Course on Design of Steel Structures
Professor Damodar Maity
Department of Civil Engineering
Indian Institute of Technology Kharagpur
Lecture 28
Module 6
Splices in Tension Members

Now I am going to discuss about splices splices with respect to tension member, in fact splices are used if the available length is less than the required length of a tension member. When the single pitch of tension member of requisite length is not available then we may have to connect with with same means with another pitch of member with the use of splices.

So different type of tension members we have, so when we are joining those tensions member with the use of splices we may face different type of problem like if we do not join means in two sides properly then eccentricity of the joint will come into picture and because of eccentricity moment will come into picture.

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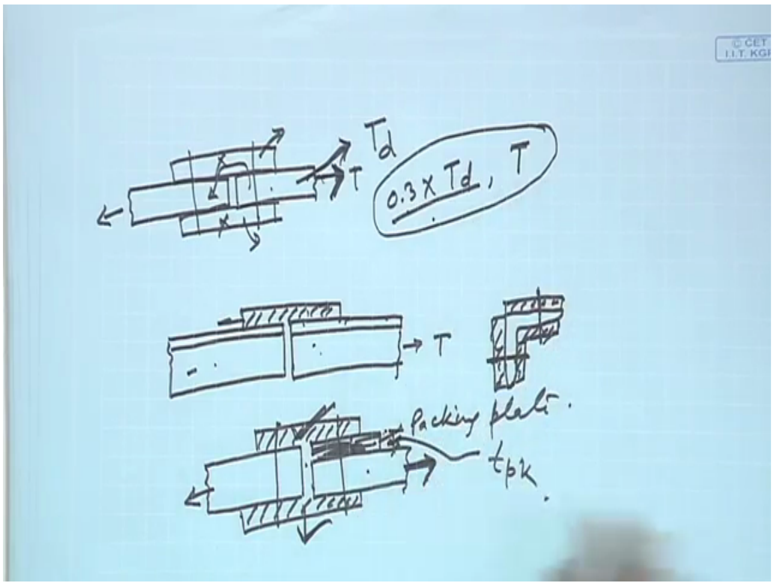

So we have to design the splices as much as possible means in such a way that there is means no eccentricity is developed, say for example if we consider a member say we need to join this member with another member, right. So if we want to join these two members, now if I provide a splice here, then it will not be symmetric this joint will not be symmetric. So transfer of the load through splice to another member will not be done properly means eccentricity will develop.

So to avoid that we always try to provide another splice in this direction, so that the symmetricity is mentioned is maintained this is what we need to do. However this is a problem when we have one say for example one angle is to be joint with another angle, right. Say for this has to be joint the requisite length of the angle section was not available so two angle sections are joint with same size.

So if we joint this with these splices then in this way if we join then we know this is T, so here the T force has to be transfer here, right. So if we have unsymmetrical joint like this then the forces will develop here and because of that eccentricity will come into picture, so we have to keep in mind that means we have to keep in mind that eccentricity does not take place that how can we do, say for this angle section say angle is like this right so if we see.

Now we can join a splice here, right and we can join a splice here in two section, right and to make concentric of the system what we can do we can join another splice here and we can join another splice here. So this is the way if we do then the problem can be avoided. So while making splice design we have to try to make joining in such a way that eccentricity does not occur.

Another case happen that say for example a member with different size that means thickness are different are joint. So in such cases what we can do we can make a splice in this phase but here when we are going to provide we have to provide a packing plate this is called packing plate. So we have to provide a packing plate to make the gap means to fill up the gap and then we can provide a splice like this. So this packing plate this is packing plate has to be introduced.

So then I can join this by bolt connection or rivet connection whatever we feel, right. So in this way one can design the splices. Now for designing splices different options will come like if packing plate is more than 6 mm then we have to we have to introduce bolt here extra and if it is not then we may we may we may not consider that and also we have to consider the reduction factor if a packing plate thickness is more than reduction factor has to be introduced that I will come into means that I will come to that slide now.

