Design of Steel Structures
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Module - 2
Connections
Lecture - 5
Design of Fillet and Butt Welds

Hello. Today, we will discuss about design of fillet and butt welds. So, while talking about design of fillet weld, we know how to calculate the strength of the fillet weld, because in last lecture we have seen the fillet weld strength can be calculated from this formula.

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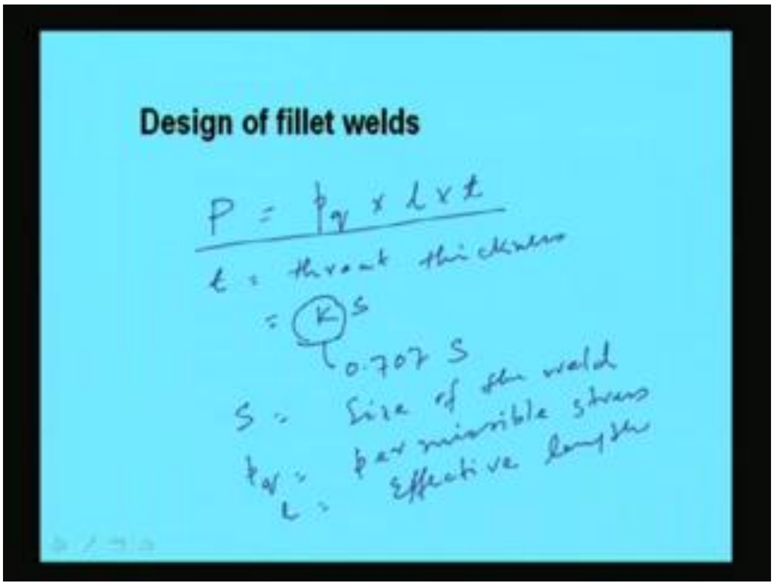

That is P q into l into t, where t is basically throat thickness. We know this is we have discussed in last lecture that is throat thickness which can be calculated from the size of the weld, where t can be written as K into S, where K we can find out from the table; in the last lecture we have discussed how to find out.

And in generally we take 0.7 or 0.707, something like this we use to take depending on the type of weld, where S is the size of the weld and P q is the permissible stress, and l is nothing but the effective length not the total length; mind it this is effective length. So, from this we could calculate the length of a weld joint.

So, when we are talking about design, design means basically we have to find out the length of a fillet weld; that means from this formula we can find out l is equal to P by P q into t. That means the length of the fillet weld requirement can be find out from this ratio, where P is the applied force and P q is the allowable stress in weld and t is the thickness, throat thickness. Thickness means throat thickness which is different from the size of the weld; we know how to calculate this thickness. Now with this concept we will try to design some plate.

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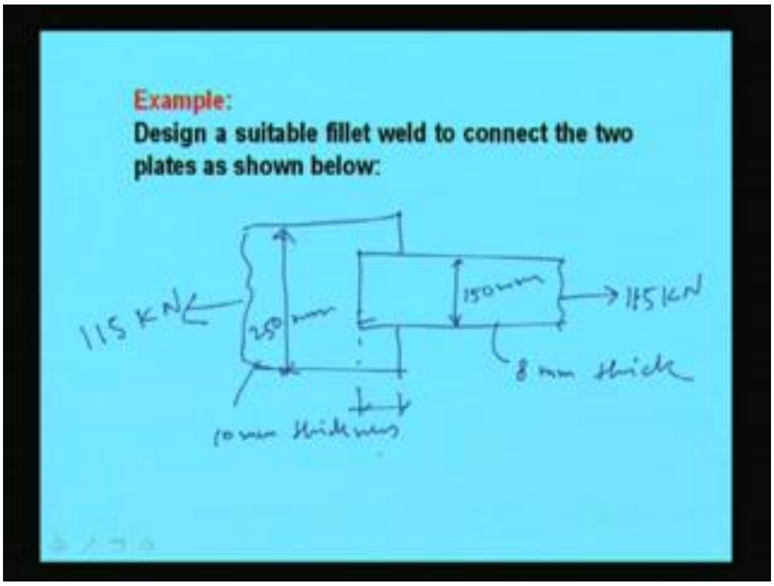

Suppose, we are considering this example; the design is suitable fillet weld to connect the two plates as shown below; say, suppose one plate is connected like this, and another plate is overlapped like this. Now so overlapping length is basically this much. Now this is having 115 Kilo Newton tensile force in this plate. So, we have to joint these two plate with the fillet weld.

Now the size of this plate is 150 millimeter width and thickness is 8 mm and, say, this is 250 millimeter width and 10 mm thickness of this plate. So, these are the two plates having 250 mm width and 10 mm thickness, and another plate is 150 mm width and 8 mm thickness that has to be connected through fillet weld joint which is carrying 115 Kilo Newton tensile force.

Now fillet weld where we will make? We can make at the periphery of this. So, we can provide weld in this; that means we have to find out the length of this weld. So, how much length will be required that we will calculate from the formula. Now available length we have from here to here. Now we will try to find out what is the length will be required to withstand this load.

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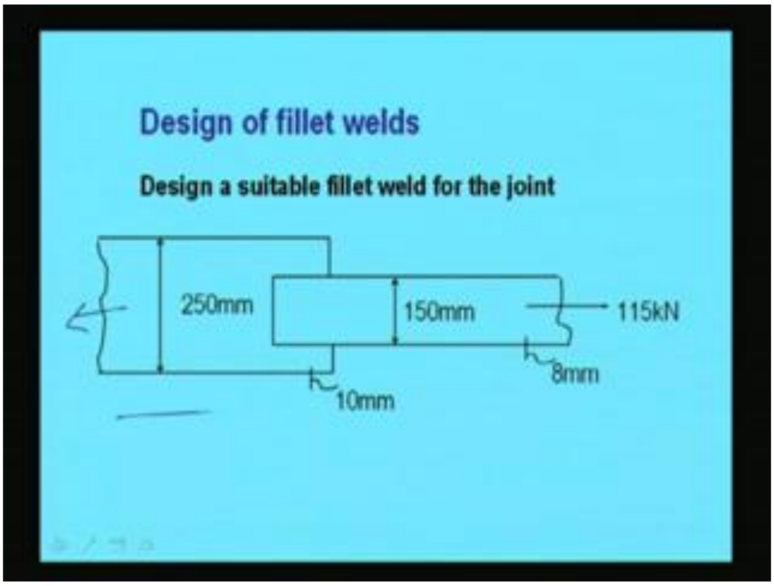

So, this is the data which has been given in the example; now we have to solve it.

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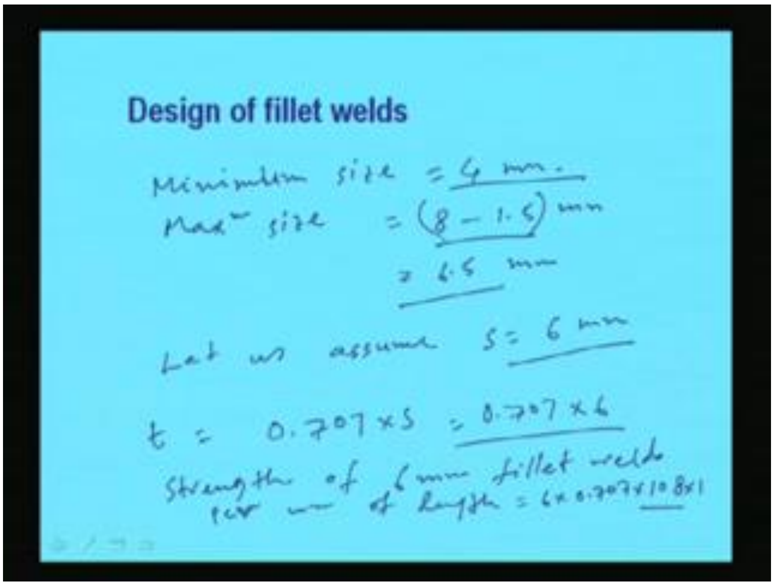

First is that minimum size of the fillet weld is given means from the codal provision; minimum size that we know this is 4 mm and maximum size we know. Maximum size we can use as 8 minus 1.5 mm because 8 is the thickness of the thinner plate. So, maximum size we can go up to this; that is coming 6.5. So, the size of the fillet weld should be in between 4 mm and 6.5 mm.

So, we have to consider some thickness with this range; say, let us assume or consider as size of the fillet weld as, say, 6 mm because this is in between 4 and 6.5 mm. So, in this way we can decide the size of the filled weld. Then the thickness will become t which is the throat thickness of filled weld that will become 0.707 into S; that means 0.707 into 6. So, this will become thickness.

So, the strength we can calculate; strength means strength of 6 mm fillet weld per millimeter of length. That we can find out which will become 6 into 0.707 into 108 which is the allowable stress in the fillet; so we can calculate the strength of the fillet weld per millimeter of length.

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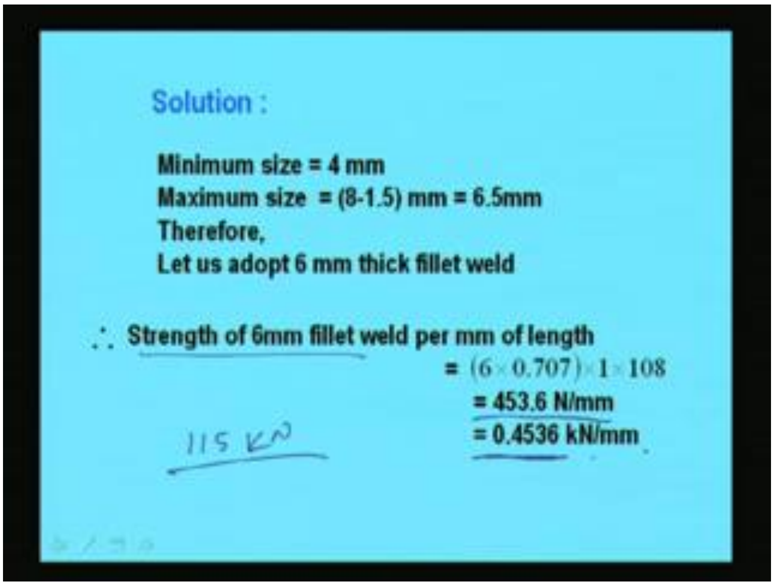

That means the strength is becoming this much 435.6 Newton per millimeter or 0.4536 Kilo Newton per millimeter. That means strength of the weld we are calculating per millimeter length as 0.4536 Kilo Newton. Now applied force is 115 Kilo Newton. So, the length we can find out from this formula.

