Course on Design of Steel Structures
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Lecture 11
Module 3
Design of Butt welds

Hello today we discuss about the design procedure of butt welds in last lecture we have discussed how to design a weld joint using fillet and the fillet strength has been calculated and we have discussed that the size of the weld then throat thickness of the weld minimum size of the weld maximum size of the weld of the fillet all that we have discussed and today I am going to discuss about the butt weld which we have given an introduction of the butt weld in last two last class.

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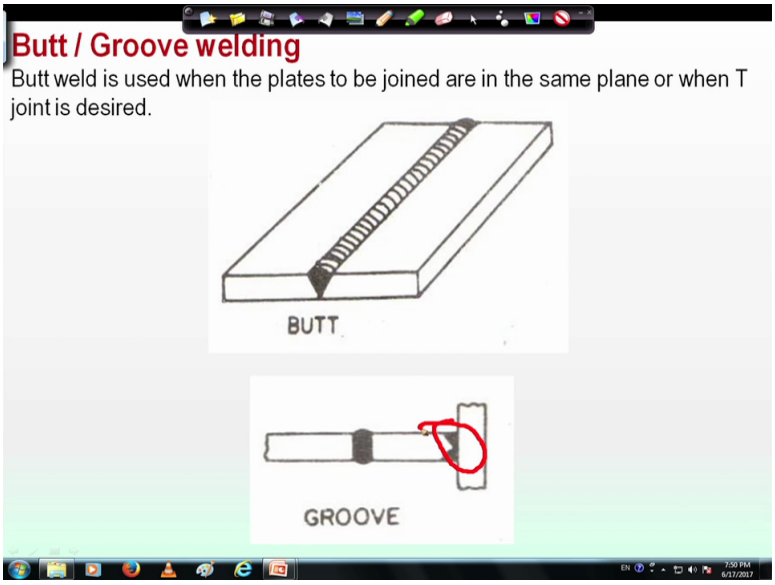

So butt welding basically a type of weld when two plates are joined at the same plane.

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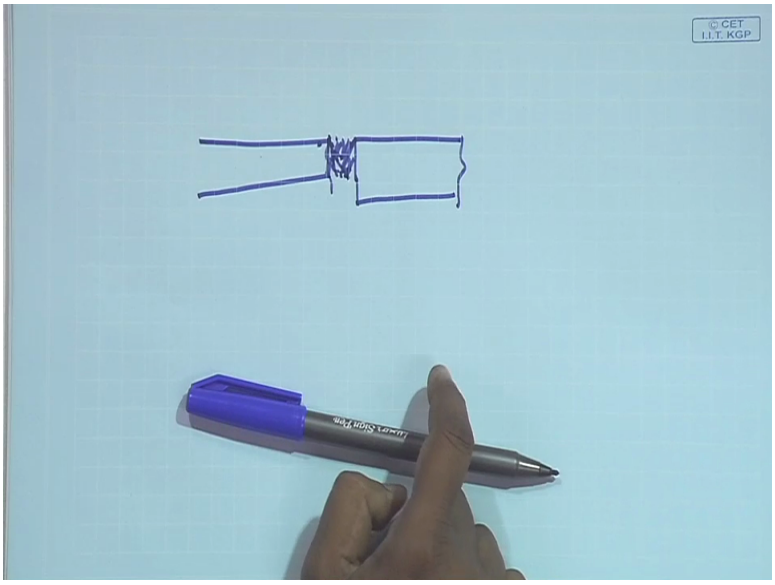

That means I had shown earlier if you remember that when two plates are joined plates may be of different size or same size when these two plates are joined together. This we can make join and groove it this type of qualities Weld joint is called butt weld also butt weld we can see that when a T joint is desired in that case also we can use this butt weld.

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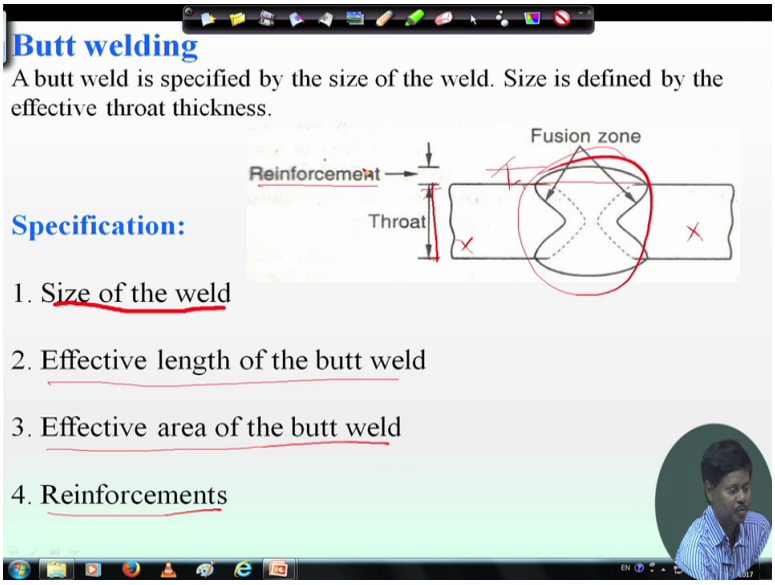

Now in case of butt welds we have certain specification so we need to know the specification like size of the weld, how the size of the weld will be calculated then effective length of the weld then effective area of the butt weld and reinforcement so if we see here the two plates this is one plate and this is another plate are connected in the same plane and through fusion

we have joined and this is called throat thickness, this called throat thickness from which the size of the weld can also be found.

