Design of Reinforced Concrete Structures
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Lecture-17
Design of Slabs Part IV

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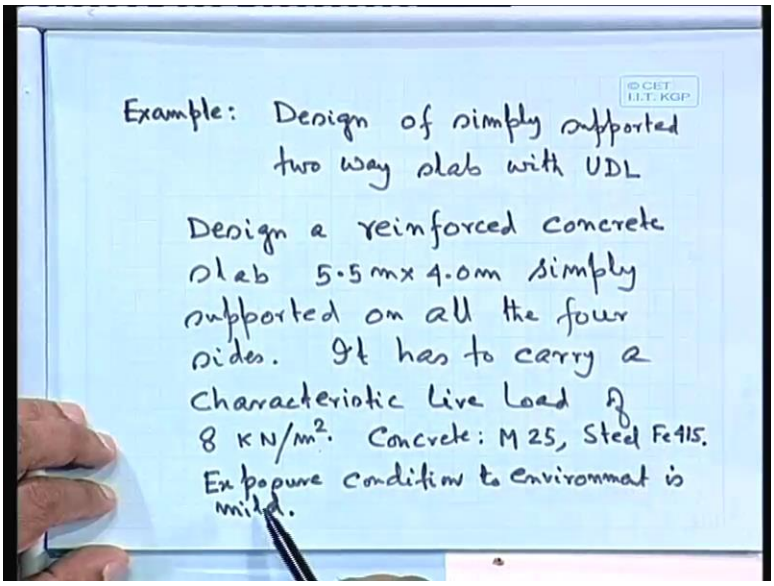

Lecture 17 design of slabs part 4. So, we have come to the part 4 of design of slabs, let us do 1 problem answer simply supported case and other 1 we shall solve according to say table 26, that is your continuous 1.So, here we shall solve example: let us state the problem first, simply supported two way slab with UDL please note uniformly distributed load we are talking. So, what we have to do; let us write down in the in a very explicit manner design a reinforced concrete slab. The dimension is 5.5 meter into 4.0 meter simply supported on all the 4 sides. It has to carry characteristic; let us say, live load of 8 kilo Newton per square meter concrete M25 and steel FE415. Exposure condition to environment is mild. So, this is your that problem

So, 5.5 meter by 4 meter so; obviously, this is a case of two way design of two way slab problem. It is supported on all 4 sides it has to carry a characteristic live load not the factored 1; that means, you have to multiply 1.5 that is quite high that is 8 kilo Newton per square meter concrete M25 and steel Fe 415 exposure condition to environment is mild, because this 1 will give you to choose or assume the cover because you are having different cover for different exposure condition. So, in this case we shall take it as say 15 millimeter and we shall provide that, bar less than equal to twelve millimeter dia bar. So, we can use a 15 millimeter that you say cover.

So, number one thickness of slab so, in our case let us assumes that 4.0 meter centre to centre and that is our effective span also, in our case we shall consider because there is no such support condition or anything nothing is mentioned. So, we shall assume in this case that 4 meter is your say effective span. If it is mentioned that, you have support that you say width of the masonry or the support then, we have to calculate you say effective span, but here in this case we shall take it as a 4 meter and cover to mild exposure equal to 15 millimeter.

Now, we can find out in clause 24.1 of is 456 there is a note quite states that, for simply supported case that, this is for span by overall depth please note that overall depth it is written as overall depth simply supported case it is 35 continuous it is 40; it further mentions let me write down here, for high strength deformed bar that is say here Fe 415 the above values, let me write down exclusively should be multiplied by 0.8 just to mention. For high strength deformed bar as per example: Fe 415 in our case the above value should be multiplied by 0.8.

So, span by overall depth we can get it and we can find out and we can take it say; so, what we can do it here, we can find out the corresponding value and which is coming as 0.8; I think, I should check it once more. So, page number 39; yes and it further states there are few things it further states that, for 2 way slabs of shorter spans up to 3.5 meter with mild steel reinforcement the span to overall depth ratio is given below may generally be assumed to satisfy vertical deflection limits for loading class up to 3 kilo Newton per square meter loading class up to 3 kilo Newton per square meter.

So, here and for there simply supported slabs that, is your 35 and continuous slab 40, for high strength deformed bars of grade Fe 415 the values given above should be multiplied by 0.8. So, this your clause, but here in our problem; please note it is told there for mild steel and this is your say, 3.5 meter up to 3.5 meter, but in for case it is more than that that is number1valuation. Number 2; it is not 3 kilo Newton per square meter it is 8 kilo Newton per square meter in our case; that means, it will little bit violate that rule. So, here what I should say, what I should say here; that means, the these are all sometimes these span by depth ratio sometimes it may mislead to you it may mislead you.

