Course on Design of Steel Structures
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Lecture 63
Module 12
Design of Gusset Base

Today I will be discussing about a design example on the gusset base. So in last lecture we have discussed the design procedure of the gusset base and which includes the determination of the gusset plate dimensions and the base plate dimensions and the number of bolts. So how to find out step by step that will be clear if we go through this example, so quickly I will start this example.

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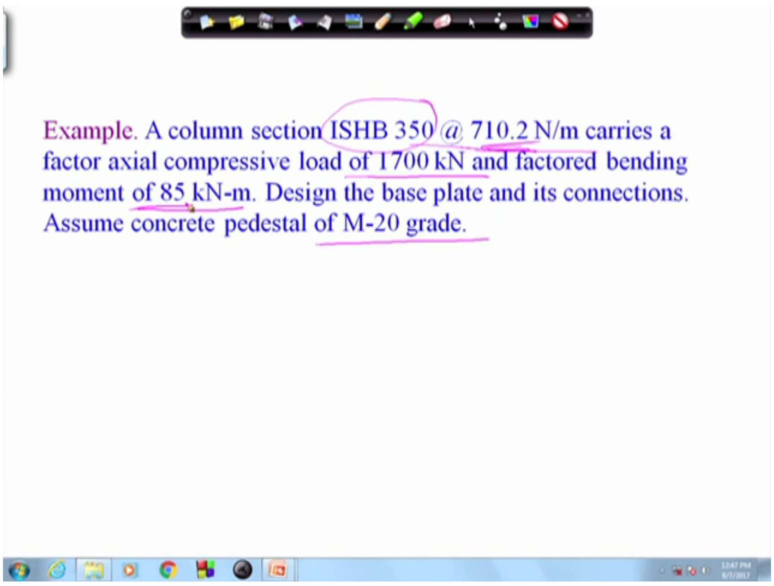

So example is this that a column section of ISHB 350 at 710.2 newton per meter carries a factor axial compressive load of 1700 kilonewton and factored bending moment of 85 kilonewton meter. Now the design the base plate and its connection. Assume concrete pedestal of M-20 grade. So here you remember ISHB 350 has two type of different width, so here we have taken ISHB 350 at 710.2 because with different width its dimension are slightly different so keep it mind this that we are going to consider ISHB 350 at 710.2 newton meter.

And the compressive load is 1700 kilonewton and also we have added here one moment that is 85 kilonewton meter, so through this example also we will see how to take the moment that means if moment are also acting on the column then how the base plate will be decided that means the thickness of the base plate and its other dimensions how it will be decided that we will will be see through demonstrated example, okay.

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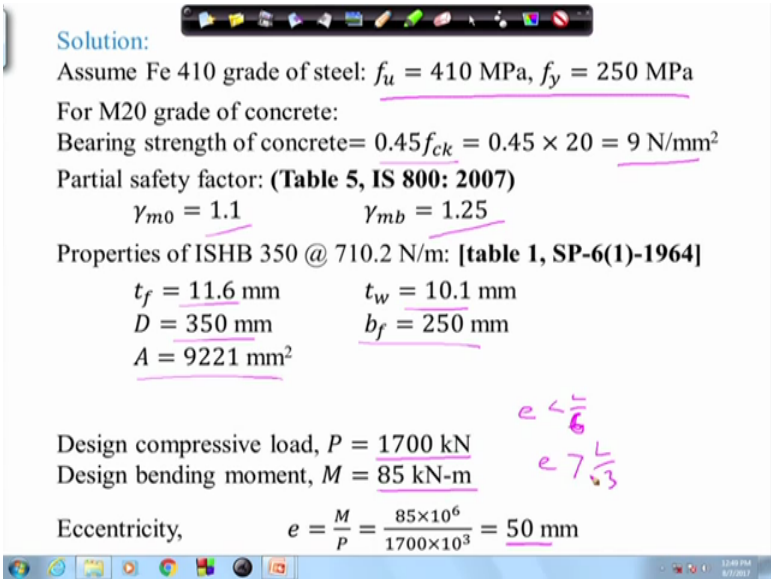

