**Design of Reinforced Concrete Structures**
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**Lecture-15**
**Design of Slabs Part II**

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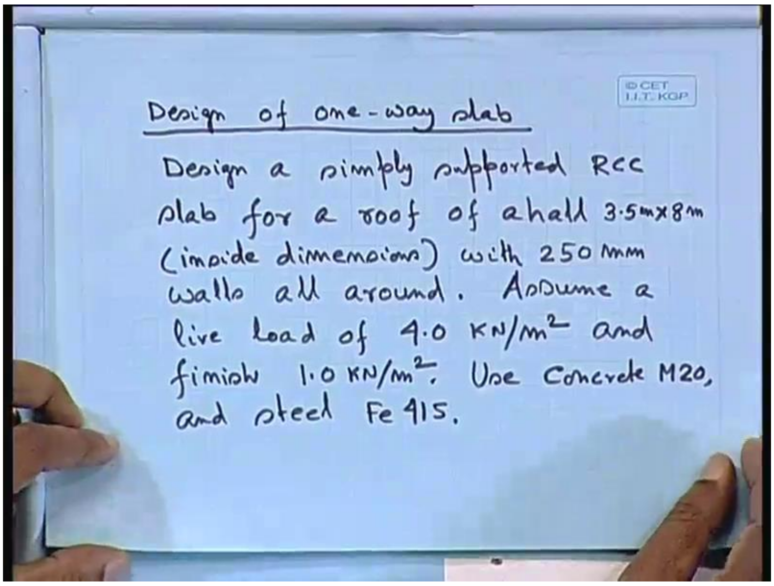


So, welcome today's lecture; today we shall continue the same design of slabs and that is part 2. So, and this is our lecture number 15, design of slabs part 2. So, let me first remind you the problem that which we have started solving in the last class, that design of 1 way slab we have started with the design of 1 way slab. Design a simply supported RCC slab for a roof of a hall; 3.5 meter into 8 meter inside dimensions with 250 millimeter walls all around.

Assume a live load of 4.0 kilo Newton per square meter and finish 1 kilo Newton per square meter concrete grid M 20 and steel Fe 415. Just to show you what we have done. so, far how far we have done. So, we have done the calculation of factored loads step one and that, we have done on the basis of step span by depth ratio.

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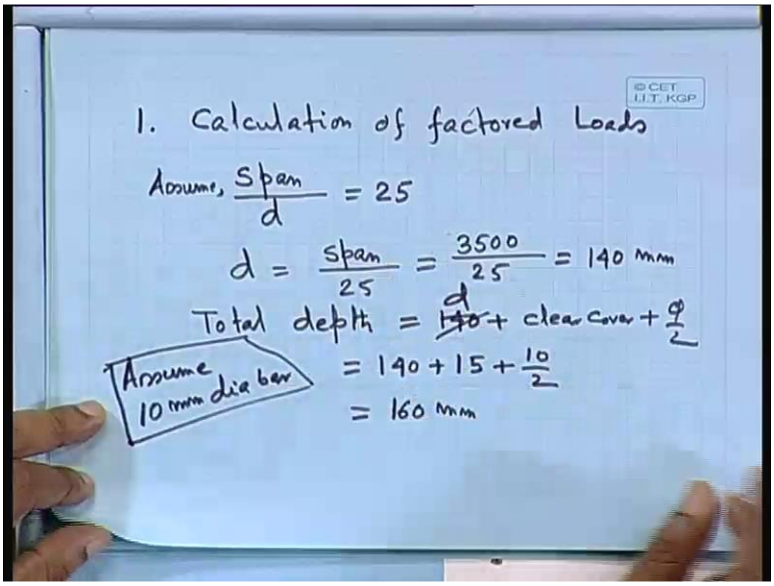


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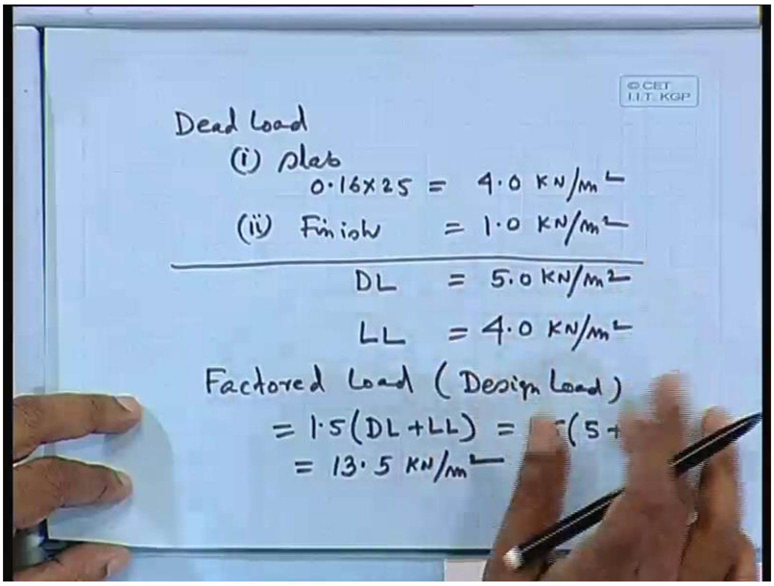


The next 1 we have calculated dead loads, on the basis of assumed thickness of the slab and finish already you have taken on kilo Newton per square meter, live load of 4 kilo Newton per square meter.

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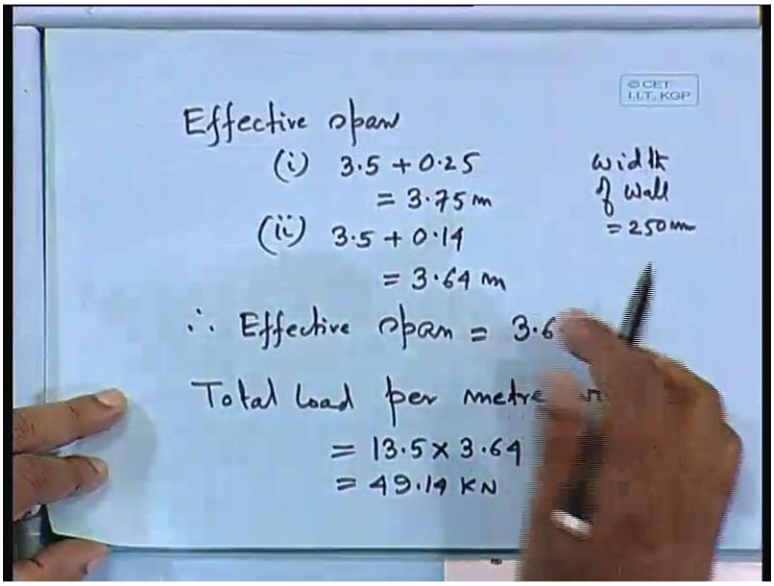


We have to calculate effective span, that also we have calculated and effective span we have got out of these 2 the lesser 1 that is 3.64 meter and total load per meter width of the slab that is 49.14 kilo Newton.