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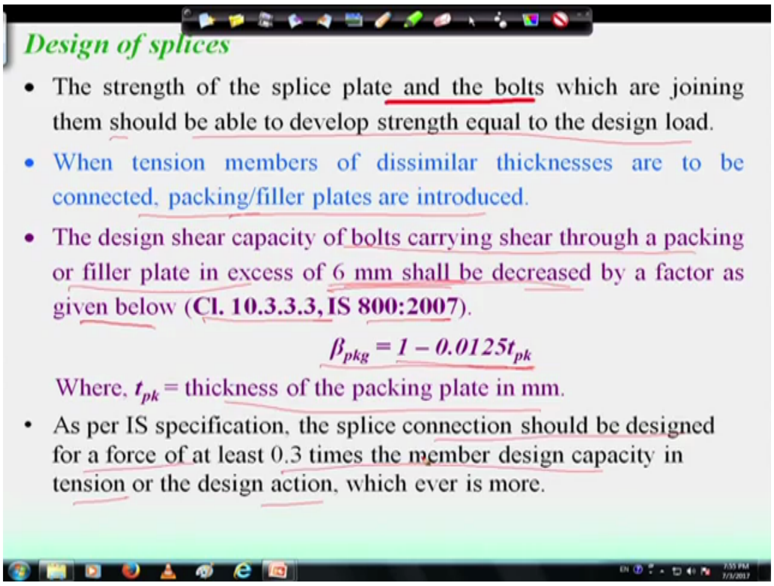

Say for this case, so what I was discussing let me tell in short once again that the strength of splice plate and the bolt which are joining them should be able to develop strength equal to design load. That means the strength of the plate whatever we are joining so should be same equal to the strength of this plate and this plate, right. So strength of plate should be equal to the splice so that the load are transfer from one plate to another plate.

Then when tension members of dissimilar thickness are to be connected, packing or filler plates are introduced what I discussed earlier that if thickness are different then we have to use packing plate or filler plate. Now the design shear capacity of bolts carrying shear through a packing or filler plate in excess of 6 mm shall be decreased by a factor as given below that is beta pkg is equal to (1 point) 1 minus 0.0125tpk, where tpk is the thickness of the packing plate.

Thickness of the packing plate means this one if we see here this is the thickness of the packing plate tpk. So this this is given in the clause 10.3.3.3 of IS 800:2007 that means the reduction factor beta pkg can be calculated from this 1 minus 0.0125tpk and this will be calculated if the packing plate thickness is more than 6, then this factor will be used to decrease the strength.

And as per IS specification, the splice connection should be designed for a force of atleast 0.3 times the member design capacity in tension or design action whichever is more.

That means if I draw once again no it is here so if the say for example if this tension capacity of this plate is T Td then this plate should be able to carry 0.3 percent means 0.3 times Td, these two splice should be able to carry atleast 0.3 Td or the force whatever is coming that one that means whichever is greater. So design has to be done on the basis of the greater value of the force acting on the member or 0.3 into the design strength of the member whichever is greater. So in this way we have to consider and we have to design.

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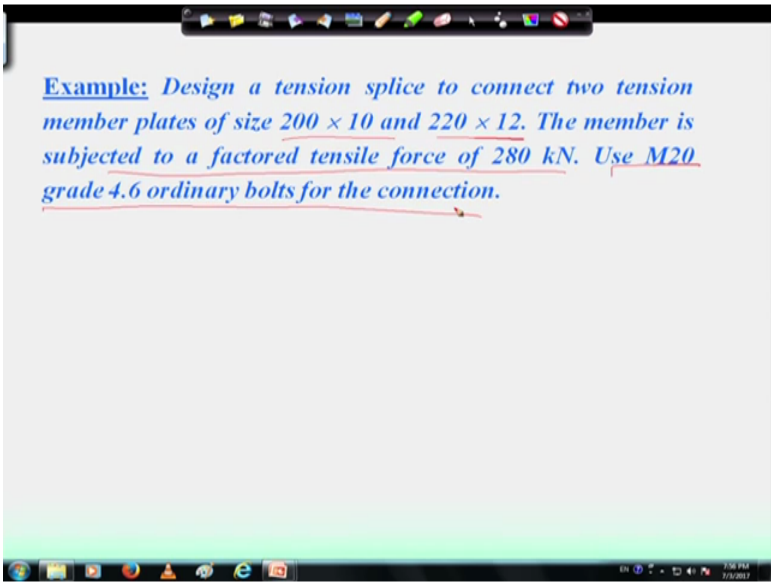

Now with this we would like to go through one example so that the things can be clear. Here example is that the design a tension splice to connect two tension members of plate of size 200 by 10 and 220 by 12. The member is subjected to a factor tensile force of 280 kilonewton. Now use M20 grade of 4.6 ordinary bolt for the connection.