So if we go to the solution then first we need to note down certain properties which will be required for the calcifications like for Fe 410 grade of steel we know these are the properties and for M20 grade of concrete which is being used here so the bearing strength of concrete will be 0.45 fck into 0.45 fck which will be 9 newton per millimetre square, right. And also partial safety factor is 1.1 gamma m0 and gamma mb for bolt as we are using bolt so 1.25 here we will be using bolt connection to demonstrate how the number of bolts are decided.

Then here thickness of the flange, thickness of the web which will be required we have noted down and whole depth of the section is overall depth, then cross-sectional area, also we need to know the Ze that also will be noted we will be noting. Then here design compressive load was given as 1700 kilonewton and bending moment was given 85 kilonewton meter. So here eccentricity will come and that amount of eccentricity will be 50 millimetre M by P, because we need to know whether eccentricity is less than L by 3 L by 6 or in between L by 3 to L by 6 or greater than L by 6, okay. So that we need to know accordingly the pressure will be calculated pressure means bearing pressure from the concrete.

So as moment is there so here simply the pressure will not be the P by A we need to find out the pressure from moment as well.

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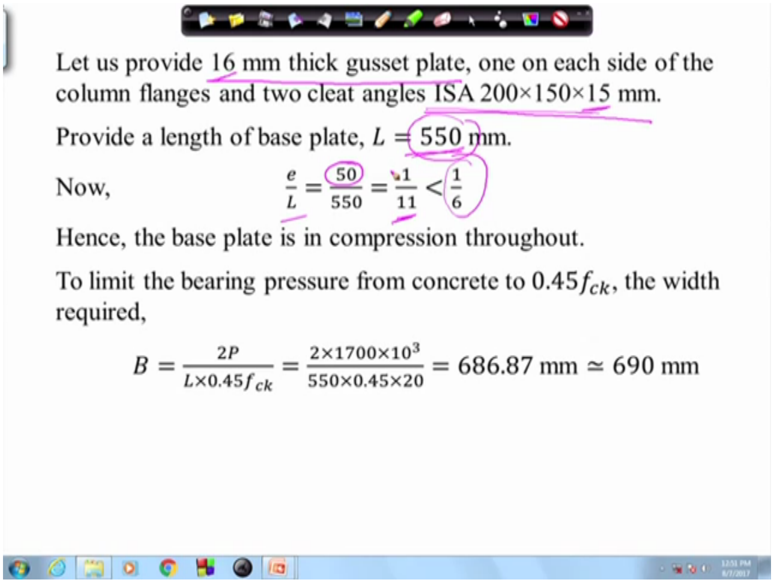

So this also we will see here. So now here you see that if we use 1600 mm gusset plate because minimum thickness of gusset plate will be 16 mm, so in each side we are going to provide 16 mm gusset plate and we are assuming two cleat angle or gusset angle as ISA 200 by 150 by 15 and I told earlier that we should provide unequal section with larger length as vertically placed, if it is so then we can hold the number of bolts properly. So to do that we are providing a larger section of angle and here you see the thickness of angle also we have considered 15 mm which is approximately equal to the gusset plate thickness because both the thickness should be more or less equal that is what we have told earlier.

Now here e by L is coming, e we calculated as M by P as 50. So e by L we are going to get 1 by 11 assuming that L as 550, remember here we are assuming a certain base plate length because we do not know the base plate length and as we do not know the base plate length we cannot find out e by L unless we assume certain base plate length. So to start with we have started with some assumption that is length of the base plate, okay.