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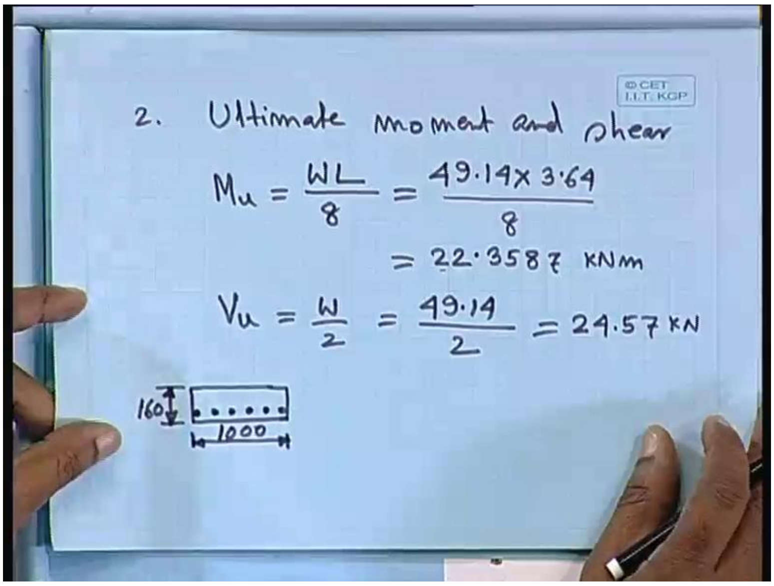


And finally, we are getting the ultimate movement as shear which, we have to do it for design and that we have got it mu equal to 22.3587 and Vu the shear force 24 .5 7.

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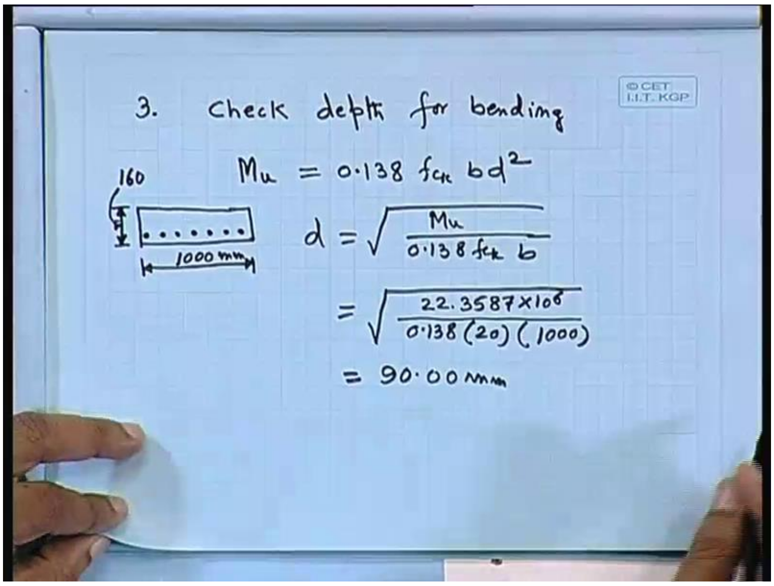


So, let us start the check number 3; check, depths for binding we have to we are considering binding first. So, you have to consider binding here. We shall use the same beam formula of rectangular beam only difference we are taking 1 meter; that means, 1000 millimeter and this is your overall depth which is 160 in our case. We have to provide the reinforcement in the slab that we have to provide as reinforcement of the slab. So, we are taking the rectangular slab the rectangular beam, 1 meter width and depth we have assumed 160 millimeter and that, we have to check whether that is sufficient.

So, mu equal to 0. 138 fck bd square; d equal to root of Mu by 0.138 fck times b; movement equal to the movement we have calculated that is, 22.3587 kilo Newton meter. So, movement we have calculated 22.3587 kilo Newton per meter; so, 22.3587 into 10 to the power 6 Newton millimeter divided by 0.138 times 20 times 1000 equals 90 millimeter and which is, less than 140 millimeter; the effective depth that we have got it. So, d is equal to 160 minus 15 minus 10 by 2 which is coming as one-forty millimeter; this is the 1 that we have we have providing.

So, d computed to make it clear; d computed equal to 90 millimeter less than d provided equal to 140 millimeter this quite high of course, but anyway we shall come back again. So, this you that check; so, which is all right, but not economic.

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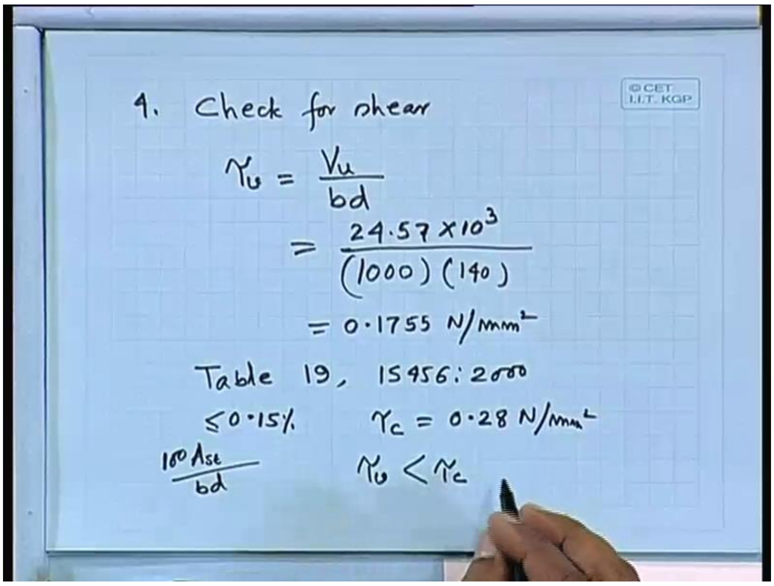


Number 4; check for shear. So, what about tov v equal to Vu by bd equals just once more let me show you that, Vu equal to 24.57 kilo Newton. So, Vu 24.57 into 10 to the power 3 Newton divided d 1000 times d 140 which comes as 0.1755 Newton per square millimeter Table 19 is 456 :2000 it gives for less than equal to 0.15 that is equal that this is what is this 1 this is Ast 100 Ast by bd. For this 0.15 percent we get tov c equal to 0.28; this 1 we will get it in table 19 is 456 tov c 0. 2.