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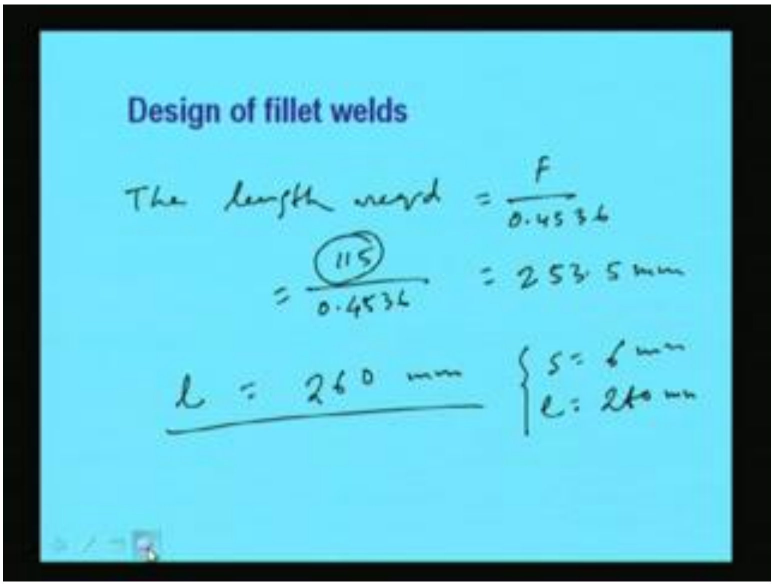

So, the effective length the length required will be force by the strength. Strength means 0.4536; that means 115 was the applied force by 0.4536 that is coming 253.5 mm. So, we can provide, say, length as say 260 mm. So, in this way the length required to withstand the load of 115 Kilo Newton will become 260 millimeter. So, in this way we can design the fillet weld; that means what is the design parameter we are getting? That the size of the fillet weld would be 6 mm, and the length will be 260 mm. So, with this we have to design

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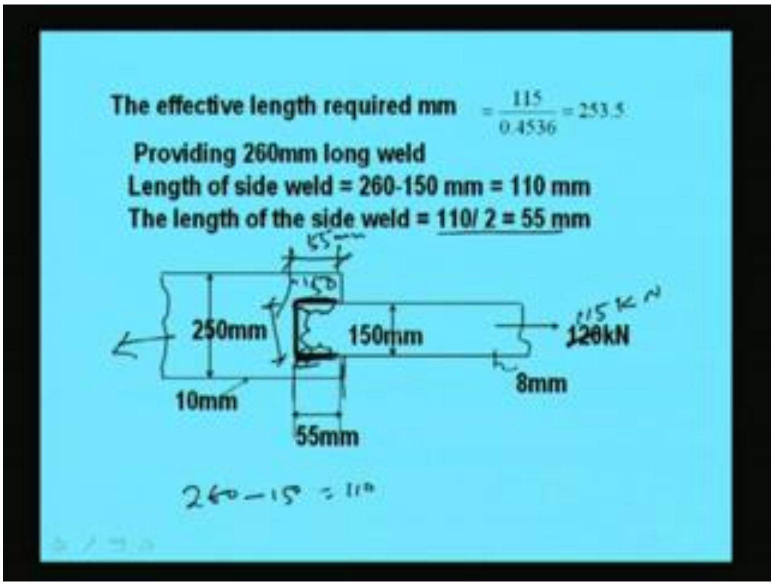

So, if we design it will look like this, say, the plate is there. So, we can provide, say, this length is becoming 150. So, 150 means we have provided 260 mm length; so 260 minus 150 that is 110. So, 110 millimeter length has to provide in this and in this area. So, that means 110 by 2 which is becoming 55 mm. So, the length of the side weld will be 110 by 2 is equal to 55 mm.

So, here I have to provide 55 and here I have to provide 55 mm. So, in this way we can decide the length; that means after joining the two load to withstand this 115 Kilo Newton load, we have to provide the weld in this periphery with having 260 millimeter length total where this 150 will be in this area. And this area will be 55, and this area will be 55. So, in this way we can make the things, okay. Now another example we will see which is different from the previous one.

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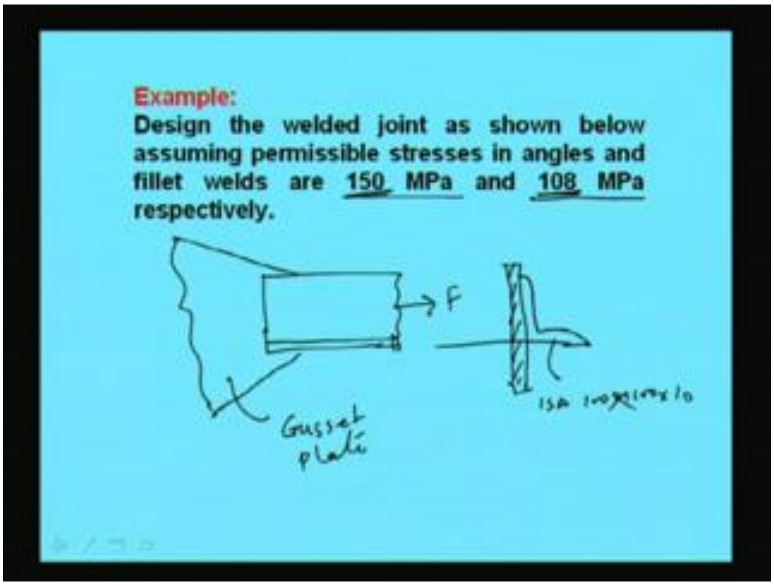

So, the example is design the welded joint as shown below assuming permissible stress in angles and fillet welds are 150 Mpa and 108 Mpa respectively. So, permissible stress in angles will be 150 and in fillet will be 108. So, the details of the joining are like this, say, the plate is having force; say, this is now the gusset plate and this is the angle. Now if we see this is the gusset plate. This angle size is ISA 100 by 100 by 10. Now the thickness of this gusset plate will become, say 10 mm.

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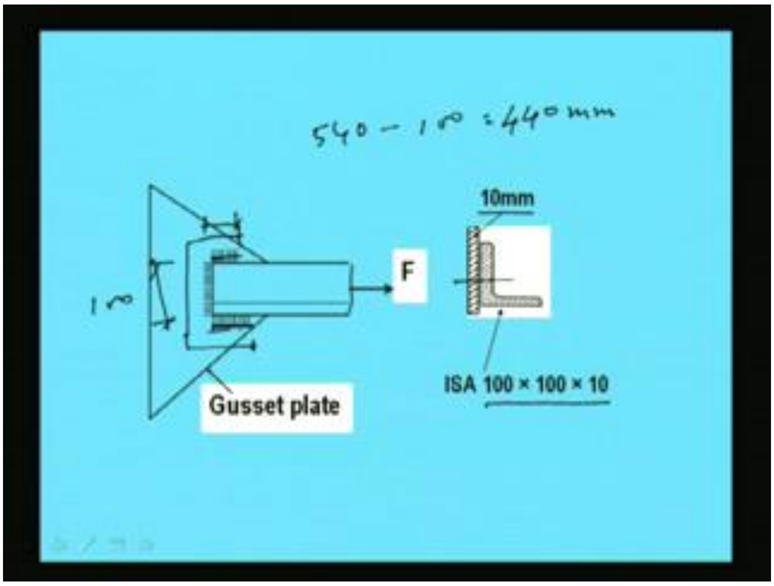

So, we can see the figure that we have a gusset plate. This angle has to be joined with this which is thickness of 10 mm. The angle size is 100 by 100 by 10, and it has to take the maximum load and the fillet weld has to be made in this way; means in this periphery the fillet weld will be. So, like in earlier case the minimum size we know.

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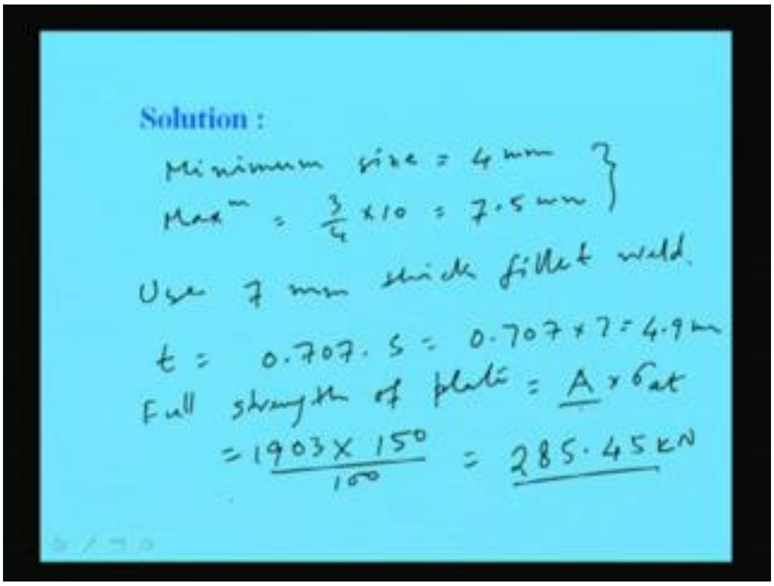

Minimum size which is required to provide is 4 mm as per the codal provision, and maximum size will be three-fourth of the thickness that is 7.5 mm. So, we can use 7 mm thickness; that means in between of these two maximum and minimum. So, 7 mm thick fillet weld that we will use, okay. So, the throat thickness will become 0.707 into S; that means 0.707 into 7. That means around 4.9 mm, right.

Now full strength of the plate; plate means that angle plate. This will be basically A into area of the angle into allowable stress. So, that is becoming from the IS code we will get IS code. The angle details have been given in SP 6, where we will get for this size of 100 by 100 by 10 angle. Means the cross sectional area of that angle will become 1903 millimeter square.

So, this is the area of that angle and allowable stress has been given as 150 Mpa. So, this will be the force means full strength of the plate. So, after multiplication of this will become 285.45 Kilo Newton. So, the total strength of the plate is this. So, this much strength can be carried by the plate. The plate can carry this much strength. Now we have to make a design of the fillet weld, so that this much strength can carry by the weld also. Then only we can optimize; means we can use the full strength of the plate as well as the full strength of the weld. So, in this way we have to calculate.