And this extra deposit is called reinforcement and I told this reinforcement is necessary though we do not calculate the strength due to this extra deposit but this is necessary for efficient joint of the members means to ensure the full strength we provide certain amount of reinforcement.

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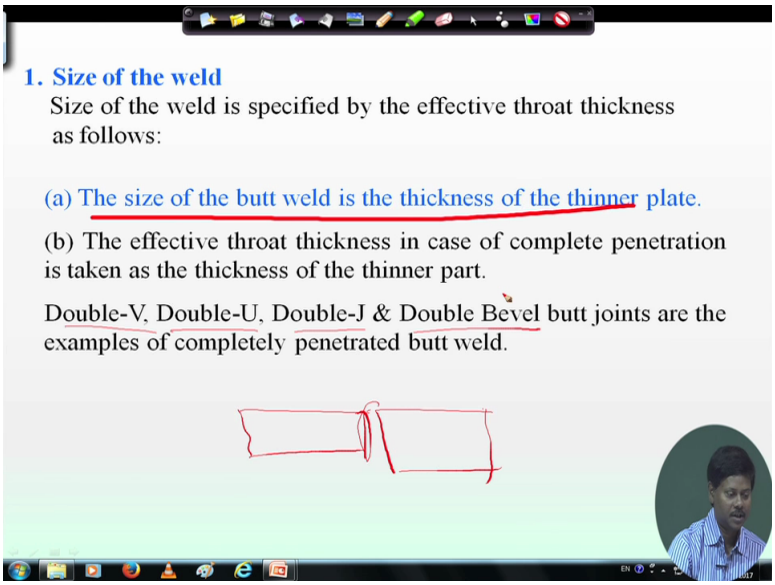

Now size of the weld can be defined by the effective throat thickness as follows like the size of the butt weld is the thickness of thinner plate, this is one that if we have two plates joined together. Suppose if we have two plate then the size of the thickness of the thinner plate will be the size of the butt weld now in case of complete penetration the effective throat thickness will be the size of the thinner plate otherwise we have to calculate I will come later and different type of complete penetrated joint of their like double V bar joint, double U bar joint, double J and double Bevel butt joint these are some example where completely penetrated. So in this case the thickness of the thinner plate will be the size of the weld.

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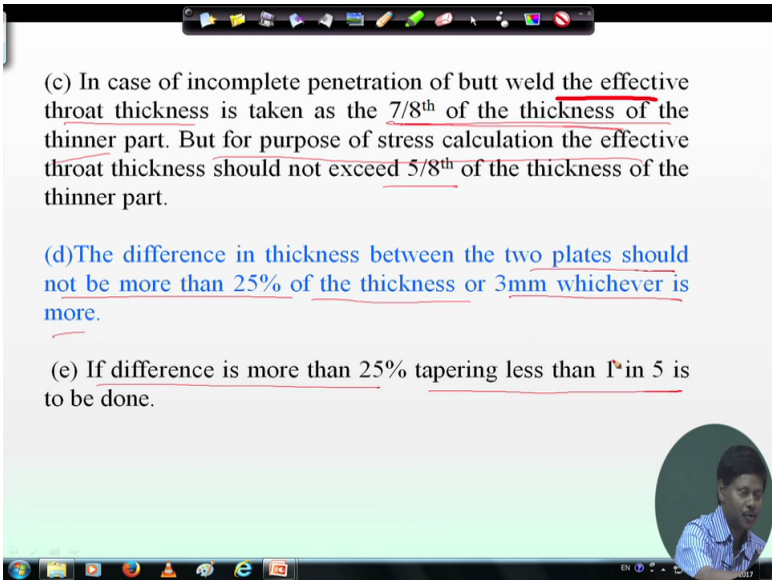

In case of incomplete penetration the effective throat thickness is taking as 7/8 of the thickness right not the full thickness, so 7/8 of the thickness of the thinner part but for the purpose of stress calculation we will calculate 5/8 of the thickness of the thinner part. So there are two things when you are going to calculate the effective thickness of the butt weld in case of incomplete penetration we will calculate the effective throat thickness as thickness of the thinner plate times 7/8 7/8 times thickness of thinner plate but when we are going to calculate the strength of the plate we will calculate 5/8 times of the thickness of thinner plate as effective throat thickness.