So, tov v less than tov c. So, we do not need any that shear reinforcement and that we do not need any stirrup. So, that why we do not provide the stirrup, but for other purposes we may need it.

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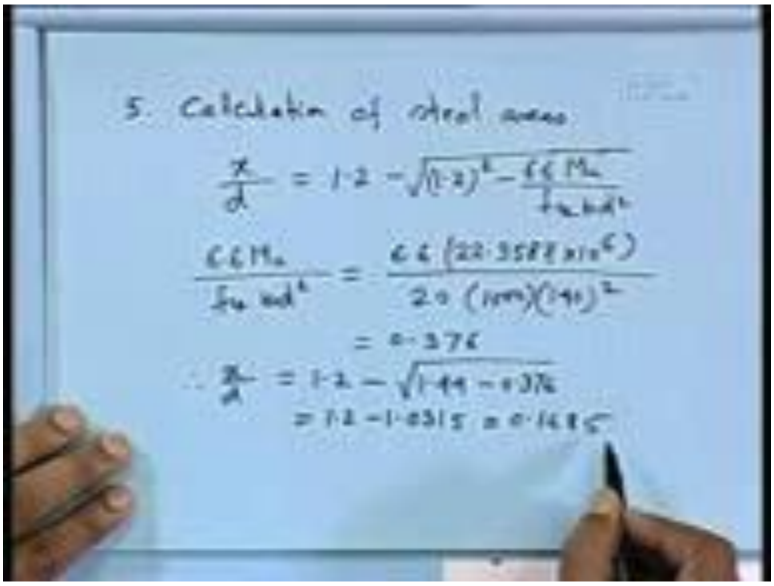


Number 5 calculation of steel areas. So, directly we can calculate this or we can go from the mu that formula or directly we can remember this formula 1 point 2 minus root bar 1.2 whole squares minus 6.6 Mu by fck bd square. So, this formula we can directly we can use it if you can remember otherwise, you can start from the first principle that using the same formula. So, 6 .6 mu by fck bd square equals 6.6 times 22.3587 into 10 to the power 6 Newton millimeter divided by 20 times 1000 times 140 square which comes as 0.376. Therefore x by d equal to 1.2 minus root bar 1.44 minus 0.376 equals 1.2 minus 1.0315 equals 0.1685. So, what about your Zx by d this is less than 0.48; x u yd this is less than, 0.48; as I said write down this is less than 0.48.

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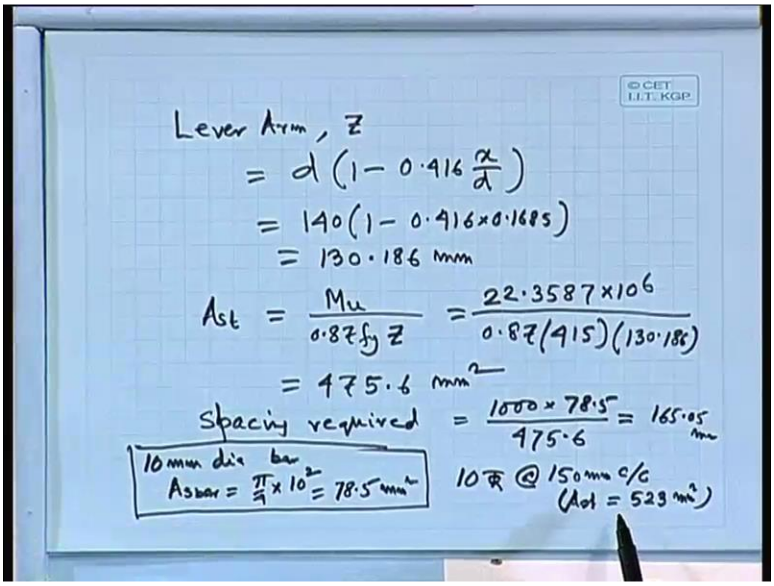


So, we can calculate now the lever arm we can now calculate the lever arm. So, what about your lever arm lever arm Z equal to d1 minus 0.416 x by d equals d equal to 140; 1 minus 0.416 times 0 point 1 6 8 5 equals 1 thirty point 1 8 6 millimeter

What about then area of steel area of steel equal to mu by 0.87 fy times Z equals 22.358 7 into 10 to the power 6 divided by 0.87 times fu 415 times 130.186, which comes as 475.6 millimeter square. What about the spacing, spacing required because here we do not provide the number of bars here we provide that how many bars at what spacing we will provide the reinforcement. Unlike say, your beam where we provide the number of bars 3 bars 4 bars like, but here we provide that 10 millimeter at the rate of that spacing we provide the where we providing stirrup.

So, spacing required 1000 times; so, how many bars we require 475.6 that, is the area of the steel individual bar. Let us take say 10 millimeter; so, we can get as bar if i consider. So, we can get here 78.5 equals 78.5 and which comes as, we are assuming that we shall provide 10 millimeter bar and we are getting here 165.05 millimeter. So, we can provide 10 at the rate of we can provide 160 also, but let us provide 160.So, 150 millimeter center to center and the area of steel provided, that is coming as 523.

So, this is your 10 at the rate of 150 millimeter center to center area of steel this is provided and area of steel this is computed; 1 is computed and another 1 is provided. So, you have to check that how much actually we are providing. So, we are providing here 523.

