Course on Design of Steel Structures
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Lecture 55
Module 11
Design of Purlins

This lecture will cover a workout example on design of purlin, in last lecture we have discussed about the design procedure of purlin members for both channel sections and angle sections, channel or I sections and angle sections. So here we will go through one example and we will try to understand how to design a member using channel section sorry using I sections because because of shortage of time we will not go through channel section we will have to do lot of calculation for that, so if we understand the design calculation of I section we can similarly find out for channel section. So using an example of I sections we will try to demonstrate the example.

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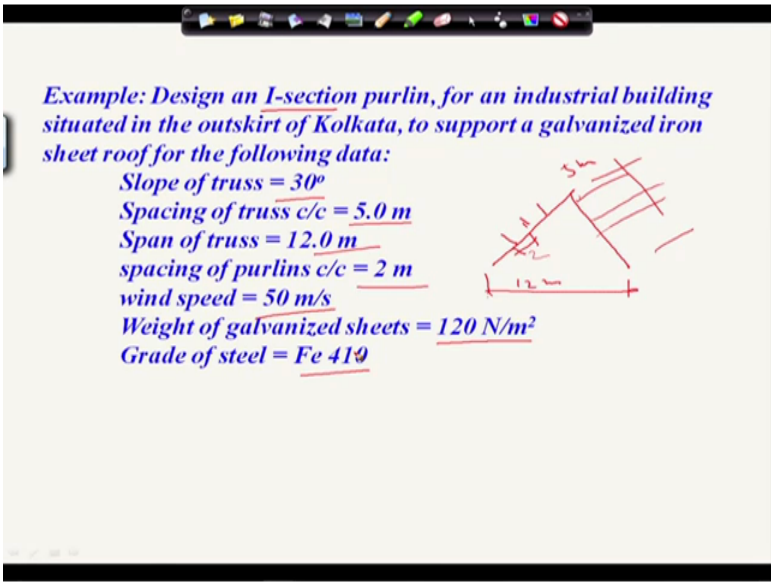

Now here example is like this that we need to design an I section purlin for industrial building situated in the outskirt of Kolkata to support galvanized iron sheet roof for the following data. So datas are given like slope of the truss is 30 degree, spacing of the truss is 5 meter that means the length of the purlin is 5 meter, span of the truss is 12 meter and spacing of purlin is 2 meter that means if we draw so we are using purlin in some places, right so this will be 2 meter, right this is 2 meter and span of truss is 12 meter, right.

And in this direction the purlin if we see in this direction these purlins are length are 5 meter. Wind speed in Kolkata we can assume as 50 meter per second and weight of galvanized sheet is given as 120 newton per meter square and grade of steel as Fe 410. So with this data we need to design a I section purlin.

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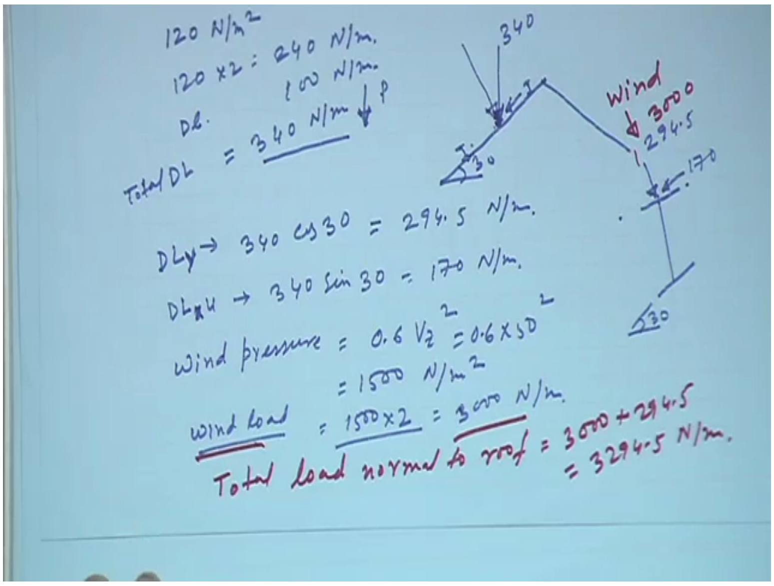

So considering this data let us try with the design of the purlin section say for Fe 410 grade of steel fy we know that is 250 by 250 MPa and weight of galvanized corrugated iron sheet was 120 newton per meter square 120 newton per meter square the weight that means if we have spacing of purlin is 2 meter then the weight per meter length will be 120 into 2 so 240 newton per meter, okay.

