Design of Steel Structures

Prof. Dr. Damodar Maity
Department of Civil Engineering
Indian Institute of Technology, Guwahati

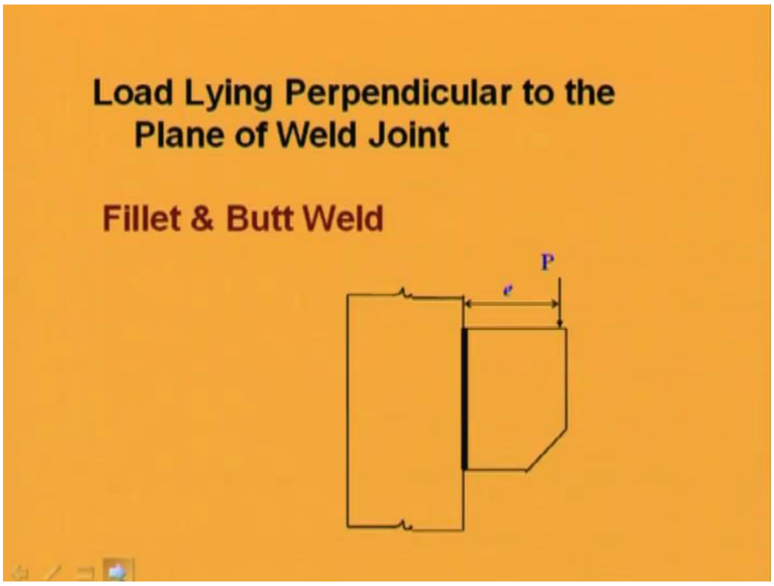
Module - 3
Eccentric Connections
Lecture - 6
Load lying perpendicular to the plane of weld joint: Fillet and Butt weld

Hello. Today, I am going to discuss about the fillet weld and butt weld. Regarding fillet weld, the remaining part of the last lecture we will be discussed first. Then we will discuss about the butt weld. And in the last lecture, we have focused mainly on the joint where the load lying in the plane of joint; that means where the direct shear stress and also the torsional stress is coming into picture.

After that partly we have discussed about the joint when the load is lying perpendicular to the plane of the joint using fillet weld; only we have discussed about the fillet weld. We have not told anything about the butt weld. So, today fillet weld as well as butt weld will be discussed, and before going to discuss about the fillet weld, we will complete the remaining part of the last lecture regarding the fillet weld when the load is lying perpendicular to the plane of the joint,

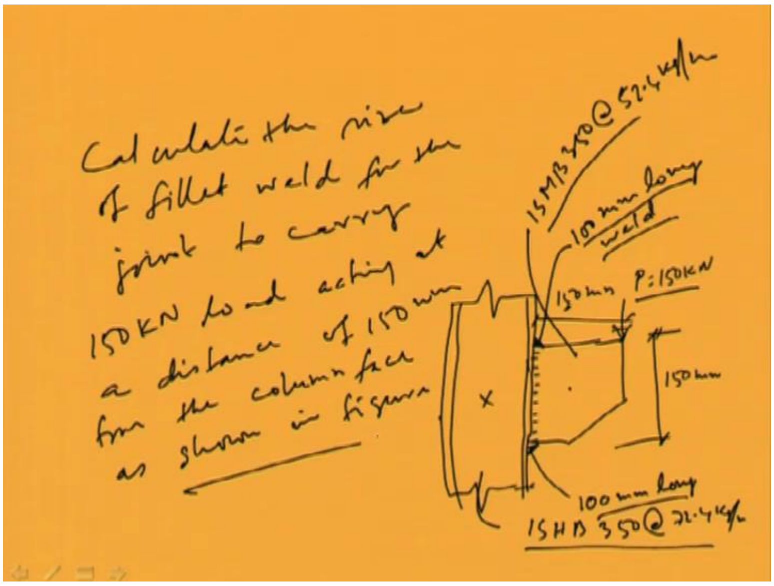
Now in the last lecture, we have seen how to calculate different type of loads means stresses for the fillet weld joint when the load is lying perpendicular to the joint. And we have seen if we provide the torsion also, then how torsional stresses is going to develop as well as the stress due to moment because of the eccentricity of the load and the stress due to direct load. So, all these have to take care in different points that also through one example we have discussed. Today, I will go through one another practical example through which we will be clear much more.

(Refer Slide Time: 02:46)



So, let us go through that example.

(Refer Slide Time: 02:49)

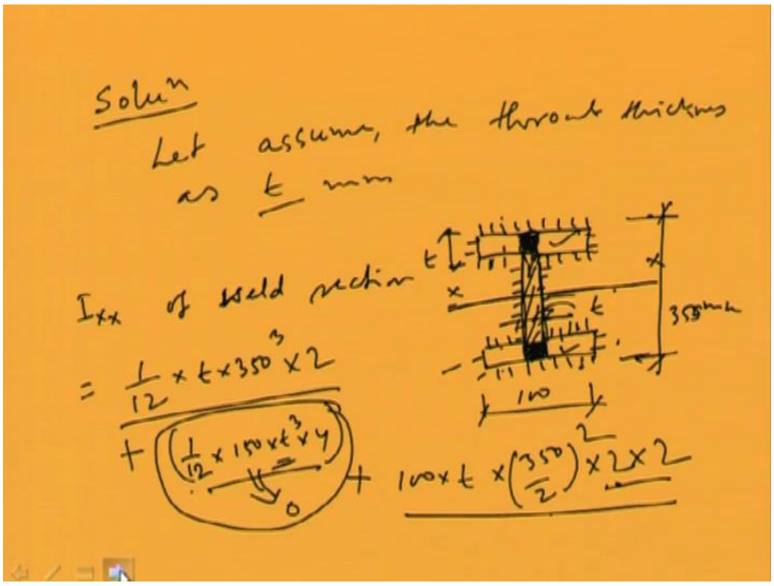


One column has to carry some load of, say 150 kiloNewton, say P is equal to 150 kiloNewton. And this eccentricity is, say 150 mm. Now this has to make the welded joint and this is the column flange we are making. Now this has to make the welded joint here, right, throughout this depth. Now this depth is 150 mm and here 100 mm long weld is also provided horizontally. Here also 100 mm long weld has been made.

So, now this is the size of the column is ISHB 350 at 72.4 kg per meter. And this is ISMB 350 at 52.4 kg per meter. So, question is that the column which is of size ISHB 350 at 72.4 kg per meter. And the beam means the bracket plate through which the load is coming that is ISMB 350 at 52.4 kg per meter.

This bracket is connected to the column through the fillet weld, and the length of the fillet weld is 150 mm along with the length in y direction, also horizontally 100 mm long fillet weld has been used. The load is 150 kiloNewton which is 150 millimeter away from the face of the column. This is the thing. Now you have to calculate the size of fillet weld for the joint to carry 150 kiloNewton load acting at a distance of 150 millimeter from the column face as shown in figure, right. So, this is the example which will carry out.

(Refer Slide Time: 06:08)



So, let us go for the solution. So, let us assume the throat thickness as t millimeter. So, first what we have to do? We have to find out the Ixx because if we see the plan of welding, we will see it is something like this. So, welding is done in this way. So, throughout its periphery the welding has been made. So, when we will be calculating the stress, what we have to know? We have to know the stress due to direct force and stress due to bending moment.

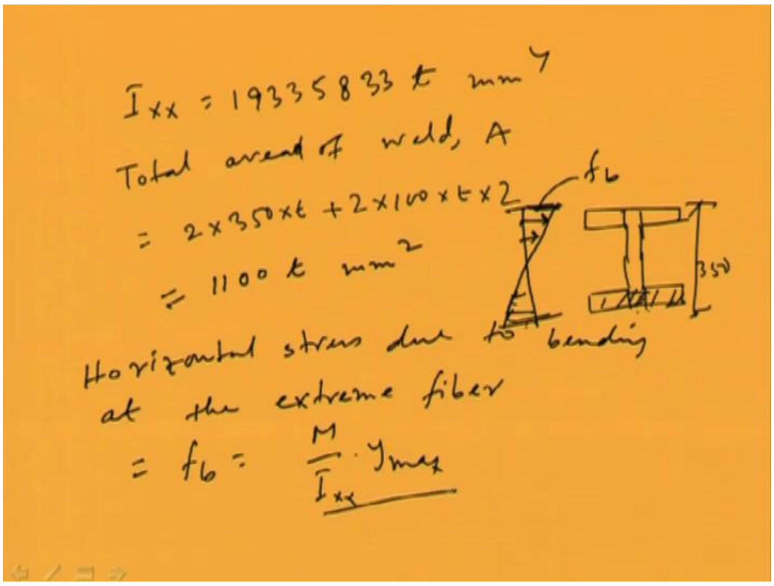
So, we have to find out the Ixx because f b will be m by I into I. So, let us find out first Ixx. So, Ixx if this is the x axis, Ixx of weld section will be 1 by 12. Okay, let me write down the dimensions. This is 100 mm, and this is given as 350 mm, and this is t; this is also t. So, this will be 1 by 12. First if you see this vertical portion, you will see 1 by 12 into t into 350 cube. And two faces are there. So, this will be into two.