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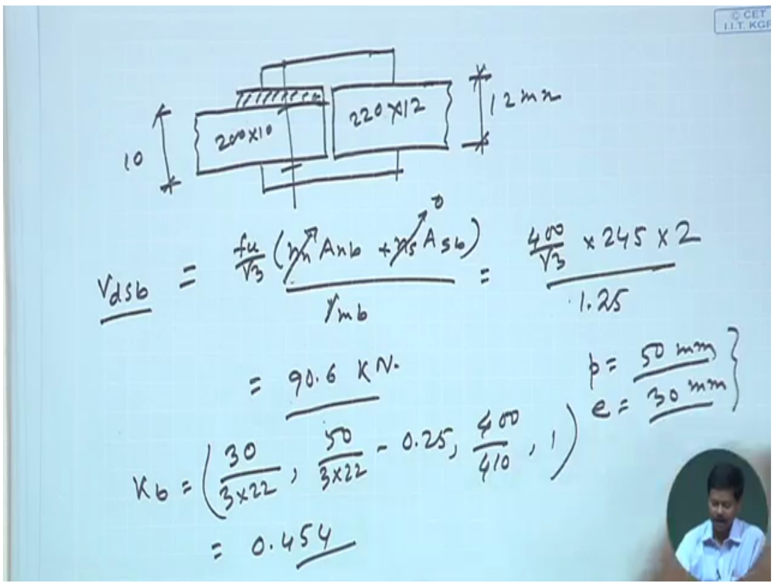

So if we drawing the figure it would be like this say this is 200 by 10 200 by 10 and another is 220 by 12 that means this thickness is 12 mm and this thickness is 10 mm and we need to design splice this tension splice where the 20 mm diameter of bolt is used. So here we can provide a splice and here we have to provide certain filler material for packing, right then we can provide a splice here.

So for this first we have to know what is the bolt value. Now in this case we know the bolt value will be in shear and bearing, so first we can find out Vdsb that is the bolt value of bolt value due to shearing Vdsb that will be fu by root 3 into nn Anb plus ns (Ans) Asb by gamma mb. Now considering number of shear plane passing through shank as 0, that means all numbers are passing through thread so here it will be in double shear because we have two side tension splice, so it will be double shear, right.

So we can find out the bolt value as 400 by root 3 into 245 into 2 by gamma mb 1.25, so this will become 90.6 kilonewton. So shearing strength of the bolt is coming 90.6 kilonewton. Now bearing strength also we have to find out for bearing strength we have to find out Kb Kb we can find out if we as we are using 20 mm diameter of bolts so pitch we can provide 2.5d that is 50 mm and and A is 1.5d that is 30 mm, minimum pitch and edge however we can increase the pitch and edge distance as well however for this case we are considering this. So if we consider this then it will be e by 3d0, then p by 3d0 minus 0.25, then fub by fu and then 1. So minimum of these four that is becoming 0.454, right 0.454. So Kb value once we find we can find out the Vdpb value that is bearing strength of bolts.

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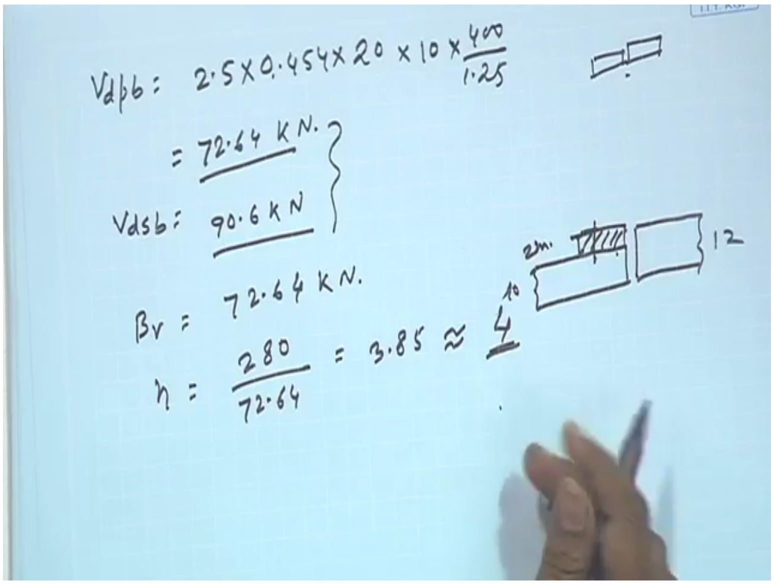

Now bearing strength of bolt will become Vdpb is equal to 2.5 Kb Kb is 0.454 Kb d d is 20 mm. Now thickness thickness is the one thickness was 10 mm, one plate thickness 10 mm, another plate thickness was 12 mm. So thickness of the thinner one we will consider, so this will be 10 into 400 by 1.25, so this is becoming 72.64 kilonewton. So in shearing we got Vdsb as 90.6 kilonewton and in bearing we get 72.64 kilonewton. So bolt value we can find out the minimum of these two as 72.64 kilonewton.

