Design of Steel Structures
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Module - 02
Connections
Lecture - 03

Design of rivet joint

Hello. Today's lecture will be on design of riveted joints for axially loaded members. In the last lecture if we see it we have discussed a details about the riveted joints particularly on various modes of failure of rivet joints.

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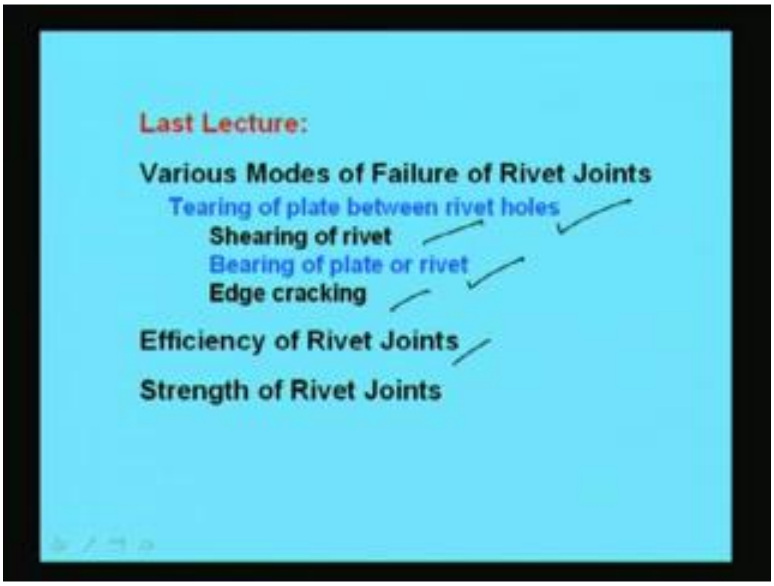

Like, we have discussed the tearing of plate between rivet holes shearing of rivet then bearing of rivet or plate then edge cracking. So, how the rivets are going to fail those details has been discussed in last class. And also we have shown what is the efficiency of a, rivet joints that also how to calculate we have discussed. And the strength of the rivet joints for a given dimension and for a given configuration of the rivet the strength of the joints can be calculated. And those things details have been shown in the last class.

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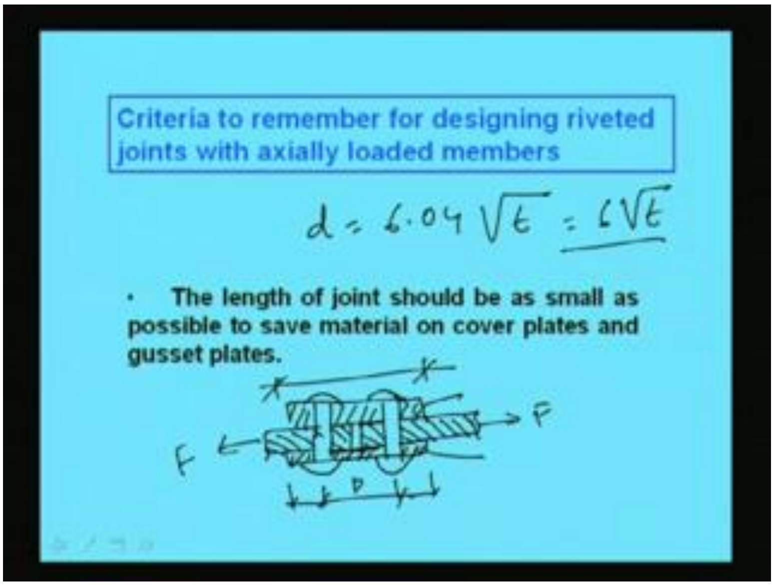

So, today will be focusing on basically on the design part means for the means for designing any joint with rivet how to take care we will discuss here. Now, here we will see the criteria to remember for designing riveted joints with axially loaded members. Now, what are the criteria we suppose to means we need to remember before going to design a rivet joints first thing is how to select the diameter of a rivet. This can be select through some approximate formula which has been given that d is equal to 6.04 root over t or 6 root over t from this formula generally we use to calculate. The rivet diameter some approximate diameter we first write to choose from this formula where t is the thickness of the thinner plate if we have multiple plates. Then the thinnest plate thickness will be taken consideration for designing the rivet joints for designing rivet diameter.

Now, the length of joint we have to remember that length of joint should be as small as possible to set material on cover plates and plastic plates. So, for designing the joint first we have to know means first have to keep in mind that length of the joint should be as less as possible to save the materials how. That means, suppose we have a say butt joint say we have a plate here. And we have a say rivet here 2 rivets have been given say this is 1 plate another plate is this 1 it has been covered by this extra gusset plate. Now, you see this is called basically pitch and this, the edge, so this pitch and edge should be as less as possible. So, that the length of the plate extra cover whatever we are introducing for joining the 2 plate the plate is 1 plate is this 1 say let us see this is 1 plate and another plate is this 1. So, now, to join these 2 plate, we need to introduce to cover. So, this cover of the plate should be as less as possible to save the material. So, while designing the joint we should take care these aspects.

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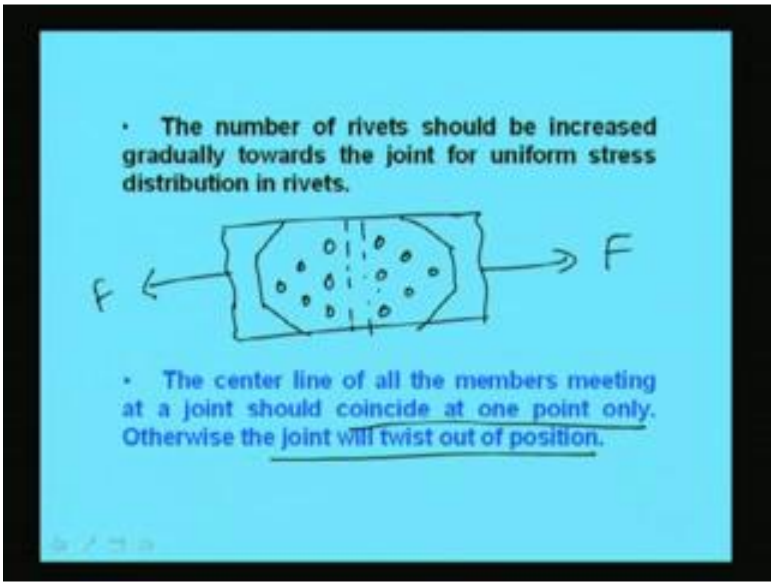

Next is the number of rivets should be increased gradually towards the joint for uniform stress distribution in rivets what does it means say suppose we have a 2 plate. So, let us see in this point say some axial forces are acting on this plate 1 plate is this 1 another is this 1 and has been connected through some plates. So, ideal configuration of the rivet joints should be like this that means the number of the rivet should be increased gradually towards the joint for uniform stress distribution in the rivet. And that center line of all the members meeting at a joint should coincide at point only. This is very important the center line of all the members meeting at a joint should coincide at 1 point only otherwise the joint will twist out of position. So, axial force only will not act in that case. So, some torsion will come into picture that is why we have to take care of properly.

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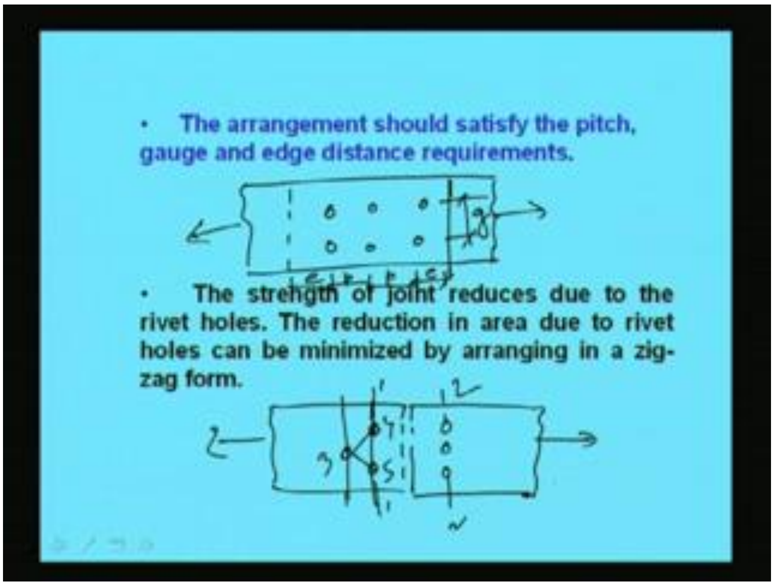

Another points we have remember is the arrangement should satisfy the pitch gauge and edge distance requirement. The code has given some provisions of gauge distance edge distance and pitch distance. So, those, has to be satisfy as per the codal provisions means that minimum pitch distance the 2.5 d. That has to be taken care like all the codal provisions whatever is given we which we have discussed earlier has to be maintained like suppose we have the rivet joints here. So, this is called we know that edge distance and this is called pitch distance, so pitch and edge distance should be that minimum distance should be taken care this is called gauge distance. So, this is gauge distance also has to be as per the codal provision. So, this point has to remember another parameter is the strength of joint reduces due to the rivet hole.

We know the efficacy we have calculated earlier that strength of the joint reduces, because of the reduction of rivet holes. The reduction area due to rivet holes can minimized by arranging in a zig-zag form now, what are the reduction that has been calculated in earlier case we have seen. So, that can minimized through the introduction of zig-zag riveting that means suppose if we have a 2 plate suppose this is 1 plate another plate is join through say some gusset uh. Now, in place of chain riveting it would be better if we can make riveting like this; that means, here the weakest section will be either through this or through this. That means reduction of area in this say section 1 1 will be less compared to section 2 2 that is why the section 2 2 will be weaker and in section 1 1.

The reduction will be 2 hole and in case of section 2 2 reduction will be due to 3 rivet 3 hole and another chances of failure will be say 1. So, if I make say this is 3 say 4 5 say 1 4 3 5 1, so in this way another chances of failure. So, here also we will see, because of the zig-zag riveting the additional strength will be come because of this. So, reduction if reduction is 3 also, but some additional forces will means additional strength will be added from that formula we know. So, this also we have to keep in mind while designing the rivet, so with this parameters in our mind we can start our design. So, those design basically design will be done through the applied force what are applied force? What is the plate thickness? What is the bearing, shearing and other details all those things we have know. And then accordingly we can design it, so those things will be clear through 1 example.

