Design of Steel Structures
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Module 9
Lecture No 41
Design of Batten using Bolt Connection

So in last lecture we have discussed the design methodology of Batten system. So in Batten system basically what we need to design is to first find out the spacing between 2 compression members for build-up section and then to find out the spacing between the Batten members. Batten plates will be provided at a certain distance, then this spacing between two Batten members is to be found and then we need to find out the dimensions of Batten member, dimensions of Batten member means the Batten depth, Batten thickness and Batten length, and this depends on in fact, whether we are going for Bolt connection or Welded connection, depending on that we have to find out the Batten dimensions. And once Batten dimension is done, we need to check whether the Batten is capable of carrying that much load or not.

Once that is done, if the Batten is dimensions of the Batten is okay from the strength point of view, then we will go for design of connection. Connection of Batten I mean connection between Batten and the connection member. So connection as I told, connection may be 2 type, one is weld connection and another is Bolt connection, so depending on the type of connection we will try to find out what are the type of forces are developing, what are the type of stresses are developing. In fact, stresses will be basically sheared stress and bending stress will come into picture and we have to find out the combine stress like (())(2:06) stress and then we need to see whether that is save or not. So these are the methodology which we have discussed, now I will go through one example in this lecture and another example after this lecture to see how to find out the Bolt connection detail and Weld connection detail.

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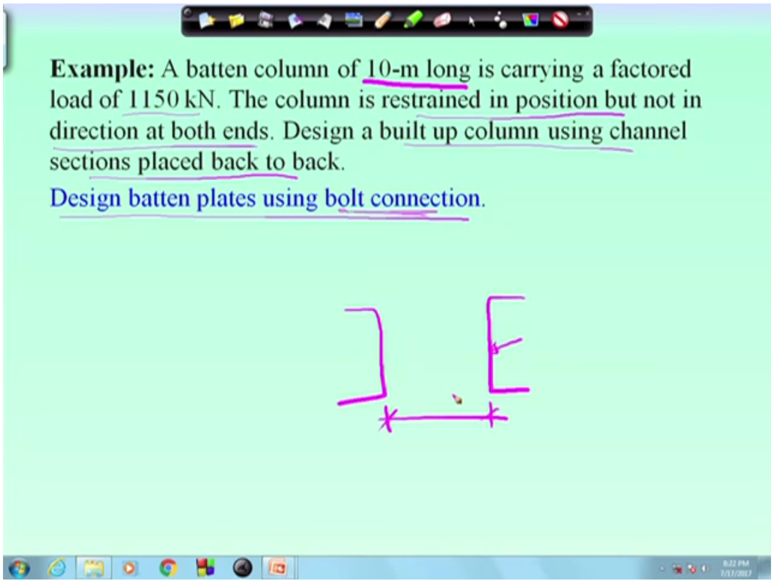

Today we will be discussing about the bolt connection details, so let us go through this example. So here we have to design a column of 10 meter length and which is carrying 1150 kilo Newton and the column is restrained in position, but not in direction at both ends. So restrained condition is given, now design a built-up column using channel sections placed back-to-back and then design Batten plates using bolt connection. So there are 2 parts, one is designing the column that means we have to know it is told that we have to use channel sections back-to-back, so we have to know what is the channel section size and what is the spacing so that the given load can be withstand by the section. So this is first part, we already know how to do it and second part is we have to design the Batten plates using bolt connection.

So first part I will go very quickly and it is known to us, but we have to go through this because we have to know the dimensions of the Batten plates and other things sorry the spacing between 2 members, compression member size, unless we know that we will not be able to find out the dimensions of Batten plates. So to find out the dimensions of the Batten plates we need to know this, so first we will go through the calculation of the Batten plates, column dimensions and its spacing.

