Design of Reinforced Concrete Structures
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Lecture - 13
Design of Shear

Last class, we have started design for shear and today, we shall continue design for shear because, we have started one problem solving. So in this lecture, design for shear that, we shall continue today

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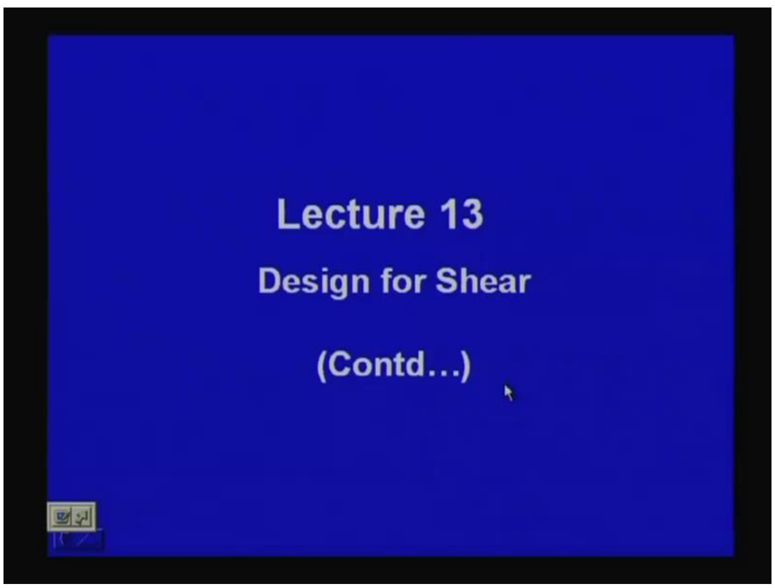

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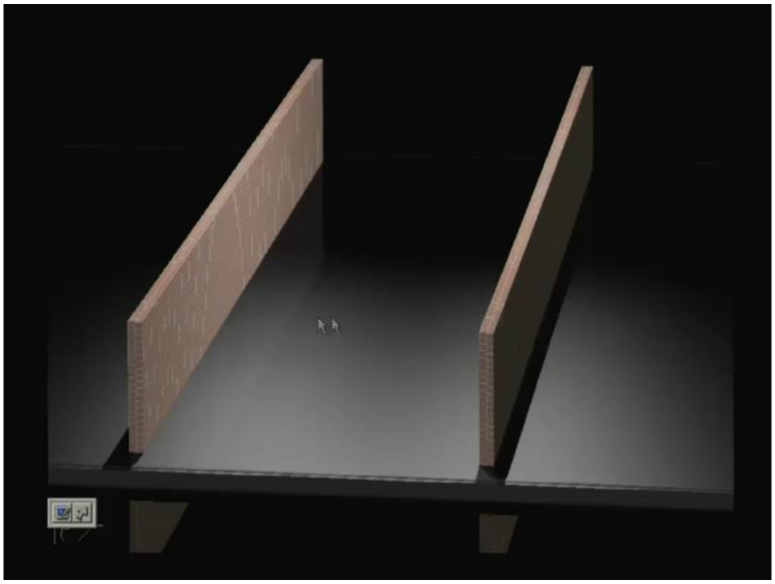

Let us, just review the problem which, we have started and just review it. So, we have 2 brick walls; 2 brick walls, we can take it this 1 say 250 mm width, having so many just for clarification, we have made it like this there are so many beams 3 meter spacing.

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Covered by the roof slab. So, this is your different beams but, we have constructed these beams integrally with the slab. So, we can take action of the t-beam.

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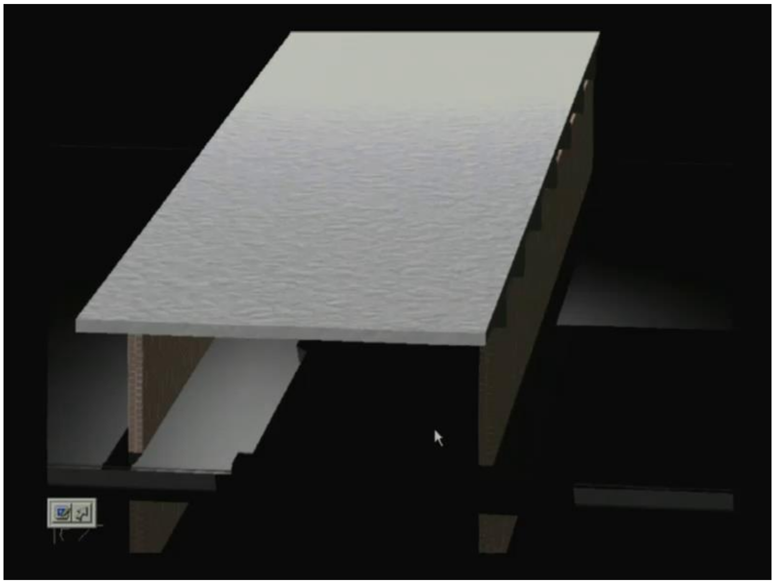

So, each of them will be t-beam and which has width of the web, depth of the flange, width of the flange and depth of the web also okay.

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So, before we come to that; let us see, that few what we have done already you have in your note book but anyway I think it is worth to for mentioning.

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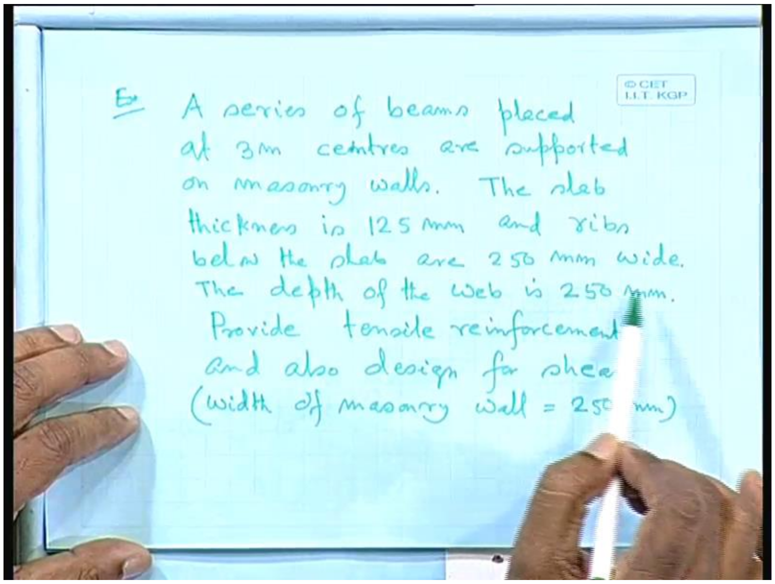

A series of beams placed at 3 meters centers, are supported on masonry walls which we have already shown. The slab thickness is 125 millimeter and the ribs below the slab are 250 millimeter wide the depth of the web is 250 millimeter provide tensile reinforcements then also design for shear. Because we do not, want to do it separately, for flexure and shear, we want to do the same problem for flexure as well as shear the width of the masonry wall that is 250 millimeter that we have done. We have calculated loading.

So, dead load we have calculated taking 250 kilo Newton per meter cube for the concrete unit rate 6 meter ceiling, we are taken ceiling plaster that is at the bottom of the slab and 30 millimeter thick floor finish that is at the top of the slab taking that; we are getting dead load 3.989 kilo Newton per square meter. And live load that we have taken 4 kilo Newton per square meter which we can get for a specific purpose.

Since, it is not mentioned we have taken 4 kilo Newton per square meter but, for the specific purpose for the particular building then we can get the appropriate loading from is 875 okay.

