Design of Steel Structures
Prof. Damodar Maity
Department of Civil Engineering
Indian Institute of Technology, Guwahati

Module - 5
Lecture - 8
Compression Members
Design of Batten Plates

Hello. Today I am going to focus my lecture on design aspects of plates. In the last lecture, we have discussed different aspects of lacing systems, the general requirements, the codal provisions for design of lacing systems. Today we will be focusing first on the design aspects and general requirements of the battening system. Then, we will go through a work out example through which it will be clear how to analyze and design a batten plate.

As we told earlier that batten plates are generally provided when the compressive loads only exist. That means, only compressive loads means axially compressive load is coming into picture, not the eccentricity. So, when the load is acting concentrically, then we can use the batten plates. Of course if eccentricity is there, then also we can provide batten plates, but extra care has to be taken. In practice we generally use batten plates only when the axial force is present concentrically, not eccentrically and batten plate means generally we use flat type of bars or rectangular type of bars as a tie which is horizontal if the member is means if the compression member is vertical. That means the batten plates are placed in such a way that batten plates and the main plate will be perpendicular to each other, right.

Now, apart from the rectangular bar flat type elements, we can use also I section, angle section or channel section as batten plates, but for that also certain aspects has to be taken care. In practice, we generally use flat type bars as a batten plate. Now, first we will draw one batten plates with the main plates, main compressive member and how it looks like, we will see what are the terms, what are the parameters used for design. We will see and then it will be clear that what the things we have to design. Like in case of batten plates, we have to see what the dimension is. That means, thickness of the plate and the depth of the plate what to be the spacing to each other, how many battens will be required. So, all these things we will see step by step, right.

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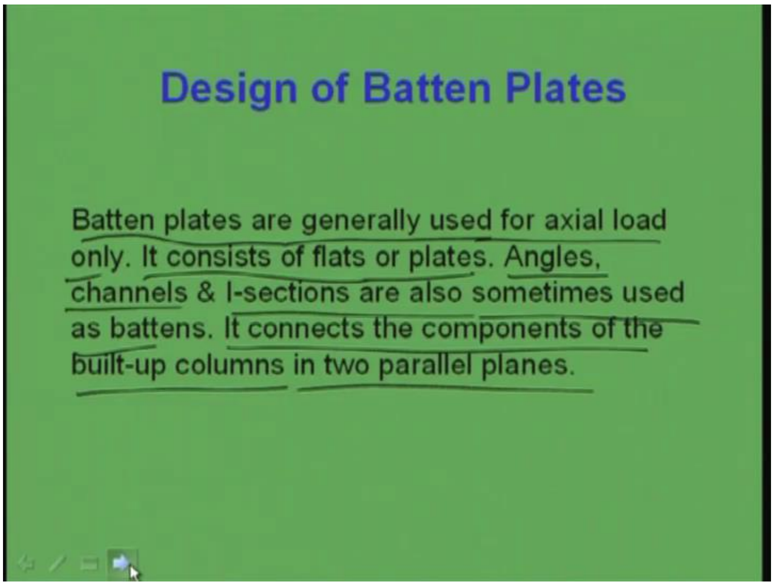

So, as I was telling that batten plates are generally used for axial load only. It consists of flat or plates. Angles, channels and I sections are also sometimes used as battens. It connects the components of the built-up columns in two parallel planes. So, how does it look let us see.

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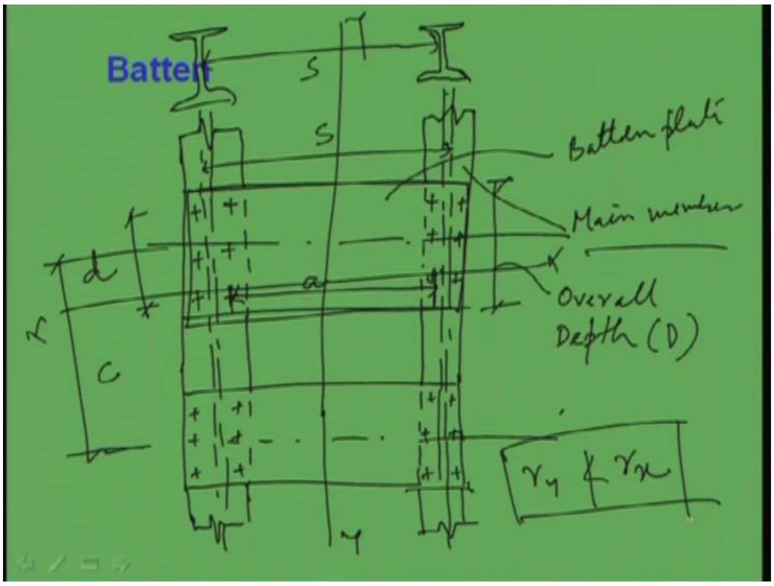

Suppose this is a section, sorry elevation of the batten plate, say here one plate is given, this is another one. This is a plate. Batten plate is here, another plate say suppose it is here. So, this is a plate, another plate is here. So, this is a compression member and this is another compression member and tied together through this batten plate. So, this is one batten plate and these are if we consider I section. So, these are the center means if we consider the I section is like this, say like this, right and say this is the I section and this is the web of the section, right.

Now, we can tell this as the spacing between two compression members. We can write as s. This is called s, right and this is the plate. One batten plate we are providing here. Now, this can be attached with the main plate in terms of rivet joint or in terms of welded joint or bolt joint. So, as per the requirement of the site and as per the availability, we can make it as bolt joint or rivet joint or welded joint. We know the advantage and disadvantage of the riveted joint and bolt joint and accordingly, we will make right.

Now, this is the plate say this is called batten plate. This is the main member, compression member, right. Now, this depth is called the overall depth of the batten plate which is written as D, and the outer most rivet distance is called the effective depth D and spacing will be middle of this plate, spacing of the batten when it is told. So, middle of this plate and middle of this plate CG distance of between two, this is called spacing which is denoted as C, right and the distance between two inner riveted groups is denoted as a distance between two inner groups. So, from here to here this is called a, right.

Now, this I can say as spacing between two compression members here I section has been used. So, accordingly it has been made. Now, here another important point will come later that if this is yy axis and if this is xx, then we have to see that ry should not be less than rx. That also we have to check and generally, we use that ry is equal to rx to get the maximum efficiency of the system. So, what we are seeing here that batten plates will be something like this.

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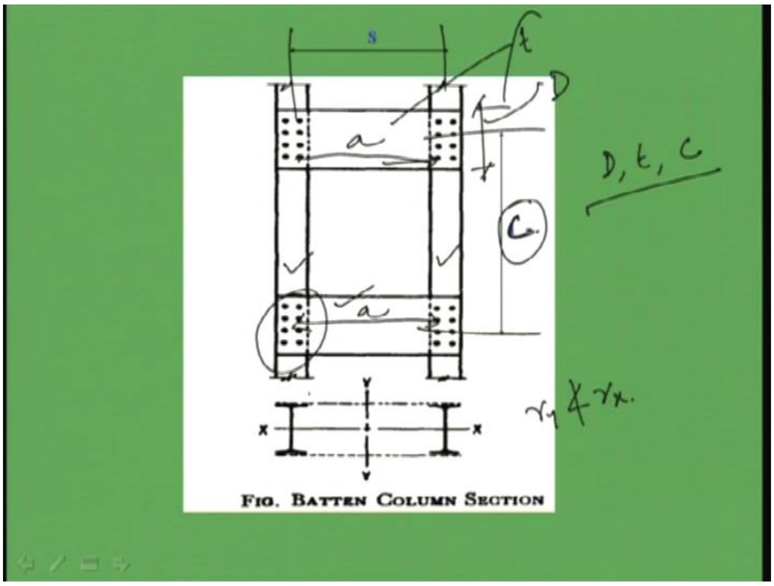

In fact, this is called C, the spacing and this is the S and this distance is called a. This distance rivet to rivet distance, this distance is called a and we have seen that ry should not be less than rx, right. So, these are the things we have to remember. So, what we are doing basically for design of battening? That means, we have decided this C spacing of the battening and then, this D total thickness. That means overall thickness of the batten and then, sorry depth of the batten and then, thickness t of the batten, right. So, these three things are important D, E and C spacing and then, attachment to the main plate. That means we have the main plate of this and we have to attach this batten.

