Design of Reinforced Concrete Structures
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Lecture - 12
Design for Shear

We shall continue with the design for shear.

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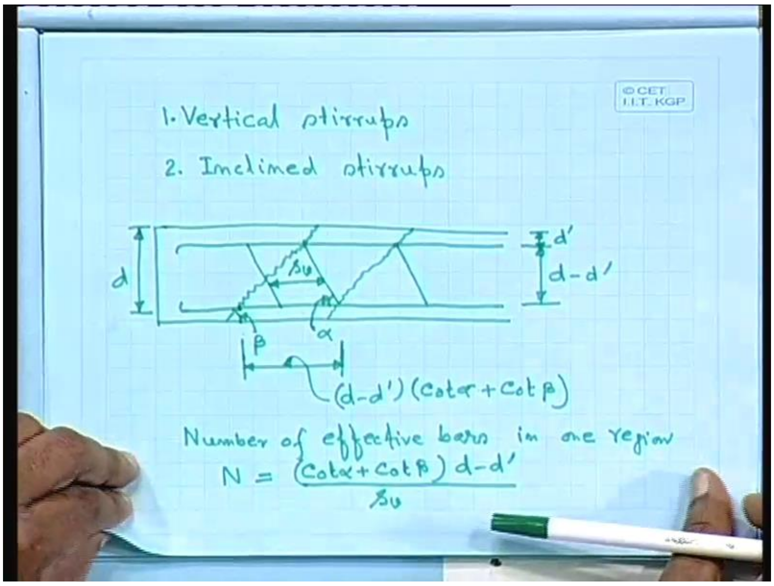

Last class we have done that, Vertical stirrups this is 1 of the cases how we can provide that stirrup. The other 1 inclined stirrups or bars. Let us, take 1 beam we have that say compression members or hanging bars and tensile members, tensile reinforcement. So, the effective depth d and we have d dash from the top that effective cover. We can have say so, this is a crack inclined 1 say at an angle beta and we are providing stirrups at an angle say alpha; this distance say sv.

So, this is another crack like that it can go and we are providing stirrups. The distance we are talking this is one from here to here; this distance will be equal to what about this 1 this depth d minus d dash. So, we shall get d minus d dash times cot alpha for this side plus cot beta. So, how many bars? Number of effective bars in 1 region we can say because, we can say this is 1 region this spacing.

So, n equal to we can say cot alpha plus cot beta times d minus d dash divided by sv the spacing of the inclined bars. So, number n so; that means, you have to provide that bars within this region and we can get cot alpha plus cot beta. Because, we are getting this horizontal length so, we can get n.

So, this is the 1 that number of bars. So, here also that instead of having d by sv we are getting this formula because, we have to provide within this region.

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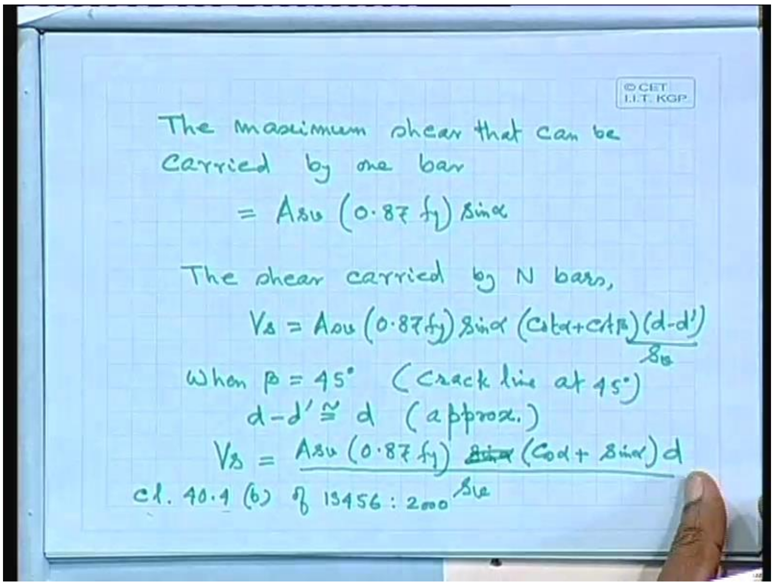

The maximum shear that can be carried by 1 bar equal to a sv that is the of the stirrups of that cross section area times the permissible maximum stress permissible maximum stress and it should be vertical because it is inclined we are taking these bars. So, it should be inclined this is inclined. So, we are taking that 1 that resting that top 1 which comes as times sine alpha.