So, 1 by 12 into t into 350 cube into 2 plus the moment of inertia due to this rectangular block this flange okay. So, that will be, first will be about its own area, then from this area to here but about its own area will be how much? That will be 1 by 12 into 150 into t cube into this will be four. Four sides are there, one, two, three, four. So, this is very less because t is very less. So, we are going to neglect. This we are making zero. We are going to neglect this portion

This plus then a r square; that means area we know 100 into t. This is the area and into r square; r square means 350 by 2. So, this is for one, and for two sides, this will be two and for two flange into two. So, this will become Ixx will become this plus this. That means 1 by 12 into t into 350 cube into 2 because of two face. This is for the web and for flange there are area is 100 into t and r square means 350 by 2 whole square into 2 into 2 because two faces and two flange, so four.

Remember, we have neglected this portion as well as again another thing is we can neglect that the area of this portion we are going to calculate twice because when we are making for web we have considered, but the amount is so less that we are not going to deduct this much, right. We can deduct, but for sake of simplification of the calculation, we are not going to deduct this; we are neglecting this.

(Refer Slide Time: 10:52)

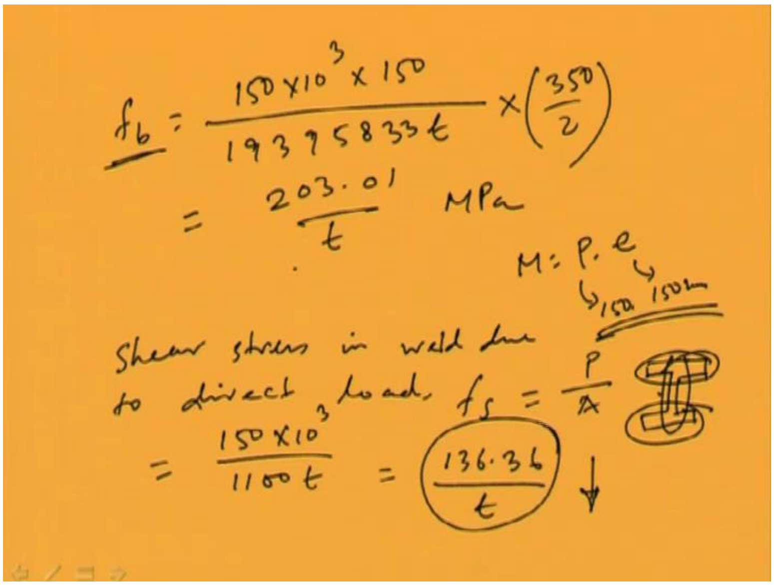


So, after this if we calculate this, we will be getting that values as Ixx will 19395833 t millimeter to the power 4. So, Ixx we are going to get this much value. Another thing is the total area. Total area of weld A will be equal to first is 2 into 350 into t. This is of web portion and then 2 into 100 into t; this is the flange portion into two. If I see this is the flange, and this is the web; here also again we are neglecting some portion because this is the total 350.

So, when we are making 2 into 350 into t, we are calculating this. So, when again we are calculating the area of this portion, we are adding this much. So, that much is very less t into t it will be which is very less. So, we are not going to calculate this one. We are going to neglect that one. So, this will become 1100 t millimeter square. So, Ixx is found. Now what we will do? Now we will find out the stresses.

So, horizontal stress due to bending at the extreme fiber because the stress will develop if I see the stress distribution over the depth of the section, we will see stress will be like this, and this stress direction will be like this. So, stress distribution would be like this. So, maximum stress will be either at the top or at the bottom; that means at the extreme fiber. So, that will be f b is equal to M by Ixx into y max, right.

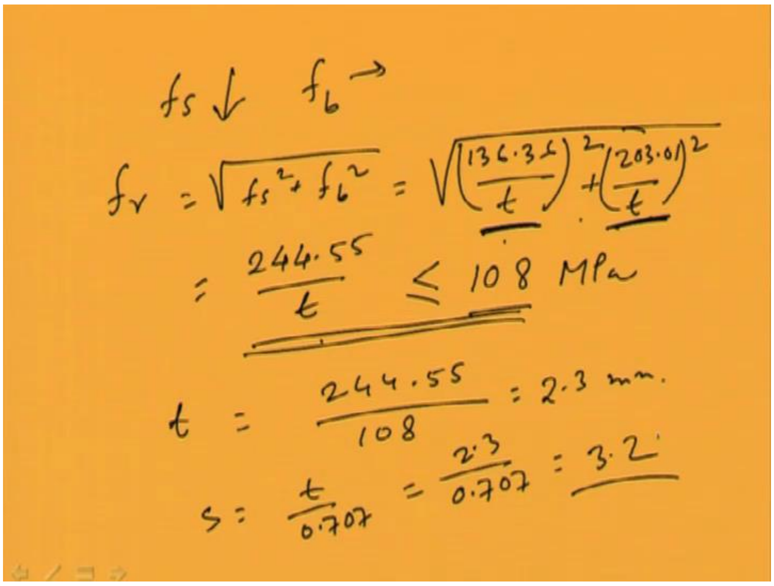
(Refer Slide Time: 13:24)



So, this value if I put M by Ixx into y max we will get F b is equal to M is 150 into 10 cube; this is p into e is 150. This is p into e which is moment by I has been calculated 19395833 t into y max is nothing but 350 by 2, okay. So, f b can be calculated which is the horizontal stress due to bending. So, this can be found as 203.01 by t MPa, right. So, bending stress due to the eccentricity of the load we are going to get 203.01 by t MPa, where moment has been calculated as P into e, where P is 150 kiloNewton, and e is 150 mm in the question it was given. So, from this we can find out the f b.

Similarly, the shear stress due to vertical load can be found out, shear stress in weld due to direct load which can be denoted as f s that can be made as P by A. Now we know P. P is equal to 150 kiloNewton, and area has been calculated; area means the total area of the welding portion. That means area of this, area of this, then area of this, right. So, 150 into 10 cube by 1100 t, which is the area we have calculated earlier. So, this is coming 136.36 by t. And this will be acting as a vertical, and this value will be same throughout the section in f b point; this value will be same. So, we are going to get f s and f b; the moment we are getting f s and f b.

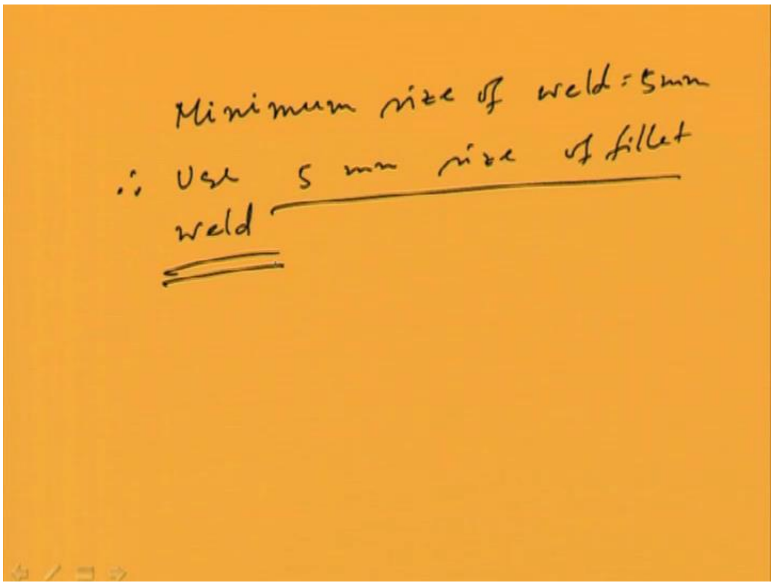
(Refer Slide Time: 15:59)



We know f s is in vertical direction and f b is in horizontal direction. So, the resultant stress will be just square root of f s square plus f b square, right. So, we can find out as 136.36 by t whole square plus 203.01 by t whole square. So, this is f s, and this is f b which has been calculated. This is in vertical direction downward and this is horizontal direction. So, as these are perpendicular to each other. So, we are making in this way to find the resultant, and after calculating this, we are going to get 244.55 by t.