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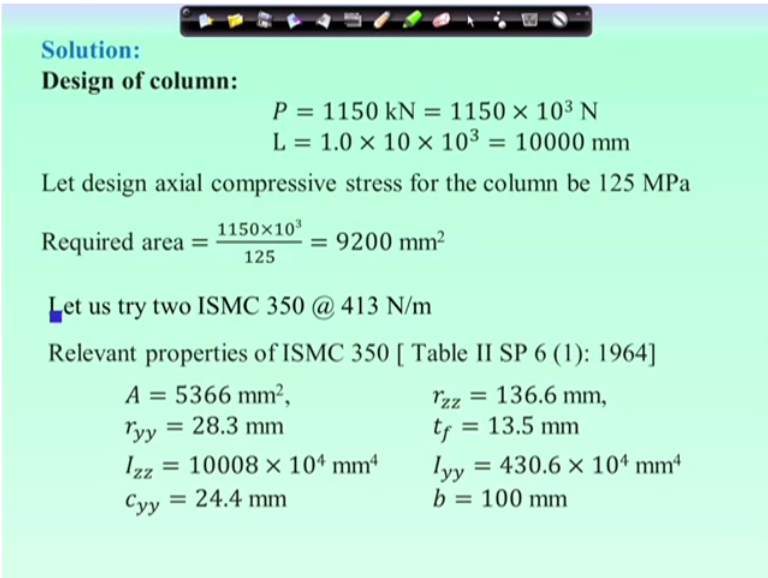

So, if we see that as we know as per the restrained condition the length will be effective length will be simply one into the actual length, so that will be 10,000 millimetres and force is given 1150 Kilo Newton, so I can find out the required area. So from that required area I can choose a particular section at channel section is told, so to fulfil the required area we can choose ISMC 350 and whose dimensions I mean cross-sectional properties are given, so cross-sectional properties of the individual channel sections are given, now we need to find out the cross-sectional properties of the combined section.

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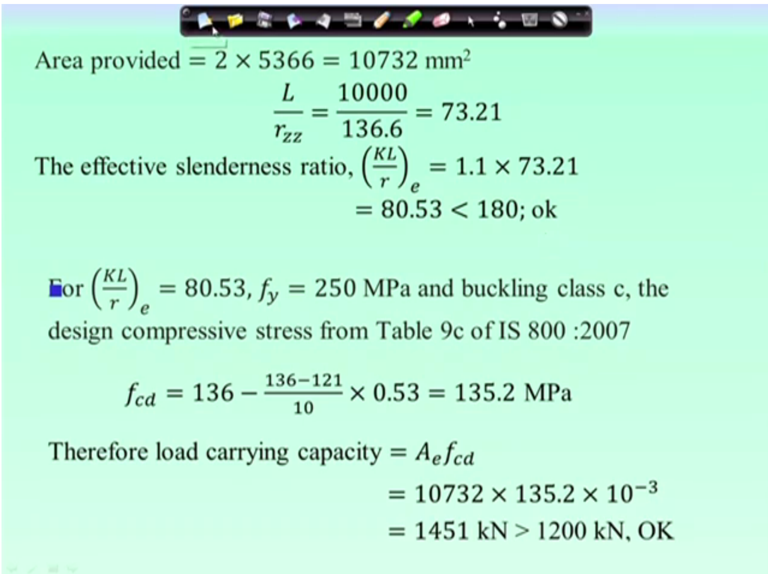

So to find that we will first find out the area of the combined section that is 2 into 5366 millimetres square, then we will find out L by r, L by r zz is this and effective slenderness ratio for Batten system it will be increased by 10 percent, so it will be 80.53, even but for lessing system it is increased by 5 percent and 4 Batten system as per calculation it is increased by 10 percent, so you have multiplied with 1.1, right.

Now effective slenderness ratio is less than 180, so it is okay, now in this effective slenderness ratio and if for if I took it t, we can find out the design compressive stress using buckling class c, from table 9 c we can find out the design compressive strength as 135.2 MPa and then we can find out the load carrying capacity p = A e into f cd, which is coming 1451 kilo Newton which is greater than 1200 kilo Newton, so this is okay. So this is how the load carrying capacity is found that means if I find the load carrying capacity is okay that means the section whatever we have chosen is fine.

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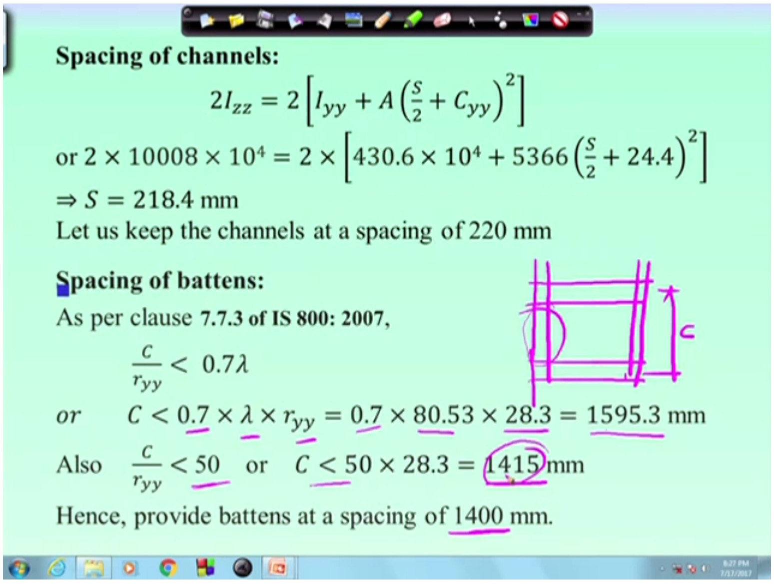