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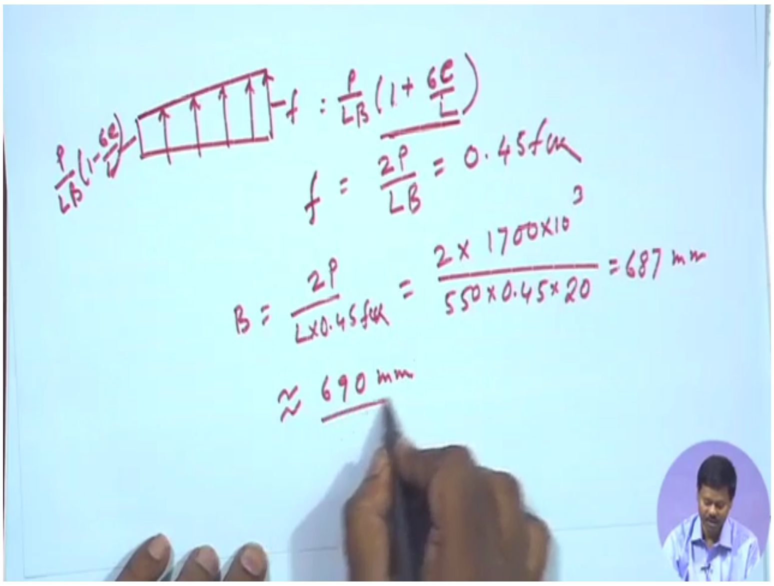

So if we consider the length of base plate then e by L will become 1 by 11 and that is less than 1 by 6, okay so if it is less than 1 by 6 then I can find out the pressure diagram as like this because in case of L by 6 the entire section will be under compression, okay. So here the maximum pressure we have to find out, if this is f we know this will be P by LB into 1 plus 6e by L, right and this is P by LB into 1 minus 6e by L, right.

So if we consider the maximum one then it will be 1 plus 1 2 so that will be 2P by LB, right so f will be 2P by LB. So the stress maximum stress developed at this will 2P by LB and it should not be greater than 0.45 fck bearing strength of concrete, so if we make equal to the bearing strength of concrete then we can find out the value of B from here, right. So B will be I can find out as 2P by L into 0.45 fck, right.

So if we put those value we can find out approximate value of B that is B as 2 into P was considered 1700 into 10 cube and then length was assumed as 550 and 0.45 fck was 20, right. So this is becoming 687 millimetre. So we can provide B as 690 millimetre, right so the dimension of the base plate in one direction we can provide 690 millimetre, okay.

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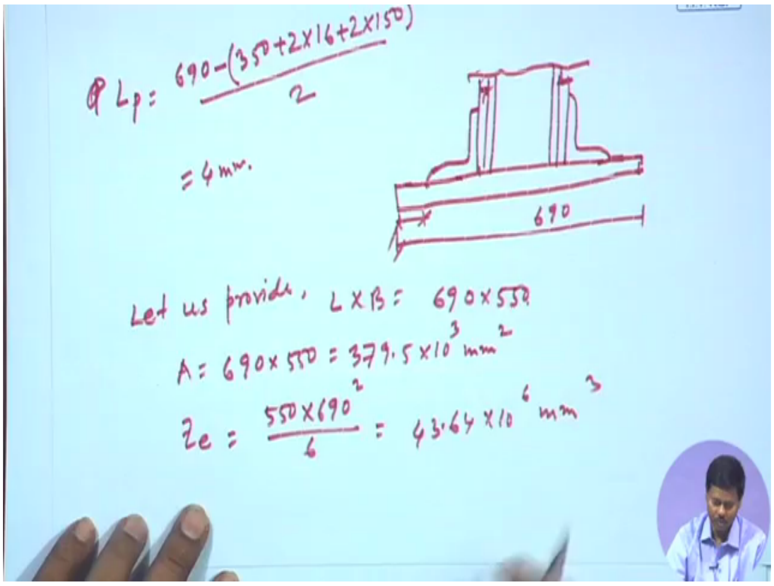

Then we will find out the projection right. So to find out projection if we draw the diagram say this is the column now it has an angle sorry gusset plate this is the gusset plate and this is an angle and this is the base plate so this base plate length is 690, so now this projection we can find out, okay. So if projection if I write P or projection length say Lp then Lp I can find out as 690 minus 350 is the depth of the section plus 2 into 16 the gusset plate thickness plus 2 into 150 the length of the horizontal angle, okay. The horizontal arm of the length angle is 150 this is then divided by 2, this is 4 meter 4 millimetre, okay. So projection length we are providing 4 millimetre.

