Design of Steel Structures
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Module - 3
Eccentric Connections
Lecture - 2
Design of eccentric connection with load lying in plane of joint (rivet & bolt)

Hello. Today, we will be focusing our lecture on the design of eccentric connections with load lying in the plane of joint. Now this joint will be connected using rivet as well as bolt; that means first we will see how to calculate the resultant force on a particular rivet with the orientation of a joint like this. And then how to find out the number of rivets and what will be the configuration of those rivet joints.

Then we will see the same problem with the bolt joint; means in case of bolt joint, we know that it is almost the calculations are similarly to the rivet joint. Only difference is the gross diameter and nominal diameter; in case of rivet joint we use gross diameter, and in case of bolt joint, we will use the diameter of the bolt not the gross diameter.

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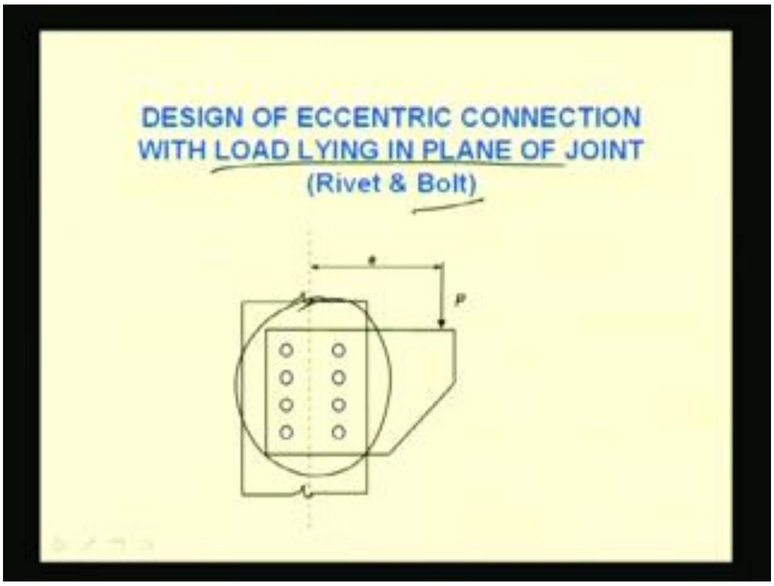

So, this difference will be there. So, the way we have designed in case of direct axial forces while coming into picture the bolt we have designed. So, in similar way we will design here also for the bolted connections. So, we will see those things. And our focus of lecture today will be only on load lying in plane of joint; means in plane of joint how to design, how to analyze; all those things we will discuss in details.

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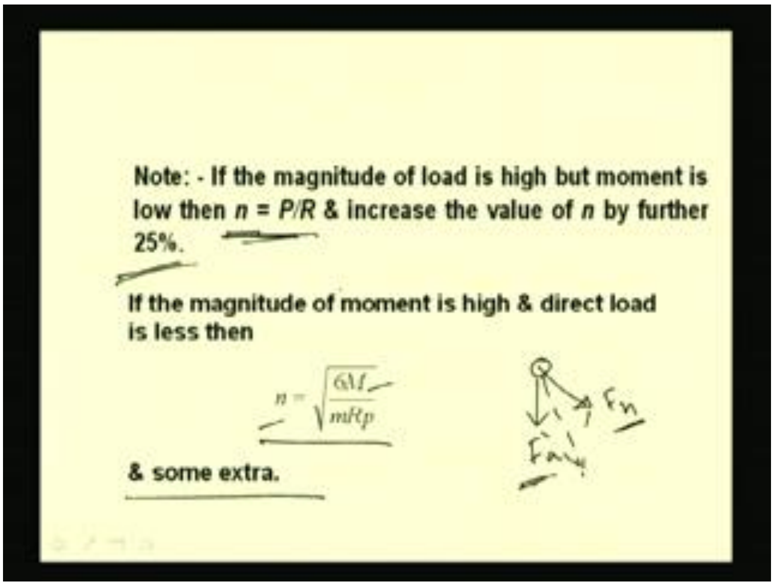

Now first, when we are going to design a riveted joint, we have to know what is the number of rivet? Now number of rivets can be decided in either from this equation that n is equal to P by R, where P is the load which is coming into picture, and R is the rivet value or from this equation that n is equal to root over 6 M by m R p, where M is the moment on that basis.

Now in general from our experience it is seen that we can use this equation if load is very high compared to the moment. And in that case, we can find out the number of rivets by increasing 25 percent and in that way we can make it. Because we know for a particular rivet, direct load is coming and another the load due to moment is coming. So, the resultant whatever it is coming, it is more than any of these two.

That is why we have to choose the number of rivet in such a way that the value is coming less compared to the expected value. So, in that way we can make the number. And if moment is more compared to the load, then that also it depends on the designers experience; some extra number we can increase. So, with this in mind, say let us design a bracket joint, then let us see how we are increasing and how it is working we will be getting to know.

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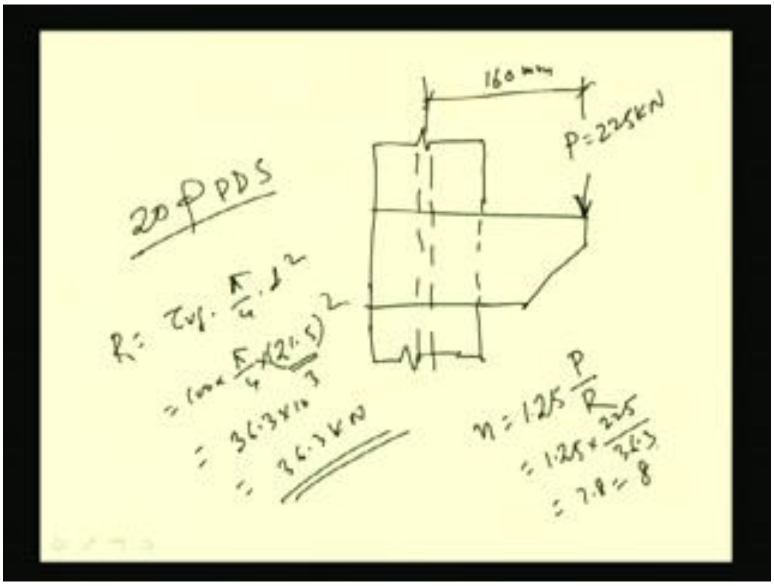

So, let us go through one example. Say, this is an example, say one bracketed connection has to be made which will pass the load to the column and the rivet joint has to made in such a way that without failure it can pass this much load. Say, P is equal to is given 225 kiloNewton. And the eccentricity is eccentricity is this one; this is say 160 mm eccentricity is given, right. Now with this we have to design the connections.

Now let us assume some diameter of rivets because on that basis I have to find out the rivet value. Say, diameter of the rivet, say 20 mm diameter of power driven soft rivet we have used. So, with this we have to make. So, now we have to find out the rivet value; for this what is the rivet value? Rivet value we know tau v f into pi by 4 into d square. So, that means 100 into pi by 4; this 100 value is coming because of power driven soft rivet which is given in the caudal provisions and these 20 mm.

So, gross diameter will become 21.5 mm. So, after multiplying this we will get 36.3 into 10 cube Newton; that means 36.3 kiloNewton. So, rivet value is 36.3 kiloNewton. So, in this way we can find out the rivet value. Now we can find out the value of the number of rivet from the load point of view. Number of rivet I can find out, say 25 percent if I make extra, 1.25 into P by R, right. So, this will become 1.25 into P is 225 kiloNewton and R is 36.3 kiloNewton. So, this is coming around say 7.8; that means 8.

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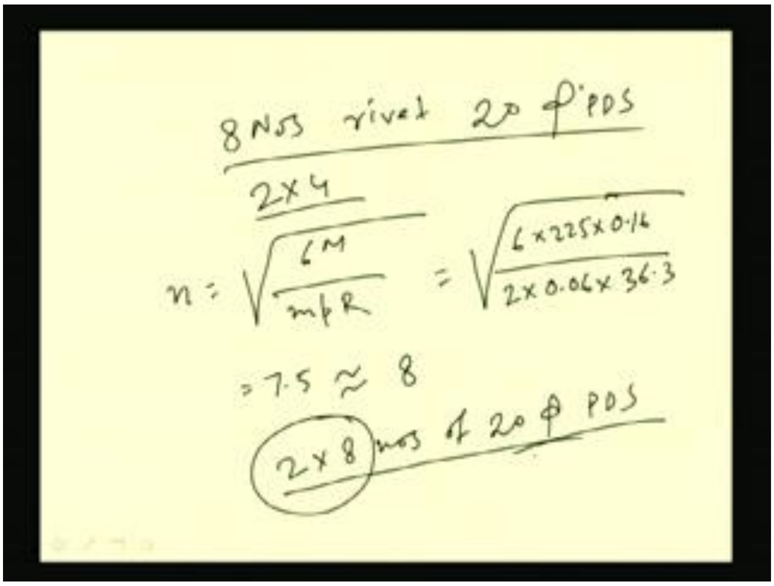

That means from load point of view, we can use eight numbers of rivet with 20 mm diameter power driven soft rivet. Eight numbers means if we use in two rows, then two rows with four numbers of rivet; means four numbers of rivet in each row we can provide, then we can make it. So, from load point of view we can find out this much number. Now let us see from the moment point of view. From moment point of view how do I find out the number?

