Course on Design of Steel Structures
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Lecture 35
Module 7
Design of Built up Compression Member

Today I am going to discuss about the design procedure of built up members, built up members comprises of two or more rolled steel section, in fact when a load when a compressive load is coming into picture sometimes the load is so heavy that a single rolled section cannot (())(0:41) that much load because there is a limitation of maximum size of the rolled section. Therefore when load becomes very high we may have to go for built up section comparison of two or more number of sections.

This is not only because of the high load but also sometimes we need equal radius of gyration in both the direction because in rolled steel section we generally see that radius of gyration in one direction is much higher than the other direction. Therefore the buckling will happen about the weaker section first and as a result the load carrying capacity of the member, member means the steel rolled section member will be less about a particular direction, to (()) (1:36) that generally we provide a built up section where higher radius of gyration can be achieved in both the direction and thereby we can increase the load carrying capacity by providing such type of built up members.

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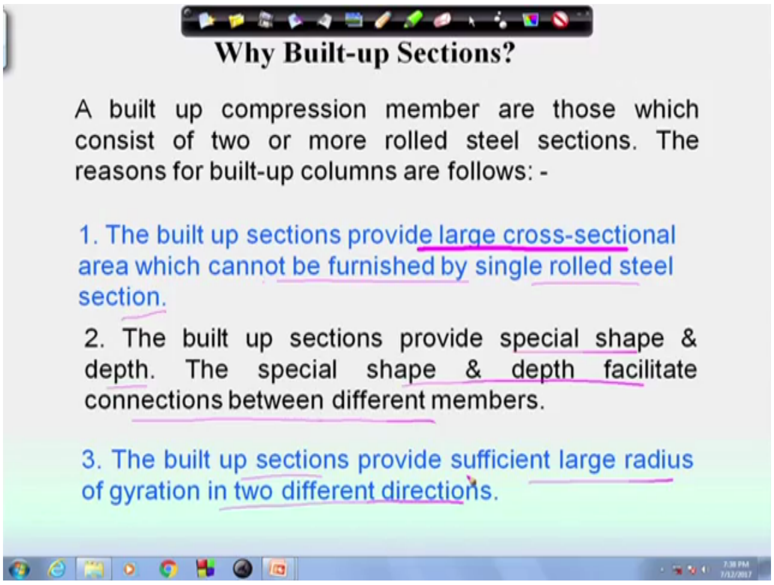

Now coming to reason as I told that one is that the built up section provide large cross-sectional area which cannot be furnished by single rolled steel section, right. Then built up section provide special shape and depth. The special shape and depth facilitated connections between different members. And another important thing is that the built up section provide sufficient large radius of gyration in two directions. Therefore we generally prefer built up members in case of long length of long length of column and with high load.

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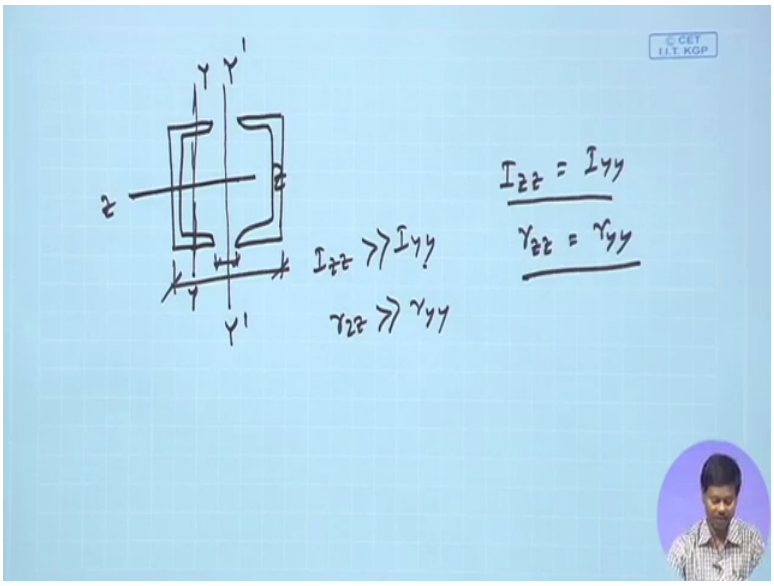

Say for example if we consider a channel section as a compression member, then we know if this is z-z and if this is y-y axis if we consider, then Izz is much higher than Iyy, right or rzz is much higher than ryy much higher than ryy. Therefore the chances of buckling about y-y axis will be much earlier than about z-z axis. So if we provide built up member then what we can do we can increase the radius of gyration by by providing another member and with a certain spacing.

So if we do that then we can see that Iyy the new Iyy of the section will become much higher and the built up member generally we provide in such a way that Izz become Iyy means we will vary this spacing between two members to such an extent that when Izz become Iyy upto that we will vary, right or rzz become ryy. So in this way we provide the the configuration of the built up member.