So now now let us provide the base plate size as provide L by B as say 690 by 550, right. So area provided we can find out that will be 690 by 550 this will be the total area that is 379.5 into 10 cube millimetre square and Ze the elastic section modulus Ze I can find out that is 550 Bt square by 6, so Bt square by 6 will be this, right so this will be 43.64 into 10 to the power 6 millimetre cube.

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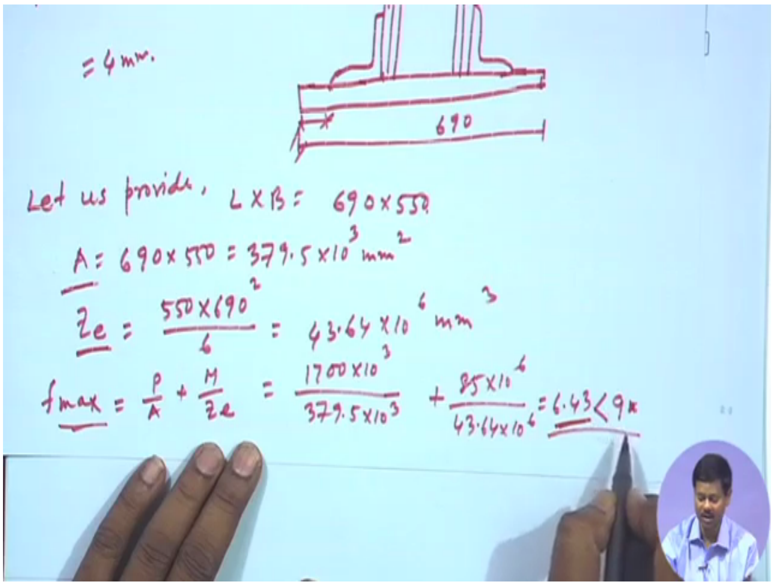

So once we get the value of area of the base plate and the section modulus then I can find out the maximum stress of the section that will be P by A plus M by Ze, so P was 1700 kilonewton, area we calculate as 379.5, right M is 85 kilonewton meter by Z is 43.64, okay. So maximum stress developed is coming 6.43 and bearing pressure of the concrete was 9 mm, so it is okay.

So the maximum stress sorry maximum pressure in the base plate from the concrete pedestal is becoming 6.43 which is less than 9 newton per millimetre square so it is okay. So this is how we could find out the maximum pressure.

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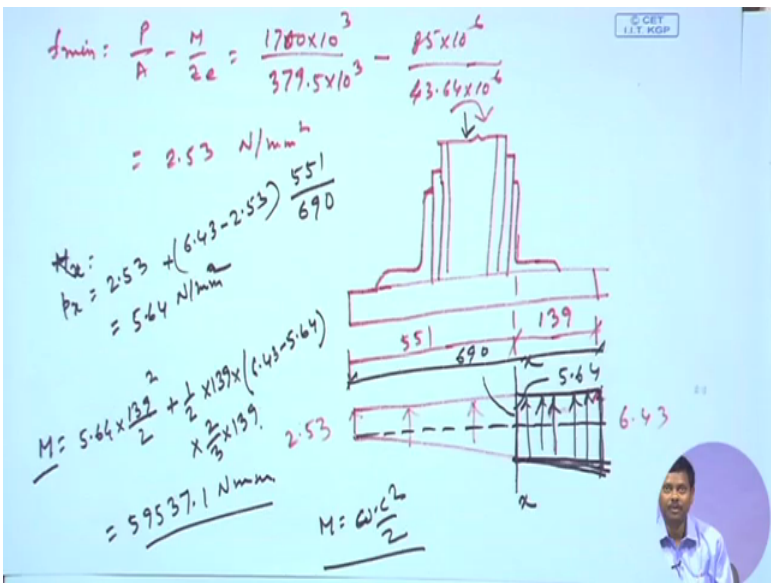

