Course on Design of Steel Structures
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Lecture 10
Module 2
Design of Fillet welds

Hello today I am going to discuss about design of Fillet welds, in last lecture I have discussed a details about the fillet welds mean different parameters used for fillet welds like what is the effective length of the weld, what is the total length of the welds, what is the size of the welds, what is the effective thickness of the weld like this we have discussed and also how to find out the maximum allowable throat thickness of the size and minimum size of the weld on the basis of the plate thickness that also we have discussed and finally we have discussed about the design strength of fillet weld, right.

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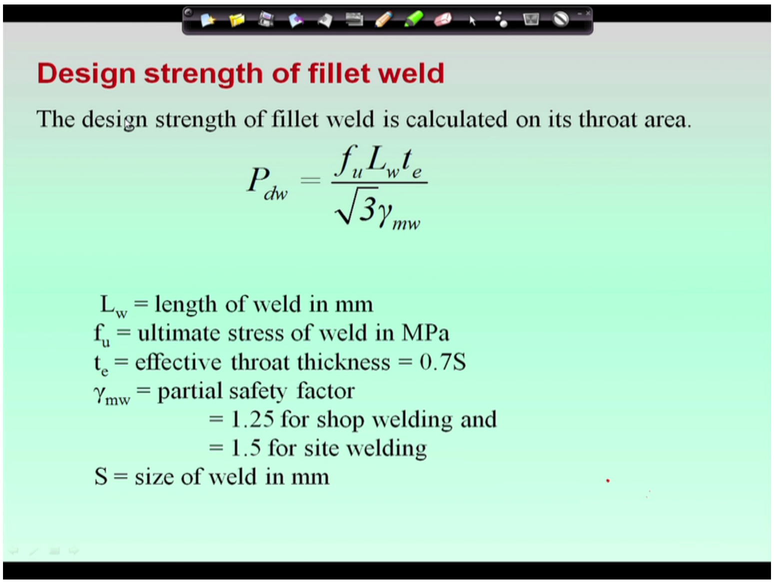

I am just giving a same formula here means whatever I have used in last class that is Pdw is equal to fu Lw into te by root 3 gamma mw where te is effective throat thickness that can be found as case and in case of generally we use right angle and for that it is 0.707S and on the basis of this we will go through one workout example where we will see how to calculate the weld length for a particular value of load.

If some load is given then how to find out the length of the weld and how to distribute the length of the weld in different site that will see through this workout example.

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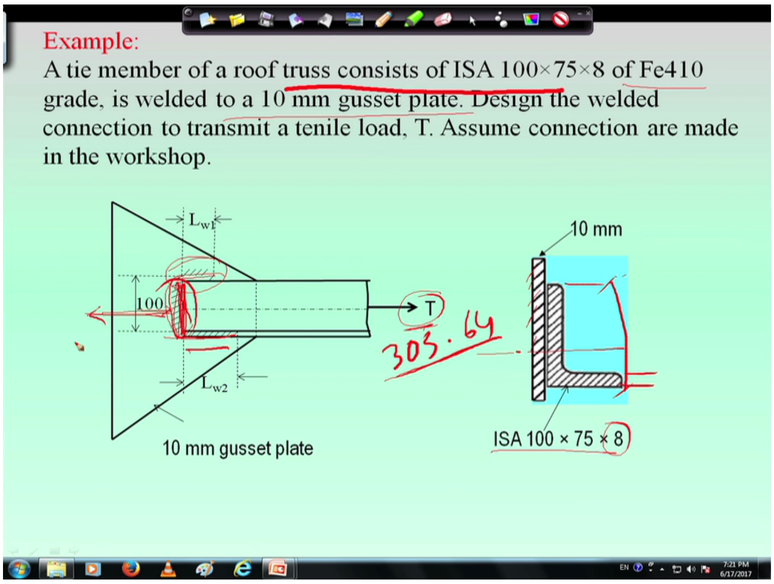

This is the example we have consider today that is A tie member of a roof truss consists of ISA 100 by 75 by 8 angle section of Fe410 grade, is welded to a 10 mm thickness gusset plate that means this gusset plate thickness is 10 mm. Design the weld connection to transmit a load T. Assume connections are made in workshop, right.

So here the thickness is giving means thickness of the gusset plate is giving 10 mm and thickness of the angle is 8 mm, so from these two we can find out the size of the weld right. So this is one thing second thing is that this is an angle section so its cg distance will not be at the middle not at will be at the centre. So that means it will not be that the length will not be distributed equally in upper side and lower side because the force whatever is acting along its cg the strength of the weld has to be make in such a way the equivalent strength passes through the cg. That means the weld distribution has to be made in such a way that weld strength equivalent weld strength are passing through this cg.