Now the difference in thickness between two plates should not be more than 25 percent this also we have to keep in mind 25 percent of the thickness or 3 mm whichever is more. So difference between two plates should not be more than 25 percent of the thickness or 3 mm and each difference is more than 25 percent then it a tapering is required of 1 in 5 has to be done, tapering has to be done to adjust this. So this also we have to keep in mind.

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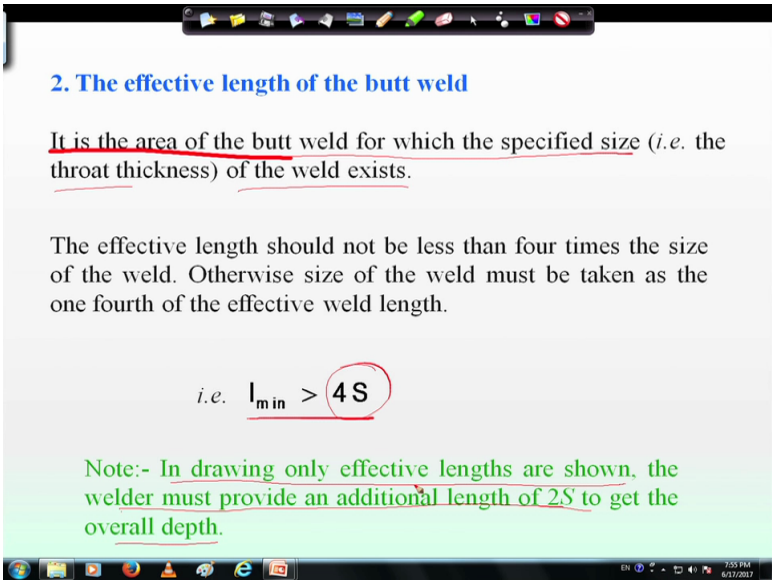

Now the effective length effective length is calculating a similar way as we have done in case of fillet weld the effective length will be based on the effective area. It is the area of the butt weld for which the specified size that means the effective throat thickness of the weld exists that means the length in which the effective size of the throat thickness are existing that length will be the butt weld length and the minimum length of the butt weld should not be more than means sorry at least it has to be more than 4S where S is the size of the weld.

So minimum length has to be 4 times the size of the weld and I told again I am repeating here that in drawing only effective lengths are shown, the welder must provide an additional length of 2S to get the overall depth. So in drawing we will show the effective length but welder has to add 2S for for designing means for at the site it has to consider.

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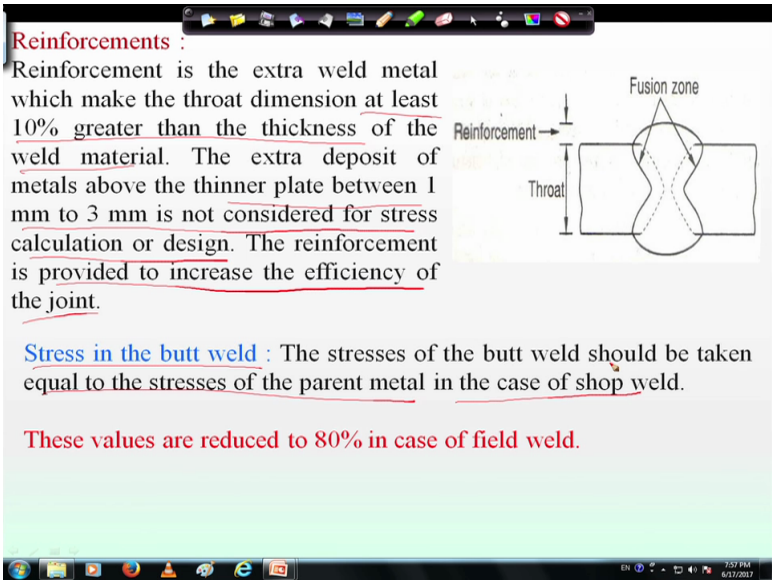

Now reinforcement, reinforcement is basically an extra deposit over the plate and this is also necessary for effective strength of the joint and this is around means at least 10 percent greater than the thickness of the weld material. So the extra deposit of the metal above the thinner plate between 1 mm to 3 mm is not consider for stress calculation or design. The reinforcement is provided to increase the efficiency of the joint.

So reinforcement has not been taken considered consideration for calculation of strength but to make it efficient we need to calculate we need to provide the reinforcement and what will be the permissible stress in the butt weld that also defined that is the stresses of butt weld should be taken equal to the stress of the parent metal in case of shop weld. So stress of the butt weld will be the stress of the parent metal.

Stress of the butt weld we can consider as a stress of the parent metal but the value will be reduced to 80 percent when it is done in field at the site if we make this than 80 percent reduction has to be done.