Now I can find out the minimum pressure fmin, so minimum pressure will be P by A minus M by Ze, so it will be 379.5 into 10 to the power 3 minus 85 into 10 to the power 6 by 43.64 into 10 to the power 6. So this will be the minimum pressure which is coming 2.53 newton per millimetre square, right.

So now let us draw the diagram pressure diagram because we have to find out the maximum moment developed at the critical section. So if we draw the diagram we can see this is a column and then we have a gusset plate, then an angle, right. Similarly here we have a gusset plate and then angle, right and then some overhang portion, okay. So now we have total distance we know the total distance and we can find out the critical distance, right. So critical distance will be this if we calculate we will see this will be 139 millimetre and rest will be 551, right and the pressure distribution if we see it will be if moment is in this direction then it will be like this, right so pressure will be like this where the minimum will be 2.53, maximum will be 6.43 and we need to know this.

So we need to know the pressure is this trapezoidal distribution and we need to know the moment at this critical section, okay. So moment at this critical section we can find out. So to know the moment at critical section we have to know the pressure here. So by linear interpolation we can find out the pressure at this section say this is section x x if we say, then the moment at this critical section I can find out say Mx okay no first pressure I I have to find out.

Say px is equal to 2.53 because I can make like this and then the linear interpolation of this, okay this so 2.53 plus 6.43 minus 2.53 into 551 by 690 total is 690 this is 690, right so from this I can find out pressure at critical section xx as 5.64, okay. So this is 5.64, so moment at that section I can now find out. So moment will be 5.64 wl square by 2 so 5.64 into L is 139 square by 2 that is for this uniformly distributed load plus the linear (())(17:41) load plus that will be half into 139 into 6.43 minus 5.64 into 2 by 3 of 139, right.

So this will be 59537.1 newton millimetre, so moment at critical section we could find out as this remember if only axial load is there than simply we can find out M is equal to w into c square by 2 and we can find out the thickness of the base plate as we have calculated earlier means in the earlier lecture one equation we have shown from which we can do. But here as moment is there we have to derive that things.

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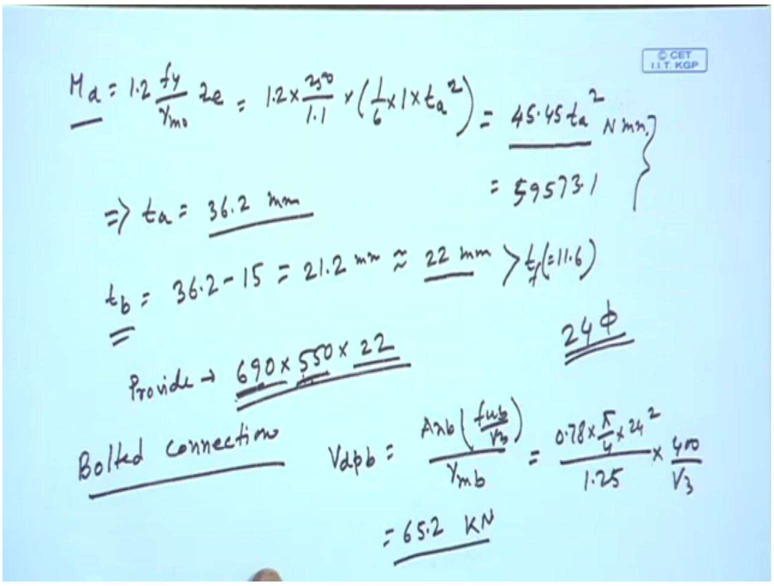

