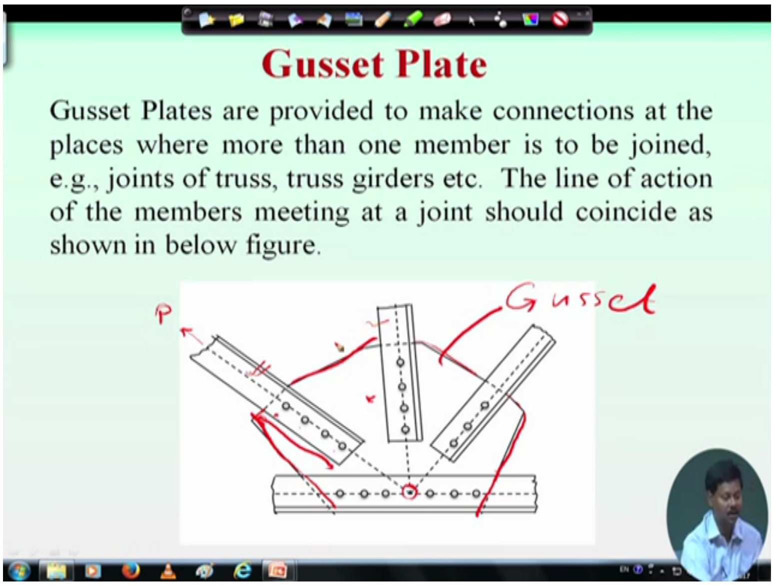
Course on Design of Steel Structures
Professor Damodar Maity
Department of Civil Engineering
Indian Institute of Technology Kharagpur
Lecture 26
Module 6
Design of Gusset Plate

Hello today I will restrict my lecture on design of gusset plate, gusset plate is a plate which is used to connect several members meeting at a joint, gusset plates are provided when more than one member that means atleast two members are joint there we provide gusset plate.

(Refer Slide Time: 0:45)

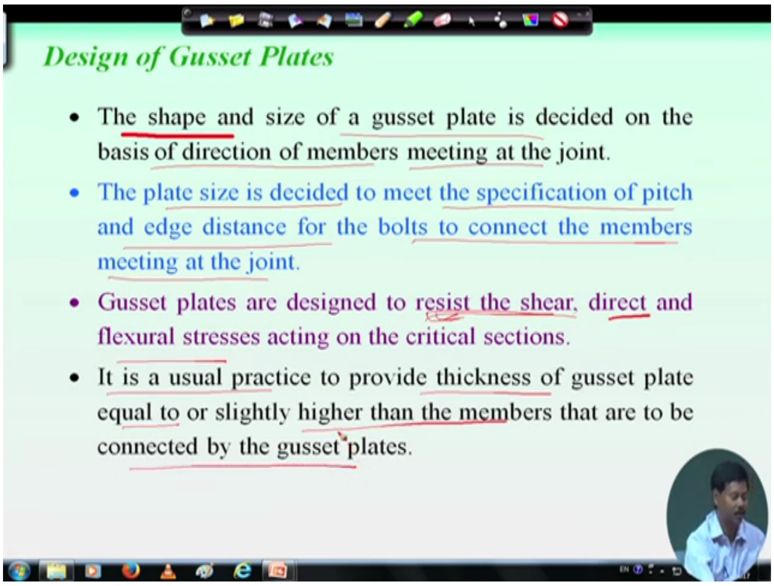


Gusset plate if we see in the picture it looks like this, say for example in a truss member when more than two or means more than one member are joint, here four members are joint together. Now in this figure we could see several aspects that first of all if I see in the first of all these are angle section in this particular case we have shown angle sections, so its Cg should meet means all the members should meet at a particular point means the Cg of all the members should meet at a particular point so that the eccentricity does not generate, so that we have to keep in mind.

And in fact this gusset plate this is the gusset plate what we say to join the different number of members, so if we join this, now what should be the size of this gusset plate, this is gusset plate right what should be the size? That actually depends on the number of bolts used or welding length of weld used to join the section, say for example suppose for this case we are seeing that four number of bolts are there, right so the length of gusset plate on this direction we have to decide on the basis of the number of bolts and number of bolts are decided on the basis of the nominal diameter of bolt and also the magnitude of the force means how much forces are being exerted in this member that means tensile forces, right.

So this is one aspect we have to keep in mind also while designing we have to keep in mind that the gusset plate length should be as less as possible so that the material for gusset plate is minimized. Another point is that as I told that gusset plate thickness thickness of the gusset plate should be little more than the member itself whatever members thickness is there the gusset plate thickness should be little higher that we have to keep in mind.