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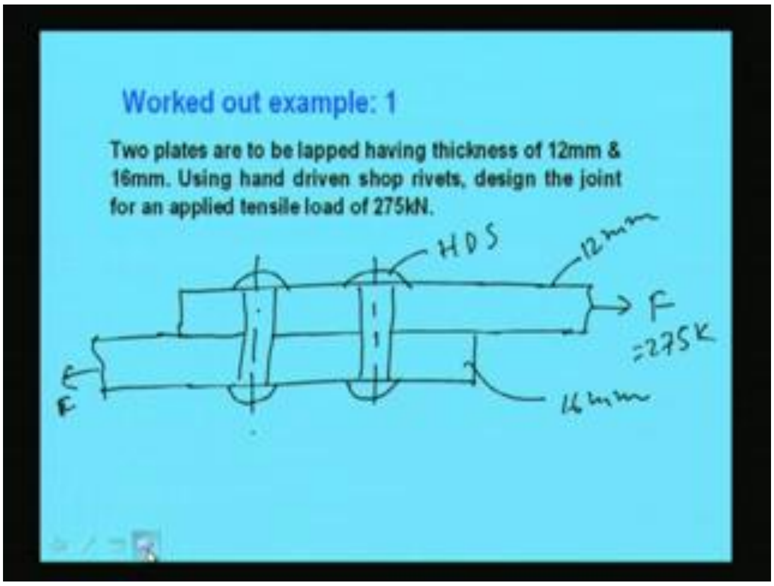

Now, I will work out some example through which we will be understanding how to design a rivet joint say in this case 2 plates are to be lapped having thickness of 12 mm and 16 mm. That means 2 plates we will be connecting through lapped joint and that will be has to be designed by the use of rivet using hand driven shop rivets design the joint for an applied tensile load of 275 kilonewton. So, what are the things have been told that 1 plate say rivet joint is given say this is 1 plate and another plate is this 1 are lapped with giving some lap length. Now, this rivets pitch diameter sorry pitch rivet diameter and other things we have to calculate from this. So, these are basically hand driven shop rivets and 275 kilonewton forces are applied axial force. Now, thickness of the plate is this is 12 mm and this is a 16 millimeter now, we have to calculate the details of the rivet joint. That means, we have to calculate means basically we have to find out what is the pitch distance, what will be the rivet diameter and how many rivets has to be provided all this we have to find out.

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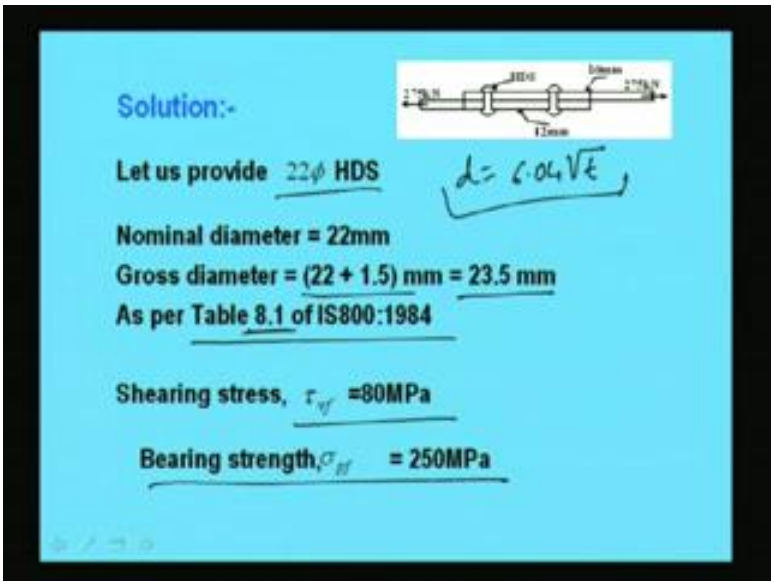

So, first let us provide some rivet diameter say for this case we are going provide say 22 hand driven shop of rivet diameter either. We can provide arbitrarily like this or we also can provide from the formula the 6.04 square root t from which that d can be calculated however here. We are considering say 22 mm later I will show in other example that I have considered through this also. Now, the gross diameter will become 22 plus 1.5 mm, so this will become 23.5 mm the gross diameter of the rivet. Now, as for table 8.1 of IS 800 1984 we will see that shearing stress is coming tau vf as 80 MPa and bearing strength will be 250 MPa. So, this values are can be find out from IS 800 1984 in table 8.1 this values are given. So, as for the type of rivet and other details we can find out the shearing stress and bearing strength of the rivet. Now, we can find out the strength of the rivet. So, to find the strength of the rivet first we will find out what is the shearing strength of rivet.

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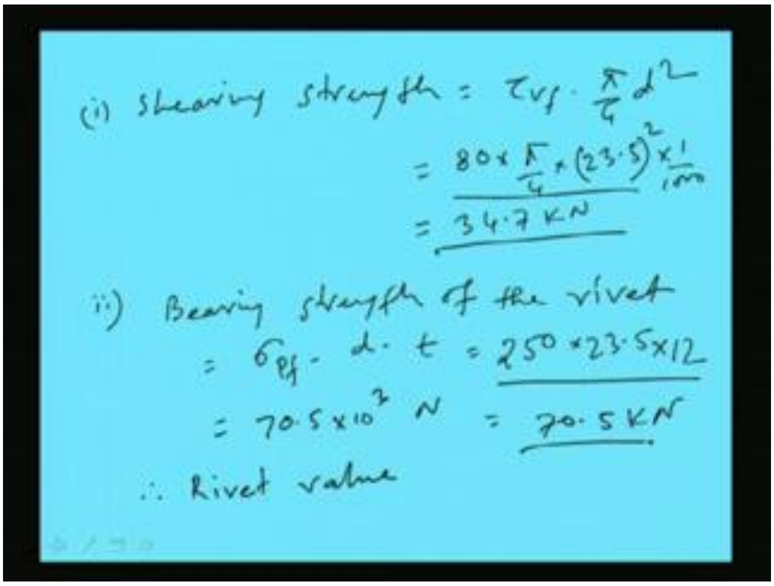

So, first will find out shearing strength, so shearing strength will be tau vf into Pi by 4 d square where tau vf is the shear stress allowable shear stress. So, this will be 80 into pi by 4 into here d will be 23.5 whole square, so after calculating this we will get this is coming 34.7 Kilonewton. Now, we have to multiply by 1000 to make it Kilonewton because this given in Newton next the bearing strength. So, 2 types of strength we will find out 1 is shearing strength another is bearing strength. So, bearing strength of the rivet will be bearing strength of the rivet that can be calculated from the formula that is sigma Pf into d into t.

That means 250 into d means 23.5 into t means the thickness now, thickness will be basically the 2 type of thickness has been given if we see that 1 is 12 mm another is 16 mm. So, thickness will consider the; that means, the lesser 1 12 mm because 12 mm will carry less strength, so failure will be first on the 12 mm plate. So, we are going to calculate on that basis is so; this will come 70.5 into 10 cube Newton; that means, 70.5 Kilonewton. So, rivet value can be find out from this to lesser of these 2 1 is 34.7 Kilonewton due to failure through shear. And due to failure of bearing this will be 70.5 kilo Newton. So, the rivet value will become the lesser of these 2 34.7 Kilonewton. So, in this way we can find out the rivet value.

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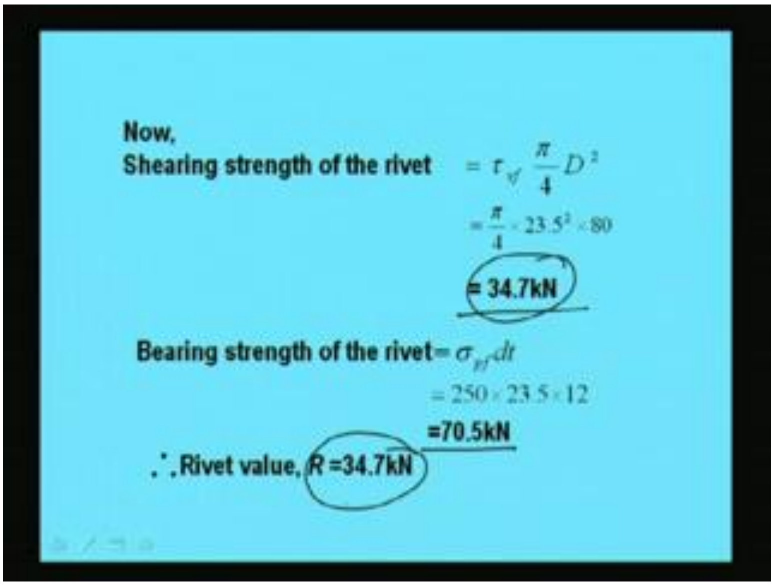

That means the shearing strength of the rivet we are going to get 34.7 Kilonewton and bearing strength of the rivet we are going to 70.5 Kilonewton. That means the failure will first accour, because of shearing strength, so we will find out the rivet as the lesser value of these 2; that means, 34.7 Kilonewton.

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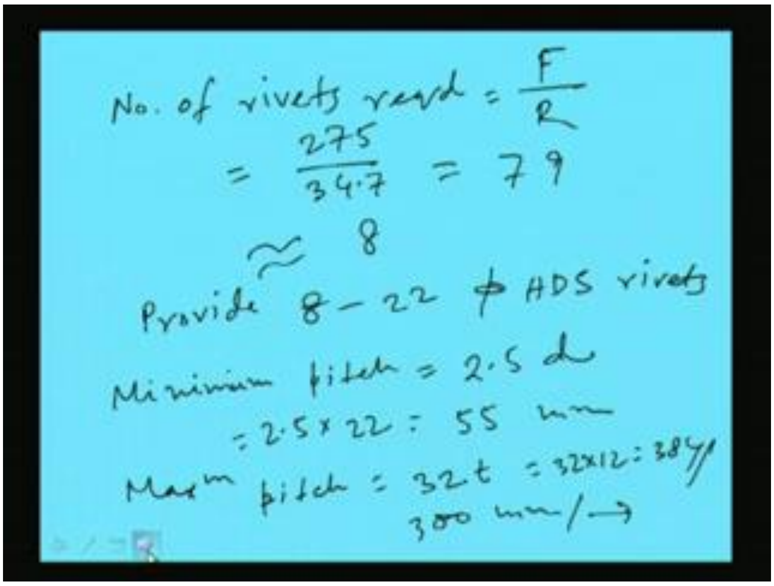

Next number of rivets can be find out from here number of rivets required will be the total force acting by rivet value. That means total force of 275 Kilonewton rivet value is 34.7 Kilonewton this coming around 7.9; that means, 8. So, we can provide say 8 numbers 22 hand driven shop we get, so for designing we need 8 number of 22 diameter of rivets. Now, we have to know what is the pitch what pitch will provide now, from a codal provision we know that minimum pitch is minimum pitch will become 2.5 d; that means, 2.5 into 22; that means, 55 mm. And maximum pitch maximum pitch will be maximum pitch that also has been given in the code which will be 32 into t; that means, 32 into t is 12. So, 3 8 4 and this will be the 22 t or 300 whichever is less; that means, maximum pitch cannot be greater than 300 mm. So, out of these 2 we will provide 300 mm. So, maximum pitch which 300 mm.

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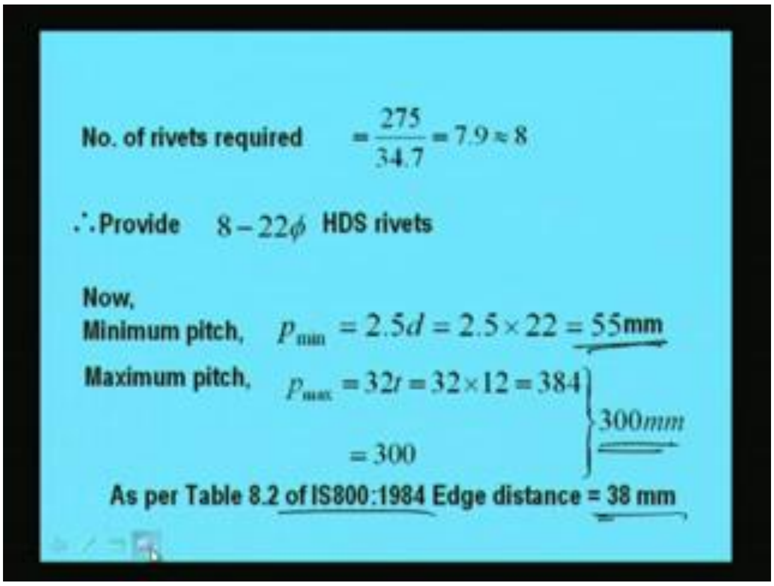

So, from these 2 criteria we can find out what is will be the pitch; that means, minimum pitch we can provide 55 and maximum pitch we can provide 300, so in between we can provide. Now, as for table 8.2 of IS 800 1984 the edge distance will become for this case 38 mm. Now, we have to configure this through pitch and edge.

