out the value of ts so Vd is 34.12 into ts and Ve was 120 kilo Newton. So from this I can find out the value of ts which is the thickness of splice plate that will be 120 kilo Newton by 34.12. So that is becoming 3.52 millimetre, so it should be should not be less than 6 mm right. So at least we have to provide 6 mm splice plate.

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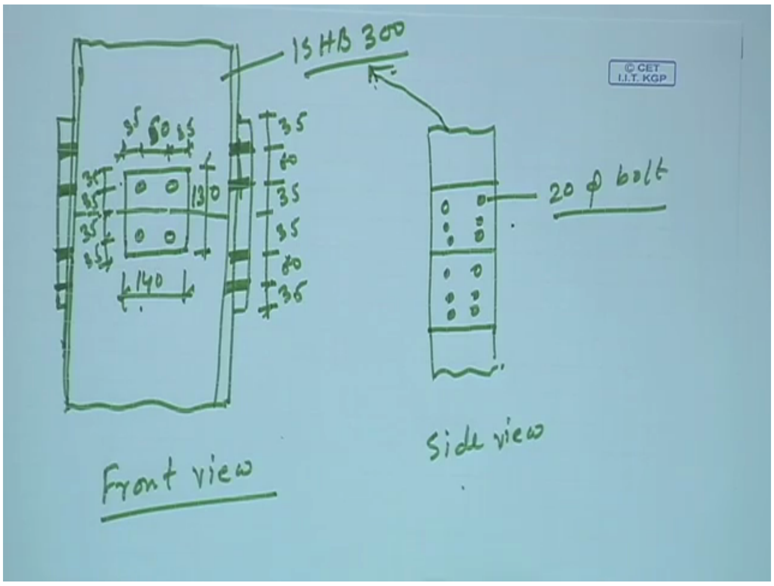

So the we can provide a pair of, a pair of 140 by 130 by 6 mm shear splice plate at each side of the web ok. So now if we draw the total diagram to see the splice plate, splice plate and its weld distribution. Then we can see that in front view it will be like this. Say this is the column, these are two columns are spliced and okay. So front view of the column will be like this and these are spliced at their flange like this so we have provided two number each so this is one bolt, this is another bolt similarly this is one bolt, this is another bolt so total four bolt at each side right at the flange.

This we have done and this is ISHB 300 and the dimension should be like this, if we see, it will be 35 again 60 again 35, 35, 60, 35 right. And also it is spliced in its web, so in the web we can see the splice plate is provided here, whereas total number of four bolts are made and pitch distance was consider as 60 and this is 35, this is 35. And here it will be 35, 35, 35, 35, so that means this should be 140 and this will be 130 right. So size of the spliced plate will 130 in two sides it has been done.

This is front view you can see this and in side view you can see say you can see like this so this is the place where the columns are spliced. So the column and the spliced plates are these and we are providing total six number of bolts in each splice ok. So this is 20 mm diameter of bolt right. This is side view and the column size is this ISHB 300, so this is how we can find out the details of the splice plate right.

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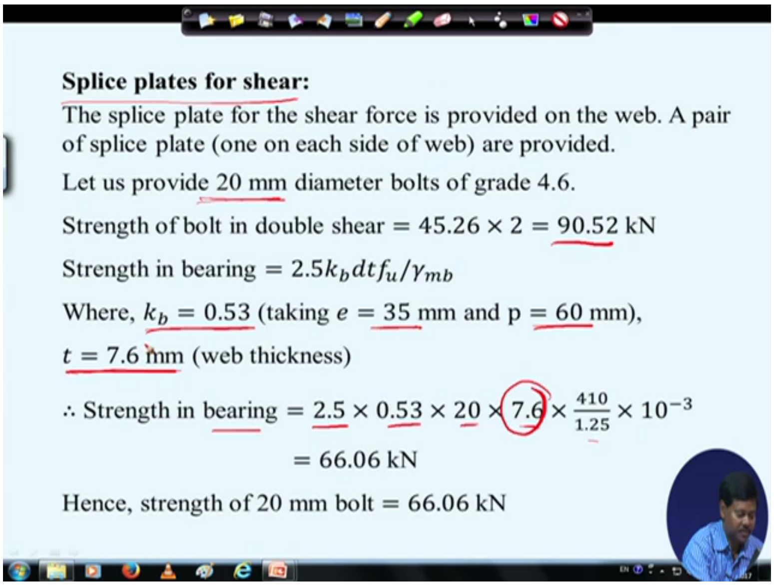

