**Design of Steel Structures.**
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**Lecture-15.**
**Eccentric Connection (Load Lying in Plane of Welded Joint).**

Hello today I will discuss about the eccentric connections where load is lying in the plane of joint and using weld connection, here basically fillet weld will be used for connections now in case of load lying in the plane of joint two type of forces means stresses will come into picture in the weld. One is due to force means direct force which would be the shear, shear stress will come into picture one another is will come due to eccentricity and the stress will come due moment.

So we have to make calculation of the stresses due to direct force and due to moment and then we have to find out its equivalent forces that means resultant forces, and that resultant forces should be less than the weld strength. If the resultant forces is less than resultant stress is less than the weld strength then our design factor is ok means design whatever we have designed we have proposed is ok otherwise we have to go for means increase of the weld size or length of the weld size or orientation means the weld length and width has to be changed and then again we have redesign it.

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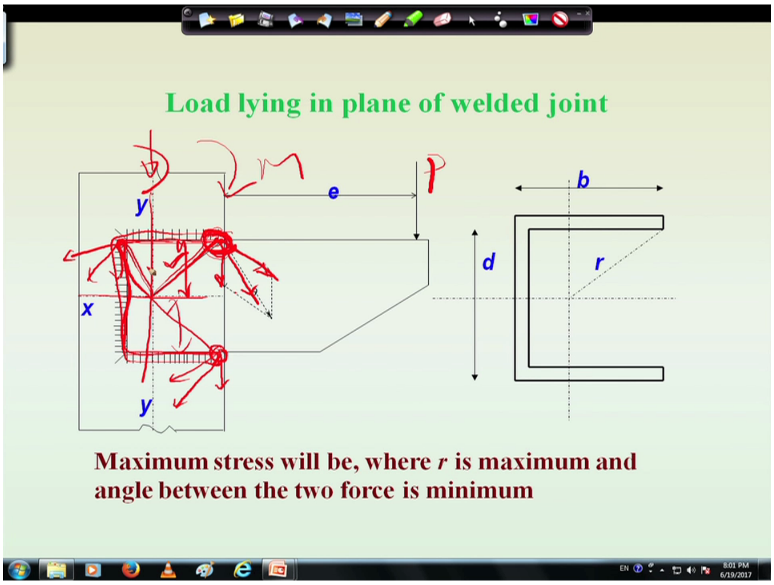


So coming to this picture if we see here that basically if there is a force P then moment will become in here as a P into e this moment will come and also the P as an eccentric force will act here P and P into e right. Now because of that the stresses will be generated on the wild.

Now if weld is connected in this way, so in the bracket throughout the bracket if it is connected then we have to find out the cg of the weld group that means cg of the weld group we have to find out.

Once we find out the cg of weld group then we can find out what will be the force stresses acting on each portion of the weld say for example in this point stress will be acting one stress will be acting in this direction vertically downward due to direct force and another will be 90 degree to the radial distance from cg to this point it is 90 degree right, and then we have to find out the resultant right.

Now again same thing may happen here we can see that this will come here and this may come here so we have to find out the resultant here. But we know the stresses will develop much more at the extreme point building stresses, so the radial distance of this point and radial distance of this point if we compare it will be more here that means the critical point will be this point. Similarly critical point will be this one and this point and this point will be same because this distance and this distance are same, it is symmetric along this direction.

Therefore the radial distance between this two will be same, the angle between two forces will be same, therefore the stresses the resultant stresses at this point and this point will be same. So at any point any of these two points if we calculate then we can find out the critical stresses of the section right. So in place of calculating entire weld length, in place of calculating in different position of the weld if we calculate only one point then we can find out the critical strength.

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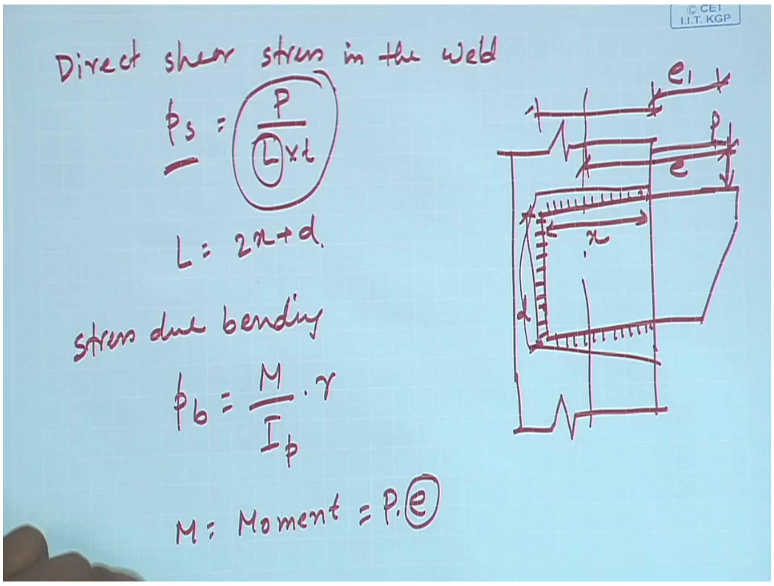