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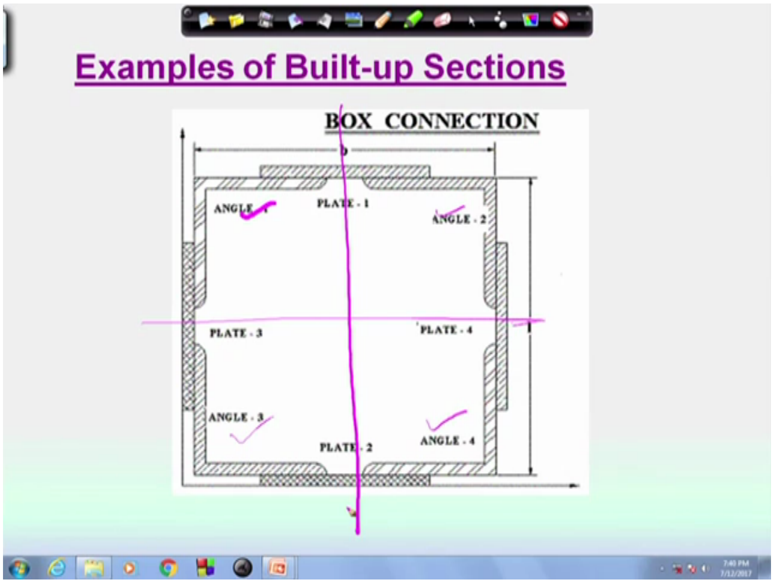

Now now examples of built-up member if we see, here we can see that we can use 4 angle section 4 angle section and to make a box type of cross section by the use of certain tie plate which is called generally lacing or battening that I will come later. So this is one example where we can use built up section to increase the Ixx and Iyy of the section.

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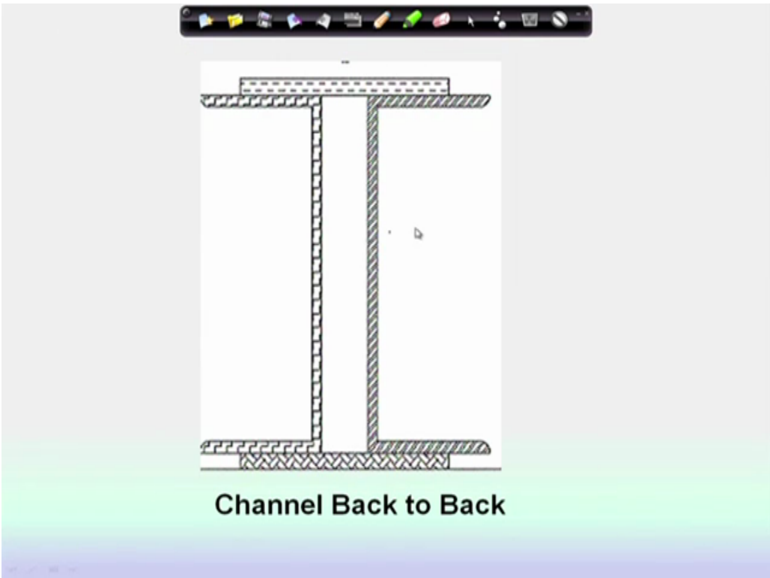

Another different type of built-up members are used another example is that when two channel sections are placed back to back, then also the built-up members means are connected with the lacing or battening member, so this is one example.

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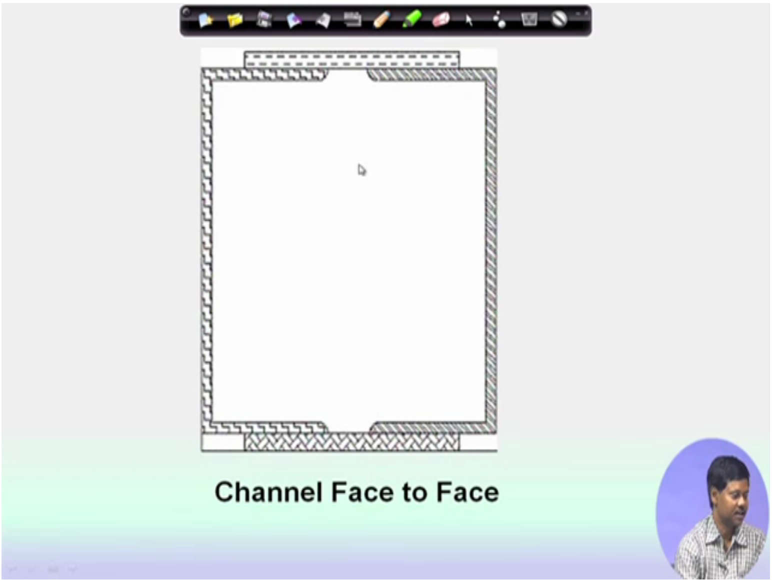

Next is channel section when facing face to face this way also we can provide a built-up member.

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Then I section with channel section at the top as per the requirement, sometimes we see the requirement and according to that requirement we may have to provide that I section with a channel section at the top.

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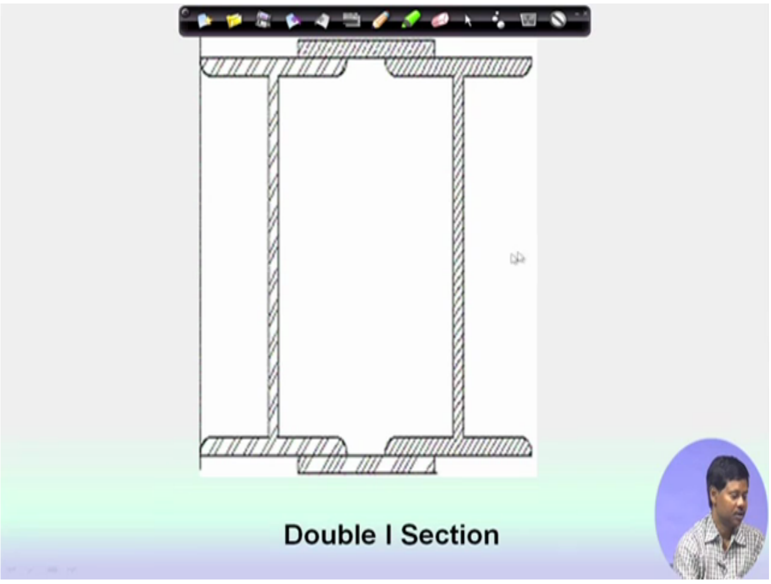

Sometimes two I sections are provided to (())(5:46) the load.