So number of bolts required we can find out that is the force the tensile force was 280 kilonewton by 72.64, so 3.85 that means 4 number of bolts are required and also packing plate thickness we can calculate because two plates are having different thickness this is 12 mm and this is 10 mm, so 2 mm plate thickness will be required, right 2 mm thickness for packing will be required, this is packing plate and as thickness is less than 6, so no additional bolt is necessary to connect these two, if it is more than 6 mm then we have to connect with additional bolt but for this case it is not required.

So 4 number of bolts will be required because we got 4 here, so 4 number of bolts we can provide in such a way that it adjust the pitch and edge distance.

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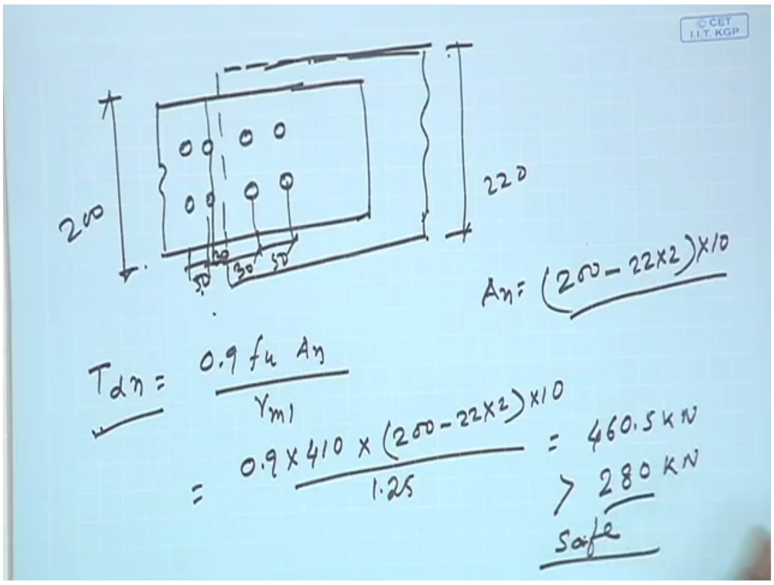

So that can be made in this way that is if I see in the plan, this is 200 by 10 and this is this is 220 by 12, this is 220 and this is 200. So if I use 2 bolts in each row then I can find out like this, right. So with a distance of this distance we are considering as 50 mm and this distance we are considering as 30 mm. Similarly this is 30, this is 50, like this I can consider, right.

Now I have to find out the strength at critical section, so so that the section is safe. So strength of main plate at critical section I can find out as Tdn is equal to 0.9 fu An by gamma m1. Now here An will be the net area along the critical section that will be 200 if I consider this as critical section then 200 minus 22 into 2 into thickness is 10 mm. So An I can consider as this, right.

So if I put the value of An here I can get the value of Tdn, this will be 200 minus 22 into 2 into 10 by gamma m1 that is 1.25. So this is becoming 460.5 kilonewton and that is greater than the external force 280 kilonewton, so it is safe that means the bolt combination whatever we have proposed is safe, right and now we have to find out the Tdg value means from net section of critical section we can find that this section is safe.

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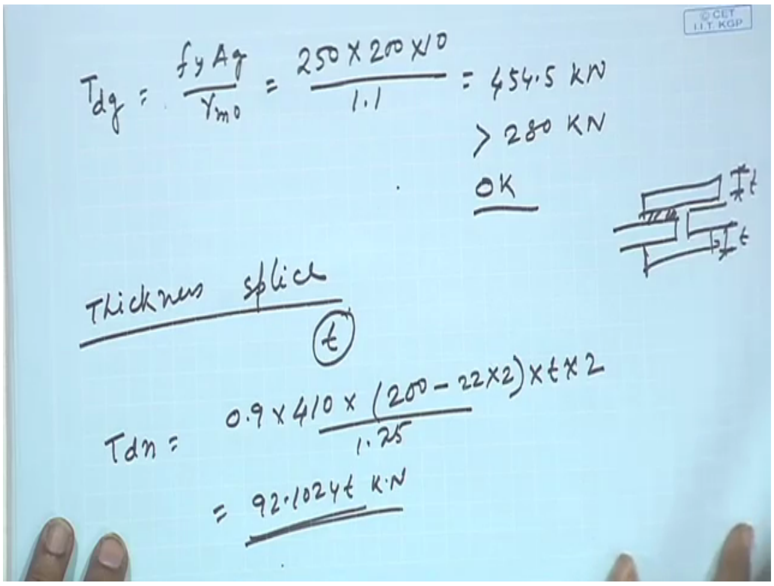