So critical strength can be found only at this point means will be developed only at this point because of its position. Now let us find out the direct shear stress in the weld, we can find out direct shear stress. So direct shear stress in the weld we can find out from this formulae that is Ps say if I make this will be total force P by L into t right. Say for example if we draw this figure whatever we have seen and this is a column which is connected by a weld. The bracket is taking a load of P right and this distance is suppose some distance say e1 and this we have this distance we have so we can find out the cg of this distance and then we can find out the x and cg e.

So we do not know what is the M value right now unless we know the cg of the weld group right. So weld if it is made through this periphery then total length here this L, L is the length of weld will be if we consider this as x and this as d then 2x + d right and P is the throat thickness of the weld. So shear stress in the weld due to direct force will be P by L into t and stress due to bending as we told that because of eccentricity bending will come into picture, moment will come into picture so stress due to bending, if we write Pb this will be M by Ip into r, r is the radial distance.

And M is the moment which is calculated as P into e now this e unless we know the distribution of the weld we cannot find out the value of e, because e is not this much, e is the distance between load and the cg of the weld group. So we have to find the cg of the weld group and cg of the weld group we can find out if we know the distribution of weld otherwise you cannot be able to find out the cg of the weld.

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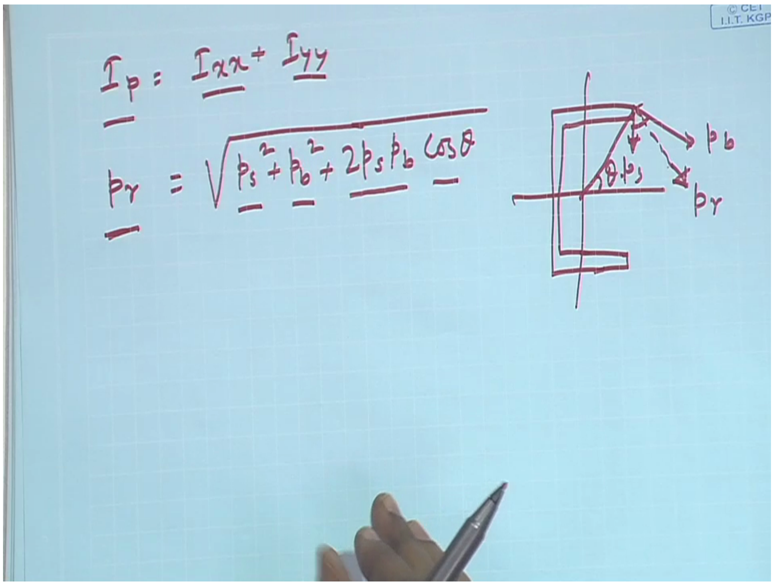

So before calculating the stress we have to provide certain distribution of the weld, then we can find out the cg of the weld, then we can find out the stress how much it is coming due to moment. So here Ip is basically polar moment of inertia of the weld and this can be calculated as Ixx + Iyy, that means moment of inertia about xxx and moment of inertia about yyy. So Ip the polar moment of inertia can be calculated, then the resultant stress Pr can be calculated as Ps square + Pb square + 2PsPb into cos theta right.

So because as we have seen earlier say if this is a weld connection then if this is a cg so this is Ps and this is Pb and this is the theta right, so the resultant force Pr this is Pr resultant force Pr can be calculated as square root of Ps square + Pb square + 2PsPb cos theta where theta is the angle between these two forces and for critical condition developed stress should be less than the permissible stress in the weld.

So this Pr value when we are going to calculate once we calculate we have to see this Pr value is less than the permissible weld strength of the material, means of the section. So if this Pr value is not less than the weld strength then we have to change the design criteria, design criteria change means either we have to increase the length of the weld or we have to increase the thickness of the weld, means size of the weld. Either of this two we can we have to do then again we have to check.