We know the equation that is 6 M by m into p into R, where moment is P into e. P is 225 into e means 160 mm; that means 0.16, okay. So, this is kiloNewton; this is meter. So, m let us assume that in two rows the rivet has been distributed. So, two and let us assume the, say pitch at, say 60 mm; that means 0.06 mm into R. R is 36.3 kiloNewton. So, from this I can find out the number of rivet.

So, this is coming around 7.5; that means, say around 8. That means from this moment consideration, the number of rivets we will require 8 into 2; that means two rows with eight, eight numbers of 25 PDS power driven soft rivet. So, in this way the number is becoming 16. So, from moment point of view we are getting 16; from load point of view we are getting 8. So, finally, we will assume that we are using this much because moment has to withstand by the joint. Now this 60 mm has been considered from here. So, if you see this is the 60 mm, right. So, in this way we have calculated. Now let us go the detailing of this.

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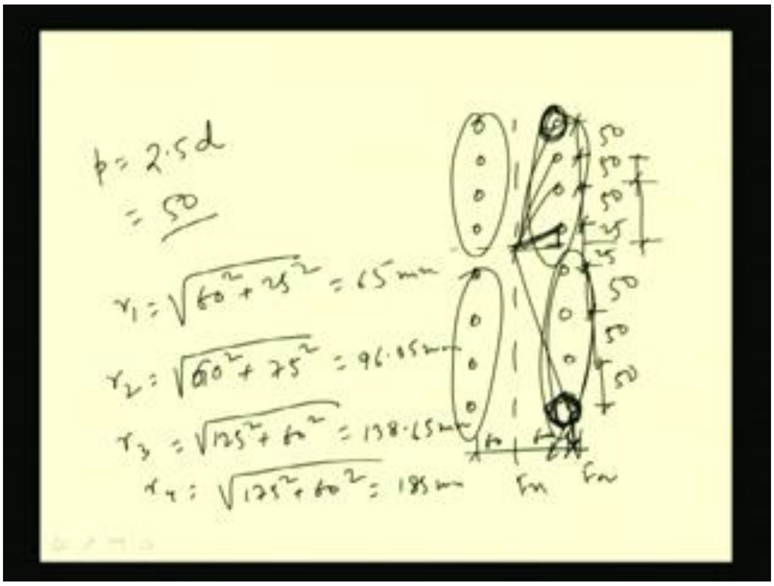

So, 16 rivets are placed in two rows. So, 8 rivets are placed in one row. So, let us place an let us find out the details of those. So, these are the pitch distance, say pitch distance can be found out from the caudal provision that is 2.5 d around we can make. So, this is becoming 50. So, let us say the pitch distance is 50, and this distance we have made 60, right. So, the neutral axis will be passing through this. So, this is 25; this will be 25, again 50, 50, 50.

So, the largest amount of load will be exerted on the outermost rivet either here or here, because from the last class we have seen why it will be the largest, because the F a will be at the downward, and this will be 90 degree with this radius; this is F n. And other rivets it will be less. So, this rivet will be the critical rivet either this one or this one. So, we will calculate the force excreted on this rivets and then we will see whether it is exceeding the rivet value or not and accordingly we check the design.

So, for calculating all these things we have to know r 1, r 2, r 3. So, let us find out r 1; r 1 means this one. This one will be root over 60 square plus 25 square; that means this will be 5 square. So, this will become 65. Similarly, r 2 will become this will become 25 plus 50; that means 75. That means 60 square plus 75 square. So, this is coming around 96.05 mm.

Similarly, r 3 will become this will become again 50; that means 125 plus 60 square. So, this is coming 138.65 mm. Similarly, r 4 will be 175 plus 60 square is equal to 185 mm.

So, this distance we are getting. This is 65; this is 96.05; this is 138.65, and this is becoming 185 mm. So, in this way we can find out all these distances.

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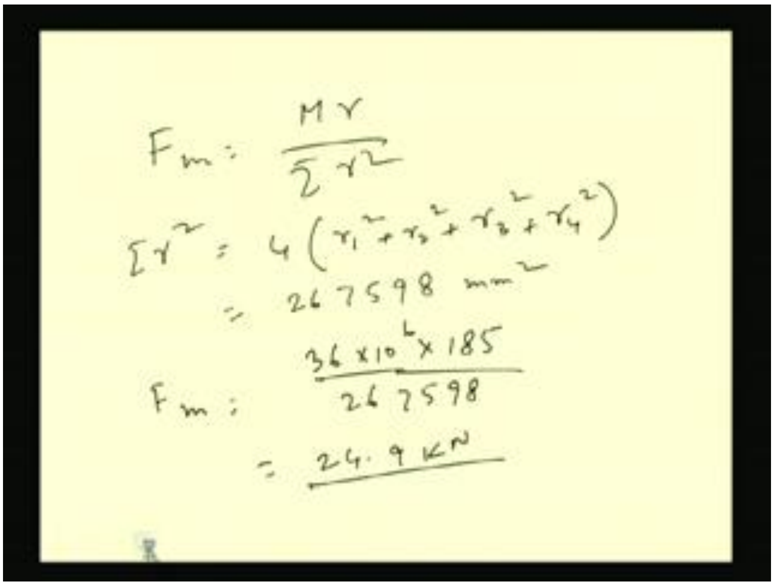

Now summation r square we have to make because we know the force developed due to this moment is nothing but M r by summation r square. So, summation r square let us find out. This will become 4 into r 1 square plus r 2 square plus r 3 square plus r 4 square. So, this will become totally four, because similar type of things this means one row if we consider from here, then into four it will be four into this r 1 square plus r 2 square plus r 3 square plus r 4 square.

So, this will become after calculation of this, we will get 267598 millimeter square. And the maximum force will develop at the outermost either of this one or this one. So, F m will become M is nothing but 36 which we have calculated kiloNewton meter. That means in Newton millimeter if we make 36 into 10 to the power 6 into r; r will be nothing but r four this will be. That means outermost rivet 185 its distance and summation r square is 267598. So, after calculating all these, we will get the value as 24.9 kiloNewton, right. So, force exerted on the outermost rivet due to moment is 24.9 kilo Newton meter; this is one force.

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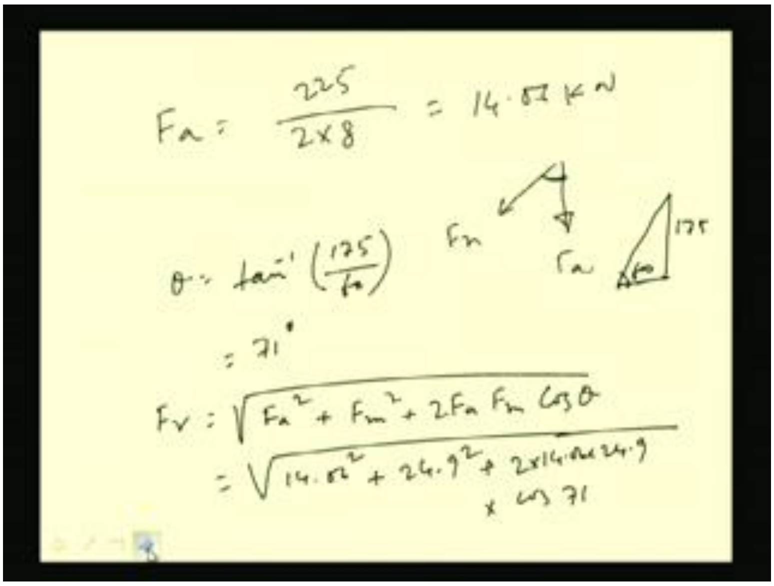

Another force is due to the direction load; that is direct load was applied 225 kiloNewton and total rivet is 2 into 8 means 16 rivets. So, this is coming 14.06 kiloNewton. So, one is this is F a, and this is F n, right. Now we have to find out the angle between these two; angle between these two you have to find out. Now, theta can be found out; from this if we see theta will be nothing but this one from which we can find out.