Now design strength due to yielding of gross section we have to find out, design strength due to yielding of gross section that is Tdg we know that is fyAg by gamma m0 and it has to be also less than the external force. So we can find out this value 250 as fy, Ag is 200 into 10 and gamma m0 1.1, so this value is coming 454.5 kilonewton, right and this is also greater than 280 kilonewton that means this is also okay. So 454.5 kilonewton is the design strength due to yielding of gross section, we could find that the member whatever we have designed is fine.

Now thickness of splice plate we have to find out, what will be the thickness of splice plate, right. Now if we want to find out the thickness of splice plate we have to find out first the design strength of splice plate with respect to thickness, so that is possible if we consider thickness as t thickness of splice plate as t, so if we consider that then Tdn value will be 0.9 into fub 410 into An An will be 200 minus 22 into 2 into t into splice plate we have provided in two side, right here we have provided one, here we have provided one with packing plate, right.

So if this is t then the total thickness will be 2t, okay by 1.25. So this is becoming 92.1024t kilonewton and this value has to be equal to the external tensile force.

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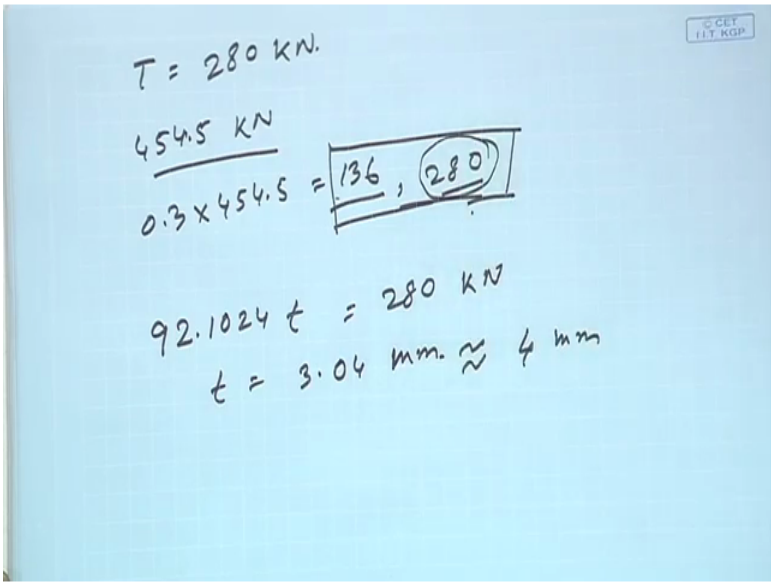

External tensile force T is becoming 280 kilonewton and we have found the design strength of the plate is 454.5 kilonewton, earlier we have found design strength of the plate so 454.5 so if we multiply with 0.3 that will be 0.3 into 454.5, that is 136. So this 136 or 280 whichever is greater we have to design against that, right 0.3 into design strength or the external tensile force whichever is coming greater we have to consider that, so if we so for this case we consider 280 kilonewton.

Therefore we can find out t by putting in this equation 92.1024 t is equal to 280 kilonewton from this I can find out t is equal to 3.04 millimetre that means 4 millimetre that means we can use 4 millimetre thickness of splice plate on both side form the member to join this.

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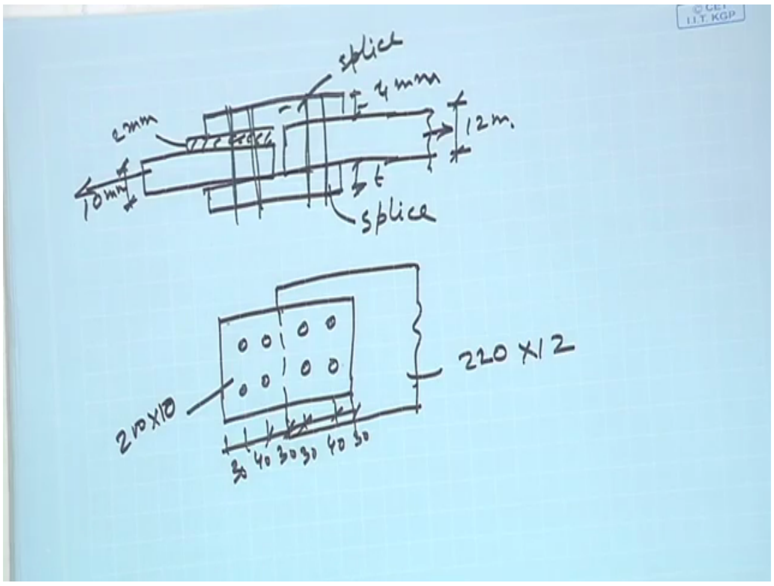