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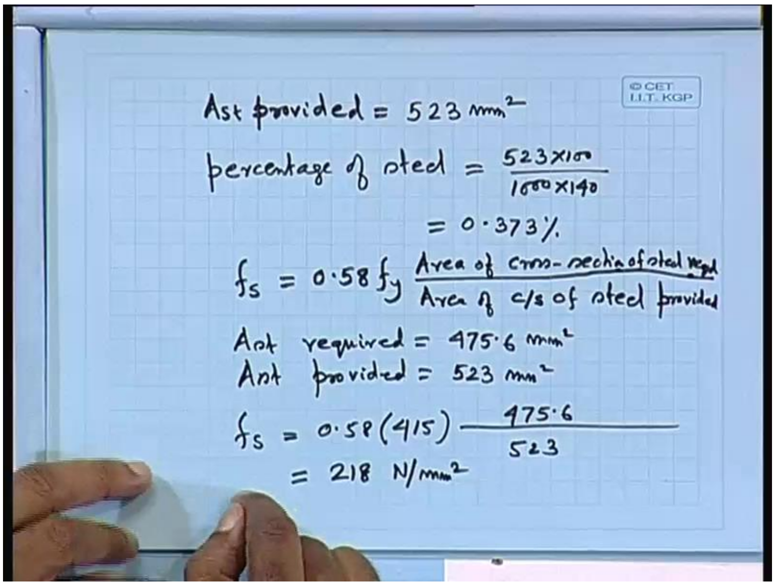


So, now we can check let us see area of steel 500 or let us say make it very clear area of steel provided, equal to 523 square millimeters. So, percentage of steel equals 523 into 100 divided by 1000 times 140, 1000 is the width and 140 is the depth effective depth which comes as 0.373 percent. There is 1 which is called fs this factor, point because we are interested we would like to modify we have assumed by l by d 25. Now, we would like to check we have that l by d we have started with l by d that is 25.

Now, I would like to check whether that is sufficient or not because we have to control the deflection also. L by d 25 we have assumed if it is less than, 25 which here comes then we have to change the depth, but if it is more if we do not consider the economic consideration then, we can stop there otherwise if we consider it is too much then; obviously, again we have to reduce the section.

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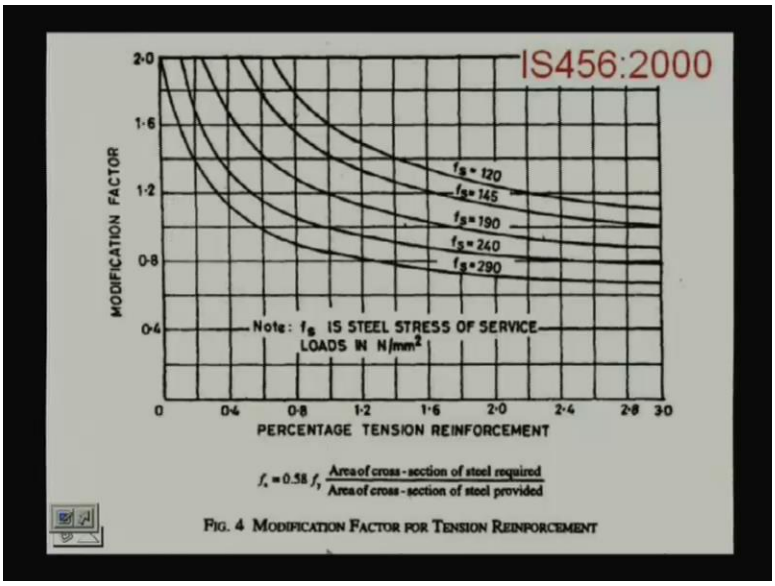


So, whatever the way our code says let us see. So, we shall use this figure 4 modification factor for tension reinforcement. We have given that tension reinforcement that, which Ast that, we calculated and that here we are getting 0.713 percent. So, for 0.3734.373 percent what shall we do? There is so, many stress level fs 120, 145 this is 145; 192 400 190, but it is not related with directly not related with the fe 415; we have to do certain kind of modification.

What is the modification? this line if we do not if you could not get it let me write down here that formula fs equal to 0.58 fy; fy is 415 fy is point fs is equal to 0.58 times fy divided by, area of cross section of steel required; this 1 will be required. Area of cross section of steel required and area of cross section of steel provided. So, we have to directly we cannot calculate not exactly 0.5 8 fy. So, here we have to do certain kind of modification. So, area of cross section of steel required, in our case that is, 475.6 and we are providing 523.

So, let me write down here clearly Ast required equal to 475.6 square millimeters, Ast provided equal to 523 square millimeters. So, fs equal 0.58 times fe 415. So, 415 divided by 475.6 divided by 523 which come as, 218 Newton per square millimeter. So, we are getting here 218 Newton per square millimeter. So, this is the 1 that value through which we can find out, the corresponding that modification factor. So, now if you come to this figure 4 of is 4562, 1000 we know this is 218 and percentage of steel we are getting here

0.373. So, 0.373 means; somewhere it will be somewhere here it will be somewhere here.

So, you can write down. So, if we write down here i think if we go something this way. So, we can get somewhere here we shall get it and what is the value 218; so, 218 you can see that fs it is dependent on the value fs 120 fs 145, 190; it means that, if you provide more reinforcement. So, you have that you say modification factor also will be more that way also you can little bit you can manipulate. So, anyway. So, if come here our case will be somewhere here our case will be somewhere here. This line possibly somewhere almost in the middle zone, somewhere may be saying some where here it will be.

So, which is coming here this value that, I have computed here that, is 1.55 because it is 1.4. So, I have taken 1.55.

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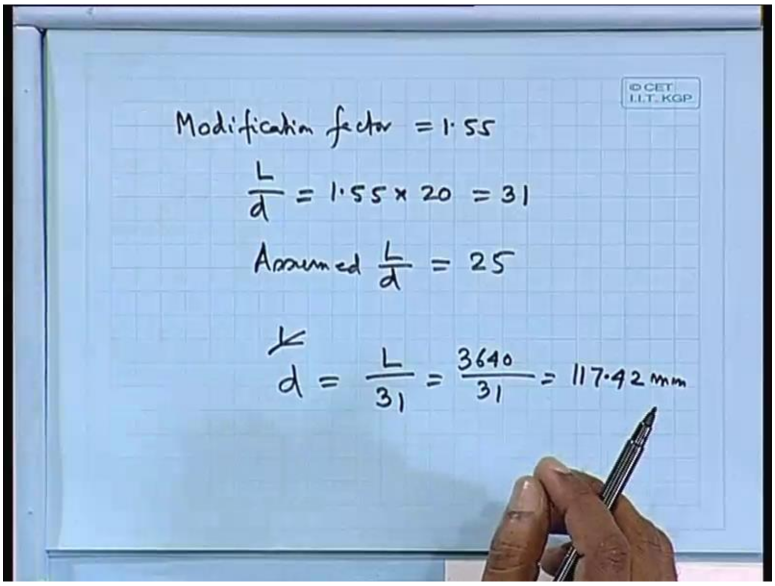


So, I can take that modification factor modification factor that is equals 1.55; so, l by d equal to 1.55 this is a simply supported case times, 20 which comes as 31 we started that assumed, l by d that is 25. So; that means, it is from here we can say; that means, we can further reduced the d. So, in this case that l by or let us say d will be equal to l by 31. So, which may be? So, we can just come back to the effective depth effective span.