So, Asv 0 87 fy times sine alpha we are getting. So, this is the 1 maximum shear that 1 bar take. So, if we consider stirrups so, Asv if it is 2 legged. So, we have taken care that twice that we have taken care here in Asv. So, the shear carried by n bars say we can say that is say your Vs equal to Asv times 0 87 fy times sine alpha for 1 stirrup inclined stirrup you can say times cot alpha plus cot beta. Because, already we have provided within these region d minus d dash divided by Sv.

So, this is the 1 for single link inclined and this 1 the number of links. So, we can get Vs equal to this much. When the crack we are assuming at 45 degree, that crack line crack line at 45 degree. So, if we say crack line this 1 this is 45 degree. So, beta equal to 45 degree and let us assume, d minus d dash equal to d. Let us, say approximately because we can ignore d minus d dash that let us assume that equal to d.

So, we can write down vs equal to Asv times 0 87 fy sine alpha times. So, we can say this particular 1 you could write down here. So, sine alpha suppose sine alpha plus sine alpha times d divided by sv. And we shall get that in the clause, let me write down here clause 40 4 b of IS 456 so, we can get this clause. Because, always every time I should refer this clause, where from you are getting this 1.

So, this 1 you will get this vs or Vs which is mentioned in this code, you will get it Vs that you will get in class 40 4 b of IS 456.

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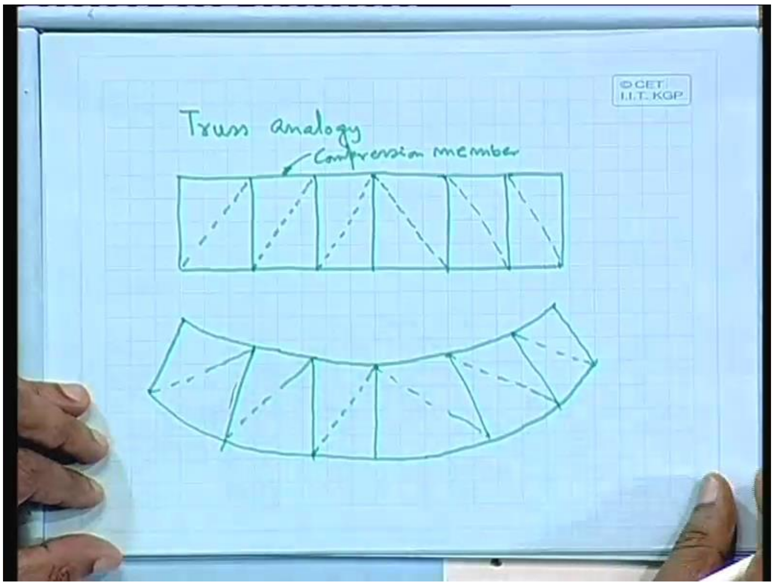

Now, let us come to few things here that 1 generally we do it say we that shear that is I just say truss analogy that is from the beginning of design we say I just say truss analogy. The shear whatever we are taking care; that means, the stirrups whatever you are providing that 1 as if it analogues to truss. So, how it comes let us find out if we take a truss; truss means say it is made of say generally most of the cases it is made of say steel bar steel sections.

The bridges whatever you will get it say railways bridges particularly we will get those are nothing, but a truss even say you any factory those are called truss. So, what will do we are making to different kinds so, this is your compression member. If it happens we can find out this way let us, say it bends like this then, what we will get? The members which will be extended, those are tensile members and the members which will be shortened those are compression members.

So, you can find out from the deformation; that means, as if it is like this so; that means, this truss it is made of say it is deformed in this fashion. So, how to we can find out? The members which are extended those will be; that means, from here you can say you can qualitatively you can say which members are the say tensile and which members say your compression.

