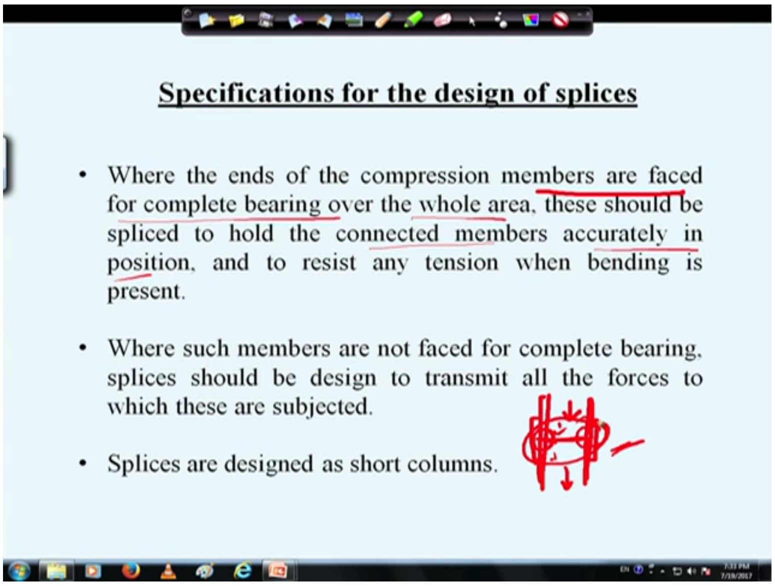
Design of Steel Structures.
Professor Damodar Maity.
Department of Civil Engineering.
Indian Institute of Technology, Kharagpur.
Lecture-43.
Design of Column Splice.

Today we are going to discuss about the column splices and how to design the column splices, those things would be discussed. Basically a joint when provided in the length of member is called splice. When the length of column is more than the available length in such cases we use splice joint. So in many cases we have seen the available length in the market is less than the required length of the column, so in that case we need to joint those together concentrically so that the load is transferred from one section to another section.

So in such cases the column splices are used and also in case of multi storage building where the columns are provided along its height we have seen the columns section, size is required less because the weight of the or force of the building from the column or the load coming to the column across the height is gradually increasing towards the ground.

Therefore we need to accommodate the column section size larger towards the ground level. And as a result we need to change the section size across the height and so that the economic design can be done, in such cases we have to provide splices between two floors to join between two unequal sections. So basically if a compressive member is loaded concentrically we should not provide any splice, means theoretically we do not need to provide any splice but load is never axial and truly it is not axial and real column has to resist the bending due to the eccentricity of the load, therefore we have to provide the splice.

(Refer Slide Time: 2:38)

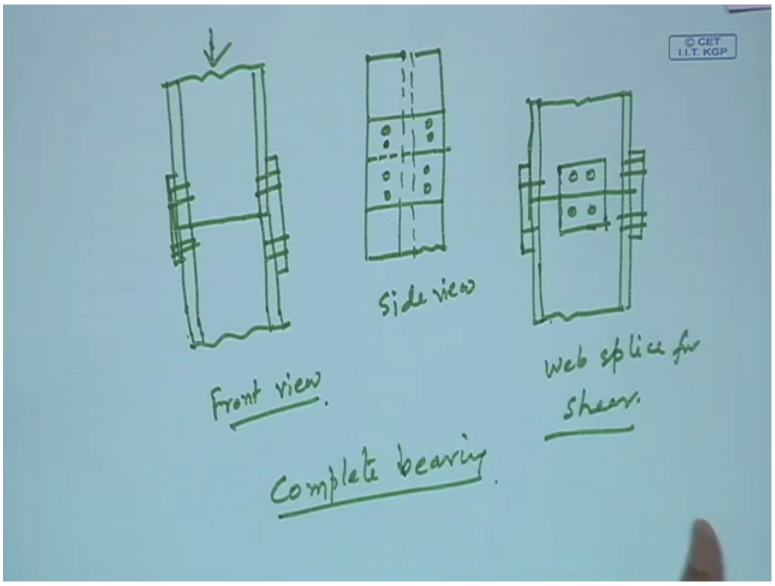


So now if we see the specification for design of splices we can see that when the ends of the compression members are faced for complete bearing over the whole area, these should be spliced to hold the connected members accurately in position and to resist any tension when bending is present. Say for example, if we provide a splice here so we have two column joint here and we are providing using this is a column and these two columns are joined by the spliced, so basically to hold the two members properly we need to connect in the these members through splice. And any tension may happen because of existing or exist of bending so that has to be also taken care.