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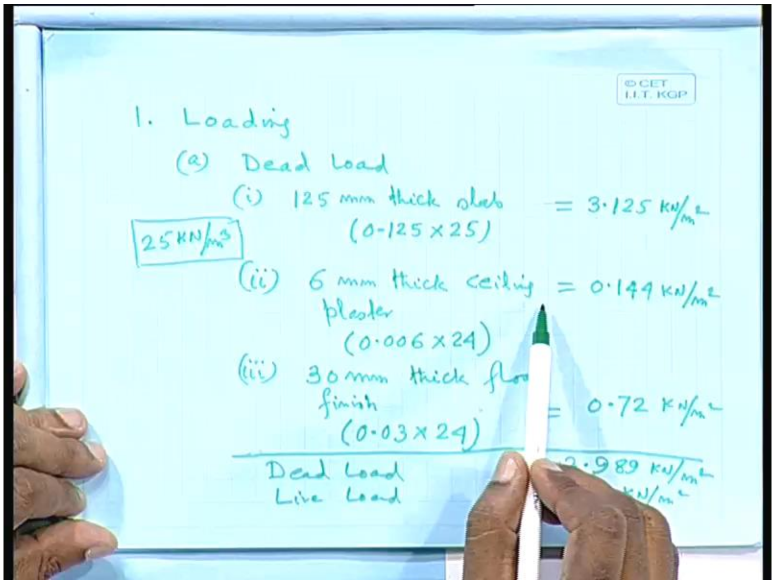

So, next 1 load on beam. So, we are getting this 1 that kilo Newton per square meter that is on the slab.

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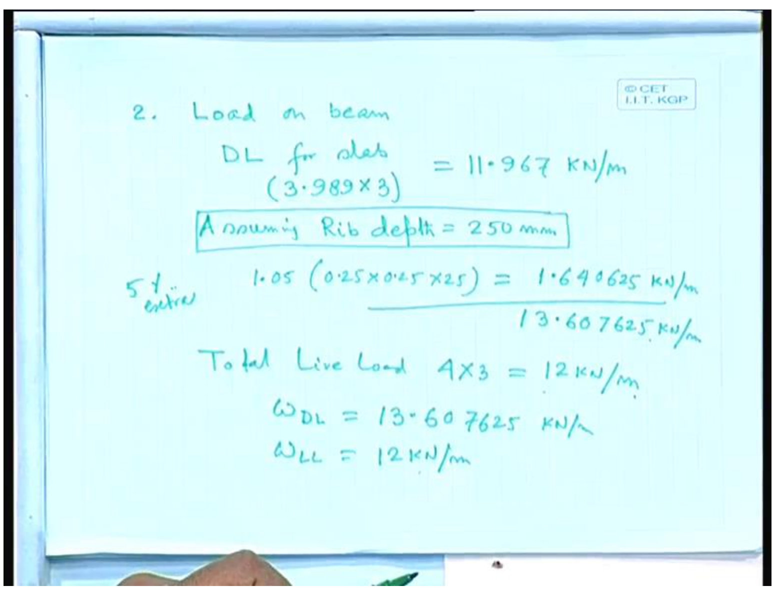

Now, we shall take that load on beam, individual beam that means; if we go back.

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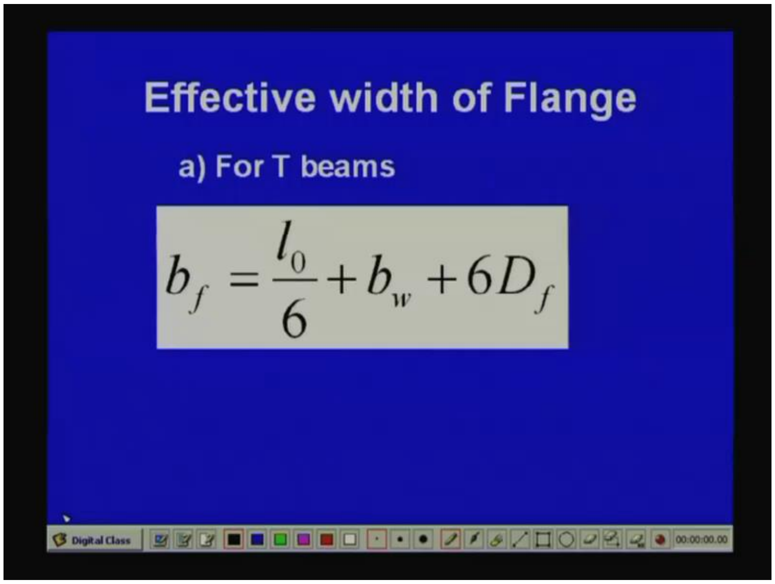

So, if we come with this problem, that means; we shall get the 1.

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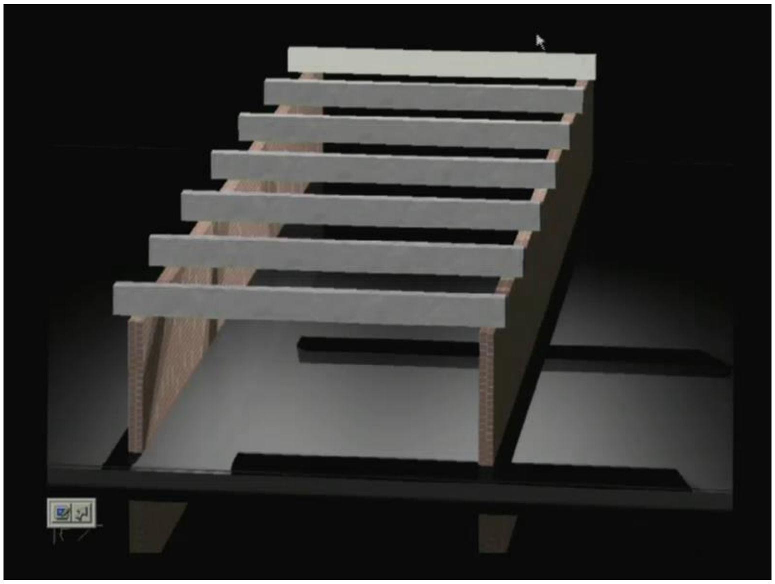

So, we shall get. So, this is the square area for on the slab unit square and we have that load from both sides.

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So, if we take this 1 you can get the load 3.898 kilo Newton per square meter for dead load and for live load 4 kilo Newton per square meter and which you are getting within this area within this area you are getting this load. So, now where to take the loading on the beam load on beam. So, how much is the load on beams. So, dead load for slab that we have already computed and that we are assuming and here we are assumed certain rib depth rib 250 millimeter.

So, we are getting an 5 percentage extra for plastering and lot of other things. So, we can get 13.607 kilo Newton per meter; total live load 4 into 3 because, spacing of beams 3 meter so 4 into 3 12 kilo Newton per meter. So, you can get along this length we are getting that; how much 12 kilo Newton per meter and 13.607625 kilo Newton per meter for dead load and we have done up to this.