So, how many numbers of rivets should be required? What will be the configuration of the rivet that we have to decide or what will be the welding link, how much weld link is required. So, that also in particular weld depth or weld thickness, those things we have to decide if we are going for the connection in connection as welding connection, right. So, these are the things we have to decide. Now, in the last lectures, in last 2-3 lectures, we have seen how to design a built-up section and after designing a built-up section, we have to make the lacing systems or battening system. We have to design the lacing system or battening and how we have done we have seen.

Now, here also in the similar process first we will see what the general requirements are and then we will see what the codal provisions are and what codal has been specifying. So, once we know the general requirements and codal provisions, then we can design the system as per the codal provisions, right. So, in today’s lecture I will try to finish all the things. That means, shortly I will discuss the codal provisions which is not match because it is almost similar to lacing system. Then, before that the general requirements I will go through. One example, work out example as how to design a battening system, right. So, let us see. So, first we will discuss about the general requirements.

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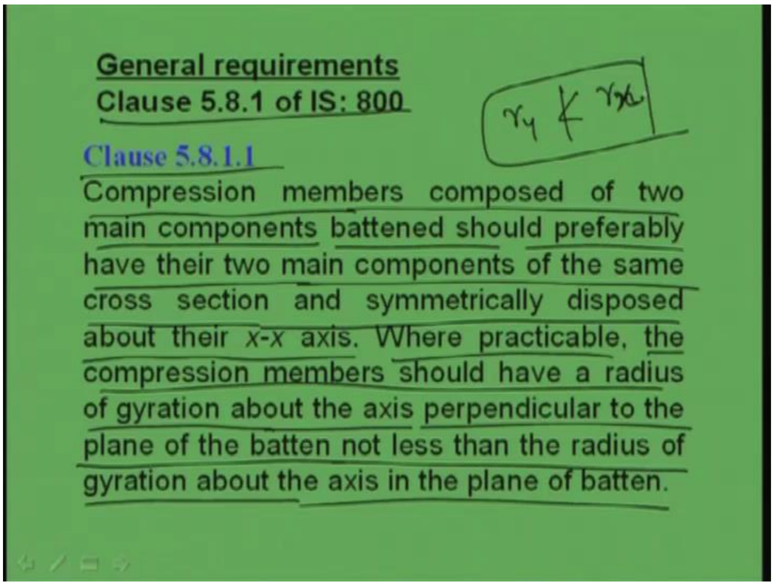

General requirement is in clause 5.8.1 of IS: 800-1984. In fact, in clause 5.8.1 of IS: 800-1984, the details requirement battening system has been given and in 5.8.1 the general requirements has been given and then, the design aspects has been the end connections have been given. So, if we see the first para that clause 5.8.1.1, what it is telling let us see. It tells that compression members composed of two main components. Battened should preferably have their two main components of the same cross-section, right and symmetrically disposed about their x-x axis.

So, the main component members should preferably be symmetric, where practicable the compression members should have a radius of gyration about the axis perpendicular to the plane of the batten and not less than the radius of gyration about the axis in the plane of batten. That means ry should preferably be greater than rx. So, these things have to be preferably maintained. This is the codal provision in 5.8.1.1.

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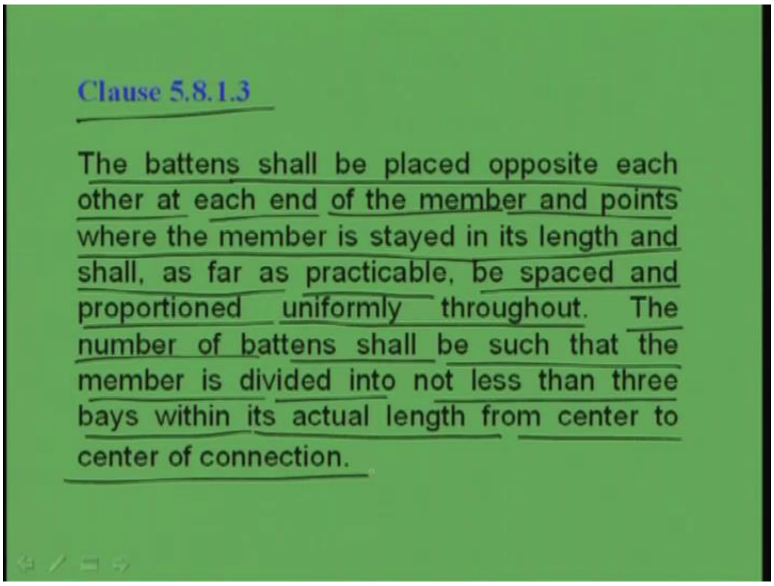

Then, in 5.8.1.3 it tells that the battens shall be placed opposite to each other at each end of the member and points, where the member is stayed in its length and shall as far as practicable be spaced and proportioned uniformly throughout. So, this is written in the code. You can go through the codal provisions and then, you will understand in better way. The number of battens shall be such that the member is divided into not less than three bays within its actual length from center to center of connection. So, at least three bays should be there, right.

So, in fact we do not have to remember all these provisions while designing. We can have a look of the codal provisions in clause 5.8.1 and 5.8.2 and 5.8.3 before going to start the designing. So, we do not have to remember. We can just have a look, we can read that one and we can understand from there, right.

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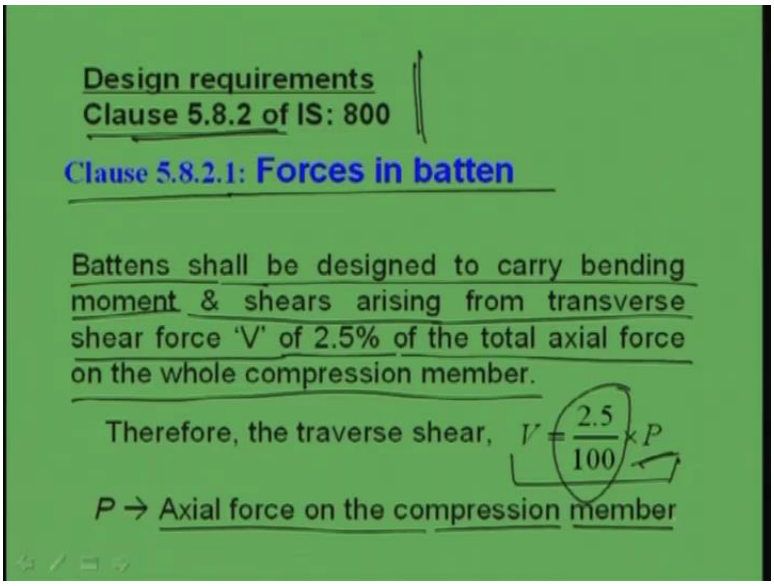

Next is the design requirement which is giving in clause 5.8.2 of IS: 800-1984. In clause 5.8.2, the details about forces coming into batten has been described. What are the forces will come into batten that has been told and according to that we have to check whether that much force exerted on the batten can be taken by the batten or not. The force which are coming to the batten from the axial compression member is able to carried by the battening plate or not, that we have to check. So, first we will see what the forces are coming and then, what the stresses due to that force is coming whether these stresses is exceeding the permissible stresses or not. That we will see and we will check accordingly, right.

So, in batten also the code has been suggested that this shall be designed to carry bending moment and shear arising from transverse shear force V of 2.5 percent of the total axial force on the whole compression member. So, like lacing system, the transverse shear will come to 2.5 percent of the axial compression. Transverse shear will come 2.5 percent of the total compression member. So, V will become 2.5 percent of P, where P is the axial force on the compression member. So, the transverse shear we can find out from this codal provision that V is equal to 2.5 percent of P, where P is the compression force in the compression member. So, from this we can find out the transverse shear force.