So, resultant stress at the extreme fiber is 244.55 by t where the maximum stress will develop. That is to become less than the permissible stress which is 108 MPa for the fillet weld. So, resultant stress we can find out as 108 MPa. So, making equal to these two, we can find out t as 244.55 by 108. So, this is coming 2.3 mm. So, s now we can find out; s is equal to t by 0.707. So, 2.3 by 0.707; this is coming 3.2 mm. So, the size of weld is going to come as 3.2 mm to carry the load which has been given.

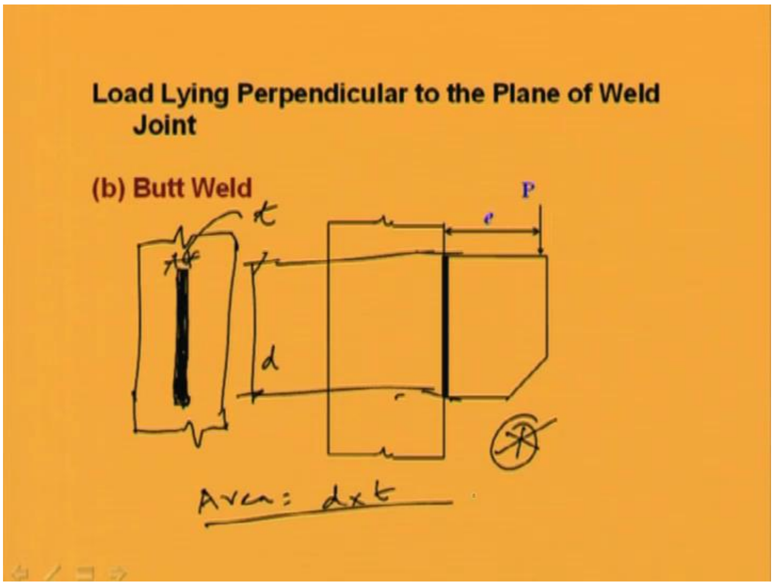
(Refer Slide Time: 17:59)



So, now as per the codal provision minimum size of the weld, this is 5 millimeter, and we are getting 3.2 millimeter. So, let us use 5 mm size of fillet weld; that means, what we are getting now? That we are getting from the calculation of the load, the size of the weld we are going to get as 3.2 mm, but the minimum size of the weld is 5 millimeter as per the codal provision. So, we cannot go beyond that; that is why we are adopting the size of weld as 5 millimeter, right.

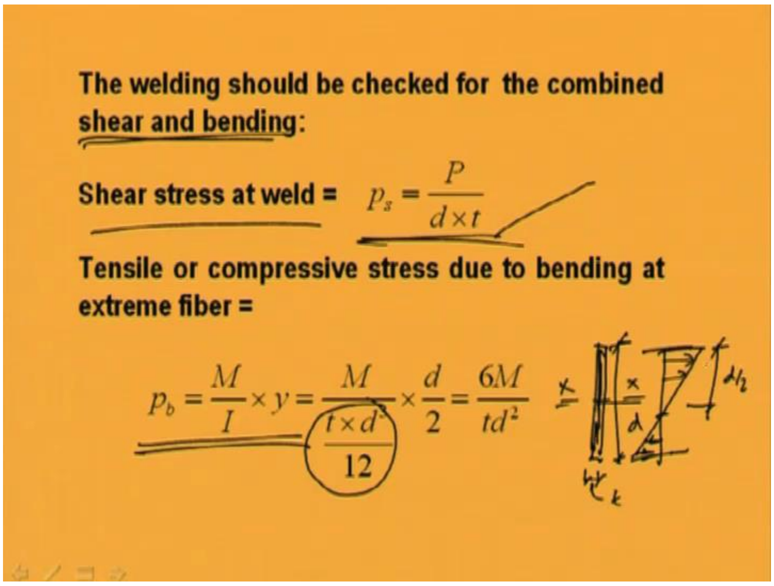
So, to carry that much load; that means 150 kiloNewton load at a distance of 150 mm with the joint as shown we need to make the weld connection with 5 millimeter size of fillet weld. Now we will go for butt weld. Butt weld will be basically it depends on the penetration; type of penetration means how much penetration we are going to give. On that basis we have find out the size of butt weld and other things, okay. So, butt weld is used generally when the load is lying perpendicular to the plane of weld joint.

(Refer Slide Time: 19:27)



That means if it shows like this. So, in that case, we can design the joint as a butt weld. This type of joint as we have seen earlier, we can join by the use of fillet weld as well as this type of joint can be made by the use of butt weld. So, if I see in the plan, we will see the butt welt be like this, right. So, if t is the thickness of the butt weld, then the area of the butt weld will be d into t. This is basically d, and this is thickness t, okay. So, area will be basically d into t. So, for butt weld very easily we can find out the area, then stress and then the resultant stress and other things, okay. Let us see how to make it.

(Refer Slide Time: 20:44)



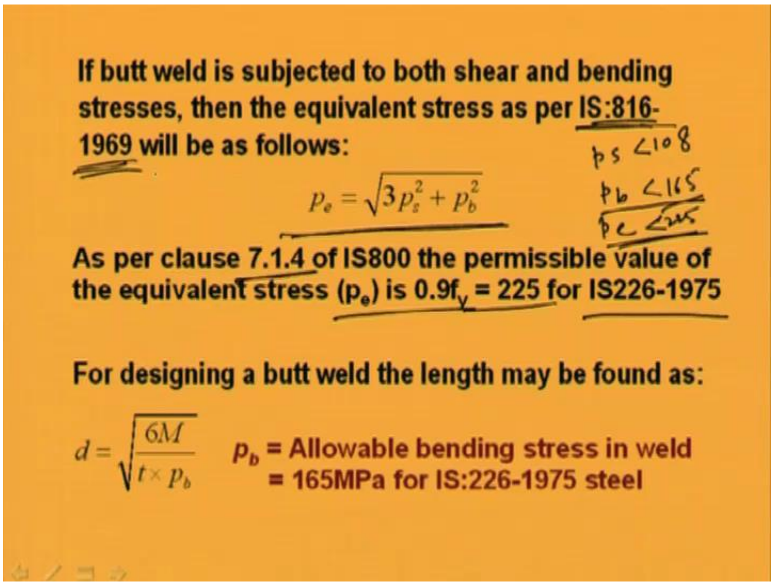
Now shear stress will become P by d into t because area is d into t. So, now the welding should be checked for combined shear and bending as we know because of the eccentricity of the joint, the bending as well as the direct shear will come into picture.

So, we have to see whether it is okay from shear point of view and from bending point of view as well as from the combined point of view. So, we have to check the three cases. So, first let see the shear stress; shear stress at the weld can be calculated from this equation. That is P by d into t, where d is the depth or length of the welding area means welding, and t is the thickness, and P is the total load.

Now again if butt weld is like this, we will see the stress is developing in this way also because of bending, okay. So, bending stress can be found from this equation M by I into y, where I has to be calculated about this x axis, okay. So, M by I into y means this will be either tensile or compressive depends on the direction of the moment, okay. So, M by I into y, where I is 1 by 12 into b d cube; b means t because this is t and this is d. So, 1 by 12 t into d cube and y means y maximum we will calculate. This will be d by 2because at extreme fiber, the maximum stress will develop.

So, for critical condition, we have to consider the extreme fiber where the maximum stress is developed. So, chances of failure will be at the end at the extreme fiber. So, accordingly we will make it, right. So, we are going to get p b is equal 6 M by t into d square.