So to go through once again quickly, or just to give an overview of the discussion what we did we can see that first what we did we have found the dimension of the splice plate. So for that first we assume certain diameter of bolt, which we in this case we have consider 20 mm diameter of bolt. And therefore the strength of bolt in double shear we could find out as 90.52 kilo Newton and similarly as kb is found already 0.53 for edge as 35 mm and pitch as 60 mm so we can find out strength in bearing.

So 2.5 kb dt, remember here t is 7.6 mm which is a web thickness. Now in the splice if we consider the splice plate thickness is 6 mm, so in two sides we have provided splice plate in the web so the total thickness will be 12 mm. So we have to consider either 7.6 mm or 12 mm whichever is less so for this we have consider 7.6 and considering that we found the strength in bearing as 66.06 kilo Newton. So the strength of 20 mm bolt is 66.06 kilo Newton.

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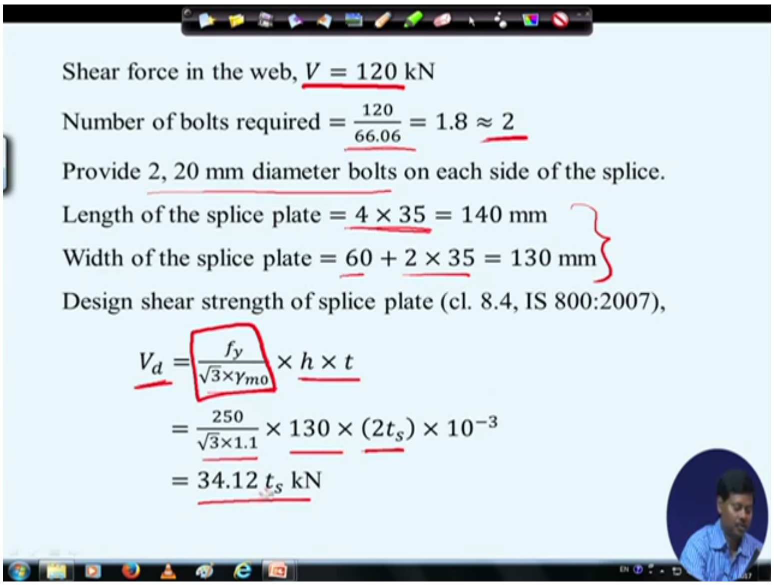