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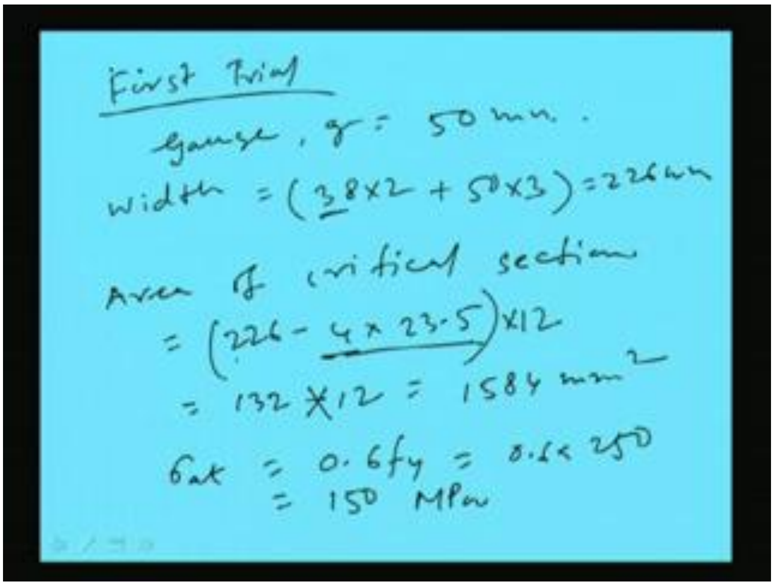

So, we have to go through some trial say first trial let us take the gauge distance, say 50 mm. Then what will be the width? Width of the plate will become 38 into 2 this the edge distance in 2 side plus 50 into 3, because we have the number of rivets total number of rivets are 8, so 3 gaps will be there. So, this will become 226 millimeter, so area of critical section will be 226 minus 4 into 23.5, because in each row we are providing 4 number of rivets. So, this is the reduction due to hole and this is the width into 12 mm thickness, so this will become 132 into 12, so 1584 millimeter square. Now, the allowable stress sigma at is equal to we know 0.6 fy; that means, 0.6 into 250 which will because 150 MPa, so allowable stress is this.

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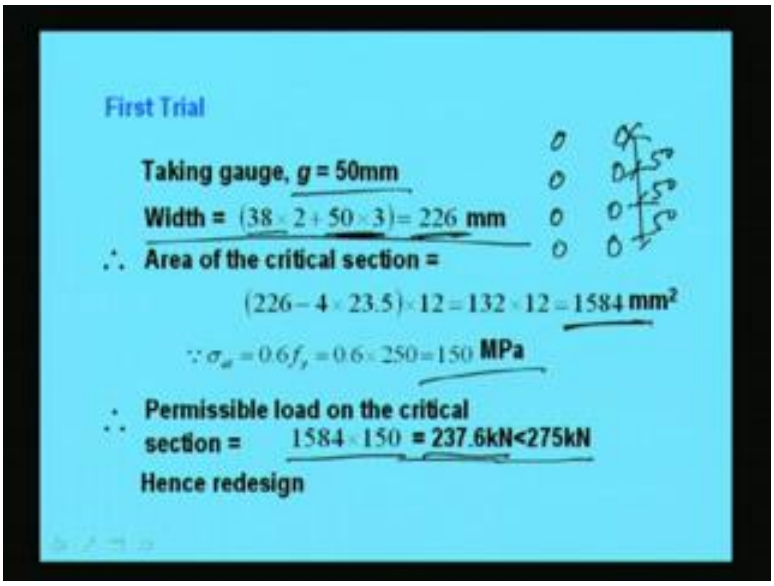

So, the permissible load on critical section will be the total area into allowable stress which will become 237.6 Kilonewton which less than 275 Kilonewton. That means in first trial what we have done that first we have assume that gauge distance has 50 mm. Now, as per the gauge distance we will get the width as 38 into 2 plus 50 into 3 is equal to 226 mm, because in each row we are providing 4 pitch in 4 rivet. So, in between distance this will be 50, so 50 into 3 plus 38 into 2 this, the edge, so in this way we can calculate. The critical section area area of the critical section in which rivet will fail that is coming 1584 millimeter square. Now, the sigma at value is 150, so permissible load on the critical section will become 237.6 Kilonewton which is less than 275 Kilonewton. That means we have to go for redesigning; that means, the plate is going to fill before the total load is going to act. So, we have to make in such way that at least 275 Kilonewton load can be distributed how? That means, we have to increase the width; that means, we have to increase either this pitch or the edge in this way we can make it.

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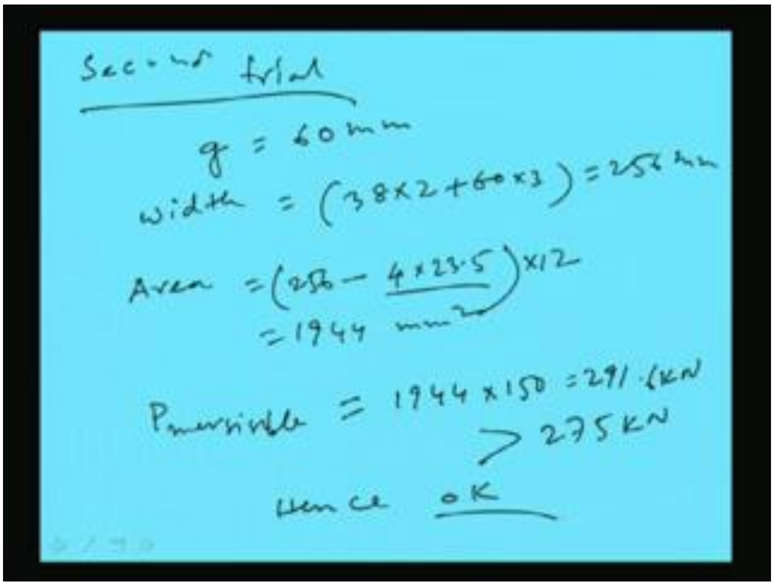

So, let us go for the second trial in second trial let us take gauge distance g is equal to say 60 mm. So, width will become in this case 38 into 2 plus 60 into 3, so this is coming 256 mm. Now, area of the critical section will become the width 256 minus 4 into 23.5. This is, because of reduction of hole into 12 that is coming 1944 millimeter square. So, permissible load will become 1944 millimeter square into 150 that is coming 291.6 Kilonewton which is greater than the applied load 275 Kilonewton, so we can say this is.

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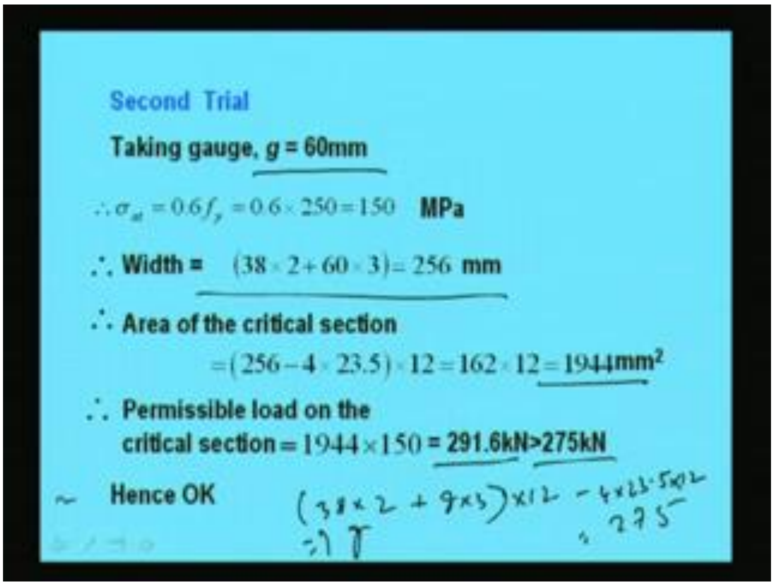

So, if we provide the gauge distance as 60 mm then the width is becoming 256 mm thus the area of critical section is coming 1944 mm square. And the permissible load is becoming 291.6 Kilonewton which is greater than 275 Kilonewton. So, the, this is if we do not consider the g value that also we can find out from the equation how that. We can find out simply 38 into 2 plus g into 3 into into 12 minus 4 into 23.5 into 12 is equal to 275. So, from this equation also we can find out the exact g through which the sections can carry just 275 Kilonewton, so in this way also we can calculate.

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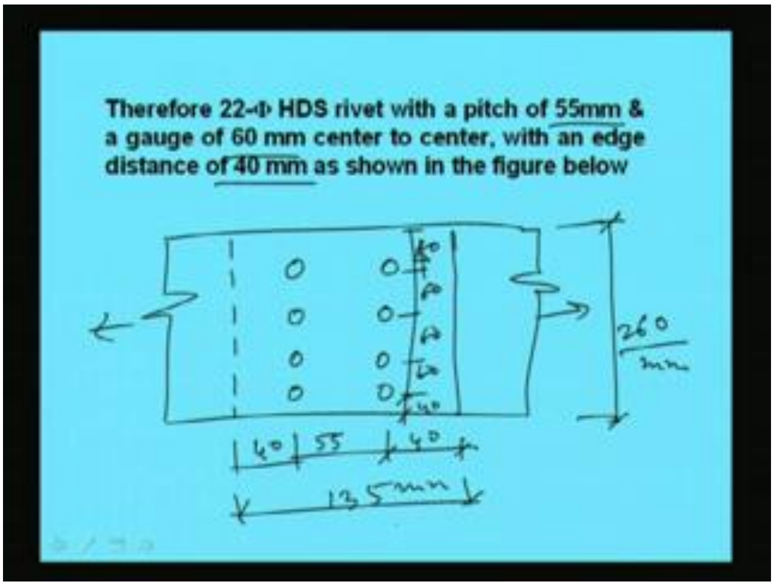

So, in conclusion what we can tell that we can provide 22 diameter of hand driven shop rivet with a pitch of 55 mm and a gauge of 60 mm center to center with an edge distance of say 40 mm as show in the figure. So, if we see the figure now the driven will be like this because the designer when designs he has to make the drawing in such a way that the construction engineer can follow the drawing. So, drawing has to be complete in all sense, so that the exhibition time the engineer should not have any confusion. So, now let us 2 plate 4 rivets in each row we are providing and the pitch distance is 55 mm. We have taken these are the minimum and this is we are taking 40 and this distances we are taking 40 60 60 60 60 in fact, this 60 can be reduced little bit and. So, this total width is becoming sorry this is 40 60 into 3 180 plus 40 into 280; that means, 260. So, total width of the plate will become 260 and the overlap length the lap length will become 40 into 280 plus 55; that means, 135 mm. So, as I was telling in last slides that the lap length should be as less as possible to shape the material. So, here we see that lap length should be at least 1 35 mm now, we will see some are example.