So, that is why and even then we take it as you say first assumption. So, in our case let us take it say, we shall assume do it as given 35 let us take, span by depth let us say overall depth itself. Let us take, I shall take it say thirty and further, I shall modify with 0.8; I say we shall multiply with 0.8. So, the span by overall depth for this problem we shall take it say 30 into say 0.8 say 24. If I am taking this span by overall depth that, 1 shall I am taking 30 because that, 1 in our case say mild steel why, I am taking that 1 for the time being because, it is not exactly matching with say your that, mild steel because in our clause say, if it is for mild steel up to 3.5 meter and also the loading that, 1 will be more than say it will be not over say 3 kilo Newton 3.5 possibly 3 kilo Newton per square meter.

So, 3 kilo Newton per square meter and 3.5 meter in our case I do not know; in our case, I do not know, whether this value will help me that is why I am going say, 30 or otherwise, what I can do let us try 1 problem here because in this problem. Let us try first, let us see may be it is not economic, but at least it will be safe that is our guideline that is our first attempt, when you are doing this problem say first time. So, what we shall do, let us keep it in a safer side and that is why I am taking 30. So, at least I know that it will be in the safer side, but if I take 35 times 085 take. So, 35 times 0.8 let us take which comes as 28. So, I do not know whether at the end after providing the percentage steel I do not know whether it will be safe or not.

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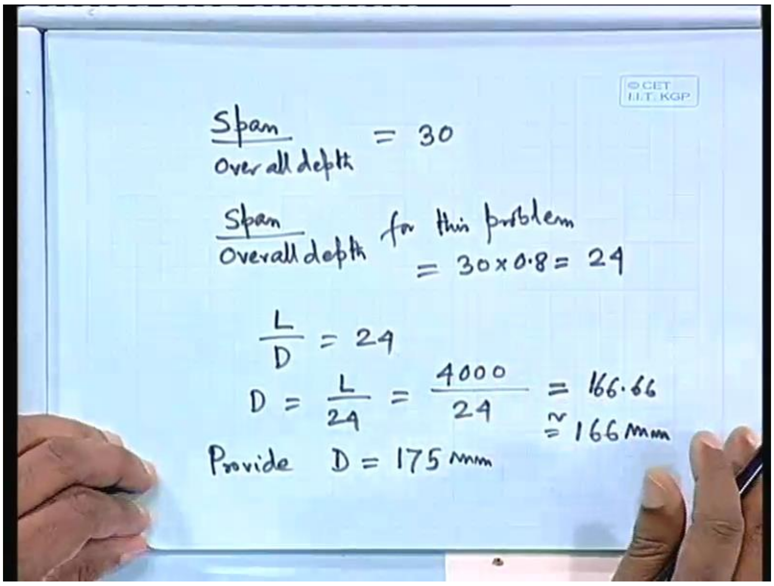

So, it is not the case of only for the bending, but we have to check it from the control of deflection . of v also and that if this span by depth ratio only will help us to that keep it to make us, in all within the, what is called within that control of deflection that is a span by 350 or span by 250 that is the guideline for the overall deflection. So, it is only with these I can keep it within that limit. So, here I am taking this 24 that 1 and it will be may be safer side. So, I can write down here L by D equal to 24. So, D equal to L by 24 and l equal to here 4000 that is in the shorter direction divided by 24 which comes as. So, 166.66; let us take 166 millimeter.

So, what we can do it here; let us provide D equal to 175 this is quite high generally in this type of slab, for most expensive find out it should be 150 may be sufficient, but any way let us take for the first problem let us take equal to 175 millimeter.

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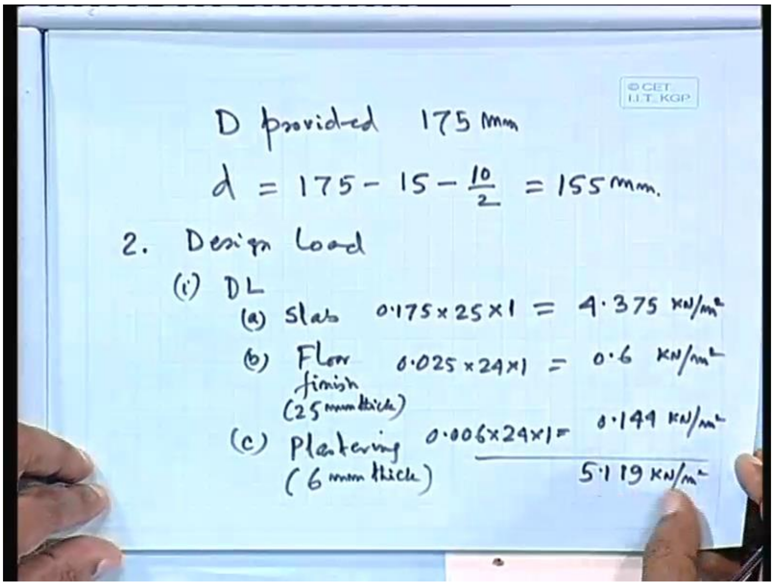

So, D provided 175 millimeter. So, D should be equal to 175 minus clear cover 15 for mild exposure minus 10 by 2, which comes as 155 millimeter. Number 2 we shall take it here as design load, 1 is the dead load it can have so, many components say slab 0.175 into 25 into 1 meter width which comes as 4.375 kilo Newton per meter let us write down per meter width we are talking. So, I can do not have square floor finish let us take floor finish of say, 25 millimeter. Let us take floor finish, 25mm thick. So, I am taking 0.025 into 24 into 1which comes as 0.6 number plaster; let us take 6mm thick which comes 0. 0 06 times 24 times 1 equal to 0.1 44 kilo Newton per square meter, which comes as 5.19 kilo Newton per square meter. What is the live load?