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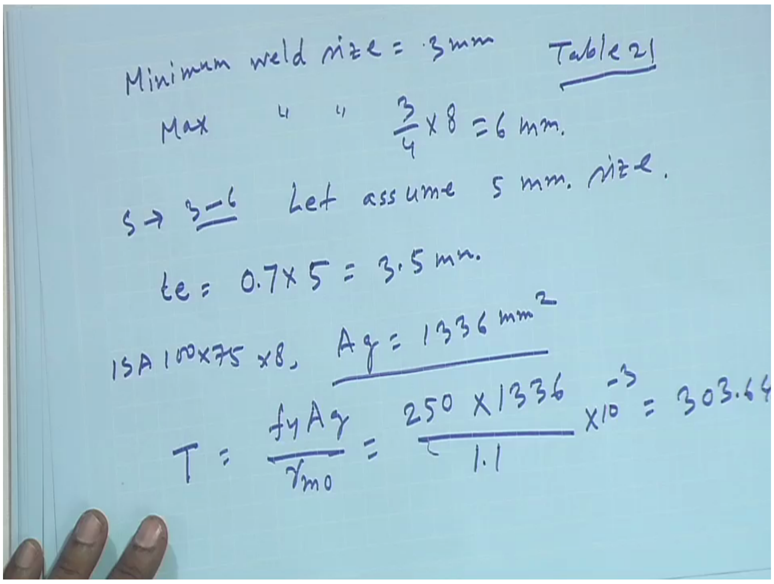

So let us see so first of all if we want to do this first what we have to find out we have to find out first minimum weld size, minimum weld size so minimum weld size will be actually 3 mm. This is found from table 21 of IS 800. In table 21 the minimum size of the weld has been given in last lecture also I have shown that table and in this case minimum size will 3 mm and maximum size maximum weld size will be three fourth by because it is angle so maximum three fourth by thickness of the angle, so this is coming 6 mm.

So the size of the weld will vary from 3 mm to 6 mm, so we can assume let assume say 5 mm ok, 5 mm size right so what will be be the throat thickness, throat thickness will be because here it is 90 degrees angle of fusion we are assuming so effective throat thickness will be 0.7 into S, S means 5 so 3.5 mm and we do not have the external load so as the external load is not given so we do not know what should be the design strength of the joint has to be calculated.

So what will do will try to design the joint to develop its full strength full strength of the joint. So for calculating full strength we have to find out the what is the strength of the joint means tensile capacity of the plate or of the angle. So that can be developed as a full strength and if we equate with that full strength with the weld strength then we can find out the length of the weld.

So for ISA 100 by 75 by 8 we can find out the full strength as say T as fy Ag by gamma m0, now we have to know Ag fy as we know that yield stress if we use Fe410 grade of steel then the yield stress will be 250 into Ag, Ag is the gross area of the angle so for this angle Ag is found from the hand book that is 1336 millimetre square. This we can find out from the SP 6 ok in SP 6 if we open we will see the gross area of the angle is given this 1336 millimetre square.

So we can multiply with this and gamma m0 the partial safety factor 1.1 and this is in newton so if you make it kilonewton it will be that means what we could see here that we do not have the T value here means we do not know what will be the T so this T we can make 303.64 kilometre right so under this load if we can design this weld then we can design for this full capacity.

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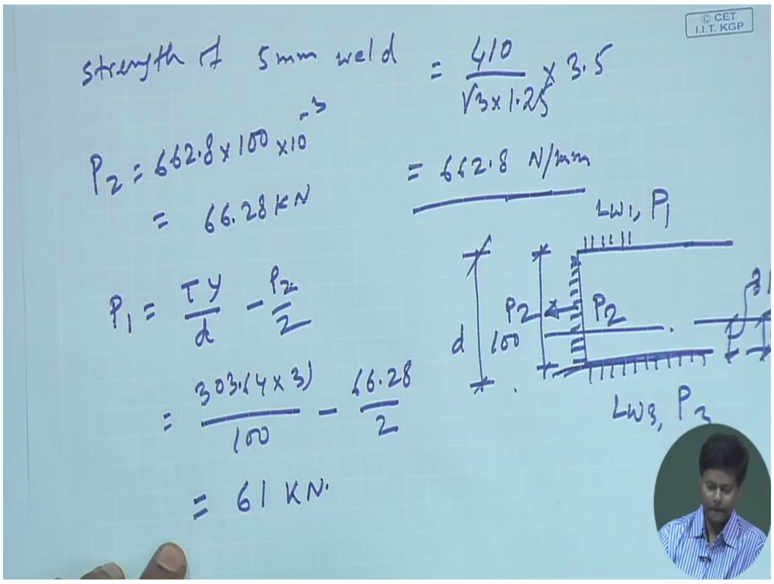