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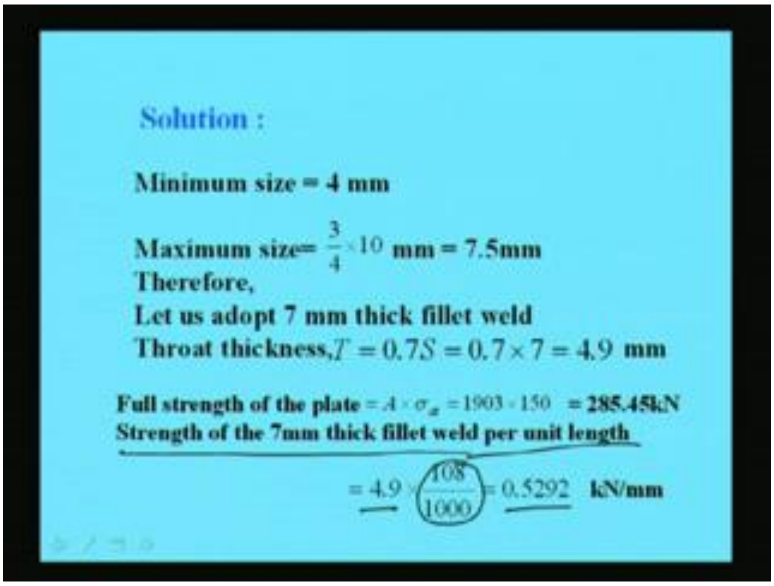

So, strength of the 7 millimeter thick fillet weld per unit length also we can calculate. That will become 4.9; that is the throat thickness, and this is the allowable stress of the fillet weld. So, strength will become 0.5292 Kilo Newton per millimeter for the 7 millimeter thick fillet weld. So, in this way we can calculate. Now what we will do? We will have to find out effective length of the weld from this. The capacity of the weld has to be 285.45 Kilo Newton. So, this by this will become the length of the required weld.

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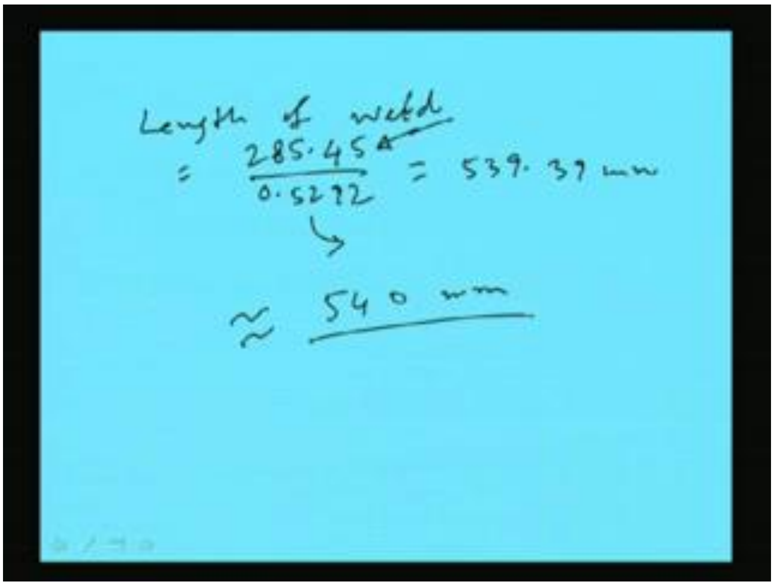

So, length of the weld will become 285.45 by 0.5292. This is the strength of weld per millimeter length, and this is the strength of the plate which can be carried by the angle. So, this is coming 539.39 millimeter; that means we can use 540 millimeter. So, 540 millimeter length has to be provided. Now if we see that 540 millimeter will be total this; this length has to be 540 millimeter.

Out of 540, this is anyway we are going to provide. So, this is becoming 100. So, 540 minus 100 have to be provided by these two areas. And these two area means these two length has to be made in such a way that the resultant of this fillet weld; the force which is coming due to fillet weld has to pass through the CG of the angle. So, this 540 means 540 minus 100 which is becoming 440. So, 440 millimeter length has to be provided for this area and this area. So, these two lengths have to be made in such a way that the resultant of fillet weld will pass through the CG of the angle. So, in this way we have to make it.

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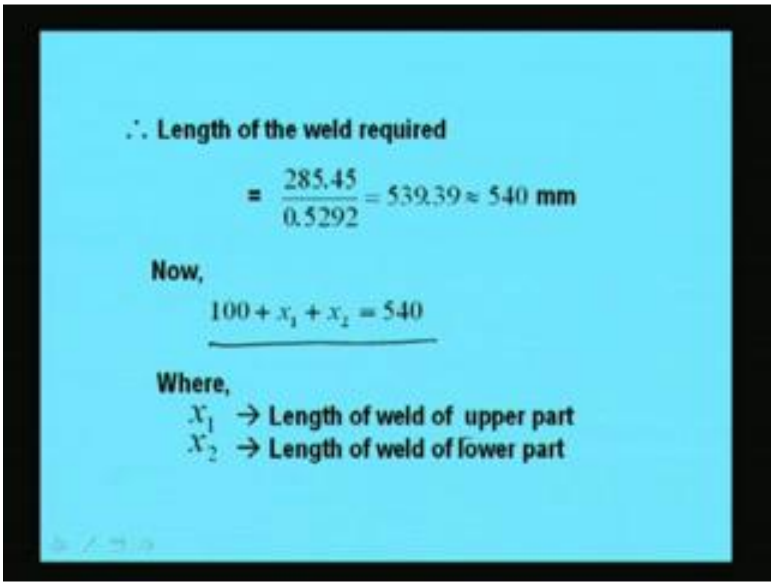

So, what I was discussing that 100 plus x 1 plus x 2 will become 540, where x 1 and x 2 has the length of upper part and lower part of the plate, where x 1 is the length of weld of upper part, and x 2 is the length of weld of lower part.

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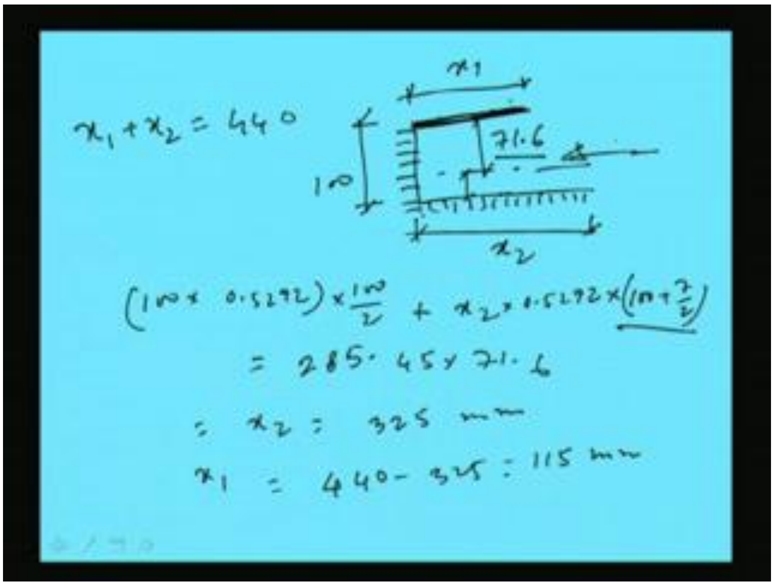

So, if we see so the plate which is going on, say, this is the x 1 let us consider and, say, this is x 2, and this is 100 already we have, okay. So, basically x 1 plus x 2 will become 440. Now it has to pass through the CG of the angle, right. Now from SP 6, we know the distance of this, and distance of this that is CG. So, this is basically we obtain from the code SP 6.

So, this CG distance from upper side will be 71.6 mm, right. So, if we take moment about the CG of the weld about this part, then what will happen? We will get 100 into 0.5292 into 100 by 2. This is due to this weld welding this area plus x 2 into 0.5292 into 100 plus 7 by 2. This is this area; means we are taking moment about this upper part. We are taking moment about upper part.

So, x 2 will be x 2 into this into 100 plus 7 by 2. This is the distance from here 100 plus 7 by 2 is the CG of this weld. So, this will be the total moment about this x 1 about the upper part. This has to be equal to the force 285.45 into 71.6, because the force in the plate is acting through the CG of its, okay, which is at 71.6 from upper side. So, this has to be equal. So, in this way we can find out x 2.

After calculating all these, we will get x 2 as 325 mm; that means x 1 we will get 440 minus 325; that means 115 mm. So, in this way we can find out the length of x 1 and x 2; that means the length we cannot make equal which we have done earlier cases, because this is an angle section, and in case of angle section, the CG is at 71.6 mm for this particular section. So, we cannot consider equal distance in upper and lower part. So, the distance has to be distributed in such a way that the CG of whole welding has to pass through the CG of the plate. So, in this way we have to calculate.

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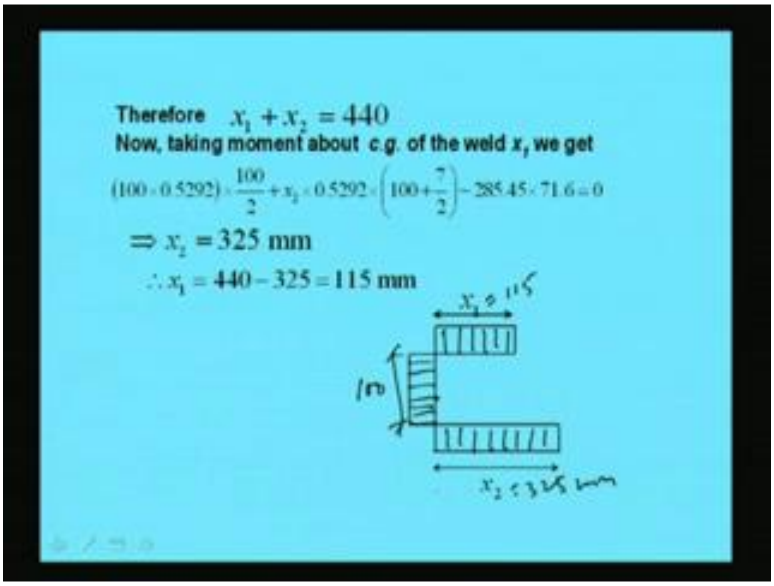

So, that is what we have calculated. So, x 1 we are going to get 115 which is welded here, and x 2 we are going to find as 325 mm which is in this side, and this is along its height. This is 100 mm which was fixed due to its dimension of the angle. So, in this way we can find out the welding length as well as the distribution of length in around the plate. So, in this way we have to design. So, I hope like this type of problem.

Now those who are listening can understand means can calculate at their own and can design at their own. In fact, case to case it will vary; we have to see what type of problems it is, and accordingly, we have to design the weld, so that it becomes perfect; the joint become perfect from our point of view. Now we will discuss about the butt welding. We know how to design and how calculate the strength of fillet weld. Now we will see how to design and how to calculate the strength of butt welding.