Also we can assume some dead load of the purlin say 100 newton per meter, okay. So total dead load total dead load we can consider as 340 newton per meter and that is acting vertically downward, okay which is P dash P, right. So total dead load acting vertically downward is 340 newton per meter and it has two components if we consider the truss member as like this so purlins are provided in different places say we have provided here, provided here like this, right so load is total dead load is 340, right.

So it has one component perpendicular to the roof, another component parallel to the roof, right. So dead load perpendicular to the roof we can calculate dead load perpendicular to the roof will be 340 cos 30 cos theta because angle is 30 degree this is 30 degree slope is 30 degree. So this will become 294.5 newton per meter and similarly so this is dead load normal to the roof say y and dead load (normal) parallel to the roof say x or I should say not y because normal to the roof means say v and this is u so that will be 340 sin theta, this is becoming 170 newton per meter.

So if we have an I section with an angle of 30 degree is placed then we have a load in this direction and we have a load in this direction, right. So in this direction is 170 and in this direction it is 294.5 this is due to dead load and also wind load is acting and as the wind speed is 50 meter, so we can find out wind pressure wind pressure will be calculated as 0.6 Vz square so this will be 0.6 into 50 square, this is becoming 1500 newton per meter square, right. So wind load will become means per meter wind load will become 1500 into 2, so that will be because 2 meter center to center distance it was so 3000 newton per meter, right.

So and it has been assumed that the wind is flowing perpendicular to the roof so wind is acting perpendicular to the roof also wind is acting perpendicular to the roof, right so this wind load is also will act on this direction that is 300 newton per meter. So factored means total load will be how much total load total load on purlin normal to roof normal to roof one is parallel to roof, another is normal to roof that will be 3000 plus 294.5, so this will become 3294.5 newton per meter, right so this is what the load will be.

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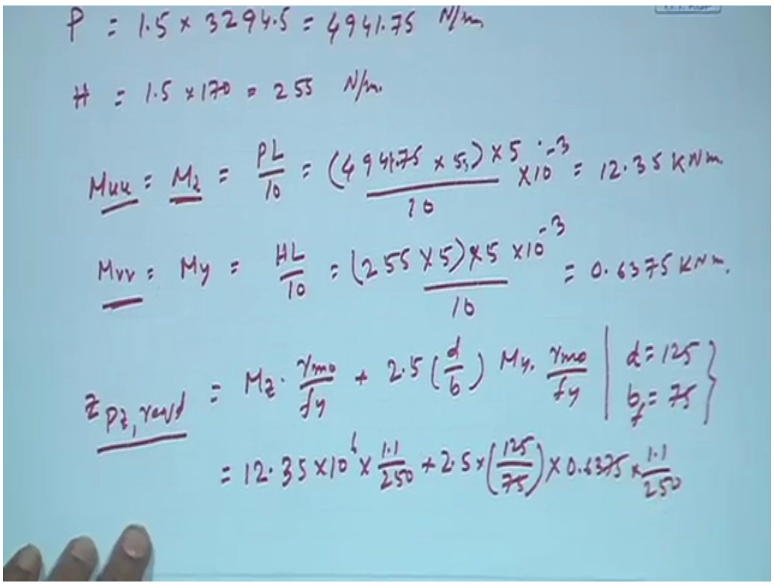