(Refer Slide Time: 22:56)

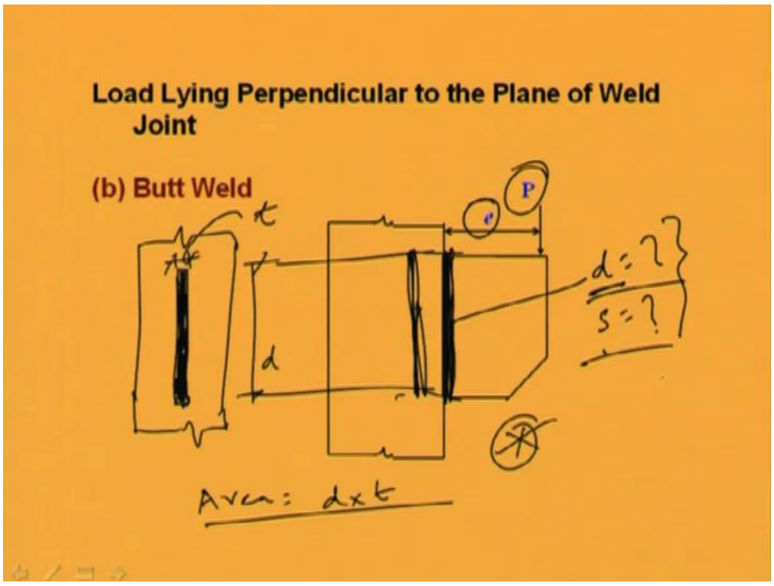


Now the equivalent stress as per the codal provision has been given as P e is equal to root over 3 p s square plus p b square. Means as per the code IS 816-1969, the equivalent stress can be written as P e equal to square root of 3 p s square plus p b square if the butt weld is subjected to both shear and bending stresses. So, for shear and bending stresses combinedly if it acts, then we have to check for the equivalent stresses also. So, first we have to check for direct stress it should be less than 108, and again similarly, p b it has to be less than 165 the bending stress and then p e the equivalent stress. So, three cases we have to check to find out the results.

Now as per clause 7.1.4 of IS 800, the permissible value of equivalent stress is generally considered as 0.9 f y. If f y is 250, then it is coming 225. So, P e will become less than 225 for this type of steel IS 226-1975. So, what I told that first is the direct shear stress it should not be more than 108, where 108 is the permissible shear stress. And the bending stress for the butt weld it is 165 MPa. So, bending stress should not be exceeding 165.

Another thing is the equivalent stress for the combined effect that should be less than 225 MPa. That means the combined stress whatever we are coming that is square root of 3 p e square plus p b square that should be less than 225. So, all this check has to be done. And this is given in IS 816-1969 the formula which has been specified by the code. Now what we will do the design. Design means basically the depth or length whatever you say this you have to find out and size.

(Refer Slide Time: 25:22)

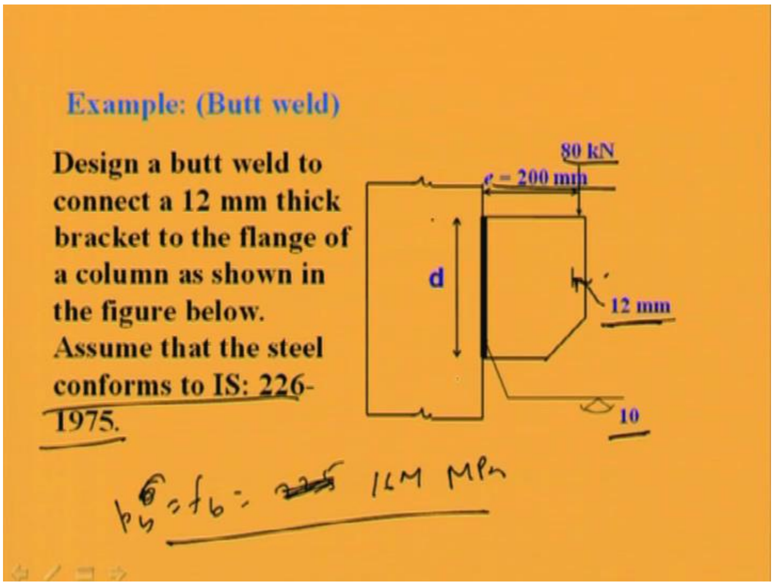


That means this depth and this depth and size. So, basic thing is depth we have to find out. So, how do find out this depth? How much depth or length we have to make weld to carry a particular load within particular eccentricity. So, this d has to be found out as well as if d is given, again the size of the weld has to be found out. So, both the things if it is unknown, we have to assume one thing and then other things we can find out.

We have to assume a parameter; generally we assume the size, then we can find out the depth or the reverse also can be done. So, depth throughout the length of the bracket, it has been welded. So, in that case we can find out the size. So, in either case we can make it. Now for designing the butt weld, the length can we found out from this equation. That is d is equal to root over 6 M by T into p b, where we got this equation basically from here we get because we know p b is equal to 6 M by t d square.

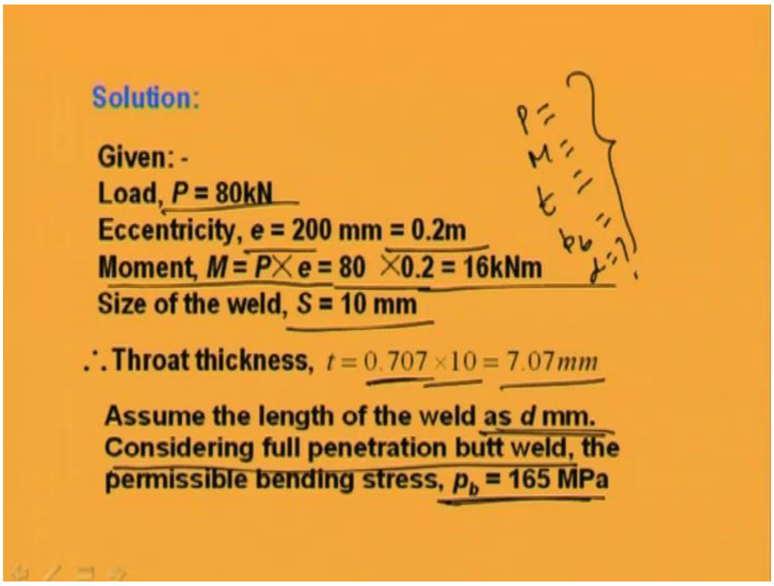
Now from this I can find out d is equal to this value. D is equal to square root of 6 M by t into p b, where p b is the allowable bending stress in weld which is given as 165 MPa for this type of steel IS 226-1975. Confirming to IS 226-1975, the allowable bending stress in the weld is given as 165 MPa. So, if I put this value 165 MPa, I know the value of M which is p into e and I know the size of weld or I can assume the size of weld. So, from this I can find out the value of d. So, with this theory we have to design the butt weld. This will be clear if we go through one example.

(Refer Slide Time: 27:23)



Now let us see the example. Design a butt weld to connect a 12 mm thick; this plate thickness is 12 mm, thick bracket to the flange of a column as shown in the figure below. Assume that the steel conforms to IS 226-1975. That means f b will be 225 which is given here, sorry 165. So, p b or f b whatever is here that will be 165 MPa, okay. Here the load is 80 kiloNewton, and eccentricity is given as 200, mm and thickness of the bracket is 12 mm. Weld thickness has been given as 10 mm. We have to find out the length of the weld d. So, d we have to find out. So, it is quite easy if you go through this.

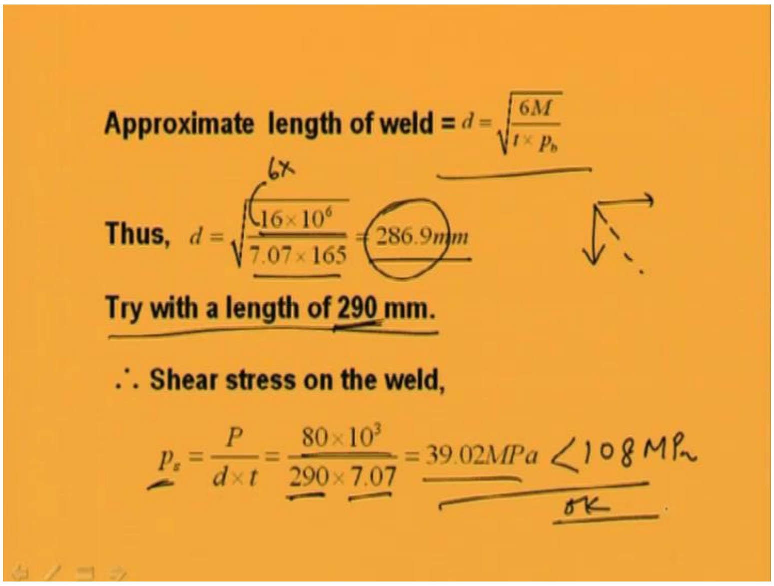
(Refer Slide Time: 28:22)



So, what is given? The load is given which is 80 kiloNewton; this load is given 80 kiloNewton. And eccentricity is given as 200 mm which is 0.2 meter. So, now moment can we found out from M is equal to P into e. So, P is 80, and e is 0.2. So, multiplying this, we are going to get 16 kiloNewton meter, and size of weld has been given which is 10 mm.