Now we have to find out the spacing of the channels between 2 channel sections, so we know that 2 Izz will become 2 into Iyy + A into s by 2 + Cyy whole square because if you know that this is the 2 channel section. Now this is s, so if I need to find out Iyy about the axis then I have to find out Iyy of this + A r square, I is s by 2 clubs Cyy, right, so equating both I can find out space S 218.4 millimetre, so we can use a spacing of 220 millimetre. So if we use a spacing of 220 millimetres then the required load can be carried in equal direction, about equal direction the same load can be carried. Now we have to find out the spacing of Batten, so in clause 7.7.3 it is told that c by ryy should be less than 0.7 lamb die and should be less than 50. So 0.7 Lambda we know so C, C means the spacing between 2 Battens.

So if we see in the longitudinal direction, so if we have a Batten here and if we have a Batten here then C will be this, spacing between 2 Battens, centre to centre distance between 2 Batten systems. So this we have to find out and C will be find out on the basis of means to restrict the local Batten right, so C can be found from this that C will be less than 0.7 into Lambda into ryy. So 0.7 Lambda value we found earlier that is 80.53 and ryy is 28.3, so C value is coming this. And from c by ryy less than 50 condition, we can find out C as 1415, so C should be lesser of these 2, so at least it has to be less than 1415 so we can provide the Batten spacing as 1400 mm, right so 1400 mm we will provide. Now we will find out the size of the Batten, so for size of the Batten first we have to provide certain bolt diameter.

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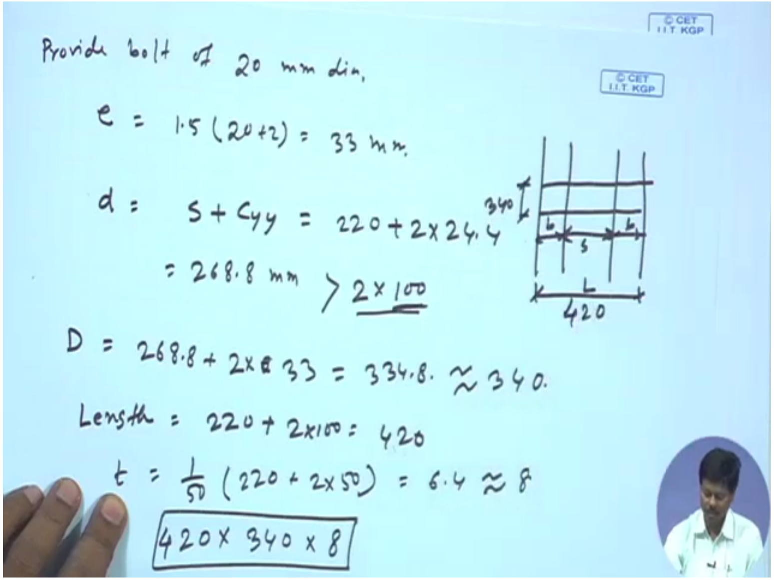

Say let us provide bolt of 20 mm, so edge distance I can find out because edge distance is 1.5 into d 0, d 0 means 20 + 2 so that is coming 33 millimetre. Now effective depth, effective depth I can find out we know as per the (())(10:16) that will be S + Cyy, right, so effective depth will be at least this one that is 220 we got S + 2 into Cyy value is given 24.4, so this is becoming 268.18. And in any case it should be greater than 2 B, 2 B means 2 into 100 that is the flange width, width of the flange. So and this is 200 that means this is okay, so effective depth is okay, so overall depth I can find out, overall depth will be 268.8 + 2 e, 2 e means 33, so I can find out 334.8, right so maybe we can use 340 right. And length of Batten I can find out, length of Batten will be 220 + 2 into 100 nearly 420 because if I consider this Batten, length of Batten will be this much.