So if we draw the diagram it will be like this this is one plate, this is another plate and this is the packing of 2 mm this is 2 mm and this is 10 mm, this is 12 mm and then we provide a 4 mm thickness of splice 4 mm this is splice, right. Similarly in this phase also we have to provide splice of same thickness t and we are providing the bolt here and bolt in this because 4 number of bolts are required. So in plan that will be visible in plan if we see it will be like this and then it will be like this, this plate is 220 by 12, this plate is 200 by 10.

So we are providing 2 bolts here, 2 bolts here these 2 bolts and 2 bolts here, so total number of bolts should be 4 means in each row 2 bolts we are providing and this we can provide as 40 and 30, this is 30, this is 40 and this is 30. So this is how we can provide. And the thickness of the splice plate we are finding.

Now it is interesting to note that the splice plate is provided in such a way that it is becoming symmetric, so we are (())(24:39) the symmetric of the section so that the eccentricity does not reply in the member.

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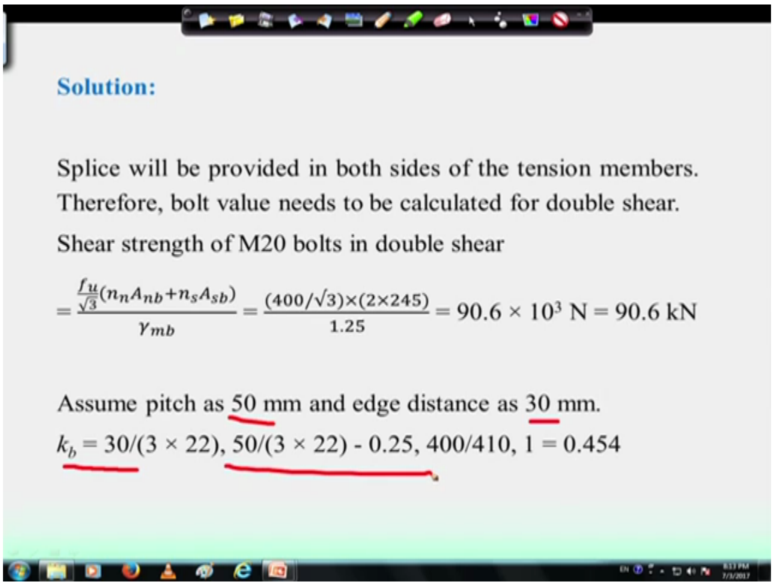

So what I have the example whatever I have discussed here once again I am showing in the power point, in short that is first what we did that we have found the shear strength of the bolt that we could find fu by root 3 into nn by Anb. Now because of double shear we have multiplied 2 and then we could find out the shear strength as 90.6 kilonewton and if we assume certain pitch and edge distance then based on that we can find out the Kb value. So once we find Kb value as 0.454 we can find out the design strength due to bearing.

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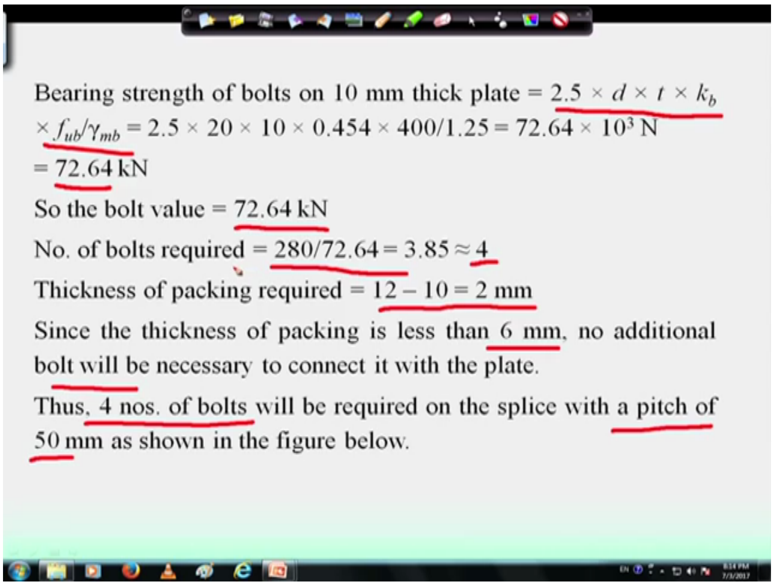