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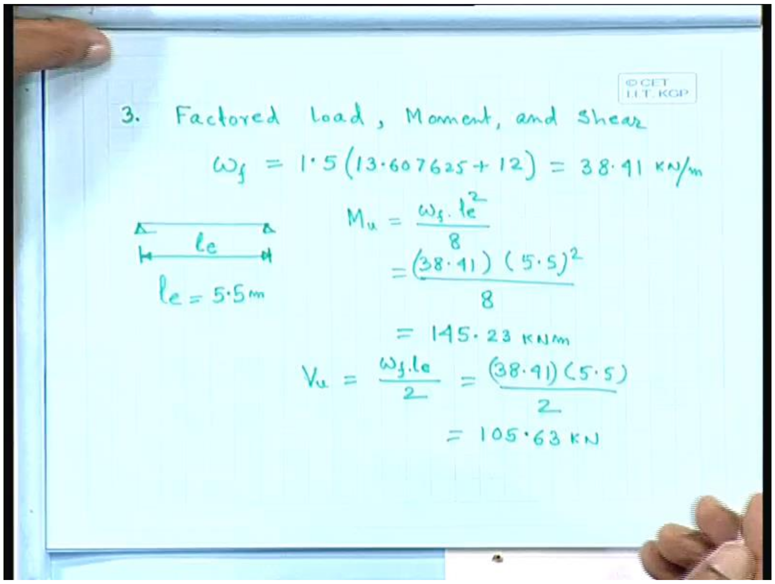

Let us, continue the number 3: now, we have to take the factored load and we have to calculate also factored load, then moment, bending moment and shear; how much will be the factored load. Let us say, wd or f you can take wf the design load, that factored load which will be equal to now, we shall multiply because hence, it is not mentioned because we are taking only the dead load and the live load. So, we shall multiply by with 1.5.

So which comes as plus live load equals 38.41 say kilo Newton meter. Our what about moment, our beams are simply supported on the masonry wall there is no moment on 2 supports because, it is just simply supported this is a case of simply supported beam. So, we can take the moment at the mid span and we need the effect we call it effective span instead of taking this 1 we call it say effective span.

What is that one, our code says even though we know say here, even though we know what should be the your effective span that you have to find out because it is dependent on that not only that your say center to center of the beam but, if it is dependent also effective depth also so, out of that minimum 1 we take it and here we are we are taking this 1 unless otherwise specified it is not mentioned we shall take it as center to center of the wall. Center to center of the wall that, we shall take.

So, we shall get moment that mu equal to wf times le square by 8. So, le will be equal to this 1 is given here 5. I think we have missed it right. So, that better let us, take that 1 say 5.5 meter that 5.5 meter is the space that your distance center center between 2 walls and that is the span effective span, we shall take it here. So equals 38.41 times 5.5 whole square by 8 equals 145.23 kilo Newton meter. What about vu that shear force design shear force we shall take w le by 2, equals 38.41 times 5.5 by 2 it comes as 105 505.63 kilo Newton.

So, this is your moment for which you have to design and this is your shear force after the factored load this is the design load after multiplication of 1.5. If it is if you have seismic load, wind load then appropriate factor we have to use. Next 1 number 4: that effective width and depth

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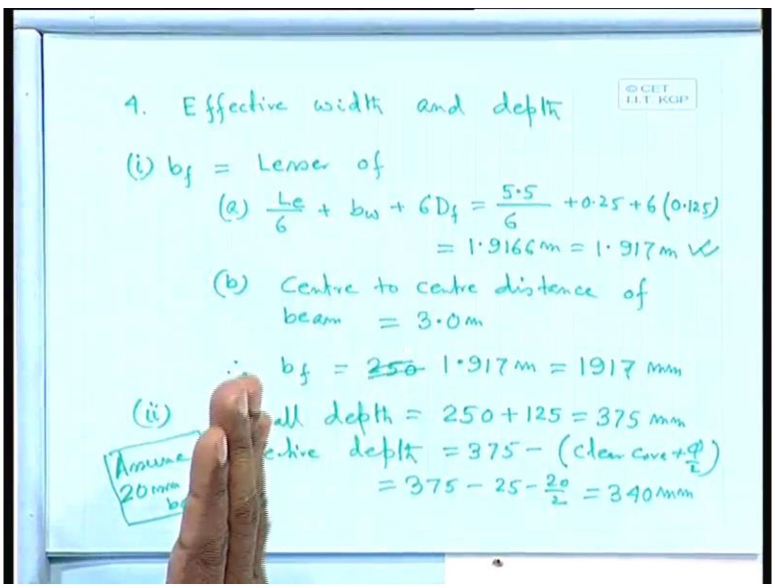

Now, we have to mention that, what is the effective width of this flange that we have to mention, where from shall we get it already, we have mention for t beam. So, we shall use this formula if it is t beam that we shall use it and that is available in the code.

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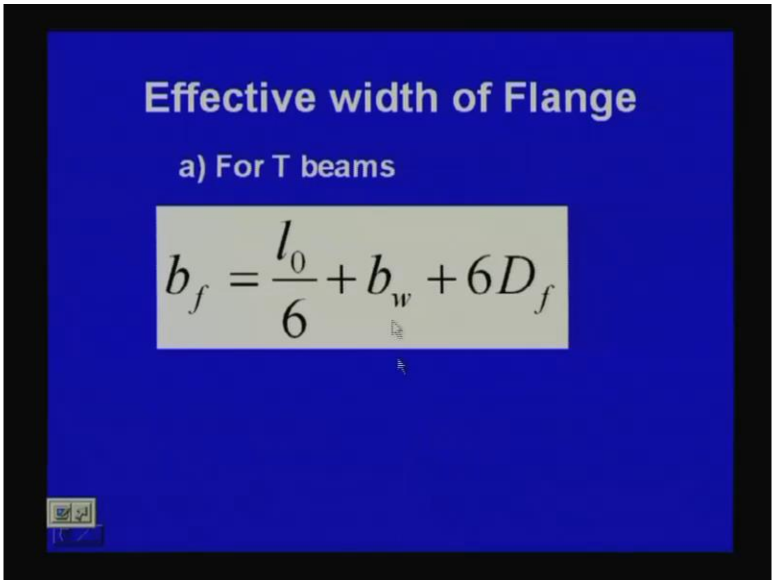

If, it is l-beam we shall use this one.

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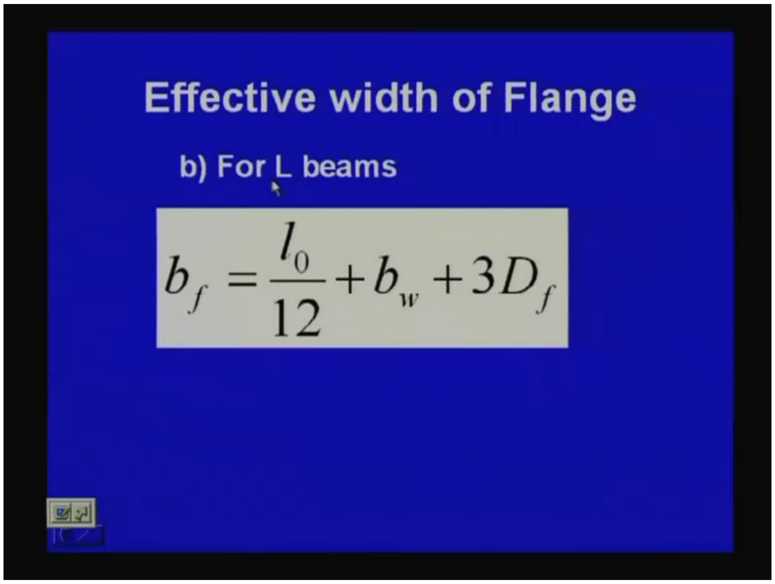

If, it is isolated say beams as per our code for t-beam, we shall get this formula.