And when such members are not faced for complete bearing, splices should be designed to transmit all forces to which these are subjected, means sometimes it may be faced complete bearing or it may not be faced complete bearing. In case of complete bearing the whole area, if it is complete bearing under complete bearing then it should be spliced just for to transfer the load from upper storey to lower storey right. And it is spliced is designed just to connect the members accurately in position, so that in position it may stay.

But in case of incomplete bearing we have to transfer the load transfer the load so the splice has to be designed in such a way the load transformation from one storey to another storey are done properly. And splices are basically designed as a short column.

(Refer Slide Time: 4:41)

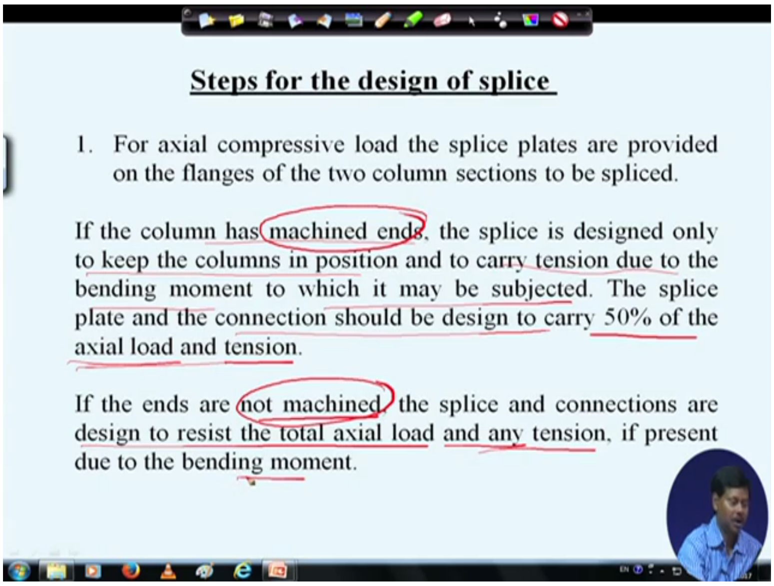


Now if we draw the a column flange having complete bearing we can see the front view if we see separate them to we are providing a I section and it is spliced here, so this is a I section another I section is there. So here if load is concentrically acting then for complete bearing the splice is provided just to hold the columns in position right. So we provide splice in two sides on the flange basically column flange are having complete bearing and the front view would look like this, front view of the column section, so maybe we have to provide certain bolt connection here and bolt connection in this right.

So and if we see the side view, we can see in the side view the columns will look like this, this is a side view. So it is spliced in this position and if it is connected by bolt then maybe we can connect two numbers of bolt at each phase of each splice right. This will be looking as side view and if web has to be spliced for shear, then it should look like this if we splice the web also then it will look like this.

Where, where splice will be provided for shear so if it is spliced at this junction, then we can provide say bolt here at the flange to make a complete bearing, and also at web also we provide we provide splicing to make means to the measure the shear. So this is web splice for shear right. So these are the columns means these are the basically columns flanges having complete bearing, means for complete bearing this is what we can consider, column flange per complete bearing.

(Refer Slide Time: 8:13)