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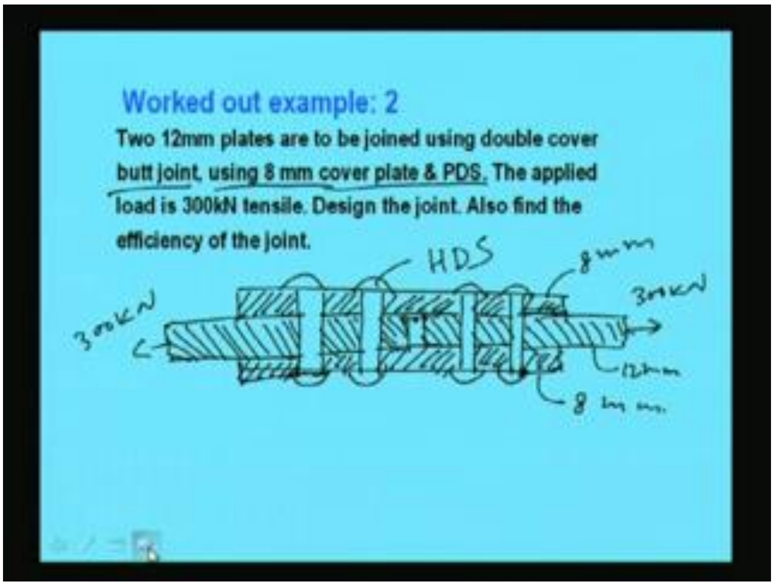

This is another type of example that is 212 mm plates are to be joined using double cover butt joint. So, in earlier example we have show the lap joint here we will show the butt joint using 8 mm cover plate and power driven shop rivets the applied load is300 Kilonewton. So, design the joint also find the efficiency of the joint, so here the joint is looking like this say 1 cover is given here first let me draw the rivets first then we will insert the plate. So, these are the rivet this is a double cover joint, so this has becoming this is 1 plate the main plate is this 1 this is 300 Kilonewton force is acting on this main plate. And then another cover like this, now this is 1 extra cover we have put with having thickness of 8 mm here also another cover which is a double cover. So, here also we are putting another cover this is also given as 8 mm and the main plate is of 12 mm main plate is this 1. This is 1 plate this is another plate, so these are HDS hand driven shop, so arrangements of rivets are like this. Now, I have to design it designing means again the pitch distance edge distance and the gauge, so all these things we have to find out the we have to find out.

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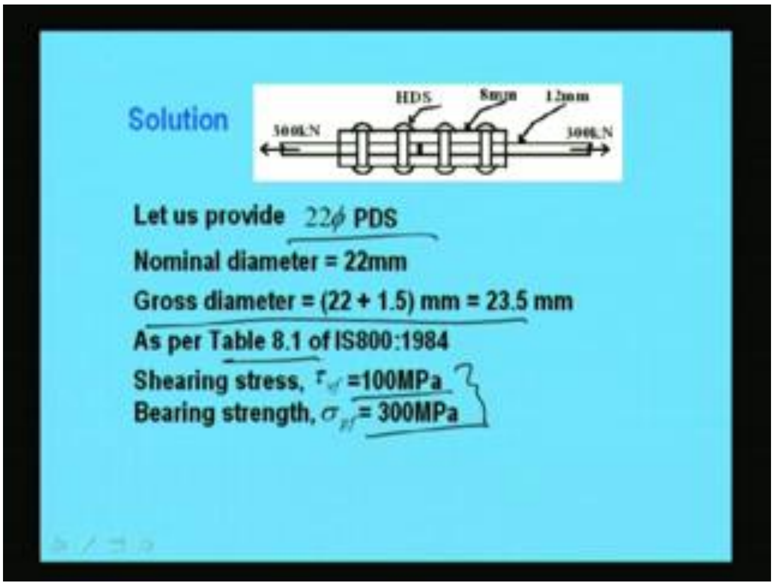

So, these are the things given 1 is let us provide some diameter of rivet say 22 Phi power driven shop, so the gross diameter of rivet will become 23.5 millimeter. And as per table 8.1 IS 800 1984 the shearing stress will become hundred MPa and bearing strength of rivet will become 300 MPa, because this is hand driven shop rivet. So, because of this HDS rivet this is given in the table 8.1 of IS 800 1984 from which we can find out. Now, we have to find out the strength due to shearing and strength due to bearing.

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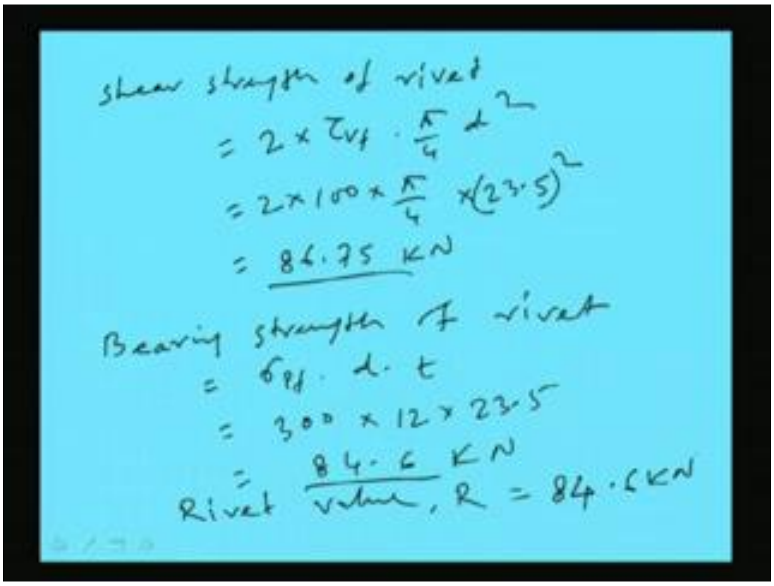

So, shearing strength of rivet we can find out shearing strength of rivet this will be this double shear, so 2 into tau vf into pi by 4 d square. So, this will become hundred tau vf is 100 pi by 4 into d square means 23.5 square, because the whole diameter is become 23.5. So, after calculating this we will get 86.75 Kilonewton similarly, the bearing strength on the rivet can be calculated from the formula sigma Pf into d into t. So, sigma pf in this case is becoming 300 into d is 12 mm and t is sorry t is 12 mm and d is 23.5. So, this is becoming 84.6 Kilonewton, so the rivet value can be find out from these 2, so we can find out rivet value R will become the lesser of these 2 value. So, it will become 84.6 Kilonewton, so in this way we can find out the rivet value.

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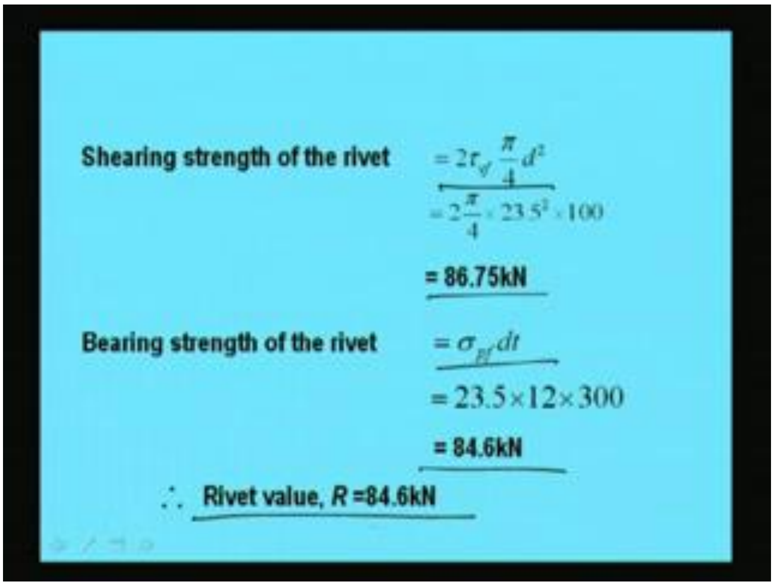

So, the shearing strength of the rivet which has been calculated from this formula 2 into tau vf into pi by 4 by into d square through which we can find out 86.75 Kilonewton. And bearing strength of the rivet which has been find out from this formula sigma Pf into d into t which is becoming 84.6 Kilonewton. And from these 2 the lesser value has to be consider as a rivet value, so rivet value we are finding out as 84.6 Kilonewton.

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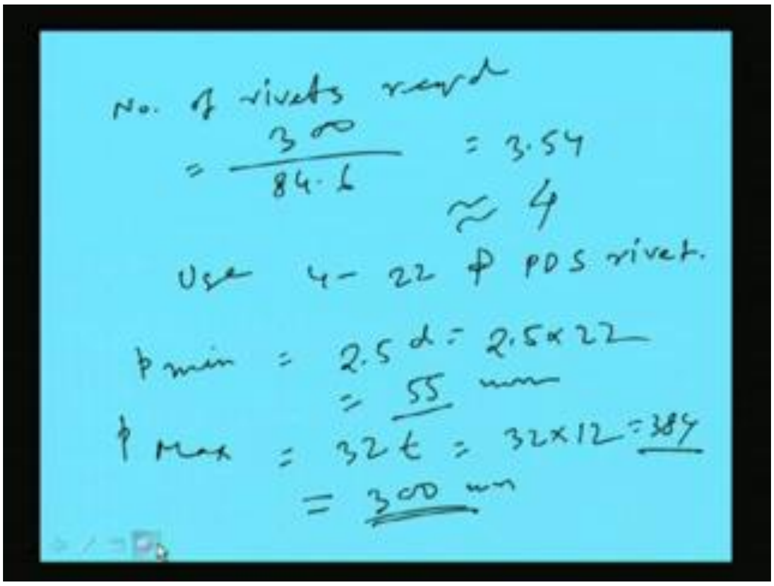

Now, let us see what will be the number of rivets is required, so number of rivets required will be applied force of 300 and rivet value was 84.6. So, this is becoming 3.54; that means, we have to take 4 rivet, so use 4 numbers of 22 phi PDS power driven shop rivet. So, this will be the answer now, again we have to calculate the minimum pitch maximum pitch and from those criteria we have to find some suitable pitch. So, minimum pitch will become P minimum is equal to 2.5 d; that means, 2.5 into 22 55 mm. And maximum pitch will become P max will become 32 into t; that means, 32 into t means the lesser thickness that is 12 mm. So, this is becoming 384 and in any case it should be less than or equal to 300 mm, so out of these 2 we can find out the pitch. So, maximum pitch will become 300 and minimum pitch will be become 55. So, from this we have to find the suitable pitch distance.