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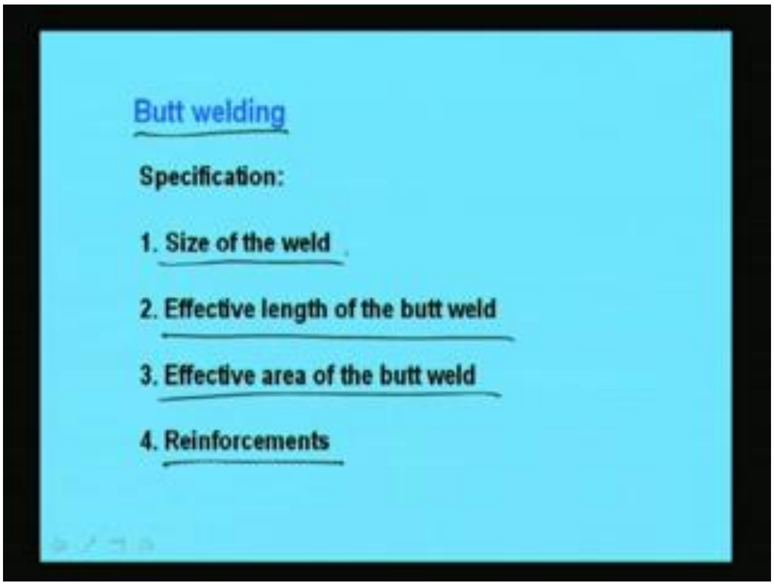

Before going to discuss about details of the butt welding, we have to know some specifications like what is the size of weld in case of but; what is it and what is the effective length of the butt weld? That we have to know, then what is the effective area of the butt weld and its reinforcement? So, these four parameters we have to know, size of the weld, then effective length of the butt weld, then effective area of the butt weld and then reinforcements.

Basically in case of butt weld, a complete penetration of weld metal can be ensured in case of double V double U double J and double bevel joint. So, complete penetration we can make with the use of double V double U or double J or bevel joint.

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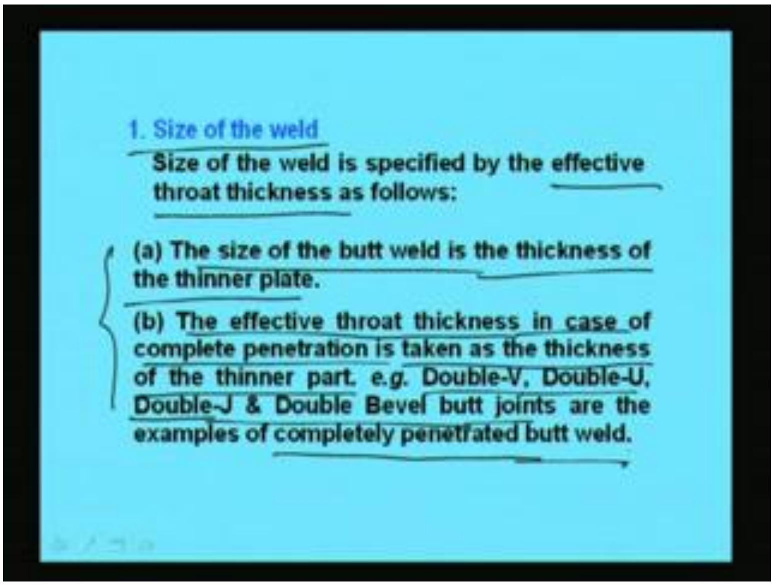

So, when we are seeing this size of the weld, so how to find out the size of the weld? So, as per the codal provision, the size of the weld is specified by the effective throat thickness which is given below, effective throat thickness how to find it? The size of butt weld is the thickness of the thinner plate; that means the size of the butt weld can be assumed as the thickness of the thinner plate where we are going to joint; this is one.

Another is the effective throat thickness; in case of complete penetration is taken as the thickness of the thinner part; that means effective throat thickness will be equal to the thickness of the thinner part if complete penetration is occurred. That means complete penetration when it will occur? If we use double V double U double J or double bevel butt joints. These are the type of joints in which we can assume that it is a completely penetrated butt weld. And in this type of joint, we can use the throat thickness as the thickness of the thinner part.

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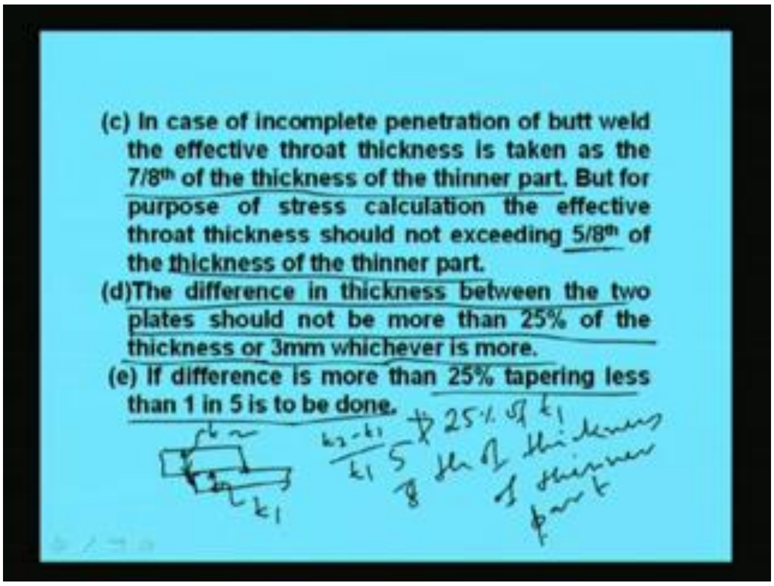

But in case of incomplete penetration of butt weld, the effective throat thickness is taken as the seven-eighth of the thickness of the thinner part. So, when a single butt joint we are using; that means when the penetration is incomplete; in that case the effective throat thickness will be calculated as seven-eight th of the thickness of the thinner part. Again for the purpose of stress calculation, the effective throat thickness should not exceed five-eighth of the thickness of the thinner part.

That means when we are going to calculate the strength of the butt weld, we will consider five-eighth of thickness of the thinner part. I think it is clear now that for incomplete penetration; the butt weld throat thickness will be taken as five-eighth of the thickness of thinner part for the calculation of strength. And seven-eighth we can calculate seven-eighth of the thickness of the thinner part as the size of the weld we can assume.

Now some certain other points has to also be remembered; that is the difference in thickness between two plates should not be more than 25 percent of the thickness or 3 mm whichever is more; that means difference of two plate when we are going to join a plate with another plate. So, it has a thickness, say t 1; this has a thickness, say, t 2 and this is a t 1.

So, difference in thickness between the two plates should not be more than 25 percent of the thickness; that means t 2 minus t 1 by t 1 should not be greater than 25 percent of, say, t 1. So, that has to be ensured or 3 mm whichever is more. Of course, if this is becoming, say, 2 mm, then we have to consider 3 mm. So, difference should not be more than this, okay. And if the difference is more than 25 percent tapering less than one in five is to be done.

Generally, we use to make tapering of one in five; in this ratio we used to make tapering. But if the difference is more than tapering, it has to be less 25 percent, then tapering less than one in five is to be done. So, tapering has to be made accordingly, okay. Now if we draw this butt weld how it looks like let us see.

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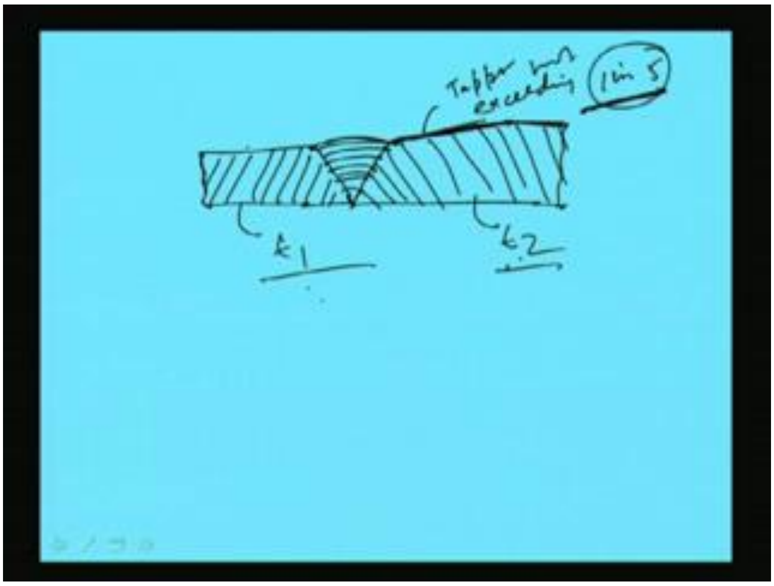

Say, one plate is something like this. Now this can be joined like this. So, this is the welding place, and this tapering will be not exceeding one in five. So, this tapering should not exceed one in five in this ratio. So, this is how the joint look like, say this is one plate and another plate is this; that means this is the plate. Now we are tapering in this way, then the butt weld is given here.

And this is the thickness means thinner part, say t 1, and this is the thickness of the thicker one, say t 2. So, in this way now if this difference is more than 25 percent, then this tapering has to be lessened. So, that has to change from one in five.

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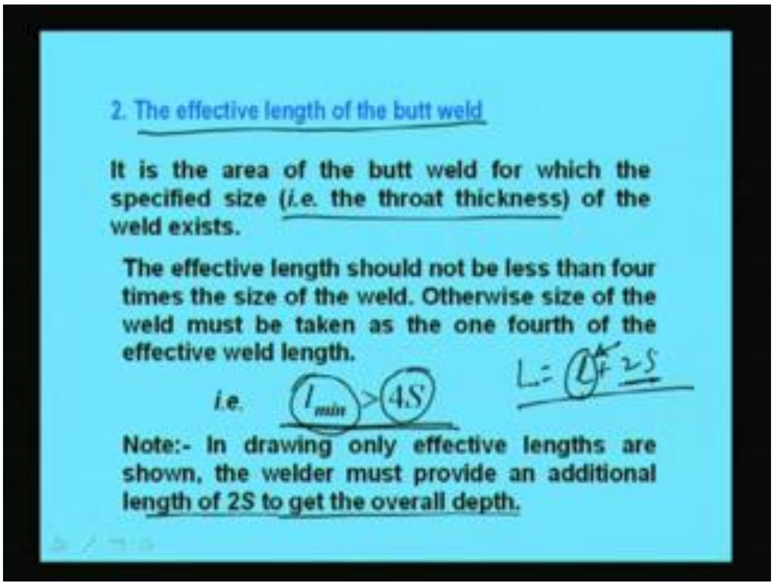

Now another parameter which is important is the effective length of butt weld. Basically, it is the area of the butt weld for which the specified size of the weld exists. That means size is the throat thickness. So, the effective length should not be less than four times the size of the weld. So, this is the minimum effective length of the butt weld should be greater than 4 into S, where S is the size of the butt weld; otherwise, size of the weld must be taken as the one-fourth of the effective weld.