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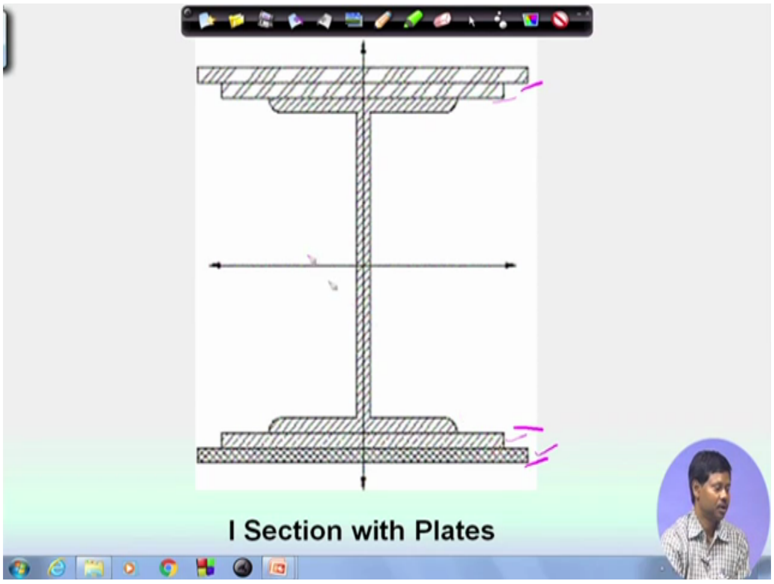

Sometimes in place of plate girder we generally see that I sections are provided with additional plates. So number of plates are added as per the requirement and in this way we increase the load carrying capacity of the member. Generally I section with plate girder means with plates, we generally provide when the bending moment of the member is become becomes high. That means when a member is under flexural action then because of bending stress may be the single I section is not capable of taking that much load.

So in that case we may have to provide the additional plates as per requirement. So this is another type of means another example of built-up member.

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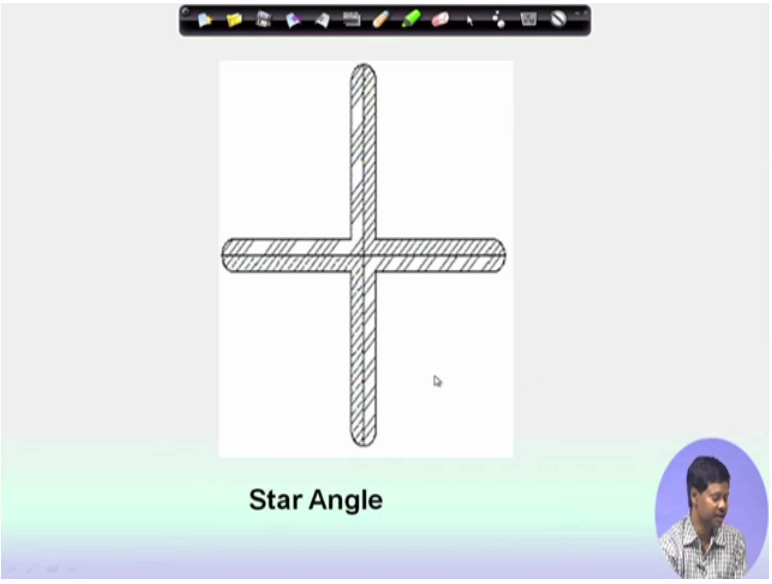

This is an another type of built-up member which is consisting of 4 angles which is called star angle.

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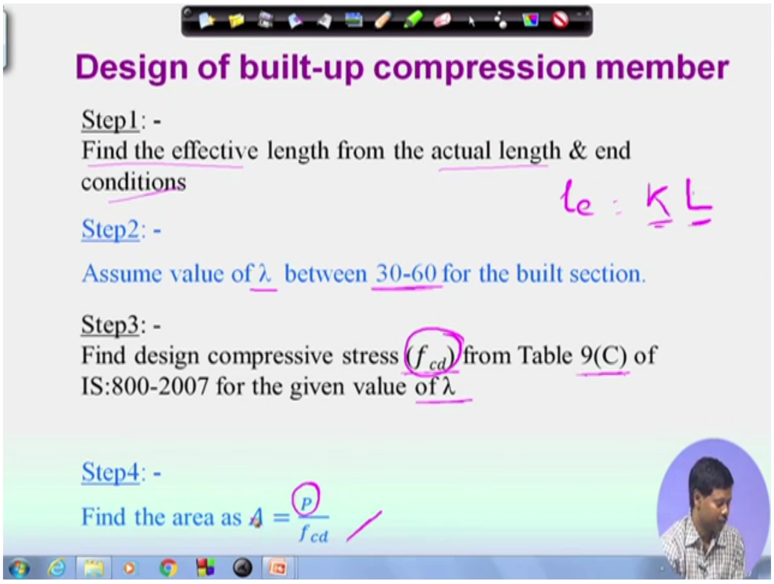

Now coming to design of built-up compression member, so now if we see that design of built-up compression member the steps first we provide the means we find out the effective length. The step 1, what we do is we find out the effective length from the actual length and end condition that means le we can find out from actual length and the end condition from that first we will find out what is the effective length.