So, 5.119 kilo Newton per square meter is the dead load live load that, number 2 live load equal to 8 kilo Newton per square meter; therefore, the design load the factored equal to 1.5 times dead load plus live load equals 1.5 times 5.119 plus 8 equals’ 19.6785 kilo Newton per square meter. Now, we have to find out the for this load we have to find out the moment maximum factored moment Ly by Lx equals 5.5 by 4. 0 equals 1.375. Let us take it from table 27 is 456 2000 Ly by Lx for 1.3 it is coming between 1.3 and 1.4. So, alpha x which is given as 0.0 9 3, 0.0 99 alpha y 0.055, 0.051.

So, I am taking that interval only 1.3 1 0.4 because it is between 1.375.So, we can calculate that alpha x and alpha y from these values we can find out. So, let us calculate that for Ly by lx equal to 1.3 75 alpha x equal to 0.09 3 plus 0.0 9, 9 minus 0.0 93 divided by 0.1 times 1.375 minus 1.3 equals 0.0 975. So, we are getting some like this; this is the slope. Alpha y equal to 0.05 5.055 it comes like this. This is 0.055 here somewhere, we are getting 0.051.

So, 0.055 minus 0.051 divided by 0.1 times 1.375 minus 1.3; so, we can get and that value we are getting as 0.0 52. So, alpha x and alpha y alpha x and alpha y you can get and those values we shall use it in our calculation.

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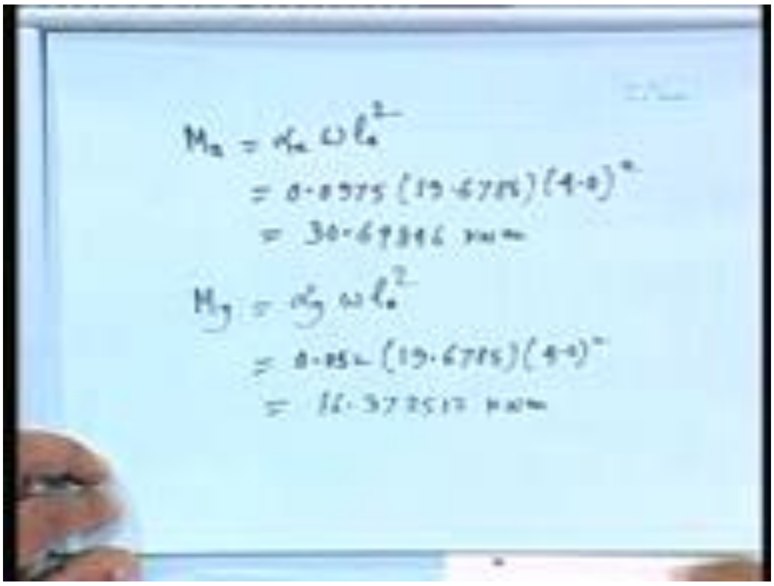

So, what is the value of then Mx equal to alpha x w l square x equals 0.0975 times 19.6785 times 4 square equals 30.69 846 kilo Newton meter My equal to alpha y w again l square x equals 0.052 times 19.6785 times 4.0 square equal 16.3 72512 kilo Newton meter. So, you can get Mx and my. Let us check depth; so, 30.69 846 kilo Newton square meter and this 1 so; obviously, we have check with this value. So, let us check depth; so, Mmax equal to 0.138 fck bd square; d equal to Mmax by 0.138 fck b equals. So, M maximum out of these 2 that, let me show you out of these 2 this is 30.6 9846 is the maximum.

So, we shall use this 1 for checking depth you then automatically this 1 also will be checked. So, 30.6 9846 into 10 to the power 6 divided by 0.1 3 8 fck M25. So, 25 times d is 1000 in this case, which comes as 94.3929 and less than 155 millimeter the depth which we have provided. So, 155 millimeter is effective depth provided and we are getting 94.39; that means, it is safe. So, what about the area of steel then, we can now calculate area of steel, we shall use this formula now it is we shall use it now on 1.2 minus root bar 1.2 whole square minus 6.6 mu divided by fck bd square. If we know, db everything.