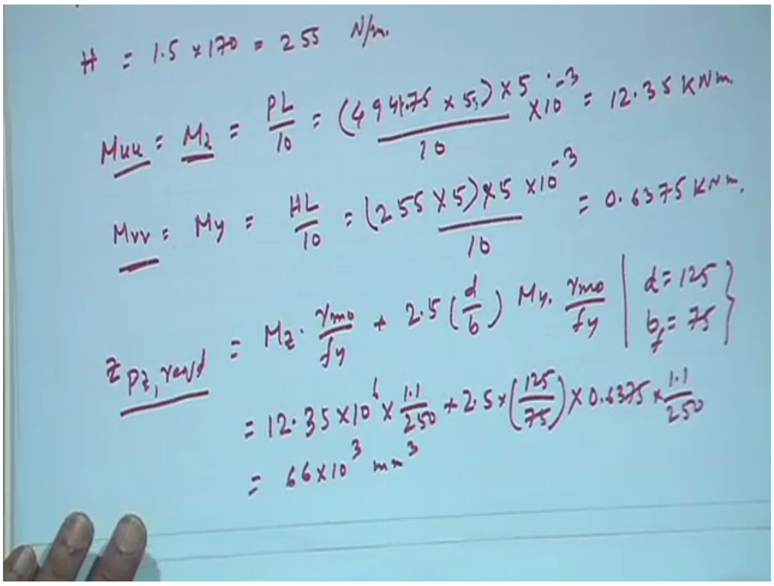

So we can now find out the factored load normal to the roof say P as 1.5 into 3294.5, this will become 4941.75 newton per meter. Similarly factor load parallel to roof that will be denoted as H it will be 1.5 into 170 so 255 newton per meter, okay. So from this I can find out maximum bending moment, right so maximum bending moment say Muu or Mz we can say either we can say Mz or in this purlin axis we can say Muu that will be PL by 10 that means 4941.75 into 5 that is P total load into L because length is 5 meter by 10, this is meter and newton newton means if we make it kilonewton then I can find 12.35 kilonewton meter, right.

Similarly Mvv we can find out Mvv will be we can say also My, HL by 10 so H was 255 into 5 total horizontal load into into we can consider 5 into 10 to the power minus 3 by 10, okay. So this will be 0.6375 kilonewton meter okay. So Muu and Mvv we obtained. Now we have to find out a approximate section that we can find out from the Gaylord equation that is Zpz required that we know Mz into gamma m0 by fy plus 2.5 d by b into My into gamma m0 by fy, okay.

Now to calculate Zpz required all the values of this parameters are known except d by b so here we can assume certain depth say we assume d is equal to 125 and b as width of flange as 75, so with this assumptions we can find out the value. So if we put the values Mz as 12.35 kilonewton meter means we can make it newton millimetre with multiplication of 10 to the power 6 into 1.1 by (10) 250 plus 2.5 into 125 by 75 this is absolutely approximate one, My we have 0.6375 into 1.1 by 250, so this is how the Zpz required can be found as 66 into 10 cube millimetre cube, okay.

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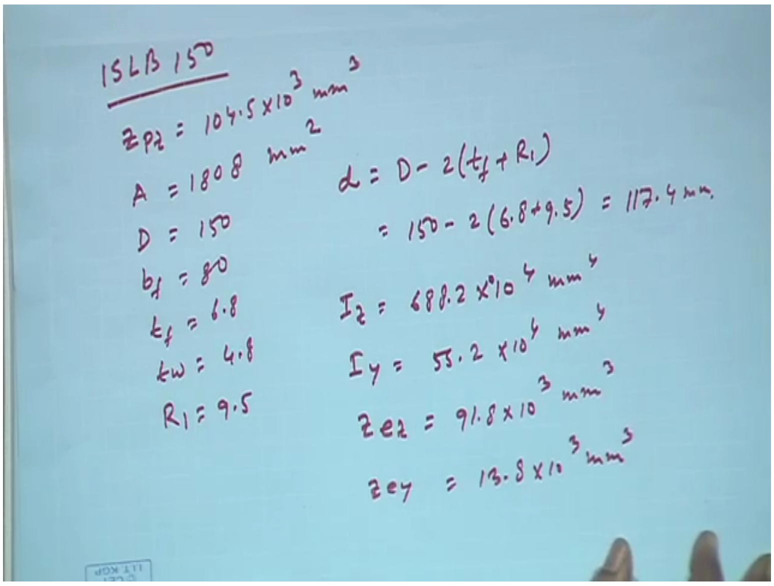

So on the basis of this approximate plastic section modulus we can choose a section. So if we choose a section of ISLB 150 from the SP 6 we can choose a section in which the section modulus is more than the required one. So plastic section modulus of this ISLB 150 is 104.5 into 10 cube and we need to have 66 into 10 cube millimetre cube, right. And from SP 6 we can find out the cross-sectional area as 1808 which will be required. So this data we can find out like depth is 150, width of flange is 80, thickness of flange is 6.8, thickness of web is 4.8 and root radius R1 is 9.5, right.