Now we know if size of weld is this, throat thickness will be 0.707 into 10. So, this is coming 7.07 millimeter. So, if we assume the length of the weld as d in millimeter, then I can find out the value. And if I consider the full penetration butt weld, then the permissible stress will be 165 MPa. So, these are the data we have from the code and from the question. One is I know P, I know M value, I know throat thickness, I know p b. So, all these things I know. So, if I know all these I can find out the value of d.

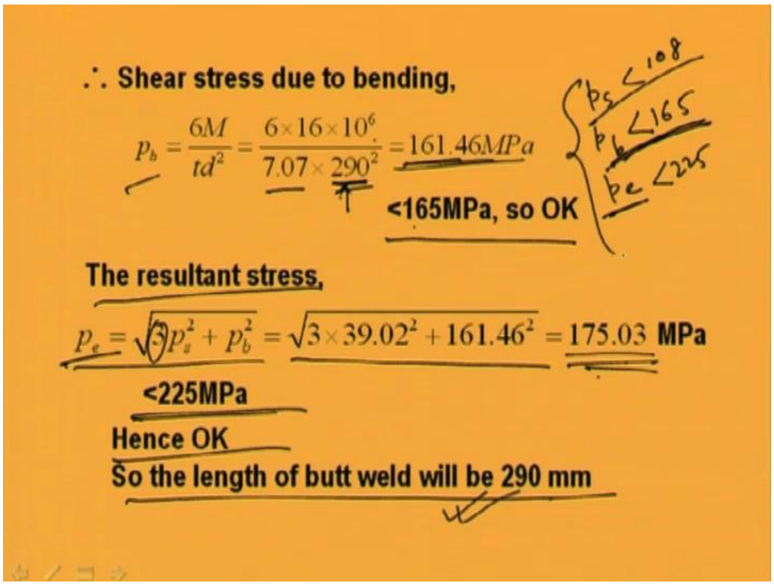
(Refer Slide Time: 29:39)



So, d I can find out from the equation root over 6 M by t into p b. So, moment is given as 16 kiloNewton So, if I put 6 MPa, sorry, this will be 6 into 16 by this one. T is 7.07, and p b is the permissible bending stress as per the codal provision that is 165 Newton per millimeter square. So, d can we found as 286.9 millimeter. So, we can try with a length of 290 millimeter. Why we are trying? Because we do not know whether that 290 millimeter will be sufficient or not, because only from the moment point of view; we have calculated the length.

Now direct shear is there. Moment is there. So, its equivalent is there. So, we are not very sure that whether this will be okay or not. So, we have to check this one. We are trying with a length of 290. So, if we make length 290 millimeter p s i can find out as p by d into t which will become P is 80 into 10 cube. And d is considered as 290 from the calculation, and t is 7.07. So, from this I can find out from the calculation as 39.02 MPa. So, shear stress from the weld P s is coming as 39.02 MPa, right. So, shear stress we are getting which is less than 108 MPa; so okay, right.

(Refer Slide Time: 31:31)



Another check we have to do. That is p b shear stress due to bending that will be 6 M by t d square from the equation. So, if I put the values 6, M is 16 into 10 to the power 6, and t is 7.07, and d is290. So, from that we are going to get 161.46 MPa, which is less than 165 MPa; allowable bending stress is 165 MPa. So, as we have increased, it was coming around 286 as we have increased to 290 mm. That is why the value is coming little less than the 165 because you have calculated considering 165.

So, now it is coming 161.46 MPa which is less than 165 MPa. So, I can find out the shear stress due to bending p b as 161.46 MPa. Now the resultant stress; resultant stress as per the codal permission, it has been given as p e is equal to root over 3 p s square plus p b square, mind it. Three has been multiplied with the ps square; not only p s square plus p b square 3 p s square plus p b square.

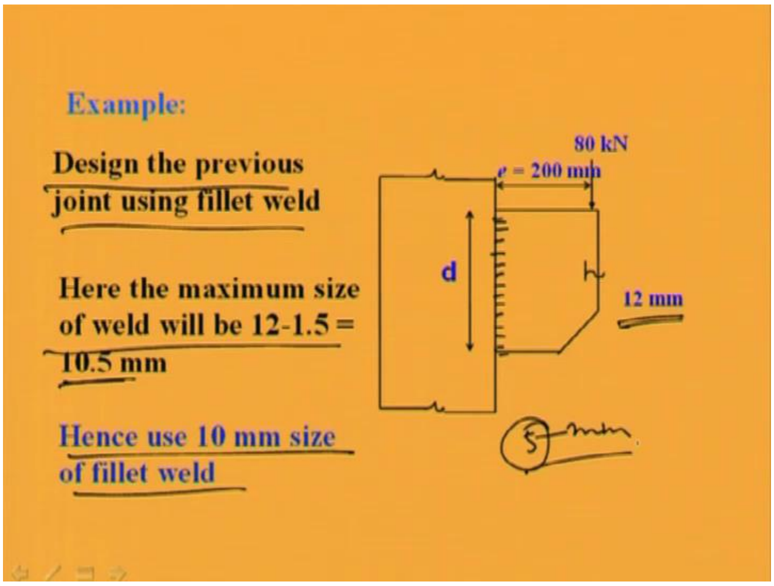
So, if we put the value of p s and p b in the equation that 39.02 and 161.46. Then the resultant is coming 175.03 MPa. So, the resultant stress p e is coming 175.03 MPa. This is the maximum stress developing at the extreme fiber at the extreme end. So, p e the resultant stress we are going to get, and this has to be less than 225 MPa as per the codal provision.

So, in our calculation also we are getting the resultant stress as 175.03 MPa which is less than 225 MPa. So, this is okay. So, the length of the butt weld which has been considered 290 is quite okay. So, in this way we can design the butt weld, right. So, it is quite easy how to make the things by the use of butt weld. So, what new things we are getting? One thing is that p s, p b and p e. P e is the equivalent stress which has to be less than 225.

And p b has to be less than 165 and from this point view of we can find out the depth. And p s has to be less than 108 MPa, okay.

So, from these three I have to check and I have to decide the length of the butt weld or the size of the butt weld. If length is given then size, if size is given then length, or other way also in some cases you may get that load carrying capacity you have to find out. In the butt weld load carrying capacity; depth or length is given, thickness is given, you have to find out the load carrying capacity. So, in case of that also similar way you can find out.

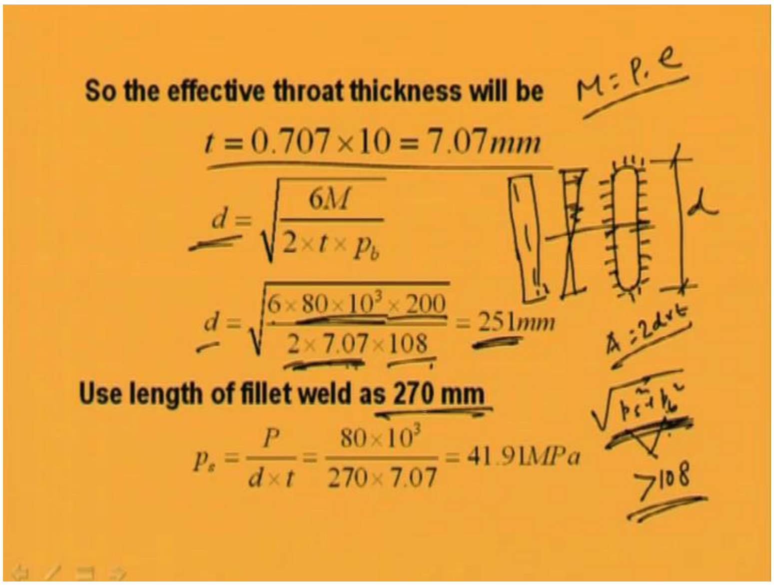
(Refer Slide Time: 35:01)



Now let us design the previous problem previous joint using the fillet weld. We have designed the earlier joint which is this one as a butt weld. Now let us design this same using fillet weld and let us see what is the depth is coming, right. Just to compare the process with the butt weld, we are just repeating the same problem with the use of fillet weld, okay. So, first what we will do? We have to find out the size of the weld. Here size of the weld also can be made. Earlier the size of the weld was 10 mm.