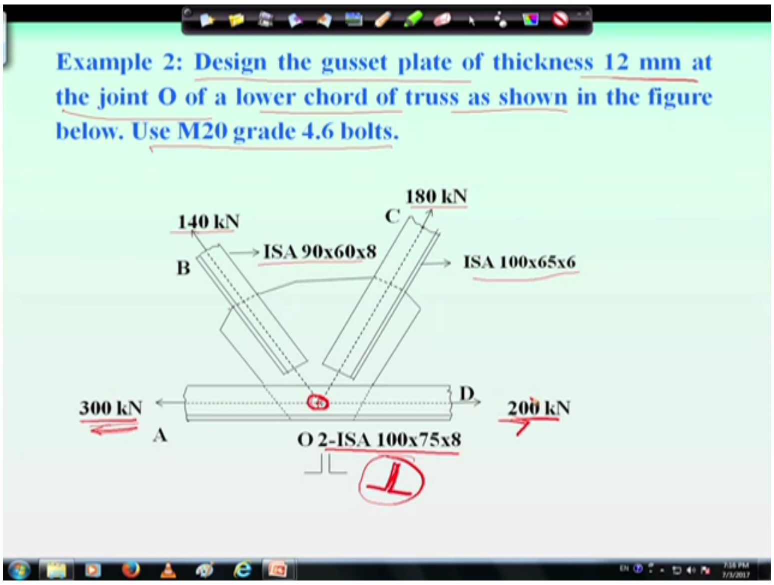
(Refer Slide Time: 3:18)



So if I look back to the design criteria we can see first is the shape and size of a gusset plate is decided on the basis of direction of members meeting at the joint. Then the plate size is decided to meet specification of pitch and edge distance, in fact what will be the minimum pitch distance and edge distance that is given in the code so for that we have to find out what will be the provided pitch distance and edge distance for that particular case and then accordingly we can find out the length of the joint.

Another thing is the gusset plates are designed actually to resist shear mainly shear and direct and flexible stress acting on the critical section. So when we will be going for designing we have to keep in mind that the gusset plates are not going to fail due to shear which are resisting shear and the direct tensile forces coming into the gusset plate and as I told that it is a usual practice to provide thickness of gusset plate equal to or higher than the members that have to be connected by the gusset plate that also we have to keep in mind.

(Refer Slide Time: 4:36)

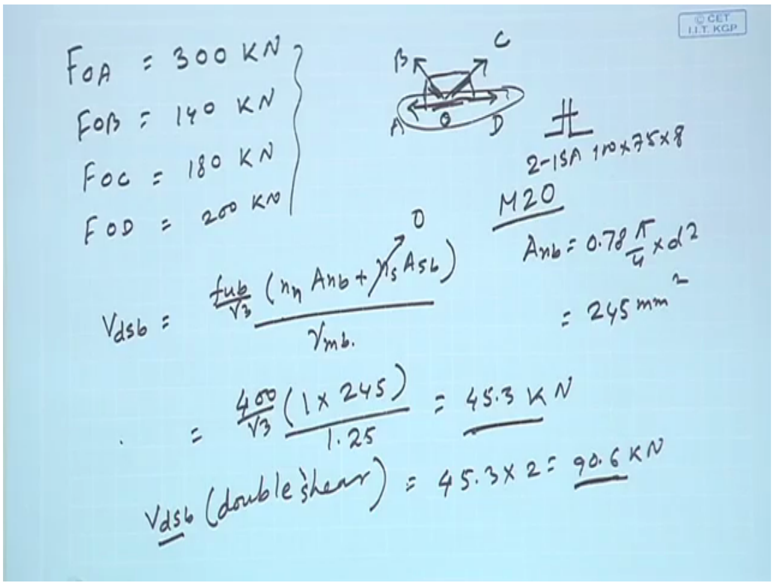


Now if we go through one example then I guess we will be able to understand how to design a gusset plate, how to decide the member of a means length of the gusset plate and other details. So here there is an example we have given where we have to design a gusset plate of thickness sorry of thickness 12 mm at the joint O of a lower chord of truss member, right and use M20 grade of 4.6 bolts.

So here loads are given in member AD we have load 300 kilonewton and 200 kilonewton in this direction and in this direction 300 kilonewton. Similarly in member OB, O is the meeting point where all the Cg of the members are meeting at the point and the force on OB is 140 kilonewton, force on OC is 180 kilonewton and the thickness means size of the angle section of OB is ISA 90 by 60 by 8 and size of the angle section of OC is ISA 100 by 65 by 6 and the bottom chord is 2-ISA 100 by 75 by 8 and these two angles are connected back to back like this, right.