Also we can find out the value of d effective depth that is we know d minus 2 into tf plus R1, so if we put this value we can find out the value of effective depth as 117.4 millimetre, right. Now we can find out also we can find out the value of Iz as 688.2 into 10 to the power 4 millimetre to the power 4 from the SP 6. Similarly Iy as 55.2 into 10 to the power 4 millimetre to the 4 and Zez the elastic section modulus is equal to 91.8 into 10 cube millimetre cube and Zey 13.8 into 10 cube millimetre cube, right. So we have all these data for ISLB 150.

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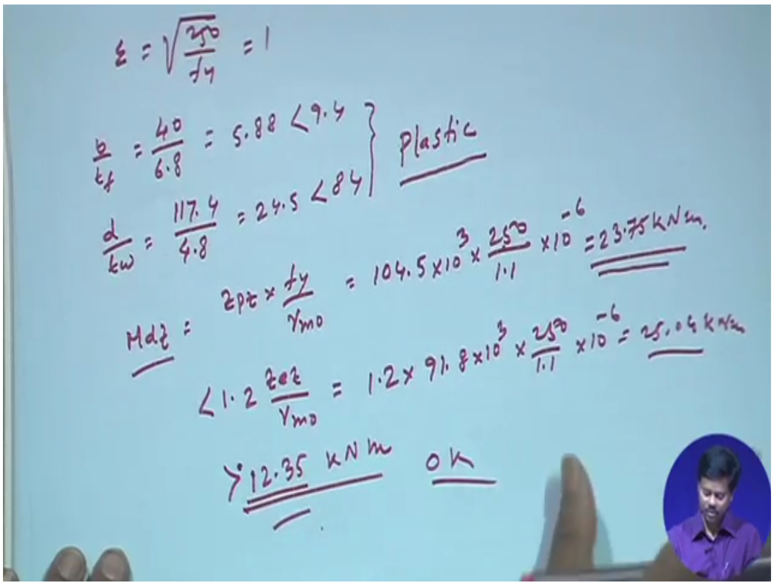

Now we need to know the section type so to classify the section we need to know b by tf ratio and d by tw and also epsilon we know that is 250 by fy so here it will be 1 and b by tf will be b was bf was 80 so b will be 80 by 2 that is 40 and tf was given as 6.8 so it is 5.88 less than 9.4 and d by tw d we have considered as 117.4 while tw is 4.8 so 24.5 and less than 84. So from this we can say that the section is plastic, right. So section is classified as plastic.

Now we have to check for bending strength, so bending strength we can calculate that is Mdz as Zpz into fy by gamma m0 Zpz value was taken as 104.5 into 10 cube into fy is 250 by gamma m0 is 1.1 and to make it kilonewton meter we can multiply as 10 to the power minus 6, so this is becoming 23.75 kilonewton meter, right and it should be less than as we know 1.2 Zez by gamma m0. So that if we calculate we can see that is 1.2 into 91.8 into 10 cube into 250 by 1.1 is equal to 25.04 kilonewton, okay. So Mdz value is coming this which should be less than this so it is okay.

Maximum moment Mz was 12.35, so it is okay. So the design bending strength Mdz was calculated as 23.75 kilonewton meter and the bending moment about z-z axis is coming 12.35 kilonewton which is less than the design bending strength so it is okay, if it is not okay then we need to increase the section size, right.

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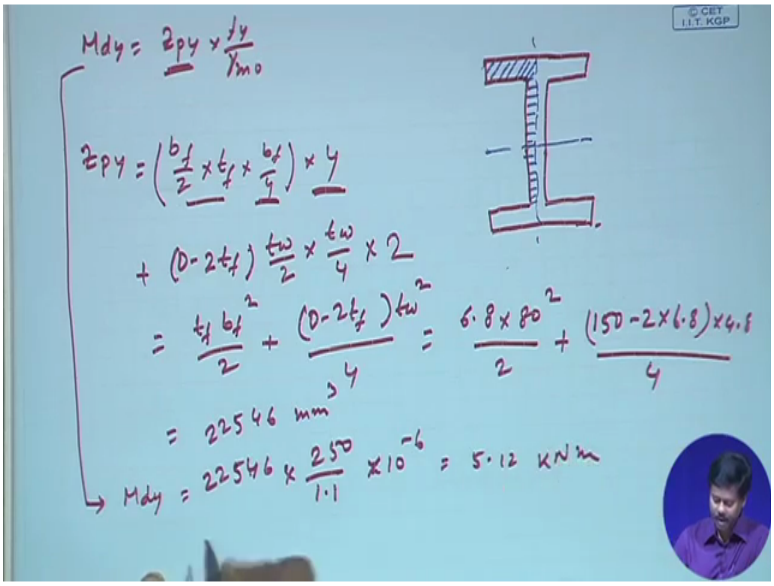

