Course on Design of Steel Structures
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Lecture 33
Module 7
Compressive strength of double angles

Now I will be discussing about the design compressive strength of a double angles section. Now double angles section is oftenly used because may cases appear when the single angle is not capable of taking that much load and also in case of single angle the radius of gyration about the minor axis is very low compared to its X axis, or Y axis, or major axis. Therefore as radius of gyration is quite low about in minor axis, so strength of the angle section is quite low because it may buckle through its minor axis about its minor axis.

And because radius of gyration if it is low then slenderness ratio will be high and slenderness ratio high means the design compressive stress will be less and therefore the design strength of the member will be less. Therefore with the given load sometimes we go for double angle section again double angle section may be placed it is back to back with gusset plate means gusset plate in in its two side two angle section can be provided or in the same side also in the same side of gusset plate angle sections can be provided. So this is how one can place the angle sections to make double angle section.

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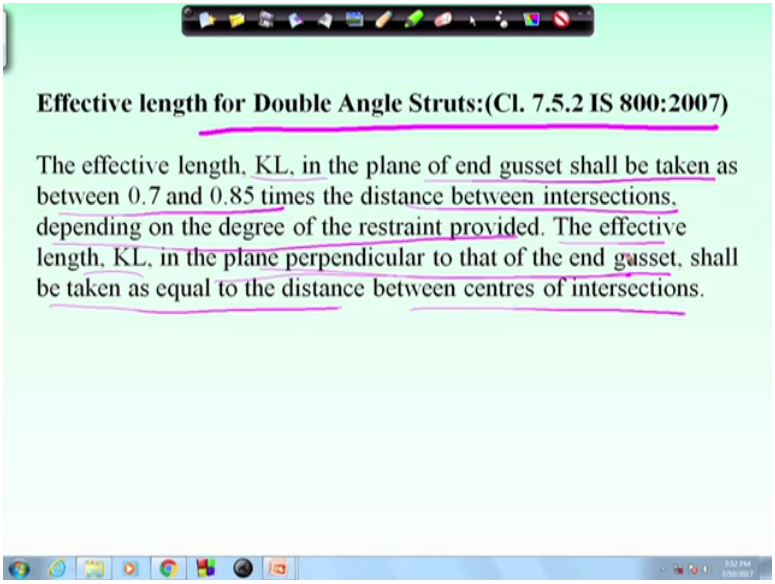

Now to know the design strength of the angle section we need to know what is the effective length of the double angles will come into come, that is given in clause 7.5.2, right the effective length of double angle struts in clause 7.5.2. So here we can see that the codal provision says that the effective length KL, in the plane of end gusset shall be taken as between 0.7 and 0.85 times the distance between the intersections, that means 0.7 to 0.85 times the L depending on the degree of restraint provided.

So depending on the degree of restraint provided the effective length will be consider as 0.7 to 0.85 times the distance between intersections and the effective length KL, in the plane perpendicular to that of the end gusset shall be taken as equal to the distance between centre of intersections. That means here K value will be 1, so this is what the codal provision says.

So when we will be going to calculate the strength of a double angle section we need means we have to follow this codal provision 7.5.2 to find out the effective length and therefore the radius of sorry slenderness ratio and then compressive stress, the allowable compressive stress. Therefore we have to know the effective length of the double angle section means whether it is according to the degree of restraint means whether the length is in the plane perpendicular to that of end gusset or other one.

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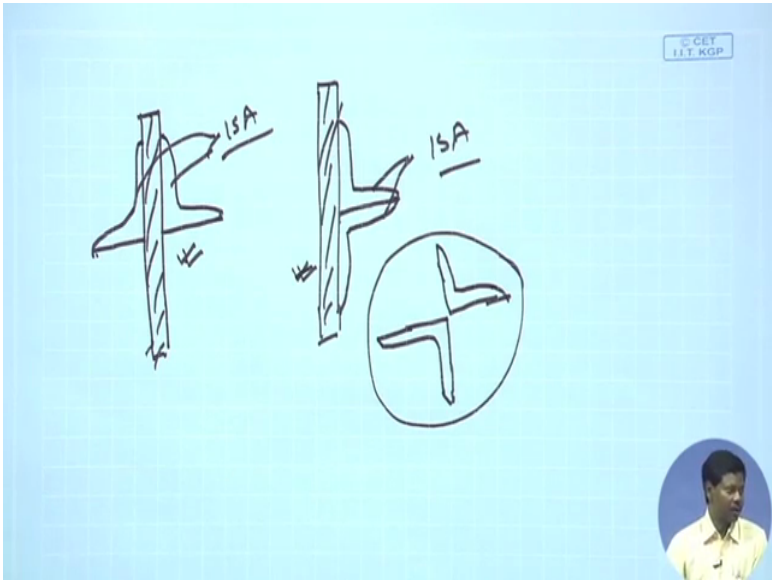