So moment once we know we can also find out the moment carrying capacity Md which is 1.2 into fy by gamma m0 into Ze, right. So that will be 1.2 into 250 by 1.1 into Z is 1 by 6 Bt square so B is 1 into t is say thickness of the plate base plate and angle. So total thickness say ta aggregate thickness, okay so ta square, this is coming 45.45 ta square. So the design bending strength of the section in terms of its aggregate thickness is 45.45 ta square newton millimetre which need to be equal to the moment at critical section which was coming 59573.1.

So by equating these two I can find out the value of ta as 36.2 millimetre which is called aggregate thickness of base plate and cleat angle. So the thickness of base plate and cleat angle is this. Now I can find out thickness of base plate say tb as aggregate thickness minus thickness of the angle angle thickness was considered as 15, so this is coming 21.2 mm so we can provide 22 mm, right and this is greater than the tf thickness of the compression flange which is 11.6.

So the thickness of the base plate can be decided as 22 mm that means now the base plate dimensions are fixed 690, 550 and 22. Now you see somebody can design in different way we have considered certain length and on that basis we have considered other values. Now one can consider length as different say in place of 550 somebody can consider it as 600 or 500 then also they can find out the other dimensions. So as per the designers choice he or she can choose a certain dimension and accordingly he can find out the final dimension.

Now we will be go to the connection and here we are providing bolted connection, okay. So bolted connections if we consider now we have to consider whether it is means what is the bolt value. So bolt in single shear because this will be in single shear will be calculated say Vdpb so that we know Anb into fub by root 3 by gamma mb, right. Now if we use say for example 24 mm diameter bolt 24 mm diameter of bolt grade 4.6 assuming 24 mm diameter of bolt I can find out the value, okay so that will be 0.78 into pi by 4 into 24 square by gamma mb into fu by root 3 fub is 400 by root 3 so this is coming 65.2 kilonewton, right. So the shearing strength of bolt is decided.

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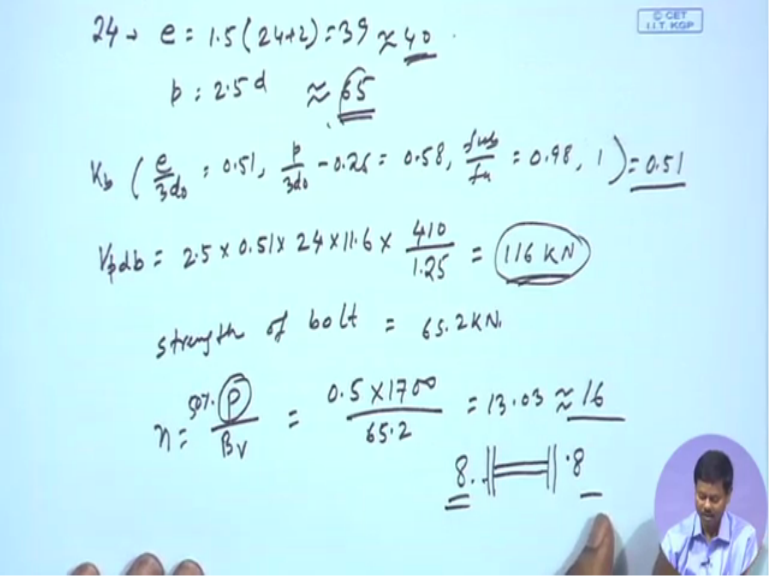

Now we have to also find out the bearing strength of bolt so for 25 mm diameter bolt 24 mm diameter of bolt edge distance will be 1.5 into d0 d0 is 24 plus 2 so that is coming 39 we can use as 40. And pitch will be 2.5d, okay so this we can use as say 65 so pitch we are providing 65 and edge we are providing 40, so from that we can find out the Kb Kb will be smaller of e by 3d0 which will be 0.51, p by 3d0 minus 0.25 which will be 0.58 and fub by fu which will be 0.98 and 1, so smaller of these four will be 0.51. So the value of Kb we can find out on the basis of edge and pitch whatever we have assumed.