So this is S and this is b and this is b, so S + 2 b this is the total length right, so this is giving me 420 millimetre. And thickness of Batten I can find out that is we know one fiftieth inner distance of bolt and that means 220 + 2 into 50, so that is coming 6.4 maybe we can provide 8 mm. Therefore the size of the Batten can be decided as say 420 by 340 by 8 so Batten plate size we found, this is 340 and this is 420, right so this is how we can find out the dimensions of the Batten. Now, this is true for End Batten, this is end Batten because in case of intermediate Batten the effective depth will be little less.

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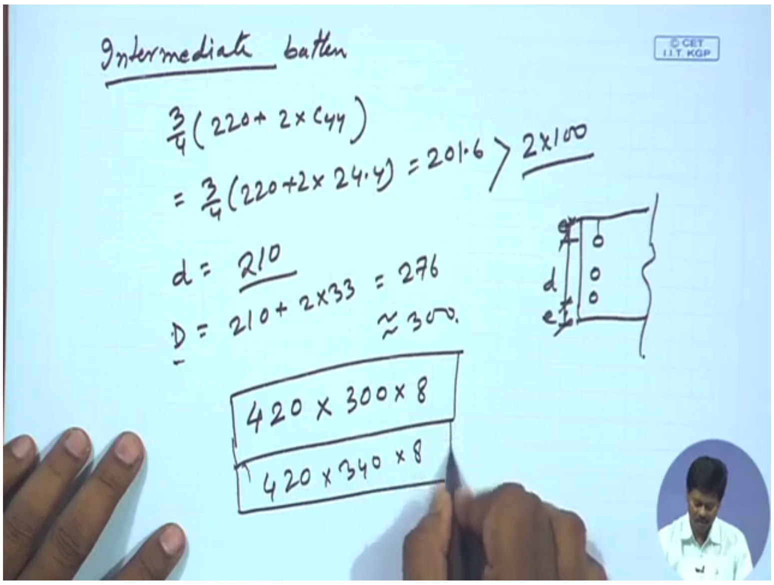

For intermediate Batten as per clause 7.7.2.3 for intermediate Batten, the thickness will be three fourth of that so three fourth of 220 + 2 into Cyy, right. So that will become three fourth of 220 + 2 into Cyy is 24.4 so 201.6 and that is also greater than 2 into 100, just more than 200 right. So we can provide intermediate Batten that say effective depth as say 210 right, so overall depth we can provide 210 + 2 into 33 the edge distance 276 because overall depth will be effective depth this is effective depth d + edge distance this is edge right. So we can find out the overall depth as this, so we can provide overall depth as say 300, right. So we can provide intermediate Batten size as 420 because length will be same by 300 and thickness also will be same 8, so the intermediate Batten size is 420 by 300 by 8, whereas the end Batten size was 420 by 340 by 8, so remember the Batten plate size is different for End Batten and for Intermediate Batten.

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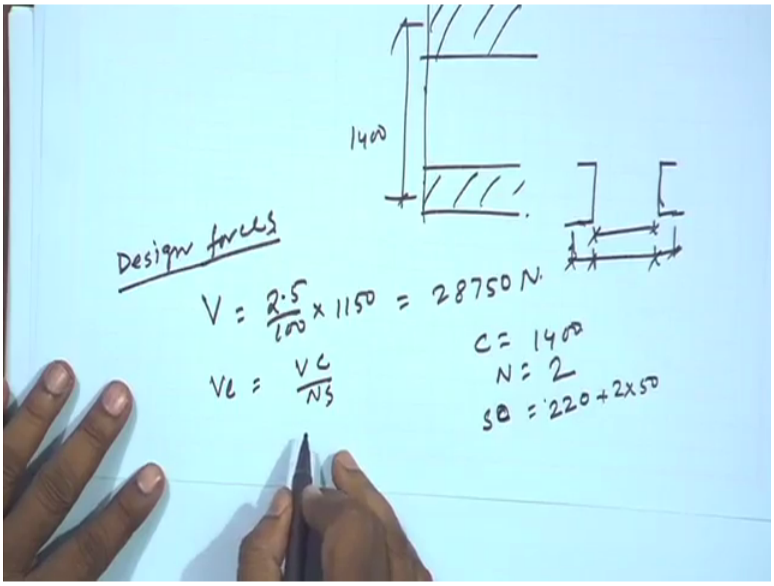

In case of intermediate Batten, pattern size will be three fourth of the end Batten in general. And also we found the spacing, spacing we can provide so Spacing also we found 1400 right 1400 millimetre. So when we are providing Batten, the spacing will be 1400 right, this is Batten, this is one Batten and this is another Batten right. Now we will find out design forces to design the n member means the connection also to see whether the Batten whatever we have provided is sufficient or not.