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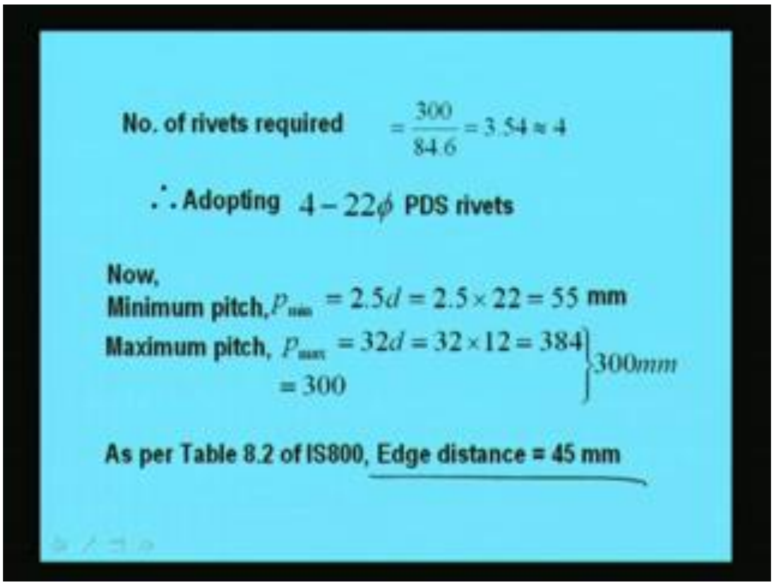

So, pitch distance we can find out now as for the table 8.2 of IS 800 the edge distance will become 45. So, with this we can find out the gauge distance and others dimensions.

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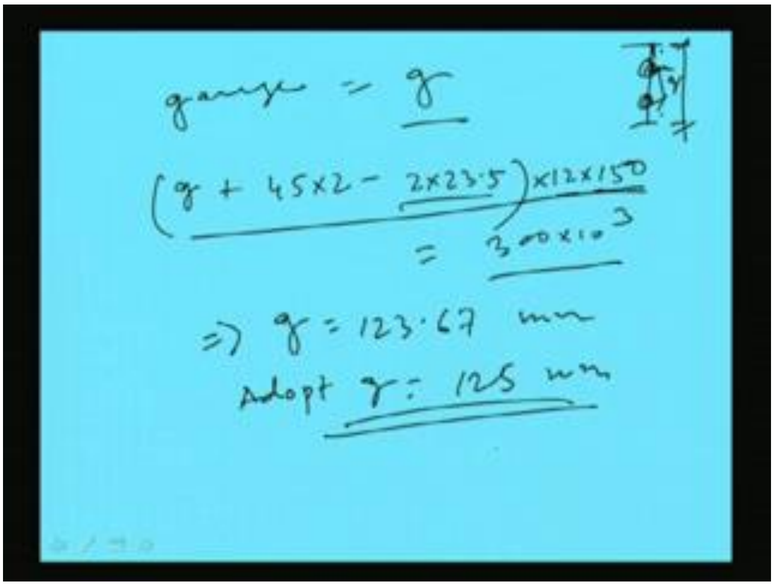

Say let us use some gauge distance g. So, gauge is equal to g either we can do through trial as we have done in the earlier case or if we assume the gauge distance g and we can find out from the equilibrium equation that means if use g. Then it should become g plus 40 into 2 minus 2 into 23.5 into 12 into 150 will become has to be equal to 300 into 10 cube what is this, because we have seen the total number of rivet is 4. That means 2 rivet in each line and to find out the plate width we have to know what is the total width. So, if we assume this is a g then g plus this is the edge distance 45 plus 45 minus the whole 2 rivets are providing in 1 line. So, minus 2 into 23.5 into thickness thickness is 12 and allowable stress is 150. So, these are the stress or these are force which can be taken by the plate and these are the force which has to be taken; that means, applied force is 300 Kilonewton. So, if we make equilibrium from this we can find out g as 123.67 millimeter, so we can adapt g is equal to say 125 mm. So, in this way we can find out g, so as I was telling that in earlier example we have shown 2 trial we thought here exactly we are finding out. So, both the way we can do, but I will suggest that we should go with this method, because exactly we will get and according to that we can choose the gauge distance.

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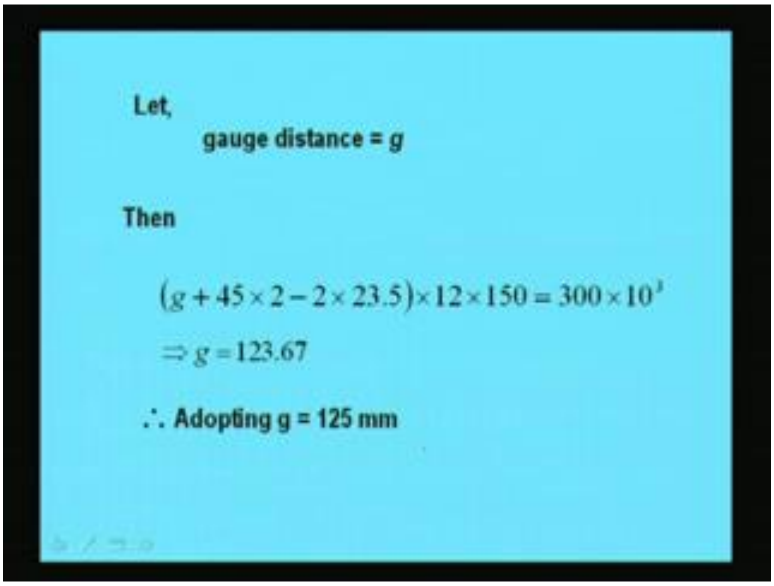

So, the process what we have discuss that how to find out the gauge distance and how to find out the total width of the plate. So, in this case we are adapting gauge distance as 125.

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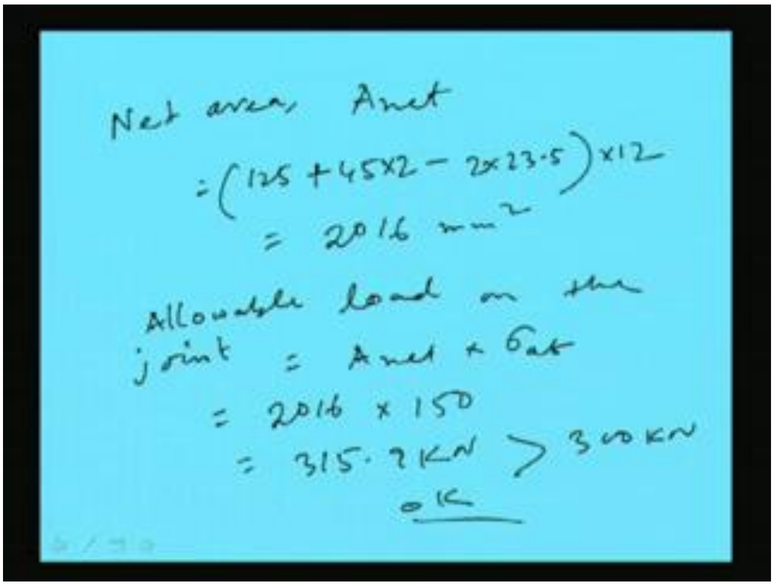

The net area we can find out net area a net will become 125 plus 45 into 2 minus 2 into 23.5 into 12 this the net area which is becoming 2016 millimeter square. So, allowable load on joint will become this will become net area A net into sigma a t. That means, net area is 2016 into sigma a t value is 150 which is becoming 315.9 Kilonewton which is greater than 300 Kilonewton; that means, the edge distance whatever we have made is.

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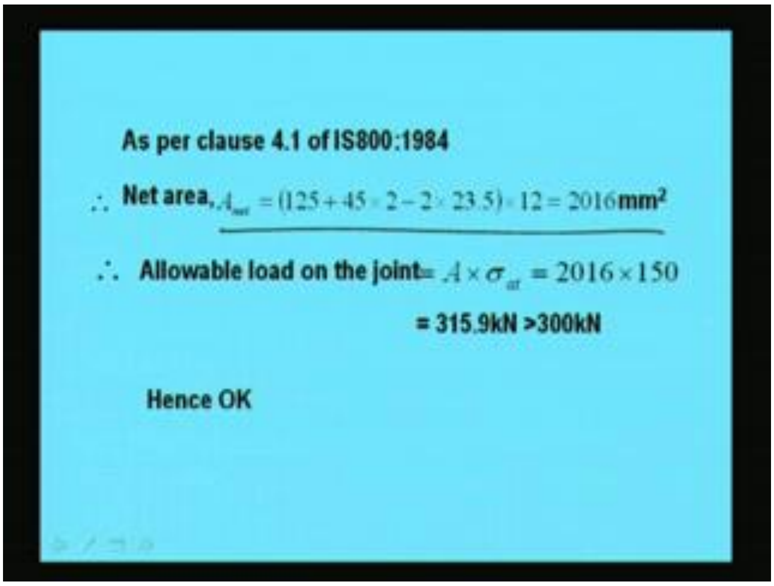

So, what we are saying that net area, because of hole of the rivet we are finding out as 2016 and the allowable load we are finding out as 315.9 Kilonewton which is more than

300 Kilonewton. So, with this dimension; that means, with considering gauge distance as 125 millimeter and edge distance as 45 millimeter we can design the joint which will take care 315.9 Kilonewton load.

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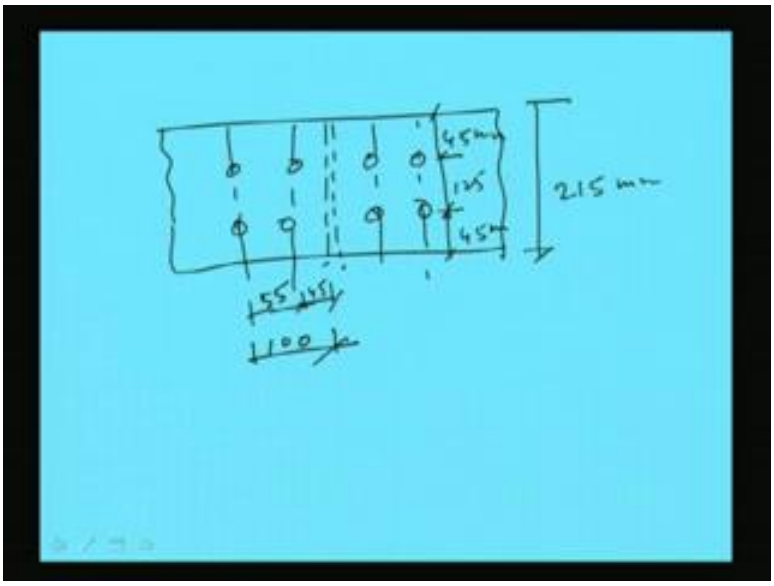

So, if we draw the figure this will look like this say the plates are like this and it is butt joint is here. So, here we are providing 4 rivet 2 rivet in each row this is the rivet line, so this distance we have as 125. And this is 45 mm and this will become 45 mm, so this will become total 215 mm, so width of the plate will become 215 mm. Now, this will become 45 and this will become say pitch distance we have calculated earlier as per that we can make that say 55 to save the material. So, this we can make as 55; that means, this length will become 100 mm 100 mm form the end of the plate we can make, so in this way we can distribute the rivet.