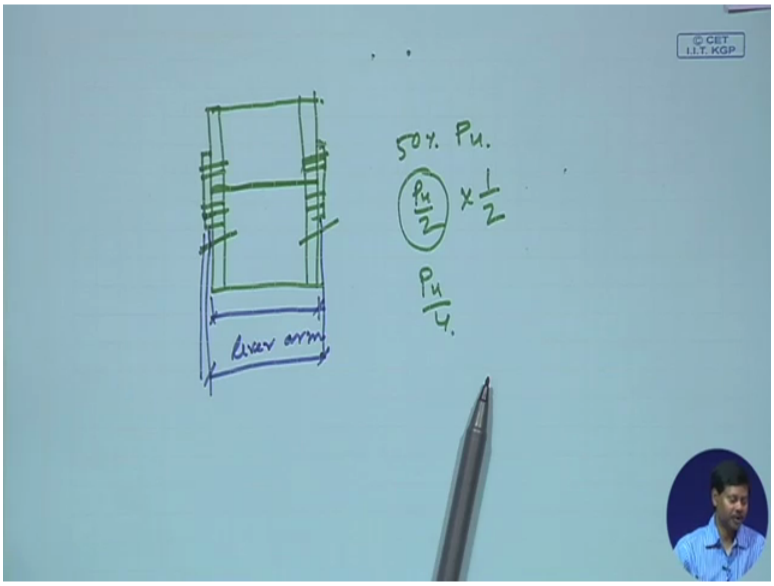


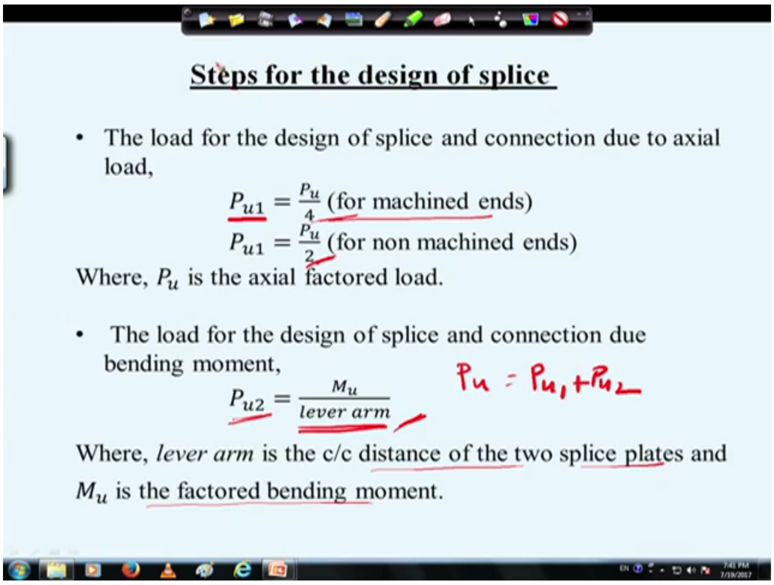
Now let us see what are the steps we need to follow so that we can design the splice properly. So if we see the steps the steps are made based on the column positions and in the means considering the column positions we have made the steps in the following order. Say first so for axial compressive loads the plates are provided on the flange, flange is of the two columns sections to be spliced.

So now if the column has the machined end then the spliced is designed only to keep the columns in position as I told. And to carry tension due to the bending movement to which it may be subjected but the splice plate and the connection should be designed to carry 50 per cent of axial load and tension. So in this case the 50 per cent load will be considered to design the splice to carry axial load and tension. However if the ends are not machined, then the splice and connections are to design to resist the total axial load and any tension if present due to the bending moment.

So there are two cases it may come one is the columns are machined means columns have machined ends, another is not machined ok. In case of machined end we will design the splice plate in such a way that it can carry a 50 per cent of the axial load and if some tension is there that tension, 50 per cent of the axial load and the tension. And if not if the column has no machine ends then we have to design the splice against total axial load and tension if present.

(Refer Slide Time: 10:13)





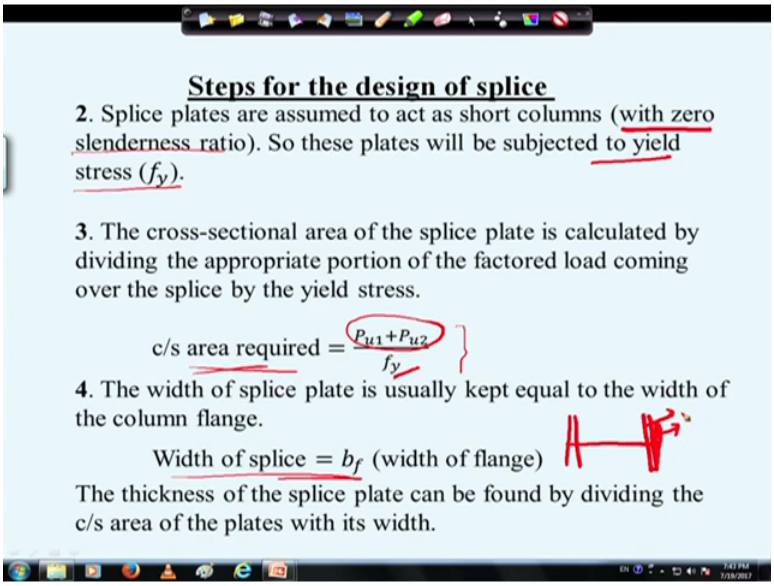
So this is what we have to remember, now how to find out the process. So here we will see the load for design of splice and connection due to axial load we can consider as Pu1 as Pu by 4 for machine end. Why Pu by 4 let us see if we see here design, if columns are spliced at a certain points then we know this has two plate right in two sides, so these are to be connected by the bolts or welds due to certain load.