So, theta will be tan inverse 175 by 60 because outermost rivets. Vertical distance is 175, and this horizontal distance is 60. So, theta will be tan inverse 175 by 60 that is coming 71 degree. So, resultant force F r can be found out from this equation that is F a square plus F m square plus 2 F a F m cos theta. So, from this we will get the value that is 14.06 square. Fm is 24.9 plus 2 into 14.06 into 24.9 into cos 71.

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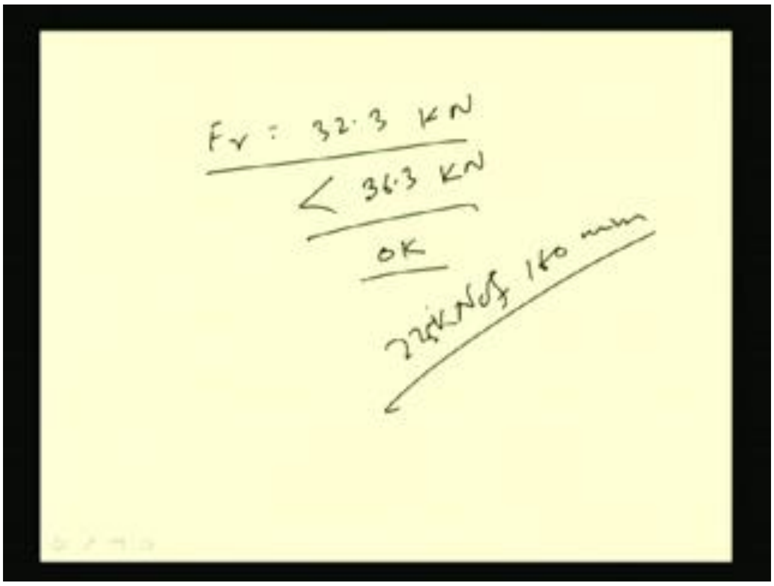

So, after calculating this value, we are getting F r as 32.3 kiloNewton. So, resultant force is coming 32.3 kiloNewton. This is the maximum force excreted on the rivet which is less than the rivet value. Rivet value is 36.3 kiloNewton for this particular diameter of rivet. So, this is okay; that means the joint is safe. That means the configuration whatever we have made; the number of rivets whatever we have assumed or we have calculated is safe to carry that much load.

That means 225 kiloNewton load of 160 mm distance from the centre of the rivet joints can be carried by the rivet with those configuration. So, finally, what the design will be because the designer will see only the design, how the design has been done, whatever the drawing says and accordingly the person who is executing in the construction site they will make the things.

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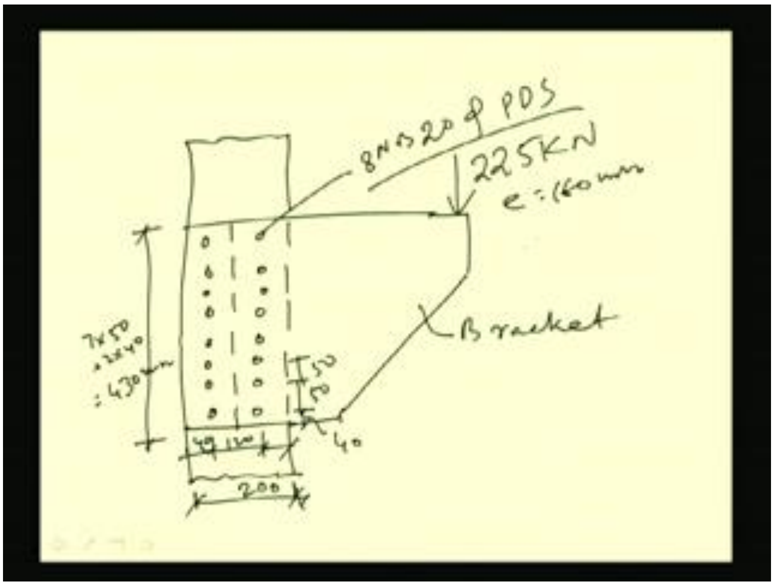

So, the design will be like this. This is the bracket. This load is here. Now this is the CG. So, in this way it has been one two three four five six seven, okay; so eight rivets in each group. So, this is, say h distance let us consider, say 40, and these are 50. And this is 120, then 60 into 60, and, say this is take as 40. So, we are assuming s distance as 40. So, this total depth of this will become 7 into 50 plus 2 into 40; that means 430, 430 mm is total distance.

And this will become, say total at least this has to become 120 plus 2 into 80; that means 200. So, this will be 200, and this number should be eight numbers 25 power driven soft rivet has been used; total eight number in each row. So, the configuration of the joint will be like this. So, in this way we can make it which can carry the load of 225 kiloNewton with an eccentricity of 160 mm.

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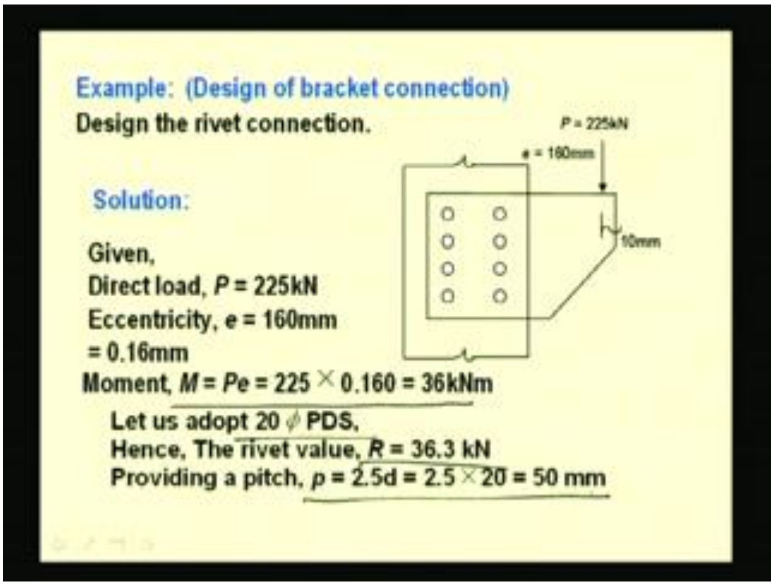

Now just let me overview that what I have done. First we have to find out the moment, what is the moment we have. Then the rivet value considering a particular diameter of rivet has been used. And accordingly the pitch has been decided as 2.5 d; that means 50 mm.

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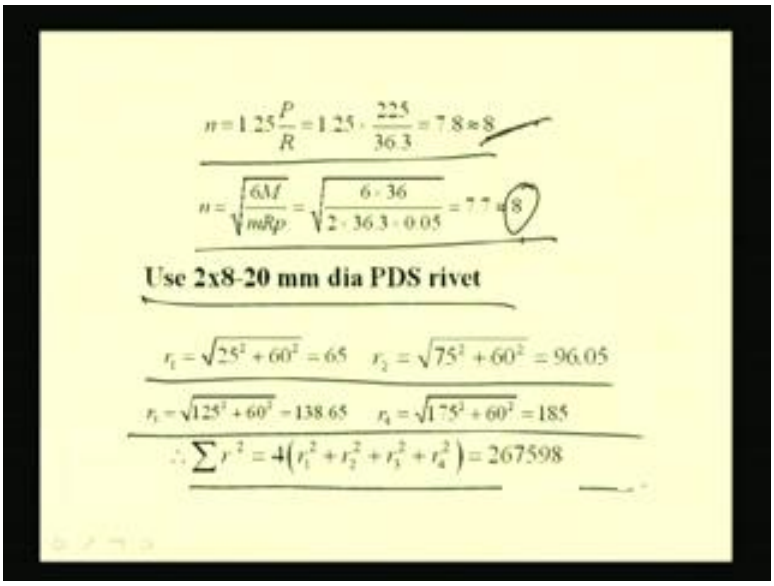

And accordingly, we can find out the total number of rivet required that is coming around eight from this. That means eight number of rivets is required from load point of view and from moment point of view it s required eight number of rivets with two rows.