So this is a double means double member double means double angle with back to back connections which is AD and having force 300 kilonewton in this direction and 200 kilonewton in this direction, right. Now let us see how to design this plate and how to find out the length of the gusset plate in different direction and how to find out the size of the section.

(Refer Slide Time: 6:43)



So if we see the given things are like this that force on OA we have that is 300 kilonewton and force on OB was 140 kilonewton and force on OC was 180 kilonewton and force on OD was 200 kilonewton, right. So these are the force acting on the gusset means acting on the joint O, where in joint O all the members are meeting this is the joint O, this is A, this is B, C, D. There is a tensile force in this direction, in this direction, in this direction and in this direction.

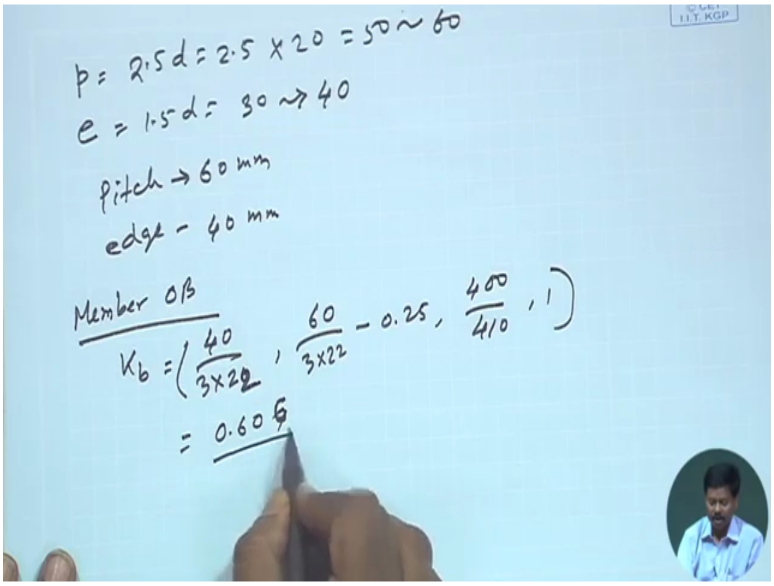
Now we need to provide a gusset plate and we have to find out the size of the gusset plate in terms of the length and number of bolts in this directions, right. Now for M20 bolt we know the shear strength we can find out that is design shear strength Vdsb as like this that is fub by root 3 into nn Anb plus ns Asb by gamma mb. Now for M20 grade of bolt means the diameter of bolt is 20 mm, so if it is 20 mm then I can find out Anb as 0.78 pi by 4 d square which will become 245 millimeter square, right.

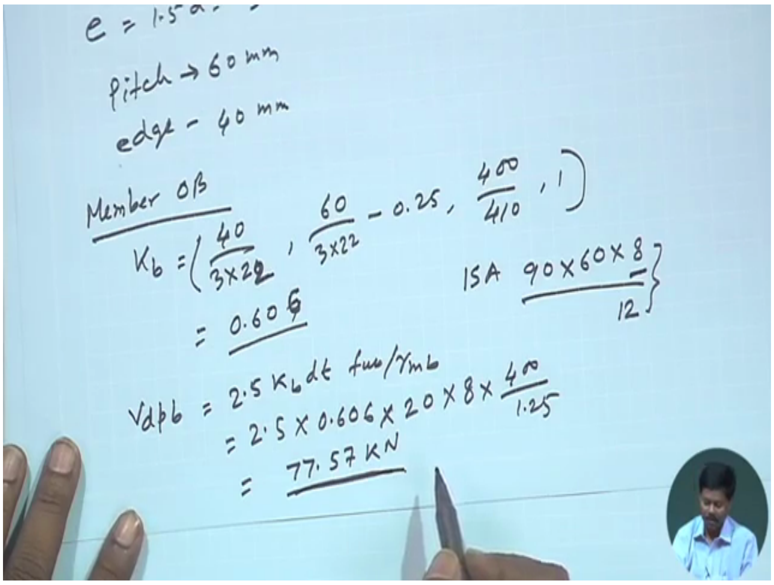
So Vdsb we can find, now we can consider that the shear plane is passing through the the the thread of the bolt so nn is 1 and ns is 0, there will be no shear plane passing through the shank. So if we consider that then we can find out the Vdsb value by putting those magnitude like fub will be 400 by root 3 into nn is 1 and 245 is the area by gamma mb is 1.25, so we can find out 45.3 kilonewton.