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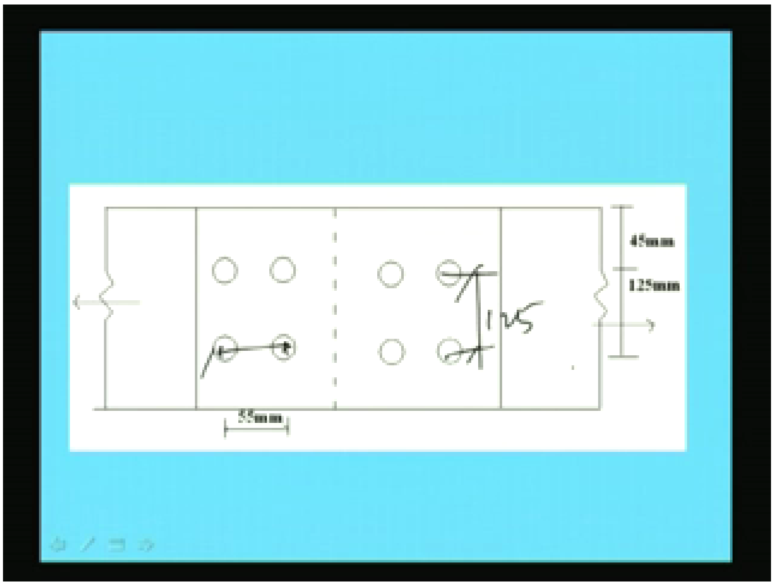

Now, we can find out the efficiency, so this is the picture which I was drawing there, so in this way we can make let say 55 mm. And this distance we made that 125, so whichever I have drawn the same thing I have reproduced here.

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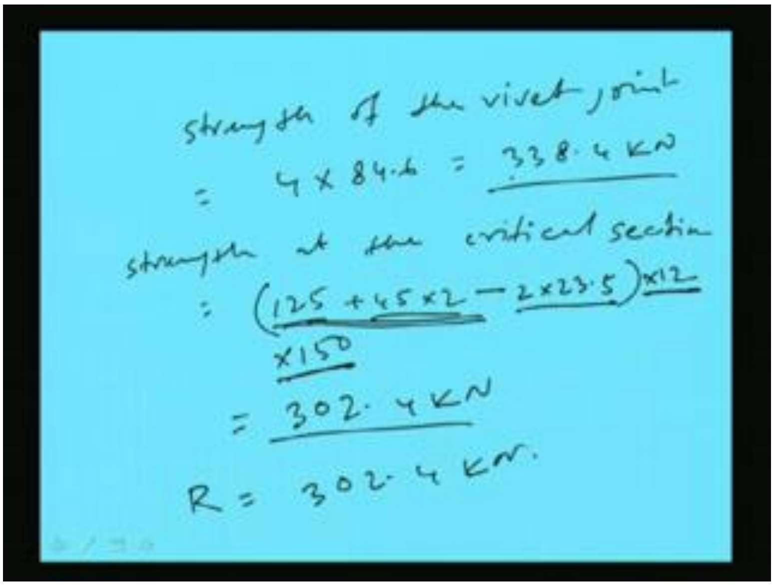

Now, if I want to show the efficiency of the joint, so efficiency how do we find out first we have to find out the strength of the rivet joint. What will be the strength strength of the rivet joint will be 4 rivets are there 4 into rivet value 84.6, so 338.4 Kilonewton. So, this is the strength of the rivet joint and strength of the plate at the critical section we have to find out strength at the critical section, because the plate may fail also. So, the strength of the plate at that section has to be calculate, so that we become 125 plus 45 into 2 minus minus 2 into 23.5 into 12 into 150 where this is the gauge distance this the edge distance. So, total width will be this minus deduction due to hole into plate thickness into allowable stress will become the strength which is becoming 302.4 Kilonewton. So, one is that 338.4 Kilonewton due to rivet and the plate strength will become 302.4. So, we can consider the the strength will be lesser of these 2, so strength of the joint will become say 302.4 Kilonewton.

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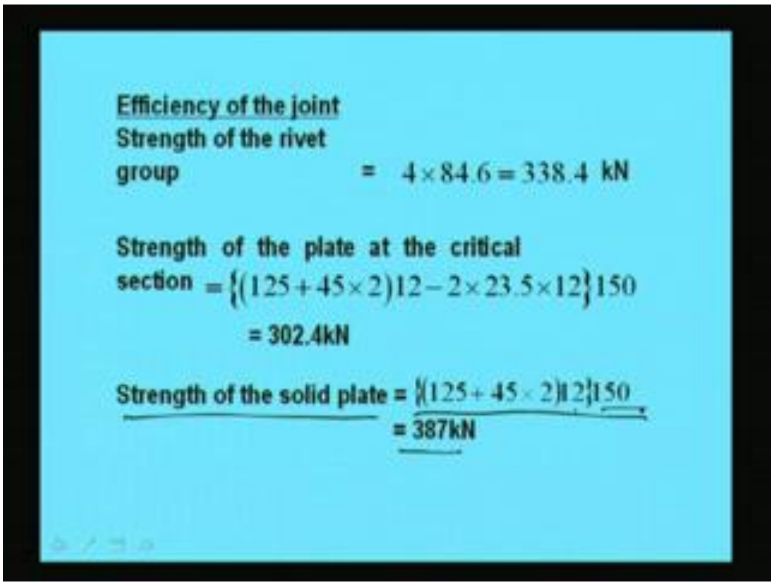

Again the strength of the solid plate will become means if rivet is not there if hole is not there then the strength of the solid plate will become this 1 125 plus 45 into 2 into 12 into 150. So, this will become 387 Kilonewton, now we have to find out the efficiency, so efficiency how do we find out efficiency will be the strength of the riveted plate by the strength of the solid plate.

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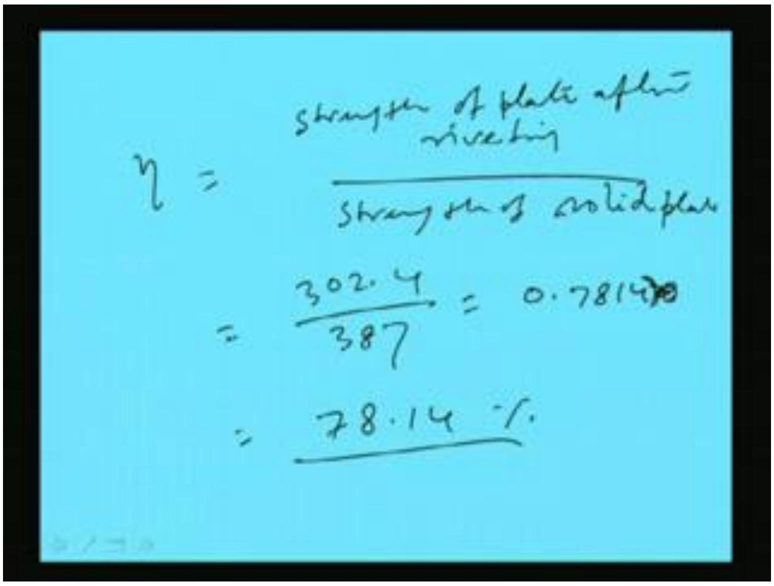

So, efficiency we can make that strength of plate of a riveting by strength of solid plate that means strength of plate of the riveting will become 302.4, because this we have calculated. This is the minimum strength is coming out of these 2 and strength of the solid plate is 387, so by 387. So, this is becoming 0.7814 percent; that means, the efficiency of the joint will become 78 point sorry this will become 78.14 percent, so in this way we can find out the efficiency.

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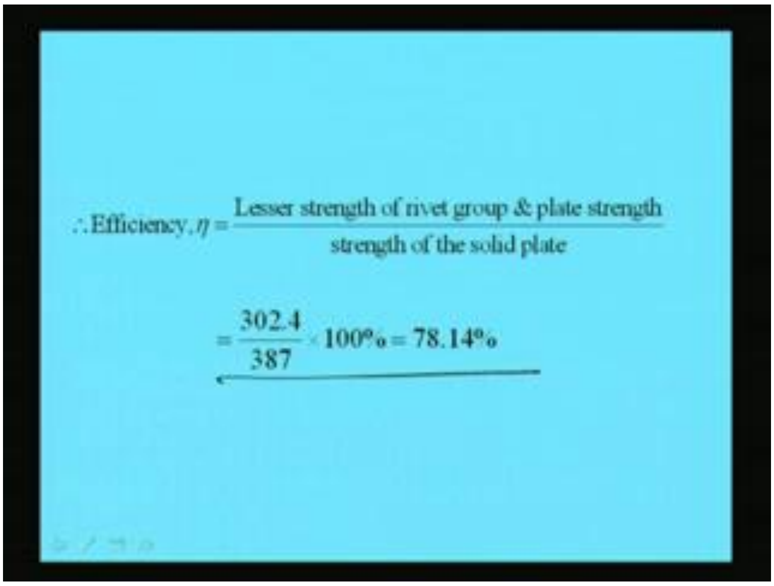

Efficiency of the joint in this case in this configuration is becoming 78.14 percent. Now, we will see 2 some other example this is very important.

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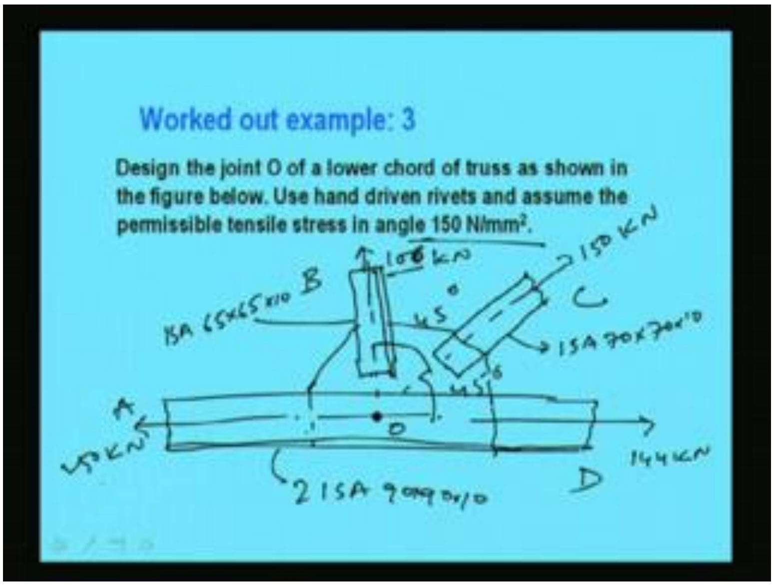

Because how to design a truss joint truss member that we will show here say design the joint O of a Lowe chord of truss as shown in the figure below use hand driven rivets. And assume the permissible tensile stress in angle as 150 Newton per millimeter square let me first draw the joint. Then we will be to understand what are the problem we have to make itsay this is the lower chord. This is having the center line here and the force is 1 sorry this force is becoming 144 Kilonewton in this side and this side force is 250 Kilonewton. This is the center point say O and from this another member has gone like this.

So, this is 150 Kilonewton and another member vertically is acting which is also having load of 106 Kilonewton this is 106 Kilonewton. So, this point let us this member OA this member is a suppose OB this member is OC and this member is OD and this angle is say 45 degree. This angle is 45 degree and the size of angle is this is 2 ISA 90 90 10 and this member is consisting of 1 angle 70 by 70 by 10 and this is ISA a 65 by 65 by 10. So, these are the details of the joint now, we have to design this joint say we have to provide some plate and we have to design accordingly say what will be the number rivets for this joint. What will be the number rivets for this joint and what will be the number rivets for this member that we have to find out.