Then we generally assume certain value of slenderness ratio lambda as 30 to 60 for built up section, generally we consider less value of lambda because because of the built up section the radius of gyration is quite high and therefore the slenderness ratio we can consider quite less means it may be from 30 to 60 which will be sufficient.

Then in step 3 we find the compressive stress fcd from table 9C because the buckling class for built-up member is C, therefore we can use table C and corresponding to table C for a particular value of lambda whatever we consider we can find out the fcd value for a given grade of steel. So once we get the fcd value we can find out the required area A which is P by fcd, where P is the axial compressive force which is acting on the member.

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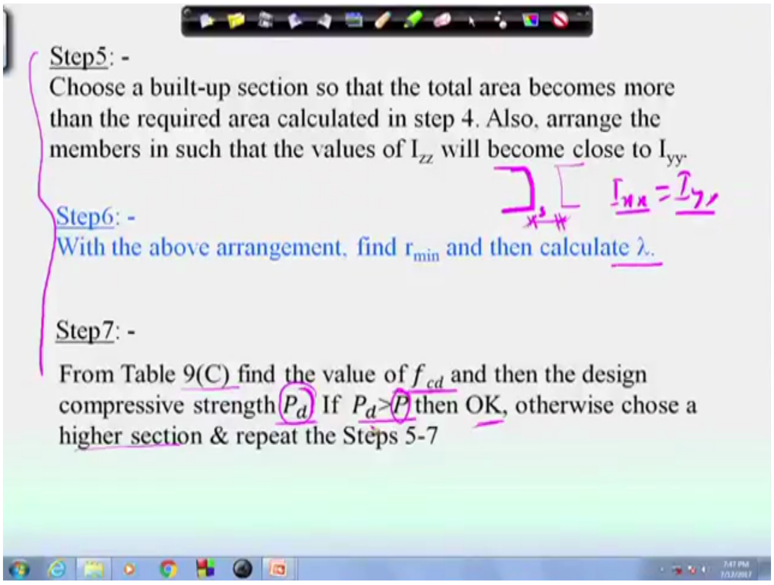

So once we get the area of the compressive member then we can choose a built-up section as per the requirement it may be channel section back to back, it may be channel section face to face, it may be I section. As per the requirement we have to decide what type of sections we are going to provide and what is the arrangement. So accordingly we will find out the required area means we will find out the area from from that considered section and then we will arrange the section in such a way may be if we use two channel section back to back, then we will arrange the section in such a way that the Ixx or Izz become Iyy, so that we can find out the value of S, S is the spacing between two section.

So here our job is to find out the value of S in such a way that Izz will become Iyy, once this is found we can find out the r minimum value which will be practically more or less equal rzz and ryy. So from the minimum value of r the radius of gyration we can calculate the lambda the slenderness ratio that is le by r.

So from the slenderness ratio again we can go back to table 9C and we can find out the value of fcd corresponding to particular lambda and grade of steel, right. So once we get fcd value we can find out the design compressive strength Pd which is Ae by Ae into fcd. So design compressive strength we can find out and if we see the design compressive strength is more than the axial compressive strength acting externally then it is okay, otherwise we can go for a higher section and we can repeat from step 5 to step 7.

That means if we see the design strength is less than the actual load then we have to go for next higher section and we have to repeat the steps so that we get Pd as greater than P and then we can stop. So this is how we can find out the section size of the member and then we can find out the distribution of the means the arrangement of the section that what what will be the spacing between two members, this is what in the built-up section we do after that we have to design the lacing system or batten system as we provide because lacing system or batten system along the length we provide to tie the members the compression members in a proper way so that the members become discompression member the built-up members become parallel to each other, it has equidistance throughout its length and the force coming into the member become means even way means evenly distributed, so this is what we will do.

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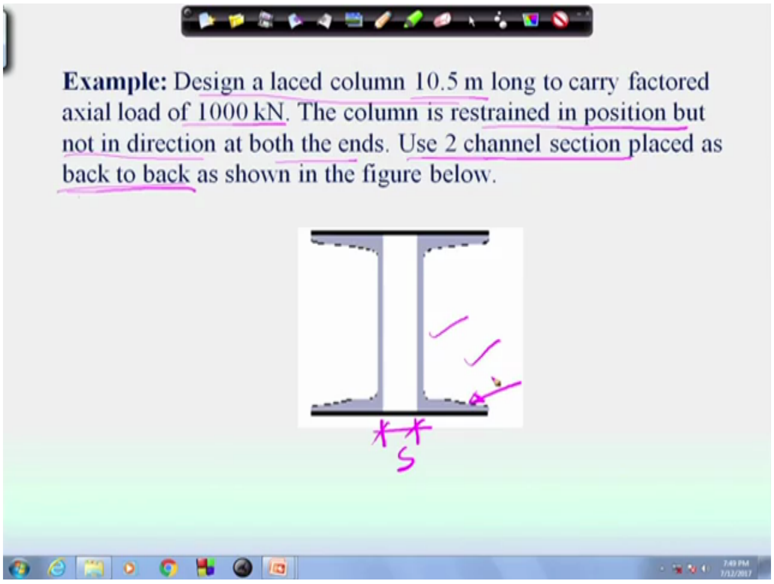

Now we will go through one example through which we will be able to understand how to design a built up section. Say for example in this case we have to design a column laced column of 10.5 meter long to carry a factored load of 1000 kilonewton. The column is restrained in position but not in direction at both ends. Now it has been told that use 2 channel sections because we have lot of options we can use I section, we can use angle section and also it has been told that use 2 channel section placed back to back we may unless it is told we may use also face to face, or other way we can use. So these are the constraint has been given that we have to use channel section and back to back.