This load is for complete machine end this load is 50 per cent of the total force. If total force is Pu then 50 per cent of Pu will be Pu by 2 and this Pu by 2 will be divided by 2 flanges in two ends, so it will be finally half of Pu by 2 that means Pu by 4. So the design load due to x sorry design load for splice due to axial load we can consider Pu1 as Pu by 4 and for machine end it will be Pu by 2, because it is 100 per cent it is taking. So total Pu and in two sides so it will be Pu by 2.

And another force may come if moment is present so because of presence of moment the Pu2 we can consider as Mu by lever arm. Lever arm is the centre to centre distance of the two splice plates and Mu is the factor bending moment. So centre to centre distance means, if we consider this is the splicing so this is the total depth + centre of this plate and centre of this plate, so this will be the lever arm right.

So Pu2 the load for design of splice due to moment will become Mu by lever arm where lever arm is the centre to centre distance of the two splice plates right. So then what will do the total Pu will be total Pu on the splice plate will be Pu1 + Pu2. So this is a we will calculate the total force coming on the splice plate.

(Refer Slide Time: 13:12)



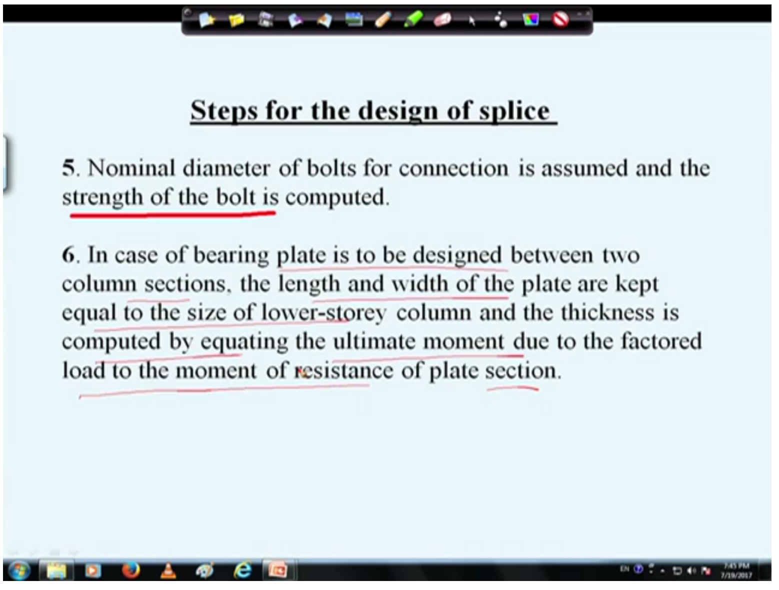
Now in second step what we will do we will find out the means we will consider the splice plates to be a short columns with zero slenderness ratio. So in the caudal position it is told that we can consider splice plate, sorry, we can consider splice plate as a zero length zero slenderness ratio.

So if we consider zero slenderness ratio that means the plates will be subjected to only yield stress, that means the filler will happen due to the yielding of the plates only, so there is no buckling theoretically. So the design consideration also will be done in that way. So if plates are subjected to only yield stress then we can find out the cross sectional area as total Pu which is Pu1 by, Pu1 + Pu2 by fy, where fy is a yield stress of the member. So the cross sectional area of the splice plate we can calculate from this that means dividing the appropriate portion of the factor load coming from the splice plate, Coming over the splice by the yield stress right.