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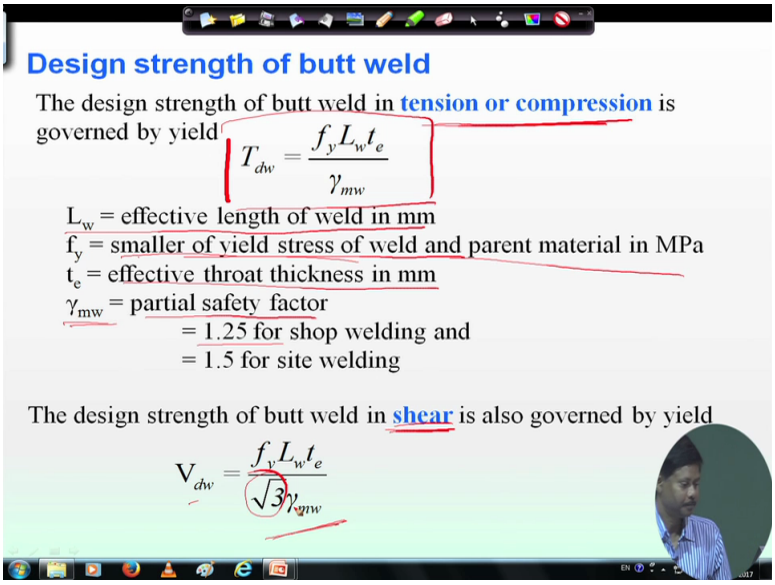

Now we will calculate the design strength of butt weld. Design strength of butt weld in tension or in compression can be found from this formula Tdw is equal to fy Lw te by gamma mw where Lw is a effective length of weld in millimetre.

So Lw is a effective length of weld and fy is a yield stress of weld and parent metal means whichever is small, smaller of yield stress of weld and parent metal., this is fy and te is the effective throat thickness in millimetre that effective throat thickness how to calculate that we have discussed that is the thickness of the thinner plate in case of complete penetration in case of incomplete penetration it will be 7/8 of the thickness of thinner plate and for strength calculation it will 5/8 of the thickness of thin plate.

Then gamma mw gamma mw as we told earlier that is a safety factor partial safety factor for welding and this values is taken as 1.25 for shop welding and 1.5 for site welding. So this is the design strength Tdw has been calculated as a fy Lw te by gamma w and this is design strength of butt weld in tension or compression but in case of shear the design strength will be divided by root 3, Vdw is equal to fy Lw te by root 3 gamma w design strength will be this.

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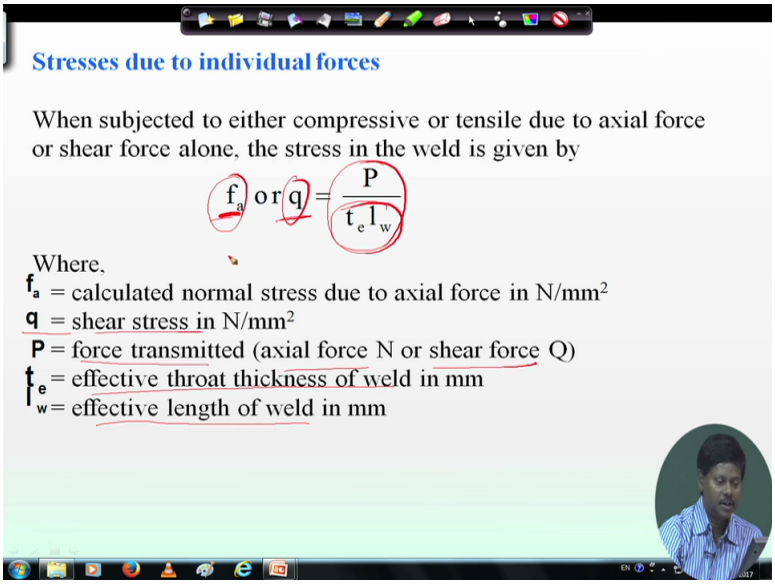

Now stress due to individual force when subjective to different types of compressive or tensile force then the stress we can calculate by the force divided by the effective area. Effective area means te into Lw.

So we can find out the stress compressive stress, compressive stress or tensile stress or shear stress that can be found from this formula P by te into Lw, fa is a normal stress due to axial force and q is the shear stress due to shear force and P is the force transmitted it may be axial force or it may be shear force and te is effective throat thickness of the weld in millimetre and Lw is the effective length of weld in millimetre.

So the compressive stress or tensile stress or shear stress means this is basically normal stress and this is shear stress this can be calculated from this formula that is P by te into Lw, Pe is the axial force or we can consider as a shear force and te into Lw is the effective area of the weld zone that is te into Lw.