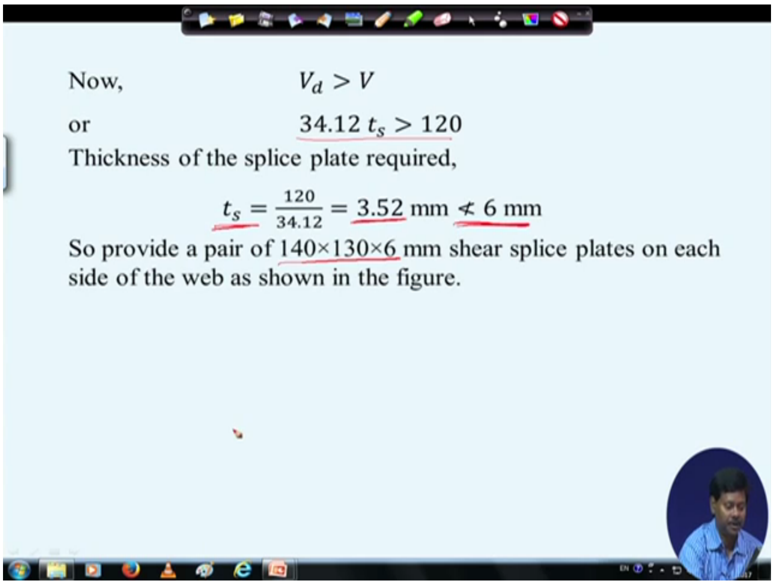

So this is what we found then we can find the number of bolts because the shear force in the web was given as 120 kilo Newton so number of bolts required will be 120 divide by 66, so that is coming two number of bolts. So in each side of the splice we can provide two number of 20 mm diameter bolts right. So the length of the splice plate will become 4 into 35 and the width of the splice plate will become 60 + 2 into 35, that how it has been calculated I shown earlier through that diagram so I am not going into details.

So the splice plate dimension can be fixed as 140 by 130. Now we have to find out the thickness of the splice plate to find the thickness of the splice plate we have to find out the design shear strength. Now design shear strength we can calculate the allowable shear stress of the plate into cross sectional area. Now cross sectional area will be h into t, t is the thickness so here two plates are provided in opposite side in, sorry in both side, so it will be 2 into ts, so if we provide this value, whereas h is equal to 130 then we can find out the design shear strength will be 34.12 kilo Newton.

So this has to be equate with the external shear force acting on the column that is 120 kilo Newton. So if we make equate with this condition then I can find out the thickness of the splice plate should be more than 3.52 millimetre. And in any case it should not be less than 6 mm as per the codal provision. Therefore we can provide 6 mm thickness of the splice plate, so let us provide 140 by 130 by 6 mm shear splice plate on each side of the weld.

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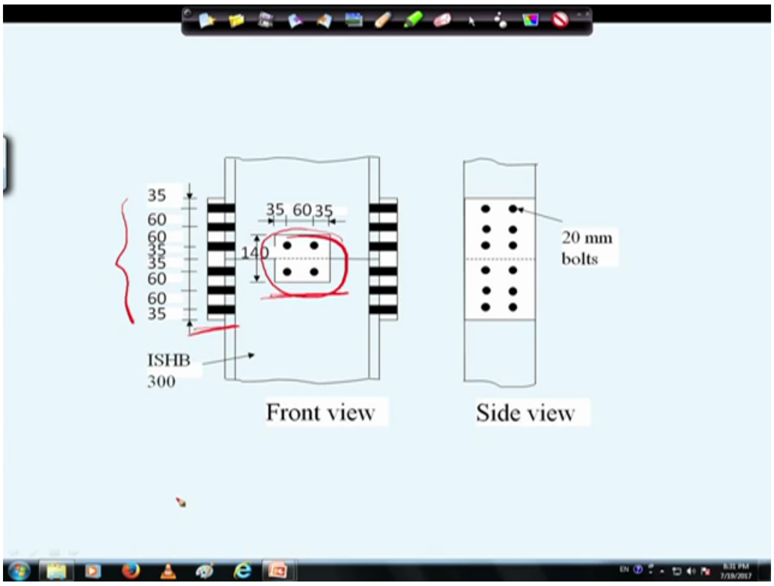

And the details have already be shown which again I am showing here. So here we can see that according to the edge and pitch, we have found the total length of the splice plate in the flange and number of bolts also total 6 in each direction sorry in each side. So this we have distributed and in the web the total number of bolts should be 4 means two in each case and the dimension will be 140 by 130, thickness will be 6 mm. So this is how the detailing had been made.

So in this lecture what we can see this is basically a continuation of the previous lecture in which we have shown how to design the column splice when the column is subjected to not only the axial force but also bending and shear. Now if only axial forces considered then we do not need to provide web splice on the flange should be sufficient for axial and bending, and for shear we have to provide web splice right. So these this through this typical example when three types of forces are acting whereas that means the axial force, bending moment and shear force, then how to design the splice plate considering its connection, connection means if we consider the bolt connections how to find out the number of bolts and how the arrangements should be done, what should be the plate thickness of the splice, those has been demonstrated through that example. So I hope this will be made clear on the design of splice plates. Thank you.