That means if our length is restricted if length we cannot increase, then we have to make the size accordingly at l minimum by 4. Means we have to reduce the size; this is important to note that in drawing only effective lengths are shown. The welder must provide an additional length of 2 S to get the overall depth; that means overall length is basically L plus 2 S, where L is the effective length, and capital L is the overall length, and S is the size of the butt weld.

But in the drawing we will show only this, effective length we will show, but welder has to weld with additional 2 S length. So, basically when it is written L; that means you have to provide L plus 2 S. That is the usual convention we use to make in design and drawing.

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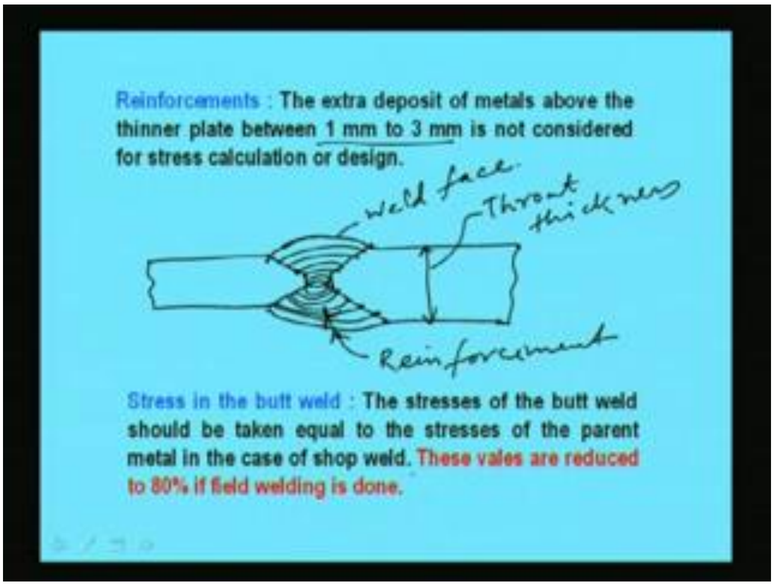

Now another parameter is called reinforcement. Basically, the extra deposit of metals above the thinner plate between one millimeter to three millimeter is not considered for stress calculation or design. So, this is basically called extra deposit basically. Now if we see in the picture how it looks like let us see; say, one plate is given like this which has to be welded by the butt, and the plate is this which is like this.

Now basically this is called throat thickness, okay. Now we have to provide, say, double V or double U type of butt weld if you provide. So, it will look like this. So, it will look like this, right. Now this is the weld phase, and this is the reinforcement. So, reinforcement basically represents these things; this is the reinforcement. So, the extra deposit of metal above the thinner plate between one millimeter to three millimeter is not considered for stress calculation which is basically is called reinforcement.

And now the stress, stress in the butt weld. What is the stress? So, stress can be calculated means which has been given in the code that is stress of butt weld should be taken equal to stress of the parent metal in the case of shop weld. That means the butt weld what we are providing that we have to find out the stress from which we are providing; that means the stress in parent metal will be equal to the stress in butt weld when in case of shop weld.

So, for the shop weld the stress in butt weld will be the same as the stress in the parent metal. And these values can be reduced up to 80 percent if the field welding is done. So, for case of butt weld whether it is shop weld or field weld we have to know. If it is shop weld, then the stress will be equal to the parent metal stress. If it is field weld, then 80 percent of that will be the allowable stress. This will be clear if we go through one small example, say, how to design a butt weld.

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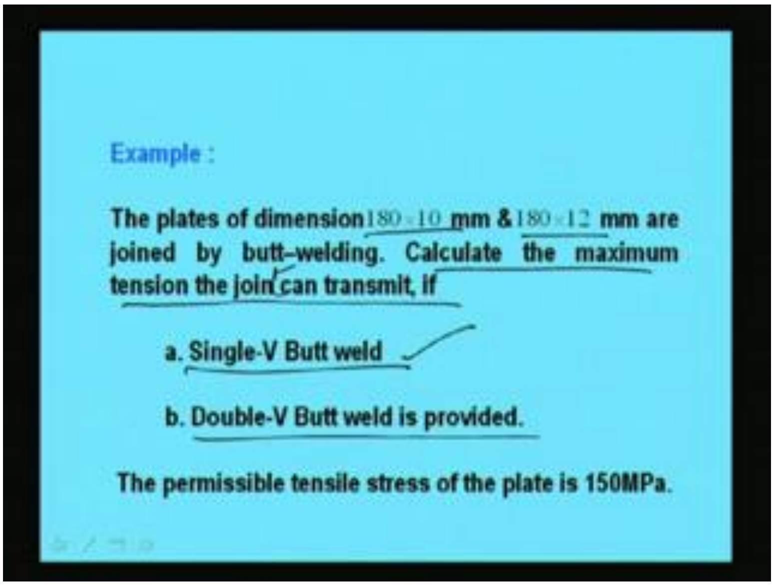

The two plates of dimension 180 by 10 and 180 by 12 mm are to be joined by the butt weld. Now we have to calculate the maximum tension of the joint; for tension the joint can carry using single-V butt weld and double-V butt weld. So, if we provide single-V butt weld, what will be the maximum tension it can carry by the joint, and if we provide double-V butt joint, what will be the tension it can carry, assuming the permissible tensile stress of the plate as 150 Mpa.

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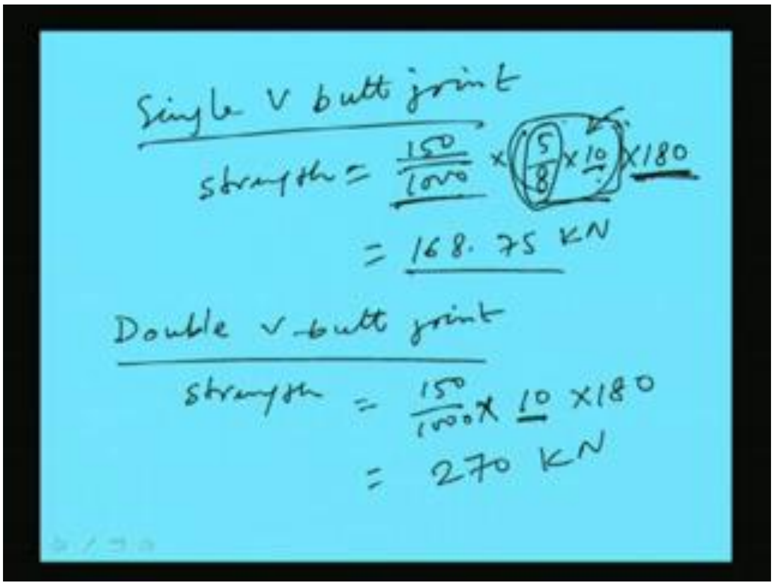

So, for the solution what we will do? First, we will calculate the strength of single-V butt joint. So, strength of single-V butt joint will be for single-V butt joint. So, strength will be permissible stress is 150. 150 into the thickness of the thinner plate is 10 mm. Thickness of the thinner plate is 10 mm. So, we can consider the size of the butt weld as 10 mm. And in case of single-V butt joint as we have seen from the codal provision that it will be 5 8 by 10, okay. And the width is 180.

So, in this case it will be 168.75 Kilo Newton. So, I think now it is clear that how to calculate the strength of a single-V butt joint. First is the strength of the single-V butt joint when we are going to calculate; we have to know what is the thickness of the butt weld. The thickness of the butt weld will be the equal to the thinner plate thickness. So, thinner plate thickness is in this case 10 mm.

So, in case of single V this will be. So, stress calculation will be five-eighth of that. And for size it will be seven-eighth of that, so five-eighth of 10. So, this is the effective thickness of the butt weld, and this is the width or length whatever you say; we used to calculate the area, this is the 180. Plate width is 180, and this is the permissible stress 150 Mpa of the plate. So, from this we can calculate the strength of the single-V butt joint which is coming 168.75 Kilo Newton.

For double-V butt joint what will happen? So, similarly the strength we can calculate. Strength will be permissible stress into the thickness of the thinner part that is 10; for V butt joint double-V butt joint, the penetration is complete. Complete penetration will happen. So, thickness will be equal to the thickness of the thinner plate into 180. So, from this we can find out 270 Kilo Newton.

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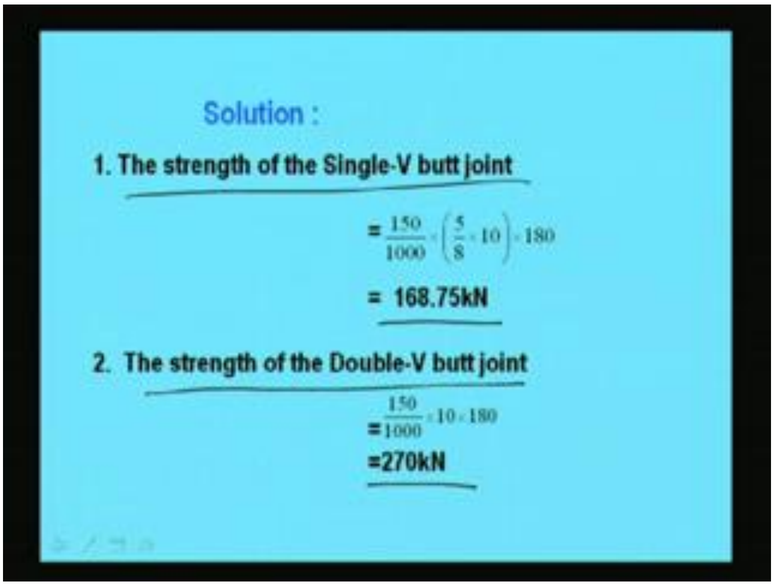

So, in this way we can find out the strength of the single-V butt joint as 168.75 Kilo Newton. And strength of the double-V butt joint can be calculated as 270 Kilo Newton.

So, what we have seen that how to calculate the strength of a single-V butt joint or double-V butt joint. That means the strength of a joint using butt welding can be calculated. So, that example we have seen. Here we will see how to design.