So bearing strength Vpdb bearing strength of bolt will be 2.5 Kb into d into t, t is the thickness of the smaller one that is tf here 11.6 because one is we have considered 16 another is 11.6 so smaller one is 11.6 into fu by gamma. So if we consider this then we can find out this value as 116 kilonewton. So the bolt value will be the lesser of these two lesser of these two means 116 and earlier we got 65.2.

So the strength of bolt value means strength of bolt will be 65.2 kilonewton. So once we know the strength of bolt we can find out the number of bolt, okay number of bolt will be P by bolt value. Now what is this P, we can assume the column end and gusset material to have complete bearing if we assume complete bearing then 50 percent of P will be transferred through bearing and 50 percent will be transferred through bolt connection to the gusset plate and to the base plate, right.

So depending on the assumptions means how the connection has been made whether it is complete bearing or not depending on that the force will be calculated for calculating the number of bolt. So if we assume the gusset material to have complete bearing then 50 percent of the load will be assumed to pass directly and 50 percent of the load will be passing through the connections. So if it is so then I can find out that 50 percent if we assume to pass through the connection then 0.5 into 1700 by bolt value. So this is becoming 13.03 that means we need to provide 16 number of bolts, okay.

So if we provide 16 number of bolts then in each side in each side we will provide 8 number of bolts, okay so 8 number of bolts in each flange will be provided and if we provide in two rows then 4 number of bolts in each row will be provided having two rows of bolt, right.

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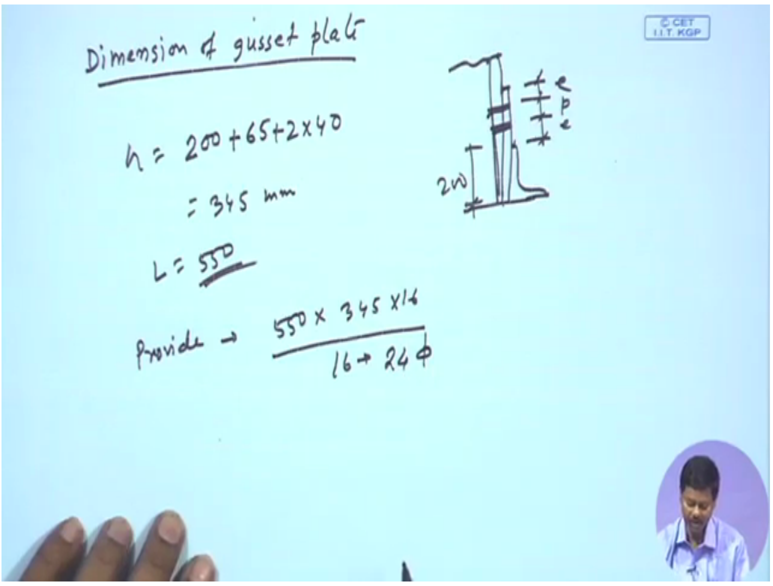

Now I will show the diagram later now before that I have to find out the dimension of the gusset plate dimension of gusset plate, okay. So here height of the gusset plate will be the height of the angle was 200 plus see if we have gusset plate this and if we have column like this and if we have angle like this then the angle height was 200, so 200 plus we have two rows of bolt. So here one rows of bolt, another rows of bolt.

So to accommodate that we need to find out this distance that will be pitch distance plus 2 into edge distance that means plus 65 plus 2 into 40 so height of the gusset plate atleast has to be 345, right height of the gusset plate and length of the gusset plate we can assume as the length of the base plate. So if we assume length of the gusset plate as length of base plate then length will be 550 because length of the gusset plate was consider 550 parallel to the web parallel to the flange, right. So we can provide gusset plate dimension as 550 by 345 by 16, so this will be the size and 16 numbers of 24 diameter of bolt has to be provided.