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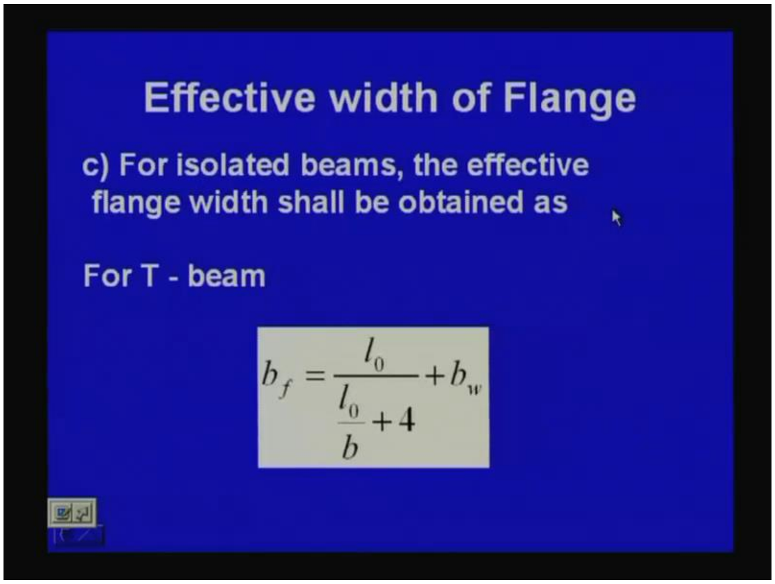

Let me, mention the other 1 for l-beam.

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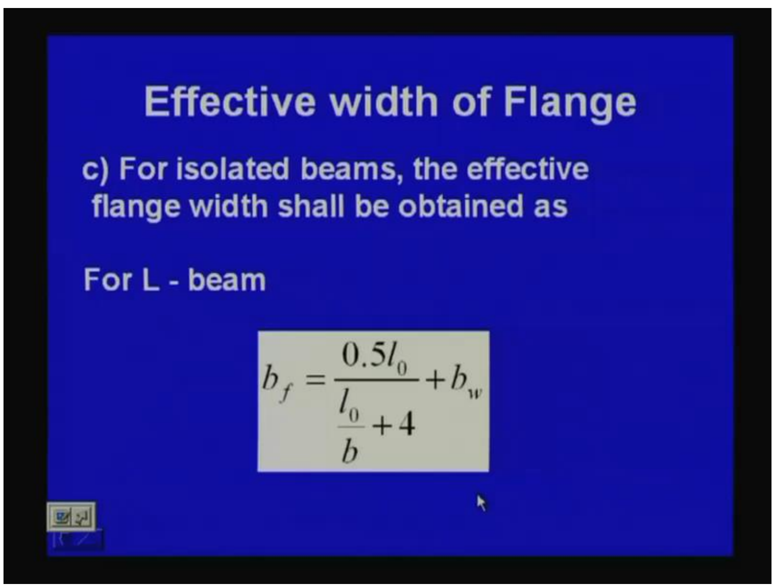

So, here in our case already I have shown while design the t-beam in our case, we shall use this formula.

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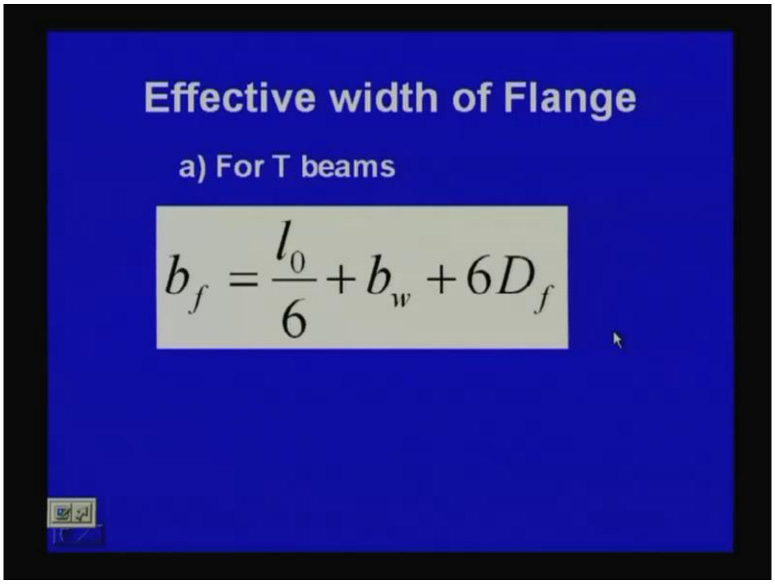

So, what is bf; bf equal to lesser of l by 6 plus bw plus 6 df, which comes as 5.5. Let us say e here divided by 6 plus 0.25 plus 6 times slab thickness 125 millimeter, which comes as 1.9166 meter. Let us take, 1.917 meter; b: center to center distance of beam and which equal to spacing that is 3 meter and we have to take out of this lesser of this 1; that which 1 is the minimum.

So, bf equal to 250 equal to 1.917 this 1 meter equal to 1917 say millimeter. Let us, write it down what about your overall depth, this is say 1 this is the effective width number 2, we are interested to find out the effective depth. So, overall depth equal to let us take, we have assumed 250 millimeter is the web depth plus 125 millimeter is the slab thickness which comes as 375 millimeter effective depth.

If we assume, that we shall provide 20 mm dia bar; assume, 20 mm dia bar that, we shall provide so, effective depth equal to 375 minus clear cover plus pie by 2 which comes as 375 minus 75 minus 20 by 2 equals 340 millimeter in this case, what we can do I am always mentioning this the other way in books also you can find that they are directly they are assuming the effective depth that, also you can assume instead of assuming that overall depth and then coming to the effective depth you can also assume that, effective depth and then go to the overall depth.

But why I prefer this one because finally we have to provide overall depth and overall depth should be some say regular number that is why I prefer let us assume, overall depth and let us also assume that, we shall provide which type of bar which diameter bar, we shall provide on the basis of that let us, calculate the your effective depth because effective depth can be any number but whereas, overall depth should be at least I prefer say multiple of 25 or may be multiple of 10 also it is dependent on the designer.

So, if we assume that, we shall provide overall depth in multiple of 25. So, let us assume overall depth and come to the effective depth. So, you have got that say overall depth then what about your mu then.

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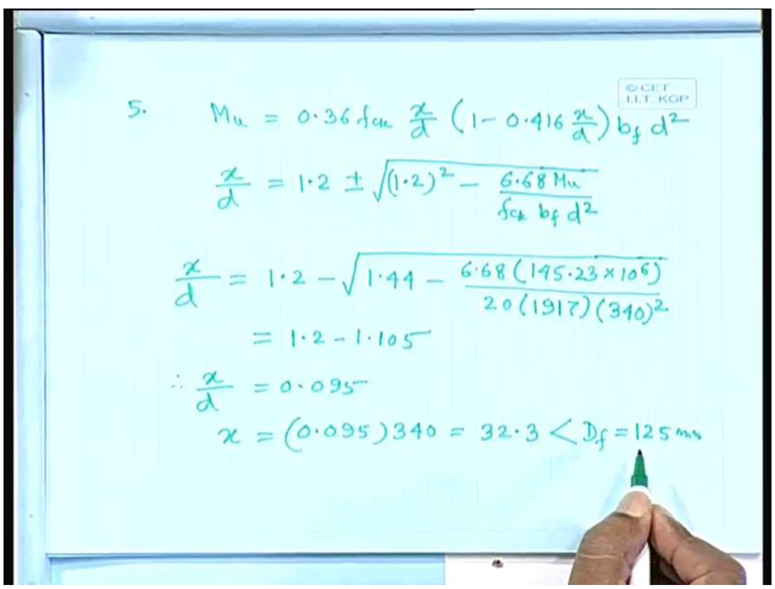

We know that mu equal to 0.36 fck x by d 1 minus 0 point four 1 six x by d bf here, in this case bf because we are talking say your that t-beam bf times d square. If we rearrange this 1 then we can get this formula. So, if you like to remember this also you can remember plus minus root over 1 point 2 whole square minus 6.68 mu divided by fck of bf d square there are so many other ways also 1 can remember directly instead of coming from the first principal always using this formula you can remember this formula also if you like.