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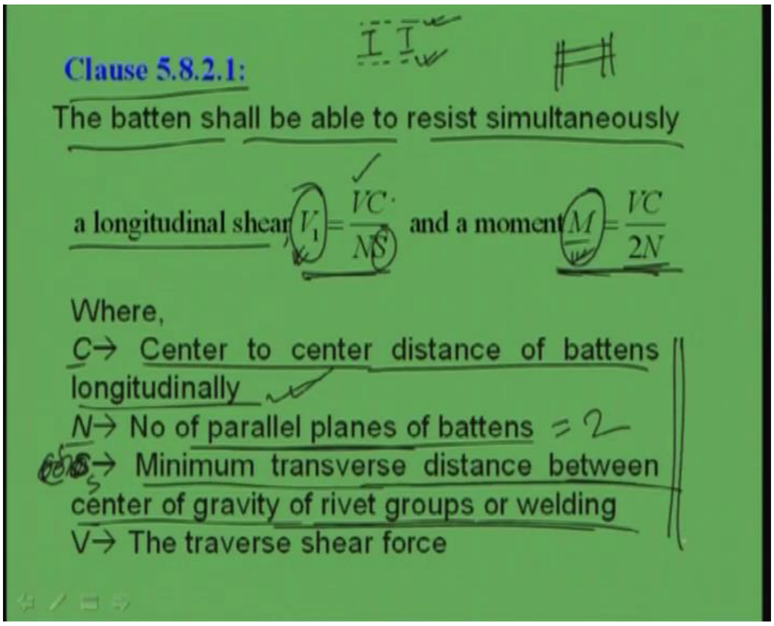

Then, what we will do? Then, we will find out the longitudinal shear and moment, right. The batten shall be able to resist simultaneously. A longitudinal shear of V 1 is equal to VC by NS and moment of M is equal to VC by 2 M this much shear and moment has to be carried by the batten. This is told in clause 5.8.2.1. So, we know V which is the transverse shear force which is 2.5 percent of the compression force P. So, we can find out the V 1 and M, where C is as we know C we can write. In fact, this is C minimum transverse distance between center of gravity of rivet groups or welding. Sorry, C has been given here. C is center distance of battens longitudinally. In fact, if we see the picture, we will understand.

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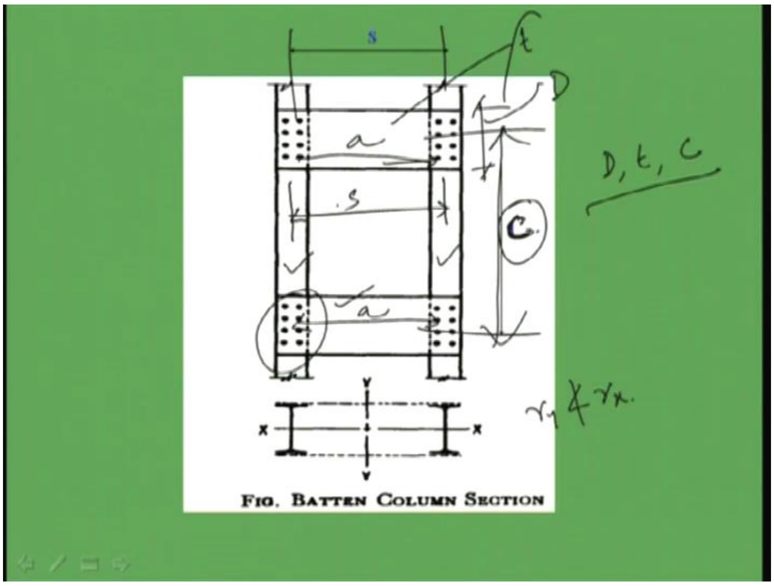

This is called C. C is this much. This is C, right. So, as we know the center to center distance of battens longitudinally. So, we can find out the value of C and N is number of parallel planes of batten number of parallel planes. That means, when two members are there, then we have a batten here and in opposite direction also, one another batten is there generally. That means if we have a I section here and if we have a I section here, we generally use to tie by this batten. So, number of batten plate is two, right. So, here N will become number of parallel planes of batten and that will become in general 2, right. Another thing is S.

This is S. S is the minimum transverse distance between center of gravity of rivet groups or welding. That means if we see the picture center of gravity distance of rivet or welding, this is called S, right. So, S we can find out from here. In this way we can find out the value of V 1 and M longitudinal shear and moment, right. So, forces in terms of longitudinal shear and moment can be calculated from the codal provision, where codes specifies that the transverse shear develop in the batten will be 2.5 percent of the compression force acting on the main member. So, we can find the transverse shear force V. Then, we can find out the longitudinal shear V 1 which is called VC by NS and the moment M as VC by 2 N, where C and N and s has been given here.

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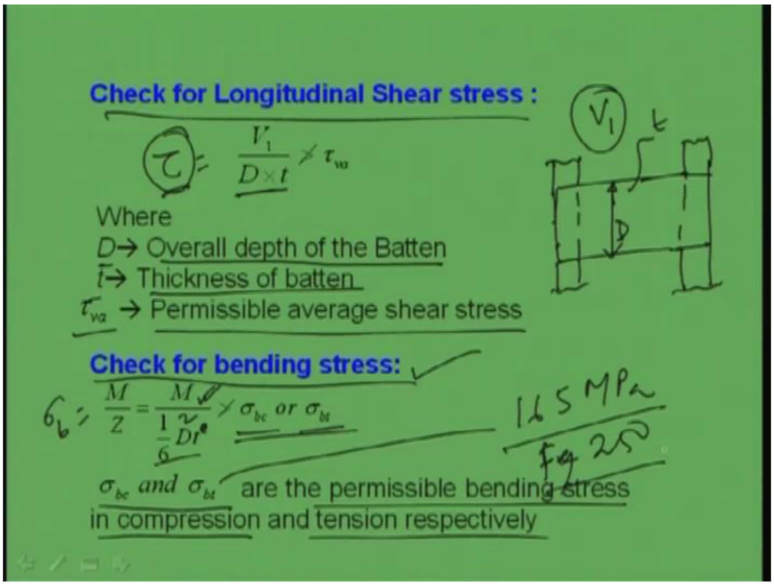

There we will check for longitudinal shear stress and check for bending stress. Now, we know the longitudinal shear force V 1 means we have calculated. So, the stress we can find out tau is equal to say V 1 by D into t which is called longitudinal shear stress. So, longitudinal shear stress tau will become V 1 by D into t, where D is the depth of the batten. If I see this is say this is one and this is another member connected with the batten. Now, this is D of the batten and thickness t, right. So, longitudinal shear stress tau will become V 1 by D into t, where D is overall depth of the batten and t is the thickness of the batten, right and this should not be greater than tau Va. Tau Va is permissible average shear stress which is given in the code, right.

In case of power driven soft rivet, we use to consider the permissible shear stress tau Va as 100 Mpa, right and similarly we will check for bending stress. Bending stress means we know the bending moment whatever it is developing. Now, bending stress we can find out sigma b is equal to M by Z and M, we have found already and Z is nothing, but the section modulus which will become 1 by 6 D into t square, right. Now, if I see sorry this will be D square into t 1 by 6 D square into t. This should be less than sigma bc or sigma bt, where sigma bc and sigma bt are the permissible bending stress in compression and tension respectively and these values are given in the code which is for Fy 250. It becomes 165 Mpa.

Sigma bt or sigma bc, the permissible bending stress in compression and in tension are generally taken as 0.66 Fy. So, from this value is coming around 165 MPa for Fe 250 means if Fy is 250 grade of steel, right. So, in this way we can check the longitudinal shear stress and bending stress. So, if it is then the assumed dimension of the batten, that means D and t is not then we have to increase either D or t suitably.

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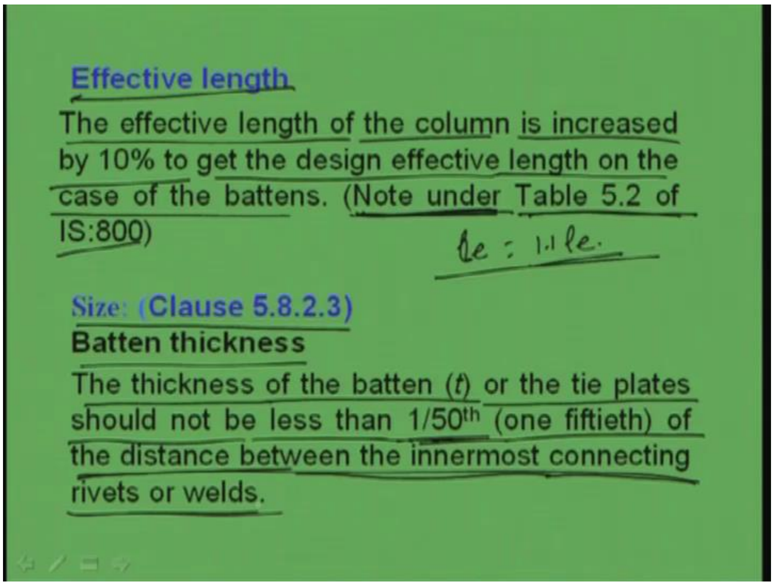

Next we will find out the other things like effective length because we have to find out the permissible compressive stress in the main member. Then, again we have to find out the radius of gyration of the main member for checking and for getting the spacing C between two battens, right. Now, in table 5.2, the effective length has been given. In that note in the table at the below one note is given, where it is told that the effective length of the column is increased by 10 percent to get the design effective length on the case of the batten. So, in case of batten, the effective length of the column will become 1.1 le. This design le will become 1.1 that is 10 percent increased.