So design process we will calculate first, so the transverse shear force we know 2.5% of the action Force, action Force is 1150 so this is coming 28750 Newton right. And the longitudinal shear Vl, I can find out, longitudinally shear will be we know V C by N S right, here C is the spacing between two Batten, which is 1400 and N is to 2 number of parallel planes or Batten, so N is 2 and c is the minimum transverse distance between the centred of the bolt roof so many more transverse distance between the centred of the bolt roof, so 220 + 2 into 5 right. If we see here sorry this is S, so as is in this case S we are getting this one; this + this + this right.

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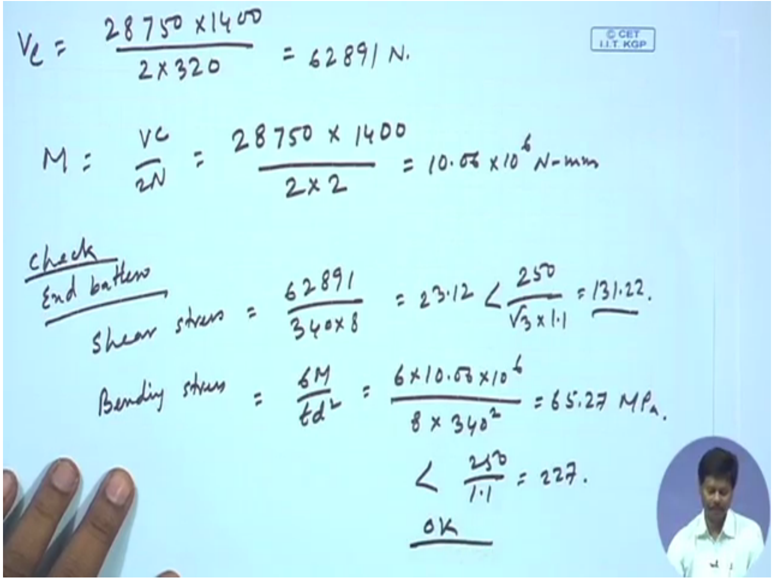

So if I have put this value then Vl can be found as 28750 into 1400 by 2 into 320, so this value will be 62891 Newton. Similarly moment also we can find out that is V C by 2 N, in Batten moment also will be developed so I find out this value , V is 28750 and C is 1400 that is spacing, 2 into N is 2 number of parallel planes or Battens, so this is coming 10.06 into 10 power 6 Newton millimetre. So design forces we get, now we check, check means we will check for N Batten and we will check for intermediate Batten, so for both the cases we will check.

So for N Batten first let us see, for N Batten shear stress I find out shear stress will be 62891 by Area is 340 into 8, so 23.12 and this will be less than 250 by root 3 into 1.1 so that is 131.22 right, so it is okay. Similarly bending stress we can find out, bending stress is we know 6 M by t d square, so 6 M is 10.06 into 10 to the power 6, t is 8 and d is 340 square, so this is coming 65.27 Mpa and it has to be less than 250 by 1.1 that is 227, so this is also okay right so this is checked, so N Batten we have checked, now we will check for intermediate Batten.

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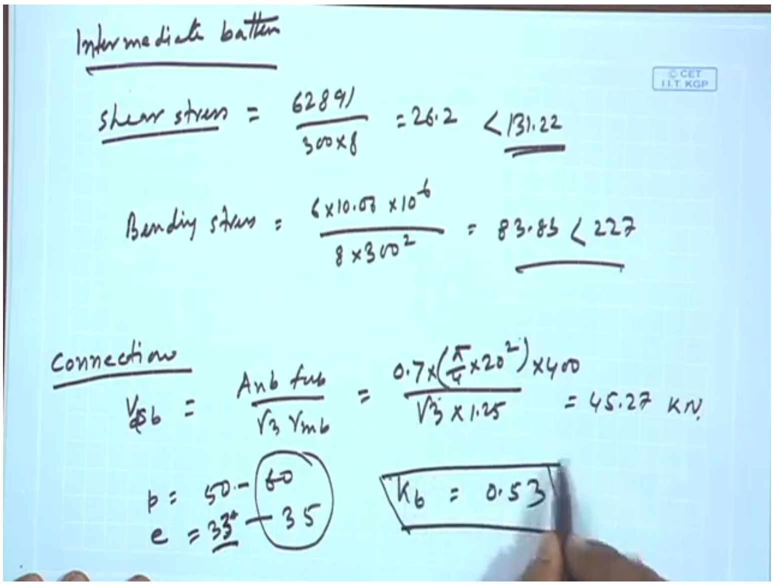