So, finally, we are providing two rows and sixteen number of rivets totally, and according to that that r 1 r 2 value r 3 and r 4 value can be found out and summation r square can be made. So, from those formulas the F m is we know that M r by summation r square.

So, from this I can find out the force excreted in the extreme rivet that is this much and actual force is 14.06 in each rivet. And the theta between these two force will become 71, degree and resultant force can be made from this equation which is coming 32.3 kiloNewton which is less than 36.3 which is the rivet value. So, this is, okay, means that design is safe to carry the given load which is 225 kiloNewton with a distance of 160 mm.

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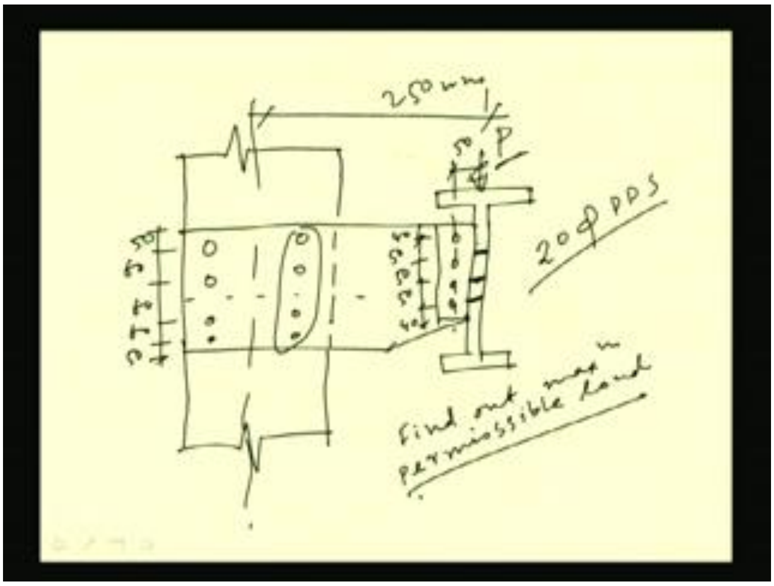

Now we will go through another example how to calculate and how to find out the allowable load of a particular joint. Joint is given in different ways; three type of rivets has been used. So, let us see through this picture we will able to understand. So, there are four rivets in each row. So, these are the rivets have been given. Again, say this is another plate and a gantry girder is carrying the load. This is P with an eccentricity of, say this is 250 mm. So, eccentricity is 250 mm.

Now with this configuration we have to find out the permissible value of P. That means here four number of rivets in each row has been provided to connect this joint, and here with this plate four rivets has been made to connect this gantry girder. And gantry girder is connected in this way, say three number of rivets, right. And this eccentricity here is 50 mm is the eccentricity and the distance between this has been given; that is edge distance is 50, and pitch distance is 60, this is given.

And here its edge distance is 40, and pitch is 50, right. So, these are the details of the joint. Now we have to find out, say find out maximum permissible load the joint can carry. Use 200 mm phi diameter means 20 mm diameter of power driven soft rivet. So, you have to find out the maximum permissible load using 20 mm diameter of power driven soft rivet with this configuration of the joint.

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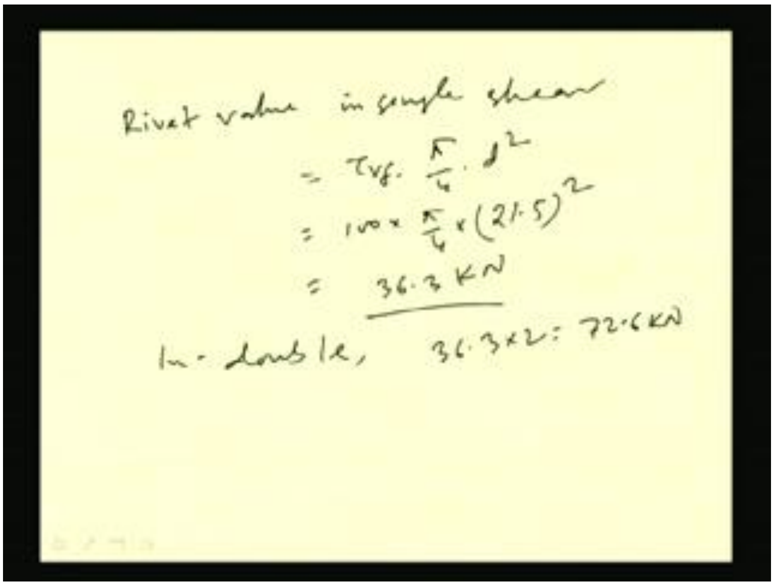

First, we will see what is the rivet value? Rivet value in single shear will be tau V f into pi by 4 into d square. That means 100 into pi by 4 into 21.5; rest 20 is the rivet diameter. So, this is becoming 36.3 kiloNewton in single shear. In double shear, the rivet value will be 36.3 into 2, 72.6 kiloNewton, right. Now let us come through one by one connection. First, we will see connection between girder and the angle. So, this is one we will see from this point of view what will be the load carrying capacity. Then we will go to this line. Then we will go to this one.

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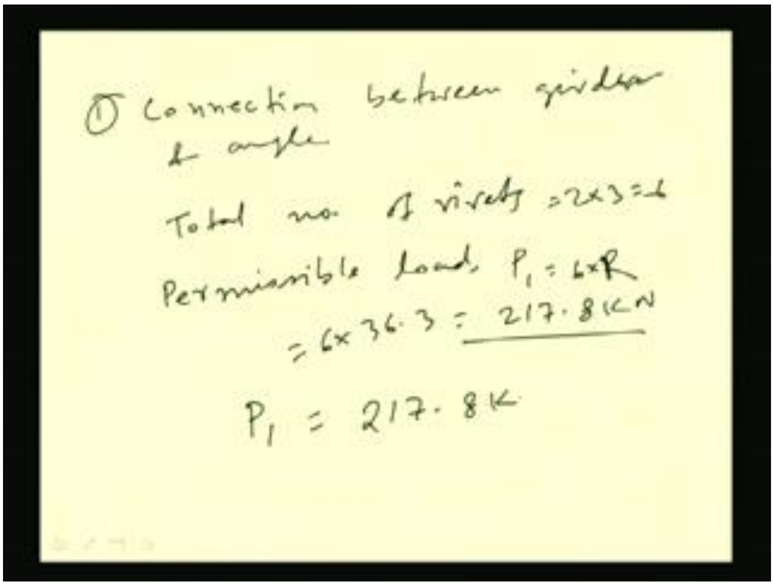

So, first let us see connection between girder and angle. Here three rivets have been used in the girder, three rivets in each. So, if two angles are used, then let us assume that two angle have been used to connect this. So, two into three, six rivets have been used. So, total number of rivets will become two into three that is six. So, permissible value permissible load, say P 1 will become six into rivet value. That means 6 into 36.3; that is 217.8 kiloNewton. So, this is the permissible value of the load which can carry by this connection, the connection between girder and the angle. So, the permissible load P 1 becomes 217.8 kiloNewton, right. This is from this point of view we can make.

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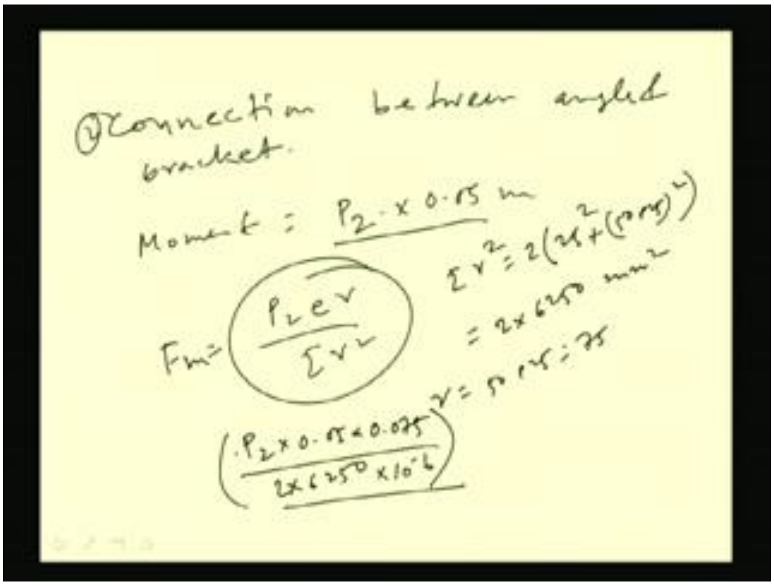

Another is the connection between angle and bracket. So, if we see the connection between angle and bracket, this two angles are connected to the bracket through four rivets and each rivets are in double shear because of two angles are located. And the eccentricity is 50 mm; the load is acting here, and we have to make connections here. So, 50 mm eccentricity is there. So, moment is there as well as the direct load is there.