Here also we are using 10 mm size of the weld, because we have to check that whether this is allowable or not. Means maximum size of the weld generally becomes plate thickness minus 1.5. Here plate thickness is given as bracket thickness is given as 12 mm. So, maximum size of the weld can be 10.5 mm. Similarly, the minimum size of the weld can be 5 mm, right. So, maximum it depends on the thickness of the plate but minimum it does not depend on the thickness of the plate, right. So, from the maximum point of view, we can go up to 10.5 millimeter and for minimum point of view 5 millimeter. So, 10 millimeter size of fillet weld, if it is used, it is quite okay.

(Refer Slide Time: 36:39)



So, using same size of the fillet weld as in case of butt weld, let us see how much depth we are going to get. So, the effective throat thickness will be 0.707 into s size. So, this is becoming 7.07 millimeter effective throat thickness. Now d; d will become from the equation if we see if from plan we see, this is the fillet weld is generally made in this way. In two sides, weld has been done. So, the area and the other things will be different from the butt weld.

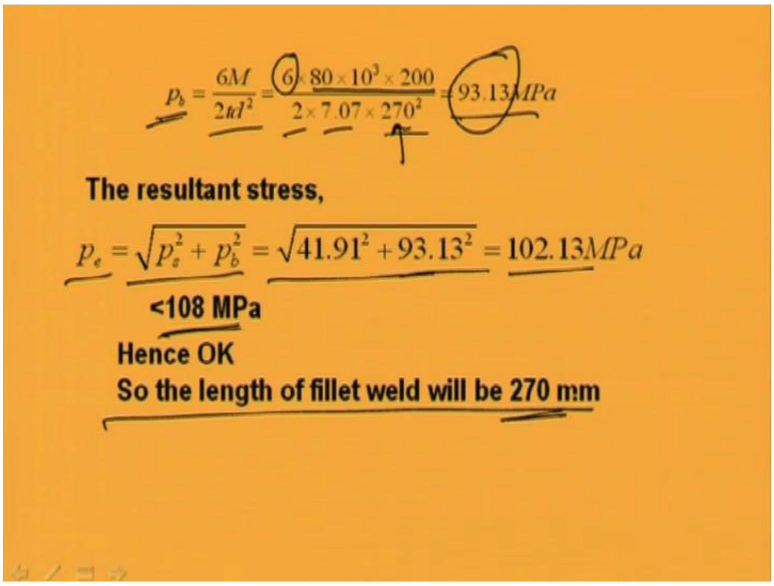
So, here we will see the area will be basically 2 d into t. Here the area will be 2 d into t as earlier we have shown also. So, similarly, when we are going to calculate the length of the weld that can be found from the equation if we see the earlier equation; we will see that is square root of 6 M by 2 t into p b, right. So, here 6 M moment is equal to P into e and p is given as 80 kiloNewton. So, P into e is 200 mm. So, 6 M by 2 t into p b. Allowable stress is 108 mm for fillet weld, and t is thickness; throat thickness is 7.07, and because of this two row 2 t has been used, right.

So, d, finally, can be calculated from this equation as 251 mm. Now we are using the length of fillet weld as 270 mm. Why not 250 or 255 or at least 260? Because we know the stress will develop two type of stress here it will develop. One is bending stress which is called p b and another is the shear stress. Shear stress will be developing same p s. And the maximum stress at the extreme fiber will be square root of p s square plus p b square. So, the length has been decided from p b.

If p b is becoming around 108, then length can be decided, but if we put the same length, then the resultant of this two will become more than 108, because p b has been considered as 108. So, whatever length is coming if we consider the same length, then the resultant will be definitely more than 108. That is why to be in safer side, we used to increase to some percentage of the original one. So, in place of 251, we are using, say 270, and let us check whether the length of fillet weld whatever you get consider 270 is okay or not.

So, if 270 mm length of fillet weld is used, then p s will become P by d into t into 2, because 2 t is there. So, p s will be 80 into 10 cube by 270 into 707 into 2. Then the value will be becoming this much by 2, okay. So, p s we are going to get this much.

(Refer Slide Time: 40:21)

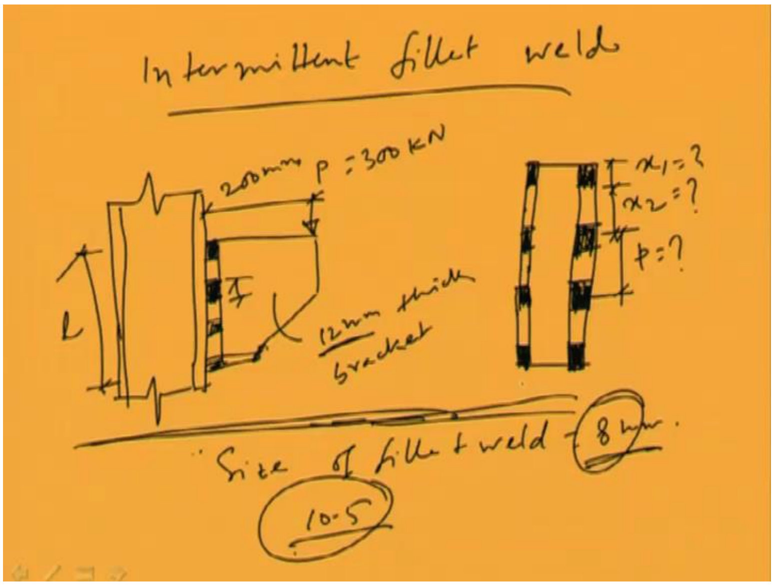


Again p b, p b will be 6 M by 2 t d square; so 6 M by 2 t d square. So, moment is p into e 80 into 10 cube into 200. So, 6 into this by 2 t d square; so this is becoming 93.13. Remember, this p b we have considered earlier as 108, then we are getting the d as 251. Now as we have increased the length up to 270 that is why the stress due to bending is coming less than 108 which is 93.13.

Now the resultant stress will be square root of p s square plus p b square which after putting the values will become this, and which is less than 108. So, the length which has been considered is quite okay. So, the length of the fillet weld will be 270 mm. Earlier in case of butt weld if you remember that the length was coming 290 mm. So, here we are going to get around 270 mm to carry that the same load with the same eccentricity for the same plate.

So, here we are just comparing that two method; means for butt weld and for fillet weld if the same joint is going to joint by the use of butt weld and by the use of fillet weld, how the depth will be varying, and how the depth will be decided; that I have shown here. Now another interesting example I will go through; after that I think we will be clear about this welding joint.

(Refer Slide Time: 42:04)



That is about the intermittent fillet weld. What is that? It is the analogous to the rivet joint; means basically if we see in a line that after some gap some welding has been done with some gap. So, this is called intermittent fillet weld. Now with the use of intermittent fillet weld, we will see one example. Say, if we consider one example, say this is one intermittent fillet weld. This is seen in the plan; that means we are making welding with a particular pitch distance.

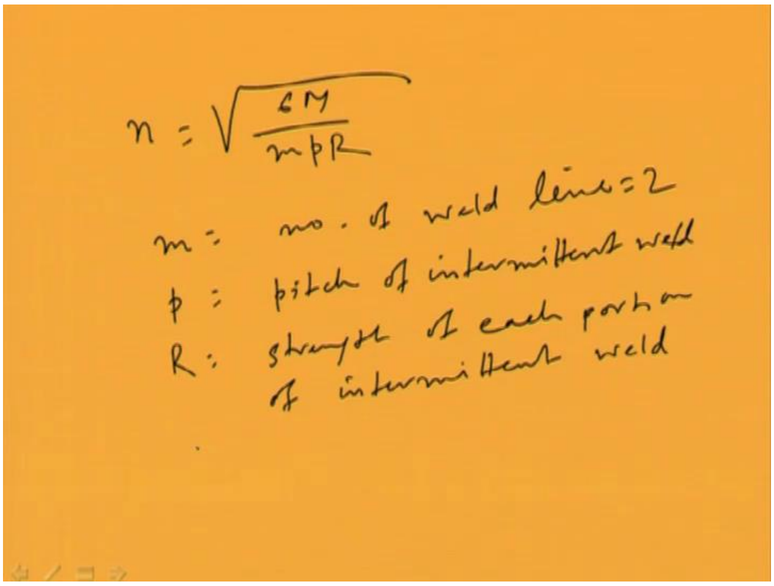
In place of riveting, we are making welding at a particular pitch distance at a particular interval. So, the calculation will be similar, right. Now this is called pitch, center to center distance of this is called pitch. Now the example let us solve one example. Say, one column is there which has to carry the load. This is the flange now, right. So, this is one, this is two three, this is, say four, okay.