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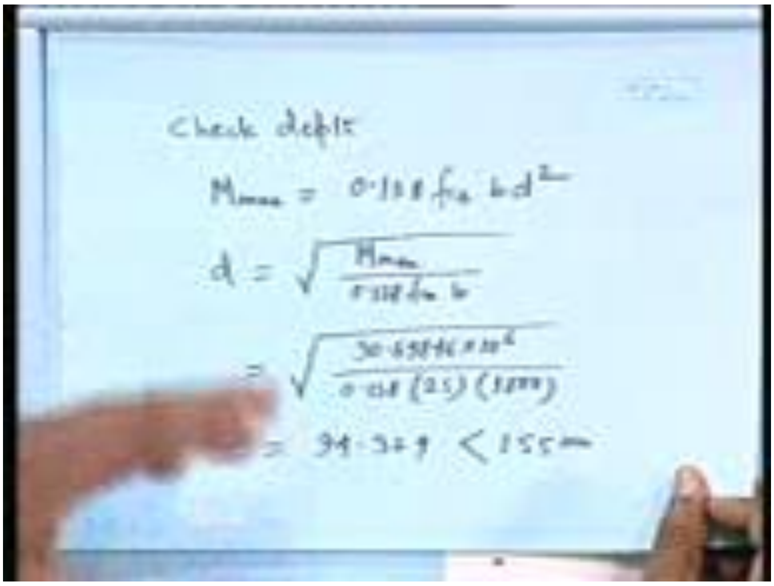

So, we can find out x by d; what is the value of this portion we can find out separately 6.6 mu by fck bd square equal to 6.6 multiplied by 30.69 846 times 10 to the power 6 in Newton millimeter divided by 25000 is the width that per meter width times 155 whole square, which comes as 0. 3373316. So, x by d equal to 1.2 minus root bar 1.4 4 minus 0.3373316 equals 1.2 minus 1.05; so, x by d equal to 0.15 less than. 0. 48 for 415. So, you can get x by d 0.15 less than 0.48 that we have to check. So, we know x by d; we can now calculate the lever arm.

So, the things that first thing whatever you are doing here the first thing is that you check or provide on the basis of that also it is not necessarily that, we have already provided, but it may happen that if you know the moment. So, from there you can find out d 94.329 from here itself you can provide the overall depth. If I forget the span by depth because after all later on we have to check it, if I forget that 1 we can what we can do for dead load calculation we can assume certain depth and we shall stop it there and shall calculate.

What we can do it here we could do other way also; that means, from d here itself we can provide our new overall depth may be say 94 plus 55 is your say which is coming 100 plus 15. So, 115 may be we can provide 120 millimeter overall depth or say 125 millimeter overall depth that also we could do, but anyway since we have already down that say 155 millimeter effective depth that we have already provided. So, on the basis of that let us continue the calculation.

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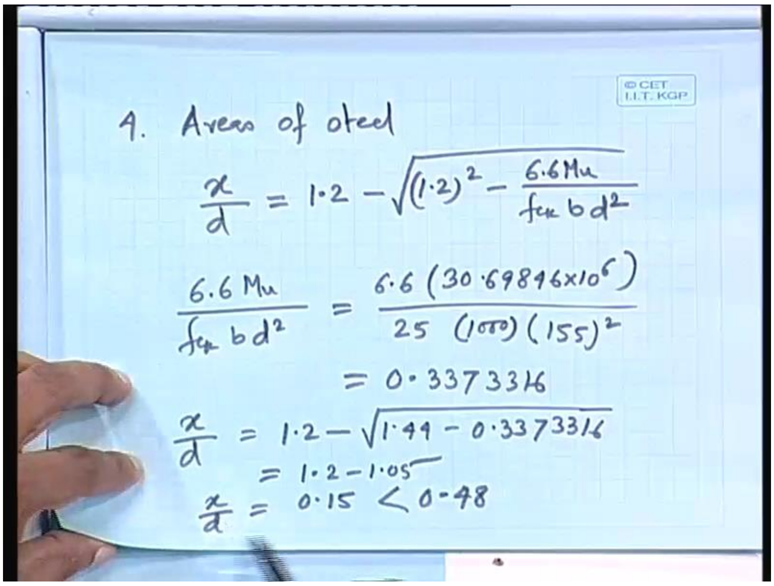

So, here we have to check whether x by d is coming within the limit or not. Now, let us find out the lever arm Z that 1 equal to d 1 minus 0.41 6 x by d equals 155, 1 minus 0. 416 times 0.15, which comes as 145.328 millimeter area of steel this 1 in the shorter direction. Let us say, Ast equals mu by 0. 87 fy that is the maximum stress permissible we are going up to that 30.6 9 846 into 10 to the power 6 divided by 0. 87415 times 145.328.So, this is your area of steel say we shall get it here 585 square millimeters. So, you can get area of steel computed that is 585 square millimeter