So bearing strength of bolt on 10 mm thick plate we can find out that is 2.5 Kb dt into fub by gamma mb and if I put those value I can find out bearing strength as 72.64 kilonewton. So once we are getting 90.6 kilonewton as a shearing value and shearing strength of the bolt and bearing strength of the bolt we are finding out 72.64 kilonewton, so the bolt value can be consider as 72.64 kilonewton which is the minimum one.

So from this we can find out the number of bolts that is 280 by this and we can consider 4 number of bolts. And here thickness of the packing plate will be 2 mm there will be gap of 2 mm, so we have to provide a packing plate of 2 mm thick and and since the thickness of packing is less than 6 mm no additional bolt will be necessary to connect it with the plate. So we will be providing only 4 bolts at each plate with the splice, right and we will consider a pitch of 50 mm and 30 mm as edge.

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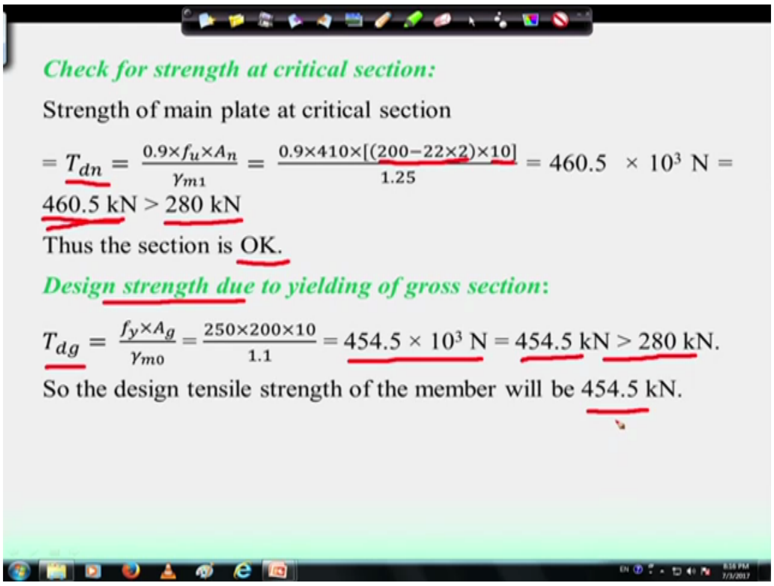

So this is how we can find out then we can go to next that is strength of main plate at critical section so strength of main plate Tdn we can find out from this 0.9 into fu An by gamma m1 and if we put those value we will get 460.5 kilonewton, here it is important to remember that at critical section the area will be 200 minus 22 into 2 because 2 bolts in each row we have provided and thickness is 10 mm, thickness of the thinner plate.

So we could find out Tdn as 460.5 kilonewton this is the strength of main plate at critical section and it is more than 280 kilonewton so it is okay. So another strength we have to find out from the yielding of gross section point of view. So design strength of design strength of the plate due to yielding of gross section can be calculated as this Tdg is equal to fy into Ag by gamma m0 that is coming 454.5 kilonewton that is also less than greater than 280 kilonewton so it is okay.

Now the design tensile strength of the member will be the lesser of these two values, one is 460.5 kilonewton and another is 454.5 kilonewton, so design tensile strength of the main plate will be 454.5 kilonewton, right.

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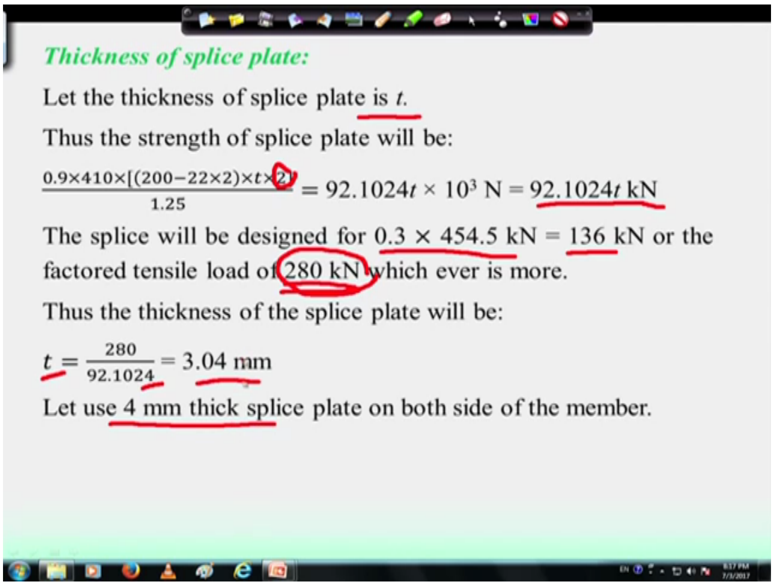