For intermediate Batten shear stress will be higher because the cross-section is less, the depth is less so shear stress will be 62891 by 300 into 8, 26.2 less than 131.22 that is found earlier and similarly, bending stress can be found 6 into 10.06 into 10 to the power 6 by 8 into 300 square, 83.83 which is less than 227 Ampere. So that means the intermediate Batten size is also okay from force point of view right, now we will go for connection. Connection means here we are going for more connection, right? And we have to design the bolt due to shear and bending, so as we are using 20 mm diameter bolt so I can find out the shear strength, design shear strength will be An B F ub by root 3 Gamma mb and it will be single shear. So as it will be single shear, so I consider the value as N s as so that is coming 45.27 kilo Newton.

And we know minimum pitch is 50 mm, 2.5 gauge, minimum edge 33 mm is coming, so we can provide 35 and it is coming 50 , I provide say 60 right. So if I provide pitch as 60 and edge as 35 then I find out the value of K b as 0.53 okay. E by (())(23:02) - 0.25 from that if I calculate, I find out the value of Kb as 0.53.

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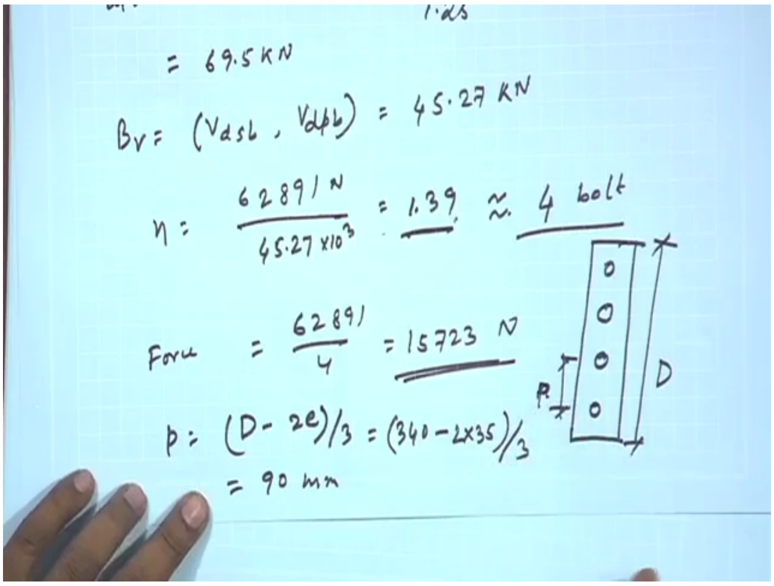

Bearing strength, bearing strength of bolt value bolt will be 2.5 into Kb into d into t, t is 8 ino fu by Gamma mb, Gamma mb value is 1.25, so if I calculate I will get 69.5 kilo Newton. So bolt value will be lesser of this Vd sb and Vd pb that means 45.27 kilo Newton, so bolt value you can find out, now number of bolt required you can find out. Number of bolt I find out the force I got 62891 by bolt value is 45.27 into 10 cube, this is a Newton okay so 1.39 that means I can provide 1.39 that means I provide 2 but I will provide 4 bolts because it is not only coming due to single action, it is not only due to shear or moment but also it is coming due to combined action, so for combined action I have to check.

So for combined action these 2 is sufficient if only shear force is there, but moment is also there so I have to find out the combine action and then we have to check whether this4 number of bolts are okay or not. So force in each bolt due to shear will be 62891 by that is 15723 Newton so this we got right. Now if we provide 4 bolts then I have to find out what will be the pitch and edge right. Now total depth is known that is which is fixed right that is D, total depth is D so I find out P, if this is P then pitch will be D - 2 e by 3 right. So for end Batten D is 340 - say we provide P is 35, so 2 into 35 right by 3 so this is becoming 90 mm, so let us provide pitch as 90 mm law okay.