Now so Vdsb is coming 45.3 kilonewton and for double shear Vdsb in double shear because in one case it will be double shear that is member AD or (())(9:27) OD, that will be in double shear so that will be 45.3 into 2, 90.6 kilonewton, because if you remember that member (O)

AD was made of two angle section back to back with ISA 100 by 75 by 8, 2-ISA 100 by 75 by 8. So as it is double shear so the Vdsb value will be twice of the single shear that is 90.6 kilonewton.

(Refer Slide Time: 10:13)





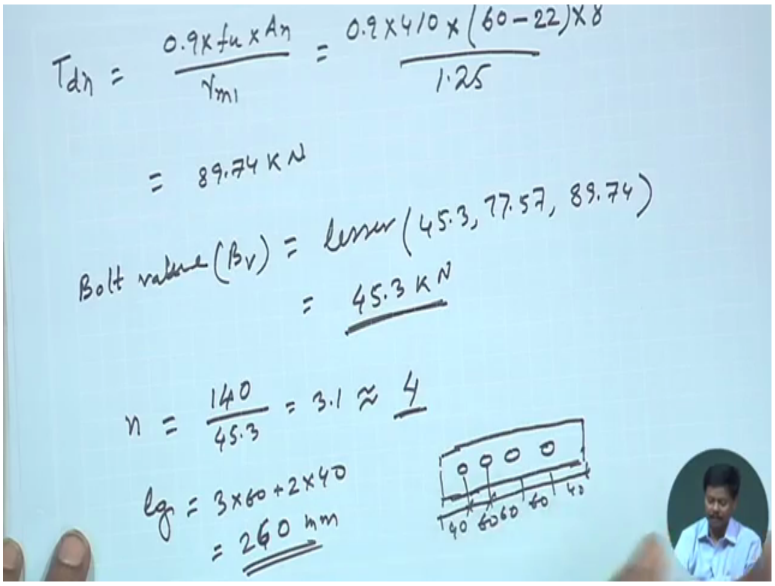
Now we have to assume certain pitch value and edge distance, so pitch value we can consider as p is equal to 2.5d that is 2.5 into 20 so it is 50 and edge value we can consider 1.5d that is 30 however we can increase means this is the minimum pitch and edge distance, we can increase to say 40 mm and may be you can increase to say 60 mm. So finally pitch distance we are assuming as 60 mm and edge distance we are assuming as 40 mm, right.

So this is the distribution of pitch and edge, now if we go for design of member OB then we can see for member OB, I have to find out Kb value now Kb value will be we know the minimum of this e by 3d0, e means shear 40 by 3 into d0 means 22 22, then p by 3d0 60 by 3 into 22 minus 0.25 then fub by fu and 1, least of these four and that will become 0.606, in fact for all the members this Kb value for calculating bearing strength this will become 0.606.

So bearing strength Vdpb, I can find out bearing strength here in member OB size of member OB is 90 ISA 90 by 60 by 8, so thickness is 8 mm, right. So 2.5 Kb dt into fub by gamma mb, if I put the values then I can find out 2.5 Kb (where) we could find 0.606 into d is the diameter of the bolt that is 20 into t is the thickness of the thinner plate means thickness of the member this angle section is 8 and thickness of the gusset plate is 12, so lesser of these 2, 8 mm and 12 mm, so we will consider 8 mm, right and then fub is 400 and gamma mb is 1.25.

So if we consider this value then the strength of bolt due to bearing I could find out 77.57 kilonewton, right. So strength of bearing I can find out 77.57 kilonewton and earlier we found the strength due to shearing as 45.3 and for double shearing it is 90.6.

(Refer Slide Time: 13:25)