So, you can find out from the from this say deformation diagram the members which are extended. So, that 1 obviously, it will be tensile members the members which are shortened those members should be compression member. Now, here these members that one will be extended and we shall get that, we have to provide that was a tensile force. And here this is the analogous to that truss; that means, we have to resist by this truss or shear.

In this case nor concrete members that concrete beam we are taking care, that we are resisting that part by the stirrups. So, that is why we say truss analogous to truss member. The other alternative also you can so, this is for particular members you can say particular stirrups.

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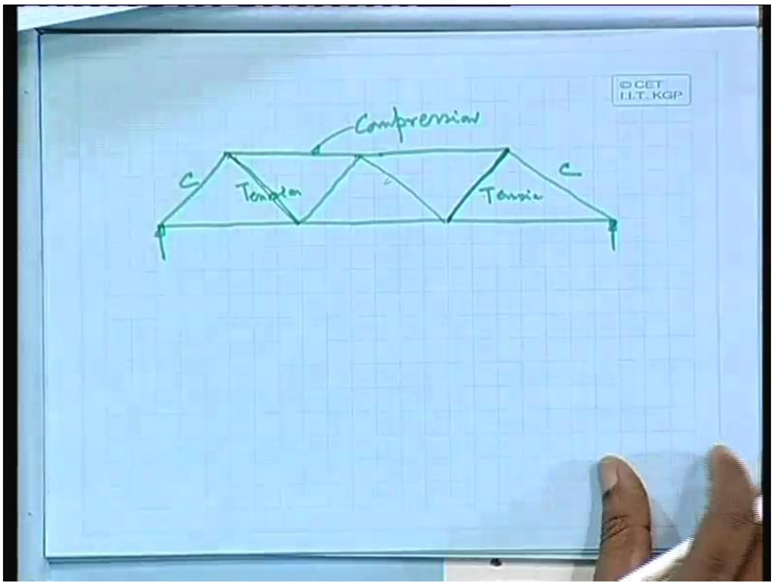

Similarly, we can I can show you for the your say other 1 also that mean for the inclined 1 which we can draw. So, we can draw out of that again these member should be compression and this member and this member will be in tension; this is even compression, this is compression. So, here we are providing that 1 the truss analogous to truss. So, that here we are providing this 1 with that say inclined stirrups. So, this is the way we generally provide.

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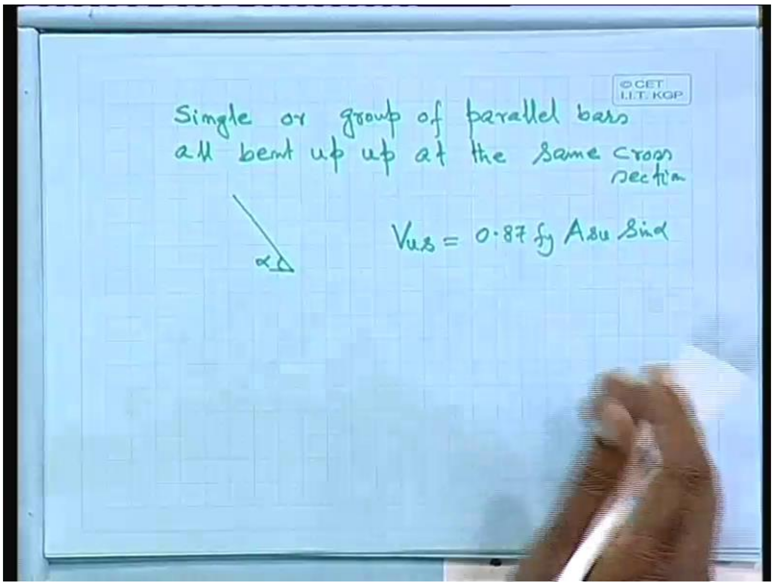

Let us, come to the single bar single or group of parallel bars all bent up at the same cross section. And let us say, that is making certain angle say alpha. So, it may be only single bar or group of that means, it means 2 legged. So, you are taking 2 legged means 2 or if it say 3 legged the 3 so, those are at the same cross section.