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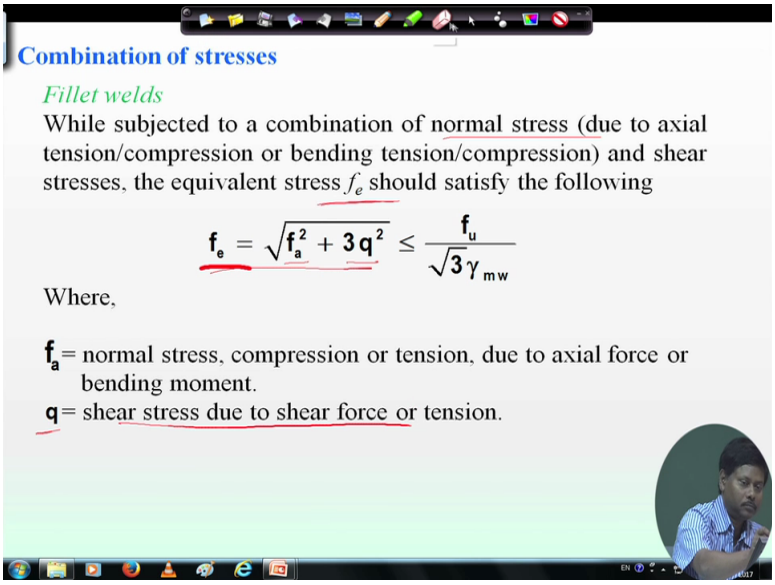

Now communication of stresses so it may happen that two type of stress or more than two type of stress are acting together combinedly, so in this case we have to find out the equivalent stress. Equivalent stress we can calculate fe as square root of fa square plus 3q square when it is subjected to a combination of normal stress, normal stress means due to axial tension or compression or bending, bending tension and compression and shear stress then the equivalent stress can be calculated in this way.

So fe we can find out with the combination of these two fa square plus 3q square and square root of their will be the equivalent stress fa is the normal stress due to axial compression or tension or due to bending, bending and also in case of bending it may be due to bending stress in tension or compression and q is a shear stress due to shear force right.

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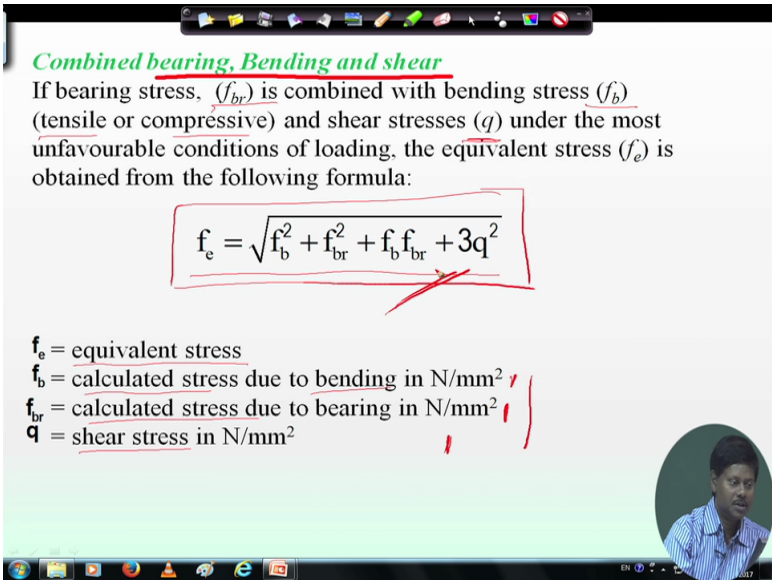

Now if we go for another stress which is called bearing combined bearing, Bending and shear. So if we combine this three stress then the equivalent stress can be calculated from this formula, that is if bearing stress fbr is combined with bending stress and which is may be tensile or compression and shear stress q another most unfavourable condition of loading then the equivalent stress fe can be obtained from this formula that is fe is equal to square root of fb square plus fbr square plus fb into fbr plus 3q square where fe is the equivalent stress and fb is a calculated stress due to bending, fb and fbr is the calculated stress due to bearing and q is a calculated stress due to shear.

So three types of stress here we have seen one is due to bending, bending stress another is bearing stress and another shear stress if three stress are acting together then we can use this formula for calculating the equivalent stress that is square root of fb square plus fbr square plus fb into fbr plus 3q square. This is how we can find out the equivalent stress when combined bearing, bending and shear are acting together.