So, you can write down x by d equal to 1.2 minus 6.68. Let us write down the full thing 145.23 into 10 to the power of 6; we are making everything in Newton millimeter divided by 20 times the width of the flange 1917 millimeter times the effective depth computed which; we are going to provide so that is the 340 which comes as: therefore, x by d 1 case x by d equal to 0.095 and x equal to 0.095 times 340 equals to 32.3 less than df depth of the flange or slab which equal to 125 millimeter.

So, in our case it is that as if, it is a rectangular beam. So, you can take this 1 say your x 32.3. So, it is less that it is within the flange it is nothing but your we can say, it is a case of rectangular beam only though; we have taken t-beam. So, we can use the formula. So, how much will be the steel provided number 6 say steel to be provided, area of steel equal to mu divided by 0.87 fy the stress in steel d minus 0.42 xu or x that is the 1 lever arm which comes as 145.23 into 10 to the power of 6 divided by 0.87 times 145 that fe 415 that steel 340 minus 0.42 times 32.3 is the that your neutral axis depth which comes as 1232 square millimeter.

So, we can provide 4 numbers of 20 tor and so, what is the ast provided area of steel this is area of steel computed this 1. So, area of steel actually provided equals 1256 square millimeter. So, you have provided 1256 square millimeter little more so, I think this is acceptable what about you your; so, we can provide that percentage equal to 1256 into 100 divided by here, we shall take it not on the basis of width either; we will take it on the basis of not on the basis of flange we shall take it here that web width of the web.
So, 250 times 340; when we shall take the percentage of steel, we shall take width of the web equals 1.47 percent our code says: then minimum steel that should be 0.85 into 100 divided by fy. So, this our code says: so, 0.85 times 100 divided by 415, which comes as a say 0.2 percent. So, the steel provided that is 1.47 percent greater than the minimum steel required.

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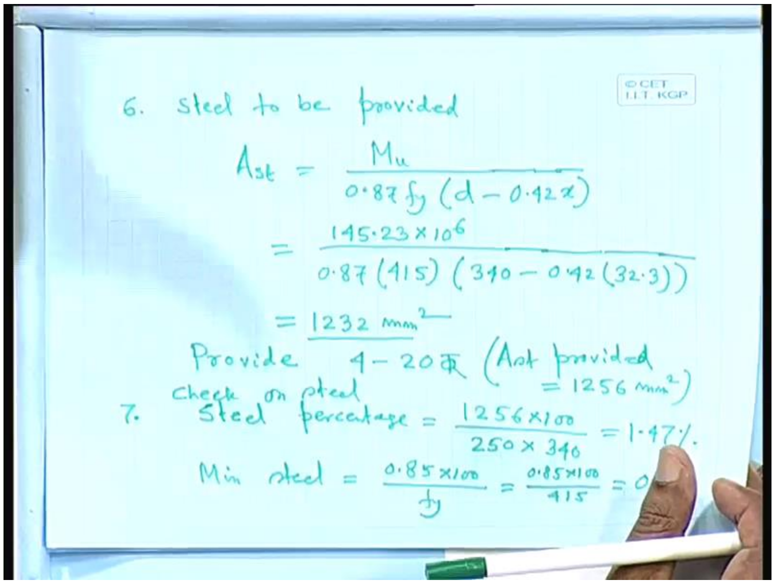

What about the shear reinforcement, I think we can this 1 we can take it as a check. Let us, take this 1 as a check so, number 7 say check on the reinforced steel that; how much your are providing and whether, it is permissible or whether it is within the limit. So, that we are checking in this case number 8. Let us come to the same problem the shear reinforcement how much is our is our vu that is 105.63 kilo Newton percentage of tensile reinforcement already, we have just computed 1.47 percent.

What is our that 2c max; maximum shear stress and that where from we shall get it that we shall get it refer table 20 is 456 and you should always mention that whenever, you are mentioning that code you also mention the year because, it differential year say 1978 is 456 days that 1 you have to mention the year also otherwise, it is not complete because there are so many revisions; so, 1978 may have other say number. So, that is why you should mention the year of publish that is when, it is revised.

So, maximum stress test we are getting 2.8 Newton per square millimeter that means; that if our nominal stress say, it comes more than that then we have to change the section. So, 2 v equal to vu by b times d what about this b; b is the width of the web though we are taking, we are talking say your t-beam that here, you have to take b as the width of the web vu equal to 105.63 into 10 to the power of 3 divided by 250 times 340. And it comes as 1.2427 Newton per square meter.

So, it is less than 2.8. So, no need of changing the section. Now, what about whether, we need shear reinforcement, what about the shear reinforcement that; we have to find out. We can get it that 100 ast by bd and we have tow c and that we shall get it in table 19 is 456. So, let us write down table 19 is 456 2000. When you do the design you always mention that, the reference clause or table of the code; that always you have to mention and we generally we do it in this side.

In the right hand side generally, we refer all these things. So, we can get it because, it is 1.47. So, 1.25 if, it is the tensile reinforcement percentage, which comes as 0.67 and if, it is 1.25 then it is 0.72. This 1 the part of the table 19. So, appropriate that values 1.25 1 .5 because, you have to take it 1.47. So, tow c you will take it linear equal to 0.67 plus 0.72 minus 0.67 by 0.25 times 1.47 minus 1.25 which, comes as 0.714 Newton per square millimeter.

So, this is the tow c which, will be taken care of by concrete the shear stress this portion that tow c times bd whatever, shear force we shall get that 1 will be taken care of by the concrete, which will be due to the that aggregate interlocking and compression of the concrete zone, and also the double action of the reinforcement steel. The tensile reinforcement steel so, that composition total we shall get it from table 19. How much we shall get and that is coming here, to tow c equal to 0.4714 Newton per square millimeter. And which is less than tow v the 1 we have computed.

So, this is your tow v which, we have computed which is coming as 1.2427, which is greater than 0.714. So, we need shear reinforcement.

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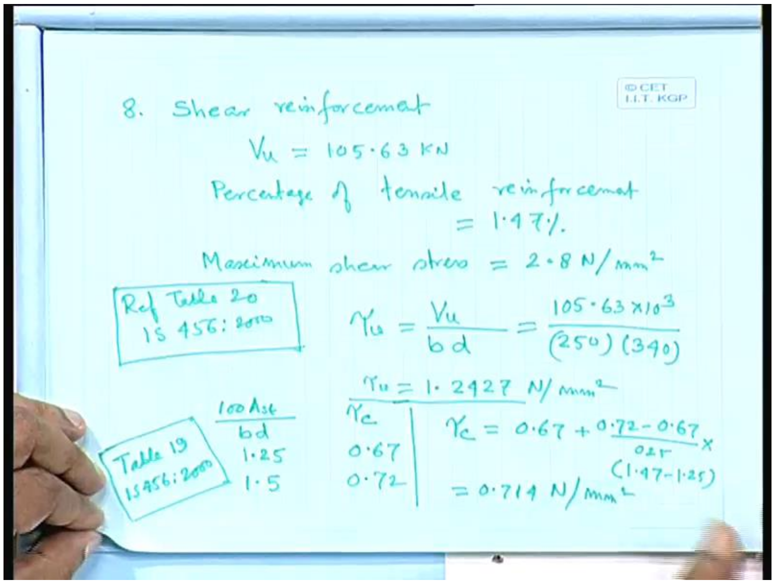

So, in our case; we can write down that tow v greater than tow c, but and tow v less than tow c max. So, no need of changing the your say section, but we have to provide shear reinforcement. So, shear the concrete due to concrete say and let us say, that 1 vc so, vc equal to 0.714 times, 250 times, 340, which comes as 60.69 kilo Newton. Shear to be taken by steel vs say equal to vu minus vc 105.63 kilo Newton minus 60.69 kilo Newton equals 44.94 kilo Newton.