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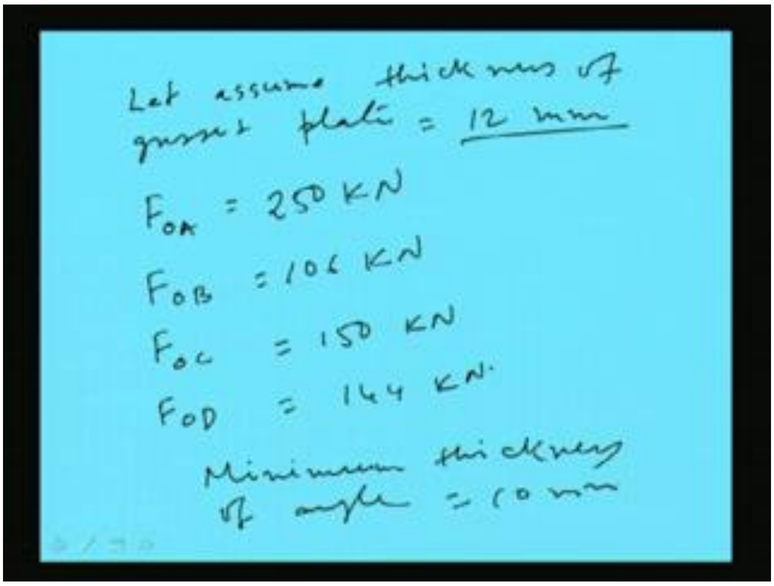

So, now what we will do first? We assume some thickness of gusset plates let assume thickness of gusset plate. So, to start with we have to assume some thickness, so we have assumed as say 12 mm because 10 mm thickness was for all the plate members. So, we are considering say 12 mm now, forces are given say for member OA this force is 250 Kilonewton. So, these are given then FOB is also 106 Kilonewton then FOC is having 150 Kilonewton all are axial forces and FOD is given 144 Kilonewton. Now, so here 1 thing is we should observe that minimum thickness of angle is 10 mm this is 1 thing.

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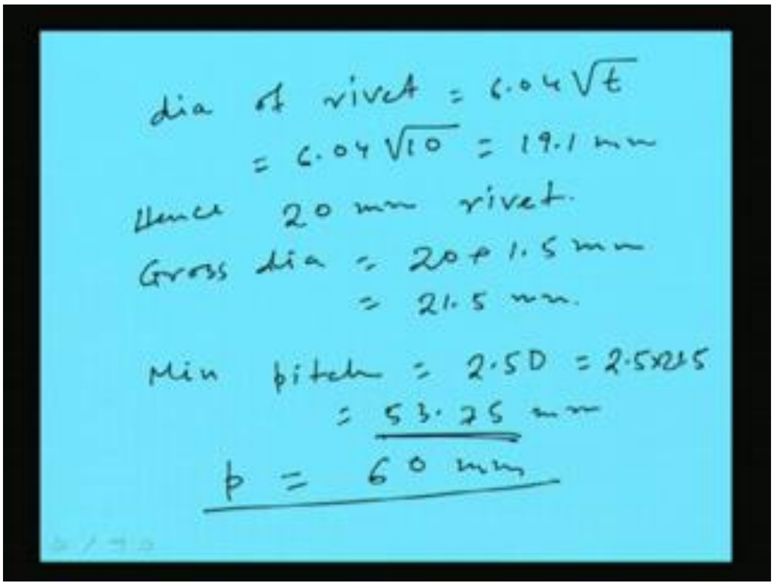

So, accordingly we can find out the approximate diameter of rivet as 6.04 into minimum thickness of the all plates, so this will become 6.04 into thickness as 10 mm. So, this is becoming 19.1 mm hence we can provide 20 mm rivet, so in this way also we can decide. The diameter of a rivet otherwise we can just approximately we can assume 20 or 22 or 18 or something we can assume also. Now, the gross diameter will be 20 plus 1.5 mm, so this will become 21.5 mm. Now, minimum pitch let us find out minimum pitch which we need to provide is 2.5 d. So, 2.5 into 21.5, so this will become 53.75 mm. So, let us provide say pitch as 60 mm because minimum pitch we have to provide 53.75 mm. And maximum is 32 t or 60 or 300 whichever is less, so from this criteria let us provide pitch at 60 mm in this design.

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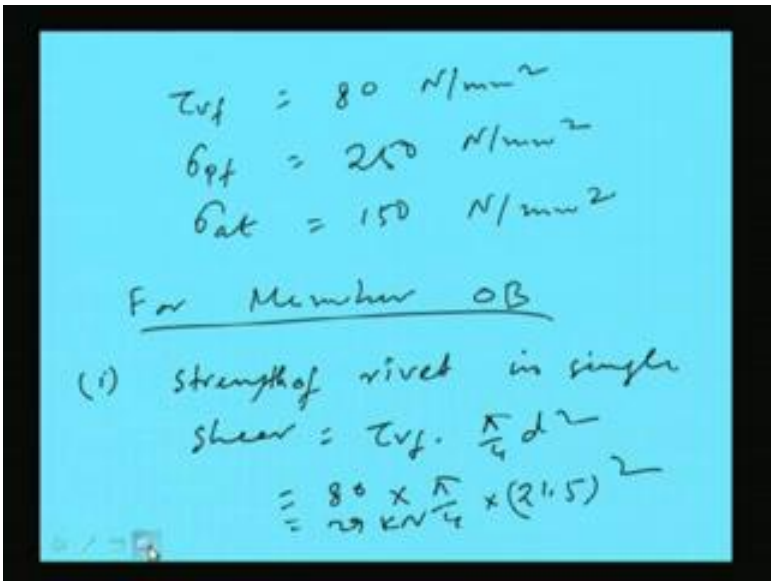

Now, for hand driven rivet tau vf will be 80 Newton per millimeter square as for the codal provision and sigma Pf will become 250 Newton per millimeter square and sigma a t will become 150 Newton per millimeter square. So, these are the values we have to consider from the IS code now, 1 by 1 member we can go say for member OB. That means, the vertical 1 that means this member first let us design this member member OB. So, what we will do first we find out the strength of rivet now, this is a, we can consider a single shear. So, strength rivet will become strength of rivet in single shear will become tau vf into pi by 4 d square. So, tau Vf is 80 into pi by 4 and d is here 21.5, so this is become 29 Kilonewton.

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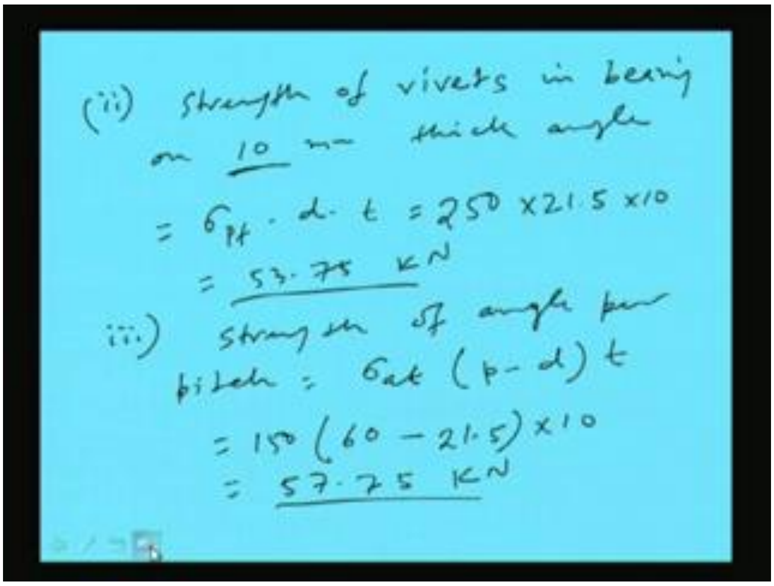

So, the rivet value due to single shear will become 29 Kilonewton the second 1 become strength of rivets in bearing strength of rivets in bearing on 10 mm thickness thick angle, because angle thickness is 10 mm. So, the bearing strength will become sigma Pf into d into t, so that will be 250 into 21.5 into 10. So, this will become 53.75 Kilonewton, so this is another strength we are calculating due to bearing another is strength of angle or pitch. We have to find out strength of angle per pitch strength of angle per pitch will become as per the formula sigma a t into P minus d into t. So, sigma it is given 150 and pitch we have consider as 60 D will become 21.5 and t is the thickness of the plate that means the angle, so this is becoming 57.75 Kilonewton. So, what we got that we are getting rivet strength as 57.75 Kilonewton per pitch and due to bearing this is 53.75 Kilonewton and due to shearing this 29.29 Kilonewton

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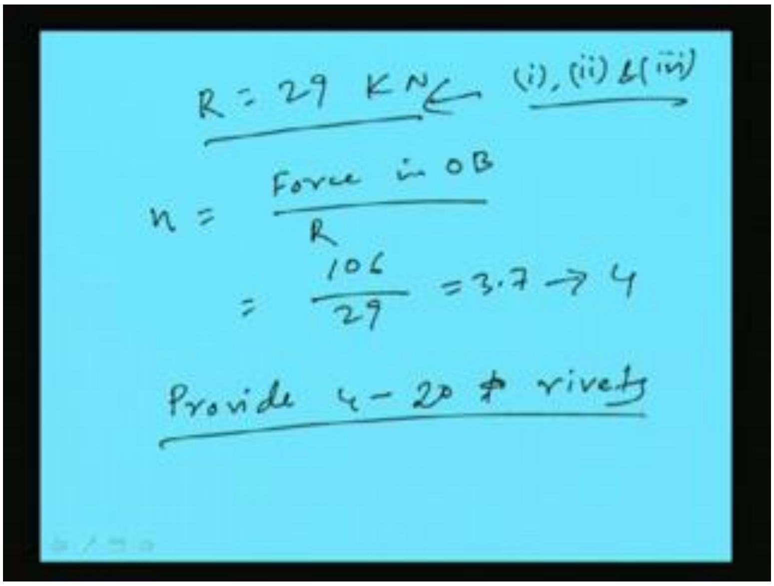

So, we have to take the, we have to take the lesser value of these 3, so the rivet value will become finally, as 29 Kilonewton. That means this minimum of case 1 case 2 and case 3, so minimum of these 3 is coming as 29 Kilonewton. Now, on this basis we can find out the number of rivets require because we know force, so number rivet required will be force in OB by rivet value. So, force in OB we have 106 Kilonewton. And rivet value we got 29, so this becoming 3.7, so we can provide 4 rivet value 4 rivets. So, we can say 4 member OB provide 4 number of 25 rivet, so this will be the answer. Now, we will design later means design means dimension of means configuration of rivets what will be pitch what will be edge and other things will discuss later, so for member OC let us see.

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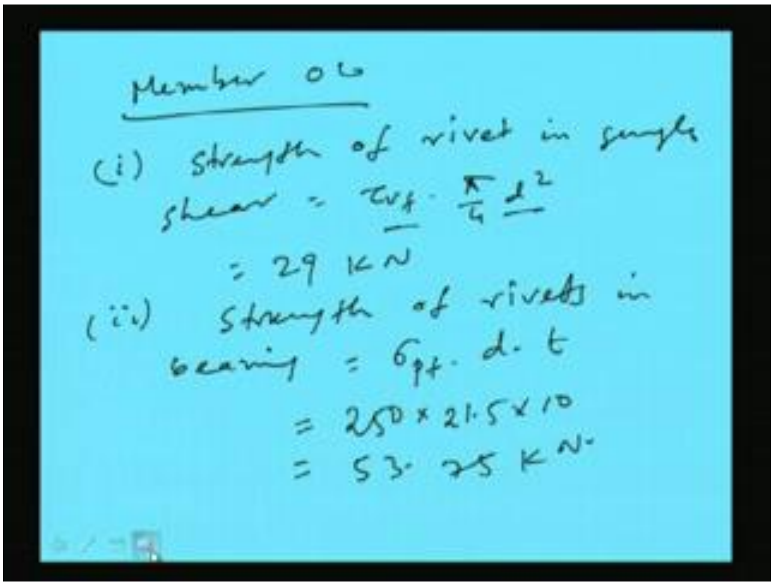

So, in case of member OC similarly we can find out the strength of rivet in single shear strength of rivet in single shear. So, this will become tau vf into pi by 4 d square., so this will be also similarly pi by 4 into tau vf will become 80 and d is 21.5. So, this is an 29 Kilonewton now, strength of rivets in bearing that we have to find out now strength of rivets in bearing. This will be also same similar to either 1 strength of rivets in bearing this will become sigma Pf into d into t here sigma Pf will be 250. And diameter will be 21.5 and thickness of the angle is 10, so this is also becoming 53.75 Kilonewton and sorry next slide.