So, for that we have to make accordingly. So, first is moment; due to eccentricity will become P into e. That means if I use the P 2 as a value permissible value P 2 into e is becoming 0.05 meter, okay. So, this will be the value and maximum force will be carried by the outermost rivet. That means that is P 2 e r by summation r square; that will be the maximum force at the outermost rivet.

Outermost rivet means this one if I see from this. So, this will be the outermost rivet. That means 25 plus 50, 75 millimeter distance away from the CG. So, this we have to find out. So, let us first find out summation r square because then we can make the values. Summation r square means this will become 2 into 25 square, the first one and then 50 plus 25 square. So, this will become summation r square.

These values are coming 2 into 6250 millimeter square, and r will become the outermost; that means 50 plus 25; that means 75 millimeter. So, I can find out this value as P 2 into e means 0.05 into r means 75 millimeter; that means 0.075 by summation r square; that means 6250, this is millimeter square; that means into 10 to the minus 6 to make it meter. So, this is the F m. F m value will become this.

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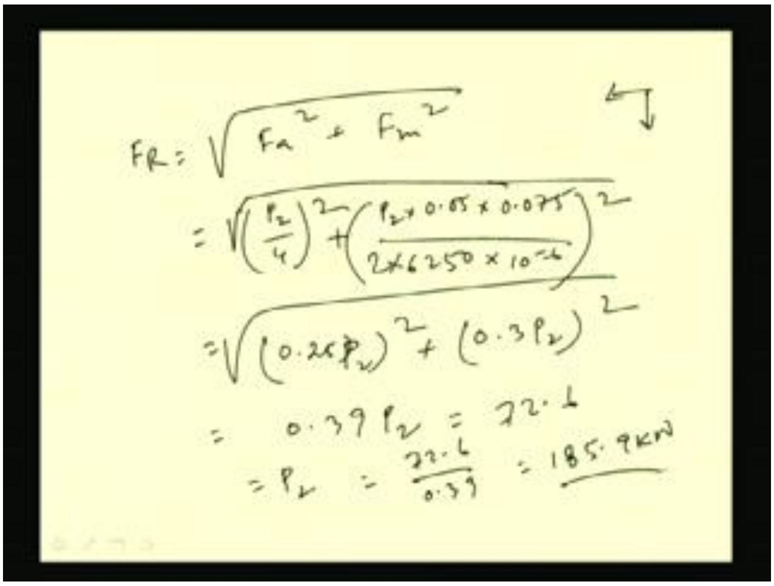

So, the resultant value F r will become F a square by plus F m square because both are acting perpendicular to each other. So, we can find out F a will be the four number of rivets, so P 2 by 4 if P 2 is the permissible load. So, this is F a and F m will be P 2 into 0.05 into 0.075 by 6250 into 10 to the minus 6, 2 into this. This is F m; this is F a. So, from this I could find out this is as 0.25 P 2 plus 0.3 P 2 whole square. So, finally, I am getting 0.39 P 2, right.

And this has to be equal to the rivet value. Rivet value in double shear is 72.6 kiloNewton. So, from this I can find out the P 2 value which is becoming 72.6 by 0.39. So, 185.9 kiloNewton. So, the permissible load in the joint between the angle and bracket is becoming 185.9 kiloNewton, right. So, this is another.

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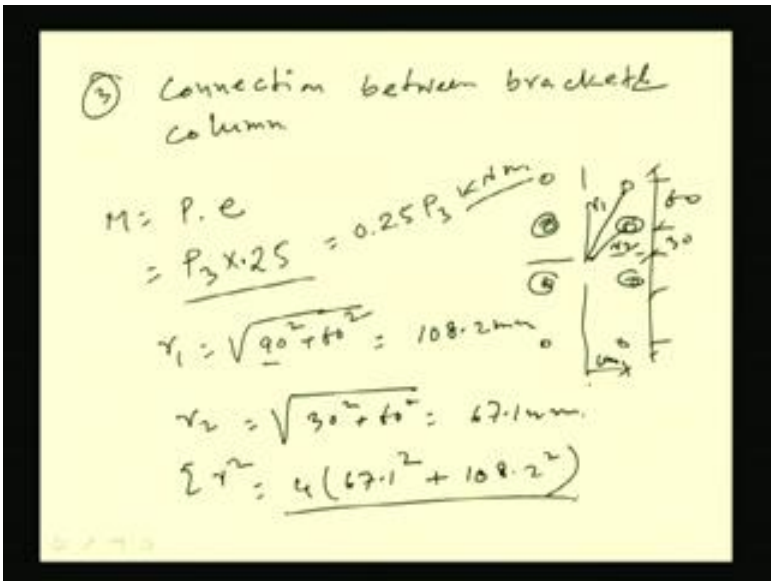

So, next will be the connection between bracket and column. So, third one will be connection between bracket and column, so connection between bracket and column if we see. So, what we will get?

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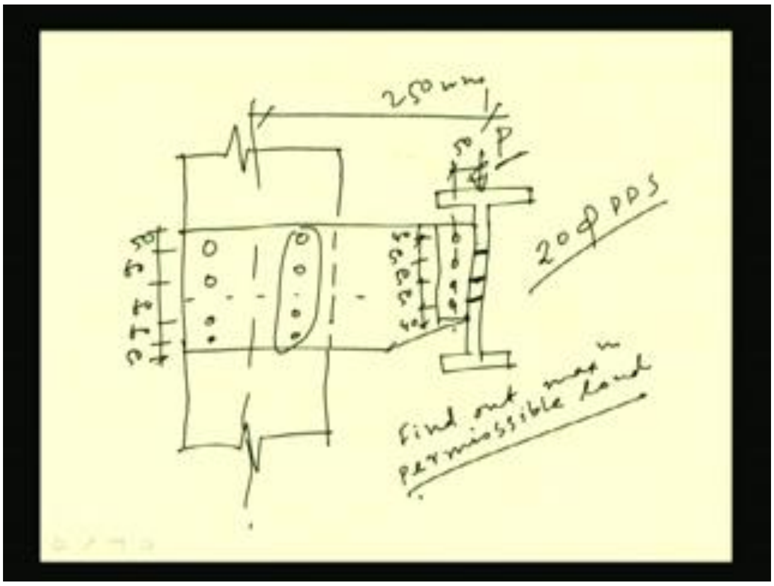

First if we see the diagram, there are four number of rivet in each row it is there. So, we have to find out if P 3 is the value, then we have to find out the resultant coming for a particular rivet. So, four number of rivets are there in each row. So, these distances are also given, okay. So, first we will find out M; M is equal to P into e. So, moment coming to the bracket is, say P 3 if we consider, the permissible value on this joint is if it is P 3, then P t3 into 250 mm; that means 0.25 meter. So, this is the moment. That means 0.25 P 3, say kiloNewton meter, okay, if P 3 is given in kiloNewton.

Now r 1 will become 90 square plus 60 square, because you see the distance has been given; these are all 60. So, this is 30; this is sixty. So, this total will be 90, and this distance is 60 again. So, this is if we say this is r 1 and if this is r 2, then r 1 square is this. This is becoming r 1 is equal to 108.2 mm. Similarly, r 2 can be found out from this. This will be 30 plus 60 is equal to 67.1 meter. So, if we see summation r square that will be four. Similarly, this rivet, this rivet, this rivet, this rivet will be same. So, 4 into 67.1 square plus 108.2 square, so this will be the summation of r square.