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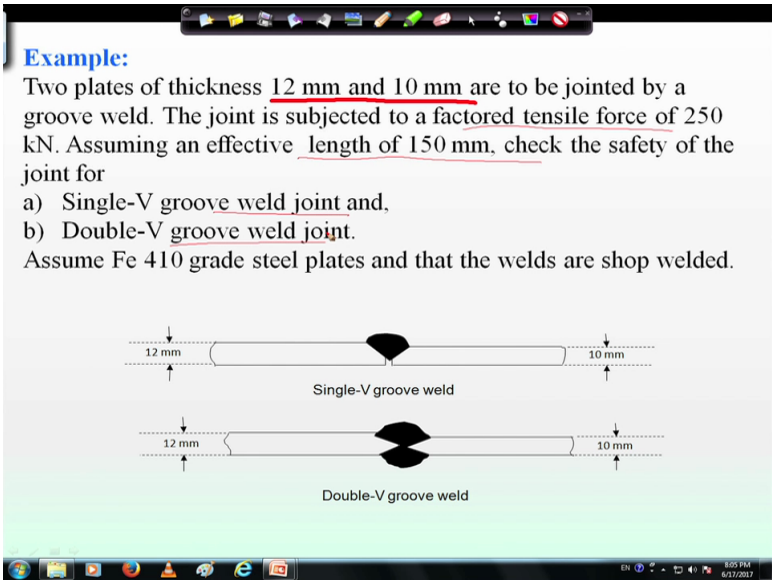

Now we will go through some examples we have seen how to find out the strength of the butt weld we have seen how to find out now through some example will see how to calculate the strength of butt weld due to incomplete penetration due to complete penetration, this also we will go through this example and we will see how the design strength is going to vary right.

Here two plates are of thickness 12mm and 10 mm are to be joined by a groove weld means butt weld the joint is subjected to a factored tensile force of 250 kilonewton. Assuming an effective length of 150 millimetre, check the safety of the joint for single V groove weld joint and double V groove weld joint right, so this is what we will calculate.

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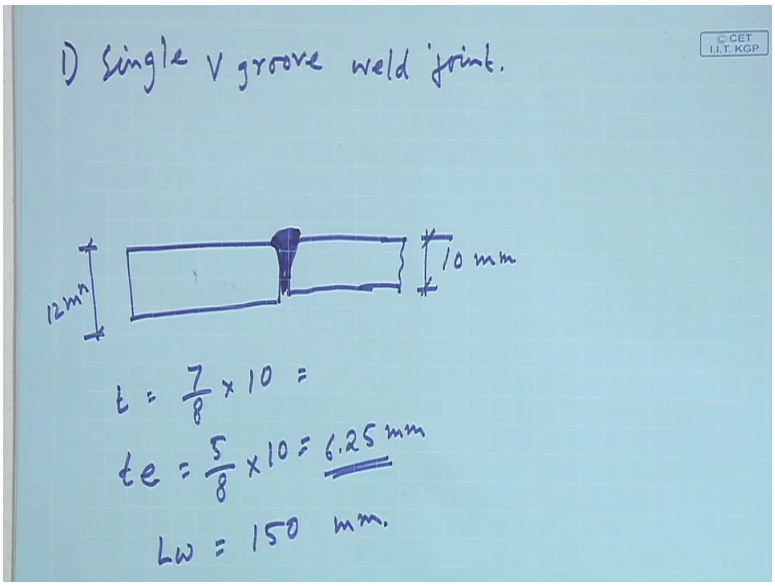

So now in first case if we have single V groove, groove weld joint. So in case of single V groove weld joint we have two plates of thickness 12 mm and 10 mm right so this is 10 mm and this is 12 mm. Now single V groove joint is done that means it is incomplete penetration so it will look like this, incomplete penetration right so in this case the thickness will be actually 7/8 by thickness of thinner plate that means it will be this but the effective throat thickness will be means calculated for calculation of the strength.

So effective throat thickness will be 5/8 of 10 that is 6.25 millimetre, so this is the effective throat thickness now effective length of the weld is given in the question that is 150 millimetre.

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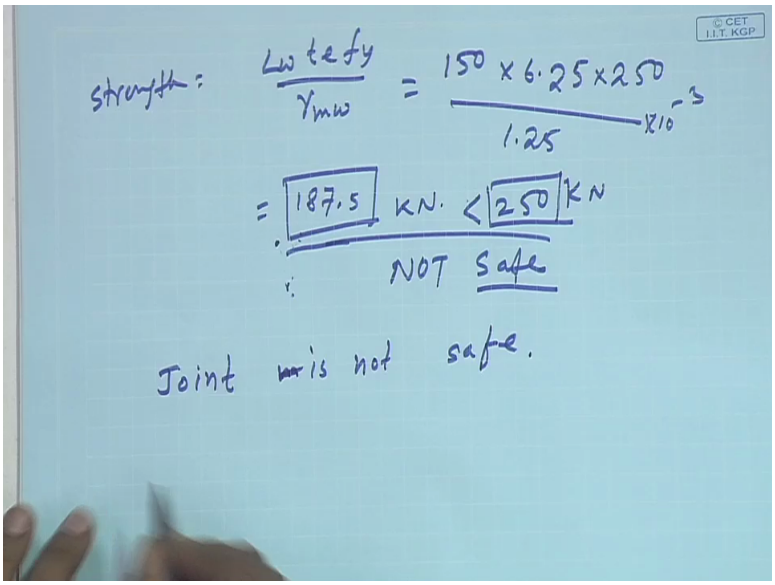

So we can find out the shear strength of the weld that is strength will be Lw te fy by gamma mw. So Lw is 150 and 6.25 is the effective thickness and fy is 250 by 1.25 into 10 to the power minus 3. So this is coming 187.5 kilonewton right and it is less than 250 kilonewton right. So it is ok joint is safe because it is sorry it is not safe the design strength is coming 187.5 kilonewton and external force is 250 kilonewton so it is not safe that means when we are using single V groove weld then under this condition joint is not safe.