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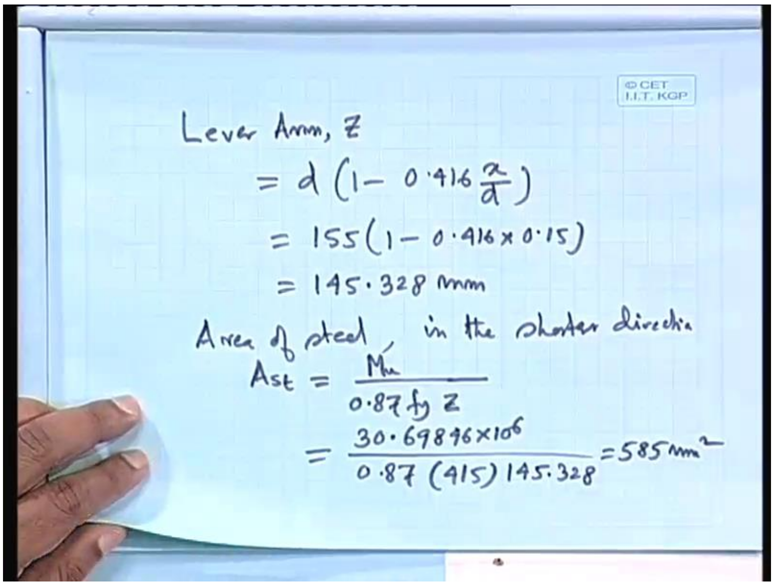

So, how much you shall provide then let us provide 10 millimeter dia bar. So, a area of steel bar equals 78.5 square millimeter; so, you can get this one. So, spacing required equal to 1000 because we have to calculate on the basis of say, 1000 millimeter power meter width times 78.5 divided by 585 which comes as 134 millimeter. Let us provide 10 tor at the rate of 134 we can provide 130 also. Let us provide 125 millimeter centre to centre. So, this is your that reinforcement in the shorter direction that you have to provide that 10 tor at the rate of 125 millimeter centre to centre.

What about the longer side longer side that you have to provide we are having movement in the direction that is 16. 372512 that is if the movement in the longer direction. So, you have to calculate the area of steel on the basis of this, but your effective depth is different, effective depth is not same as the longer one.

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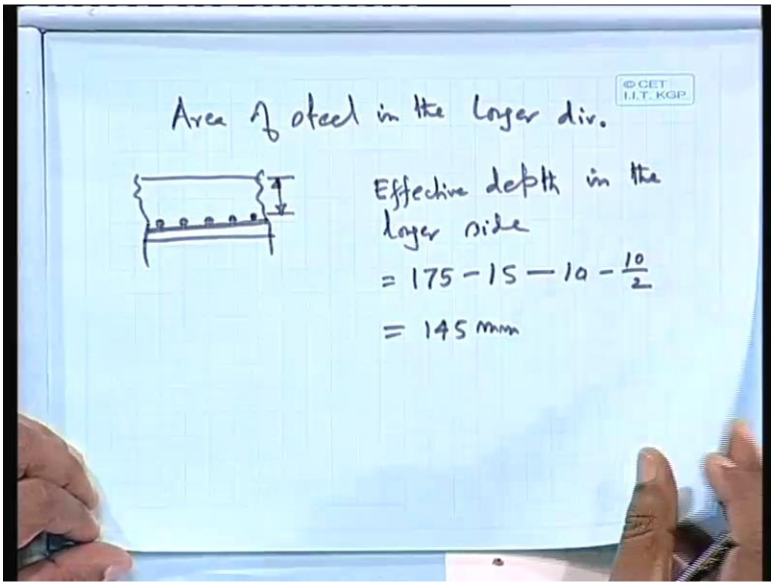

So, we shall do it here area of steel in the longer direction if this is your slab we can find out that 1 side we have I can say like this if this is your reinforcement, the longer side reinforcement will be such like this. This is your shorter side reinforcement and there is longer side reinforcement. So, if this is your longer side reinforcement your effective depth will be less. So, what we shall get it here then, the effective depth, in the longer side equal to overall depth minus 1 bar that is 1 bar dia meter that is your 10 minus 10 by 2 even if we provide say 10; so, we shall get this one.

This is the difference; that means, your effective depth in the longer side that will be reduced by the bar dia meter of the shorter side. So, that 1 it comes as 145 millimeter; so, we shall get this 145 millimeter. So, what we can do it now again we can calculate that x by d on the basis of this. What is the value of x by d then, x by d equal to 1.2 minus root bar 1.44 minus 6.6 mu by fck bd square. So, let us find out this part separately fck bd square equal to 6.6 times 16.37251 2 into 10 to the power 6 Newton millimeter divided by 25 bar meter width 1000 times 145 that is the effective depth which comes as 0.20558.

So, x by d equal to 1.2 minus root bar 1. 44 minus 0. 20558 equal 1.2 minus 1.11 equals 0.089. So, x by d we are calculating here let this is; obviously, less than 0.48; so, we need not change any depth or anything. So, you can take that x by d this value; so, we can calculate there now lever arm. So, lever arm will be equal to d times 1 minus 0.416 x by d. So, in our case in all the cases you will find out for slab we are basically we are using only 3 formulas. So, formula number 1 mu equal to 0.138 fck bd square formula number 1 that is mu equal to 0.138 fck bd square.