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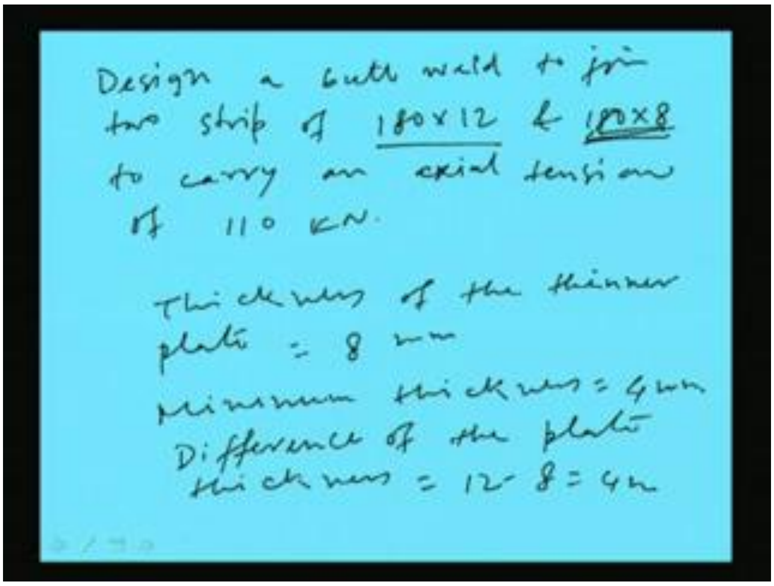

So, for design of a butt joint say let us consider one problem that, say, design a butt weld to join two strip of 180 by 12 and 180 by 8. So, the two plate size is this 180 by 12 and 180 by 8 mm thickness to carry an axial tension of 110 Kilo Newton. So, what we will do now? So, we have to first find out what is the thickness of the thinner plate. So, thickness of the thinner plate will be 8 mm. This is given in the question and minimum thickness we know has to provide that is 4 mm. Now the difference of plate thickness, now let us see what is the difference, because accordingly the slope has to be made one in five or lesser than that; that we have to make it. So, difference of the plate thickness will become 2 L minus 8 is equal to 4 mm.

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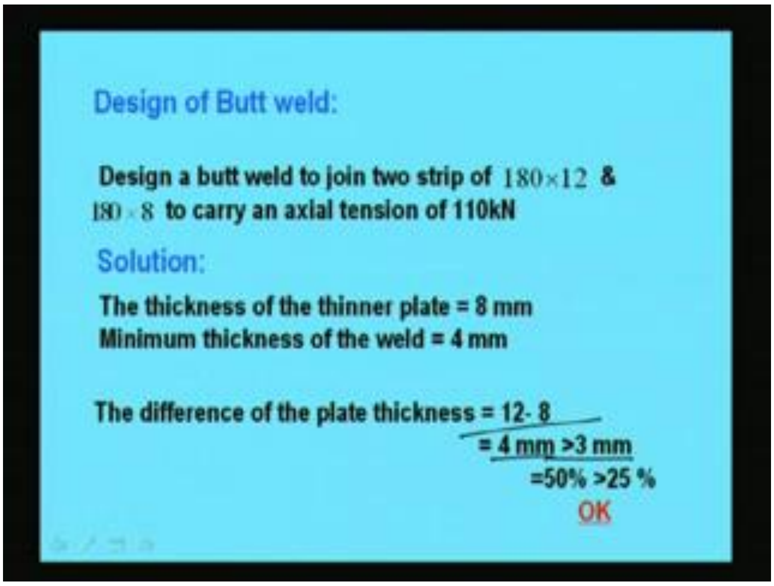

So, the difference is becoming 4 mm which is greater than 3 mm, okay. What we have seen from the codal provision as that difference will be how much. This is 50 percent; that means this is greater than 25 percent. So, it is okay. So, accordingly we have to make it, right.

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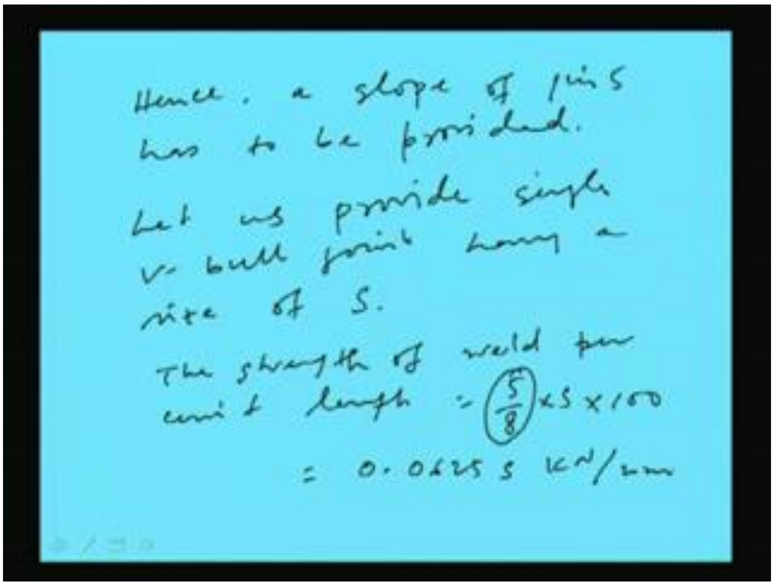

So, let us provide hence a slope of one in five has to be provided. So, now whether we will go for single V or double V. So, that we have to see. So, let us provide single-V butt joint having a size of, say, S. Now the strength, what will be the strength? Now the strength of weld per unit length will be. So, because of single V, this will become 5 8 of S into 100. So, this will become, say, 0.0625 S Kilo Newton per unit.

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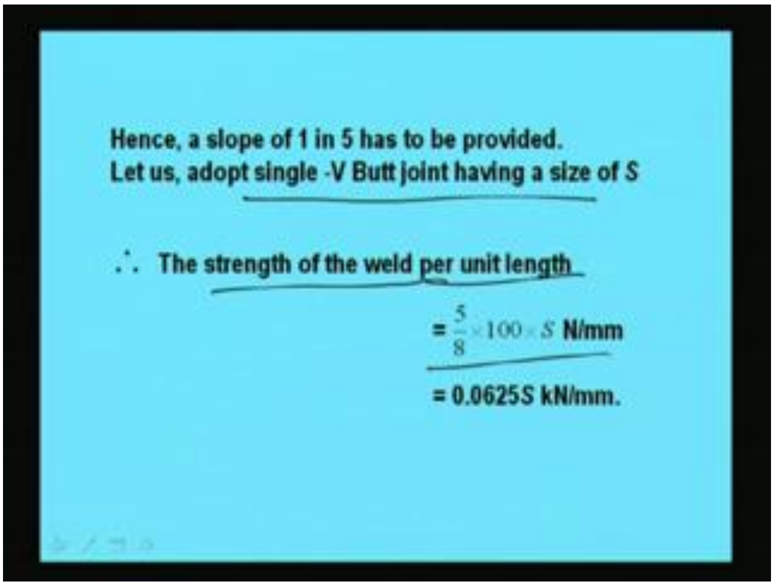

So, that means using single-V butt joint we are going to get the strength of the weld per unit length as this 5 by 8 into 100 into S which is coming 0.0625 S Kilo Newton per meter.

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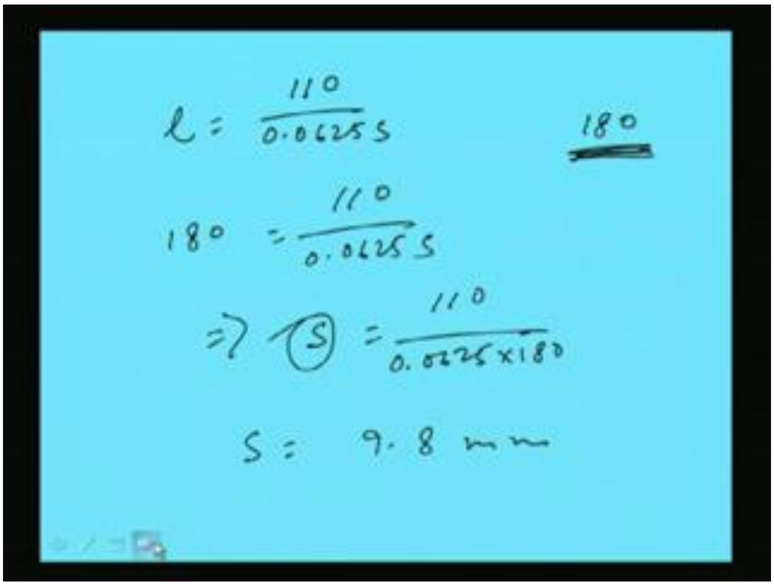

So, the required length will be becoming 110 Kilo Newton was there. So, 110 by 0.0625 S, okay and here we have seen the maximum length of the weld was 180. So, maximum we can provide 180, right. So, 180 will be equal to 110 by 0.0625 into S. So, from this I can find out the value of S which is becoming 110 by 0.0625 into 180, because 180 is the maximum length which we can provide. So, length is fixed; we can find out the value of S, right. So, from this we can find out S as 9.8 mm.

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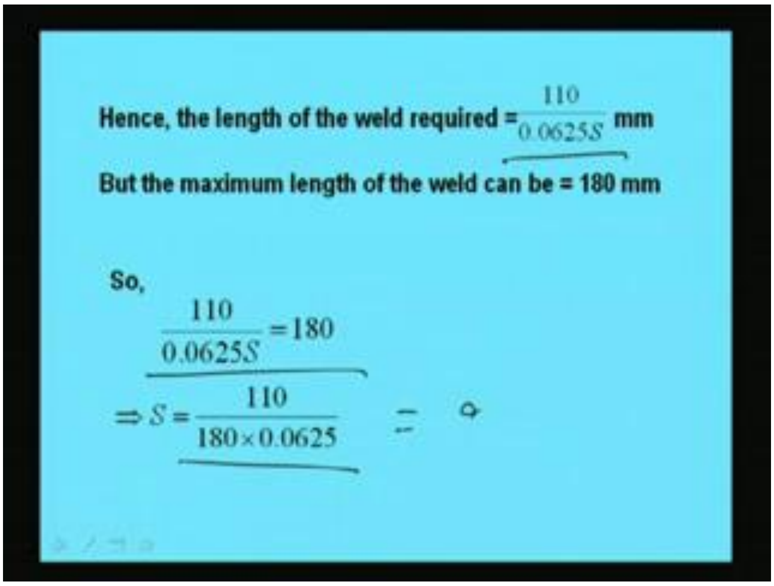

So, in this way we can calculate of the size of the weld which is becoming 9.8 mm. Now what we are seeing that 9.8 mm it is becoming; that means which is greater than the maximum size of the weld, because we have seen the maximum size of weld we can provide as 8 mm as the thickness of the thinner plate is 8 mm.