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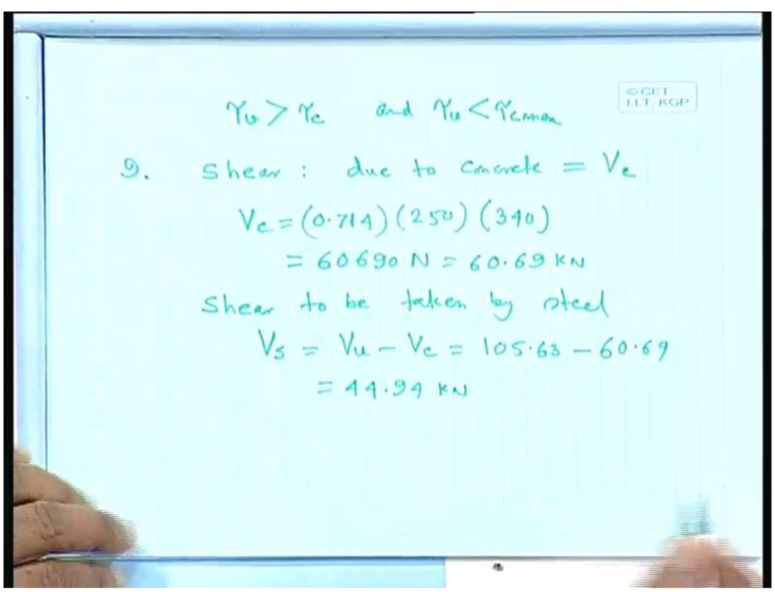

What about vus. Let us go the next page then vus that is: as per the code 0.87 fy times, asv times d divided by sv the spacing asv by sv equal to vus in our case divided by 0.87 fy d or asv by sv equal to 44.94 into 10 to the power of 3 divided by 0.87 415 times, 340 equals 0.366. This the 1 asv by sv we can get 0.366. If we use. Let us say, use eight mm tor. So, asv and we shall use 2 legged therefore, asv equal to 2 which will be equal to say 2 into 50 equal to say 100 square millimeter.

We can write down asv by sv equals 0.366. So, sv equal to asv by 0.366 equal to 100 by 0.366 equal to 273 millimeter sv equal to 273 millimeter.

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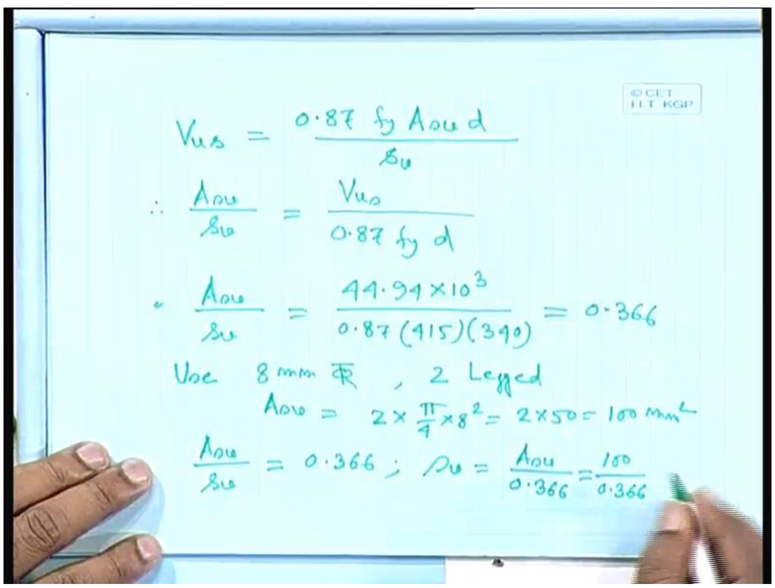

So, let us write down the spacing sv 273 millimeter. We are using 8 mm tor 2 legged. What our code says that: maximum spacing a 0.75 d 0.75 times 340 equals 255 millimeter b not greater than 300 millimeter output says. So, minimum of this minimum or I can say, lesser of the above 2 equal to 255 millimeter. So, it is governed by this 1. So, we can provide though it is maximum spacing here 273, here 255, here 300. So, we can specify use 8 tor 2 legged at the rate of 250 millimeter center to center.

So, this is the 1 that we are providing, it is always better that after this, it is always better to summarize our result, it is always better to summarize our result. So, what we can do then.

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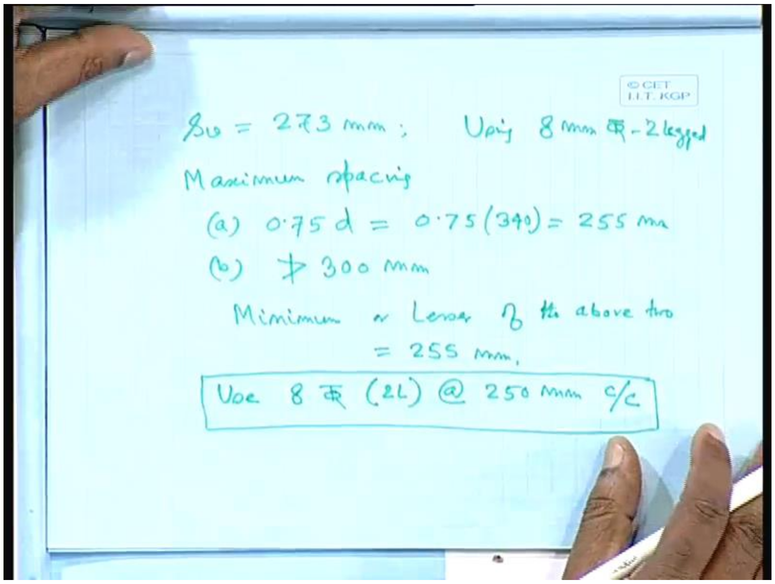

We shall provide the t-section, we are here 125. And this 1 250; we have 4 420 and the stirrup other 2 bar, we are ah just providing say: that we need not specify here, but anyway because for our design we shall not specify. So, we shall get 250, 420 tor 8 tor 2 legged at the rate of 250 millimeter center to center. Concrete m 20 steel fe 415; that only we have taking fe 415. So, anyway so, that we have used this 1; clear cover.

Let us mention, 25 millimeter main longitudinal tensile reinforcement 420 tor, stirrup 8 tor, at the rate of 2 legged , 2 legged at the rate of 250 millimeter center to center. So, this your the summary of the results it should be at the end you should summarize the whole thing. Because finally that; this 1 only will go for drawing or to the draftsman because, they dont need any calculation all those things, it should be very clear. And though, it is not mentioned.

So, we can provide let us, complete this 1 that hanging bars. Let us take here, that 2 10 torque. This is not in our calculation; it is not mentioned to complete this figure. Let us take, this is 2 10 toque because, it is not you are just providing the minimum 1. So, we can provide 2 10 torque. So, this is that your whole design that step by step that you have to make it that whole design step by step you have to make it for your say flexure as well as for shear.

