Design of Reinforced Concrete Structures
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Lecture - 18
Design of Slabs Part V

Well today, we shall start the same design of slabs and this is part 5. So, far the design of slabs concerned we are doing right. Now we are doing design of two ways slabs.

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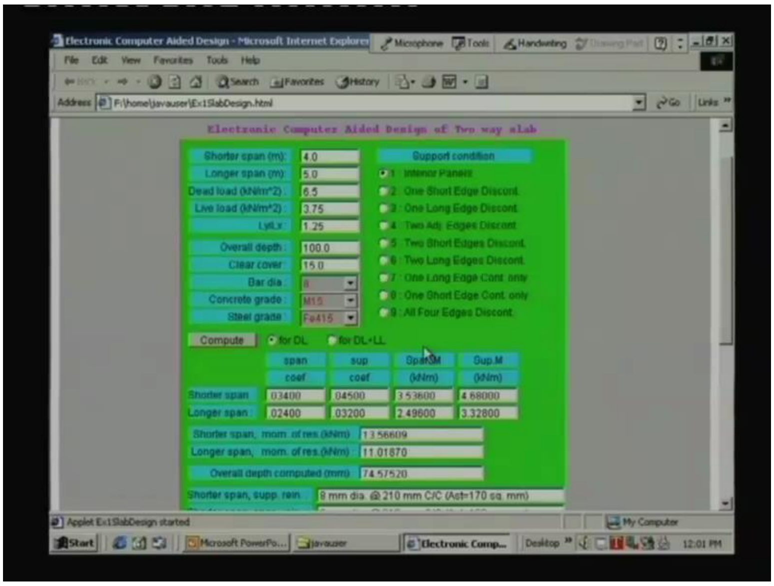

Let me see whether, I can show you 1 problem; I do not know whether, it is can you view it, but, only thing I want to tell this is your that this initially long back; I said 2 years back I tried to make it in java. Because, my initial plan was to make it in internet but, java is somehow the way, it is started and somehow possibly, it is flopped and the way. So, any I have stopped and discontinued this project but, I had lot of things regarding this that say your clause as well as beam as well as your say plan frames all those I made it in java but, anyway I just found this 1.

Now, I am trying to make this 1 in visual c plus plus, because I am now, again going back to the old system to that c only and that stand alone program instead of going to that internet; I think it is better to it is in internet still is not grown up possibly though, with the graphics and lot of things lot of things are there but, even then. So, far that technical thing is the concern possibly it is still in the infant stage. So, any way I am now, developing this 1 as a dual project that day doing afterward live load that, I have told you in the 1 of the lecturers and this is the part of the design under RCC.

So, what I am trying to do the language this language was really good and we have. So, many clauses like c plus plus that lot of things; we can make it but, anyway. Let us come to the this is this particular applet originally, in java we called it applet it is for only for 2 way slabs but, 1 thing I have not considered here that your deflection criteria that have not considered, because I thought I shall make it only to show. So, what happened here we have interior panels I think it is to I do not know whether can you recognize this 1.

So, interior panels then 1 shortage discontinuous, I have told nine different cases. So, interior panel 1 shortage discontinuous, 1 long edge discontinuous, 2 adjacent areas discontinuous, 2 short edges discontinuous, 2 long edges discontinuous, 1 long edge continuous only 1 shortage continuous only and all 4 edges discontinuous. So, we have 9 different cases as per your say table 26 as per table 26 of is 4 5 6 of 2000 what I have done for all the cases; I have simply given the input for made a table internally, in this all the your say coefficients alpha x alpha y for ly by lx.

So, what is the input we want that shorter span; which will be in meter that is a 4 meter here you can change it longer 1 that is 5 meter dead load here, I have to specify the dead load I should specifically mention that it is the factored load but, any way this is actually factored load or design load. That means; after calculation of dead load you should have my initial plan was to give you the rectangle only and corresponding you say, that 1 rectangle l like this what I am trying to make say my initial plan was like this.

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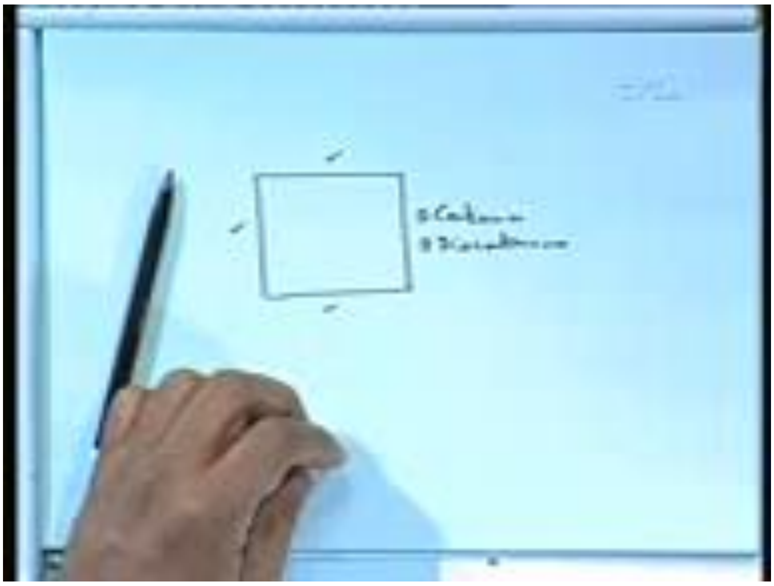

It may be something like that and I shall try to make that 1 is visual c plus plus; if this is your rectangle. So, what we can make over the this edge is continuous or discontinuous, I need not specify that 1 whether that which case but, even I can go and this could be radio button, I am trying to make little bit say computer aided. So, 1 of them only 1 of them could be either continuous or discontinuous similarly, this 1 also, this 1 also, this 1 also. And we can specify the you say length and you say lx and ly.

So, your go that interface may come this type of 1 instead of like this though it is not a bad one, but, anyway, but, we have to specify that which is the case, but, we can go little more further. So, dead load here we can specify and live load but, this 1 here all of them of design load and ly by lx. So, let us find out let me just show you. So, and overall depth you have to specify overall depth, we can specify which we can get it from the control of deflection by any way, I will specify the overall depth and clear cover you can mention depending on the exposure condition and bar diameter.