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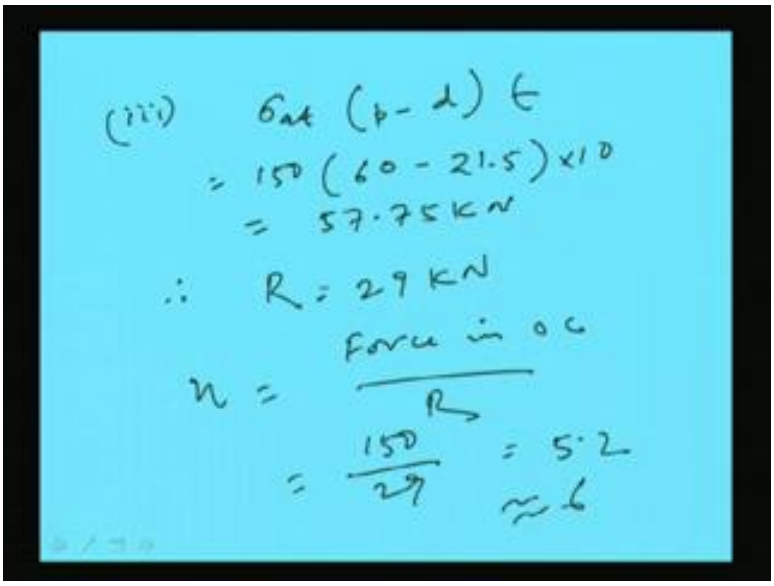

And the strength of angle per pitch will be become; that means, case of 3 strength of angle per pitch will become sigma at into p minus d into t; that means, this will become 150 into 60 minus 21.5 into 10. So, this will also become 57.75 Kilonewton, so we can find out the rivet value R as 29 Kilonewton. So, number of rivet required for this member OC number of rivet will be required force in OC by the rivet value. That means this will be force in OC was 150 and rivet value was 29. So, this is becoming 5.2; that means, we can provide 6, so in this way we can find out the rivet value.

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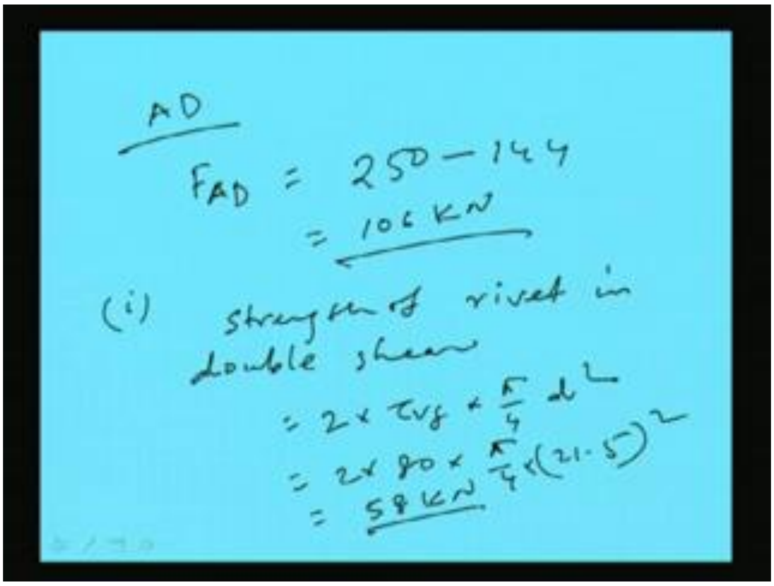

So, next is 4 member AD for member AD, so for memorial AD what will be the force FAD that will be 250 in 1 direction and in another direction opposite direction 144. So, the balance of these 2; that means, 250 minus 144; that means, 106 Kilonewton. So, remaining force in member AD is becoming 106 Kilonewton. Now, strength we have to find out now, strength of rivet here it will be double shear, because double angle is provided. So, strength of rivet in double shear that will become 2 into tau vf into pi by 4 d square, so this will become 2 into 80 into pi by 4 into 21.5 square. So, this is becoming 58 Kilonewton, so strength of rivet in this case is becoming 58 Kilonewton due to double shear.

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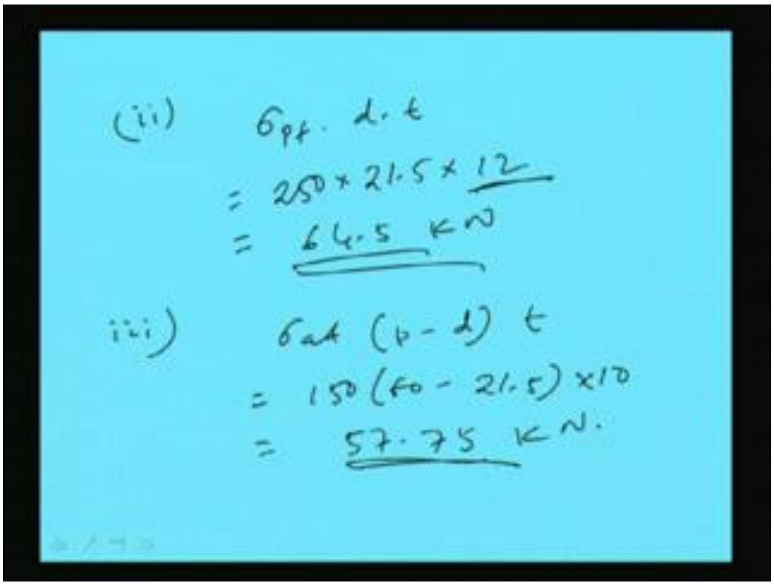

And strength of rivet in bearing on 12 mm thick gusset plate will become sigma Pf into d into t that means here sigma Pf is as usual 250. And d is 21.5, but t will become here as 12, because we are considering the gusset we are considering the gusset. We are considering the plate AD member AD we are considering, so this is becoming 12, so this some defines we needed from earlier. So, this coming 64.5 Kilonewton, so strength of rivet in bearing on 12 mm thickness will be 64.5 again strength of angle per pitch length will become sigma 80 into p minus d into t. That means 150 into 60 minus 21.5 into t will become here 10, so this with will become 57.75 Kilonewton. So, here we have seeing the least value is becoming 57.75 Kilonewton out of these 3 1 is 58 Kilonewton and another is 64 and another is 57.75 Kilonewton.

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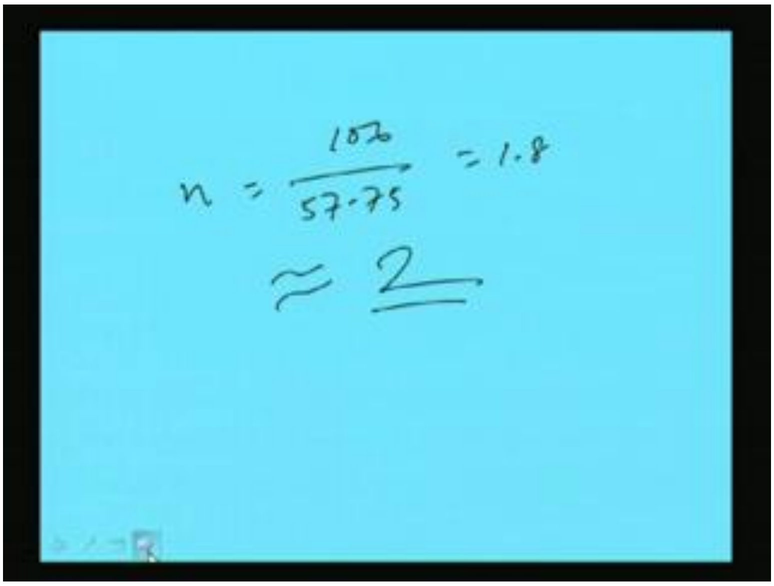

So, the number of rivet required will be 106 by 57 .75, so this is becoming 1.8; that means, 2 number of rivets will be required. So, we have to provide 2 rivets in member AD. So, if we draw the joint how it will look like as for designing it will look like this.

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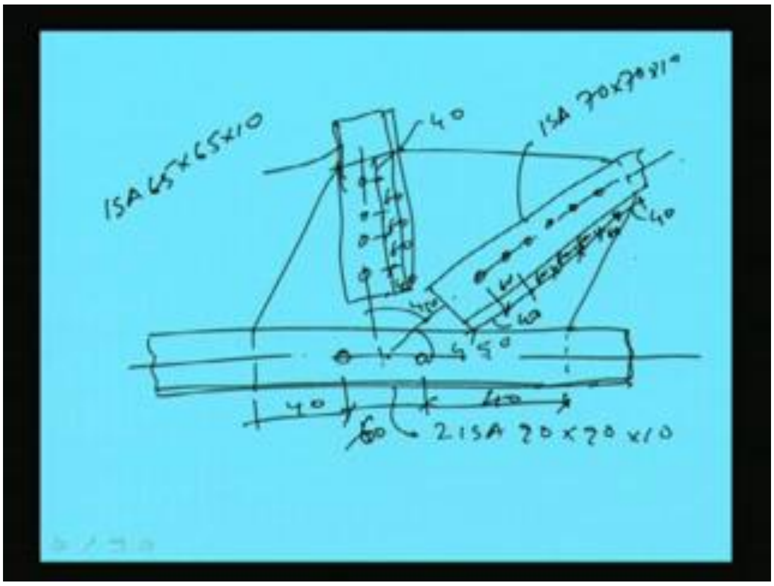

Say this is the button chord with having 2 angle this is 2 ISA 90 into 90 into ((01:01:20)) 10 this is the center line this is the vertical line. Now, another member is here another member is here another member is this 1, so this is 45 degree this is also 45 degree. So, we are providing some rivets if we are it is 4 number rivets will be required and the pitch distance we have provided 60 and this is 40. These are 60 60 60 and this is 40, so in this way we have to make it and here we have make it. So, in member OC we need 6 number of rivets, so 1 2 3 4 5 6, so accordingly we have to make the pitch. So, this edges distance for t and these are all 60 60 this is 60 this is 60 and this is again 40.

And here the in the bottom chord in here 2 rivets, so this we can provide as 40 sorry 60 and this will be 40 and this will be 40. So, in this way we can draw the joint now, this is ISA 65 65 10 and this is ISA 70 by 70 by 10. So, this an example we have shown here how to draw a joint how to design a joint truss joint particularly with having different type of forces. So, in next class, we will discuss about welding joint because riveting joint in details has been discussed how to calculate the strength how to calculate its efficiency. And how to design a rivet joint that we have discussed. So, in next class we will go for the welding joint.

Thank you.