Now we have to find out the full strength of the sorry strength of 5 mm weld, strength of 5 mm weld. This will be fu by root 3 into gamma mw into te so if we make this will get 662.8 newton per millimetre. So strength of weld per millimetre run we can find out as 662.8 newton per millimetre. Now we can find out force at different site say the angle is connected with gusset plate so first we will see how much strength is going to take by this weld 100 mm weld means 100 mm length of weld because this is 100 right this is 100.

So if this is 100 then what will be the strength carrying by this portion if we found out if we find then again what we can do we can take a moment about this and we can find out what should be the require amount of force at this weld phase right. So we if have to do that then we can find out say if this is the distribution of weld say this is Lw1 and this is another one and this is 100 mm length of weld.

So if this is 100 mm length of weld then this strength this is say this is Lw1 and P1 and say Lw2 and P2 and Lw3 the length of weld and strength is suppose say P3 right. So P2 I can find out the 662.8 into 100 mm distance ok so we can find out 66.28 kilonewton, so P2 will be 66.28 kilonewton. Now if we take if we take moment about this line then we can find out P1 as T into Y by d minus P2 by 2 right T is acting at its cg, this is T this is T is acting and this distance is the cg distance right.

And now this is basically Y ok and if you consider this is d so from these we can find out P1 as so 303. 64 into Y is that we can find out from SP 6 that is becoming 31, 31 mm right. So 31 by 100 minus P2 by 2, P2 is becoming 66. 28 by 2. So if we calculate this we can find out value as 61 kilonewton.

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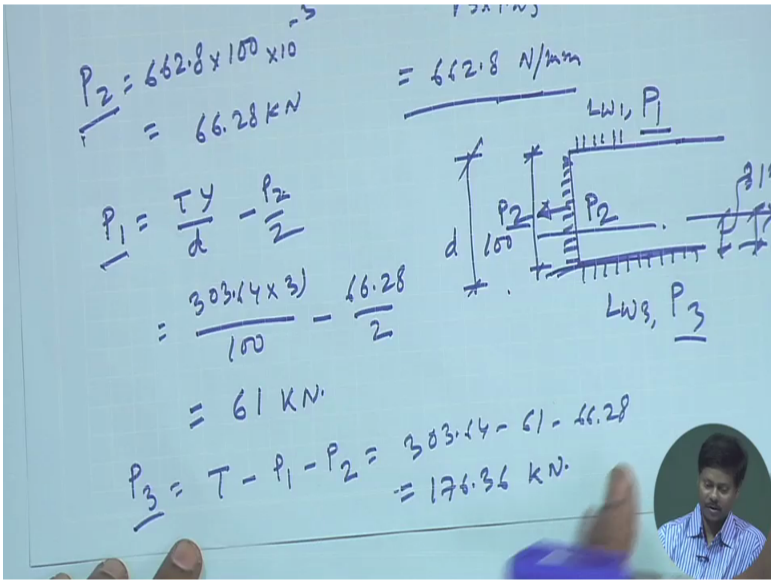

So force to resist at lower site of the angle P3 will be total force minus P1 minus P2 so P3 we can find out that will be 303.64 minus 61 minus 66.28 is equal to 176.36 kilo newton right.

So force at P1 means force P1, P2, P3 can be found out P1, P2, P3 this is found in such a way that the the resultant of these three force will be equal to T the external force without producing any additional moment right.

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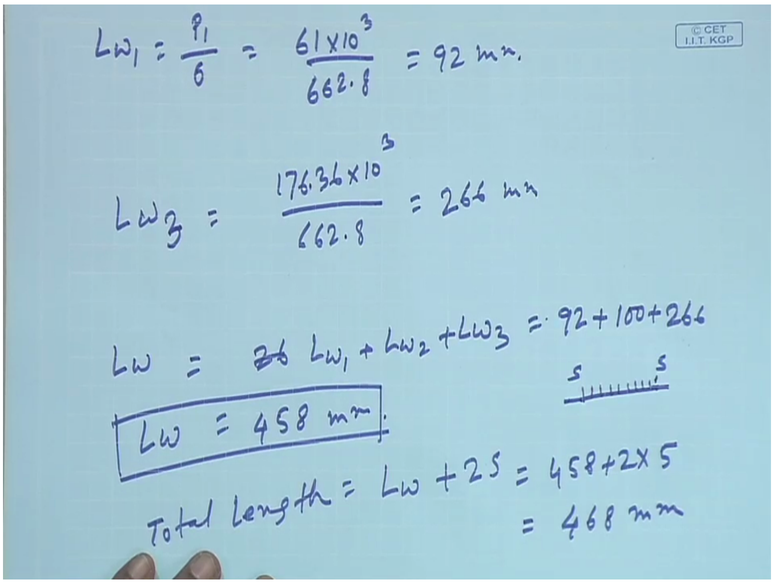