So, you are having. So, many bar diameters so, you started from 6, but, since in bar slab we start from 8. So, initial 18. So, 8 10 12 like that, I have given all the bar because, it is a plus. So, bar diameter is a clause. So, I am just giving this 1 here. So, automatically whatever I shall select. So, that 1 will come here. Now, concrete gate what are the different gates I have taken m 15 m 20 m 25 m 30. In is 45 because it was made on based on is 456 1978. So, that is why I have kept it in 15, but, in anyway sometimes we require also.

So, I would like to keep this m 15 also. Then what about the steel grade steel grad we are having fe 250 500 and since we mainly use 415 that is why the default 415 sometimes we may check it for dead load only and also dead load and live load only. That means; I can either go for this is called radio button. So, either I can check this 1 or check this 1. Now, what will happen here? Let us say this is your case and let us say for dead load and live load let us compute. So, if I compute that 1 immediately these coefficients will be taken from the table in our table 26.

So, immediately it will be taken from that table and span moment and support moments for shorter span and longer span will be computed. If I choose say 1 shortage discontinuous let us compute once more. So, you see all the values are change. So, what we can do taking care all of them say let us say 2 longer edge discontinuous this particular 1 and let us compute. So, I shall get immediately I shall get those values and here you can say that there is no support movement here your 0 minus that in this case discontinuous almost I say simply supported case. So, you can take that.

So, these values will be automatically taken and it is linearly interpreted and we have getting and immediately span movement all those things should be computed and the moment of register also taking care of all the values, it will be taken and we can find out the what is the overall depth computed that also you can find out. So, and finally, I can provide the reinforcement, because we can have 4 different types of reinforcement shorter span, supported reinforcement, shorter span, standard reinforcement, longer span that supported reinforcement and longer span standard reinforcement and.

So, we can get I think there is something wrong here it should be something little more, because 8 mm to while at 10 it should be little more. So, we can have that all the 4 cases and automatically you can choose. So, we can say all 4 edges discontinuous. Let us see. So, increase depth that means; it is not sufficient; that means, it is telling increase depth. So, I can increase the depth. So, I can increase the depth by 125 and now I can see that it is coming. So, like that we can check, because it is very much handy.

The initial plan was that it will come under all them will come under that 1 site and we can go to that site and immediately anybody can just use this program and that was my intention. But, anyway I have found that there is some other problem that somehow it was not happened and coming back to that you say stand alone program. Anyway this is the thing which will come under that dual project.

All those things including the you say analysis as well as design and I hope that before the design of earth quake resistance structures reinforced concrete that time; when I shall take a separate module starting from the analysis to design and that time I shall use everything under dual and I shall find out whether I shall be able to get that good then; I shall show otherwise I shall show only numerical values.

But anyway and I meant to say that design is such that it is very interesting also, I really like this 1 because there are. So, many constraints and with those constraints if I have to design a proper economic as well as safe design and that is really a challenge and we do check a lot of work also that; we are getting say you bridges for checking bridges bridge design analysis also see our residential building. So, we project like those and continue, but, anyway. So, now let us come back to the problem that few things before starting 1 say you example problem.

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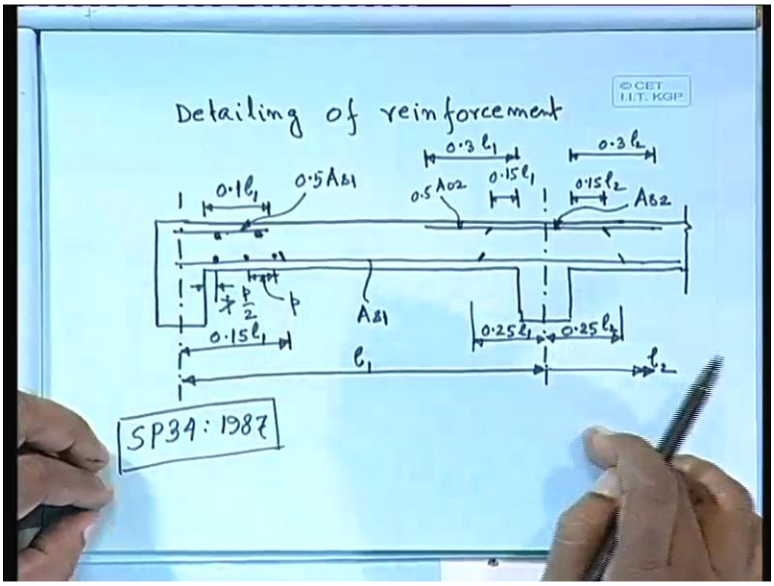

Let us start with the detailing, because last class I have not finished that part. So, detailing of reinforcement that is very important. So, I shall just tell you very few things that which we should know. Let us say this is beam cross sorry slab cross section and let us give a centre line and we have the length l1 and other part we can specify like this that is say your l2. There are these detailing is very another important aspect of your say structural design that, you can design it you can provide the reinforcement, but, the proper placement of your say reinforcement that is very important.

So, in the wrong side particularly in cantilever if you specify the reinforcement, in the wrong side because the reinforcement in the cantilever I say at the top not, in the bottom the main reinforcement and this is a sometimes there is a failure eventually after say casting. So, casting and when it is removed started immediately it fells immediately it breaks. So, that it very common 1 and it happens also. So, that is why this detailing of reinforcement is very important and it should be done carefully.

There are 2 things in the holidays they used to make say reinforcement as if it is like this just I am not writing, but, as if you have I think we can make it in a separate page.