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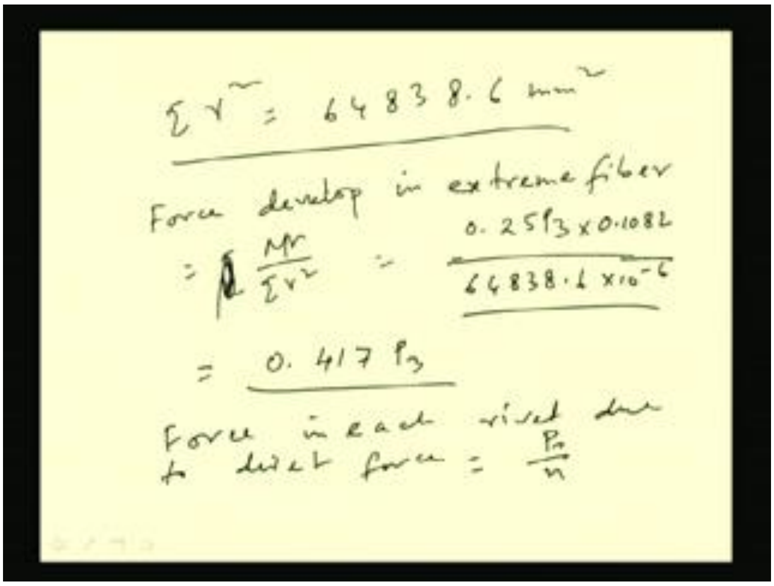

That means this is becoming summation of r square will be coming as 64838.6 millimeter square. So, summation r square can be found from this formula, okay. Now force developed in the extreme fiber. This will become M r by summation r square. That means M is 0.25 P 3 into, sorry, this summation will not be here M r by summation r square.

So, P 3 into r, r will become maximum distance is this one, and the maximum force will be exerted in this rivet the outermost rivet either here or in this rivet, okay. So, r 1 is 108.2. So, we can make 0.1082; this is in millimeter by summation r square 62838.6 into

10 to the minus 6 meter square if you want to make. So, after calculating this we will get as 0.417 P 3, right.

So, force developed in extreme fiber due to moment is this much. And force developed in each rivet is due to direct force in each rivet due to direct force is equal to P by n. This will be the P by n; P by n means P 3 by n, because P 3 is the permissible load in case of joint means case three.

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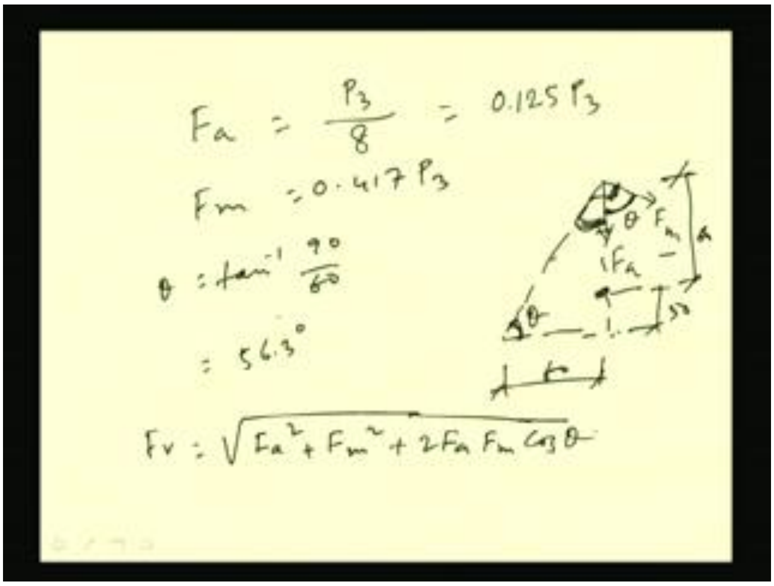

So, here F a will become P 3 by n is eight, total number of rivets have been given eight. So, this should become 0.125 P 3. So, one is vertically F a which is 0.125 P 3. Another is because of moment this at 90 degree angle to this radius, this is Fm and these value are F m we got 0.417 P 3. F m we got 0.417 P 3. So, F a we got and F m we got. Now we can find out the resultant. To find out the resultant, we have to know the angle.

So, we know this angle. This angle will be theta will become tan inverse 90 by 60, because this distance is 60 and here one rivet at 30 and this is 60. So, total is 90; so 90 by 60. So, this is becoming theta is becoming 56.3 degree. So, if this is theta, this will become 90 minus theta. So, again as this is totally 90. So, this will become theta. So, this is coming theta. So, resultant force F r can be found out now. Resultant force will be F a square plus F m square plus 2 F a F m into cos theta. So, from this formula we can find out the resultant force in extreme rivet.

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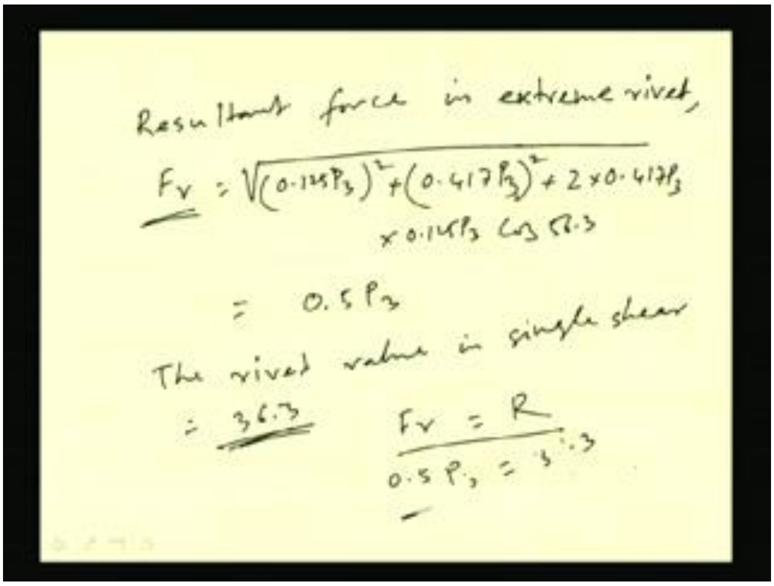

So, resultant force in extreme rivet; that means we can write as F r will become F a square means 0.125 P 3 plus F m square; that means 0.417 P 3 square plus 2 into 0.417 P 3 into 0.125 P 3 into cos 56.3. So, from this calculation, finally, we will get this as 0.5 P 3. Now the rivet value in single shear; in single shear, this will become 36.3 as we have calculated earlier. So, this should not exceed, the resultant force should not exceed the rivet value. So, F r should become R for getting maximum permissible value. That means 0.5 P 3 will be equal to rivet value 36.3 kiloNewton.

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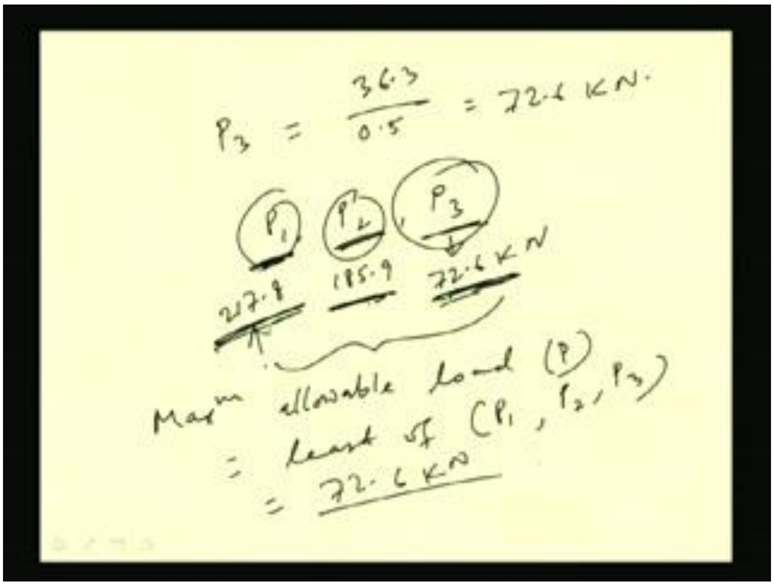

So, from this I can find out P 3 is equal to 36.3 by 0.5; that means 72.6 kiloNewton. So, for three types of joints, three allowable load we have derived P 1, P 2 and P 3. P 1 we have got from the connection between girder and angle; P 2 the permissible load due to the connection between angle and bracket, and P 3 is the permissible load due to connection between bracket and column. And in P 3, we are getting 72.6 kiloNewton.

P 2 we are getting 185.9 kiloNewton. And P 1 we are getting 217.8 kiloNewton. That means if we apply 217.8 kiloNewton that joint which has been made between girder and angle can be taken care but this cannot take. Because the joint between angle and bracket can take maximum 185.9 kiloNewton. So, this will fail if we apply this one as well as this joint is also going to fail; this joint means connection between bracket and column.

So, the least of this three we have to consider as a permissible load. That means if we use 72.6 kiloNewton as permissible load; that means this can be withstand by this joint; that means joint between bracket and column as well as other joint. So, the permissible load means maximum allowable load will be what? Say, P is basically least of P 1 P 2 P 3. So, this is coming 72.6 kiloNewton, okay.