So angle sections may be provided like this, say suppose two angle sections I want to provide. Now that may be possible if I use two angle section on the opposite side of gusset plate, this is one way we can make, this is gusset plate, right otherwise we can arrange the angle sections as like this also that means in same side of the gusset plate this will be. So this

is the gusset plate and we are providing two angle sections this is ISA some ISA in a single angle we can provide, right.

Also the two angles can be provided in a in this fashion also however it depends on the requirement means what type of architectural requirement is there depending on that also we can provide such type of double angle section. And also we will see if I provide angle section opposite side to the gusset plate and same side of the gusset plate then what will be the strength that means whether if I arrange in these ways strength will be more or if I arrange in this way strength will be more that also we can through one workout example we can compare.

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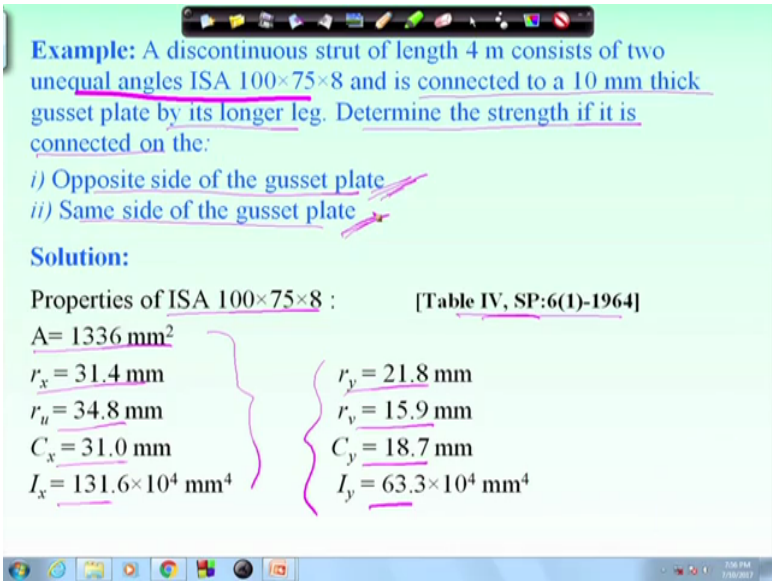

So let us go to one example which is given as this that is an discontinuous strut of length 4 meter consists of two unequal ISA ISA 100 by 75 by 8 and it is connected to a 10 mm gusset plate by its longer leg. So longer leg is connected to the gusset plate and thickness of gusset plate is 10 mm and size of angle is ISA 100 by 75 by 8. Now find the strength if it is connected on the opposite side of the gusset plate and same side of gusset plate.

So here we will compare the results using these two orientations one is opposite side of the gusset plate and another is same side of the gusset plate and we will see which one is taking more load, right.

Now properties of the single angle section can be found from table 4 of SP: 6-1964, where the cross sectional area is given rx, ry, ru, rv these are given then cx, cy and Ix, Iy are given and these are the properties which will be required to find out the equivalent properties of the

section equivalent properties of the section means what is the combined gross area of the section, what will be the radius of gyration minimum radius of gyration of the section, what will be the Cg of the section, so all these things we can find out from these properties and according to the orientation according to the placement of the gusset plate and angle we can find out its strength.