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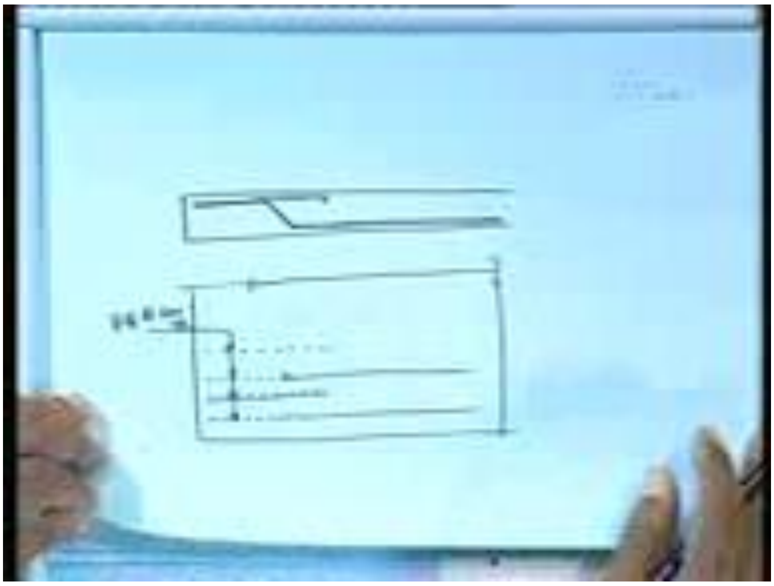

What we do say this is your slab what we can do that we make a crank here, the bars these type of thing and we make it and there is another cut piece bar which can go start from here to here. This bar is if I start this bar this is your 1 bar length of bars; the 1 we have already done it in the beam the other 1 it can be cut piece. If you see the bar you will find out in the plan this is a plan of I, say slab if I start say leaving this bar if I take the bars which added the bottom those bars say. Let us take say that is form a line solid line and bars which added the top which I shall show it as I said dotted line.

So, what about this bar if I look from the top then it will happen and we shall find out dotted certain portion and then; it will start from I meant to say these bar this is the usual way of showing the bar the other 1 because it may not be sufficient. So, what we can do we can specify the other bar like this it can go and again form like that but, in between that say these spacing is not sufficient. Let us say these spacing is not where to specify the little more worse in that case; what we do this is another bar this is another bar and what we do.

We specify another bar like this cut piece we specify here like this. So, that actually it should be sorry it should be dotted please excuse me; it should be dotted. So, this bar should be in the ratio of form we are talking at the top 1. So, this bar should be dotted and similarly, here also there are another bar; it will be dotted and this spacing whatever, it has to be that has to be specify that whatever, say may be say for example, 8 tor at the rate of may be 200 centre to centre like that. So, that cut pieces are avoided and few bars cranked.

Now, we shall we do we do not go this type of thing, because after all it needs certain kind of say that detailing also that you have to know that how many bars say to crank all those things. Now, what we shall do we take 2 different 1 bottom bars in the bottom top; top bars in the top. So, what we do that we just simply make the cut pieces that means; here this bar it is bottom. So, if it is not require I shall cut it here itself.

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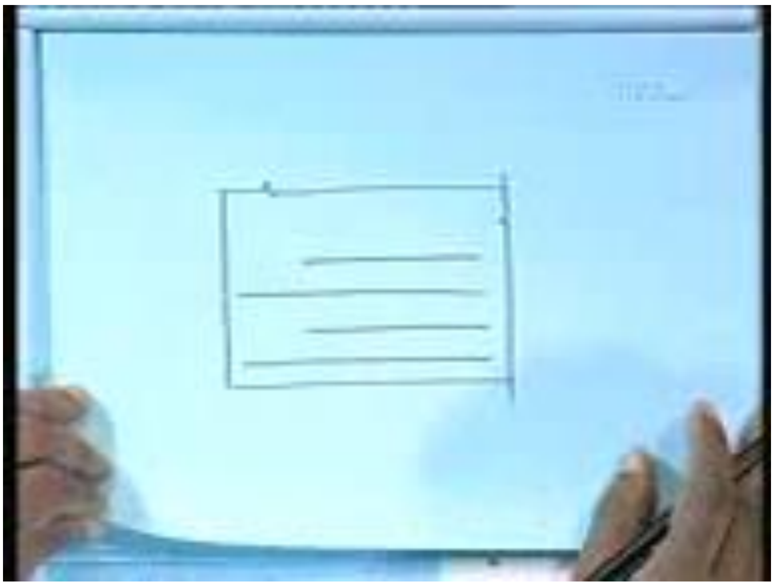

So, I shall show you, it may go like this. So, say this is 1 bar in the bottom the other bar we just simply cut it here, I am talking about the bottom similarly, another bar here the other bar which is coming here because we do not require at the bottom we do not require at the bottom we do not require that much of spacing. So, if I can provide. So, here we can just curtail the bar. So, that is the idea. So, if I do it now what about the top 1 the top 1 we shall take it the bars simply cut off bars will be.

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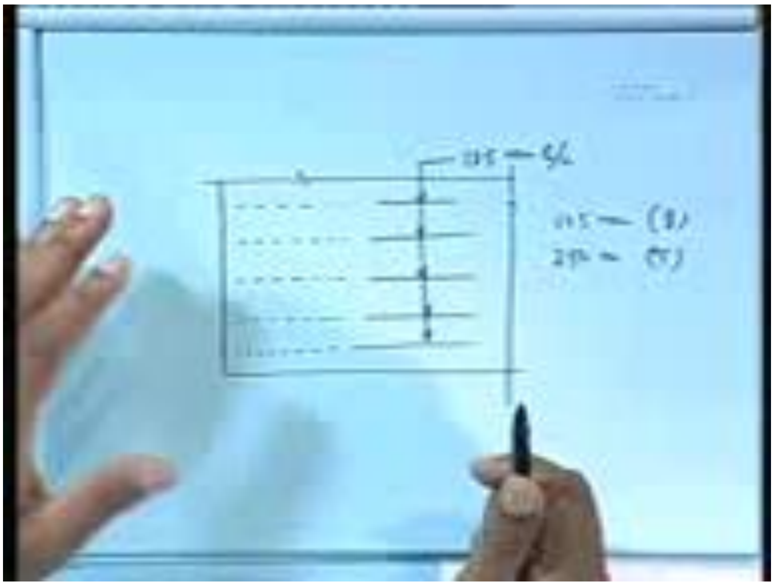

The top bars here what will happen to the top bars that top bars here will be say we have started. So, it will be dotted the second 1 also will be dotted. These are all separate bars and we follow these type of detailing now a days we do not go that crank all those things we do not go nowadays and that is why it is easy also. The top bars having separate spacing all those things otherwise we have to do for detailing since, you are doing that alternate crank. So, if it is say 250 millimeter say your spacing.