So, we can find out that Vus equal to 0 87 fy times Asv times sine alpha because, we are taking that particular 1 only. So, we can consider this 0 87 fy Asv sine alpha this is the 1 for the single or group of parallel bars. So, that is the 1 the shear resistance that you can find out using this formula.

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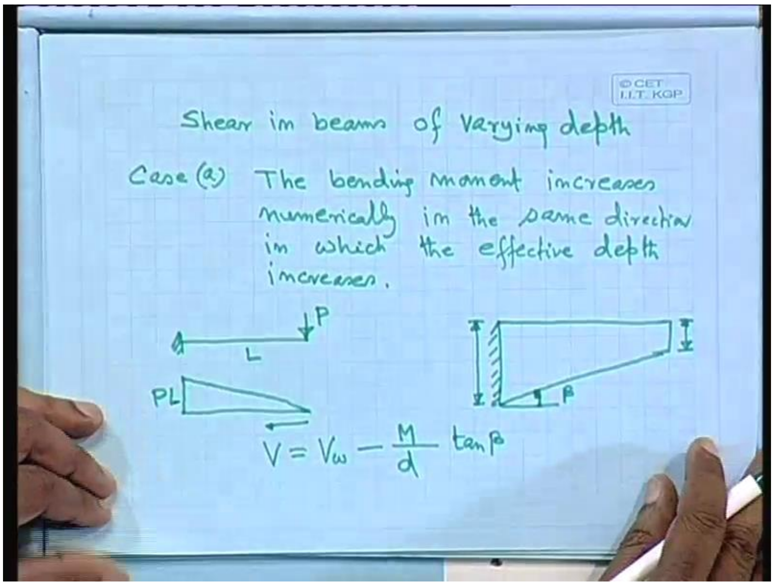

There is 1 more that I should say shear in beams of varying depth. This is a special case so, there are 2 cases the bending moment increases numerically in the same direction in which the effective depth increases it means, let us particularly in the cantilever beam. In the cantilever beam let us, say this is your cantilever beam and we have certain say concentrate load p or say udl. Then, what about the bending moment diagram? The bending moment diagram we will get it if it is l so, we shall get P times L.

So, the bending moment increases in this direction. It is not a good practice that we shall provide the same depth, generally we provide the maximum depth in the support and in the free end we provide a little less may be say 250 or 200 millimeter 150 millimeter depth we are providing in the free end. Whereas, in this side we are providing maximum because in the support.

So, what we can do we can do this 1. So, this is your diagram we are having say certain depth here and we are providing certain depth here. So, what happens in this case? The bending moment increase numerically, we are talking numerically in the same. Because whether we are talking positive or negative we are not talking that so, it is increasing here.

So, bending moment increases numerically in the same direction in which the effective depth increases; this is the case well it is increases. So, in that case V will be equal to Vw whatever the shear force we shall get at that particular cross section minus M by d effective depth times tan beta what about beta? Beta means this angle; so, we can get this beta.

So, V that modified V that 1 due to this varying depth the shear force will be modified actual shear force due to this applied load at a particular cross section, we shall get certain Vw that is Vw minus M by d tan beta. So, we shall get the V for which we have to design for shear. So, this is the 1 case the other case obviously, the other way. So, let us take the other case.

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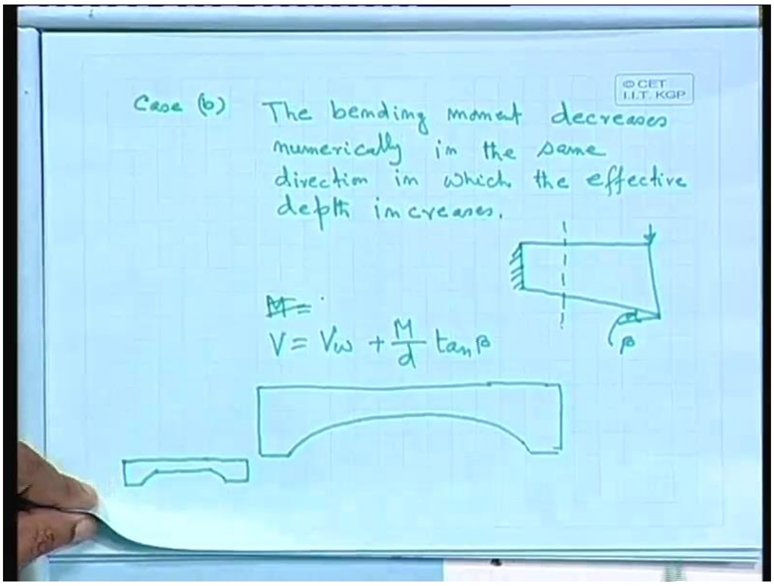