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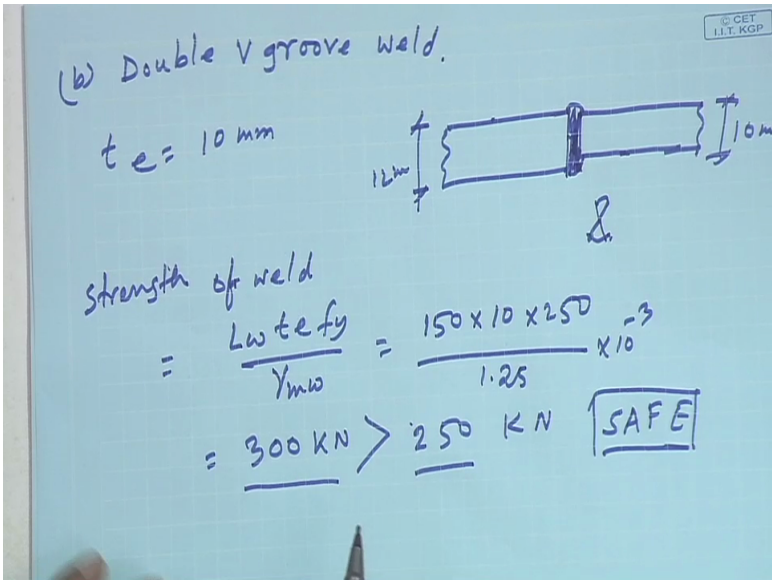

Now let us see for double V groove weld for double V groove weld in second case throat thickness will be, thickness of thinner plate that will be 10 mm in case of this it will be, this is 10 mm and this is 12 mm so this is double V butt joint so it will be groove like this right it will be groove like this so it will be like this double V butt joint right.

So strength will be strength of weld will be Lw te fy by gamma mw is 150 into 10 into 250 1.25 into 10 to the power minus 3 this is becoming 300 kilo newton and it is more than 250 kilonewton that means it is safe right because the strength of the weld is coming 300 kilonewton and external force is the tensile force is coming 250 kilonewton. So the strength is ok means the joint is ok.

So what we have seen here that if we for same case if we use single V butt joint then joint is going to fail and if we use double V butt joint, joint is safe now why because in case of double V groove weld its thickness is becoming more effective throat thickness is becoming 10 mm the thickness of the thinner plate but in case of single V butt joint as incomplete penetration is there therefore the thickness of the effective thickness of the weld is quite less that is 5 by 8 of 10 mm right that means 6.25 mm therefore the force carrying capacity of that weld is becoming comparatively less and we could see that it is going to be fail but in this case it is not, it is safe it is not going to fail.

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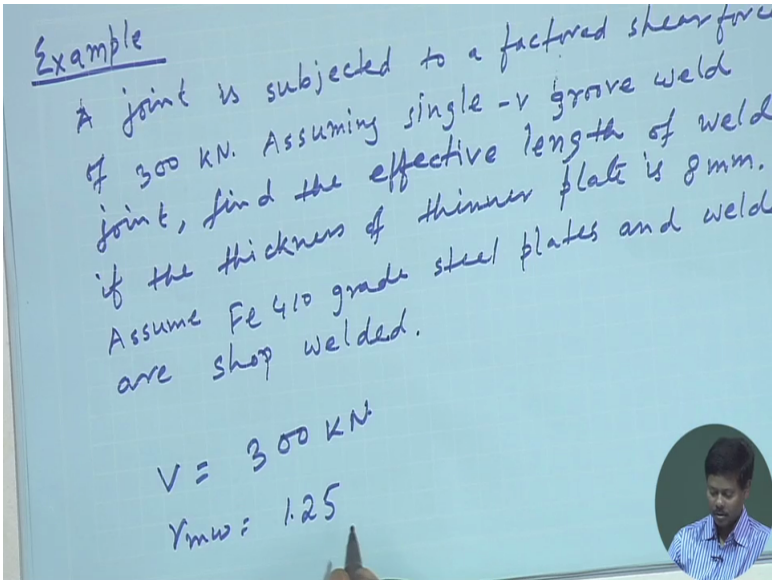

Now we will go through another example. A joint we just write down a joint is subjected to a factored shear force in earlier case we have considered tensile force shear force of 300 kilonewton. Assuming in this case we will assume single V groove weld that means its thickness will be 5/8 of the thickness of thinner plate right. Single V groove weld joint, find the effective length of weld, if the thickness of thinner plate is 8 mm right.