The effective length whatever we are going to calculate will increase by 10 percent. If this is used for batten for calculation of batten forces and other things, designing things, we will calculate the effective length as 10 percent more than the actual effective length, right. This is given in table 5.2 of IS: 800-1984 in the note, right and in clause 5.8.2.3, the thickness of batten has been defined. The thickness of batten has to be 150th of the distance between the innermost connecting rivets or weld. What it is told actually that the thickness of the batten t or the tie plates should not be less than 150th of the distance between the innermost connecting rivets or welds. So, in this way we have to decide the thickness t.

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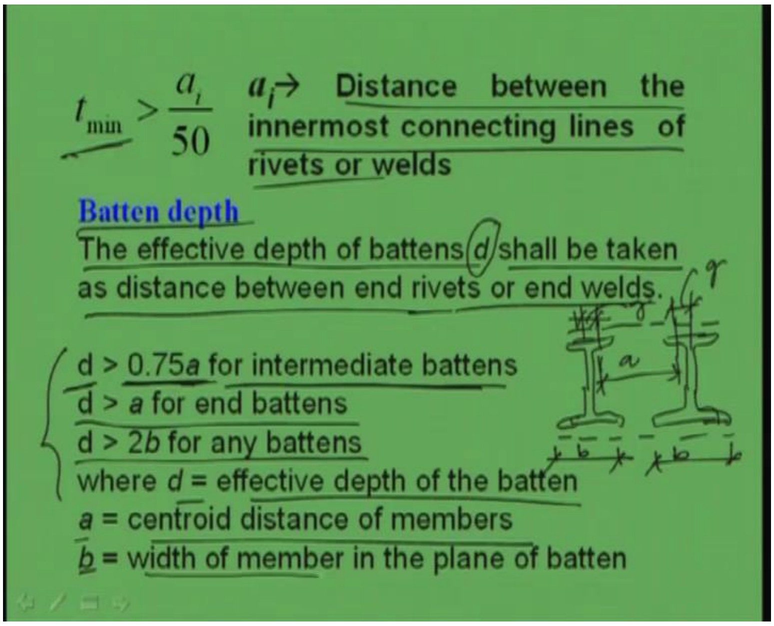

So, t will be minimum thickness. T will be ai by 50, where ai is the distance between the innermost connecting lines of rivets or welds. That means as we understand that suppose this is I section and this is another I section which are connected each other through batten plates. That means if we have connected two batten plates, if I see the plan, now this is the rivet line and this is called gauge distance. Now, this distance is called a, right. So, a by 50 minimum thickness of the batten should be greater than a by 50, right. Now, in this way we can decide the thickness of the batten.

Another thing is depth of the batten. As per this clause, it is told that the effective depth of battens d shall be taken as distance between end rivets or end welds as follows. So, this d should become greater than 0.75a for intermediate battens. So, the effective depth of the batten should become more than 0.75a where we have already told this a, the distance between the innermost connected lines of rivets or welds, right. So, d we can find out as 0.75a for intermediate battens and for end batten, this should become d should become greater than a for end battens. So, in general end battens depth will be little greater than the intermediate battens. This is as per the codal provision and in any case, always it should become greater than 2b, where b is the width of the main plate. This is web width, sorry flange width. This is called b. So, d the thickness of the batten should be greater than 2b. So, d is the effective depth of the batten, a is the centroid distance of members and b is the width of member in plane of batten. So, in this way we can decide the depth of the batten.

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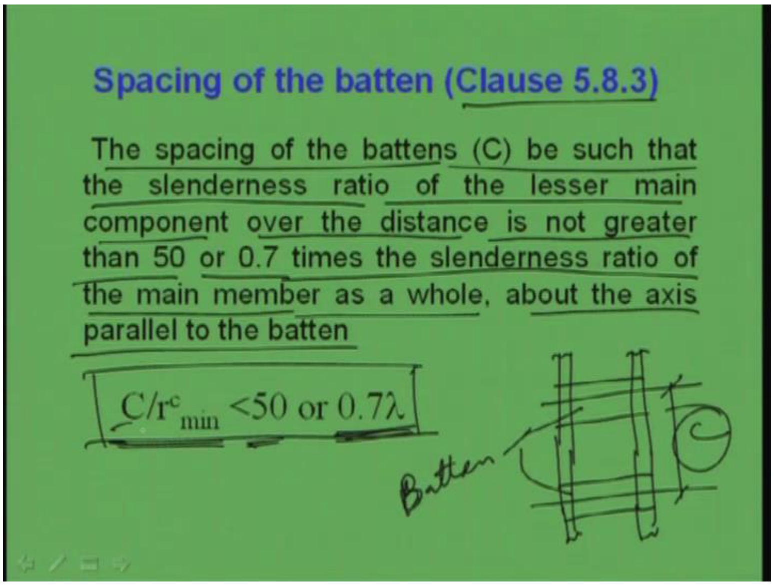

Then, another remaining part is spacing. Spacing means if two plates are connected through batten say suppose like this is connected. So, suppose one batten is here, another batten is here. Now, spacing will be this one means middle, middle to middle, this C, this is one batten and this is another batten. So, this is defined in clause 5.8.3 of IS: 800-1984. What does it told that the spacing of the battens C be such that the slenderness ratio of the lesser main component over the distance is not greater than 50 or 0.7 times the slenderness ratio of the main member as a whole about the axis parallel to the batten. That means C by rc minimum should become less than 50 or 0.7 times the lambda, where lambda is a slenderness ratio of the main member as a whole about the axis parallel to the batten, right.

So, this is the condition from which I can find out the value of C, the spacing between two battens, right. So, as for the clause 5.8.3, we have to find out the spacing between two battens. That can be decided from this equation which is called C by rc minimum is less than 50 or C by rc minimum is less than 0.7 lambda which was lesser, right.

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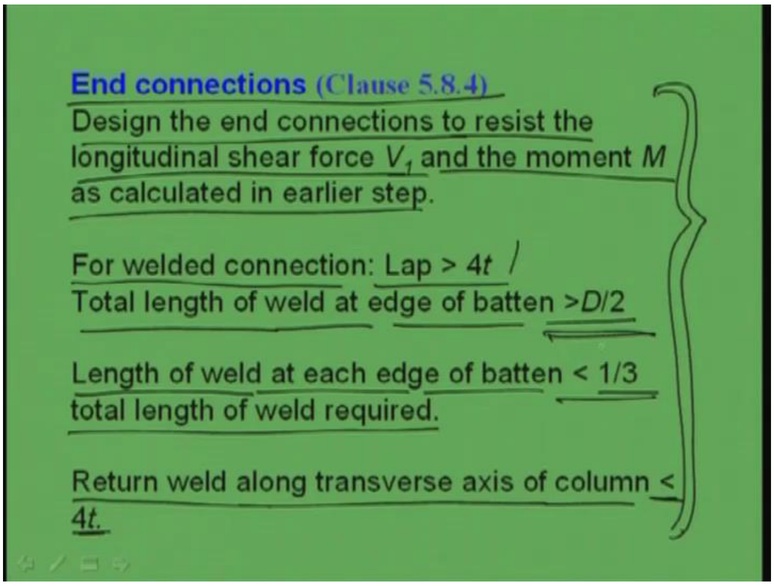

So, from this we have to find out, and then is the end connections. End connection means batten are connected to the main plate, the compression member. So, these battens either we have to connect through welded joint or through rivet or bolted joints. So, as per the designer choice, he or she has to choose any type of joint and accordingly he has to find out the configuration of the connections, right. In case of riveted joint, what we will do? Riveted joint we know the force what is coming. So, for a particular diameter of rivet, we know what will be the rivet value.