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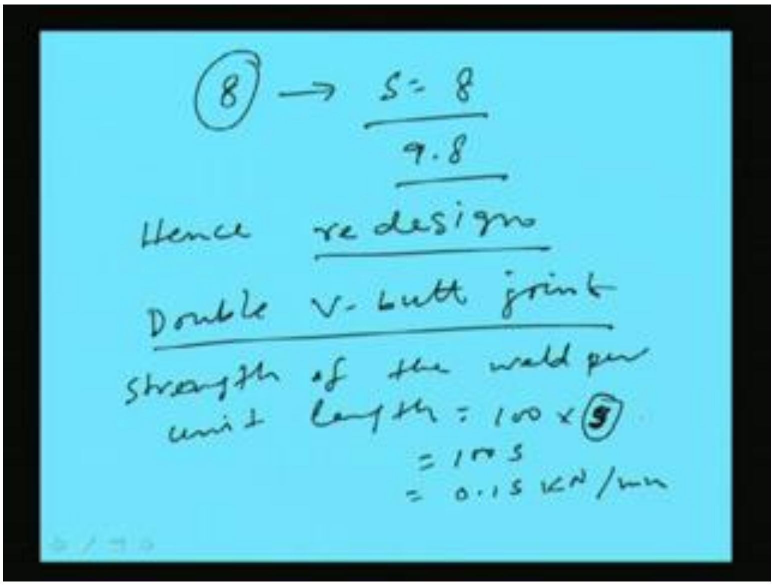

So, the maximum size of the weld can be 8 mm maximum, but we need 9.8 mm. So, we need to redesign it. So, go for redesign. Redesign means, say, we have used single-V butt joint. Now we will use, say, double-V butt joint. So, if we use double-V butt joint, what will happen? The strength will increase. So, strength of the weld per unit length will become 100 into S. That means 100 S; that means 0.1 S Kilo Newton per millimeter. So, that means here we are not going to multiply 5 by 8 because of double-V butt joint. So, thickness is becoming equal to the thickness of the thinner plate. So, in this way we can make it

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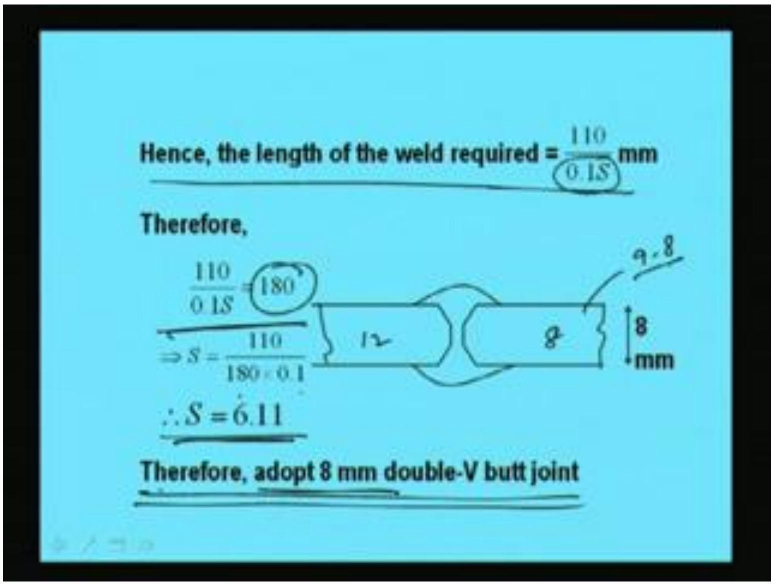

So, the length of the weld required will be 110 by 0.1 S, right, because 0.1 S is the strength of the butt weld per millimeter length and maximum length can be used as this one 180. So, equating these two, we will be getting S as 110 by 180 into 0.1; that is becoming 6.11 mm. That means we can adopt that 8 mm double-V butt joint. So, in this way we can make it. So, in summary if we see what we are going to do that the two plates are there with having 8 mm thickness of one plate and 12 mm thickness of another plate.

So, for single-V butt joint we are seeing that we have to go the size of the weld beyond 8 mm which is coming 9.8 mm. Now we have to go for redesign because of the excess size of the weld. So, we have gone for double-V butt joint. So, if we use double-V butt joint, we will see the required thickness is 6.11. Size of the weld is 6.11 if we go for double-V butt joint. So, we can adopt, say, 8 mm which will be more than 6.11. So, it can carry that much load. So, in this way we can design the butt joint. So, this is how we can design a butt joint for two plates.

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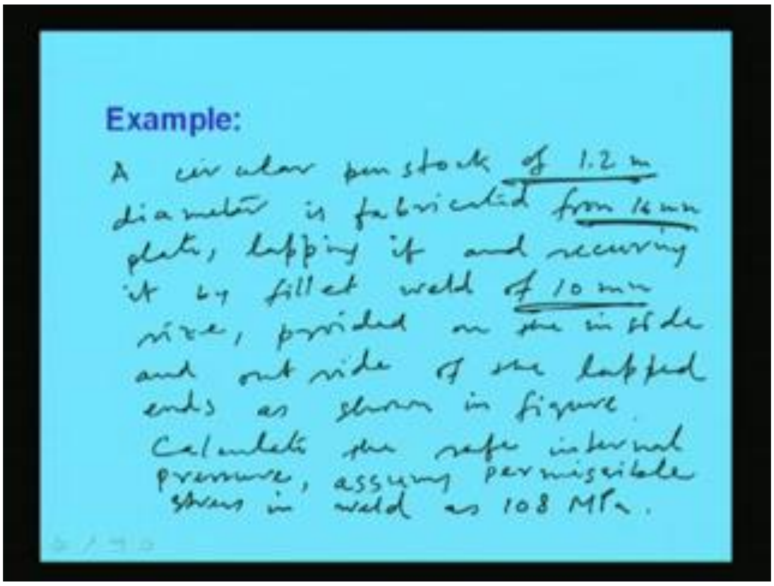

Now I am going through one example to see how to find out the pressure on a penstock. A circular penstock of 1.2 meter diameter is fabricated from 16 mm plate lapping it and securing it by fillet welds of 10 mm size. So, filled weld size is 10 mm, diameter of the penstock is 1.2 meter, and plate thickness is 16 mm provided on the inside and outside of the lap ends as shown in the figure; figure I am going to show. Now calculate the safe internal pressure assuming permissible stress in weld as 108 Mpa.

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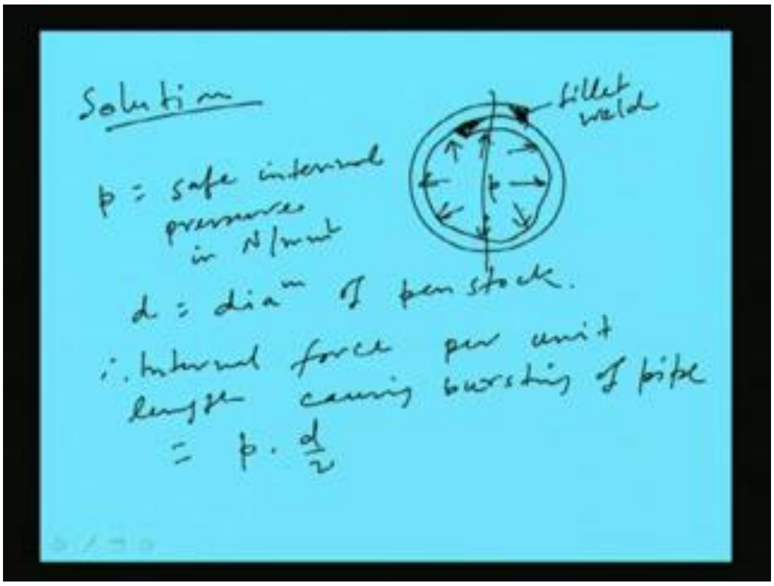

Figure is something like this. So, internal pressure will be there. So, we have to find out what is the pressure it can carry. This is fillet weld. So, to make the solution, first we have to find out the internal force and the force which can carry by the fillet weld. Now, say, assume P as safe internal pressure in Newton per millimeter square. So, P is safe internal pressure which we have to find out and d is diameter of the penstock. So, the internal pressure means internal force. Internal force per unit length causing bursting of pipe is equal to p into d by 2 because d is the diameter.

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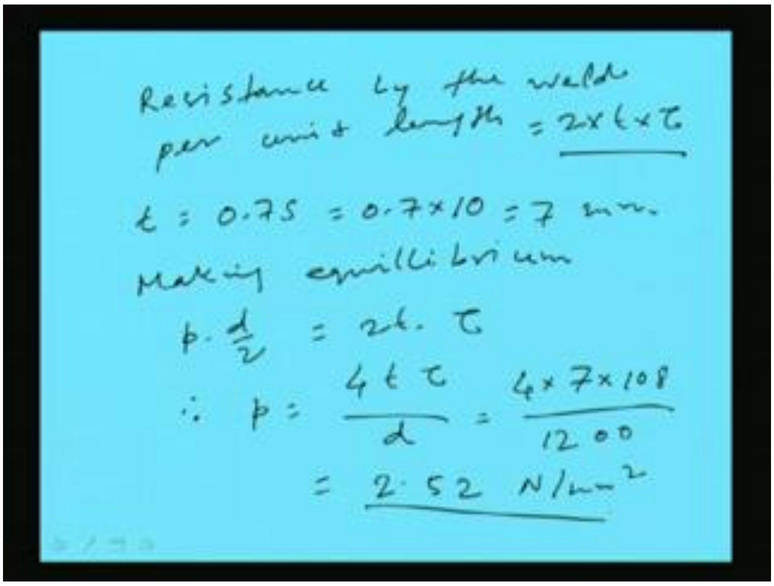

So, p into d by 2 will be the internal force and the resistance by the weld which has to be calculated; weld per unit length will become 2 into t into tau. So, this will become 2 into t into tau where t is basically the throat thickness which is 0.7 S. So, 0.7 into S means basically size of the fillet weld which will be maximum 10 means we can assume maximum this. So, this is becoming 7 mm.

So, making equilibrium; equilibrium means the internal force will be equal to the force resistant. So, making equilibrium we can say p into d by 2 is equal to 2 t into tau. So, p will become 4 t tau by d. So, 4 into t means 7 and the allowable stress in the weld is tau which is 108 in this case and d is 1.2 meter; that means 1200 mm. So, this is becoming 2.52 Newton per millimeter square. So, the internal pressure which can be carried by the penstock will become 2.52 Newton per millimeter square. So, in this way we can find out the safe internal pressure from this penstock.

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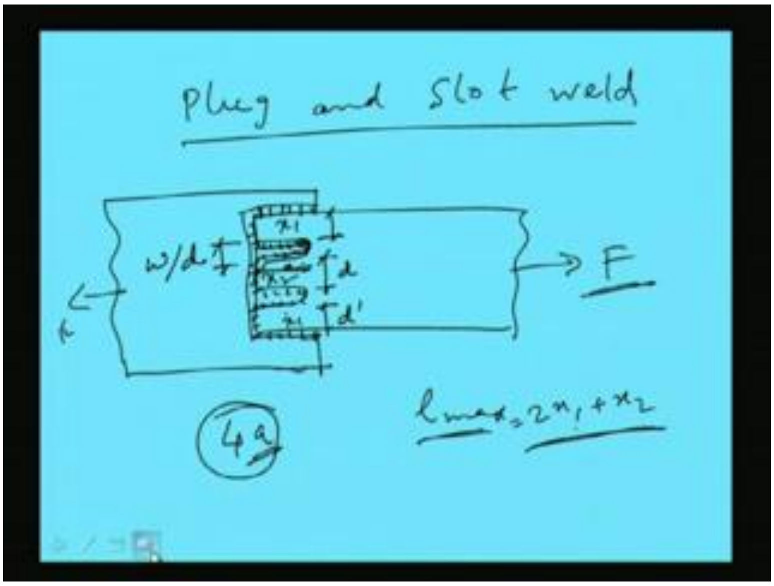

Now another type of joint we used to do which is called plug and slot weld; what is this? That we know, say, one plate is like this and, say, another plate is like this which has to be joined with some load. Now if force is becoming more, then length of the weld will become more. Length of the weld will become more. But we cannot go beyond a certain length because this length is fixed. Maximum length will be, say, this is x 1, and this is x 2.