So, 36 43.64; so, 3640 divided by 31; so, which comes as 117 point say 42 that means we can come to this, 117.42 and we have seen also that d that is coming 90. So; that means, in this case what we can do? 125 that effective depth; so, that way we can take it, but any way let us complete the problem here, but it is the; that means, it comes the solution is not economic it is safe, but not economic. So, in that case you can take 1 can again, further 1 can do the problem and he can again do the next trial and he can modify the section.

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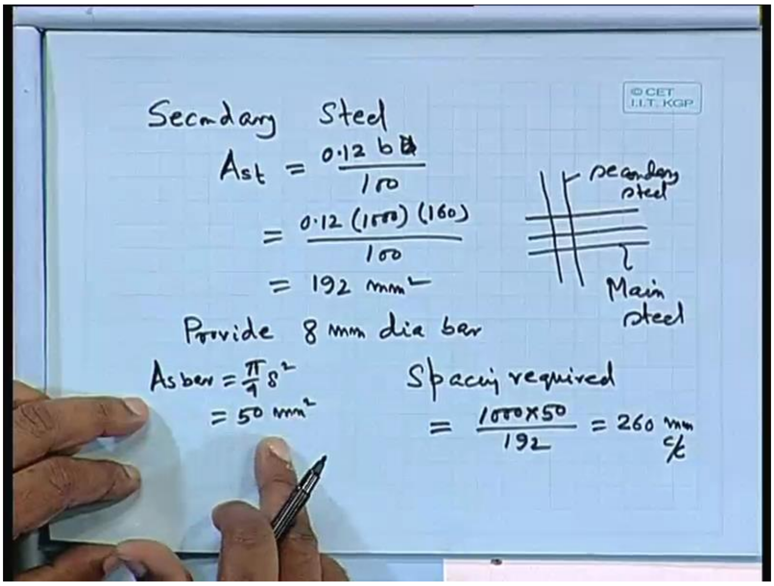


So, next 1 what about the secondary steel secondary steel will be Ast secondary means the other way; that means, here whatever the longitudinal steel we were providing here along the span say, this is along the span and then this is the other side that you say secondary steel or we call it distribution steel. And this is the main steel, which you are computing on the basis of your bending moment. So, Ast will be equal to 0.12 percentage that is the minimum you have to provide times bd for mild steel it is point 1 5 for tod steel it is 0.12 percent which comes as, 0.12 times 1000 times.

This overall depth overall depth divided by 100 equals 0.92 square millimeter. Let me check it once more. So, we are getting here 0.12 times 1000 times 160 divided by 100; 192. So, if you provide 8 millimeter dia bar as of bar area of bar, that is equal to say which comes as 50 square millimeter. So, spacing required that is equal 1000 times 50 divided by 192 equal to 260 millimeter center to center. So, we can get that area of steel of individual bar, that is 50 square millimeter. So, on the basis of that we can find out the spacing required that, is because we are calculating on the basis of everything per meter width that is why you are taking this 1000; just to Refer this think.

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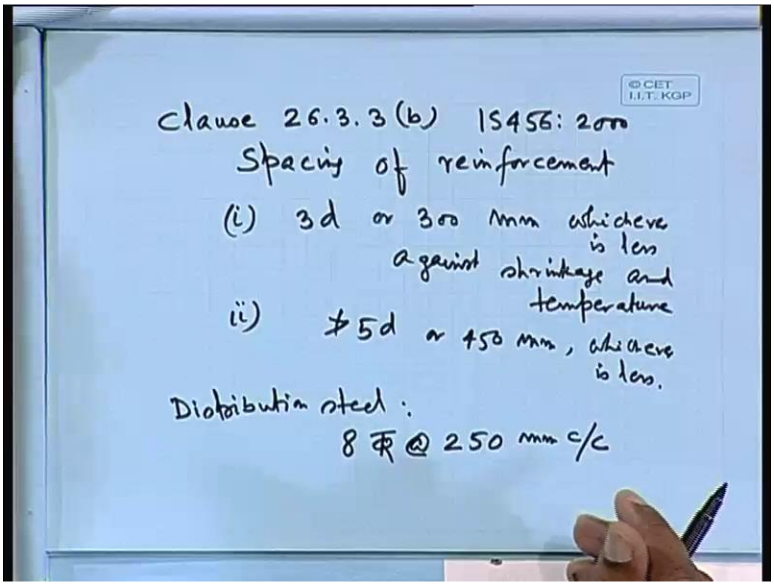


We should refer that, there is a clause 26.3.3 b this 1 related to the spacing of reinforcement; let us make it here. So, spacing of reinforcement; there are 2 cases 3d or 300 millimeter, whichever less is and another 1 this is also including against shrinkage and temperature. There is another 1number 2 this is also doing shrinkage and temperature that is your 5d or 450 millimeter whichever is less. We shall in our case it is coming 260 millimeter center to center. So, we can provide which is less than these values. So, you can provide the distribution steel; that is, 8 at the rate of let us provide 260. So, let us provide 250 millimeter center to center.

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So, we can provide 8 at the rate of 250 millimeter center to center. Now, finally, we have to show the detailing for each reinforcement that, reinforcement concrete structures. We have to show the detailing; that means, for beams we have to provide cross section also your 1 longitudinal section we have to provide for beams and also the cross section we have to provide, in the longitudinal section.