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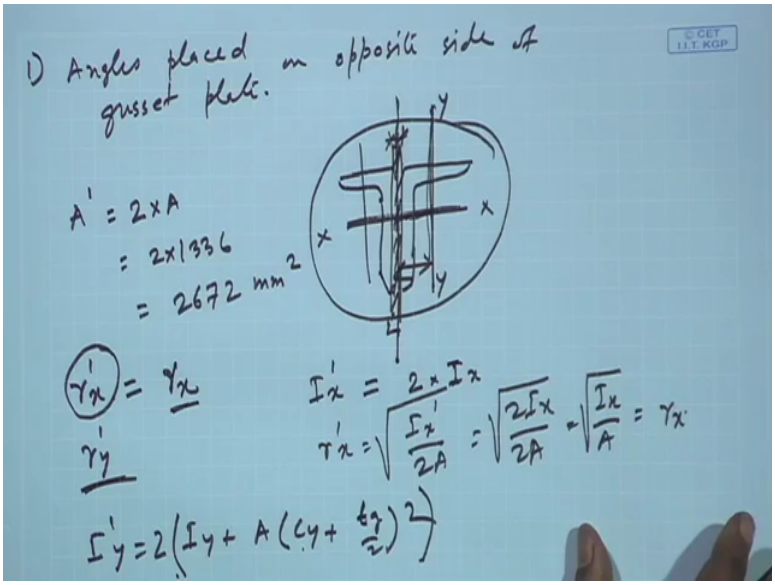

Now let us first come to the case where angles are placed on opposite side of the gusset plate of the gusset plate that means we can consider that a plate a gusset plate is there and it is in its opposite side one angle is placed with its longer side longer leg and another angle of same size are placed in other side, so this will be the arrangement, this is the gusset plate, right. Now we have to find out the combined properties, like the area of the double angle say I can say A dash A dash will be 2 into area that means 2 into I got 1336, so this will be 2672 millimetre square.

Similarly I can find out the value of rx and ry, that means r dash x and r dash y, so first let us find out r dash x, r dash x when we are going to find out that r dash x means we can find out in this direction, this is x-x. So to find out r dash x first I have to find out Ix dash that means moment of inertia about x-x direction of the combined section. So that will be 2 into Ix means 2 into moment of inertia of the individual section because Ix will be in this same in same Cg distance means Cg it will it will buckle, so Ix will be same.

So I can find out r dash x as Ix dash by 2A, so 2Ix by 2A that means Ix by A that means I can find out sorry this will be square root of this so root of Ix by A so rx, that means the r dash rx

dash value will become simply rx. So in this way means in this arrangement if we use then we cannot increase the rx value or r dash x value, right. So rx value is constant, only we can increase the value of r dash y by changing the gusset plate thickness.

Now let us see how the r dash y value is going to be calculated, so for that we have to calculate first I dash y, I dash y will be I dash y means in this direction, so I dash y will be Iy this is y-y, Iy about this axis plus Ar square, so Iy plus A into Cy plus tg by 2 whole square, right. So I dash y about this axis will be Iy plus A into Cy square, Cy square means Cy plus tg tg is the thickness of gusset plate. So if this is the thickness of gusset plate then it will be tg by 2, right and into 2 because two angles are there, so for this also it will be same so it will be added, so I dash y can be found like this, right.

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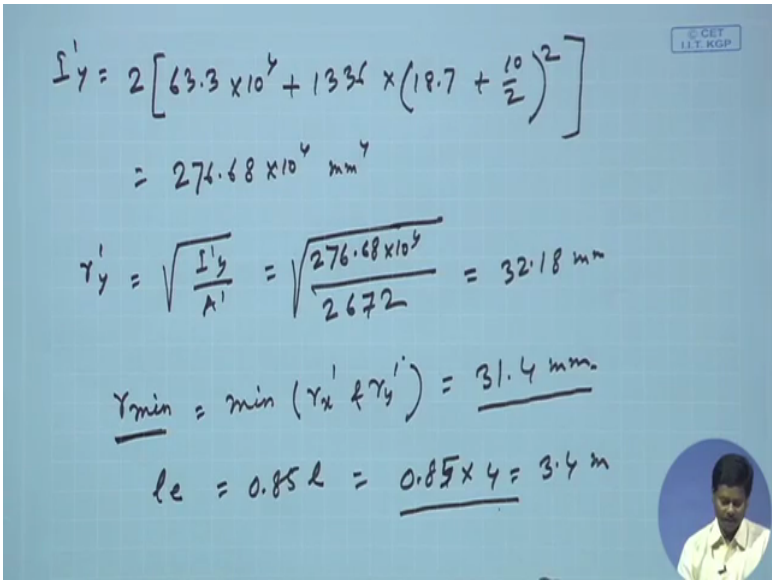

So if I calculate the I dash y value, I can find this as 2 into 63.3 into 10 to the power 4 which is Iy value plus A was 1336 into 18.7 plus 10 by 2 thickness of gusset plate is 10, so 10 by 2 like this. So I dash y I can find out 276.68 into 10 to the power 4 millimetre to the 4. Now once I calculate I dash y, I can find out the value of r dash y also, r dash y will be simply I dash y by A dash, so here I dash y value we have calculated as 276.68 into 10 to the power 4, A dash is basically 2 into A that is 2672, 1336 into 2, so this is becoming 32.18 millimetre.