So, case b the bending moment the bending movement decreases last row you please come to this side, last row you come this side. In the bending moment decreases numerically in the same direction in which the effective depth increases so, this is the other way.

So, though it is not a practical 1, but anyway let me give this example because; in the cantilever case it is not the actual 1. So, in this case what happens the beta and we shall get that V equal to Vw plus M by d tan beta this is the case.

So, we can find out that m at this say we are interested to find out at this section what is the value M we know the effective depth. And we also know the Vw so, we can find out the corresponding V. So, these are the 2 that means, we have to modify that we have to compute the V depending on the bending depth. We can yes.

So, this say for example, we can use you will find out say this type of beam in previous also you will find out. So, this type of arch and also we can we can also get it say something like this also we can get it. Sometimes we provide the reinforcement that your depth, near the support we provide that more possibly for you see that in your hall possible I do not know in few halls you will find out, the beams are given in this fashion.

There is near the support you will get more depth whereas, in the middle you will get that less. Because, it is shear dominated it means it is shear dominated.

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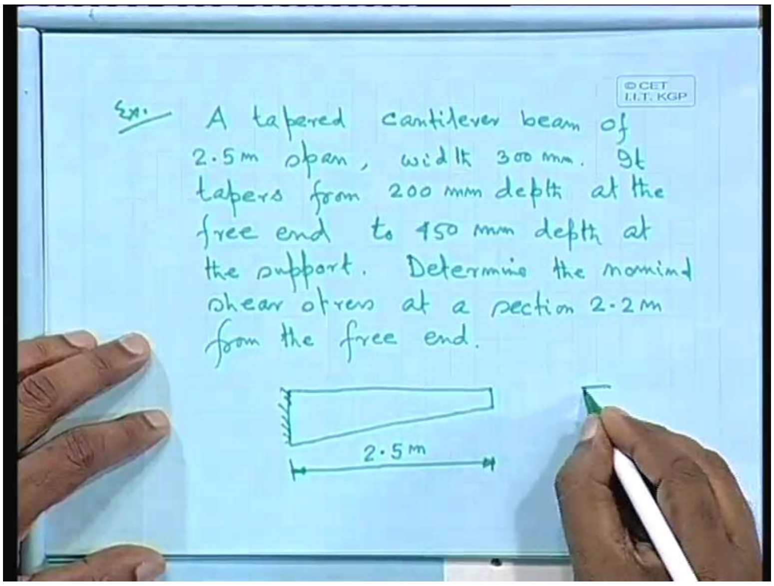

Let us do 1 example. Let us say a tapered cantilever beam of 2 5 meter span, width 300 millimeter. It tapers from 200 millimeter depth at the free end to 450 millimeter depth at the support. What we like to find out let us, determine the nominal shear stress at a section 2 2 meter from the free end.

So, a tapered cantilever beam let us draw the figure. Tapered cantilever beam of 2 5 meter span this is 2 5 meter, width the cross sectional width 300 millimeter. This is 200, at the free end and at the support 450.