So, a load of 300 kiloNewton has been applied at a distance from the column face as 200 millimeter, right. The bracket is 12 mm thick bracket, right. Now design the joint as shown below using intermittent fillet weld, design the joint. So, this joint has to be designed using this intermittent fillet weld. So, this will be clear if we just go through this example if we solve this example, we will be able to clear.

Now let us first assume the size of weld. Say, size of fillet weld, say may be, say 8 mm, okay. Now why 8 mm? Because this is the 12 mm; so maximum 10.5 will be required. So, less than that we are making, say 8 mm fillet weld. Now let us see. So, what we have to do? For this we have to find out the length of this. This is the length and the width of individual intermittent fillet weld. That means this one and the pitch. So, pitch has to be known, this has to be known; that means if I make this is as x 2. So, these are unknown which has to be designed, and the size of the weld has been considered as 8 mm, okay.

So, what we will do?

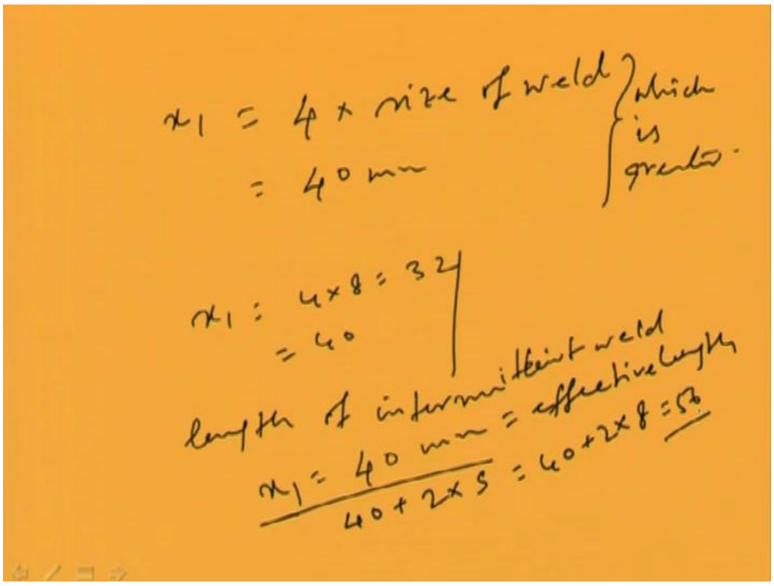
(Refer Slide Time: 46:00)



Now we know we can write n is equal to 6 M by mpR. As per the rivet joint connection if we see when the load is perpendicular to the joint; in that case, the formula which we use is n is equal to 6 M by mpR, where n is the number of rivet we used to make. Here n is equal to number of intermittent fillet weld, and M will be the total moment, and here M will be number of weld line. So, here weld line is made two; in the plan if we see this is the weld line. So, M we are going to consider as two.

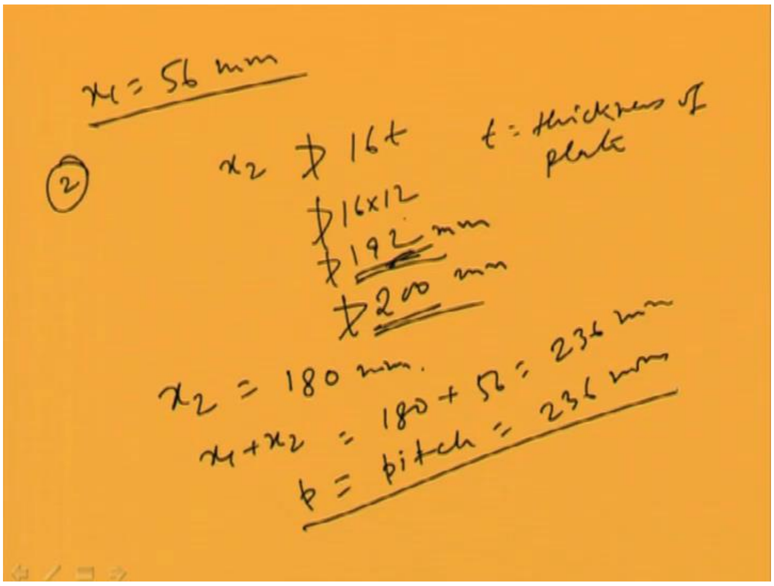
Now p is pitch of the intermittent weld, okay. And R is the strength of each portion of the intermittent weld, okay. So, what we have seen? So, pitch we have to find out. X 1 we have to find out. And R is nothing but the strength of each fillet weld means each intermittent weld, okay. So, these are we have to first decide. Now, say from the codal provision, let us see you what are the things, we can make it.

(Refer Slide Time: 47:42)



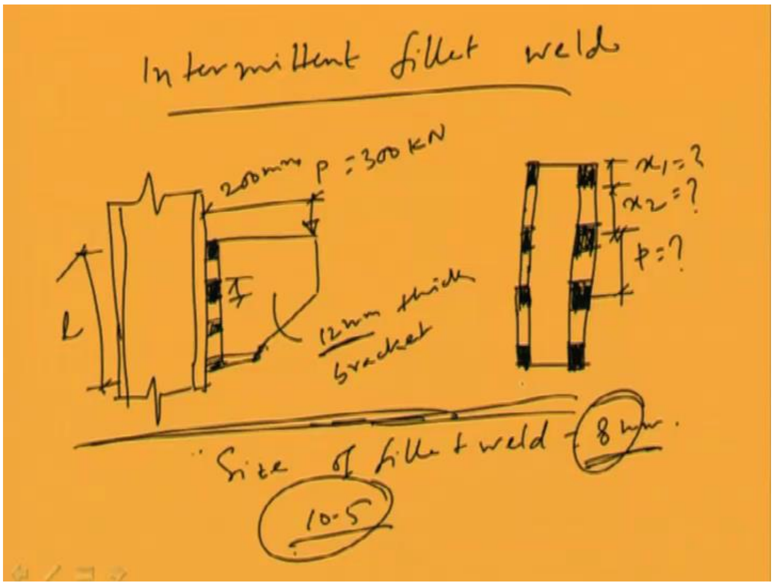
Now as per codal provision, minimum length of intermittent weld is, say x 1 4 into size of weld or 40 millimeter whichever is greater. So, size of weld is 8 mm. So, x 1 will become 4 into 8 is 32 or 40. So, what we will do? We will consider length of intermittent weld as 40 mm which is denoted by x 1. So, this is fixed now. So, what we did? This x 1 is 40. Now other things we have to decide. So, this 40 mm intermittent length, this is basically effective length which is called effective length. So, actual length will generally become 40 plus 2 into size of the weld. So, 40 plus 2 into 8; so this is coming 56.

(Refer Slide Time: 49:10)



So, I can write x 1 as, finally, x 1 will be 56 mm. Because when I am talking that x 1as 56 mm; that means the actual length is 56 minus 2 s; that means 40 mm, right. Next we will do x 2; that means clear spacing between that two adjacent intermittent.