So, whatever effective depth you will get it computed on the basis of that we can provide the overall depth also and then find out the effective depth provided that is number one. Number 2; you have to calculate that x by d if I know mu; obviously, we know mu fck we know b also we know and d already we provided. So, there is on the basis of that we can find out the value of x by d; if we can find out x by d then we can find out the lever arm which d equal to 1 minus 0.416 x by d.

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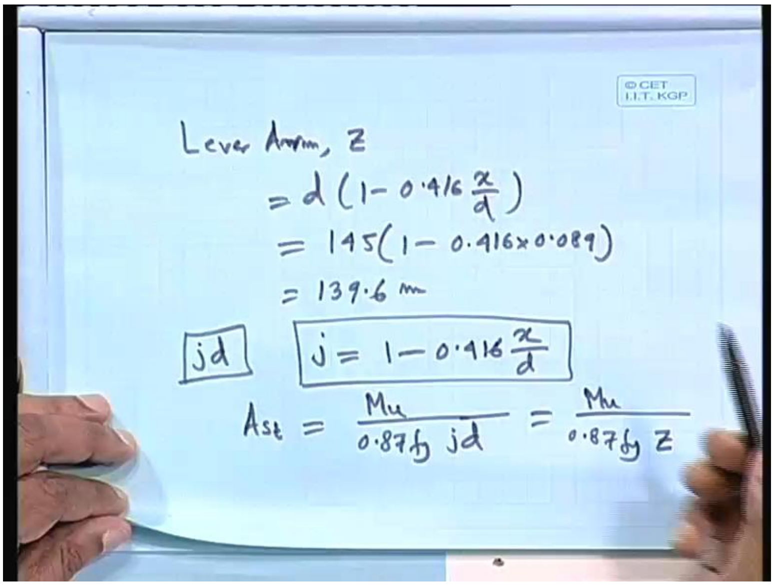

So, these are the 3 formulas we are using in the slab design and we can find out area of that area of steel finally. So, those 3 formulas and now lever arm Z equal to d 1 minus. 416 x by d, which comes as 145 1 minus not 155 because we are doing in the other direction 0.416 times 0.089; so, which comes as 139.6 millimeter. One check I should say, let us find out these value which comes as 0.416 into 0.089, which comes as a 0.9629. If you remember this also you can say j if you remember that working space method; if you remember that working stress method that we used to say jd.

So, this value is nothing but, here to just with the analogous to your working stress method I can say j is nothing but, 1 minus 0.416 x by d. This is the 1, I can say and in other way I can write down this equation in the similar fashion that Ast equal to mu by

0.87 fy that is the stress times jd is nothing but, lever arm also I can say. This 1 or in our case let us say mu by 0.87 fy times Z. So, this is the stress times the lever arm the same thing this is the 1 we used it in working stress method. The same 1 we can write down here also in other way I can say that, if you are familiar with that if you are interested to make it your working stress.

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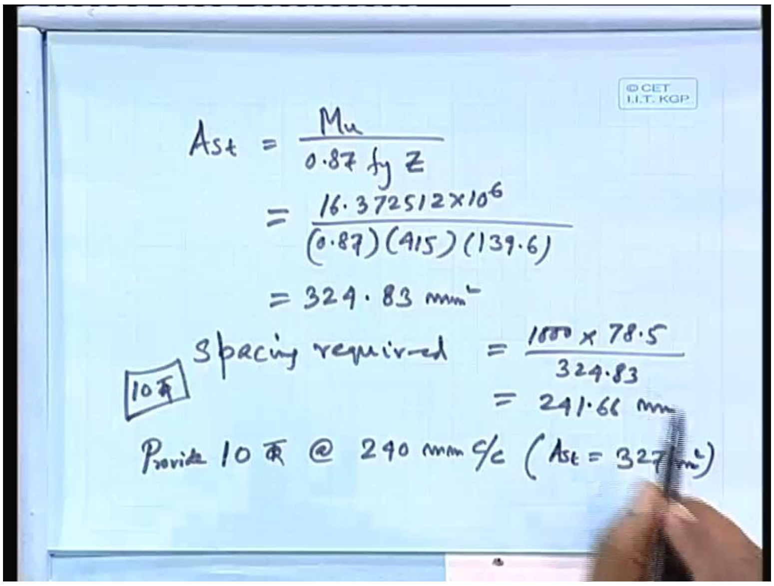

So, I acknowledge that jd; j is nothing but, this 1that way also 1 can write down. So, here Ast equal to Mu by 0.87 fy z; I think I should write down this 1 similar to working stress method. So, that jd that I should write down here; so, Ast equal to this much. So, Mu equal to16.372512 times 10 to the power 6 divided by 0.8741 5 times139. 6 which comes as 324.83; I think we can ignore these 4.83. So, we are getting this much. So, spacing required equal to 1000 times 78.5 I am using that 10 tor. So, 78 .5 divided by 324.83 comes as 241.66 millimeter; let us provide 10 tor at the rate of 240 millimeter centre to centre.