We have to provide curtailment of the reinforcement and how is the shear spacing all those things it will come and your cross section, will show a typical cross section. That means; at which section you are taking along the longitudinal 1 that you have to provide. Here also we have to provide thus for slab we have to provide the reinforcement. That detailing you have to provide.

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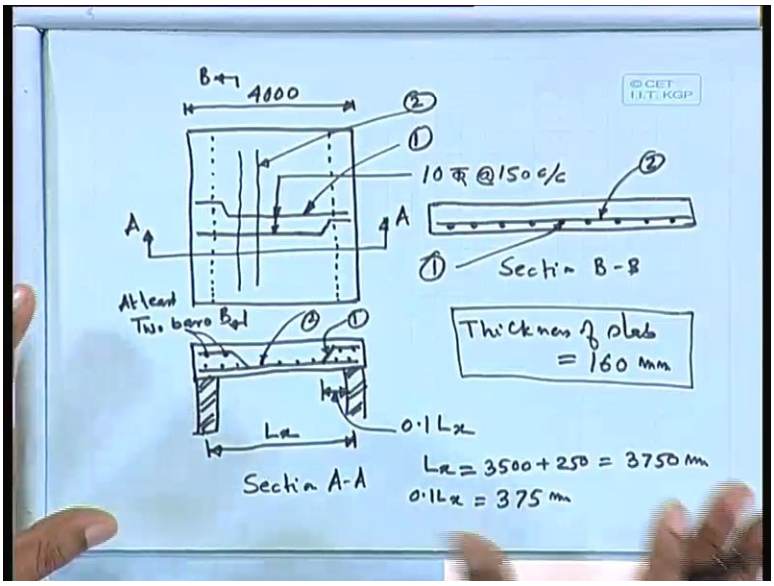


Let us take; this is your 1 panel for which we are considering and as our problem says this is the slab supported over masonry wall in both sides, this is the symbol of masonry. Our reinforcement, what we shall provide our reinforcement please look, I think we can keep the dotted line here this is the support. What we shall do? We shall give 1 reinforcement our main reinforcement. How much we have provided on main reinforcement 10 at the rate of 150 millimeter center to center we have provided on main reinforcement 10 at the rate of 1 fifty millimeter center to center.

And this is our span that 3640 and it is more than that, but effective span 3640 and this 1 how much this 1 is 3500 plus 250 plus 250. So, clear span 3500 plus 250 plus 250 which comes as 4000.And effective span we have calculated 3640 3460. What we shall do; we do not provide the reinforcement here we can just simply provide the reinforcement say just 1 horizontal line, but we have to provide the reinforcement at the the bottom as well as at the top.

So, what we do here in the support also we shall provide certain nominal reinforcement that we shall provide. If we are provide that, nominal reinforcement here then what we shall do? We shall calculate let us start, this is the 1 we are starting here 1 bar and then, it will be cranked and go up like this. We are starting from here, then go up and this 1; the other 1 what we shall do this is 1 reinforcement. Similarly, what we can do here the other 1 i can start go up and this one; that means, alternate. So, your reinforcement will be same, the bars will be same only thing 1 will be placed this side and another load will be placed other side.

So, it will be cranking 1 side only when it will be at the side they will crank in 1 side, but they will place alternate way. So, I shall get the other reinforcement, I shall get it like this this , is your reinforcement and it will keep on going like that. So, here because we want simply supported case, we want this 1 as 10 at the rate of 150 center to center. And if we take a section here; let us say this is section, a. So, we can get we can say this is our section a and we have to provide, we have to provide the where shall will crack what about this distance. If it is say Lx center to center distance is lx then, this 1 will be 0.1 Lx that is the 1 it will 0.1 Lx.

So, in our case lx equal to 3500 plus 250 center to center, which comes as 3750 millimeter? So, point 1 lx equal to 3 hundred seventy 5 millimeters. So, from the end of the support that, you will crank at 375 millimeter and on both sides you will do it like that, but we have to provide the distribution steel also like this, where to provide the distribution steel also and if I provide the distribution steel. So, since you are cutting this section.

So, we shall get it like that we shall get it like that because that all the longitudinal that you say other direction that on got. So, you will get all say the circular 1 will get that the respective to the bar diameter and similarly at the top also, similarly at the top also please. Note, we have to provide at least 2 distribution steel, at least 2 bars at the top to hold the 1 at least 2 bars you have to provide even if it is small, but you have to provide at least 2 bars you have to provide.

Now, what about the other side this side what about the other side; that means, I can take another section that, is bb and which we say provide here though it is not a good choice. So, generally will provide somewhere here and this is your that bar. Please note the dots in 2 different sections please, note the dots in 2 different sections this is your section bb. If I say this is 1, this is bar type 1 and this is bar type 2; the distribution steel. So, 1 and this 2 here this is 1 this bar 1 and the other 1 the dots are 2 whereas, here this 1 is your 2 and this dots 1;

So, because we are taking in the other section that is, very important whenever you are showing the section. So, which side you are cutting. So, that is very important and you can see the main reinforcement always the main reinforcement will have the maximum effective depth main reinforcement here this is your main reinforcement that should have maximum depth effective depth. So, that is why it is always in the below of the distribution steel.

So, we have to provide the reinforcement also we provide the thickness of slab that is here 160 millimeters. So, we should provide the detailing including the summary of results 1 detailing. So, that from there at least a draftsman should be able to draw the figure, as per the convenient he can place it, but we need this say 1 plan and 2 section .

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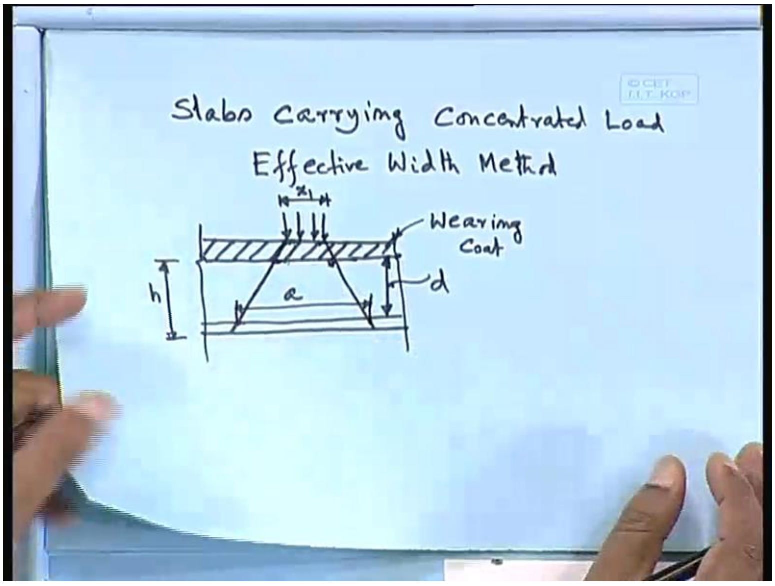


There is 1 more thing that is called; so, far we have done the udl, but if we have say slabs carrying concentrated load. If the slabs are carrying concentrated load then, what will happen in that case we have 1 is called effective width method. We have to calculate the effective width, it happens where we need that we can experience the concentrated load.