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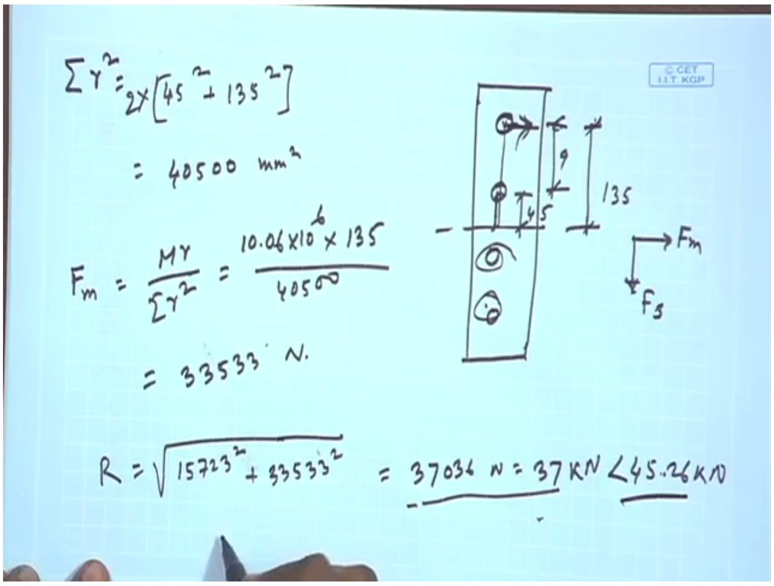

So if pitch is 90 mm then if we see the moment, the moment will be as we provided bolt in single line so I have to find out moment in this bolt, moment in this bolt right and moment will act like this, so I have to find out submission r square, submission r square I have to find out so that will be this will be 45, because 90 is total and this will be 90, so extreme bolt distance will be 135. So submission r square will be 45 square + 135 square right into 2, into 2 side so submission r square will become 40500 millimetres square. So force due to movement say Fm, forced due to moment I could find is equal to M r by submission r square. So M we got earlier 10.06 moments we got right in the Batten, and r will be the maximum moment will develop at the extreme bolt, so I will be 135 by submission r square will be 40500.

So if you calculate, you will get the value as 33533 Newton, so resultant force now I can find out. Resultant force will be what, 1 this is Fm and shear say Fs is along this direction. So R, I find out say route over Fs square 15723 square + Fm square 33533 square, which is coming 37036 Newton that is 37 kilo Newton and that is less than 45.26 kilo Newton because bolt value is 45.26 kilo Newton, so the resultant force is becoming 37 kilo Newton and which is less than the bolt value so it is okay, so due to combine action also the connection is okay.

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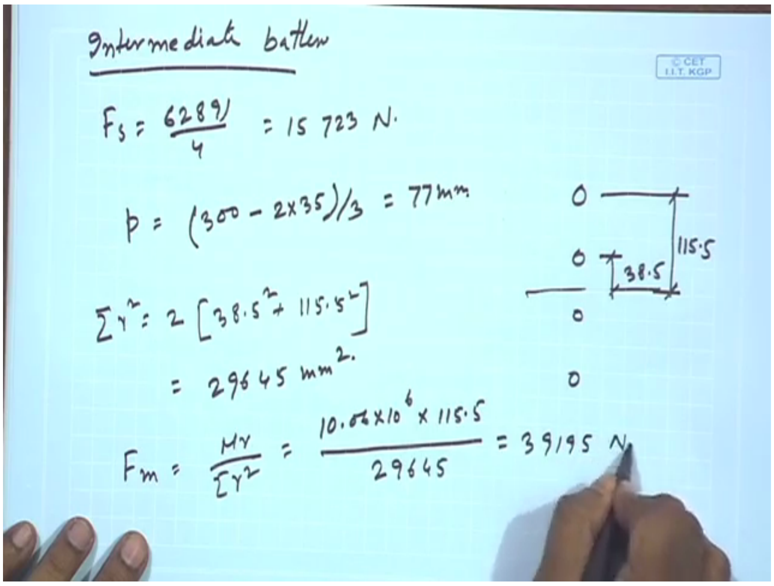

Now we will check for intermediate Batten due to combine action. So for intermediate Batten similar way we will find out shear force so Fs if I consider shear force 62891 by 4 that is 15723 Newton. And here pitch will be D this 300 - 2 into 35 by 3 so that will be 77 millimetre 4 bolts are provided so I can find out so this will be so this value will be 77 by 2 that is 38.5 and this value will be 77 + 77 by 2 that is 115.5 right. So I can find out submission r square as 2 into 38.5 square + 115.5 square, this will be 29645 millimetres square. So force due to moment Fm at the extreme bolt I can find out as M r by submission r square, M is 10.06 into 10 to the power 6, r is 115.5 by submission r square we found 29645 millimetres square, so this we are getting as 39195 Newton right, so now we will combine this force to get the resultant force.