So this is how we can find out the cross sectional area now if we know the cross sectional area then we can find out the width of splice sorry thickness of splice. Thickness of splice will be found because the width of the splice plate will be constant that will be bf, because width of the flange when we are going to use the splice plates to connect the flanges so the flange width of this section and width of the splice plate remain same.

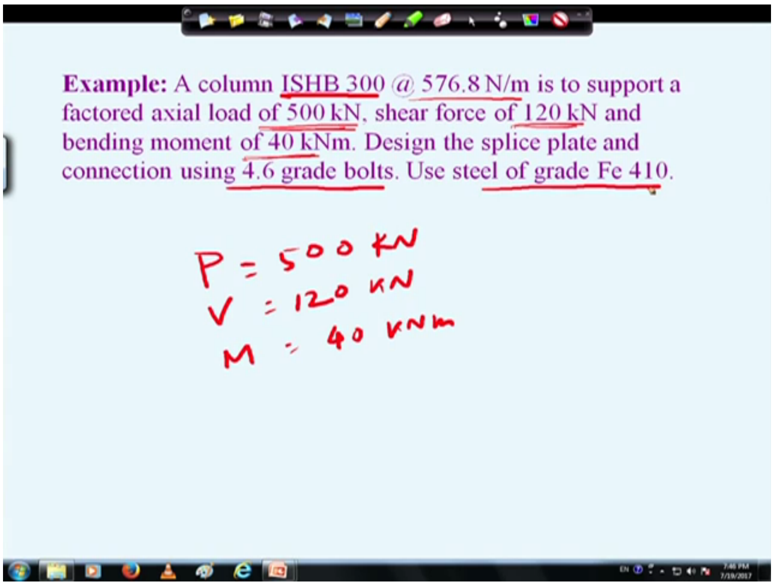
Therefore the thickness of the splice plate can be found by dividing the cross sectional area with its width. That means whatever area is coming area divided by width of flange will be the thickness. So this is how we can find out the thickness of the splice plate.

(Refer Slide Time: 15:28)



Then we can assume certain diameter of bolt for connections or you can assume the weld connections and if we use bolt connections we can find out the strength of the bolt due to shear and due to bearing. So if we know the strength of the bolt then we can find out the number of bolts also. However in case of bearing plate is to be designed between two columns sections the length and width of the plate are kept equal to size of lower storey column and the thickness is computed by equating the ultimate moment due to the factor load of the moment, factor load to the moment of resistance of plate section.

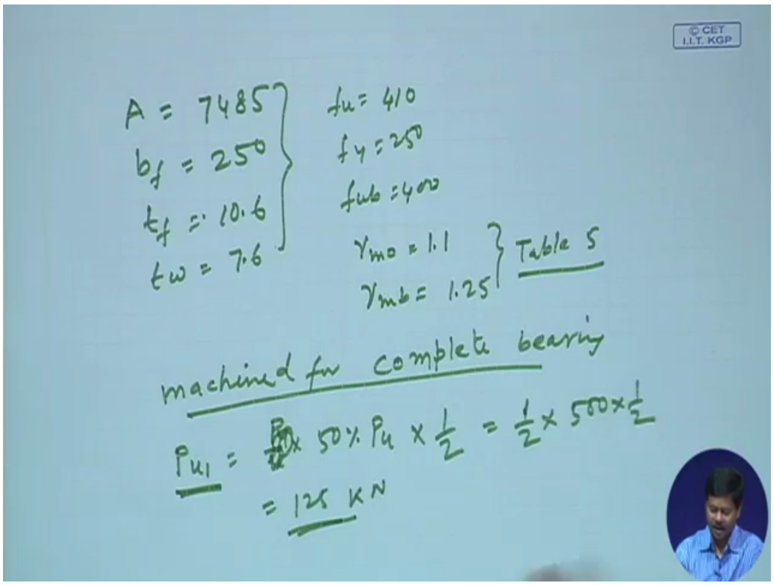
(Refer Slide Time: 16:32)



So in case of bearing plate if it is to be designed between two column sections then we have to consider these aspects. So these are the steps which we need to remember. Now following the steps we will go through this example and we will be able to understand how to design a splice ok. So the example is like this a column of ISHB 300 at 576.8 Newton per metre is to support a factor load of 500 kilo Newton. So Pu that P total factor load is 500 kilo Newton and shear force 120 kilo Newton and bending moment 40 kilo Newton.