So what we need to do here is we have to find out what is the section size of the channel and what will be the distance between these 2 channel section that is S, spacing between these 2 channel section this is what we have to find out at the moment after that lacing design we will do later. So so to do this what we will do as per the steps we can first find out what is the effective length and then what will be the what is the approximate area as per the requirement of the lambda, so this this is what we will try to find out.

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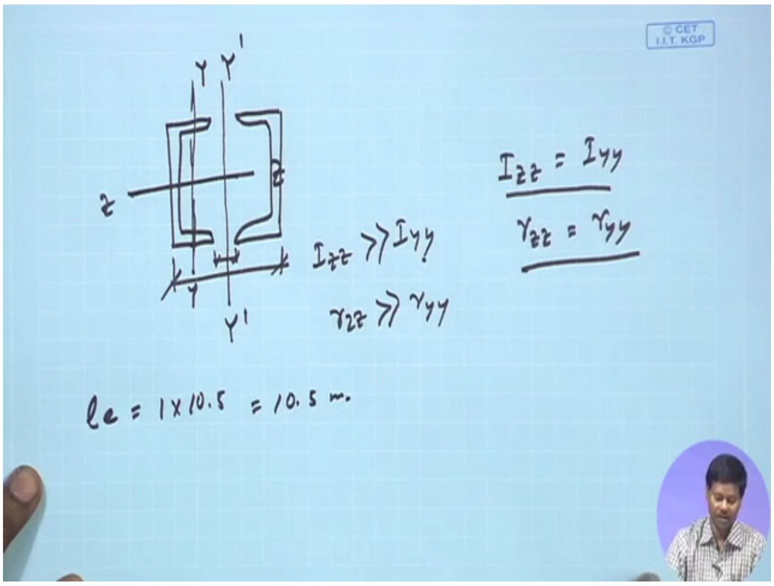

So first from the given problem we can find we know that the le the effective length is 1 into 10.5 that is 10.5 meter, right.

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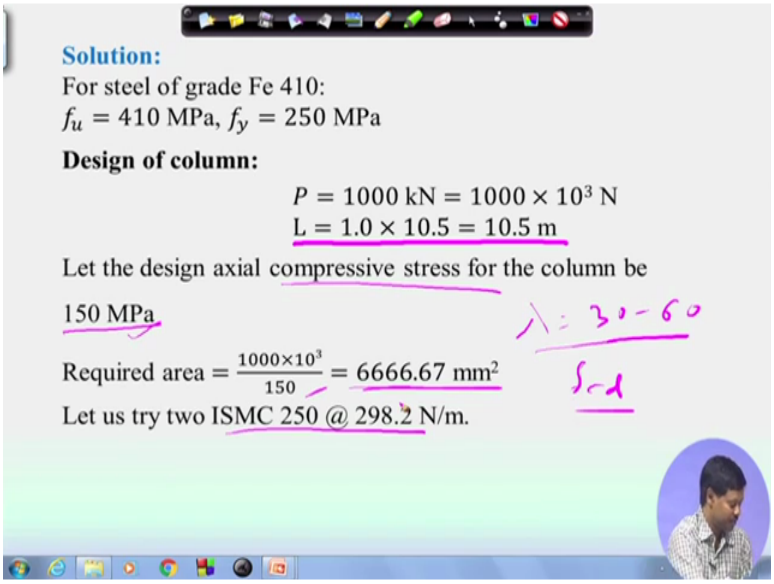

So that can be shown here that that effective length we can find out as 1 into 10.5 that is 10.5 meter and we can consider either some lambda as say 30 to 50 or 60 or directly we can consider some compressive stress design axial compressive stress that also we can assume. In steps I have shown that we can assume some lambda value and then we can find out the fcd value but directly also we can assume some fcd value and we can find out the required area. So if we assume some fcd value so for example in this case 150 MPa, then required area A will be 1000 kilonewton divide by 150 that will be this 6666.67 millimetre square. So to accommodate this area we need to provide ISMC 250 to ISMC 250.

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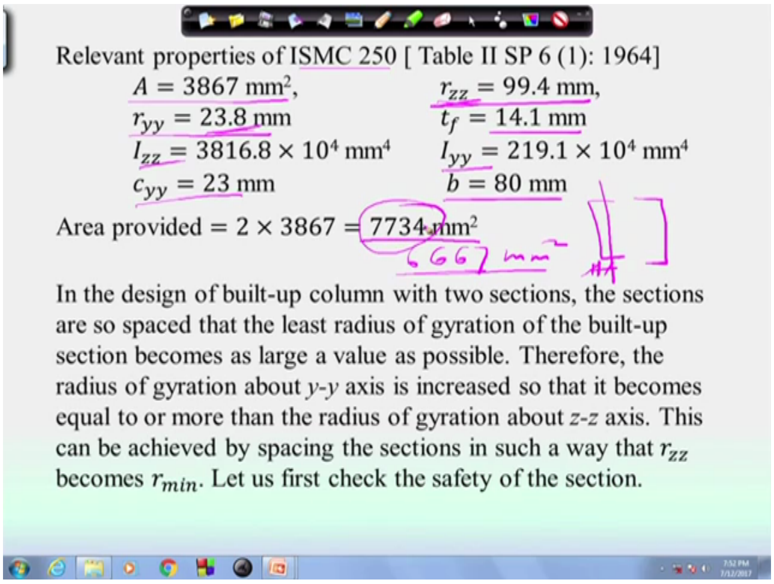

So if we provide 2 ISMC 250, let us see what will be the combined area and its properties. So if we see that relevant properties are given here that one is the for ISMC 250 area is 3867 millimetre square, ry is 23.8 and rz is 99, so here you see rz is much greater than ry. So if we use a single section single section then it will buckle about weaker axis that is y-y axis. So to resist that we use 2 section, right.