Now on the basis of P1 and P3 we can find out Lw1 and Lw3 so Lw1 I can find out P1 by the permissible stress, permissible strength of the weld ok say sigma so that means P1 is 61 into 10 cube by 662.8 which we have calculated earlier so this is coming 92 mm.

Similarly length required at lower side Lw2 3 will be 176.36 into 10 to power 3 by 662.8 this will become 266 mm this is how we can calculate. So now the total length of the weld can be calculated Lw the total length of the weld that will be 266 means sorry Lw1 plus Lw2 plus Lw3 so Lw1 we found Lw1 we find 92 plus Lw2 was 100 and Lw3 was 266. So this is becoming 458 mm right.

So Lw the total effective length is becoming 458 mm. Now total length will be total length will be Lw the effective length plus 2S because as we told the length whatever required we have to make additional length of S here and additional length of S here to get total length to make efficient of the joint. So this is 458 plus 2 into S, S was calculated how much S was 5 mm.

So it will be 468 mm so this is how we can calculate, so finally this is not all actually we have to find out the distribution in terms of drawing so we have to make a diagram.

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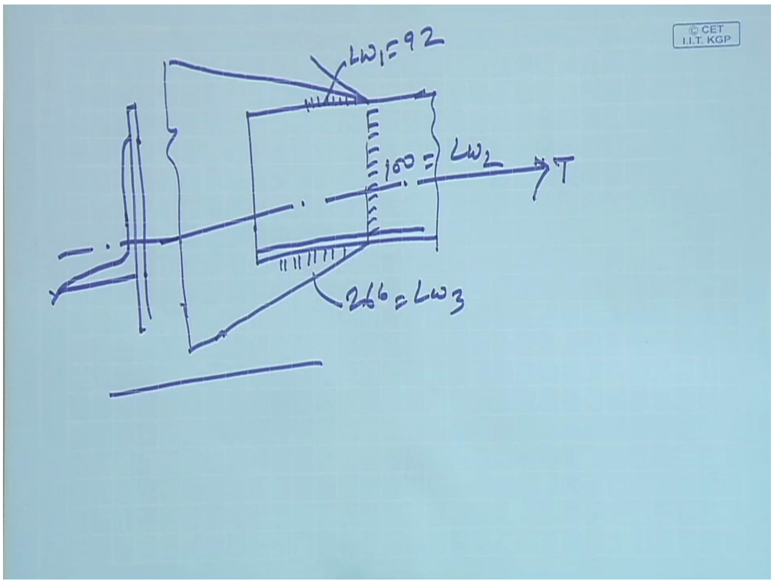

So if we see the angle section if it is connected to a gusset plate, then the distribution this is Lw1, this is Lw2 which is 100 and this is Lw3 so we have to give the value of Lw1 here that is 92 this is 100 and this is 266 mm right.

This is Lw2 and this is Lw3 right and its cg is in this direction here force T is acting ok and if we see this this is the gusset plate connected with the angle right so unless you finish this diagram it will not be complete because whatever we as a designer whatever we calculate we have to represent in terms of drawing because at the site when engineer will see site engineer will see it will not see the detail calculations or anything else it will see the drawing.

So whatever you are getting you have to represent in terms of drawing so that engineer can understand at the site and here one thing we have to remember we provide the effective length suppose length whatever we are providing is effective length and engineer has to add to this that means the size of the weld it has to add and then it has to fabricate right. So this is one example.