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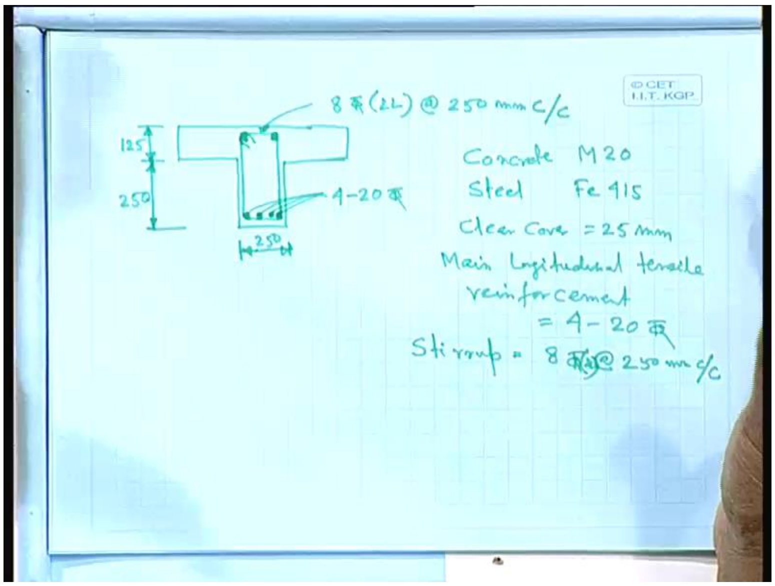

Let us, solve 1 more problem I think that 1 will give you; that your for the nominal shear here. So, design of stirrups for nominal shear. Let us, take b equal to 250 millimeter, d equal to 450 millimeter longitudinal, tensile reinforcement that is: 520 tor, vu that shear force that is: the factored 1 60 kilo Newton concrete m 20 steel fe 415. So, what is the effective depth. Effective depth equal to 450 minus 25 is the clear cover minus the 20 by 2 that is: the diameter of the bar, half of the diameter which comes as 415 millimeter. Area of steel ast equal to 5 into pie by 20 square equals 1.570 square millimeter.

Let us, write down here percentage of steel p 1.570 into 100 divided by 250 times 415; 415, is the effective depth please not this is 415 is the effective depth, which we have computed here, it comes as 1.513 percentage; 1.513 percentage okay this p, we shall take it for our that tow c to calculate the tow c.

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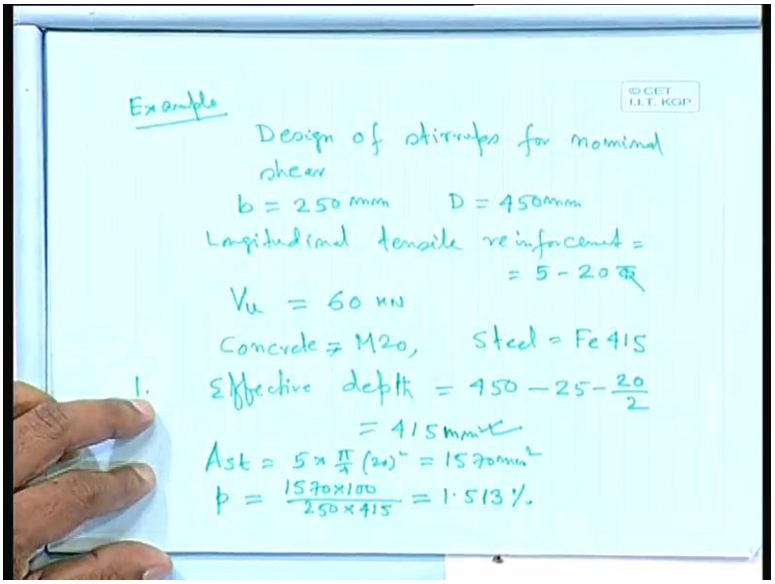

What about the shear force number 2: the that tow v equal to vu by bd v u equal to 60 into 10 to the power of 3 divided by 250 times 415 this 415 is effective with depth please note that the 1 the steel 0.578 Newton per square millimeter tow c max from table 20 of is 456; 2000, which comes as 2.8 Newton per square millimeter less than tow c max. From table 19, we shall get 100 ast by bd and tow c that we shall get 1.5 we are getting 0.72 this is in Newton per square millimeter, 1.75, 0.75.

So, tow c equal to 0.72 plus 0.75 minus 0.72 divided by 0.25 1.513 minus 1.5 percentage of steel, which comes as 0.722 Newton per square millimeter. So, tow c we shall get as 0.722 Newton per square millimeter and tow v 0.578 Newton per square millimeter.

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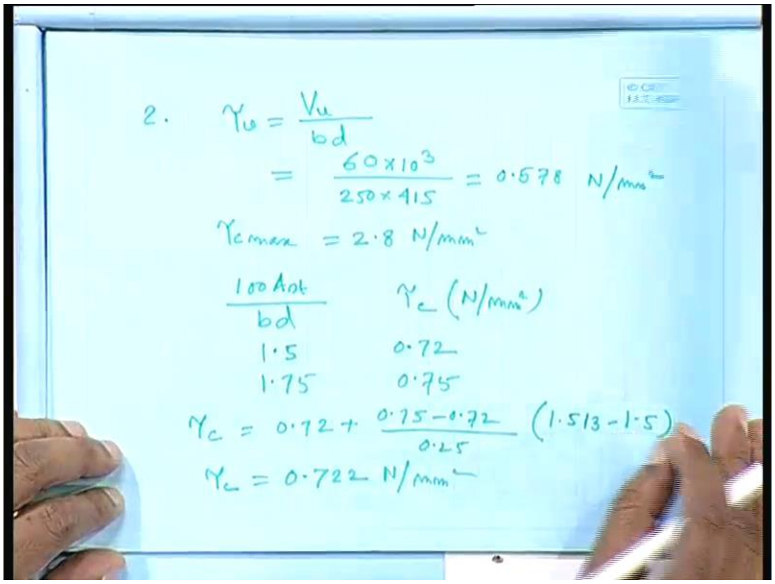

So, if we write down tow v 0.578 Newton per square millimeter tow c computed 0.722 Newton per square millimeter; tow c max 2.8 Newton per square millimeter. So, we can write down tow v is less than tow c and less than tow c max. So, we can write down only nominal shear reinforcement is required what our code says: our code says that: what will be the nominal shear reinforcement.

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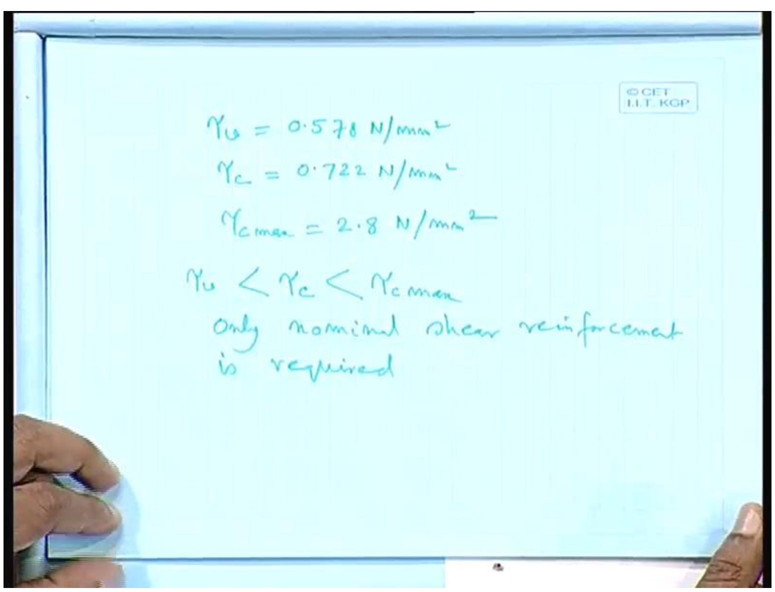

We can get it in clause 26.5.1.6 that, we shall get it 26.5.1.6 of is 456, 2000 here, that asv by bsv 0.4 divided by 0.87 fy 0.4 by 0.87 fy you can get, this value or asv by sv equal to 0.4 b times 0.87 times 415 equals 250 times. So, 0.87 asv equal to again s 0.87 times 415. So, you can get it. Let us, provide use 8 tor 2 legged. So, asv equal to again 2 equal to 100 square millimeter sv equal to asv by how much is this value asv by sv, which comes as 0.276.