So, alternate crank; that means, 125 all those things you have to make it. So, the spacing and all those things it is dependent on the top bars also; say for example: you are getting say 125 millimeter at the bottom for example, 125 millimeter bottom and 250 millimeter top and in that case, I can specify that 125; that means, the bottom we can have this type of thing these are all 125 millimeter centre to centre and the top alternate 1 we are making crank. So, that means, then we can specify these 250 so; that means, here but, if it is say something 130 140.

So, alternate 1 may not be 100 for 240 or 280 that we cannot provide is actually restricted to say 250 may be. So; that means, your top and bottom bars all of them are dependent. So, here in this case when you are making that separate 1 the detailing for the top as well as the bottom then there is no dependency and. So, we can go separately for top bars as well as separately for the bottom bars. And that is the idea what we nowadays follow.

So, if I come back on to the specific 1 why I am telling this that if I take this section then where is the curtailment that we have to mention. So, here what we do what we can do it here there are 2 types of thing. So, these bars whenever, you are specifying as well as here also 1 bar number 1 where from the bar we will start. This bar if I take it where from this bar will start that is the first question. So, if the spacing this is you say spacing. Let us say: this is x or p ph also we call it p or s and then what will happen this 1 should not be greater than let us say either we can say p by 2 or s by 2, I meant to say this length that is your p.

So; that means, it should not be greater than p by 2. So, we that we should always it will be within p by 2 that we shall start the bar number 1, number 2. Let us say this is your as 1 area of steel 1 of this 1 similarly, we can have the area of steel other also; if this is the area of steel which we are providing here if span is l 1 what we shall do what about the top bars the top bars this length please note that from the end of the support from the end of the support this length will be point 1 this is the length l 1.

So, it is l 1 then percent that length you have to specify and what about the area of steel this area of steel will be equal to half of the as1. We are talking the end 1 the 50 percent of the as 1 area of steel this 1 the area of steel we are providing. So, 50 percent of that we have to provide here. We are supposed to get 0 but, 50 percent of as 1 or 0.12 percent that is the minimum steel we have to provide from that control of that crack width.

So, that 0.12 percent of the cross section area that we have to provide here whichever is more in that case we have to provide. And what about these 2 bars these 2 bars at least 2 or 3 whatever you provide, but, earlier there should be 2 bars not 1 bar we should have at least 2 bars. So, this is 1 case number 1 this number 1 say; number 2 in medial here in the support we do not mean; the span whatever area of steel you have got it in the span we do not meet that much here. Because after all here that span movement here the moment is less at the bottom.

So, we do not need that much. So, what we shall do it here we can curtail the bar may be we have curtailed the bar somewhere here. We can curtail the bar here similarly, we can curtail the bar here these are the bars we are specifying here; that means, we can say here 1 bar this length the other bar will go. So, that alternate we can provide the bars. So, what about this length that length will be equal to where we shall curtail it. This 1 from the centre line it comes 0.1511

So, it comes from 0.1511 but, where from I talking these, I am talking this all of them from sp 34 1987. This is the detailing of the reinforced concrete reinforcement. So, sp 34 has a special publication number 34 1987 by Indian standards. So, I am taking from that 1. So, everybody has to follow these detailing this length becomes 0.2511 and here what about this length. This length will be equal to 0.25 this is l 2. So, this will be l 2. So, 1 side is in 0.2511 and other side 0.0.2512.

So, because we are talking this span so, 25 percent of the length and the other side also l 2 using the span difference, it will be 25 percent of that what about the top reinforcement top reinforcement can also have 2 different 1; that means, we can curtail it here itself, because we are not going that much. So, the 2 lanes 1 is called this particular length we are getting from the end support 0.15 l 1 and the other 1 it goes up to 0.311. Similarly, this side 0.15 l 2 and this length is 0.312; what about the reinforcement.

The reinforcement here, I am talking this 1 this reinforcement if I say as 2 area of steel on the support as 2 then; this 1 will be point 5 as 2. So, here we are having the curtailment because we know there movement also we will reduce here. So, there is not provide the full. So, 15 percent of the length this side other side 15 percent of the length for this span 15 percent of this span that is the total as 2 then 15 percent of that we shall provide here and which is going up to say 0.3 l 2. This side the view of the span is l 2 and 0.3 l 1 this side, because the span is l 1.

So, we specify like this we specify all the that you detailing that you have to that curtailment of reinforcement all those things you can do it otherwise; it will not be economic and that you have to maintain it this is 1 part.

There are so, many other things also just I am giving few examples so, that we can find out.

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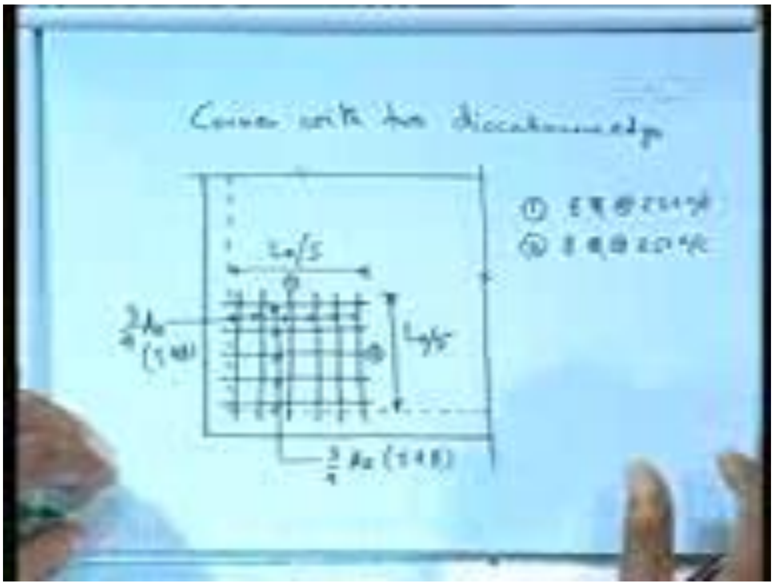

The other examples: I can show you that is your actually for corner reinforcement, with 2 discontinuous edges. So, this is your corner of a slab let us provide the that support I dotted. So, what we can do it here this 1 if we start. So, let us start here the corner reinforcement you can provide and the other side also. So, this is your that corner reinforcement; we have to provide. Let us make, it 1 more here like this. So, if I have this corner reinforcement. So, what about your that length.