So minimum radius of gyration r minimum I have to find out because about which it will buckle, so that will be minimum of rx dash and ry dash, right so minimum if will see it will be 31.4 millimetre, right this radius of gyration minimum radius of gyration we could found we could find as 31.4 millimetre.

Now le value the effective length le can be found as 0.85l, so this will be 0.85 into it was 4 meter so this is 3.4 meter. So as per clause 7.5.2.1 I can find out the value of effective length as 0.85 into l that is 3.4 meter.

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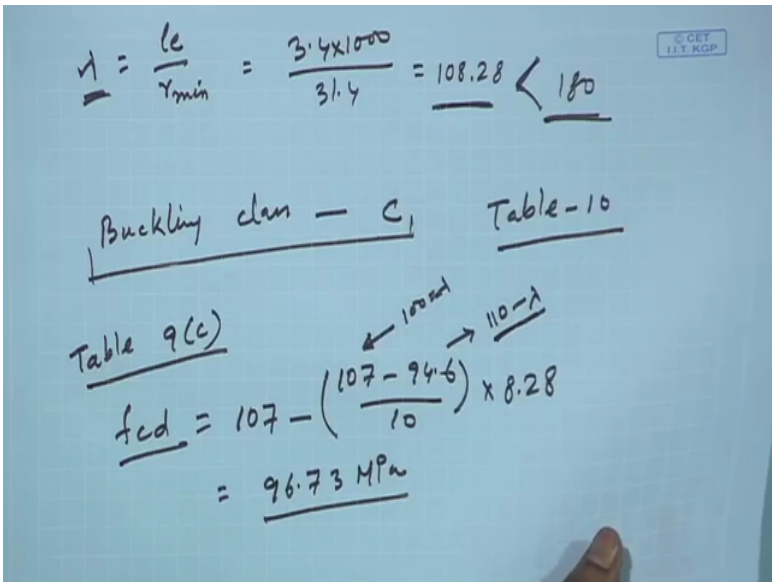

So now I can find out the value of slenderness ratio, so lambda slenderness ratio I can find out le by r minimum that will be become 3.4 into 1000 to make it millimetre by 31.4 this is becoming 108.28, right and this is less than 180 so it is okay as per table 3 it should be less than the permissible slenderness ratio. So lambda value the slenderness ratio value we can find as 108.28.

Now for angle section or for built-up section we know buckling class will be C buckling class of the section will be C from table 10 we can find out from table 10 I can find out the buckling class as table C and then I can find out the value of fcd. Now if we use table 9c table 9c to find out value of fcd fcd either I can find out from the formula which are expressed in the code otherwise I can find the value from table 9c table 9 has been given to find out the value means for different value of slenderness ratio fcd value has been given for different grade of steel.

So this fcd value are given in table 9 a, b, c, d for class a, b, c, d. Now as this is the class C buckling class C, so we are using table 9c directly and if we use table 9c we can see that fcd value will be 107 minus 107 minus 94.6 by 10 into 8.28, this 107 is correspondent to 100 lambda 100 and this correspondent to lambda as 110, for lambda 110 this is 94.6 and for

lambda 100 it is 107. So if I interpolate for 108.28 I can find out the value of fcd as 96.73 MPa. So fcd value can be found from table 9c as 96.73 MPa.