So, this is x 1. So, maximum length is becoming 2 x 1 plus x 2. So, with a particular load sometimes the maximum length become more than this 2 x 1 plus x 2. So, in that case how to accommodate it; that means welding length whatever it is coming 2 x 1 plus x 2, how to accommodate more than this length? So, this can be accommodated through some plug through the interaction of plug and slot weld.

That we are cutting some portion and we are making like this. That means welding is done through this area and again we are going through this just to increase the length of welding. So, what we are doing? We are using this one which is called plug or slot weld, right. So, now this is called the width of the plug or slot width or we can call d also diameter of because this is rounded, so diameter of plug.

This is called diameter of plug or width of plug, and this is basically the edge distance, and this is the distance between two slots. So, this distance is basically called d. So, this distance, say, d; this distance is, say, suppose another type of d dash. So, in this way we can introduce. So, in this case length will become this much plus this much. So, we are introducing some more length; say, if it is a, then a plus a plus a plus a plus a means 4 a, extra 4 a we are introducing.

So, on the basis of requirement of the length for carrying a particular load, we have to decide what should be the length of a and what should be the number of plug or slot, on that basis we have to decide.

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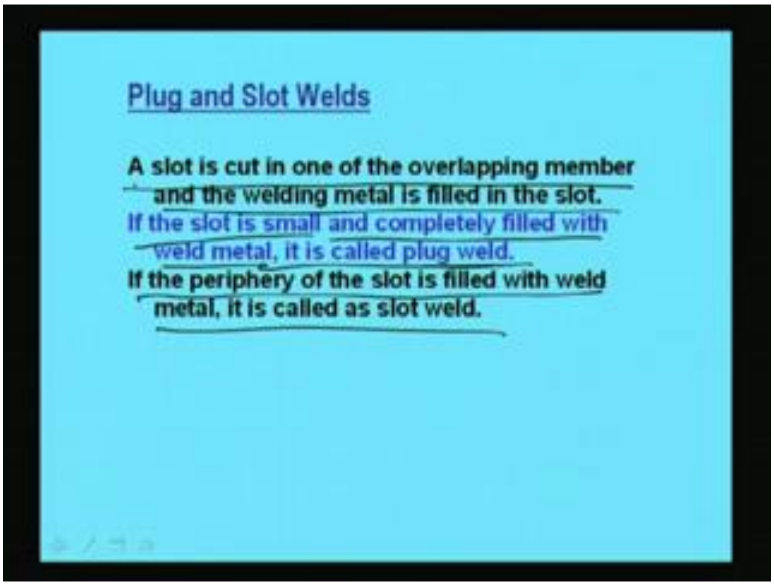

So, in short if we say that a slot is cut in one of the overlapping member and the welding metal is filled in the slot. Now what is the difference between slot and plug I am coming. Now if the slot is small and completely filled with weld metal, it is called plug weld. That means if slot is small and completely filled with weld metal, we can call this as a plug weld. And if the periphery of the slot is filled with weld metal, it is called slot weld.

So, in this way we can differentiate it, right. Now, excuse me. So, after this I am coming this.

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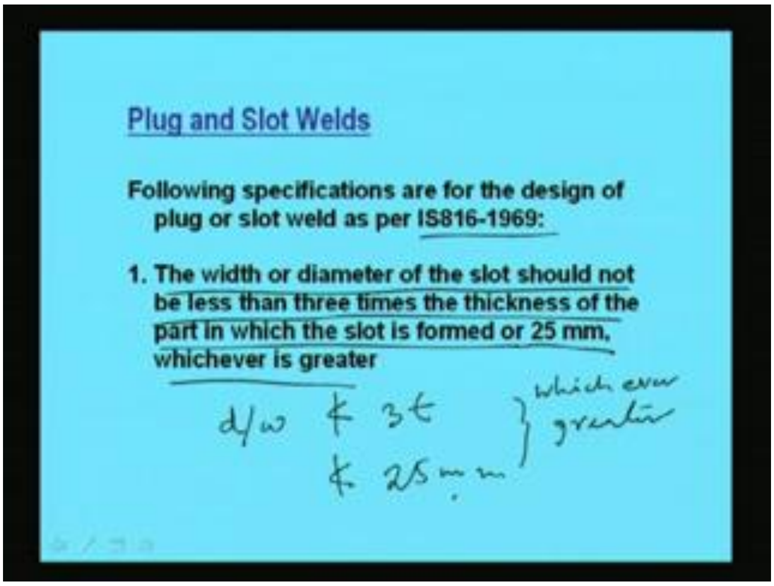

Now some specification has been given by IS816-1969. So, I will discuss some specification on the basis of which we have to design the slot weld or plug weld. So, before designing the slot weld and plug weld, we have to know what are the restriction given by the code. And according to that what will be the specification of the slot weld? What will be the distance d? What will be width? What will be the diameter of the slot? All these things will be given here.

First is the width or diameter of the slot should not be less than three times the thickness of the part in which the slot is formed or 25 mm whichever is less. That means the diameter or the width it should not be less than 3 t, three times the thickness of the part in which the slot is formed or 25 mm whichever is greater. That means what does it mean? If we see in the picture that this d or diameter or the width of the slot; this is the diameter of width of the slot. This should be greater than 3 t or 25 mm. So, this is one specification; what is another specification?

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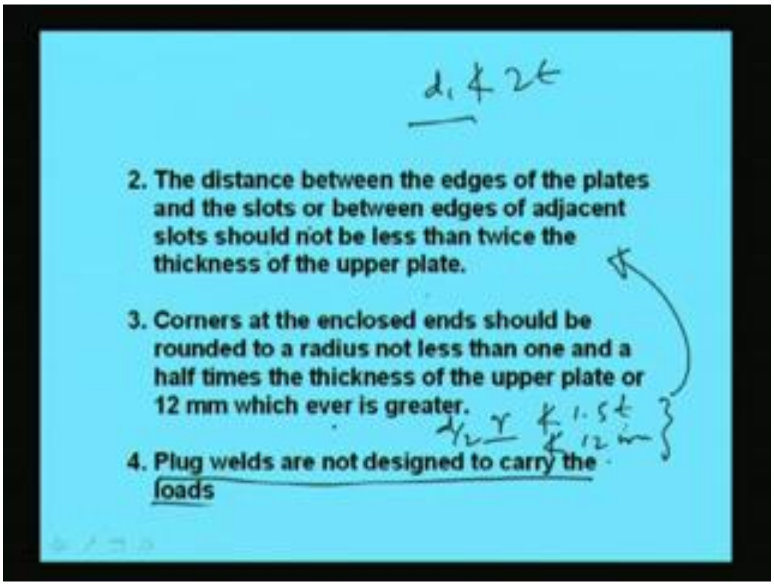

That is the distance between the edges of the plates and the slots or between edges of adjacent slots should not be less than twice the thickness of the upper plate. That means this should not be less than twice the thickness of the upper plate. If we see the picture we will see. So, this is the distance between two; say, let us say this is d 1. So, distance between the two slots or distance between the edge and the one slot which is d dash d 1 and d dash, this should not be less than 2 t, where t is the thickness of the upper plate. So, that also has to maintain.

Another thing is corners at the enclosed ends should be rounded to a radius not less than one and a half times the thickness of the upper plate or 12 mm whichever. That means r should not be less than 1.5 t and should not be less than 12 mm, whichever is great; means this is basically the earlier version. Here it has told diameter; here it is we are telling r; that means d by 2. So, this should not be less than 1.5 t where t is the thickness of the upper plate, and it should not be less than 12 mm. So, minimum we have to make this, and we have to remember that plug welds are not designed to carry the loads. Only slot welds are designed basically to carry the loads.

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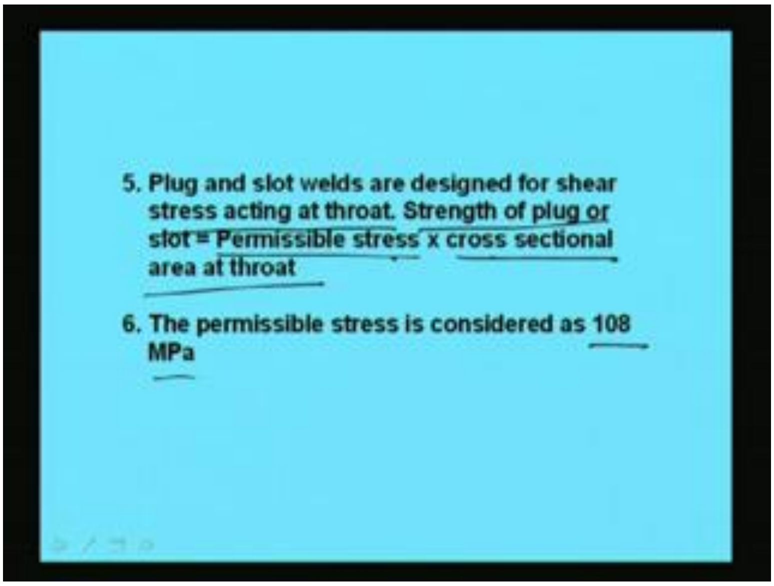

Other things are that plug and slot welds are designed for shear stress acting at throat. So, strength of plug weld means plug or slot weld will be becoming permissible stress into cross sectional area at throat. So, strength how to find out? That is basically permissible stress into cross sectional area at the throat. And the permissible stress is considered as 108 Mpa. So, this is how we have shown how to design a plug weld or slot weld; means what are the bases of design of plug weld and slot weld.

Basically, we have to find out the certain restriction which has given by the code. So, from that we have to find out the specification of the distance the d and d 1 width or diameter of the plug weld and the spacing of the weld; that means two slots what will be the spacing in between them.

Now in the next class we will discuss one example for this type of weld. Then we will be cleared how to design a slot weld or plug weld. So, with this I like to conclude today, and in next class we will discuss about the details; means how to design the plug weld that we will discuss, after that we will again go for some other type of connections.

Thank you.