This length will be equal to lx by 5 the other 1 also from the end of the support face this is also lx by 5; what about the reinforcement, the reinforcement we are providing here. So, this reinforcement that 1 is coming as three-fourth of area of steel in the shorter span whatever, your area of steel you are getting in the shorter span moment due to shorter span movement. So, three-fourth of area of steel that you have to provide here and that should be at the top and bottom both it should be at top as well as at the bottom.

Similarly, the other reinforcement that, we have to provide it also here three-fourth is area of steel top and bottom so, we are not directly computing that. So, what you are doing since, we know the span moment longitudinal side as well as a shorter side as well as longer side shorter side 1 we shall take it and three-fourth of that we shall provide it here and that is why in top and bottom. Generally, what will do here for detailing we marked those bars that whenever, you are having that although it may be crowded.

So, that is why I have to do with the simply provides say your this is 1 and this 1 you could say 2. So now, what we shall specify here 1 this is ball number and may be say we are providing something say we can say 8 tor at the rate of maybe say 250 centre to centre that we are providing. So, like that number 2 also it may be say 8 tor at the rate of 250 centre to centre. If the spacing and your bar diameter same then; we can take it as a same type so; that means, I can say simply say this is 1 and this is also 1.

So; that means, we can reduce the number of bars. So, from the drawing itself, will come to know how many different types of bar you need. So, that itself and that is that you have to make that list that you have to make it that; bar bending schedule also you can specify that we make it say separately, in the right hand side of the drawing. So, from there they will now that this many number of bars different types of bars we have to provide lx is the lx is the span that 1 we are talking.

So, lx ly the 1 for the slab so, that is always in the shorter direction; when you are talking lx. So, you mean to say that is in the shorter direction.

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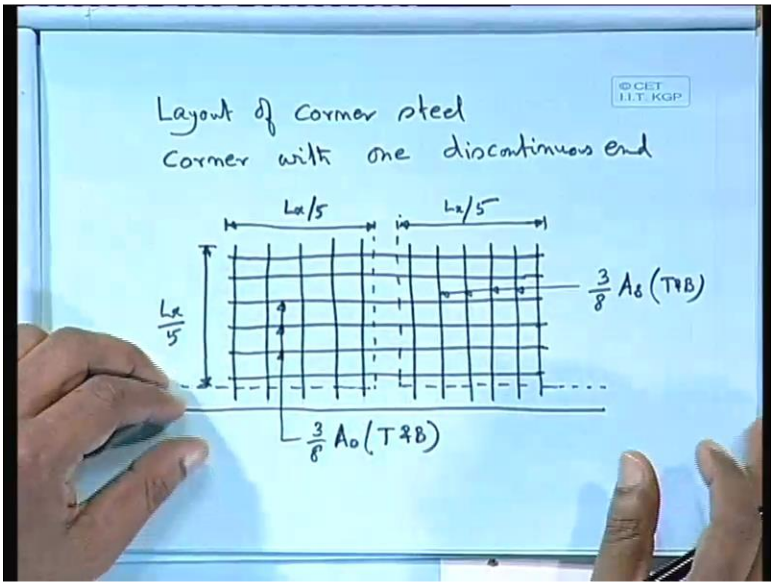

So, 1 more I should make it. So, the layout of corner steel so, this 1 we can say corner width 1 discontinuous end that is only 1 discontinuous end what will happen; so, in that case what we do. This is you say middle support. So, this is your 1 beam may be this is also another beam. So, here only 1 side is discontinuous in that case what shall we do, we shall provide the reinforcement here. So, this your reinforcement. Similarly, this side also. So, let us extended little bit.

So, if I have this type of reinforcement here then what about this length this is again lx by 5; what about this length. This 1 also lx by 5 and we provide the reinforcement this side that 1 should be equal to three-eighth of area of steel that suspend that steel whatever, we have got it and that 1 also be at the top and bottom; what about the other 1 you also get the same 1 this side and that also we take it three-eighth of area of steel and that is top and bottom. So, we can provide that. So, these are the corner reinforcement that you have to provide.

So, 1 is the total 2 is the discontinuous and just 1 another 1 that only 1 discontinuous edges. So, this is your problem that we have to finish it until and unless you finish this detailing then the work is not complete that you have to specify. There are few other things also that I am not going that because otherwise; it is too boring that may be in the latter stage I shall tell you that 1.

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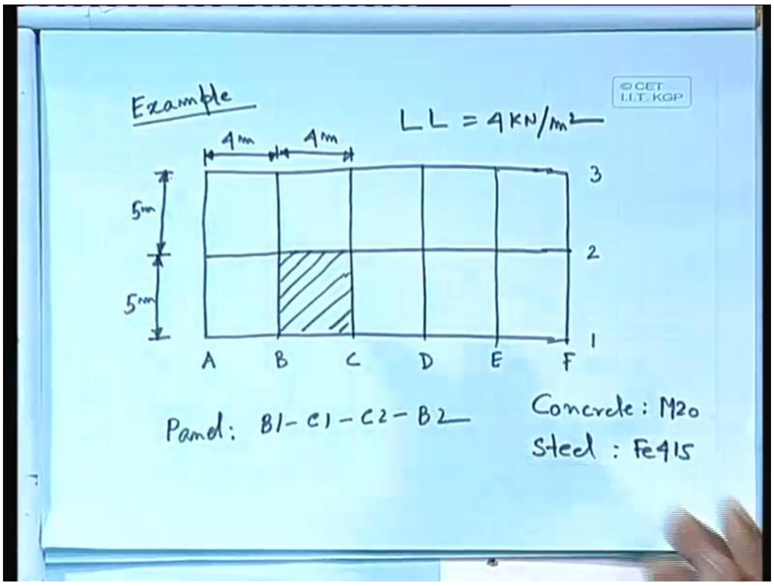

So, let us just take at least 1 example problem for 2 way slab with so, many cases. Let us take just 1 case, I am taking; say I can write down this as A B C D E F these are all the column positions and this side I can say 1 2 and 3. This 1 say 5 meter, this 1 also say 5 meter and this side we are having typical, I can say 4 meter and we are interested for this panel that is B1 C1 C2 B2. So, this is your panel generally we specify in this fashion. So, panel B1 C1 C2 B2 that is the panel that you have to design it.