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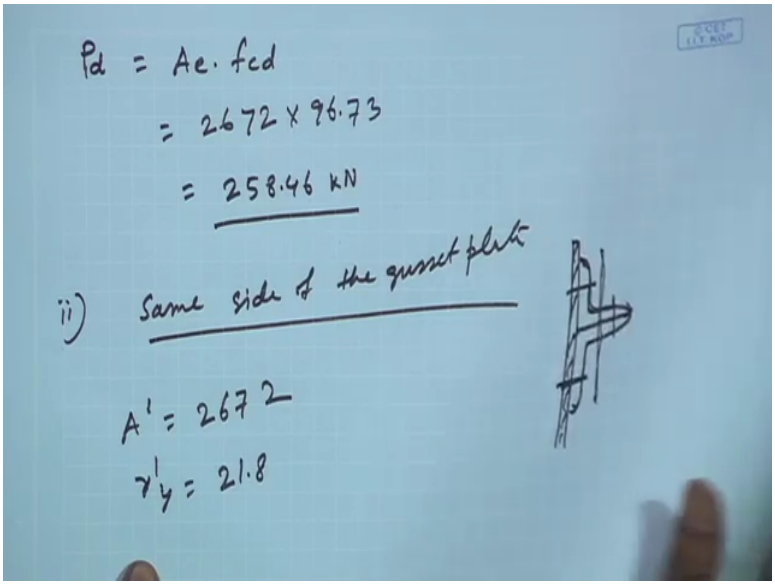

Now the strength design strength of the member now I can find out that will be Ae into fcd, so if I put those value of Ae and into fcd, Ae is 2672 which is the area of two angle section into 96.73 is the fcd value. So this will become 258.46 kilonewton, right. So design strength of the member can be found as 258.46 kilonewton.

Now let us come to the second case second case is angle placed on same side of the gusset plate same side of the gusset plate. So if we use same side of the gusset plate then it will be something like this, say this is gusset plate and angle is connected through the same side of the gusset plate like this, right. So so for this case several things will be similar like A dash the gross area of the combined section will be same that will be 2672 and here r dash y will be same 21.8 which was considered earlier, r dash y means along this because r dash y, ry of the single section whatever it is coming r dash y will be same because the Cg is not going to be changed but r dash x will be going to change.

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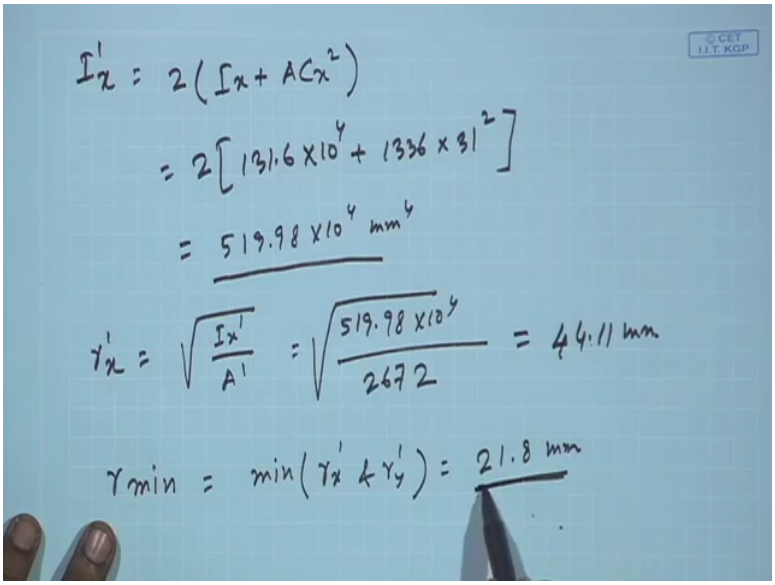

So we have to calculate the value of r dash x to find out r dash x, I have to find out I dash x I dash x will be 2 Ix plus A into Cx square, so if I put the value of Ix as 131.6 into 10 to the power 4 plus 1336 into Cx square is 31 square. So Ix means I dash x value is becoming 519.98 into 10 to the power 4 millimetre to the power 4. So moment of inertia of the gross section about x-x direction I am getting as this.

Now r dash x can be found that will be Ix dash by A dash Ix dash we got as 519.98 into 10 to the power 4 by A dash is 2672. So after calculating the value is coming 44.11, right. So now I can find out the value of r minimum, so r minimum will be the minimum of rx dash and ry dash, so this is becoming 21.8 mm, right. Now if we remember in earlier case r minimum was the rx and here r minimum is the ry, right.