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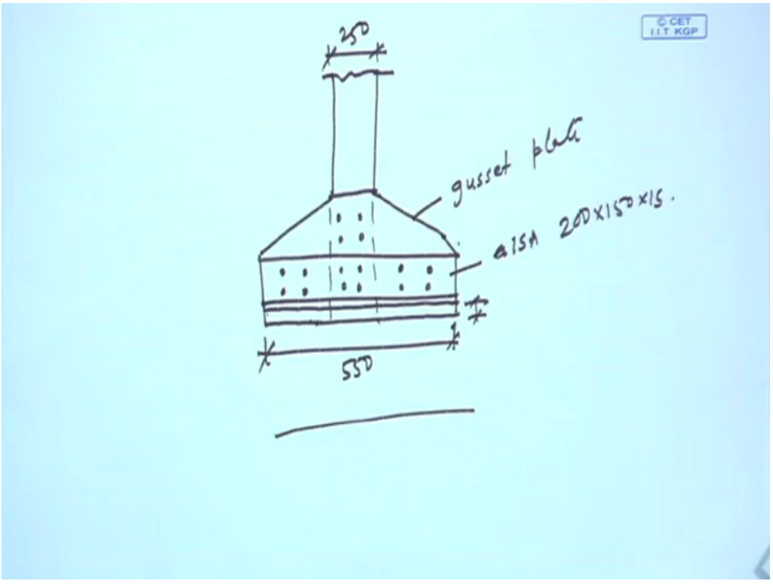

So finally we can draw the diagram so gusseted base with bolt connections we draw I am drawing just the side view because we do not have much time so if it is so it will be like this then this is the angle thickness and this is the base plate, right and these dimensions will be 550 and let us provide the number of bolts. So bolt will be provided total 8 in each direction, so 8 into 8 16, okay.

Similarly to hold the members in other direction we are providing here are few bolts and this will be the gusset plate and this is the angle ISA 200 by 150 by 15, okay this is flange width 250 all are in millimetre. So this is gusseted base with bolted connections, right. But in case of welded connection calculations will be different. So in that case you will see the thickness of the base plate will be little higher because here thickness of the base plate is calculated considering the thickness of angle as well, right.

So this is how one can design a gusset plate when the column is under compression and moment, okay. So this is all about the todays lecture and before going to finish this entire lecture I would like to suggest one thing that please go through the IS code 800-2007 IS: 800-2007, this is not a mathematical course or some structural analysis course that everything you will be understanding through logic, here logic is definitely there but numerous numerical equations are there expressions are there which is derived from the from some experimental observations like some coefficients are obtained from experimental observations, right.

So and those are given in tabulated form which will be to remember few of them or we have to go through that code and then we can find out. so when you will be going through my lecture I would suggest you take a code and try to follow that code with this lecture then it will be easier and you do not have to remember all the expressions many big expressions are given where many numerical expressions means are given which is difficult to remember its coefficients are difficult to remember so those things you can follow from the code, okay.

So whenever you will go through the lecture please sit with the code as well and revise the things along with code and try to find out in which page or which clause these codal provisions are there so that you can remember, right. And through this lecture you will not understand everything unless you go through some workout example, okay and if you go through workout example then it will be clear and when you will be going through workout example please refer the code so that how the coefficients are obtaining, how the equations we are going to get that you can find out and accordingly you can design the thing.

So through this lecture means entire lecture means I hope that you will get a concept of design of limit state method for steel structure. So how to design a steel member using limit state method that concepts I hope it will be clear however it will be much clear if you work out some example then the concept will be much clear, I thank for your patients and I hope you will enjoy this lecture, thank you.