So, what we shall do it here. We can say shall I keep it for some time have you copied this 1; what we shall do this that, we would like to design this panel and let us say that your live load 4 kilo Newton per square meter; I can give the concrete grade possibly concrete grade I have used m 20 possibly That concrete grade that 1 we had using it here m twenty and steel fe 451. If I do this 1 we have to design this because out of that nine cases we shall find out 1 of the cases and we shall design according to the values given in table 26.

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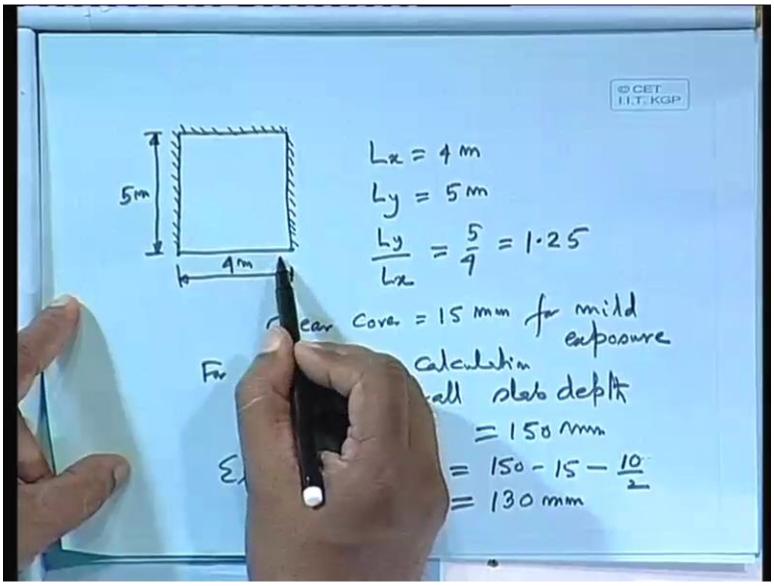

So, generally we mention we can mention in this fashion this is the continuous 1 well this is 4 meter and this is 5 meter. So, lx equal 4 meter and ly equal to 5 meter. So, we can take ly by lx equal to 5 by 4 which comes as 1.25. So, we shall use table 26 to find out that values. We can use it say clear cover 15 millimeter clear cover 15 millimeter for mild exposure. Let us take for your dead load calculation assumes overall slab depth equal to 15 millimeter I shall. We can check latter on whether, we are getting the exact depth by span ratio.

So, here we are assuming say 1 hundred fifty millimeter. Then; we shall find out the design load. So, 15 millimeter is the overall slab depth and effective depth we can also calculate. Let us find out the effective depth d equal to 15 minus 15, I can check again say 10 millimeter may be we shall get little less but, anyway we take this 1 and which is coming as say here. So, 15 plus 130 millimeter so, d is the effective depth d that is coming say 130 millimeter, because I am assuming 10 means; the 10 tor this is your 10 tor we are assuming that we shall use it, but, may be later on we shall we may use it 8 millimeter, but, anyway.

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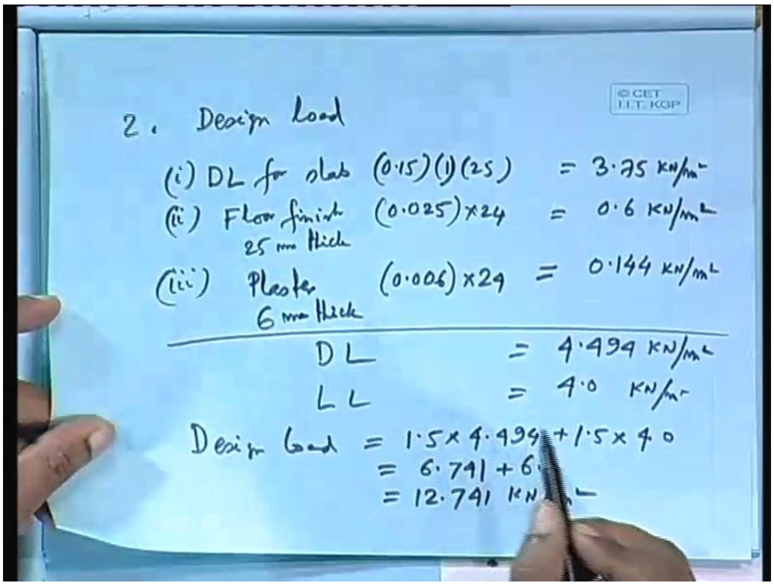

Number 2: design load. So, dead load for slab that is 0.15 into 1 into 25 equal to 3.75 kilo Newton per square meter. Number 2: floor finish 0.025, if we take it as 25 millimeter thick times equal to 0.6 kilo Newton per square meter; number 3: plastering say 6 mm thick. So, this 1 you say 6 mm thick that we had using. So, 0.006 times 24 that is equal 0.144 kilo Newton per square meter so, we can get the total dead load equals 4.494 kilo Newton per square meter. And live load that is 4 kilo Newton per square meter.

So, design load 1.5 times, 4.494 plus 14.5 times 4.0 equals 6.74; I think I should make it little bit clear so, 4.494 into 1.5; so, 6.74 1 plus 6, which comes as 12.741 kilo Newton per square meter. So, this is your design load that you should have to take it. So, design load we are getting 12.741 kilo Newton per square meter; what about your type of slab that is your type of slab according to your table 26, it is your according to table 26, we are taking that shorter edge is discontinuous. So, that is your actually in table 26 if you go then you will find out that is you say case 2. Then; you will find out that is you say case 2.