We can go little less also, but anyway. So, which is coming as Ast 327square millimeter it is always necessary to write down how much area of steel you are providing, because you may require later on. So, that is why you always write down this the other 1 last time also you have written. So, that you can check it; so, anyway this is up to this; that means, you are provided the area of steel in the longitudinal side as well as in the shorter side.

So, next part is you say check for deflection. So, percentage of steel along Lx equal to how which 1 shall we take we shall take that, how much actually needed. So, much required not the 1 how much you are provided. So, you are getting this 1; so, let me write down the needed please note 585 that which we have computed. How much we require not the 1 that how much you have provided please note that particular 1. So, fs equal to 0.58 fy time Ast required divided by Ast provided, which will equal to 0.58 times 415 divided by 585 divided by 608; which comes as 224 Newton power square millimeter.

So, you can show these which we had using that, figure 4 modification factor for tension reinforcement and this is the formula we have to use for fs, because that 1 will give you the guideline and we have got the percentage steel 0.3774 somewhere here when 3747 somewhere here, we have got it and that 224; it means, along this line it means along this line. So, we can say it may be somewhere here it may be somewhere here we get it which we take it as please note I think you can see that 1 that this is the 1 while we can find out that after that is 1.5 that I have taken it as 1.5.

So, modification factor for p equal to 0. 377 4 percent and fs equal to 224 Newton per square millimeter. So, that we can take it and we can find out that f equal to 1.5. So, available L by d equal to 20 times 1.5 equals 30.There is a case here that, you could find out that is 1 discrepancy in 1 side it is retained l by effective depth that, when you have told in the last 1 that, is L by that span by effective depth whereas, in this note they have written as span by overall depth.

So, this particular 1 we can take it as span by effective depth also we can also take it because therefore, beam and other things when you have use that say basic value 20 in that clause they mentioned that say you 20. So, I can just read it. So, that is in your say clause 23.2 0.1 it reads say other basic values of span to effective depth ratios for spans up to 10 meter cantilever 7 simply supported twenty continuous 26 please note it is written as span to effective depth ratios.

There has few things that, I think you should be mention clearly that this quote is not writing the other 1 is that the span to depth ratios. So, this is little bit say confusing some have in writing span to depth ratio some have that, in say span to effective depth the other part in writing say span to overall depth ratios that there in writing, but anyway; we shall take it say to be on the safer side we can take it say, if you take effective depth if you take overall depth then we shall get 1 value. If you take effective depth then also you shall get other value.

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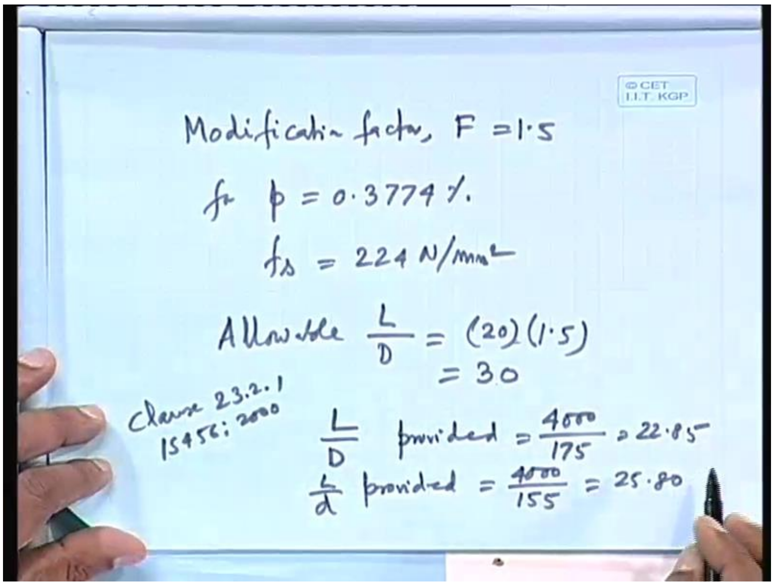

So, in our case at least we should be satisfied with the 1 that it suggested by all of them. So, anyway only the available 1 you are getting l by d that, 1 we are getting here this particular 20 by 1. 530 and L by d provided say if I say l by d provided; there were 2 values you are getting. So, 4000 by 175 which is coming as very less 22.85 where as if I say L by d 155 which is coming as 25.80. Now, let us see how much you have taken in the very beginning, let us find out. So, you have taken say you have 24. So, now, what is your status then, in 1 case we are safe and 1 case we are not safe, that is 1 that where the confusion comes.