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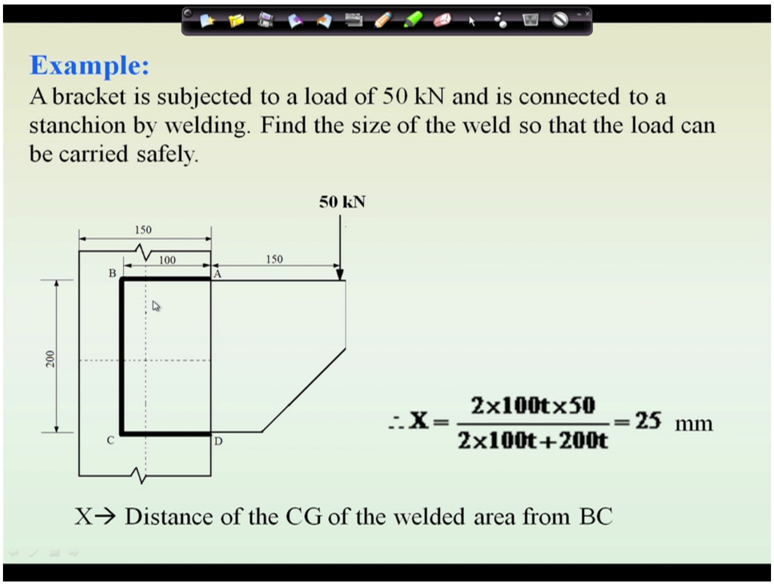


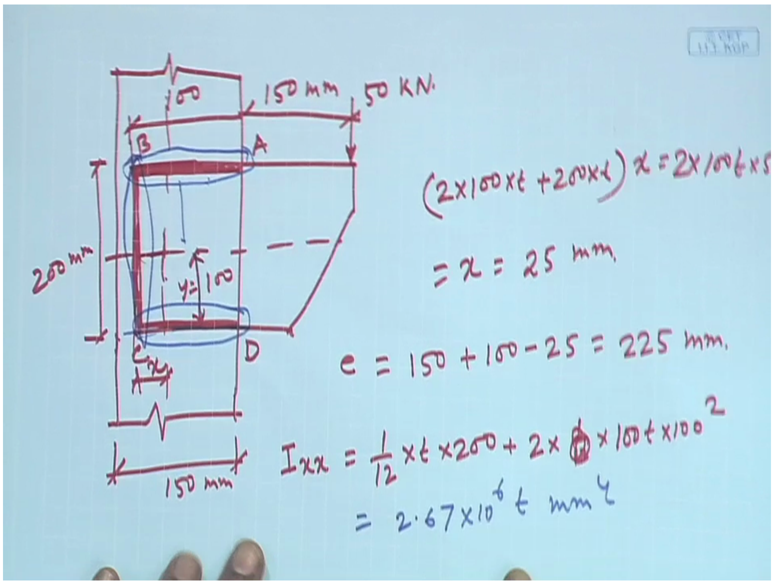


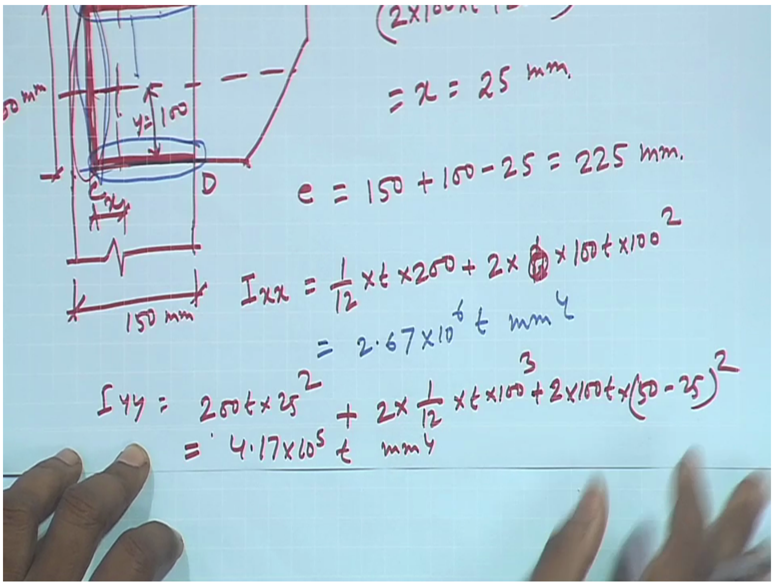

So with this theory we will go through one example this example let us see. This is the example so a bracket is subjected to a load of 50 kilo newton and is connected to a stanchion by welding. So this is a column and is connected to a bracket and it has a load of 50 kilo newton and weld distribution has been given. So this is the distribution ok, this portion is welded. Now this distance is known that is 150 mm and this is 100 mm right and this distance is this length is 200 mm. This is 150 mm and let us make point A, B, C and D, now as I told at the beginning we have to find out the cg of the weld group right cg of the weld group we have to find out.