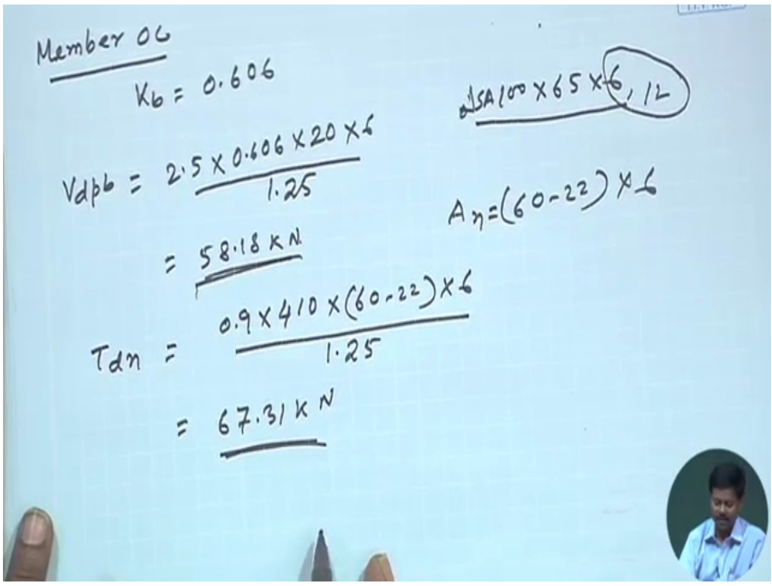


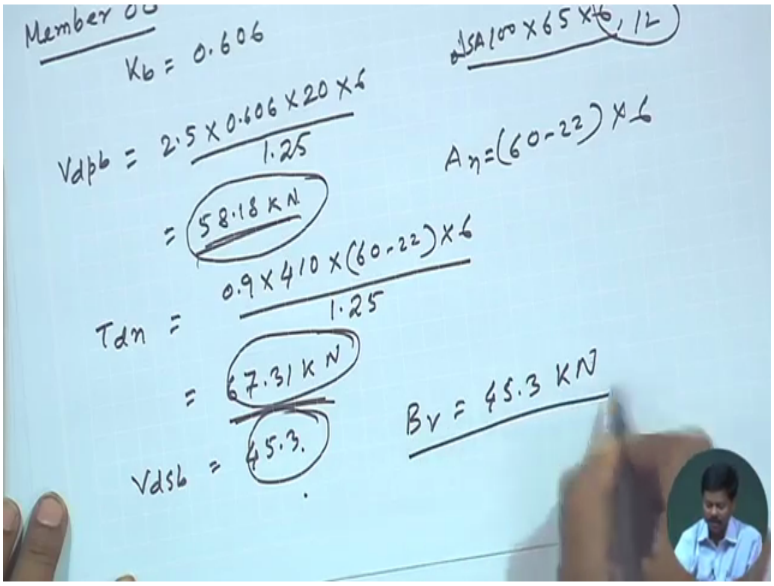
Now strength of angle for pitch we have to also find out that is Tdn that is we know 0.9 into fu into An by gamma m1. So if I put the value it will be 0.9 into fu is 410, now now An An will be per pitch if we consider so 60 is the pitch and diameter is diameter hole of hole diameter of the bolt is 22 into thickness is 8, right by 1.25. So strength of angle per pitch length we can find out this will become 89.74 kilonewton, right.

So what we get here the bolt value means bolt value will be the lesser of these three, bolt value Bv bolt value I can find out lesser of three value we could find one is 45.3 which is single shear for member OB, then bearing strength we got 77.57 and the strength of angle per pitch we got 89.74 that is tensile strength. So this lesser of these three is coming 45.3 kilonewton, so the bolt value is finally we are getting 45.3 kilonewton, right.

So number of bolt for member OB will become the total load the load acting on the member that was 140 kilonewton by the bolt value 45.3, so this is becoming 3.1 that means we can consider four number of bolt, right so four number of bolts we have to provided and if we see if this is the member then four number of bolts we are providing, so total length required for gusset plate will be this is 60 and this is 40, right this is 60 and 40. So total length will be length of gusset plate lg if I write it will be 3 into 60 plus 2 into 40, so that will become 260 mm, right so 260 mm length will be required along member OB.

(Refer Slide Time: 16:33)