What will be the rivet value for a particular diameter of rivet and the thickness of the batten, we can find out. Generally a rivet value can be found out from single shear and from bearing of the plate. Then, the lesser one will be the rivet value and then, we can find out what the means if the number of rivets is decided, then what the force is coming to that. Then, also we know the CG of the rivet. We can find out from the configuration and then, we have to find out what the force is coming due to the eccentricity due to the moment, right. Then, we have to find out the resultant of the forces coming from the axial directly and from the moment, right and then, once we find out the total forces coming due to moment and the axial force means direct force. Then, we have to see whether it is becoming the resultant is becoming more than the rivet value or not.

If it is becoming more than the rivet value, then we have to redesign. We have to increase the number of rivet or we have to increase the dimension. Otherwise if it is less than the rivet value, then it is (( )). The assumed configuration is to find to carry that much load in this way the rivet joint can be done. In case of welding joint, certain parameters means certain guidelines have been given by the code which has to be taken care. This I am discussing. This is given in clause 5.8.4. In clause 5.8.1 of IS: 800-1984, this is given. What it is told that design the end connections to resist longitudinal shear force V 1 and the moment M as calculated in earlier step. So, we will design the end connection in terms of V 1 and M which already we have calculated. Then, what we will do? What are the things guided by the code, that is that for welded connection lap should be greater than 4 t. What is lap type coming? Lap should be greater than 4t.

Another thing is total length of weld at edge of batten should be greater than D by 2, where D is the overall thick depth of the batten plates. Then, length of weld at each edge of batten should be less than one-third of total length of weld required. This should be less than one-third of total length of weld required and returned weld along transverse axis of column should be less than 4t. This is also important. So, these are the criteria guidelines which are provided by the code in clause 5.8.1 of IS: 800-1984. So, through this guideline we have to design the weld connections. That means, how do we do the design, the weld connection? First we have to see what the forces are coming.

Then, we have to see what length of weld and depth of or thickness of the weld is required. We will calculate. Then, we will distribute the weld in such a way that these are maintaining these codal provisions, right. So, in this way we can design. Now, I will give the details of this in the diagram, so that we can understand what lap is and what other things are telling by the code.

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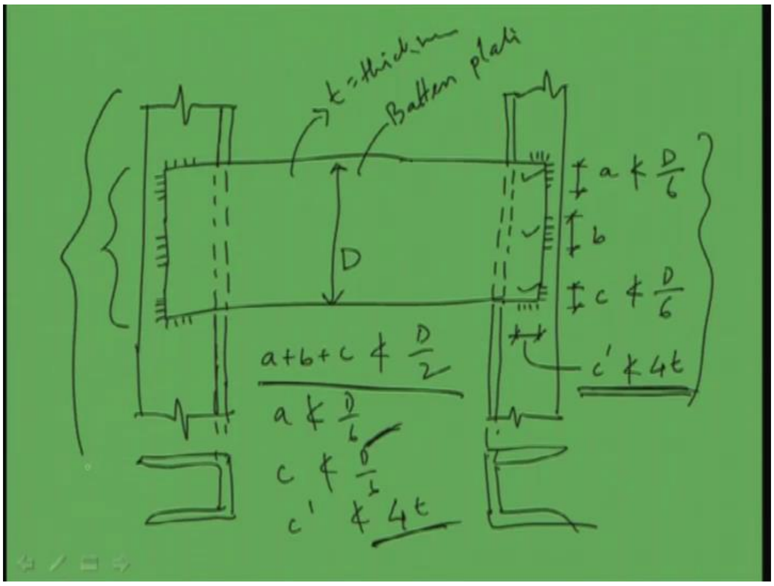

So, this is one main member. This is the batten plates, another main member is here. So, these two main compression members are tied together through the batten plate. This is batten plate. Now, this has been welded. Now, this is the overall depth of the batten plate and thickness is t of the batten plate. Now, welding has been done say in this way. First we have to decide what the total length are equal for welding with a particular thickness of the weld and then, we have to distribute properly, so that the codal provisions are maintained as well as the total lengths are also maintained.

So, this is if I say a, this should not be greater than means less than D by 6. That means this should be greater than at least D by 6, where D is the overall depth of the batten plate and this is called b and this is say again c. If we say this also should not be less than D by 6 and this we can say suppose c dash, this should not be less than 40, right. This is in our case we are using channel section. We can find out the diagram. Accordingly, this will be the diagram and if we see the plan, it will be something like this. It is not to scale just tell if we use channel section. Then, this will be like this, right. So, these are the channel section welding has been done like this.

Now, here condition is that a plus b plus c. That means, this plus, this plus, this should not be less than D by 2. This is 1, right and other things are I told that a should not be less than D by 6 and c should not be less than D by 6 and c dash should not be less than 4t, where t is the thickness of the plate. So, these codal provisions have to be maintained.

So, whatever I am telling here I am writing means I mean diagram is given here. So, what we told here is that we see for welded connection lap should be greater than 4t. That means, lap should be greater than 4t. That mean it should not be less than 4t c dash.

Then, another thing is that the total length of weld at edge of batten should be greater than D by 2. So, total length of weld at D is a plus b plus c total length. This is the total length. It should be greater than D by 2 and a and c, the end return should be at least D by 6. That has to be maintained. So, with these codal previsions, we have to design the weld connection for the batten plate. So, whatever we have seen in case of design of batten plates that certain general requirements are there which we have to follow and certain guidelines for design of batten plates are there in the codal provisions. Guidelines means what should be the minimum thickness of the batten plate, what should be the minimum depth of the batten plate and what should be the minimum spacing of the batten plate. That has been given in the code maximum spacing of the batten plate.

So, from the codal provision we can find out these three that is thicknesses of the batten plate, depth of the batten plate and the spacing of the batten plate. Then, other things are that we have to check the longitudinal shear stress whatever developing in the batten plate and the stress due to bending, we have to check and we have to check whether D the developed stresses are less than the allowable stress or not. If it is less than the permissible stresses, then it is fine. Otherwise, we have to redesign. Redesign means we have to increase the dimension of the batten plate in terms of either thickness or in terms either depth. Then, what we will do? Then, we will go for end connections. End connections means either we will do the connection between batten and the main plate with the riveted joint or bolted joint or welding joint.

So, in case of riveted joint, we know what the loads are coming and what the diameter of rivet is. So, accordingly we can find out the configuration of the rivets. That means where the rivet should be placed, how many rivets should be placed and what should be the capacity of the rivet group we can find out and if we go for welding joint, then we have to see what will be the length of weld is required for the force is coming into picture. Then, we have to maintain the codal provisions that what will be the distribution of the welding length and means return weld lap length. All these things we have to decide as per the codal provisions and we have to see whether we are maintaining or not.

So, in this way we can design. Now, we will go through one example through which we will be able to clear that how to design the batten plates.

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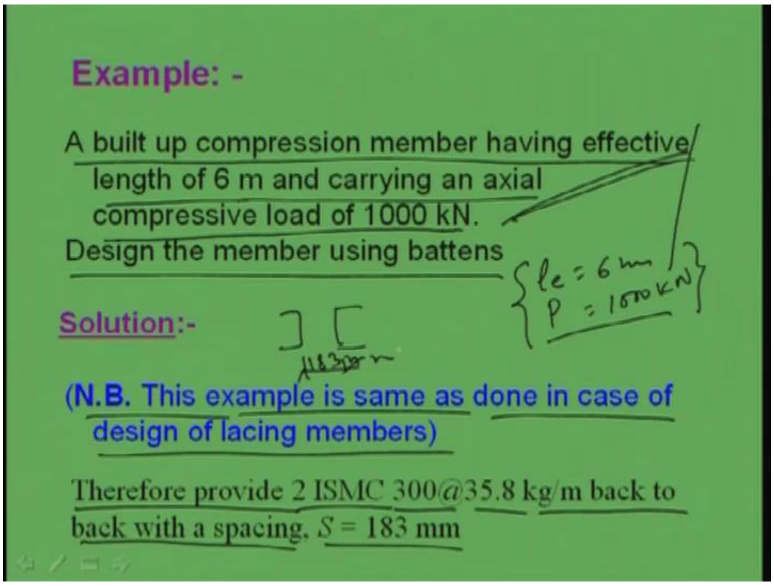

So, this example has been worked out in previous lecture that a built-up compression member having effective length of 6 meters and carrying an axial compressive load of 1000 kilo Newton design the member using battens. In last workout example we have done same thing using lacing plates. So, here what we are seeing that effective length is 6 meter and the compressive load which is carrying by the number is 1000 kilo Newton and actually this example is same as done in case of design of lacing members. So, we will do the same thing for the batten members. The advantage of doing the same problem is we can see the difference as what are the different things are coming in case of battening with respect to lacing systems and the first step. That means, the design of built-up sections we do not need to iterate again because we have done in the last class. So, we can have a look there, right.