So how to find out cg so along vertical directions cg will be if this distance will be 100 because this is symmetric but along, this is y say suppose, but along this direction say x that we have to find out. So that can be find out so if we take a moment along this direction means along this line BC line along BC line if we take a moment, then we can find out 2 into means total area will be 2 into 100 into t + 2 into 200 into t, this is the total area of the weld into x will be equal to 2 into 100t into 50.

So from this I can find out the value of x that is coming 25 mm. That means after taking moment along BC we can find out the value of x right. So now we can find out the eccentricity, eccentricity will be how much it will be 150 + 100 - 25, that means it will be 225mm, right. Now we have to find out the value of Ixx, value of Ixx, so Ixx value we can find out that is 1 by 12 into t into 200 for this portion for BC portion Ixx will be this then + 2 into 1 by 12 into sorry 2 into 100t into 100 square.

This is for this portion Ixx of this this area is 100t into 100 square because this is 100, this is 100 Ar square we are ignoring the moment about its own axis, about x axis, right, because that be much less t is very less. Thickness of the weld is very less so 1 by 12 into t cube into 100 would be much less that is why we are ignoring that value. So we can find out the value as 2 point 67 into 10 to 6 t millimetre to the y.

So similarly Iyy value we can find out Iyy value will be 200t into 25 square means Ar square for this portion right + 2 into the horizontal portion, 1 by 12 into t into 100 cube and then to bring it to its cg, 2 into 100t into 50 - 25 square. So this is we are getting Iyy as 4 point 17 into 10 to the 5 t right. So Ixx and Iyy we can find.

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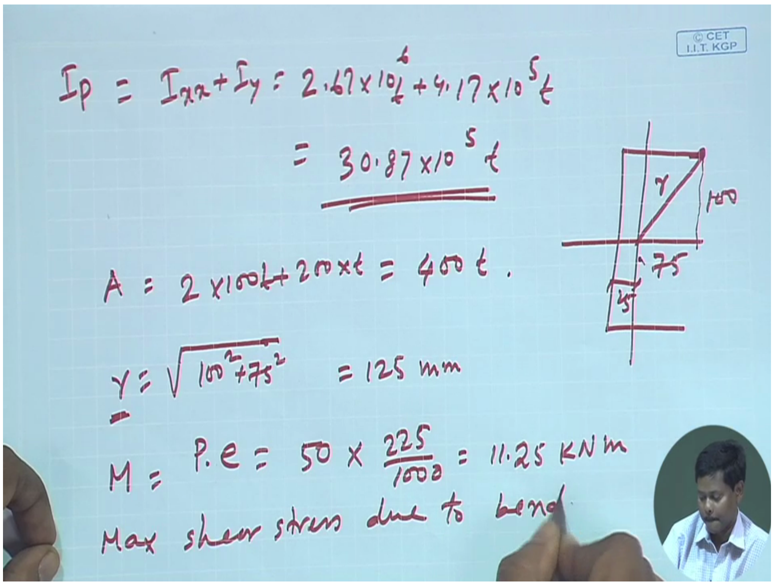