So three type of forces are there right factor load P is 500 kilo Newton and shear force is given 120 kilo Newton and bending moment is coming 40 kilo Newton metre. Now design the splice plate connection using 4.6 grade bolts and let us use steel of grade as Fe 410. So if we use this this data then we will see how to design the splice, splice plate ok, due to this axial load and shear force and bending moment.

(Refer Slide Time: 17:58)

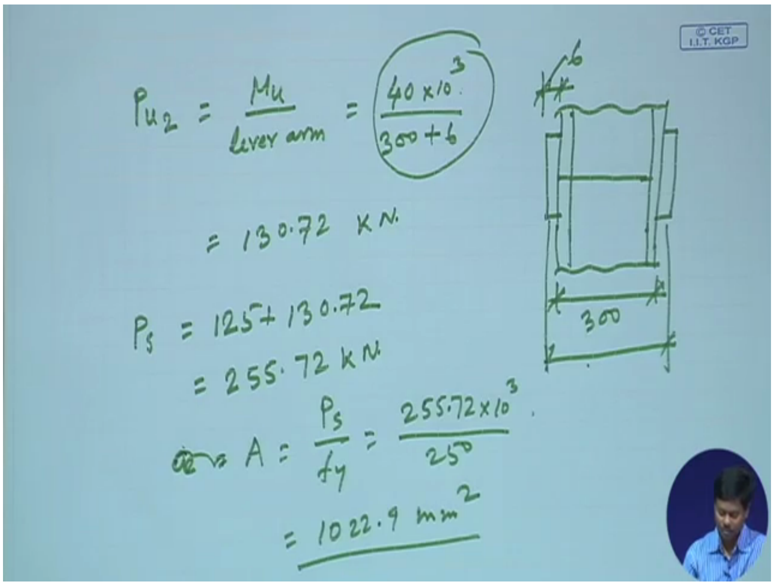


Now for this ISHB 300 we know few things like the cross sectional area of the ISHB 300 will become 7485 this is required we need to know now flange width of the ISHB 300 is 250 and thickness of the flange 10.6 millimetre and thickness of the weld is 7.6 millimetre right. So these are the things which we can found we can find from Sp 6 from the table we can find. And also we know for Fe 410 grade of bolt Fe we know this data also will be required for designing, Fu, fy is 250 and for 4.6 grade of bolt fub will be 400.

And partial safety factor like gamma m0 which will be used that is 1.1 and gamma mb is 1.25 from table 5 we can find out this partial safety factor table 5 of IS800 2007, so these are the some data which will be used for calculation of the design details right. Now if we consider the 50 per cent means column sections are machined for complete bearing so maybe we can assume machine for complete bearing, then we can consider that 50 per cent of the load will come into splice right.

So if 50 per cent of the load comes into splice that means it will be the Pu1 will be Pu, sorry Pu 50 per cent of Pu and half of that will come to each splice, that means 50 per cent means half of 500 into half. So this is becoming 125 kilo Newton. So direct load on each splice I can find out as under 25 kilo Newton. Now again as moment is present so I have to find out load of splice due to moment.

(Refer Slide Time: 20:22)