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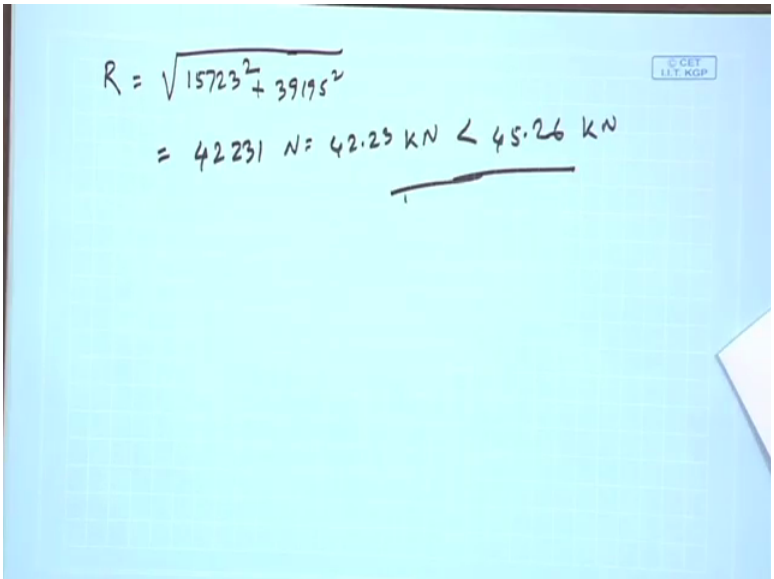

Resultant force will be square root of 15723 + 39195; this is coming 42231 Newton means 42.23 kilo Newton, which is just less than 45.26 kilo Newton so the number of bolts whatever we have provided is saved. So what we can see here that number of bolts required was due to direct shear was 2 but we have provided arbitrarily means we can increase arbitrarily to 4 to check that the number of bolts provided is okay due to combine effect or not. And we have seen if we provide for number of bolts, it is just passing before reaching the bolt value.

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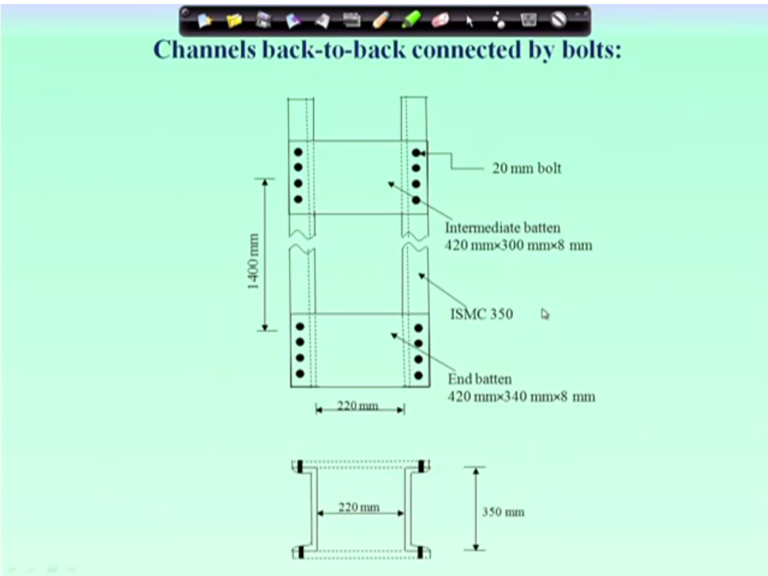

Okay, so if we see the diagram of the design of the Batten plates if we see, it will look like this. The spacing between 2 channel is to 20 and section 5 is I think it is 350 and we are providing 20 mm bolt, 4 number of bolts we are providing and size of intermediate Batten will be 420 by 300 by 8mm, and size of End Batten they have provided 420 by 340 by 8 mm and this is the spacing between 2 Batten members right. So this is the useful properties, which are required to know the design specification of the system because these are the outcomes of the design.

Okay so outcome of the design means 4 number of 20 mm bolt can be used for both the intermediate and end Batten and for intermediate Batten its size should be this 420 by 300 by 8 and for end Batten size should be 420 by 340 y 8 and spacing should be 1400, this is what the output we got right. Now the same example will be done in next class using weld connection okay, so thank you for today’s lecture.