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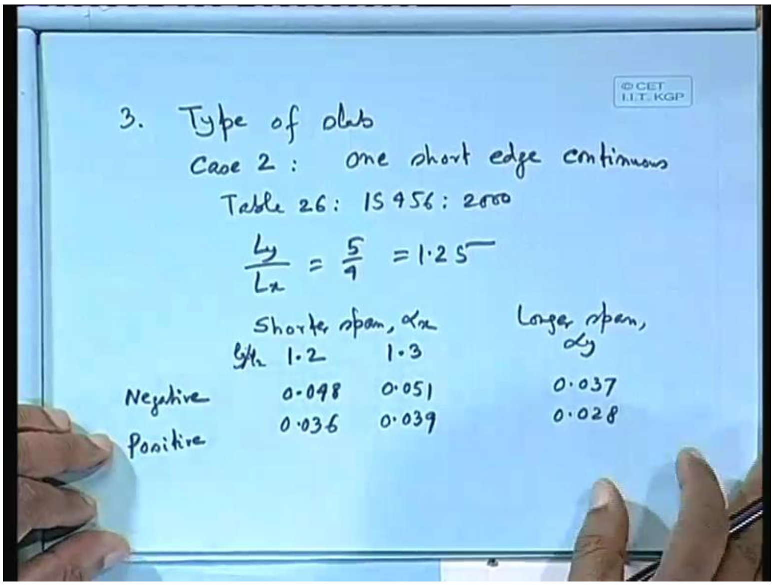

So, we can write down type of slab case 2 1 short edge other way also you write down continuous also. And you will get it in table 26 is 456 2000; ly by lx already you have computed 5 by 4 equals 1.25. Now, let us write down expulsively shorter span alpha x and we have; that means, it is between 1.2 and 1.3 that it should be ly by lx between, 1.2 and 1.3 and we can have negative movement that is at the support and positive movement in the span and the values comes 0.048; you can check it in table 26 0.048 and 0.051 0.036 0.39. Longer span alpha y that is same for any ly by lx 0.037 and 0.028.

So, we have to find out for 1.25, we have to find out from the linear interpolation. So, what we can get it. So, you shall get the values you shall get 4 values 2 from here and 2 already we have got it. So, this 4 values give me the 4 moments. So, shall I continue.

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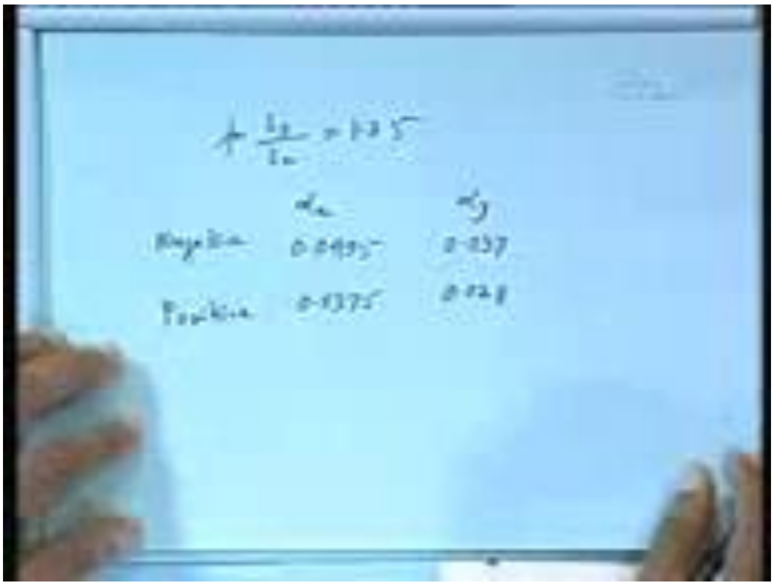

So, negative movement for ly by lx equal to 1.25 alpha x and alpha y. So, negative movement negative coefficient and positive coefficients. We shall get it here 0.0495 0.0375 0.037 and 0.028. So, these are the 4 coefficients times w l square x w is the design load. So, you shall get 4 different moments we shall get it, you can get it from table 26. So, that table 26 you should consult.

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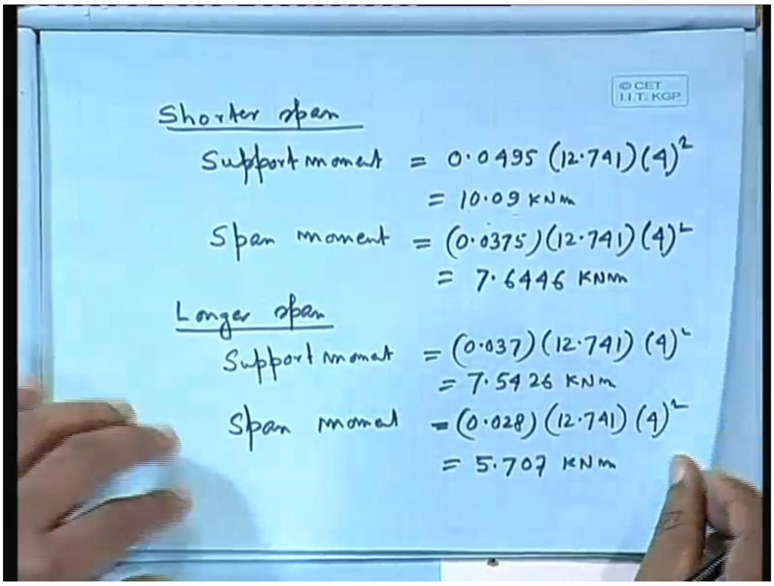

So, shorter span support moments 0.0495 times 12.741 times lx 4 square which comes as 10.09 kilo Newton meter span moment, in the shorter span we can get it 0.0375 times

12.741 times 4 square 7.6446 kilo Newton meter; what about the longer span. So, support moment 0.037 times 12.741 times 4 square equals 7.5426 kilo Newton meter and span movement equals 0.028 times 12.741 times 4 square equals 5.707 kilo Newton meter. So, we are getting 4 different values at different position.

This is the span movement in the shorter direction. This is the corresponding support moment out of that we can find out 10.09 is the maximum 1 we are getting. So, we can stop from here itself, we can find out the depth from taking these movement. So, 10.09, we can take it. So, what we can do it here then, let us find out the depth.