So, in class what we have seen for this effective length and the load, we need to provide 2 ISMC 300 at 35.8 kg per meter back to back with a spacing 183 millimeter. That means 2 ISMC we are going to provide with a spacing of 183 millimeter. This we have calculated in last lecture, right. In last lecture up to the calculation of built-up section means finding out the built-up section and the spacing is common for this problem also.

So, we are not going into details that then there we have done design of lacing using single system and double system. Here we will do the things using batten, right. So, let us see how to do it.

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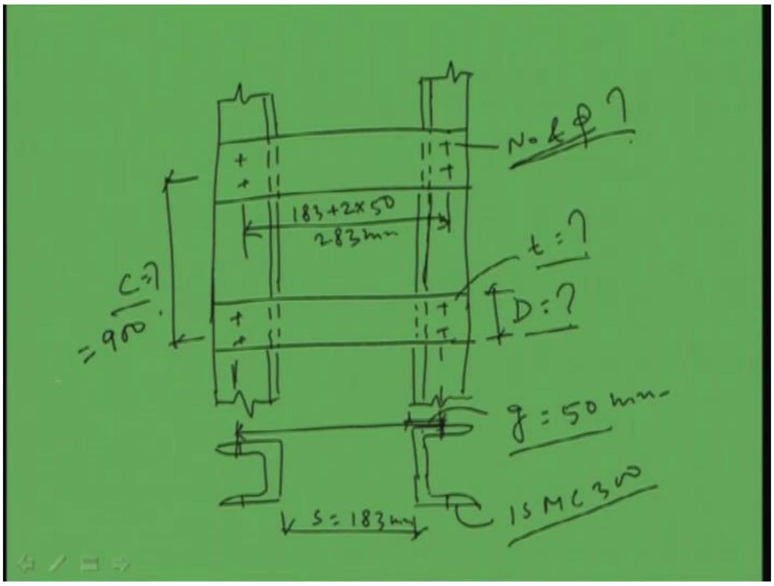

So, first let us draw the things which we got in earlier design and then, we can go the details of the battening. Suppose these are the battening, these are another plate. So, this is a channel section and this is another one. This I am drawing because from this configuration we need means many dimensions in our calculation of the batten plates, right. So, what are the things we know already that is we know the spacing, clear spacing s 183 millimeter and we know this is the web, right. Now, another thing is we know the rivet group as per from the SP 6. We can find out the gauge distance. This is called g and this is given as 50 in code. If you see in SP 6, we will g is given as 50 millimeter, right. So, if we provide the rivet here, right if we provide the rivet in this then we can see this distance also we can find out. That means this distance, right.

So, this distance will be 183 plus 2 into 50. That means 283 millimeter. So, this distance also we have, right and this channel sections we have ISMC 300, right. Channel section we have chosen ISMC 300 with back to back and 183 mm spacing. So, these things are already calculated in the last lecture. Now, we have to find out what is the depth, overall depth. This we have to find out as what the thickness is. This we have to find out. What is the number of rivet number and diameter of rivet that also we have to find out and this

C we have to find out the spacing. So, these are the things we have to find out, right. So, let us see step by step how to find out all these unknown. So, these four unknowns are there. So, while we are going for design of batten means first we will go for design of the built-up section which is common and which is done in earlier class.

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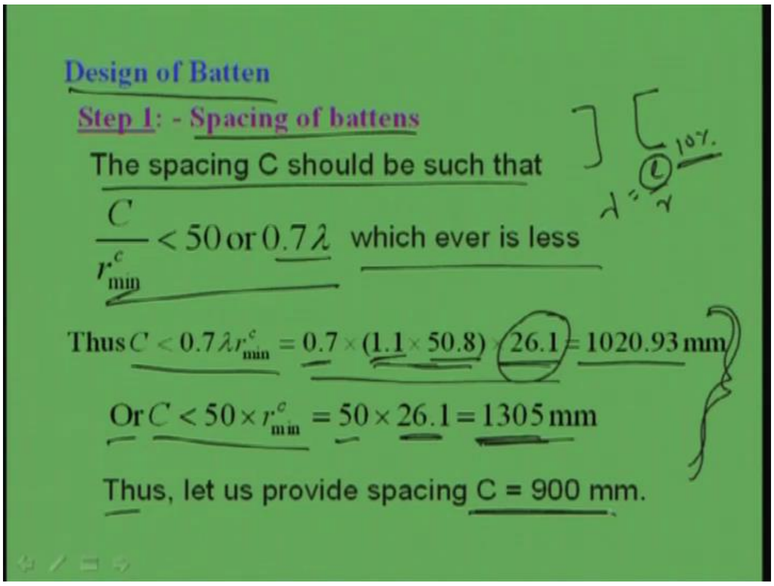

Now, we will go for design of batten. In step 1, we will first find out the spacing of the batten spacing C. So, as per the codal provisions C should means this express also be maintained the C by rc. Minimum should be less than 50 or 0.7 times lambda whichever is less. So, first we can see C should be less than 0.7 lambda into rc minimum. That means 0.7 lambda into rc minimum. Rc minimum is given in the code means for this configuration what the rc minimum is we can find out which has find out in last class that is 26.1 millimeter.

Another thing is lambda. Lambda is also found out in the last class. Only thing is what is lambda? Lambda is l by r. Now, as per the codal provision in table 5.2, it is told that length will be increased by 10 percent. Length of the compression member, effective length of the compression member will increase by 10 percent for the case of batten. So, here lambda will be going to increase by 10 percent. So, I am multiplying 1.1 with the earlier 158.8. So, this will become 1.1 into 50. So, if we calculate this, the C value is coming 1020.93 millimeter. So, the spacing between two battens is coming from one expression that is 1020.93 millimeter.

Another is C should be less than 50 into rc minimum. So, 50 into rc minimum that is coming 1305 millimeter. So, these are the two. So, C should become lesser of these two at least. So, now let us provide spacing CS say 900 millimeter. Let us see because the spacing of two battens should be less than these two. So, we say providing say 900 millimeter, right. Then, what we will do is thickness of batten. So, C first is defined. So, C is now known that is 900 millimeter. Now it is known.

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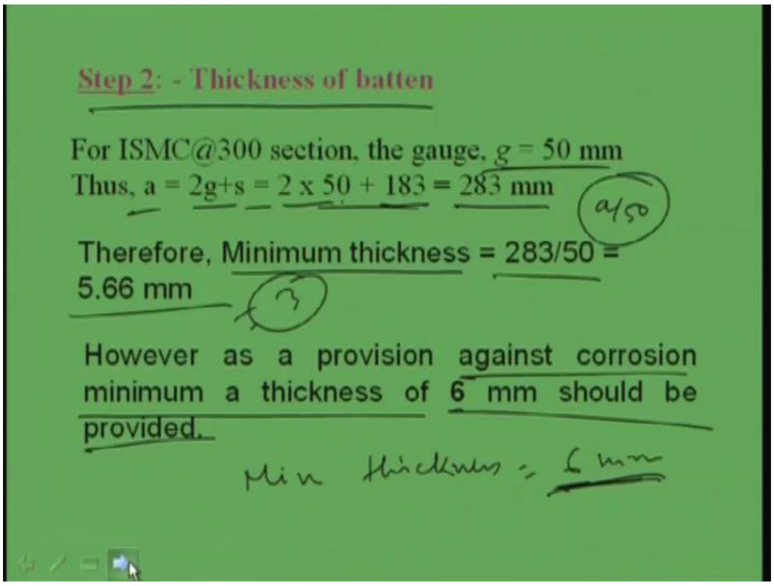

Step 2, we will try to find out thickness of the batten. Now, the thickness of the batten we know that this should become a by 50. So, what is a? We know we have calculated. This is a value. So, we are finding out a, because gauge distance is given 50. So, a will become 2 g plus s. So, 2 into g is 50 plus s is 183. So, this is becoming 283 millimeter. Thus, a is becoming 283 minimum. So, we can find out the minimum thickness as 23 by 50 which is coming 5.66 millimeter. So, the minimum thickness we are also getting. However, we see as a provision against corrosion minimum a thickness of 6 millimeter should be provided.