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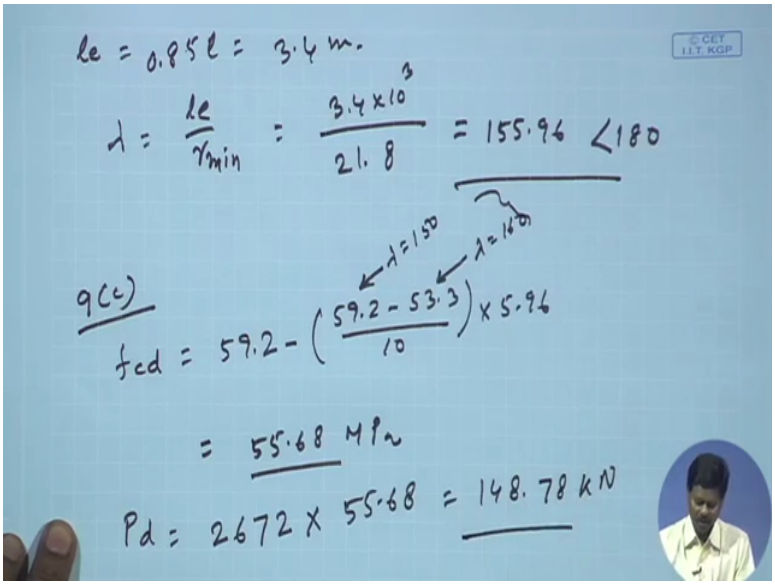

Now let us come to effective length so effective length will be same for this case also le will be 0.85l, so 3.4 meter and lambda I can find out slenderness ratio as le by r, r means r minimum, so this will become 3.4 into 10 cube to make it millimetre by r minimum is 21.8, so this is becoming 155.96 newton per millimetre square which is less than 180, right. So this is okay, from slenderness ratio point of view it is okay.

Now this will be buckling class C as similar to earlier case and we can use table 9c of IS 800, then I can find out the value of fcd as 59.2 minus 59.2 minus 53.3 by 10 into 5.96. So this I can find as 55.68 MPa, here the value 59.2 is coming for lambda is equal to 150 and 53.3 is coming for lambda is equal to 160, so we are interpolating between 150 and 160 to find the value of fcd at a lambda of 155.96 which we are getting as this. So the design strength I can find out Pd as Ae will be same 2672 into fcd value is 55.68, this is coming 148.78 kilonewton, right.

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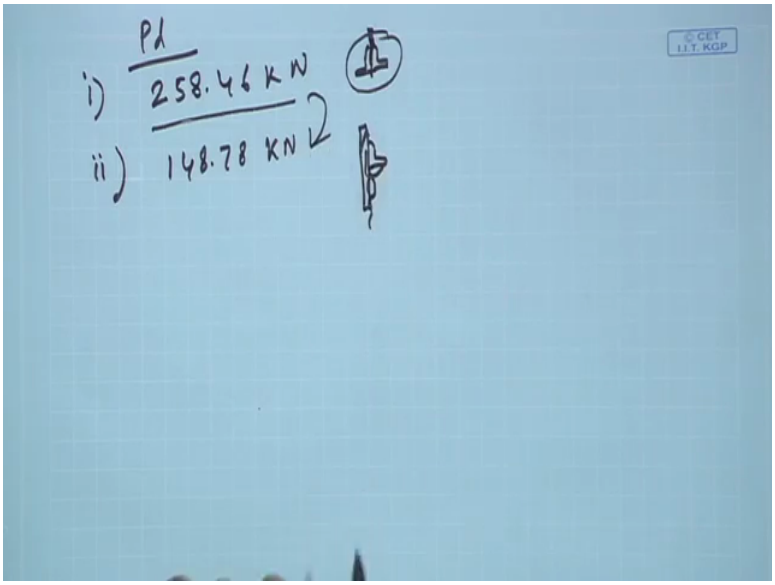

So what we could see that for first case when opposite sides of the gusset plate angles are placed opposite side to gusset plate we got 258.46 kilonewton and for second case we are getting 148.78 kilonewton, this is when angles are placed opposite side of gusset plate, here angles are placed same side of the gusset plate, so this is the difference, right. So what we could see for the same angle if it is placed opposite side to the gusset plate its strength is quite high compared to this that means we will try to prefer always the angles to be placed opposite side of the gusset plate. So that the strength can be achieved more compared to the earlier case means other case other case means when angles are placed same side of the gusset plate, right. So with this I like to conclude todays lecture, thank you.