Now thickness of flange of this channel is 14.1 which will be required for calculation, then Izz and Iyy is also given in SP: 6 from which it has been taken, then Cyy is (23 point) 23 millimetre Cyy means the Cg distance and b the width of flange is 80 mm. So area provided will be 7734 millimetre square, we need 6667 millimetre square means as per the assumptions we can try with this, so we are trying little higher of this section and that is 7734.

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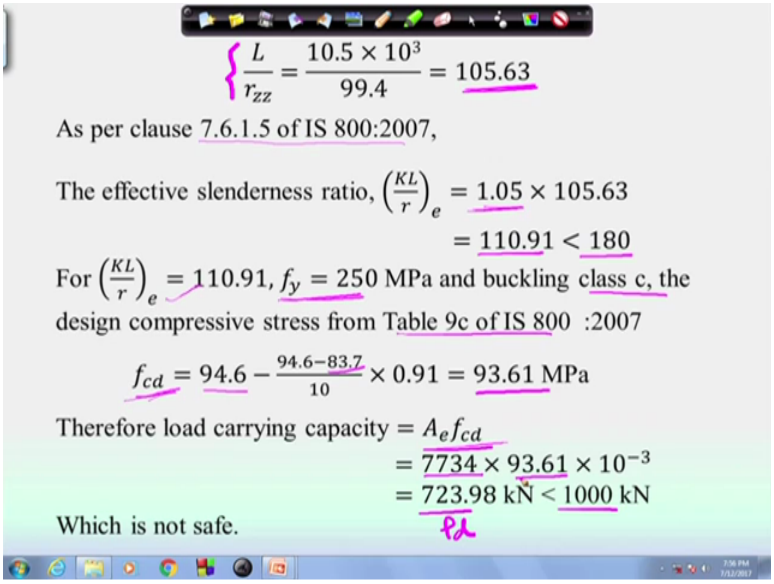

Now if we try to calculate the slenderness ratio then we can see that L by rz will be this one.

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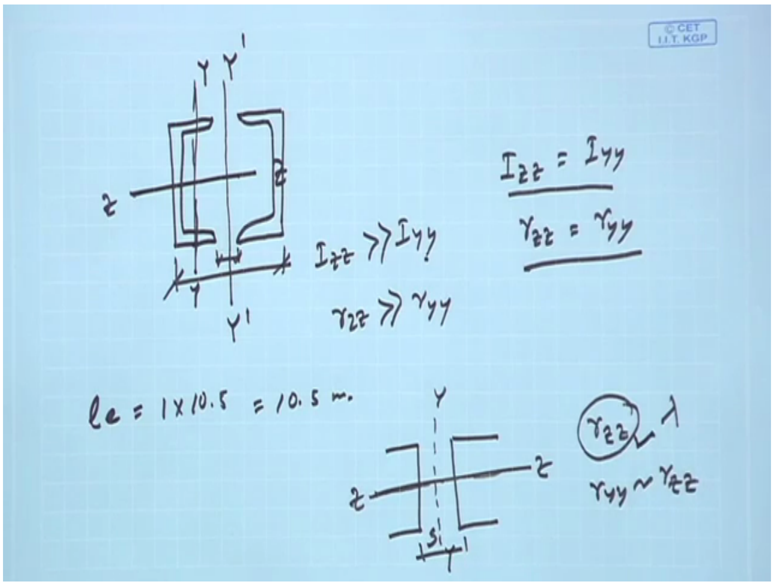

Why we are calculating L because rz, if we see when 2 channel sections are placed say back to back, then this rz will not increase rz will be rzz will be constant this cannot be increased that will be same. But we can increase the ry, ry will be increased ry was quite less which can be increased for the combined section upto rzz, so ry will be means assuming that the spacing of these 2 sections will be such that ryy will become rzz and as we cannot increase the value of rzz for this particular section by the change of S, so we first calculate the rzz value and then slenderness ratio value and then we will find out the design compressive stress.

So as per clause 7.6.1.5 if lacing member is used then its slenderness ratio is increase by 5 percent, so if we increase by 5 percent then slenderness ratio is coming 110 which is less than 180 so this is okay means from slenderness ratio point of view the member is fine. Then what we can do for for this slenderness ratio and for a particular grade of steel for this case this is fy is equal to 250 MPa and buckling class c, as it is built up section we can find out the value of fcd, fcd value we can find out from table 9C and in table 9C for 110 the fcd value is 94.6 and for 120 fcd value was 83.7. So by interpolation we can find out the fcd value for 110.91 which is coming 93.61.

Therefore the load carrying capacity we can find out which will be the area of the combined section into fcd value which is coming 723.98 kilonewton and this is less than 1000 kilonewton that means it is not safe because the design strength Pd we are getting this value and the axial compressive compressive force coming on the column is 1000 kilonewton, so the section whatever we have chosen is not safe. So what we need to do, we have to try with other section other section means the next higher section we can try.