So, 22.85 2 5.80 for the particular 1 here. So, we are getting 2 different values so; obviously, that here we have to find out. So, the thing is that 2 satisfy all of them in our case with that, in the quote itself; that means, we should modify our values and we should at least, we should be safe that a conservative designer what you will you do? You will do that particular 1 here that, case that you modify you will do it, but I shall wish to stop I shall be I shall find out this 1 will be within this limit. It will be all right that the other values you are getting within that it will be all right.

But as a conservative designer you will find out that you will again you calculate you will do it. For the most of the cases we have found that, 150 millimeter could be safer 1 for this case. So, the thing is that this is your simply supported case now we have to provide the you say that reinforcement that is your part that, we have to provide the reinforcement. What you have to do? We have 2 parts.

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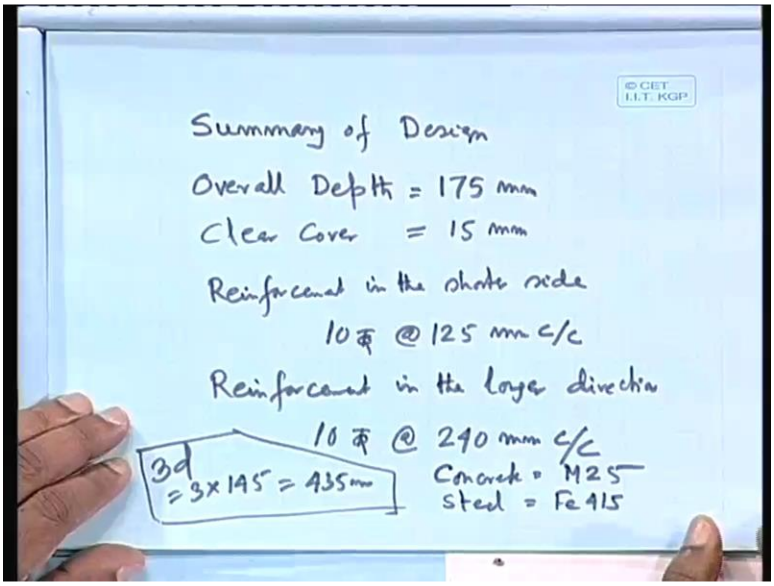

So, let us first summary overall depth 175 millimeter, clear cover 15 millimeter, reinforcement in the shorter side. How much we got it in reinforcement in the shorter side, 10 tor at the rate of 125 millimeter centre to centre, reinforcement in the longer direction. So, that you are getting it here 10 tor at the rate of 250 millimeter centre to centre.

Let us find out the 3d 3 times d 240 that is your 3 d, 3d means; how much we shall get it 3 times 145 which comes as 435; 3d means 3 times 145, which comes as 435 millimeter or 300 millimeter whichever is we are getting that, 1 it is within the limit of the spacing. So, that also you have to check I am telling you that 240 millimeter that is, the 1 spacing you are providing. Now, you have to check that 1 as per is 456 it should not be more than 3d 3 times the effective depth.

So, in that case we are getting that 1 here 240 and 3 d means here 435. So, let us see I can show the clause that is spacing of bars. So, I think I missed it somewhere yes we can find out effective span all those things we have got it. So, we can find out, minimum slab yes, you all getting the between the bars. So, between bars horizontal distance between parallel and main reinforcement bar shall not be more than 3 times the effective depth of slabs or three-hundred millimeter whichever is smaller. So, here that is, the restriction we have to provide. So, it should not be more than in our case it should not be more than 300 millimeter.

So, there what we are getting it here this is you that summary of design and also you have to made that, concrete M25 we have used and steel fe 415. So, at least this much it should go to the drafts man and from here, he should be added to that make the drawing. But it does not we do not stop it here, but at east that the drafts man require at least 1 sketch, structural sketch, design sketch while at least your that bar reinforcement all those things are given though our quote gives that, why is the curtailment all those things though it mentions when we expect that drafts man who is doing that 1 at least he is little bit reluctant that technical part.

So, he will be able to provide that 1, but finally, the responsibility comes to the designer that, who has designed the responsibility comes to the designer and he will only satisfy whether it is collect or not. So, but at least it should be here and then, from there we can make the drawing for that, we have drawing that we can make it. So, I think we shall make it in the next class, that the detailing of that we shall make it separately that is 1 part and we generally the concept that 1 what is the design process.

The design process is that the designer will do the design then, drawings will be made. So, your design calculation and your drawings that 1 should be compliant each other; that means, whatever in the design book that design reward and whatever in the drawing that should come same that is 1 part. The other part here that, it does not stop it there if the client requires or needs that repeats if he desires he can again go for further checking and that is called proof checking or the other way you can call that batting that it should be batted that root.

So, design and drawing should be batted by a third party third person meant to say, any academic institute like us. So, something we do it like that 1 again what we do we again go through the design calculation and also the drawing and whether it is as per you're quotes or the relevant quotes or reports whatever it is. So, then only we certify this is alright and then only it is goes for your construction. This is the process which is not the 1 very simple 1, but it is say very regular process. I think I can stop it here. So, today tomorrow we shall continue the next one. Thank you.