Now we can assume Fe410 grade (bolt) steel steel plates and welds are and weld are shop weld right. So this is a joint where shear force V is coming means V will be 300 kilonewton and here gamma mw gamma mw will be basically 1.25 because of shop weld, so gamma mw will be 1.25.

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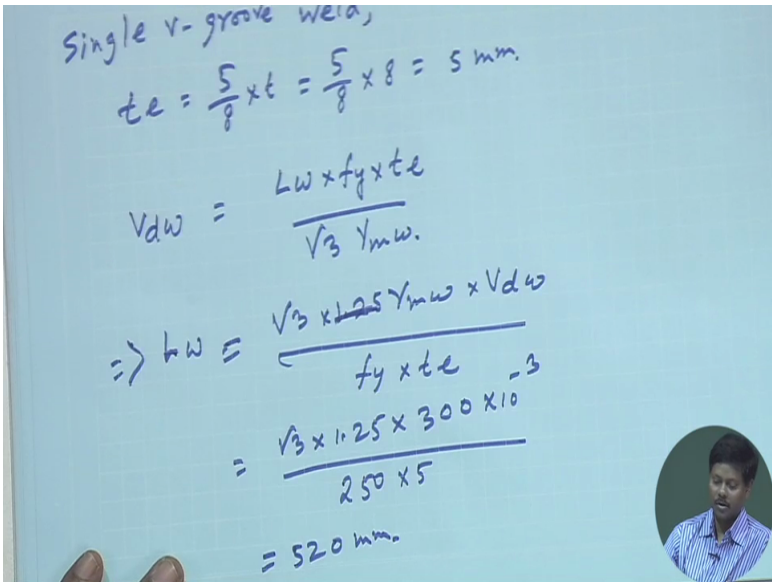

And for single V groove weld this is single V groove weld weld te will be 5/8 of t, here thickness of thinner plate is 8 mm. So 5/8 of 8 that means 5 mm so we can find out the length of weld. Now we know the formula for design calculation design strength calculation of part weld for shear as Vdw is equal to Lw into fy into te by root 3 gamma mw. So from these I can find out Lw as root 3 into 1.25 sorry root 3 into gamma mw into Vdw by fy into te. So Vdw is basically V here means design strength has to be equal to the shear force.

So we can find out root 3 into 1.25 into 300 for making kilonewton we will multiply with 10 to the minus 3 into 250 into 5, so this is becoming 520 mm right. So the effective length of the weld will be 520 mm.

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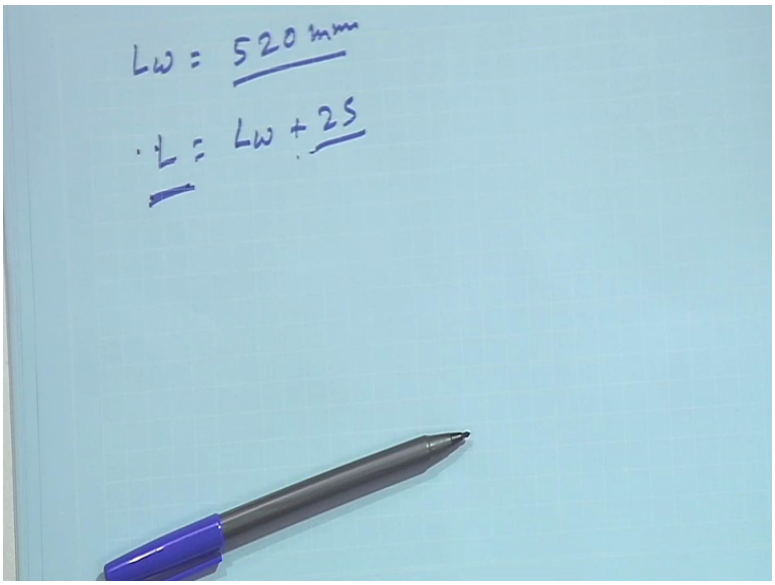

Effective length of the weld Lw will be 520 mm and if effective length of the weld is 520 mm then the total length we can find out total length will be Lw plus 2S where S is size of the weld right so this is how we can find out the total length of the weld right.

So in todays lecture what we have seen that how to calculate the design strength of butt weld and this butt weld may undergoes under means it may be under tension or compression means normal stress, normal process or under shear so both the cases we have calculated how to find out the design strength of the weld and off course here we have to remember whether it is going to be full penetration or partial penetration incomplete penetration and accordingly we have to find out the throat thickness or effective thickness of the weld properly because the strength depends on the effective thickness of the weld. So for today this is all about the butt weld, thank you very much.