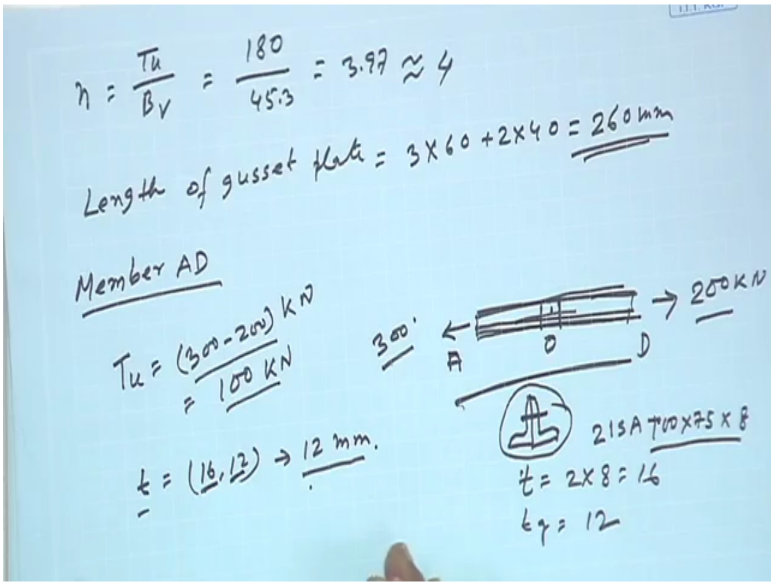


Similarly I can find out the length required and the number of bolt required for member OC. So for member OC in a similar way I can calculate that is here we know that Kb value is same because that will be 0.606 whatever we have calculated earlier because here pitch distance and edge distance are same for all the cases the bolt we are using 20 mm and we have assume pitch value as (50) 60 and edge distance as 40. So Kb value will be same for all the cases.

So we can find out the bearing strength Vdpb bearing strength of the bolt that we can find out as 2.5 into Kb into d d is 20 into t, here t is the size of the member is 100 by 65 by 6, size of the member ISA 100 by 65 by 6. So the thickness is 6, 6 and gusset plate thickness is 12, so lesser of these two will be the thickness divided by 1.25, so I can find out 58.18 kilonewton and similarly I can find out the strength of angle per pitch length that is due to tension, I can find out Tdn as 0.9 into fu fu is 410 into An here An will be per pitch length it will be 60 minus 22 into thickness, right.

So An I can find out as 60 minus 22 into thickness of the angle by gamma mb gamma m1 sorry. So if I find this value I can find this is 67.31 kilonewton. So bearing strength is this and the tensile strength is coming 67.31 and the shearing strength Vdsb we could find out earlier that is 45.3, ok. So the bolt value will be lesser of these three, therefore I can write bolt value as 45.3 kilonewton that means this is same as earlier.

(Refer Slide Time: 19:16)



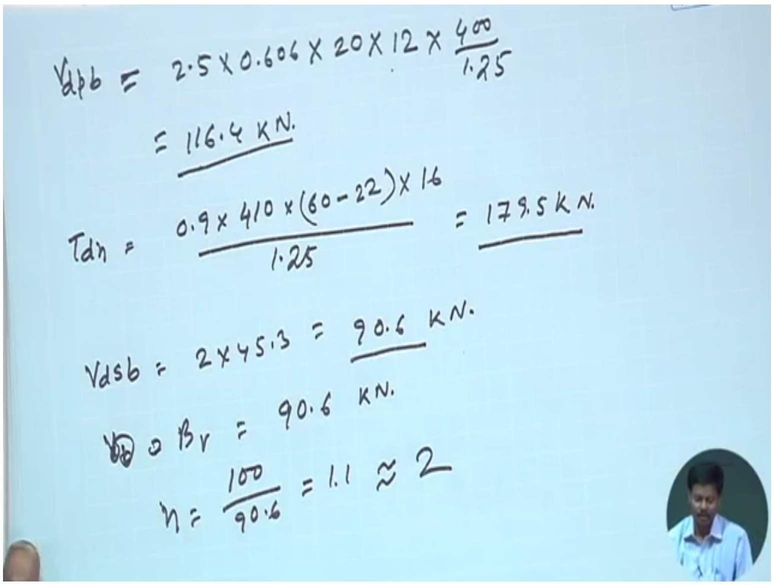
So number of bolt I can find out number of bolt required will be the Tu the tensile force acting on the plate by bolt value that is 180 by 45.3 that is becoming 3.97 that means it is also 4. So length of gusset plate also could be found length of gusset plate will be the pitch distance means keeping pitch distance as 60 and edge distance as 40 we can find out 3 into 60 plus 2 into 40 that will be 260 mm, so similar to member OB, right. So length of gusset plate for member AB towards towards member OC will be 260 mm and number of bolt will be required 4.