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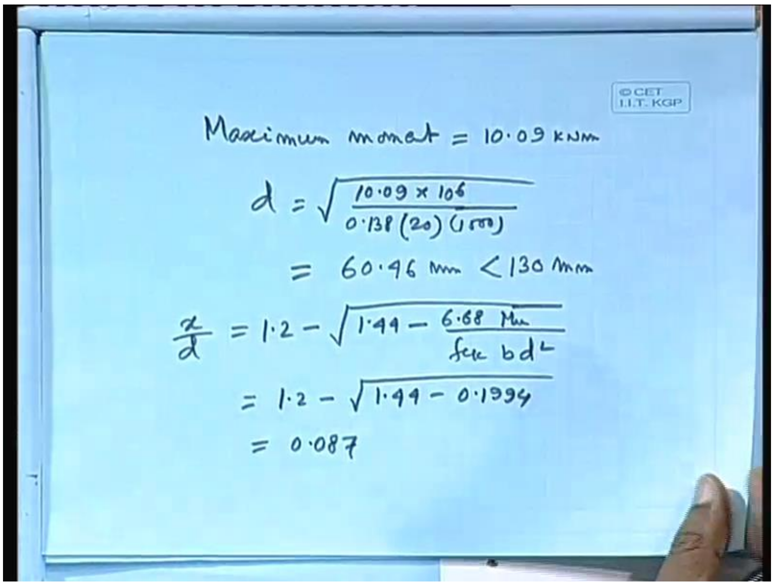

So, maximum movement so, d equal to square root of 10.09 into 10 to the power 6 by 0.138 times 20 times 1000; 1000 is the width we are talking unit width; which comes as 60.46 millimeter less than; 130 millimeter. So, let us complete this 1 that; we could find out immediately x by d 1.2 minus root bar 1.44 minus 6.68 mu by fck bd square which comes as; I am not going in detail, which comes as 1.2 minus root bar 1.44 minus 0.1994 equals 0.087. We are going very fast any way x by d equal to 0.087. So, you check these values so, x by d 0.087.

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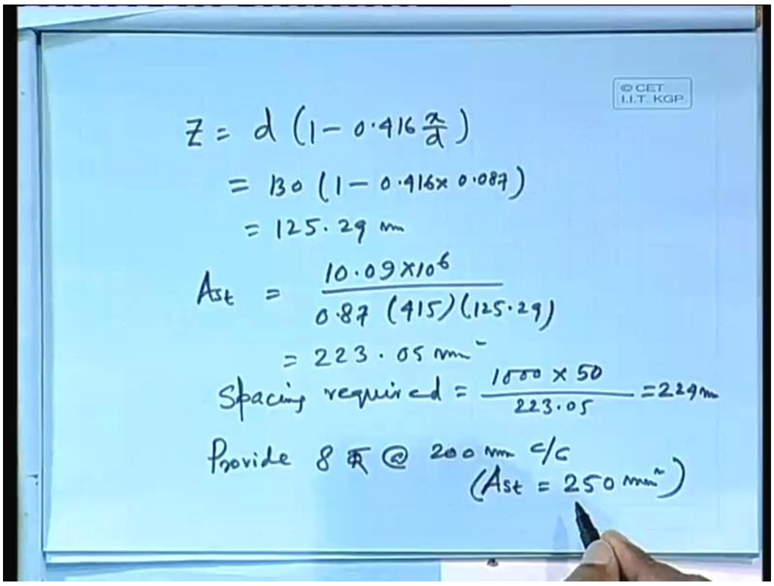

So, the next formula we shall use it as z; z equal to d times 1 minus 0.416 x by d equals 130 times 1 minus 0.416 times 0.087 equals 125 0.29 mm ast directly. Let us compute 10.09 into 10 to the 6 divided by 0.087 times 415 times 125 0.29 equals 223 0.5 square millimeter. So, spacing required equal to 100 times let us assume that, 58 millimeter dia bar we shall use it, because it is too less. So, 223 0.5, which comes as 224 millimeter so, you can provide 8 tor at the rate of 200 millimeter centre to centre.

So, ast provided equal to after computation you can find out 250 square millimeter. So, provide 8 tor at the rate of 200 millimeter center to center that we can provide. Now, similarly, we can take it that directly, what we shall do now we shall not change the depth; what we shall do, because it seems it is checked with these maximum movements. So, it will be true for other values. So, now we can directly we can compute x by d z and then provide that ast and also we have to check that 0.12 percent steel that whether, it is coming more than that.

If it comes that any value, because moment may be less. So, in that case if it comes moment less then; what you have to do then you have to provide the minimum reinforcement and which is 0.12 percent of the cross section area.

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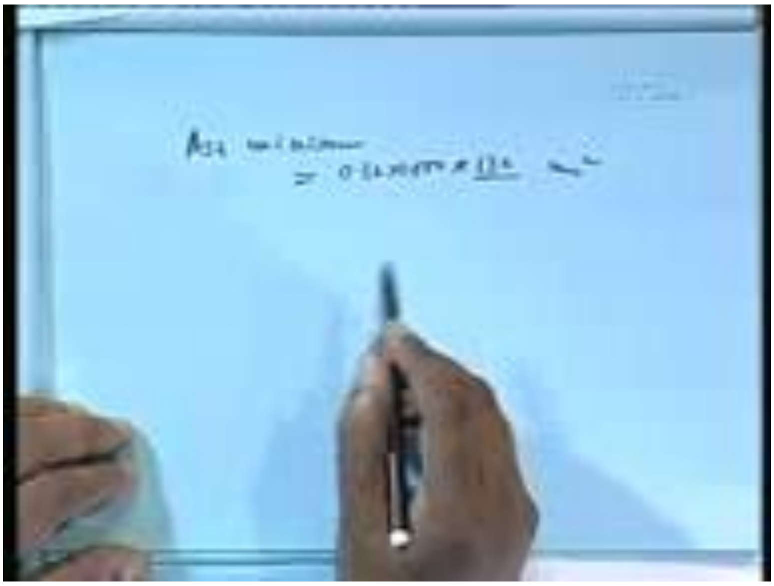

So, in this case it will be area of steel minimum that 1 it will 0.12 times; 1000 times130 shall we take, because 130 is not the 1. It could be little more also because 131. So, please note because, I have taken 10 millimeter but, now since I have providing say 8 millimeter. So, it will be little more. So, than 1; so, any way whatever, it is on the basis of that we can find out the area of steel and that area of steel always; you have to check whether, it is coming more than; this otherwise this is the criteria of the crack width also that crack.

So, we shall stop it here and we shall, in the next class. We shall start, with that at least I shall give you some introduction, on the concentrated load. So far, we have done on the uniformly distributed load on slabs. But, I shall give the next 1. That is on the concentrated load.

Thank you