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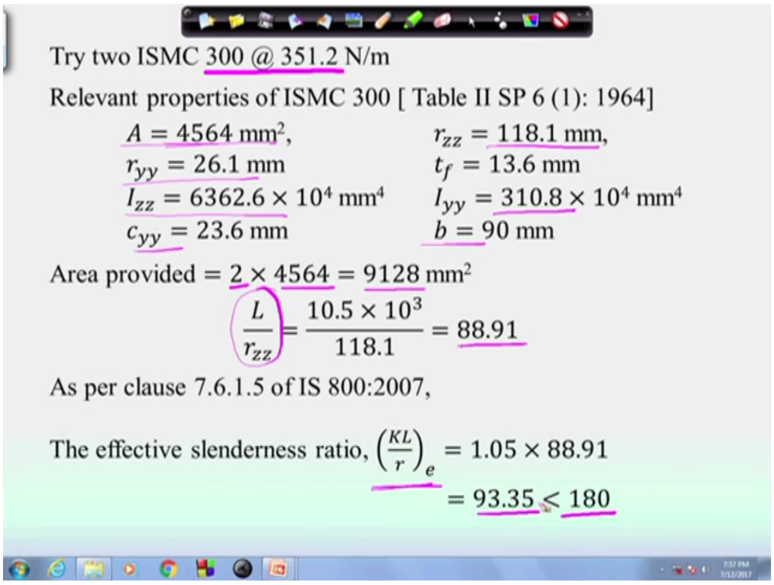

So next higher section is ISMC 300, so if we choose ISMC 300 then we can see the relevant properties of the section as the cross-sectional area of individual section is this, ryy is this, rzz is this, remember that rzz is increasing from the earlier one also A is increasing, so load carrying capacity will definitely increase. Then Izz is this, Iyy is this and Cyy, b from table 2 of SP: 6 we can found as this.

Now area of the combined section will become 2 into the area of individual section which will become 9128 millimetre square. So the slenderness ratio of the section will become L by rzz, that is becoming 88.91, right. So slenderness ratio is coming 88.91 and the effective slenderness ratio will be 5 percent more than the original one, so that is becoming 93.35 and this is less than 180, so from slenderness ratio point of view the section chosen is okay, right. So the effective slenderness ratio we could find.

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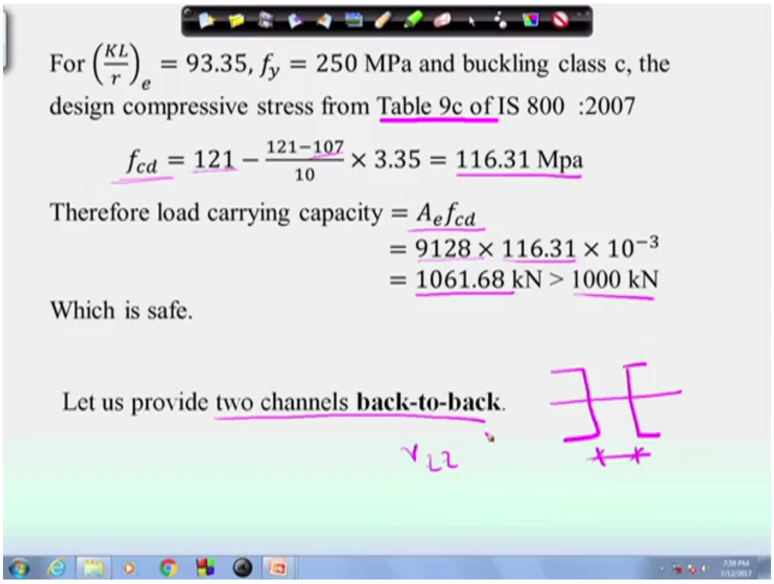

Now once we find the effective slenderness ratio we can find out the fcd value, that is found from IS: 800-2007 of table 9c table 9c is for buckling class c and for fy is equal to 250 the fcd value is given as 121, for lambda is equal to 90 and 107 for lambda is equal to (10) 100, so by interpolation we can find out fcd value as 116.31 MPa, right.

Now the load carrying capacity we can find out load carrying capacity will be the area of the section combined section into fcd value. So if we put those value the area of cross section of the combined section into the design compressive stress 116.31, then we can find out the load as 1061.68 kilonewton which is more than 1000 kilonewton, so the section whatever we have chosen is okay, right. So we can provide two channels section back to back and channel section will be the section whatever we have chosen that ISMC 300, right.

Now next question is that what will be the spacing what will be the spacing of these two channel, so as I told the spacing will be decided on the basis of the equal strength from each direction. Now as we have seen that Ixx or Izz cannot be increased that means rzz cannot be increased, so maximum strength can be achieved with respect to rzz maximum strength can be achieved with respect to rzz.

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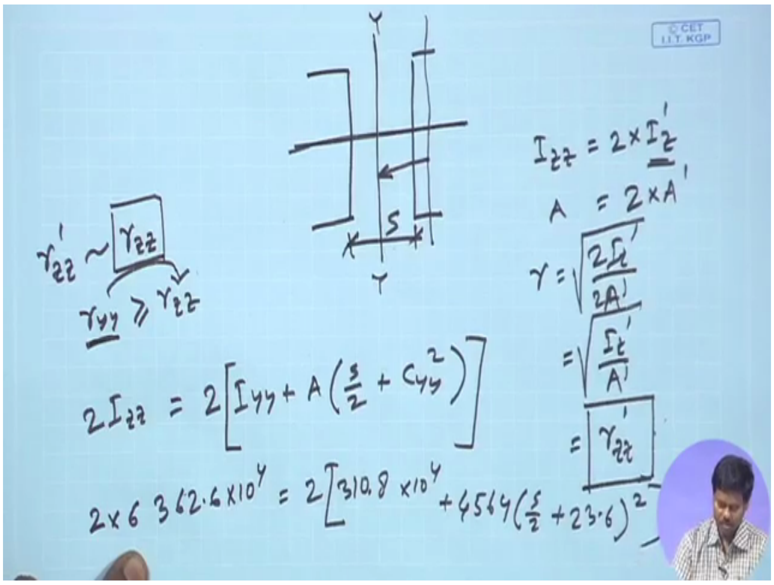