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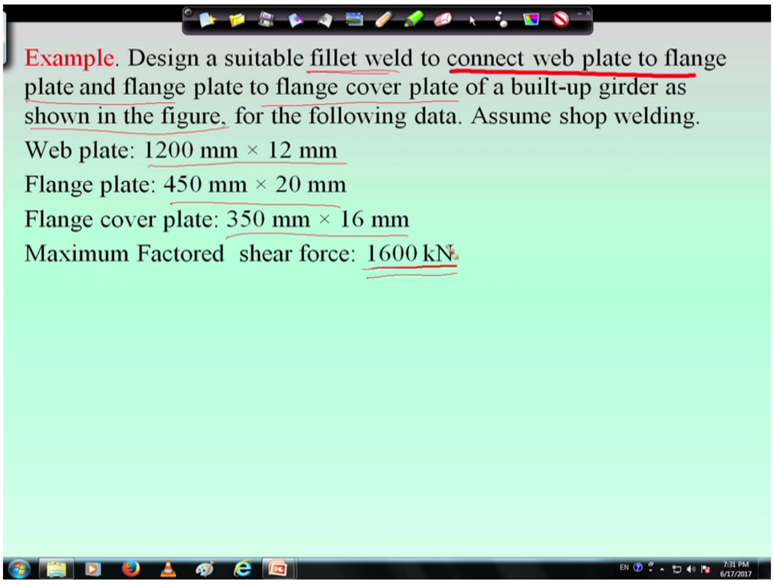

Another example I go through to see the weld connection. This is another example, Design a suitable fillet weld to connect web plate to flange plate and flange plate to cover plate of a built up girder as shown in the figure, I will show the figure for the following data. Assume shop welding. Web plate is 1200 by 12 and flange plate is 450 by 20, flange cover plate is 350 by 16 and maximum factored shear is 1600 kilonewton. So what we need to know we need to know the what will be the size of the fillet weld so that it can be connected to the web with this flange and cover plate to strength the maximum shear force of 1600 kilonewton.

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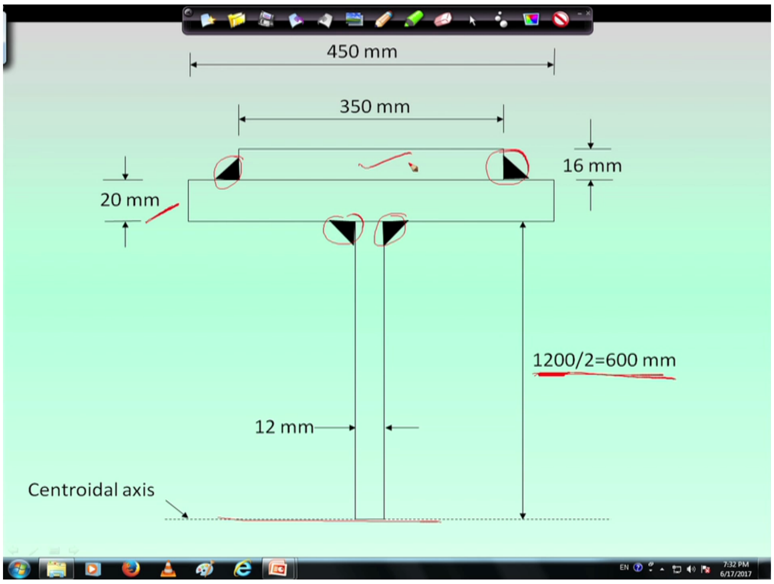

So if we see the diagram it will look like this so the web is 1200 by 12 so half of the distance has be taken hat is 1200 by 2 that is 600. If we consider this is a centroidal axis then the flange plate thickness is considered as 20 mm and is width this 450 mm and another cover plate is added this plate of 350 mm by 16 mm. So we have to weld this area to join the plate with the web and similarly in a to weld this area to join the cover plate with the flange plate. So this is how we have to do.

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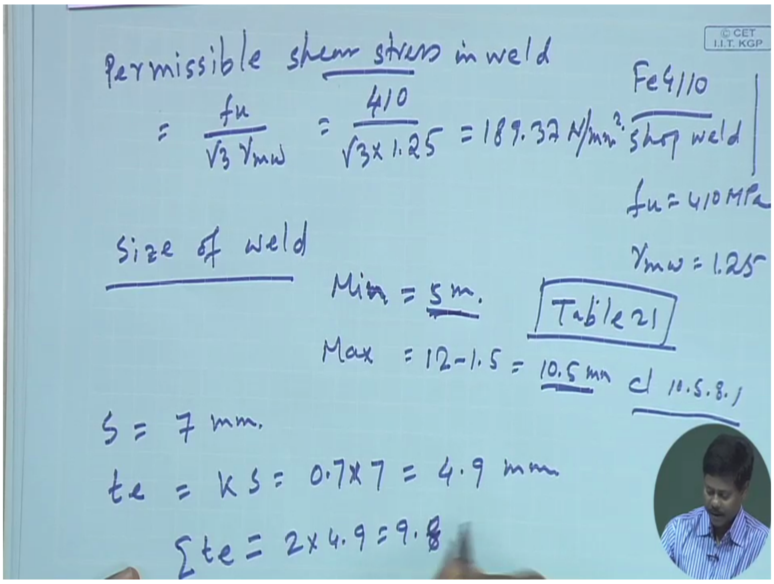

Now how do we find out the solution let us see. So in this case fast way to find out the permissible shear stress in the weld, permissible shear stress in the weld that will be how much we know fu by root 3 gamma mw right, so for this case say Fe410 has been used and shop weld has been used. Let uss assume that shop weld and Fe410 grade of steel has been used.