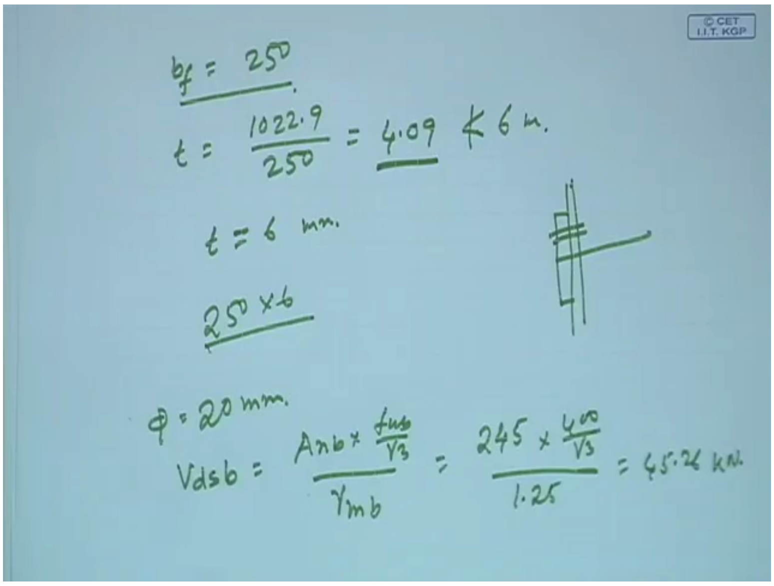


Load on splice due to moment which is we can say as Pu2 that will be Mu by lever arm. So we have to find out lever arm right so Mu is given which is 40 into 10 to power 3 Mu was given 40 kilo Newton metre, so 40 kilo Newton into 10 to the 3 to make it kilo Newton millimetre by lever arm, lever means 300 is the depth of the I section + 6 mm is the plate thickness. If we assume plate thickness, splice plate thickness as 6 then we can consider 6.

Now let us see in the diagram that how we have considered the lever arm so these are the this is the column which needs to be spliced, so this is say this is a plate. Now this column depth is 300 and this is assumed as 6 mm thick splice plate. So lever arm will be centre to centre distance of plate, so this will be 300 + 6 by 2 + 6 by 2. So I can find out Pu2 like this ok. So that is becoming 130.72 kilo Newton so total Pu which we can say as total design load for splice Ps as Pu1 is 125 and Pu2 as 130.72.

So this value is coming 255.72 kilo Newton. So the sectional area I can find out the sectional area required sorry A, so it will be Ps by fy so it will be 255.72 into 10 cube by fy is 250 so this is becoming 1022.9 millimetre square. So cross sectional area of the splice plate is 100, 1022.9 right.

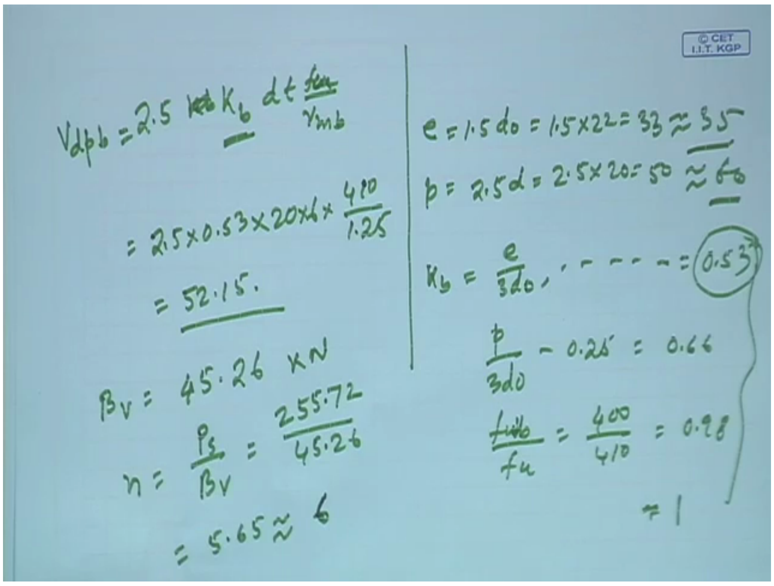
(Refer Slide Time: 23:15)



Now if we consider the width of the splice plate at the flange width then we can consider flange width as the 250 right. So thickness so the splice plate I can find out as 1022.9 this is the total cross sectional area by 250 is the width of the splice. So this is becoming 4.09 and in any case it has to be means it should not be less than 6 mm, it should not be less than 6 mm. so I can provide the splice plate thickness as 6 mm so t is equal to 6 mm right. So if t is equal to 6 mm then I can I can make the splice plate dimension as 250 by 6 so provide 250 by 6 mm splice plate.

Now once we get this now we can find out the number of bolts required on the splice plate, because we have to join the splice plate with the column with certain number of bolts right. So if we provide certain number of bolts when we need to know what is the strength of the bolt. So as we are using 20 mm diameter of bolt so I can find out the shear strength of bolt Vdsb will be say Anb into fub by root 3 by gamma mb. So that will become say 245 into 400 by root 3 by 1.25, so this is coming 45.26 kilo Newton right.