So, in any case if it is coming less than 6, also we have to provide at least 6 mm from the corrosion point of view, right. So, minimum thickness, we are going to add is 6 mm. Suppose, it is becoming say 3, then also we have to consider at least 6 mm, right or more than that. So, let us see with the minimum thickness 6 mm. So, let us decide the thickness as 6 mm. So, what else we need? We need to know the d depth of the batten plate, right.

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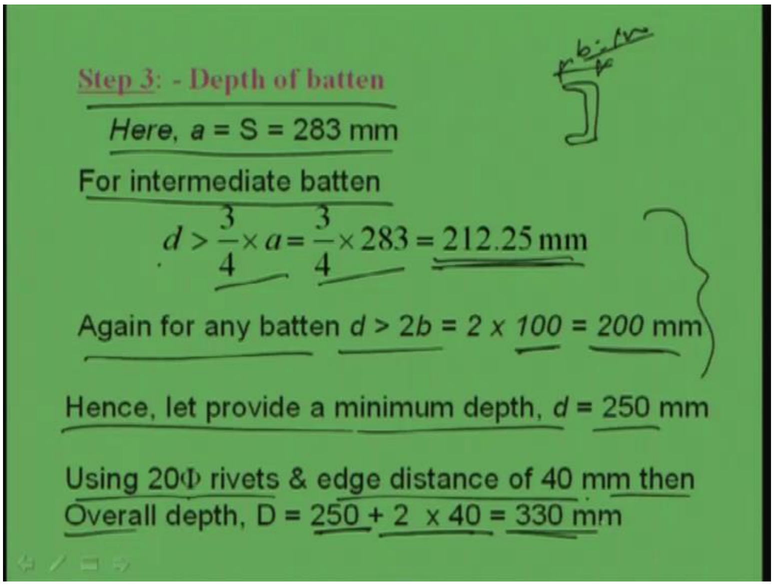

So, step 3 will become depth of batten. So, depth of batten as we know a is basically 283 millimeter which we have calculated. So, from the codal provisions, we know for intermediate batten, d should become less means at least greater than three-fourth of a. So, if we put the value of a as 283, then d will become three-fourth of 283 which is becoming 212.25 millimeter, right. So, d has to become 212.25 millimeter. Again for any batten, d should become at least 2b, where b is given 100 mm means for ISMC 300, we know this is b which is given in SP 6 as 100. From code we can find out the dimension of this. So, b is given. So, here at least 200d should be greater than 200 and 212.

So, from these two we can provide a minimum depth of say 250 millimeter. The effective depth as 250 millimeter we can provide and if we use 20 mm diameter of rivet and edge distance of 40 mm, then the overall depth will become 250 plus say edge distance is 40. So, 2 into 40 will become 250 plus 2 into 40 is equal to 330 millimeter. So, the overall depth we are going to find out as 330 millimeter because we are assuming the effective depth as 250 millimeter and the edge distance as 40 millimeter. So, we can find out as 330 millimeter.

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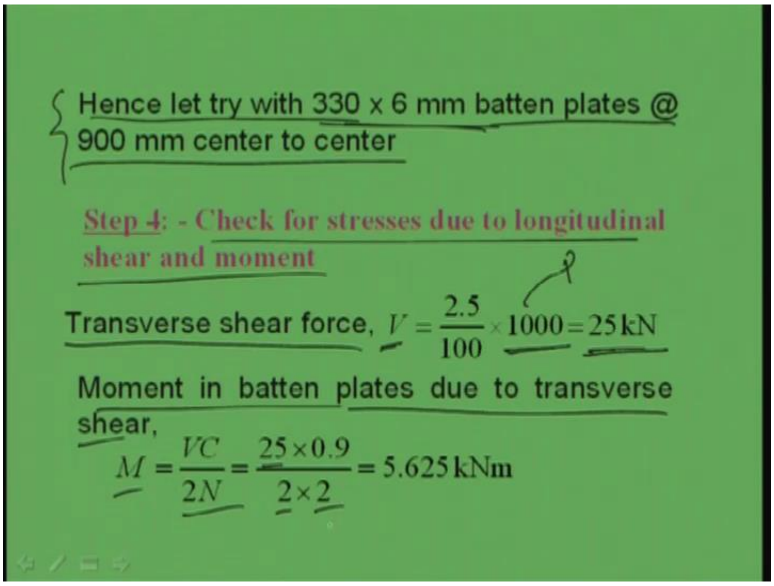

Next we can find out the stresses. So, we are going to provide this is the thing that theta t by 6 mm batten plates at 900 mm center to center. So, this is the outcome we got, right.

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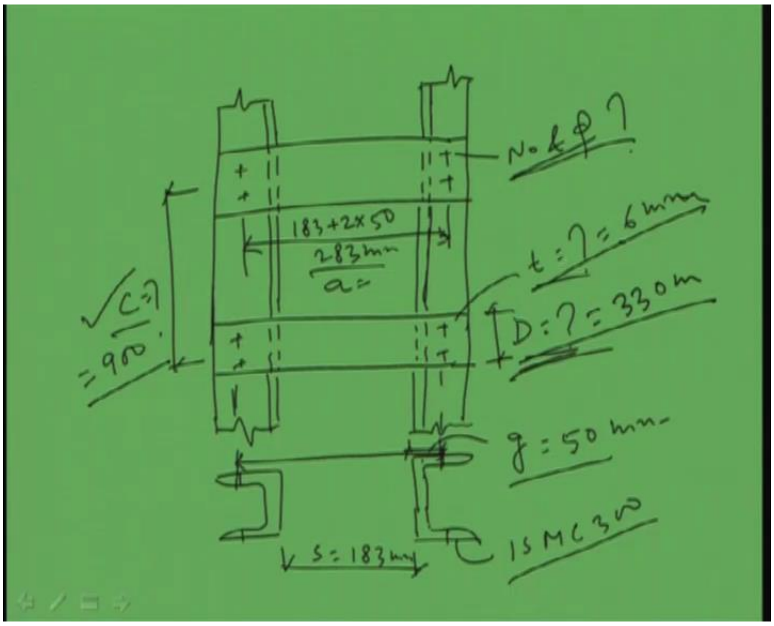

So, here D we are going to decide 330 mm. So, all the things we found thickness, depth and spacing. Now, we have to find out number and before that we have to check the stresses. So, in step 4, we will check the stresses due to longitudinal shear and moment. So, we can find out first transverse shear V is equal to 2.5 percent of the total load. This is P. So, this is becoming 25 kilo Newton, 2.5 percent of 1000 kilo Newton, right, so 25 kilo Newton. Now, moment in batten plates due to transverse shear we can find out from the formula M is equal to VC by 2 N. So, V is 25 and C is 900 millimeter. That means, 0.9 and 2 into N. N is equal to number of parallel planes that is 2. So, if we calculate, we will get 5.625 kilo Newton meter. So, moment we are getting.