We can experience the concentrated load in bridges in bridges we can that, because wheel load whatever we have that is you say concentrated load. So, if we take generally; I think it is what it mentioning before going to that the there are so, many kinds of bridges that are different types 1 is called say highway bridges another 1 the railway bridges. So, these are the 2 different purpose; highway bridges there we had having say wheel load and another 1 we have say that is called tracked load. The loading whatever we get, the 1 say tyre, this is you the tyre or it can have say some track load that having say very little bit longer length.

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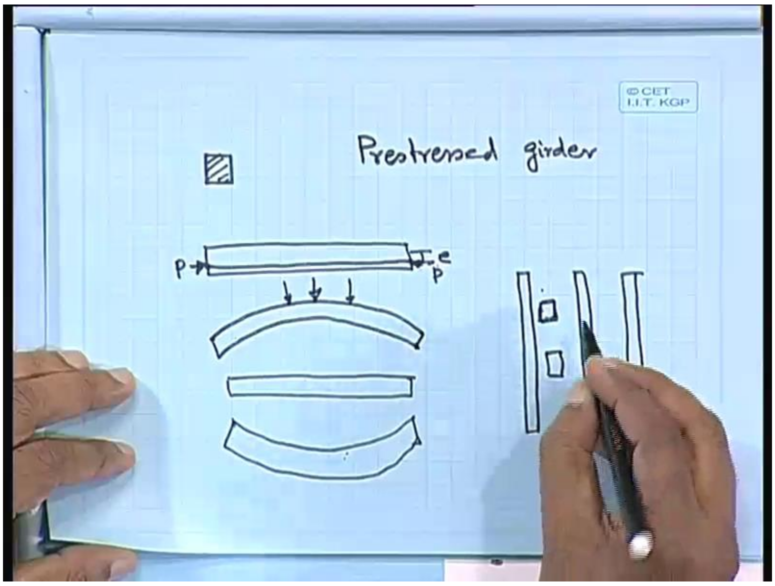


So, while you have that impression on the surface of the bridge, how the bridge comes there is 1 bridge that is called, a popularly used for reinforced concrete that is pre-stressed girder, I shall, if I get opportunity I shall tell little bit on pre stressed girder. So, this pre stressed grider, which we can construct with which we can make it outside pre stressing it means; I can show you 1 example, let us say that we have stake of books, which has simply 1 after another all the books not like this, you are keeping the books 1 after another in this way.

Now, if would you like to carry it what you will do; you have to press it otherwise it will fall. If what I am trying to say, the books are not placed like this 1 after another instead of that books are placed like this. And you are pressing it and then you are carrying it

That means you have to compress it to that way and then you have to do it. Here what happened, here it does the same way there is 1 that cable the steel cables are there high tension cables are there and those are pulled. If they are pulled and if they are restrained on that 2 ends then it will try to compress.

You are pulling the there is once a hole, there are 2 there is once a hole through that we have done the casting of the beam say and you have kept 1 hole through the that longitudinal section longitudinal way effective through that, after 28 days after that, what you are doing when it is hardened fully hardened then you are passing once a pre stressing cable. Now, while you are putting that 1 then what you are doing you are pulling it in 2 sides and then, you are restraining something resting somehow and then when you have rested then, it will try to compress when it will try to compress. So, what will happen then initially the beam was like this; I want to say something like this and keeping say here, I am not going in detail, I am keeping here, I am giving certain kind of say eccentricity E and this is your force P which is put like this.

So, it will be like that due to bending due to that moment developed there is a moment developed here. So, initially it will be like this not that much, but anyway it will try to bend in this fashion because you are applying that I am not directly, I am not putting that center instead of that, I am giving intentionally, I am giving this 1 at a certain eccentricity. So, it will try to make 1 moment that developed and due to that, and also excel force. So, what will happen it will make like this.

So, what will happen if you would like to for failure if we apply the load like this then what will happen, it has to fast neutralize and then moves. So, automatically we can understand that, it will take more loads. The other 1, I can give you example that is, you say that cycle that 1 that ring, there also the spokes that, whatever you are using there also if you have noticed you will see there also they are doing certain kind of pre stressing. Because all the say your spokes they always rotate like that and there are doing the that is why it does not bend; otherwise what will happen, it will just make certain kind of say bending of the your ring

So, there also they are doing the pre stressing; so, this is the thing what they are doing, but anyway we are going little away, but anyway just to conclude this pre stressing. This is called pre stressed girder and so, we can go say 20 meter 25 meter 40 meter which we shall not be able to do it by reinforced concrete reinforced concrete beams that 1 we cannot go say 5 meter 6 meter 7 meter maybe we can go say 10 meter, but your depth will be enormous that depth you have to because mu equal to 0.138 fck bd square. So, from that you can find out that, what will be corresponding depth, if we have the span more with the same load the depth will be more. But here what we do we use that, pre stressing girder pre stressed girder we use it and that can go say 40 meter also we can go and depth will be say you 1 meter 1.5 something like that, it can happen and we use number of cables and in bridges we use it

So, while you have 2 girders say like this there are so, many may be say the bridge having say 6 girders, if you notice now a day's say, bridges when if you go by train itself always there will be always 1 another highway bridge at least. So, if you notice that you can see that, depth slab and the depth of girder that you can see there is a difference. So, that is now here, we are having that wheel load these wheel load is coming as I say concentrate load. So, now, if I have the concentrated load here then, what will how I shall take, the effective width effective width of the loading.