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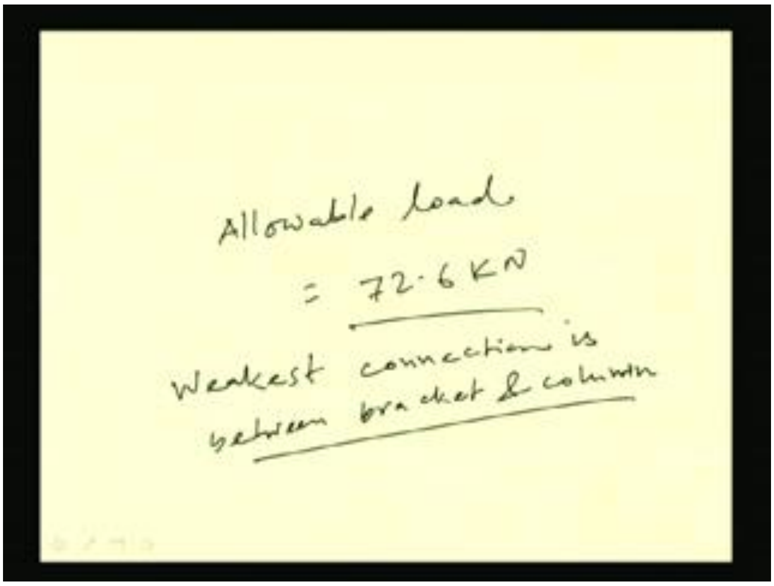

So, in the way we can find out the allowable load on this connection is coming 72.6 kiloNewton. And we can say the weakest connection is the joint between angle and bracket; weakest connection is between bracket and column, right. So, first failure will happen here, after that the second; that means the connection between angle and bracket.

And then the strongest connection is connection between girder and angle. So, in this way we can make it.

So, when we are going to connect a joint through different way; that means a system of members which has been connected through bracket, angle and girders, we have to see which one is the weakest and the maximum allowable load will be based on that weakest connections; on that way we have to make it. Now I will go through means we will discuss about the design of bolted connection. As we have discussed that bolted connection is nothing but similar to the riveted connection. So, just I will give a small overview of this.

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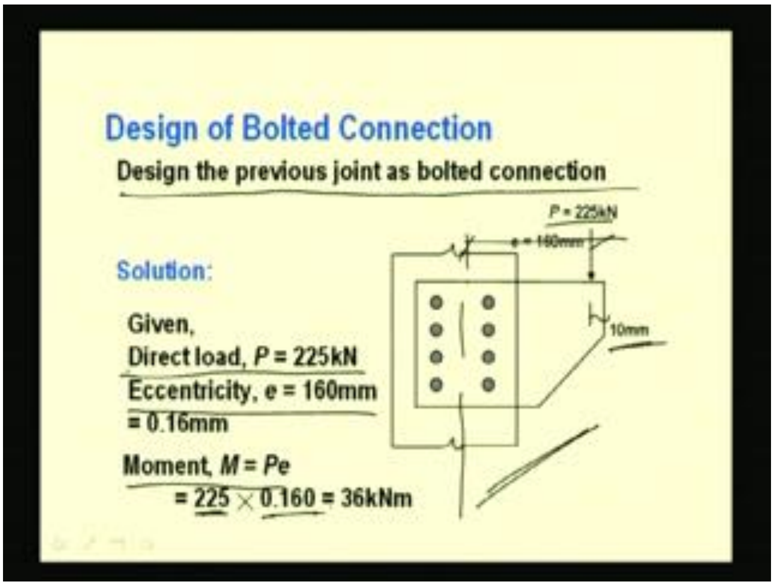

That means we will design another joint means same problem whichever we have done for riveted connections, we will design through the bolted connections. So, let us see that design the previous joint as bolted connection; previous joint means same values we will take. That is force is 225 kiloNewton with eccentricity. Eccentricity is 160 mm and 10 mm bracket has been used; we have to design the joint using the bolt, okay.

So, let us see the same connections which have been designed by using rivet. Let us see how we will make through bolted connection. So, given things are that direct load has been given 225 kiloNewton, and eccentricity has been given as 160 mm or 0.16 meter. Then moment can be calculated from the formula that M is equal to P into e; that means 225 is P. The load and e is 0.16, 160 mm or 0.16 meter.

So, multiplying these two, we are getting 36 kiloNewton meter. So, moment we are getting as 36 kiloNewton meter. And here we are seeing that the load is lying in the plane of the bolted joint. Load is lying in the plane of the bolted joint. So, calculation will be similar exactly similar to that of rivet joint with the similar case that load lying in the plane of joint.

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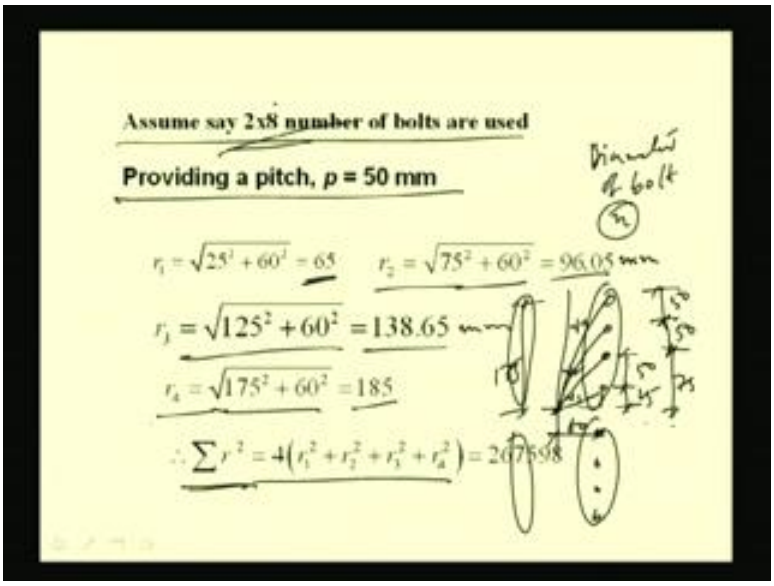

So, what we will do? Now we have to assume some number of bolts; that is difficult to exactly decide what should be the number of bolts. It depends how much depth is available means how much depth we can have here. So, if we have more we can take accordingly; if we have less, then we have to make according means rivet diameter can be more if this is less, because number of rivets will be less in that case, sorry, the number of bolts will be less.

So, if we increase the diameter of bolt, then this number of bolt will be less and as well as the depth of this bracket will be less. Now as earlier cases, we have used two rows with eight number in each row rivets. So, let us use the same. That means two rows we will use and eight number of bolts will be used. And similarly, we will provide pitch as 2.5 d; that means 50 mm, okay; of course d we do not know here.

Here we do not know the diameter of bolt and the number. So, to start with what we are doing that we are assuming some number and assuming some pitch. And accordingly, we are trying to find out the other details; that means we have eight numbers. So, that means eight numbers we have bolt. So, the CG will be here, eight numbers again will be here. So, r 1, r 2, r 3, r 4 can be found out.

R 1 will be what? This one is r 1; that means this is 60 as we have assumed, and this will become 25. So, root over 25 square plus 60 square which will become 65. So, this is r 1 is becoming 65. Similarly, r 2; r 2 can be made 25 plus this is again 50 as pitch has been consider as 50. So, this will become 75. So, 75 square plus 60 square; this will become r 2. So, r 2 will become root over 75 square plus 60 square; that means which is coming 96.05 millimeter.

Similarly, r 3; r 3 can be found out as this will become more another 50. So, this will become 125. So, 125 plus 60 is root over 125 square plus 60 square. This is becoming 138.65 millimeter. Similarly, r 4; r 4 will become this one. This is r 4; that means another 50 will come. So, this will become 175 total 175, and because of 175, the r 4 will become root over 175 square plus 60 square. So, this is becoming after calculation 185.

So, summation r square will become r 1 square plus r 2 square plus r 3 square into four times because, similarly, at the bottom it will be and at the left side also four numbers will be 4 into r 1 square plus r 2 square plus r 3 square plus r 4 square. So, this is becoming 267598; after calculation we are getting summation r square as 267598 millimeter square.