So fu will be 410 MPa and gamma mw will be 1.25 for this case, so if we consider this then we can find out the permissible shear stress in the weld is as 410 by root 3 into gamma mw that is189.37 millimetre newton per millimetre square ok. Now will see first will see first this this connection, connection to web and flange. First we will connect this will see what will be the length and other details so first what will see that size of the weld we have to find out the size of the weld from minimum and maximum criteria.

So size of weld will be minimum will be for this case minimum will be 5 mm from table 21, table 21 if we look will see that for this thickness of the plate the minimum thickness of weld will be 5 mm and maximum thickness of weld will be thickness minus minimum thickness minus 1.5 minus10.5, as per clause 10.5.8.1 in this clause you will find out right.

So we can assume a size of the weld in between 5 mm and 10.5 mm that means we can assume the size of the weld as say 7 mm, size of the weld as 7 mm then effective throat thickness of the weld we can find out that is K into S that is 0.7 into S so this is 0.49 millimetre right. Now total thickness of the weld will be means summation of te I can write 2 into 4.9 why 2, 9.8, why 2 here multiply because weld is not done in one place in two place.

Here one set of weld is given here another set of weld is given so total load will be carried by this two side therefore the thickness of weld has been added. Now we have to find out the shear stress at this junction, shear stress at this point and it has to be withstand by the weld.

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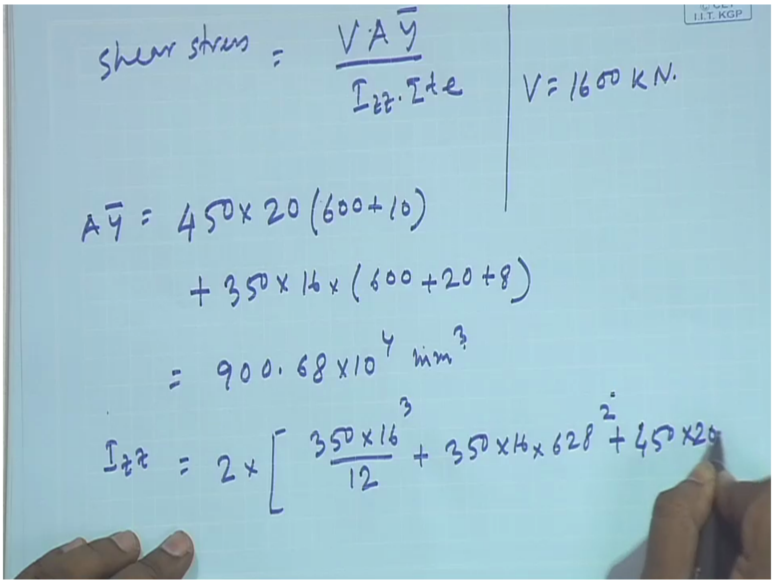