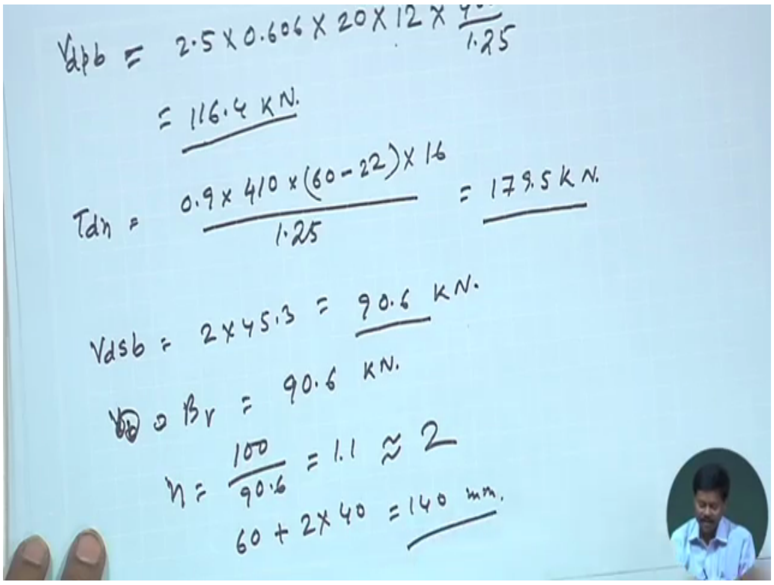
Now we will come to member AD member AD so in case of member AD we we could see that this is the bottom chord so if we see that it is meeting at point O and towards this is A and this is D and forces along this direction is 300 kilonewton this is tensile force and along this direction it is 200 kilonewton. So in case of if it is single member means AD member then I can say that the Tu will be the net force that means 300 minus 200 kilonewton. So in this case Tu will be 100 kilonewton, right.

However if these are not the single member means if two members are connected here separately then this will be 300 and this will be 200 but as it is acting as a single member therefore the unbalanced force will be the force acting on the member that is 100 kilonewton, right. And in this case the thickness we can consider thickness of the plate will be this is 8 mm because 2 angles are placed together so the thickness we can consider as twice of the single angle thickness that means the this is consider 2ISA 100 by 75 by 8 that means the thickness here will be 2 into 8 is equal to 16 and thickness of gusset plate we have 12.

So for this case we will consider minimum of 16 and 12 that means it will be 12 mm, so while calculating the bearing strength the thickness will be considered as 12 mm, because this is a double angle section which are used so the thickness of double angle section will become jointly 16 mm, whereas the gusset plate thickness is 12 mm, so minimum will be 12 mm, right.

(Refer Slide Time: 22:57)



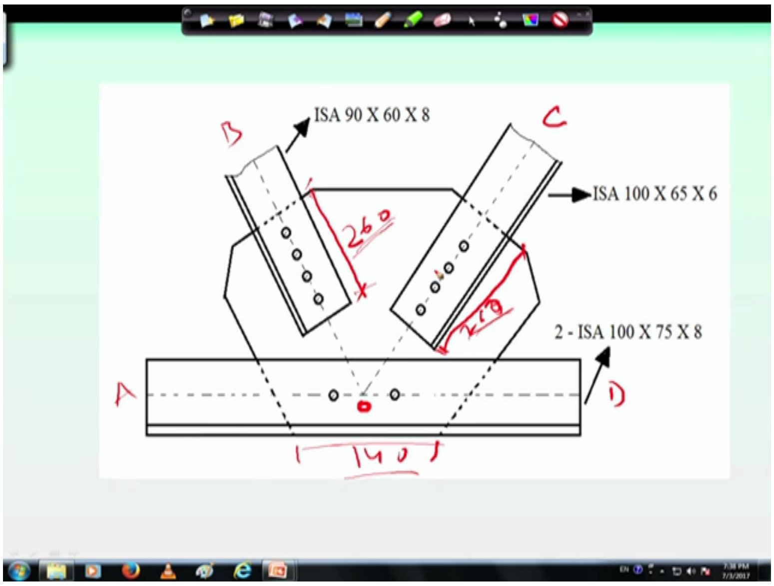


So we can find out bearing strength of the bolt that is Vdpb as 2.5 into Kb Kb will be same because Kb is depend on edge and pitch distance, so this will be same for all Kb into d is 20 mm bolt diameter and t we are considering 12 that is gusset plate thickness then fub was 400 by gamma mb was 1.25. So after calculating we can find this is as 116.4 kilonewton. So bearing strength we can find out 116.4 kilonewton again the strength of angle per pitch length that also we can find out Tdn that will be as 0.9 into fu fu is 410 into 60 is the 60 is the pitch per pitch we have to consider and 22 is the bolt hole into thickness thickness will be 16, right by 1.25. So this will become 179.5 kilonewton.

So the bolt value, right another Vdsb we got earlier that is the shearing strength of the bolt that is 2 into 45.3 kilonewton that means 90.6 kilonewton, so we got the strength of the bolt due to bearing as 116.4 kilonewton, due to tensile as 179.5 kilonewton and due to shearing as 90.6 kilonewton. So the bolt value we can find out as minimum of this bolt value will be sorry (Vb) Bv will be 90.6 kilonewton. So number of bolts required will be Tu here will be 100 unbalanced force is 100 kilonewton by 90.6, so that will be 1.1 that means 2 bolts are required here.