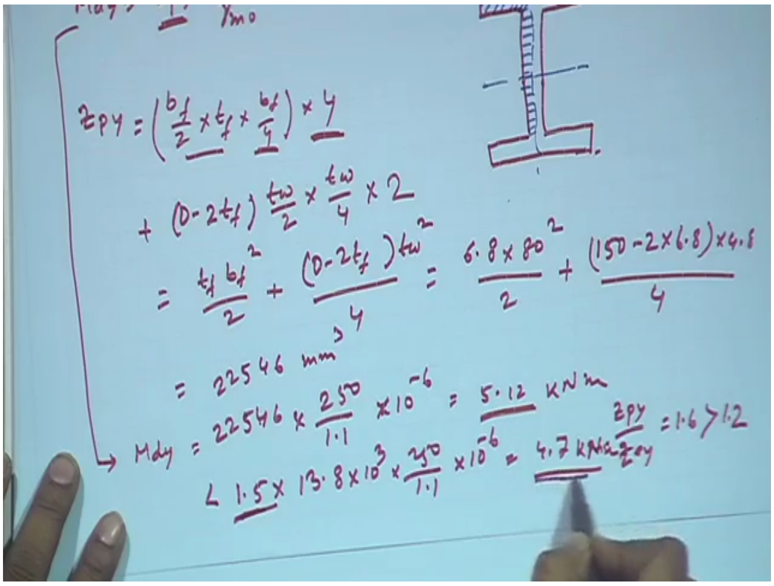

So next will calculate the Mdy value, right to calculate Mdy value we need to know say Mdy is equal to Zpy into fy by gamma m0. So we need to know the value of Zpy, right. So Zpy we can calculate from the formula the Zpy is the section modulus along y-y, so Zpy we know for a I section we can calculate the Zpy value in this way that is the cg will pass through middle of the section so here we will calculate this portion into 4 that means that will be Zpy is equal to bf by 2 into tf into bf by 4 into 4, right. So area into cg distance area is this and cg distance is bf by 4 into 4 plus D minus 2tf this portion this portion will be this so D minus 2tf into tw by 2 into cg distance that will be tw by 4 into 2 side so into 2.

So finally it will become tf into bf square by 2 plus D minus 2tf into tw square by 4 and if we put the values of these parameters we can see that (bf) tf is 6.8, bf is 80, then overall depth is

150 and thickness of flange is 6.8 and width of the web is 4.8, right. So this is becoming 22546 millimetre cube. So now we can find out the value of Mdy, right so Mdy will become 22546 that is Zpy into fy by gamma m0 so into 10 to the minus 6, so this is becoming 5.12 kilonewton meter.

And it should be less than 1.2 into Zey into fy by gamma m0, so here 1.2 will be replaced by 1.5 why I am coming so 1.5 into Zez was Zey was 13.8 into 10 cube into fy by gamma m0 into 10 to the power minus 6 is equal to 4.7. Because here we have consider in place of 1.2 we have consider as 1.5 as gamma mf because here Zpy and (Zez) Zey ratio is greater than it is 1.6 which is greater than 1.2. So if Zpy, Zey ratio is greater than 1.2 we know that the gamma mf value will be consider in place of 1.2 as 1.5, so the value is coming 4.7. So Mdy value is coming 5.12 and it has to be less than or equal to 4.7.

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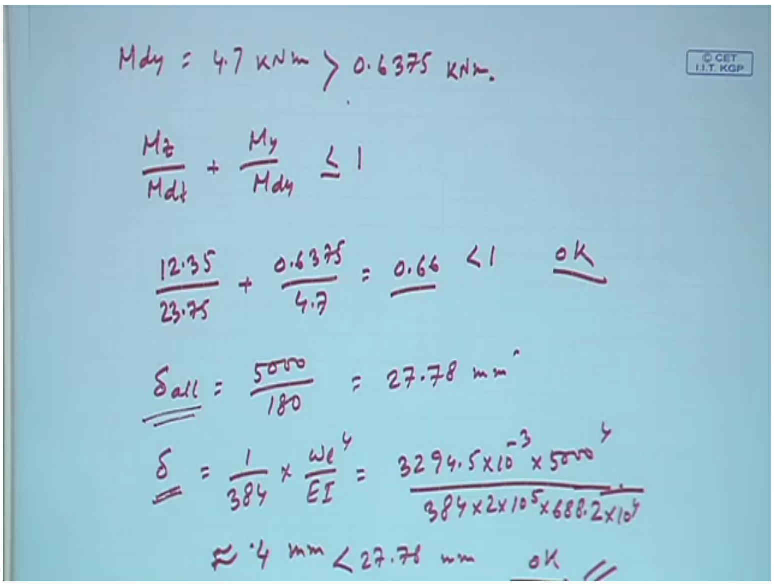