(Refer Slide Time: 25:31)

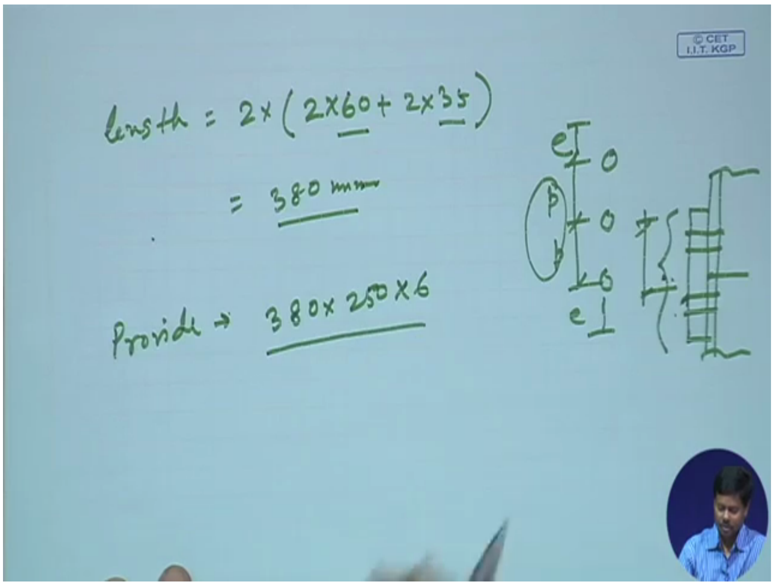


So the design shear strength of the 20 mm diameter of bolt are calculated as 45.26 kilo Newton. Similarly I can find out the strength due to bearing so bolt in strength of bolt in bearing will be 2.5 kb kb dt into fu by gamma mb. So now I need to know kb value, for finding kb value I have to know what is the e and p that means edge distance and pitch distance. Edge distance I can provide as 1.5 into d0 so that will be 1.5.22 which are coming 33 so I can provide say 35. And similarly pitch distance is 2.5 into d so 2.5 into 20 equal to 50 so let us use 60.

So if we use edge as 35 mm and pitch as 60 mm then I can find out kb value as e by 3d0 like this I can put the all the value e by 3d0 which will become 0.53, then P by 3d0 -.25 so this will become 0.66 fub by fu, it will become 400 by 410, 0.98 and 1. So the lesser of this value will be the kb value so lesser of this four will be 0.53. So if I put the value to find out the strength of bolt in bearing Vdpb, so this will become 2.5 into kb is.53 into d is 20 thickness is 6 and fu is 410 by 1.25, so this is becoming 52.15.

That means the strength due to bearing is coming 52.15 and we have calculated earlier strain due to shear as 45.26 so strength of bolt will be minimum this two that means the bolt value I can find out minimum of this two as 45.26 kilo Newton. So the number of bolt I can find out number of bolt will be the total load coming on the splice Ps by Bv, that will be 255.72 by 45.26. So this is coming 5.65 which is 6 mm right. So we can provide 6 number of bolts for each splice.

(Refer Slide Time: 28:24)



So if we provide 6 number of bolts then we can find out the length of splice plate, so length will be if we provide 6 number of bolts that means it will be 2 into pitch is we have considered 2 into 60 + 2 into 35 right. So because total number of bolts are 6 right, so if we consider say 3 bolts here, then this is P and then edge, then edge. So 2P + 2e ok into 2 because we are providing splice plate like this, if it is spliced here, if this is a column, if this is spliced then total length will be twice of this length.

So this is coming as 380 mm. So with the pitch of 60 mm and edge of 35 mm the length of splice plate we are getting 380 mm. so we can provide a splice plate finally as 380 by 250 width we have considered earlier and 6 mm we have calculated the thickness. So this will be like this right. Now we have to provide so this are the splice plate due to the axial load and bending. And we have to also find out splice plate for shear because it is under shear also, spliced plate for shear right.

So this splice plate for shear will be discussed in next class because time is over, we cannot continue more so in next class I will continue and we shall discuss about the design of splice plate for shear. Thank You.