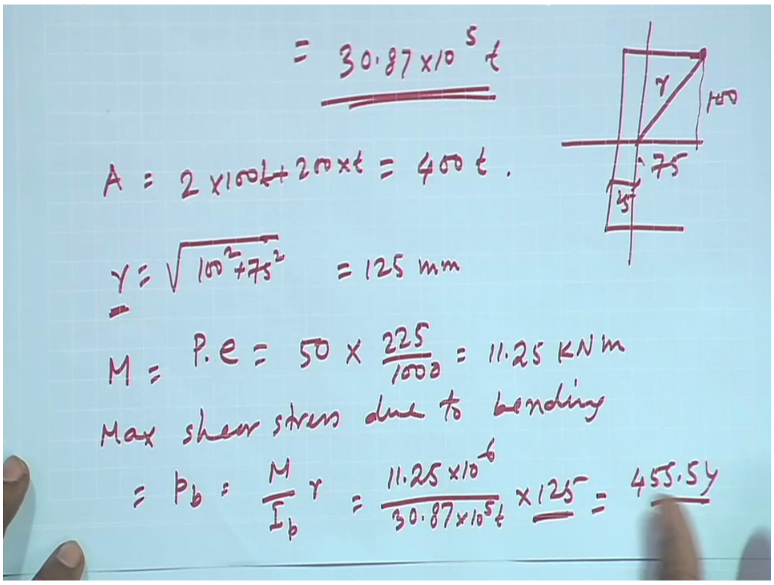


Now we can find out the polar momentum of inertia. Polar moment of inertia is nothing but Ixx + Iyy so if we put these value 2.67 into 10 to the power 6 + 4.17 into 10 to the 5 t. So this will become 30.87 into 10 to the 5 t right. So polar moment of inertia we can find out ad total area of the weld will be 2 into 100 + 200 into t, 2 to 100 t + so this will be 400t and maximum radial distance.

Maximum radial distance we can find out this will be the maximum radial distance so this r we have to find out. This r will be square root of this, this distance is how much, this is 100 and this is 75, this is 25 right. So r we can find out as square root of 100 square + 75 square, so that we can find out as 125 mm right. So now once we find r we can find out the Pv value ok.

For getting the maximum shear due to bending, first we have to find out the moment, moment will be P into e so here e we found P is 50 kilo newton and e is 225 millimetre, that means 11.25 kilo newton meter. So maximum shear stress maximum shear stress due to bending we can find out that will be Pb. Pb will be M by Ip into r, so if we put these value of M this is newton millimetre Ip is 30.87 into 10 to the 5 t into r is 125, so maximum radial maximum radial distance maximum stress due to bending will be developed so that if we calculate we can find out 455.54 by t right.

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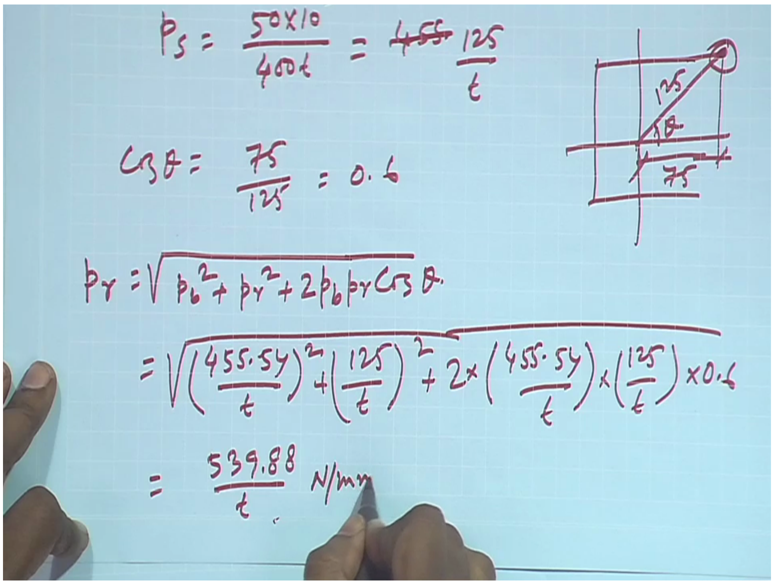


So 455.54 by t will be the maximum shear stress due to bending. Similarly I can find out direct shear stress, direct shear stress will be how much that will be Ps, Ps will be P by a, that means 50 into 10 cube, this is load by area is 400t total area of the weld is 400t. So this will become 455 sorry 125 by t , and here cos theta will be 75 by 125, cos thet, a because if we see the distance this is this is theta, so cos theta will be this is 125 and this is 75 right. So this can be found as 0.6, so the resultant stress Pr I can find out that will be Pb square + Pr square + 2 PbPr cos theta.

This value will be if we put this value we can see this 455.54 by t square + 125 by t square + 2 into 455.54 by t into 125 by t into cos theta 0.6. So this will become 539.88 by t right. So Pr the resultant stress at this extreme point will be 539.88 by t newton per millimetre square now this resultant stress has to be less than the weld strength, now strength of weld I can find out.