So the length of the gusset plate we can find out as 60 plus 2 into 40, that means 140 millimeter, right 140 millimeter. So accordingly we can arrange the bolts.

(Refer Slide Time: 25:45)

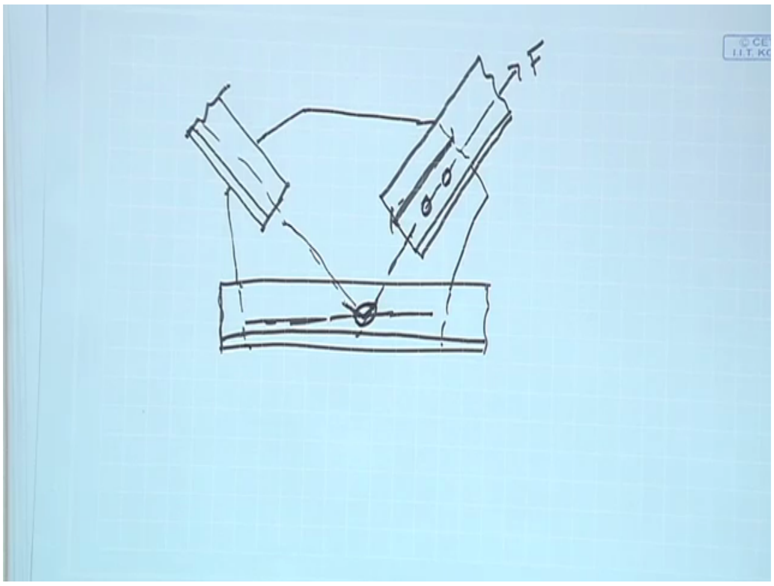


We can see here in the figure I can show the screen, this will be the arrangement, here if you see we have consider 4 bolts here these are 4 bolts along member OB, this is O, this is B, this is A, this is C, this is D. So if we see that for member OB we need 4 4 bolts, so we could find out the length accordingly length of the bolt we can find out that is actually we got here is 260 mm, right so this will be 260 mm.

Similarly this length also will be 260 mm 260 mm, right because 4 bolts are required for member OC as well and for member AD we need 2 bolts therefore this length we calculated as 140 140 mm, right. So in this way the gusset plate dimensions have been decided, right. So in case of this if we consider in place of 20 mm diameter bolt if we consider little higher than this length could be reduced, this length could be reduced.

So length of the gusset plate in different directions can be reduced by increasing the bolt diameter and if we increase the bolt diameter the number of bolts will be reduced and as a result we can find out lesser length of the gusset plate towards that member. So this is how one can find out the gusset plate gusset plate dimensions.

(Refer Slide Time: 28:04)



Here before going to end again I am just giving importance that making a connection say this is a angle sections having in these directions and another section is this is another angle connected whose Cg is this and this is another angle sections whose Cg in this direction. So what I wanted to tell that this should meet at a at this point that means Cg of this member, Cg of this member and Cg of this member should coincide at a particular point, if it does not coincide then eccentricity will develop and as a result additional moment will come into picture in the member for which we need to design properly that is why to avoid that moment or eccentricity we have to make the alignment in such a way, we have to place the angle sections in such a way that all the Cg of the sections are meeting a particular point, that we have to keep in mind.

And (())(29:39) to mention again that the length of the gusset plate will be reduced by different way means we have to keep in mind to reduce the length of gusset plate by increasing the bolt diameter so that the number of bolts required less and as a result the length of the gusset plate become less. Because to (())(30:05) the particular force on a particular member we can provide n number of bolts and that can be reduced if I increase the diameter of bolt then I can decrease the number of bolts and if I decrease the number of bolts then I can decrease the gusset plate length towards this.

And if gusset plate becomes means larger that means if length of gusset plate become larger than the weight of gusset plate will be more and if the weight of gusset plate become more then the structure the (())(30:45) of the structure is (())(30:46) become more that is why it will not be (unecono) means it will not be economic, economic in the sense that if gusset plate (thick) if gusset plate size becomes more and we know for a particular structure number of gusset plates are used means many. So total weight of the gusset plate should be huge.

So the dead load due to the gusset plate can be reduced if we can properly properly make use of number of bolts that means by increasing the diameter of bolt if we properly reduce the number of bolts so that the gusset plate name can be reduced and if it is reduced then we can reduce the weight of the gusset plate and as a result the dead weight of the structure will be less, right. So this is what I wanted to discuss about the gusset plate, thank you very much.