These loading directly that, whatever the impression we do not take it we take little more. So, how much more we can take it that we have to find out. So, what we shall do it here, in this case there is always 1 wearing coat; now, come to the problem here there is always 1; this is called wearing coat this is not reinforced and then we are having that slab let us say, this is up to the this is the reinforcement and this is the loading that, concentrate load having certain area we take 45 degree dispersion.

If we take this 1 as h and we have to find out what should be the this length a and let us take this 1, say your x1 is the impression say in 1 way other way say y1. So, x 1 times y1 that is, at the top that is the impression x1 by y1 and we can take this is you say d is effective depth this is the effective depth. There are 2 concept, 1 concept is that particularly this portion you go up, to the top of the slab other alternative that 1 because this 1; if you take this much then that this we divide this 1; that means, your concentrated load and so, you are taking actually moment if you compute moment that, will be more because this 1 this length is less. So, distributed less.

So, moment will be more computed moment will be more. Whereas if i take this 1 then the moment will be less because it distributed along this 1 if you take this length then it will be further distributed. So, your moment also will be further less. Now, the designers 1 who are a 1 type of designer, 1 class of designers they take it say up to this another 1 they take it up to this obviously; I can say they are more conservative the designers who are using this 1 upto this; that means, they are more conservative then, the designer who are taking this 1; because here your moment all this things will be calculated less compared to this 1.

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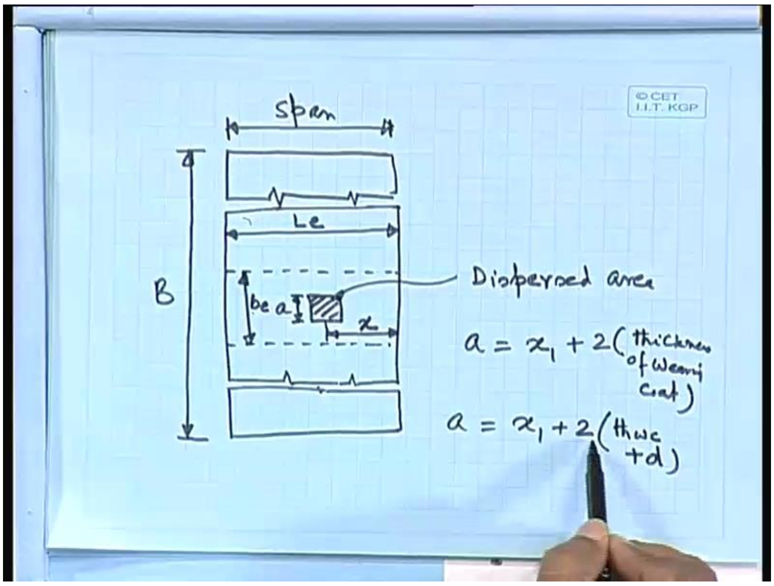


So, I can further write down let us say this is continuation. So, if we take this length say B and this is your span let us say, this is your le that effective span and we have certain impression here, this is a impression either from the tyre or any other concentrated load and after dispersion we are getting, say like this is our a is the 1; this is the support span means this 1 span. So, we can assume that there are 2 girders 1 girder say this is 1 girder this is another girder and this is the over the there is bridge depth may be say 250 millimeter or say 200 millimeter in that range it comes, but whereas the girder if may be say 1 meter 1 point 5 meter. So, that 1 will be considered as support.

So, a is the 1 parallel to this girder and from the nearest support, this distance is x from the nearest support this distance is x. So, what we can do? This is your dispersed area after the dispersed area means after the 45 degree the dispersion this is dispersed area and we have to find out, the effective width be. Let us say, B is the effective width if we have to find out and that impression that, 1 having say at a distance say x from the nearest support. So, how shall we find out that, we can say a equal to either we can write down say x1 plus twice the thickness of wearing coat or we can write down a equal to x1 plus twice say, let us say; thickness of wearing coat plus d. There are 2 options I have told, I have told either it could be up to this or it can go after to the effective depth.

So, you can write down that x1 plus twice thickness of wearing coat or x1 plus twice thickness of wearing coat plus d. So, that we can find out and our code says our code says, be the effective width equal to k times x1 minus x by le plus a. So, this is 1, a; I know x, I know, Le I know. So, I can find out Kx Le effective span and a, I can find out the effective width this is the effective width instead of taking this a part of part of meter width or anything. So, it could be that effective width.

So, I have got this 1 effective width and what is the value of k this 1; I shall get it from table 14 is 456 2000. So, we have to calculate that due to concentrated load we have to calculate that, effective width instead of taking say 1 meter you have to calculate that effective width and that we can find out from this formula and which is I have in the code.

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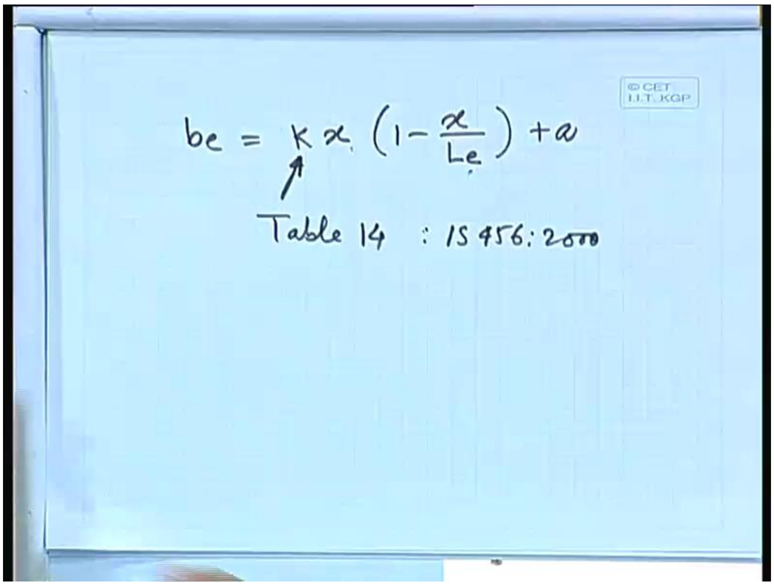


Similarly, for the cantilever beam also. So, we shall stop it here then we shall continue in the next class the slab. I think we shall take few more classes for slab we have 1 more that is you say, 2 way slab also this is called 1 way slab similarly we have 2 way slabs .