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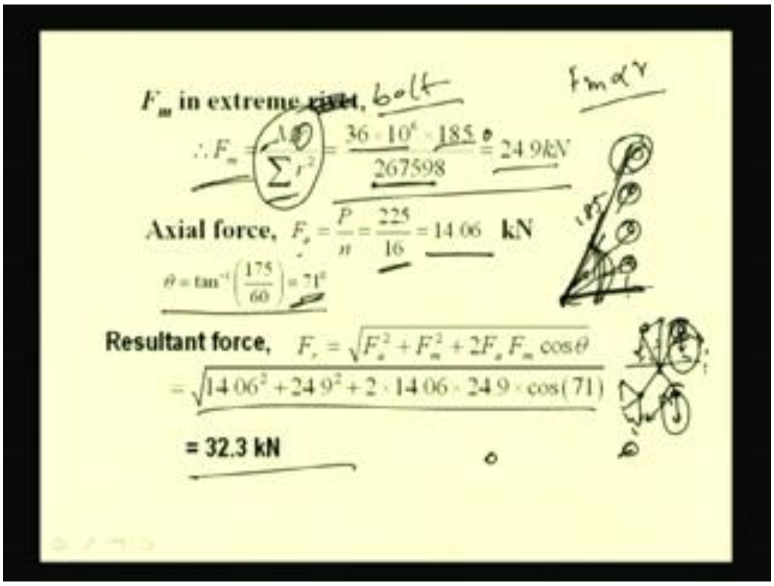

So, now we will find out the force at the extreme rivet. So, here we have seen which one will be the extreme one let us see. So, sorry, this is the CG, right. Now this is not rivet; this will be bolt we will say. Force at the extreme bolt. So, we know for this type of connection, basically F m varies with r. Fm varies with r; that means more the distance Fm will be more because you see if we see the equation F m is equal to M r by summation r square.

Now M is fixed. M is constant; summation r square is constant. So, we have r means if r is more, then F m will be more. So, at the extreme point, this will be more; that means here it will be more, either here means or at the bottom here or at the left side. So, F m will become this one 24.9 kiloNewton, because M is 36 into 10 to the 6 Newton millimeter, and r is the distance which is the maximum distance is 185 r 4. And summation r square we have calculated. So, from this we can calculate that F m as 24.9 kiloNewton, right

Now similarly we can find out the actually force. Actual force means actual force exerting in each rivet that will be simply F a is equal to P by n. In case of each bolt also, this will be P by n. So, 225 is the force and sixteen number of bolt has been used. So, total is coming 14.06 kiloNewton. So, 14.06 kiloNewton is coming the actual force in each rivet. And theta means the angle between these two.

So, theta will be becoming tan inverse 175 by 60; that means 71 degree, right. And as we have seen that if we have rivet, say extreme rivets are here, we have seen that because of the direction of force due to moment is perpendicular to the radial direction. So, this rivet will be becoming the maximum force or this rivet. Here it will be like this; this is ninety degree, but in this case as we have shown earlier, this will be like this and this will be like this. So, here resultant force will be less.

Similarly, here also resultant force will be less because one is nullifying other. So, the maximum forces excreted will be either here or here. So, that can be found out from this equation that is F a square plus F m square plus 2 F a F m cos theta result to this one 32.3 kiloNewton. So, resultant force we get.

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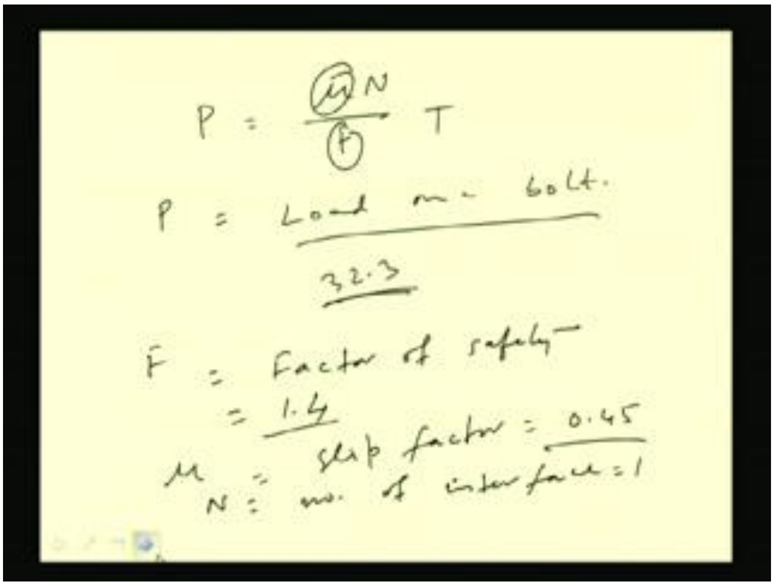

Now what we will do? Now the new things for bolt will come. In the bolt, we know the equation that P is equal to mu N by F into T where P is the load on a bolt. And in this case means load on a bolt in C r basically; in this case it will be 32.3, because this much load has to be carried by the bolt. So, 32.3 kiloNewton is the P. And F we know in case of bolt F is factor of safety. And we generally take in case of bolted connection this is 1.4; factor of safety is 1.4. And mu is nothing but the slip factor. So, this we used to consider as 0.45 unless it is mentioned. So, mu value we know F. So, F we know, mu we know. Now N; N is the number of interface. And this will be one in this case; number of interface is only one.

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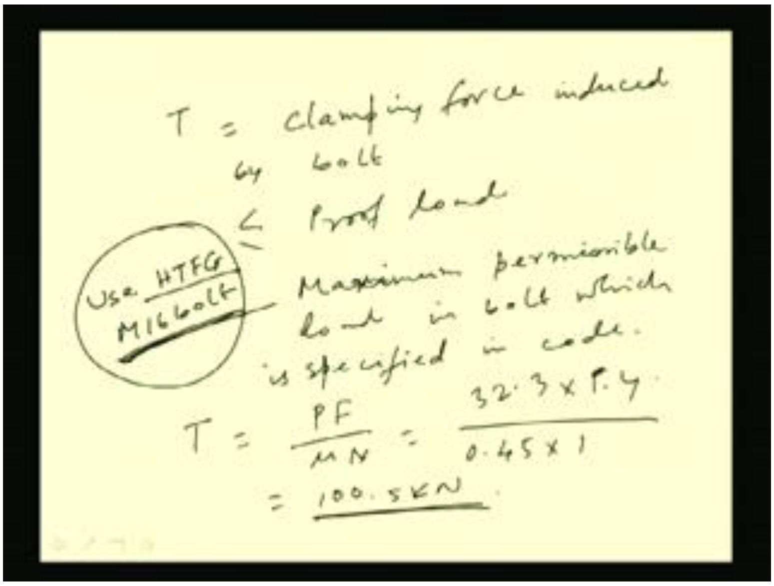

So, with all these we can find out the value of T. T means T is basically we can say clamping force induced by bolt which should be less than or equal to proof load. That means maximum permissible load, right. So, maximum permissible in bolt which is which is basically specified in the code, right. So, we can find out now the value. Say, T is equal to we are getting now P F by mu into N.

So, P is the resultant force which is exerting on the extreme bolt that is 32.3 kiloNewton. F is the factor of safety that is 1.4, and mu is the slip factor that is 0.45, and N is the number of interface which is one. So, after calculating this we are going to get it as 100.5 kilo ewton. So, the clamping force induced by the bolt is 100.5 kiloNewton. Now we will see the bolt is taking 100.5 kiloNewton; from the caudal provisions now we have to find out which bolt with what diameter can be taken that much.

So, we can use from the code we can see that use HTFG high tension friction grip M 16 bolt which is taking the value more than 100.5 kiloNewton. So, the 16 mm diameter of bolt has been used HTFG M16 bolt. So, what we have seen? In case of bolt design, the difference is how to chose the diameter of bolt and how to choose the number of bolts. In case of rivet, you can chose diameter of rivet, then we can find out the number of rivets.

But in case of bolt, first we will assume the number of bolts. After assuming the number of bolts only, we will be able to find out what should be the diameter of the bolt. So, in case of rivet, first we are going to find the number of rivet and then we are going to design. Some approximate number of rivets we are going to find, then according we are going to design and we are going to specify. And in case of bolt, first you have to assume and then you design means you assume some pitch, you assume some age, sorry, number of bolts, then you will find out the value of T; that means the maximum permissible load which is coming. And accordingly which diameter of bolt can be taken that much load that can be found out. So, in this way we can make.

In next lecture, we will see the riveted connections with load perpendicular to the plane of joint. Today, we have discussed mainly on load means basically the load which is acting in the plane of the connections using bolted connections, using riveted connections. So, in next class we will focus the same type of means with rivet joint but the load will be in the perpendicular to the plane of joint. Then we will see how to design and how to analyze this.

Thank you.