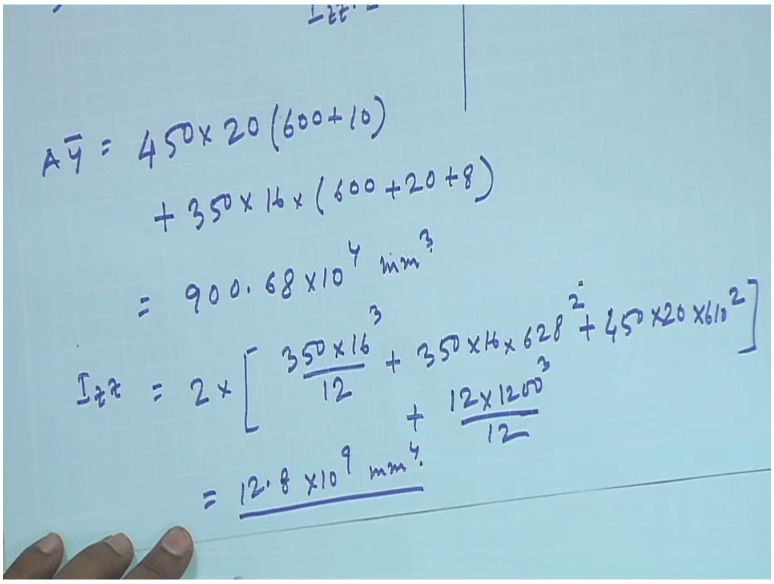

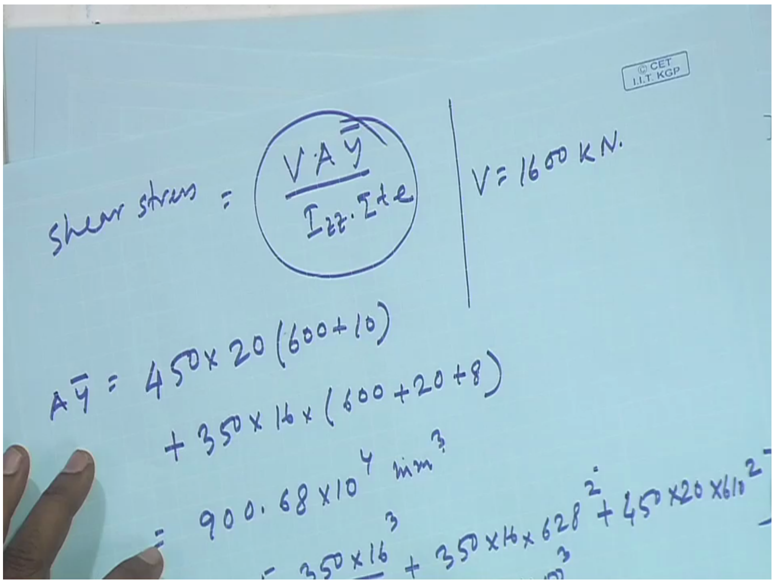

So shear stress we know shear force V into Ay bar by Izz into te bq by iv ok, so this is what we have to find out. So finding out we have to know what are the details. So here we know V is given V was 1600 kilo newton right now I have to find out A into Y bar and Izz. So Ay bar I can find out if we see that 450 into 20 this is A this is the flange area into y bar will be 600 plus 20 by 2 this is 1 then 350 into 16 into 600 plus 20 plus 8 right. So we can find out this as 900.68 into 10 to that 4 millimetre cube right.

Again I can find out Izz. So Izz if I find out will see that will be 2 into 350 into 16 cube by 12 Bd cube by 12 plus Ar square 350 into 16 into 628 square plus 450 into 20 into 610 square plus the moment of inertia the web portion, 12 into 1200 cube by 12 Bd cube by 12 ok so from this I can find out the value as 12 into 8 12.8 into 10 to the power 9 millimetre square 4, right. So this is the Izz general root now if we put the value in this formulae I can find out the shear stress.

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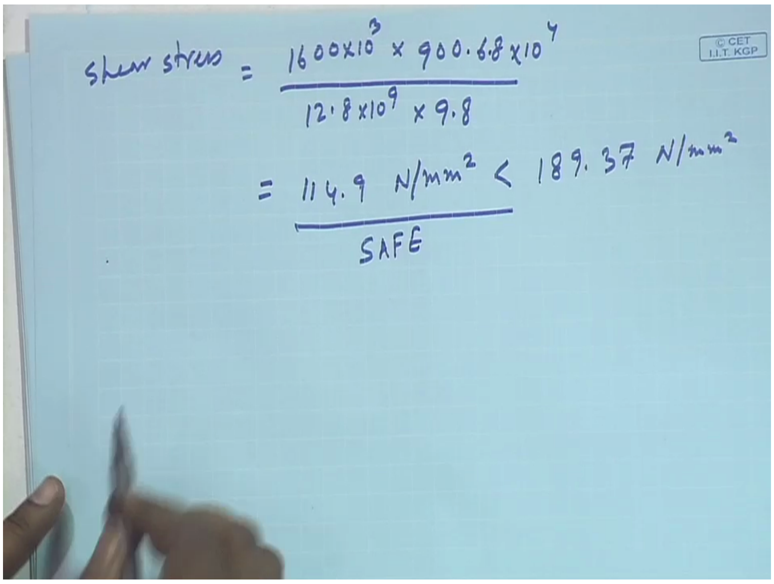

So if I put this value shear stress will be will become V into Ay bar 1600 into Ay bar was calculated as 900.68 into 10 to the 4 by Izz was 12.8 into 10 to the power 9 into summation of te is 9.8 right so this is the shear stress. This after calculating we can find out 114.9 newton per millimetre square and the permissible stress calculated was 189.37, earlier we have calculated fu by root 3 gamma mw that is the permissible shear stress of the weld. So it is less than 189.37 that means it is safe. The joint is safe under that much stress shear force.