So, asv by sv so, from there we can find out 0.276 equal to 362 millimeter. what about the spacing, maximum spacing a 0.75 d equal to 0.75 times 415 comes as 311 millimeter, b not greater than 300 millimeter that is: a numerical value mention in our code. So we are we can provide, we have to provide, the shear reinforcement stirrup 8 tor, 2 legged, at the rate of 300 center to center because we are taking 300 that is the 1 minimum and here 311.

So, we have to provide 300. So,8 tor 2 legged at the rate of 300 center to center that, we have to provide and that you can get it that is the 1 minimum that nominal reinforcement. So in your problem that, we have given so, there you have to take this you have to calculate according to these steps.

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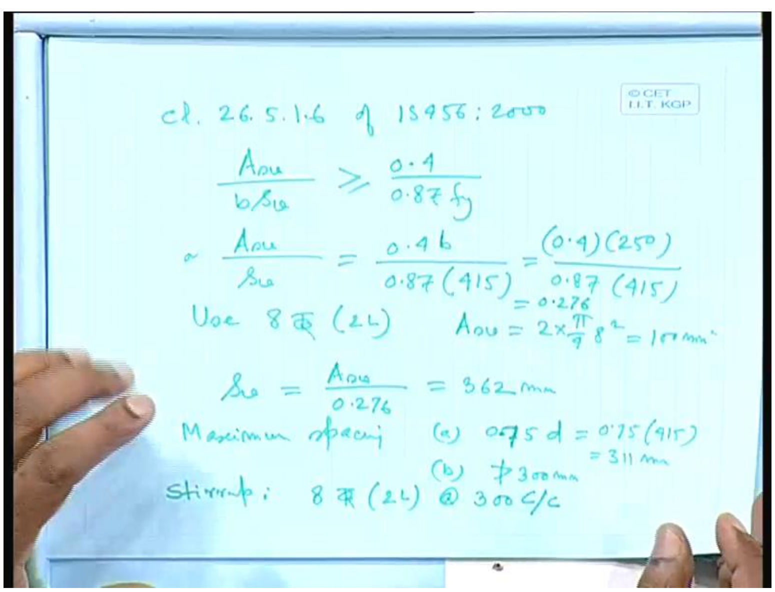

So, this is all regarding your say uh beam design that your flexure as well as say shear and it should be complete and it should follow that steps. And you should not keep everything in your calculated only then only in the final result not that 1 because sometimes you have produce your design calculation also. And there is another 1 say: the designer has done, it sometimes it has to be proof checked that means; that calculation everything done according to is codes, according to the analysis methods design.

So, that is again proof checked so, it should be rated by somebody else so, that is why your calculation all those thing if you do everything in your say only calculator and put the result then, it will be difficult may be it will be difficult for you also even after say may be 1 month or 2 months also or if it is more than it will be more difficult so, that is why it is a good practice that you have to refer your clause of is 456 or any other code which, you are using that is number 1.

Number 2: that your calculation you write your formula first equation first and what are the if you remember everything fine if the say asv, that is the convention if you follow that asv is for the shear or shear your say area of steel ast that is, the area of steel for the tensile reinforcement if you mention that way and if you can have in the very beginning of your report. The list of that your say symbols used so, that is fine and otherwise you have to mention what is that ast asv all those things that you have to mention that is number 1.

So, what you have to do, you have to use your formulas you have to write your formulas first and then you put your numerical values in the corresponding position wherever, you are used that formula that your say different variables and then you write down the final result; not the 1 you have used your formula, written your formula and then finally your writing that you say equation and final in result then, it will be difficult for you to check it; if it is required.

This is that always you do it and you use and you write down your that clause tables whatever, you are using say for example, in table 19 whenever, you are using I am writing that one say your that percentage of steel and corresponding tow c again percentage of steel and corresponding tow c that I am mentioning and then I am again writing that 1 because it helps in future otherwise in the calculation itself, I can do it but in result sometimes if you do any mistake then again, it will be too much confusing so that you have to avoid.

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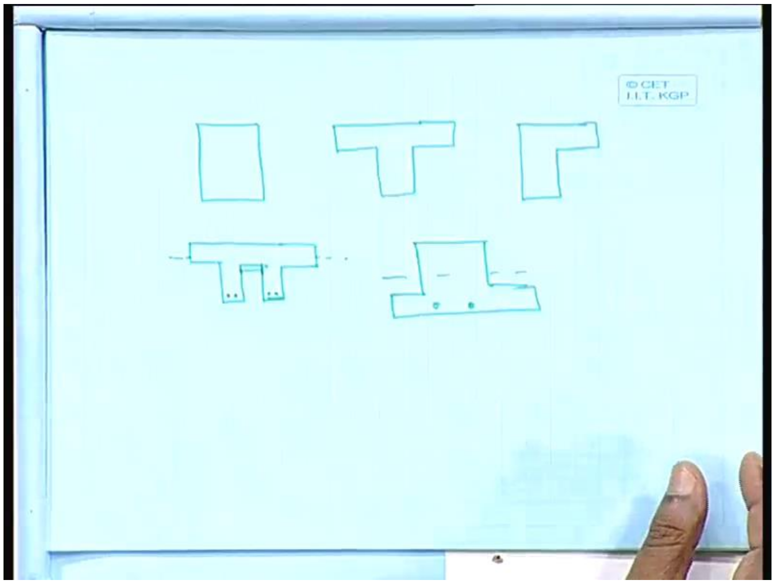

This is one part, the second part that not necessarily that your section will be simple rectangular or t-beam or l-beam not like, that sometimes you have to design your section which, may be some say your different shape say it may happen like this also, if we take this one up to this may be due to from the architectural point of view or may be from some other view say, we would like to provide your say tables all those thing through that. So, whatever you have this is also another section.

So, here gain it is nothing but the t-section because that your neutral axis if it comes within, if you can provide within the flange then there is no problem because then, it is the simple say rectangular 1 only. And another part the concrete is not taking any load or anything any moment. So, whatever reinforcement you are providing here so, that is the 1 your area of steel. So, it is nothing but again you can say this nothing but your t-beam or again you can come back to that 1 otherwise if it comes the other option the neutral axis. So, then you have to do that your calculations. So, in this case, it is always preferable that I shall keep the neutral axis that is one way of tricky solution, that your providing the solution within that limit. So, our calculation and other things will be easy. So, this is this is your one problem, it may happen say sometime, it may happen though, it is not 1 but sometimes, it may happen that it can be something like this also the other way. But even then your reinforcement whenever, you are providing the reinforcement here, but this one will not come into picture when that your neutral axis is within this limit.

So that way you can solve your different problems that you can solve. So, your problem for example, purpose other things that this type of cross section may come so, that also you can consider.

Thank you.