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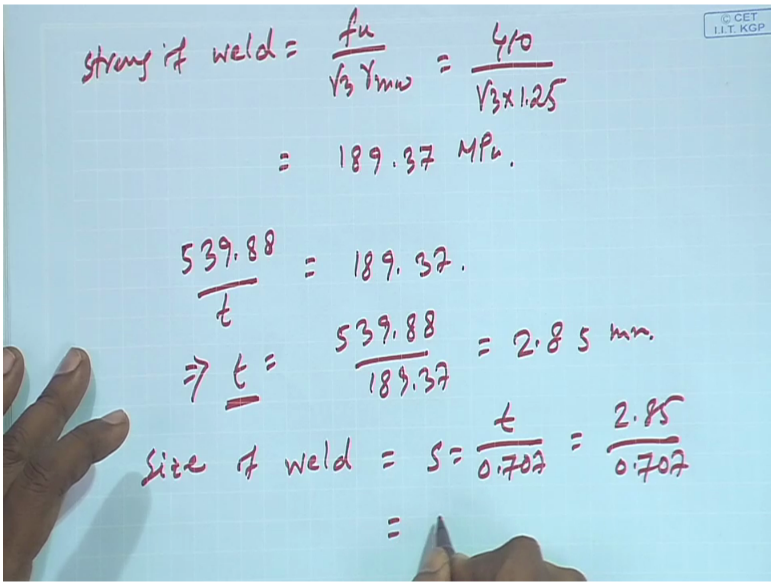


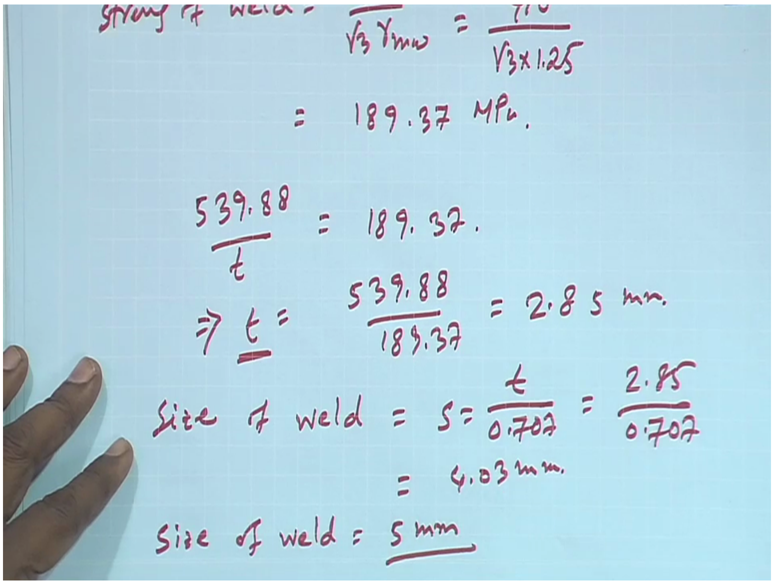


Strength of weld depends on the weld material and whether it is soft weld or at side depending on that gamma mw can be calculated means can be used. So if we assume soft will then strength of weld we can find out fu by root 3 gamma mw. If we put the value it will be root 3 into 1.25 so that is becoming 189.37 Mpv, that means we can equate that 539.88 by t is equal to 189.37.

So from this I can find out t is equal to 539.88 by 189.37 is equal to 2.85 millimetre right. So size of the weld I can find out now this is t means throat thickness, so size of weld will be S is equal to t by 0.707 that means 2 point 85 by 0.707 so that is coming 4.03. That means size of the weld we have to provide as 5 millimetre ok. So from the calculation we can see the size of the weld is coming 5mm.

Now from minimum and maximum criteria means what should be the minimum size of weld that from the caudal permission we have to find out. And then we have to see whether it is exceeding or not if it is less than the minimum then we have to provide the minimum otherwise this we can provide right. So for this case the minimum thickness will be 3 mm so we can we can provide 5 mm thickness, size of the size of the weld as 5 mm we can provide right.

So now if it is , say suppose this in this example, if size of the weld is given and the distribution is given then also we can find out what will be the load carrying capacity of the weld joint. The reverse way we have to do that means first we have to find out the strength of the weld then according to the size of the weld we will can find out what is the Ps and Pb then from that we can, in a reverse way we can find out the load acting at a particular distance P, that also we can find out.

So either of the way we can find out right. So the weld joint when load is lying in the plane of joint then how to design the joint that has been discussed today. In next class we will discuss about the load acting perpendicular to the plane of joint there, we how the stresses are developed that will discuss and then we will see how to find out the resultant stresses and how to design a particular joint. Thank you.