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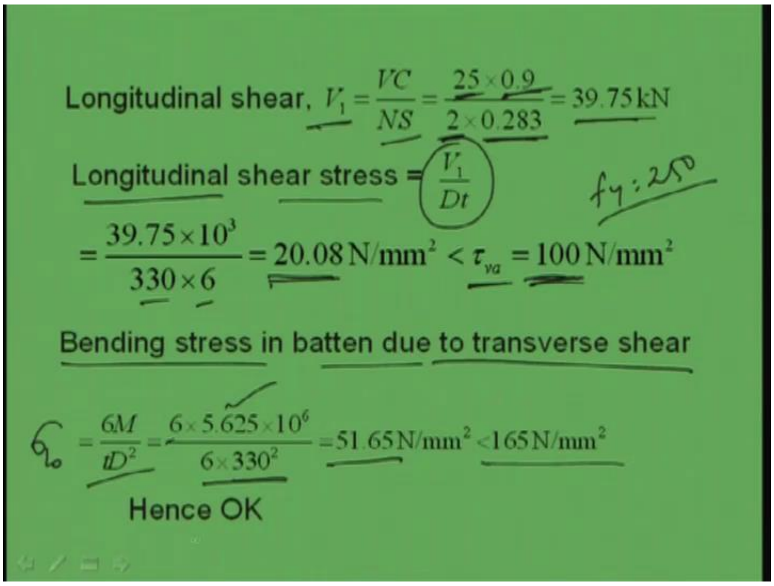

Next we are getting the longitudinal shear V 1. This will become VC by NS. So, V is 25, C is 900 mm and N is 2 and S is spacing that is 283 millimeter. So, from that we can find out the longitudinal shear. V 1 as 39.75 kilo Newton. So, longitudinal shear stress also we can find out which will become V 1 by Dt. Now, if we put the value of V 1 and D and t, we will get the value as 20.08 Newton per millimeter square which is less than tau Va. In this case, tau Va is 100 Newton per millimeter square for the steel as we are using Fy 250 with. So, tau Va is 100 Newton per millimeter square. That is why longitudinal shear stress whatever coming as 20 is less than tau Va.

Similarly, the bending stress in batten due to transverse shear can be found out that is sigma b is equal to 6 M by t into D square. 6 moment is this one and t is 6 mm and D is 36. So, from this I am going to get as 31.65 Newton per millimeter square which is less than sigma bt or sigma bc which is 165 Newton per millimeter square. So, from stress point of view, these are quite also we can make.

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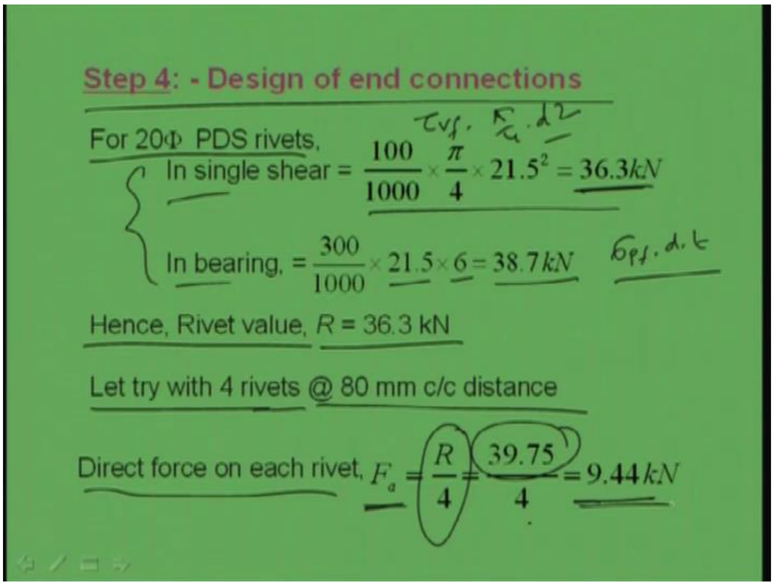

Next what we will do? Now, we will go for design of end connections. So, in case of end connections, if you use 20 mm power driven shop rivet, then in single shear the rivet value will become tau Vf into pi by 4 d square tau Vf into pi by 4 into d square, where d is the graph diameter 21.5. So, this is coming 36.3 kilo Newton and in bearing this will be sigma Pf into d into t. So, if I put the value sigma Pf as 300 d is 21.5 and t is the thickness 6. So, this is coming 38.7. Hence, the rivet value will become lesser of these two that is 36.3 kilo Newton. So, rivet value also we are going to get.

Next what we will do? Next is direct force on each rivet, right. So, for that we have to start with some number of rivets. Let us provide four rivets at 80 mm center to center distance. So, direct force on each rivet we can find out because four rivets are there. So, Fa will become R by 4, where R we found earlier R, right. Longitudinal shear is 39.75. So, R by 4, this is coming 9.44 kilo Newton. So, direct force on each rivet is coming 9.44 kilo Newton.

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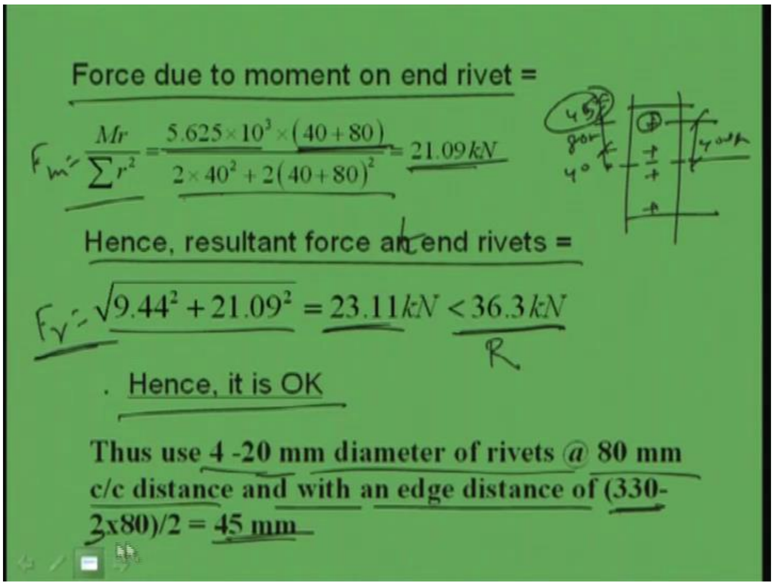

Similarly, force due to moment on end rivet will be becoming Mr by summation r square. So, now, if we provide four rivets says this is a batten plate say 1, 2, 3, 4. Now, this distance has been taken say 40, sorry 80mm. So, this is 40 and then again this is 40. So, this will work on 45. We will calculate this one, yeah 45. So, we have to find out the distance of extreme rivet that will become 40 plus 80. So, M into r, this is the R. This extreme distance of extreme rivet by summation r square two rivets in each sides. So, it is 2 into 40 square plus 2 into 40 plus 80 whole square. So, this will become 21.09 kilo Newton. This can be clear Fm force due to moment. Hence, resultant force at end rivets will become Fr will become root over Fm square plus Fa square.

So, the resultant is coming 23.11 kilo Newton which is less than the rivet value. A rivet value was calculated as 36.3 kilo Newton. So, the resultant force is coming less than the rivet value. So, we can use that four number of 20 mm diameter of rivets at 80 mm center to center distance and we can edge distance of 45 millimeter that we calculate because total depth is 330 minus 3 into 80 equal to 45. So, we are going to get 45 mm.

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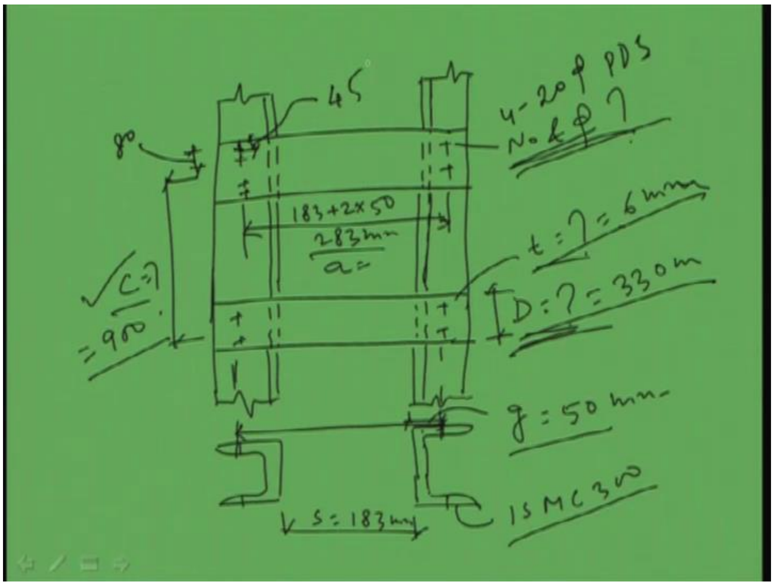

So, if we see now the details of the design, we will see that here number is four numbers of 25 rivets. 25 diameters of power driven shop rivets and four numbers means say suppose this four let us provide and this rivet distance will become 80 and this edge will become 45, right. So, in this way we are going to get all the details. So, with this I like to conclude today's lecture as well as the chapter of compression member. In the next class, we will start a new chapter.

Thank you very much.