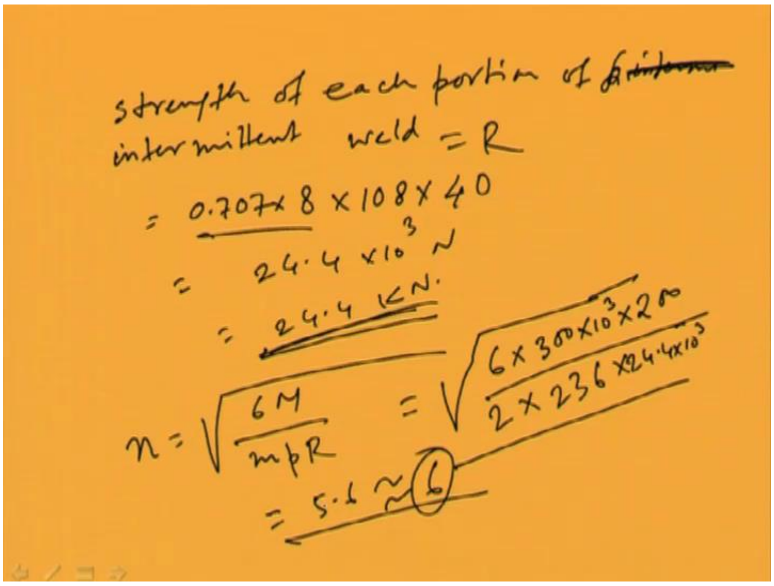
(Refer Slide Time: 49:30)



This is the x 2. So, x 2 is clear spacing between two adjacent intermittent. So, how to find out? So, this also has been mentioned in the code. As per code, this clear spacing should not be greater than 16 t, where t is the thickness of the plate, and here plate thickness is 12. So, 16 into 12; that means it should not be greater than 192. So, as per the codal provision, the clear spacing between intermittent weld should not be more than 16 t. That means 16 into the thickness of the plate which is 12; that means it should not be more than 192 millimeter. This is one thing.

Second thing is in any case, it should not be greater than 200 mm. That means if it more than 192 say 300, then we should take 200. So, now with this, we can assume the value of x 2. Now, say assume x 2 value as 180 mm, okay. So, x 1 plus x 2 will become 180 plus x 1 was 56. So, this is coming 236 mm. So, x 1 and x 2 is nothing but the distance of pitch. So, p is pitch; it is going to become 236 mm. So, pitch is decided. Now what will do? Now we will find out the strength of each portion of weld.

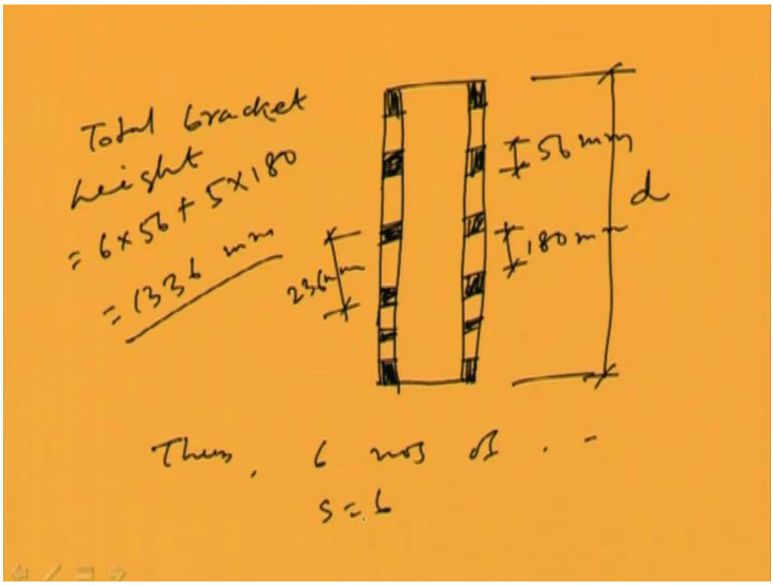
(Refer Slide Time: 51:20)



Strength of each portion of intermittent weld; that is R which will be required that will be is equal to R which can be written as t. T is nothing but 0.707 into s is the throat thickness into allowable stress is 108, and length of the intermittent weld is 40, effective length is 40. 56 is the actual length, and effective length is 40. So, this will become 24.4 into 10 cube Newton which is 24.4 kiloNewton. So, the strength of each portion of intermittent weld is becoming 24.4 kiloNewton. This is almost equivalent to the rivet value.

What we call rivet value. That is you can say here as strength of intermittent weld of each portion, okay. So, now the equation which we written earlier that is 6 M by mpR can be made now. So, 6, m is we know the load is 300 kilo Newton. So, 300 kiloNewton into p into e is 200 millimeter the eccentricity. And M is the number of lines of intermittent weld that is 2 and pitch p has been decided as 236 and R is 24.4 kiloNewton; that means into 10 to the power 3. So, these are the values we have put. So, from this we are getting n as 5.6. So, we can assume the number as 6, okay. So, number of intermittent weld we are going to get as 6. So, I think step by step how I am making all the dimensions and other things you have understood. Now the moment we are going to get the number of intermittent weld.

(Refer Slide Time: 53:58)

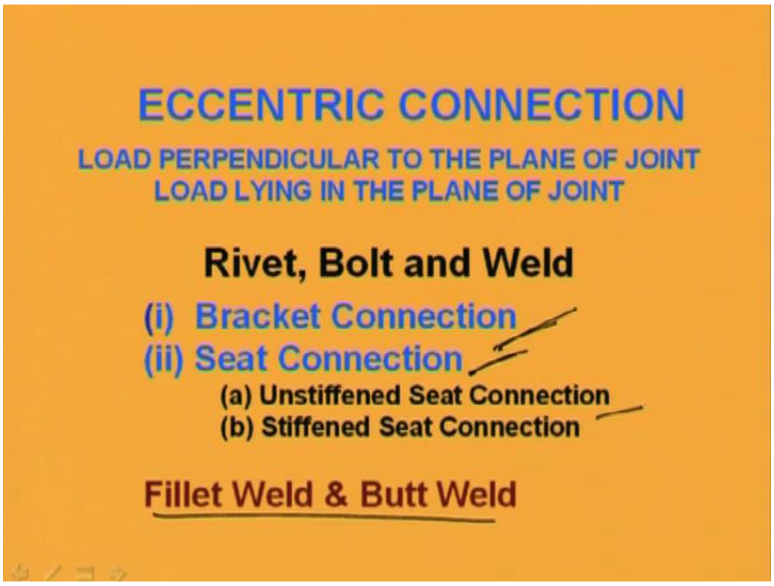


So, let us now in plane if I see let us make. So, in this portion one, in this portion another one. So, six intermittent welds we have made. So, this is not two scale. So, six intermittent weld had been provided, right. Now I know all the details like the length is 56, actual length is56; effective length is 40 and this clear spacing is 180 what we have considered all are in millimeter. And the pitch is 180 plus 56 that is 236 mm, right.

Now the total length can be found out now. So, total you can say bracket height which is required for the connections that will be here six intermittent length is there. So, 6 into 56 plus clear spacing is 5. So, 5 into 180; so this is becoming 1336 millimeter. So, thus the answer will be that thus six numbers of intermittent fillet weld on both side has to provide and size of weld will be 6. So, the answer is means when it is asking to design the joint; that means we have to make the detailing of the joint in terms of the length of the intermittent weld, spacing of the intermittent weld and the number of intermittent weld, and the total height of the bracket which is required to make the welding, right.

So, this is some another type of example what I have shown here. In fact, more we will go through different type of example we will be able to understand more deeper way. In design like classes it is difficult, because all the things are given in the code many things; it is difficult to make interactive with the students in this way. So, I am trying to make some example, so that you can understand. So, in short if I say that in the eccentric connection, what we have discussed? One is that eccentric connections are basically categorized as from the load point of view.

(Refer Slide Time: 57:12)



One is load perpendicular to the plane of joint; another is load lying in the plane of joint. So, these are the two basic categories in which we can differentiate the eccentric connections. Again when we are going to make the connections, we have to see whether it is bolted connections or riveted connections or welded connection; that also we have to see. If it is riveted, accordingly we have to make whether bolted or welded, again weld connections means whether it is butt weld or fillet weld; that also we have to think and accordingly we have to design.

So, as per the requirement, as per the situation demands, as per the availability, we have to decide whether we will go for rivet, bolt or welded joint and again whether fillet weld or butt weld in case of welding joint. Other thing is that in case of eccentric connection, one is through bracket we may connect; another is through seat. So, there are two categories; one is bracket connections, another is seat connections.

Again in case of seat connections, we can categorize as unstiffened seat connection or and stiffened seat connection. So, in this way we can make it. So, all these details has been discussed in last few lecture. So, I hope these connections will be clear to you because connection is very important to transfer the load from one system to another, from one member to another member safely. So, unless we do the joint correctly, the whole structure will be unsafe; though the individual members are safe, but joint are unsafe because of inaccurate design.

So, while going for design and going for calculation, going for analysis of the joint, we have to be very careful. Again as I told joint may be rigid, semirigid or flexible. So, in case of rigid or flexible means in case of, in fact, rigid, it is very easy to design, but in case of semirigid, it is quite difficult which is beyond our scope of lecture. So, with this I like to conclude to this lecture.

Thank you.