Therefore the Mdy value can be consider as 4.7 kilonewton and it is more than the My value that is 0.6375 kilonewton meter, right so this is also okay, right. Now so so individual moment carrying capacity in both the directions we could find it is satisfying. Now we have to check for overall member strength means local capacity from the interaction formula that Mz by Mdz plus My by Mdy it has to be less than or equal to 1.

So Mz was 12.35 Mdz was 23.75 plus My was 0.6375 by 4.7 so that is becoming 0.66, right and it is less than 1 so okay. So the bending moment point of view the section is okay. So now what we need to do we need to check for deflection, right. So allowable deflection delta we know L by 180, so length was 5000 by 180 is 27.78 millimetre and delta actual is actually

1 by 384 into Wl to the power 4 by EI okay so this is coming as W is 3294.5 remember this W is the service load not the factored load 10 to the power minus 3 into l to the power 4 equal to 5000 to the power 4 by 384 into EI E is 2 into 10 to the power 5, I is 688.2. So this we are calculating 688.2 into 10 to the power 4 sorry right.

So I was so after calculating we can find out value as around 4 millimetre which is less than 27.78 millimetre so okay. Now similarly we have to check against the lateral deflection okay, so deflection in both the directions also we have to check and in other direction deflection is quite less because the load is very less so that will be also okay. So this is how one can design the purlin by checking the deflection and prior to that checking the moment, okay.

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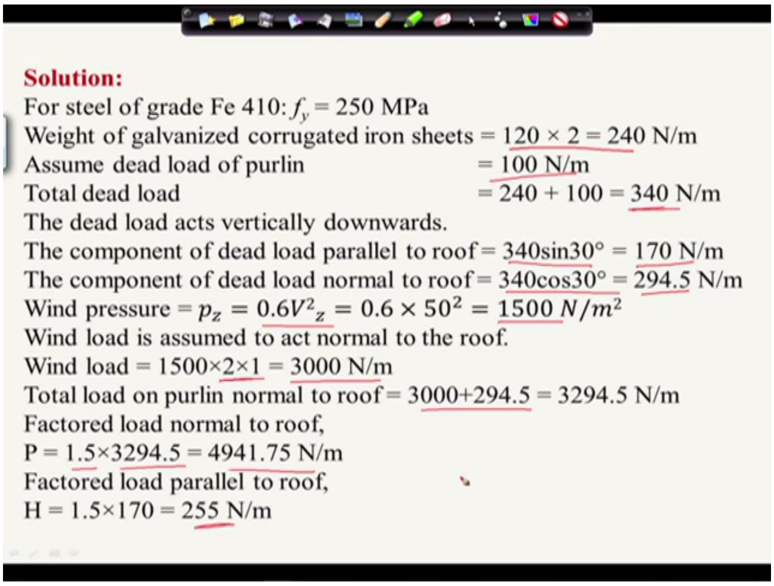

So whatever I have discussed I am going through the PPT to review once again as we have little time. So what we did is this first that is first we have found the weight of galvanized corrugated sheet which was given 120 into spacing 2, we have assumed dead load as 100, so total dead load is becoming 340. Now component of dead load parallel to roof will be 340 into sin 30 so 170 this is parallel to the roof and normal to roof it will be 340 into cos 30 that is this 294.5.

And wind pressure will be calculated as 0.6 Vz square which is becoming 1500 newton per meter square. So the load will be into the influenced area so 3000 newton per meter and the total load on the purlin normal to roof we can calculate as 3294.5 newton per meter, right and factored load normal to roof thus we can calculate as 1.5 into this dead load plus wind load, okay and factored load parallel to roof we can find out this. So once we find out the factored load in both the directions then we can find out the moment.