Now we will see another one the connection of flange plate to flange cover that means this one connection of flange plate to I am sorry this one connection of flange plate to flange cover so we have to join this means 2 weld again has been provided so we have to see whether this safe or not.

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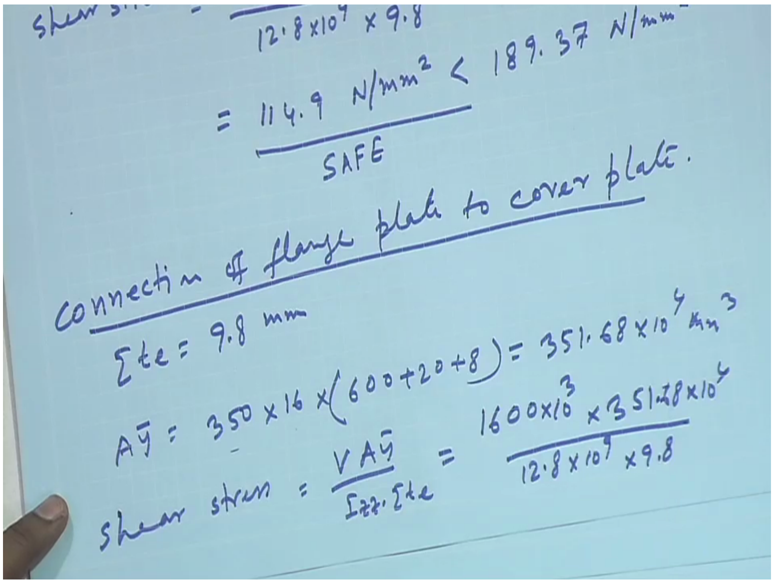

So it will be connection of flange plate to cover plate so if we see this in this case the summation of te will be same 9.8 mm if we use same size of the weld and Ay bar will be different Ay bar will be 350 into 16 this the area into 600 plus 20 plus 8 y bar, so this will be 351.68 into 10 to the power 4 millimetre cube. Now shear stress I can find out shear stress shear stress will be V into Ay bar by Izz into te is equal to if I calculate the value this will be 351.68 into 10 to the 4 by Izz 12.8 into 10 to the 9 into 9.8.

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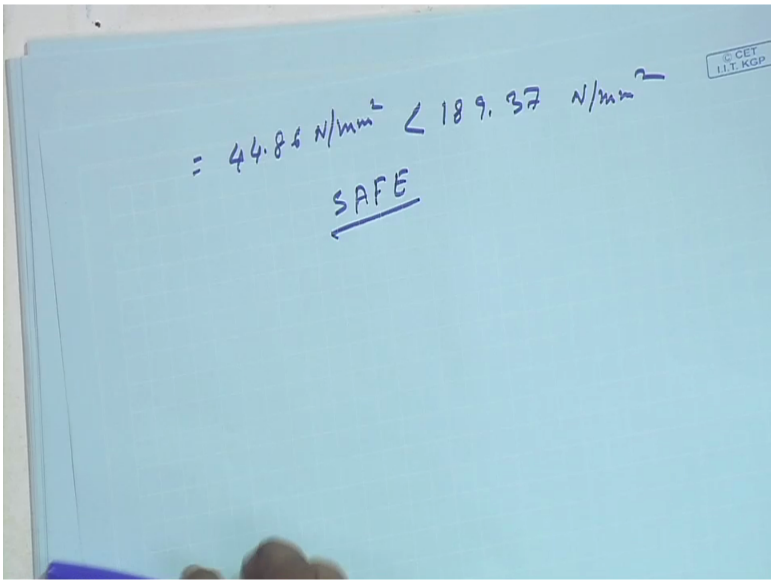

And this is after calculation this we are getting 44.86 newton per millimetre square and it is less than 189.37 newton per millimetre square. So this is also safe right so weld is safe that means what we have seen here is that the shear force of the connection was given and we have assumed certain size of the weld based on the minimum size and maximum size from the thickness and then we have calculated what will be the developed shear stress at the web plate and flange plate connection and flange plate and cover plate connection.

So the developed stress we have calculated and we know permissible stress is fu by root 3 gamma mw so we have seen that and the developed stress is less than the permissible stress therefore the joint is ok. This is how we can check the joint whether it is ok or not right. So in todays lecture what we have seen that two type of problem we have come across and we have seen how to calculate the design strength of the weld or how to design the weld joint and in first case we have seen how the distribution of the weld will be done for an angle section because in angle section cg distance is not at the centre so we have to make the weld connection in such a way that strength of the weld connection coincide with the cg of the joint. So this is what we have done, this is all for todays lecture, thank you.