So coming to this if we see here that if we have two section, now here Izz will be say 2 into Iz individual Iz and A combined A will be 2 into A dash, right. So r will be the combined r will be basically 2Iz dash by 2A dash because I by r, so this is becoming Iz dash by A dash which is the rzz dash, this is the radius of gyration of the individual section. That means the radius of gyration of the individual section if it is r dash zz then this will become rzz the radius of gyration of the combined section as well, right.

So there is no scope of increasing the value of rzz that means maximum strength can be achieved with this radius of gyration. Now what will be the radius of gyration of Iyy means about y-y that we have to find out, right.

Now radius of gyration about y-y will be we will make we will make in such a way that it will be more than or equal to rzz that means the the weaker section which was y-y about y-y that can be increased by the use of particular spacing and ryy can be increased upto rzz. So ryy varies and it can be increased by the increase of spacing and that is so what will be the spacing, so spacing we can find out if we make equal Iyy of the combined section and Izz of the combined section as equal.

So Izz of the combined section will be 2Izz, right and Iyy of the combined section will be Iyy plus A into if this is S, then S by 2 plus Cyy square, right because Iyy we could find out from this and we are transferring to this Ar square. So from this if we put the value we can find out the value of S by putting the value Izz as 6362.6 into 10 to the power 4 and Iyy value is 310.8 into 10 to the power 4 plus Ar square 4564 into S by 2 plus 23.6, this is the Cg distance.

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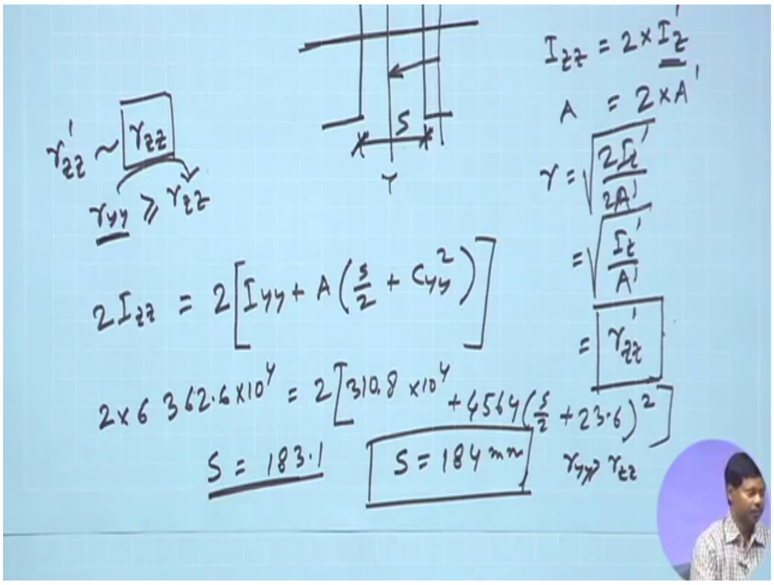

So from this I can find out value of S as 183.1 that means if I put S the spacing between two section as 183.1 then equal strength can be achieved. So we can provide say S is equal to little higher say 184 that means ryy be little higher than rz, right. So the spacing between these two members should become 184.

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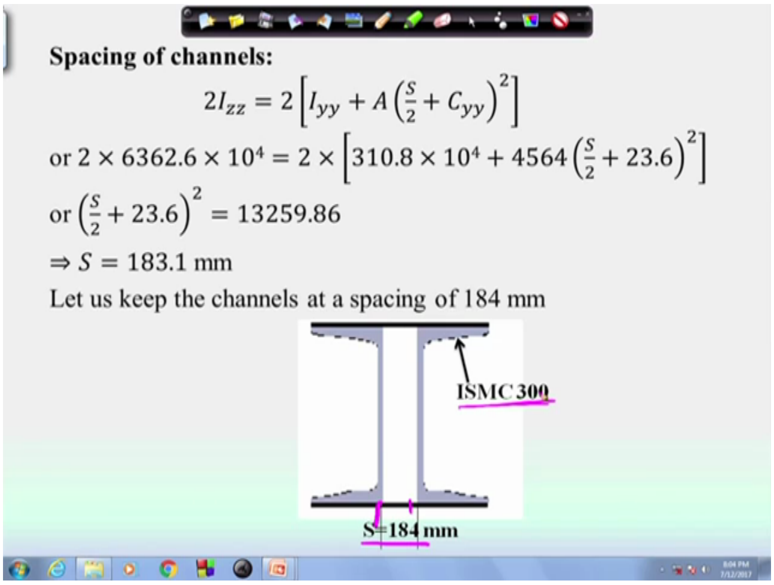

This is what we have calculated in this slide, so the spacing between these two member will become 184 and ISMC 300 section will be used. So in todays lecture what we could see is that the design steps design procedure of built up section and a work out example has been done to demonstrate the procedure for designing a built up section. In this example we have restricted upto the calculation of the section size that means what will be the section size and its spacing spacing between two section, right upto this we have discussed today. Next day we will discuss about the lacing member, thank you.