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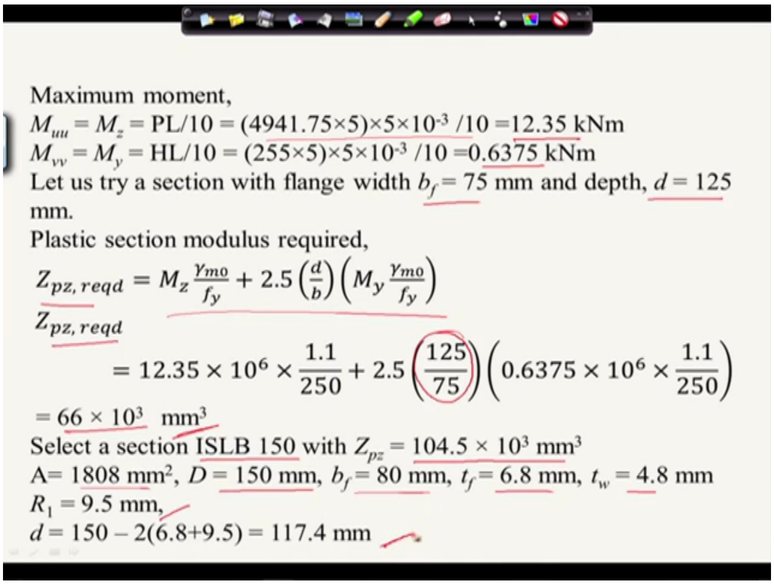

So moment will become Muu as Wl by 10 that is this 12.35 kilonewton meter, similarly Mvv will become 0.6375 kilonewton and now we need to know a approximate plastic section modulus to start with an approximate section so Zpz required we can calculate from this formula which was proposed by the Gaylord Et Al. And according to that we need the Zpz as 66 remember for finding out Zpz required we need to put some assumed value of d by b, so d and b we have assumed as this to calculate the Zpz required.

So once we calculate the Zpz required as 66.10 cube we can select a section and for this we have selected a section of ISLB 150 for which the Zpz value is 104.5 into 10 cube and for this ISLB section the relevant properties are consider from SP 6 like the cross-sectional area, the depth, the width of flange, thickness of flange, width of the web, root radius R1 and we can calculate the effective depth as this 117.4.

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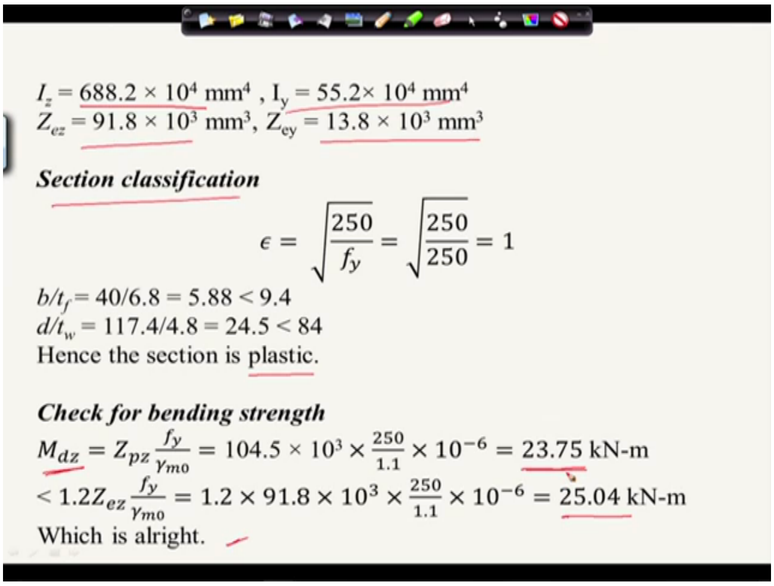

Also we can note down the properties of Iz as this, Iy as this, Zez and Zey and then we can find out the type of section through section classification and we could see that the section is plastic. Then we can find out the Mdz value the design bending strength which is coming 23.75 kilonewton meter and which should be less than the value that is 1.2 Zez into fy by gamma m0. So as this is less so we can say this is okay and the design bending strength is more than the bending moment coming on that direction. So the member section whatever we have chosen is okay.