So after this we can find out the thickness of the splice plate, so that can be found if we consider a thickness of splice plate as t and if we consider thickness of the splice plate t then the Tdn value the strength of splice plate we can find out that is 0.9 fu into (200) mean An this is An An will be 200 minus 22 into 2 into thickness thickness is t and 2 splice plates at top and bottom we have provided so we are multiplying 2 and thus we are getting 92.1024t kilonewton where t is the thickness of splice plate.

Now this splice plate has to be designed against the 0.3 times the design strength of the member main member or the tensile load coming in the member whichever is more. So design strength of the tensile member was 454.5 kilonewton, so 0.3 times of this is coming 136 and factor tensile load on the member was 280 kilonewton so we will consider 280 kilonewton as the force for designing splice plate.

So splice plate we can find out t as t by 92.1024 which is coming 3.04 millimetre so we can use 4 mm thickness splice plate on both sides of the member. This is how we can find out the thickness of the member.

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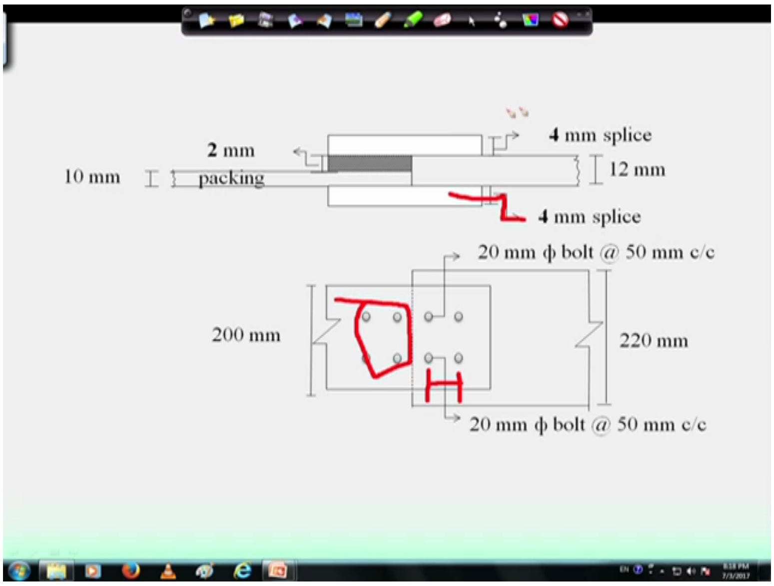

Then if we draw the diagram we can see that 4 number of bolts are provided in each plate, right and with a particular pitch value which was we consider 50 mm and pitch distance as 50 mm and thickness of the splice plate we have consider 4 mm like this, so the diagram will be looking like this. So this is how we can design a splice plate, so the main main thing we have to remember is that while designing the splice plate we have to design in such a way that the eccentricity does not occur.

So the load has to be transfer from one member to another member in a in such a way that additional forces due to eccentricity are not going to occur, right. So in this way we can design the splice member with respect to tension member.

So this is all about the design of splice plate as well as I am completing today the design of tension member chapter means tension member in case of tension member we have seen how to find out the design tensile strength from different criteria like like shearing, like block shear, block shear so we will come into picture not shearing sorry we will consider the design strength due to gross yielding of the member and rapture of the net section and the block shear failure.

So from those three points of view we have to design the member, also we have to consider the slenderness ratio value also for designing so that the it does not exceed the limiting value of the slenderness ratio and while coming across the design of tension member we have seen that the gusset plate sometimes we use where more than one members are meeting at a point then we may have to provide gusset plate like in case of truss bridges many members are coming into joining in one point so in those cases we have to provide gusset plate.

Also we are we when the required length is not available in case of tension member then we have to join 2 members with the use of splice that also we have discussed today and also we have discussed about the lug angle, how to provide lug angle that also we have discussed. So with this I would like to conclude the tension member design, thank you.