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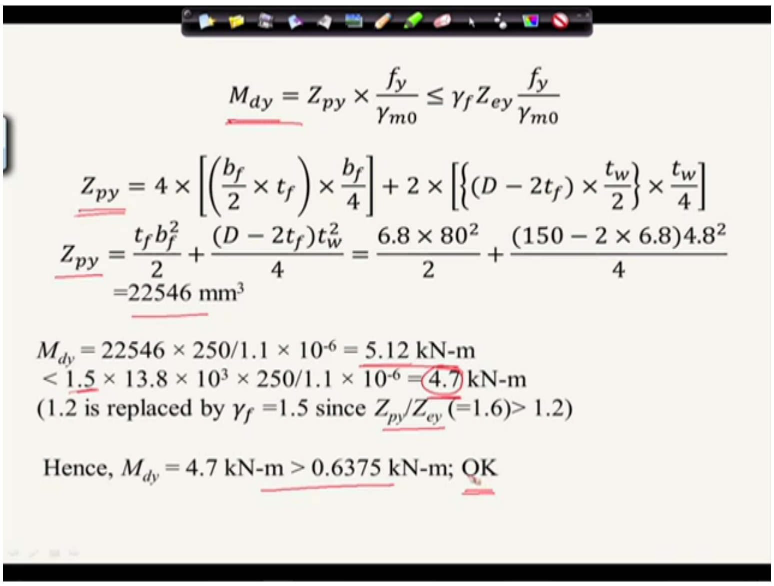

Similarly in other directions also we have calculated the design bending strength Mdy, so to calculate Mdy we need to find out Zpy which is not given in the SP 6 or IS 800, so we need to calculate manually so Zpy we have calculated from this formula how we have derived we have shown while working out. So from that Zpy value was this, so then Mdy value we can find out as this, okay. So Mdy value is should be less than the value that is 1.2 into Ze fy by gamma m0, here 1.2 will be replaced by the gamma f as Zpy by Zey value is more than 1.2.

So with those the Mdy value is coming 4.7 and as it is less than 5.12 so we should consider Mdy value as 4.7 kilonewton meter and it is more than 0.6375 so okay, right. So individually the bending strength in both the directions are fine for the assumed section.

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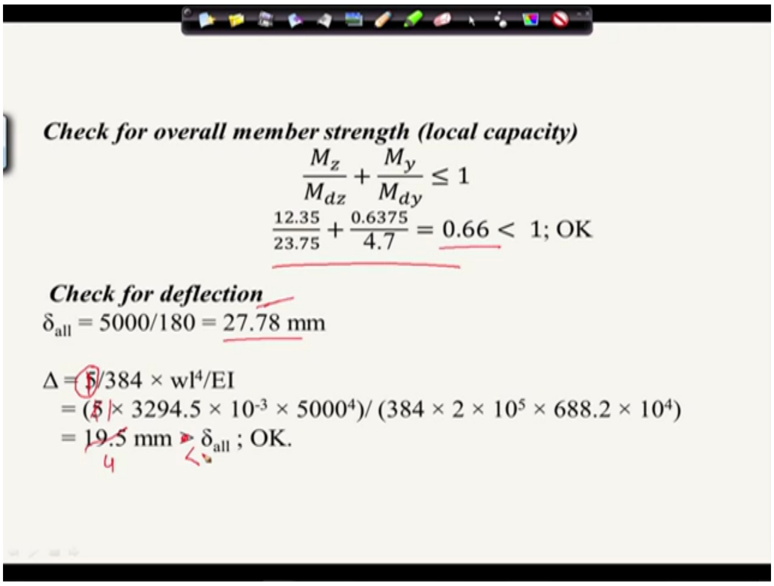

Now we will go for the combined one that through the interaction formula we can see that Mz by Mdz plus My by Mdy is less than 1 because the value is coming 0.66 which is less than 1 so it is okay. Now we will go for deflection check for deflection check allowable deflection is 27.78, now the actual deflection will be 1 by 384 into wl to the power 4 by EI, here we should consider 1 because it is a continuous, right.

So if we consider 1 then the value will be around 4 millimetre and which is which is less than allowable allowable deflection so it is okay, right. So this is how we can find out the section, right. So in todays lecture we could see that how to find out the section of a purlin member while using I section and how to calculate the biaxial bending moment formula means how to check the biaxial bending moment that also we have seen. And first we have seen how to find out the approximate section from the Gaylord formula that also we have noticed. So using this we can design a purlin, right. Next we will discuss about the Gantry Girders because

Gantry Girder is nothing but one type of flexural member. So how to design that Gantry Girder that will be discussed in next class, thank you.