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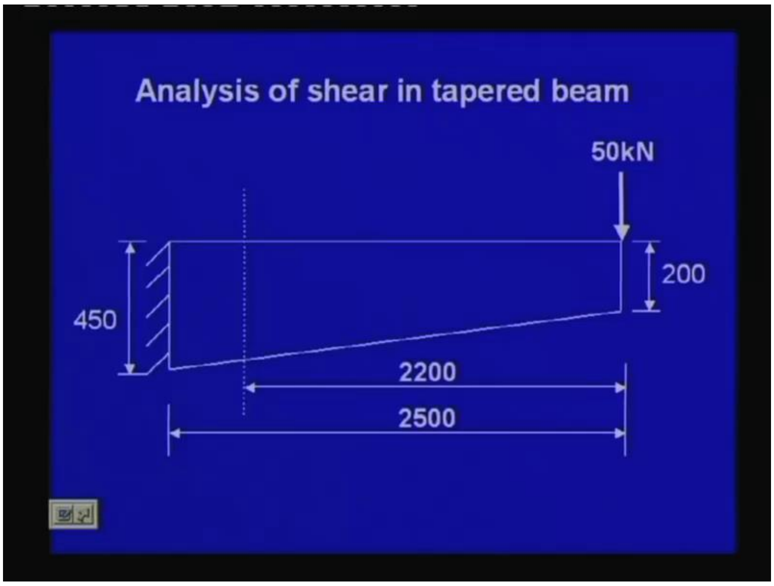

I think I have a figure 1 thing I would like to tell you in the last class actually this was wrong because both of them was like these. So, you should note because, that 1 in compression so, it should be the other way last class when I showed that 1 it was in other side. So, anyway these are the we do not want to tell these things. So, this your problem. So, we are interested to find out that shear force here; at this section due to this bearing depth.

So, we are having 200 millimeter all dimensions are in millimeter 200 millimeter. And I have forgotten to tell you that, p that applied that is 50 kilo newton. So, if we have this 1 so, before going for design what we have to do we have to find out the V due to this change due to this bearing depth, that we have to find out. So, V equal to how much?

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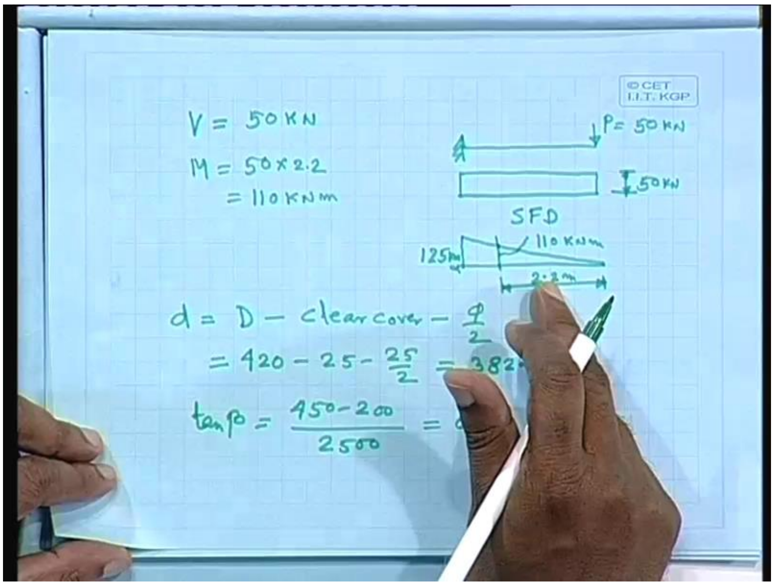

That shear force V that is 50 kilo newton, we are interested to find out that P equal to 50 kilo newton. What about the sheer force? Shear force constant which is nothing, but 50 kilo newton this is your shear force diagram. What about the bending moment diagram? So, we shall get so, 50 into 2 5 which comes 125 kilo newton meter. But we are interested to find out somewhere here; this is 2 2 meter.

So, this 1 it comes as M 50 into 2 2 110 kilo newton meter. What about D? D equal to overall depth minus clear cover minus that say phi by 2 let us that 25 millimeter not a bar what we are using. So, we can get what about D? D at this point it will be 420. So, we shall get 420 minus 25 minus 25 by 2 which comes as 382 5 millimeter. Because, we can get 200 on other side we are getting 450.

So, we shall have to find out the D the overall depth d that we have to find out, which is coming as 420 at that particular section. What about tan beta? 450 minus 200 by 2500 equals 0 1.

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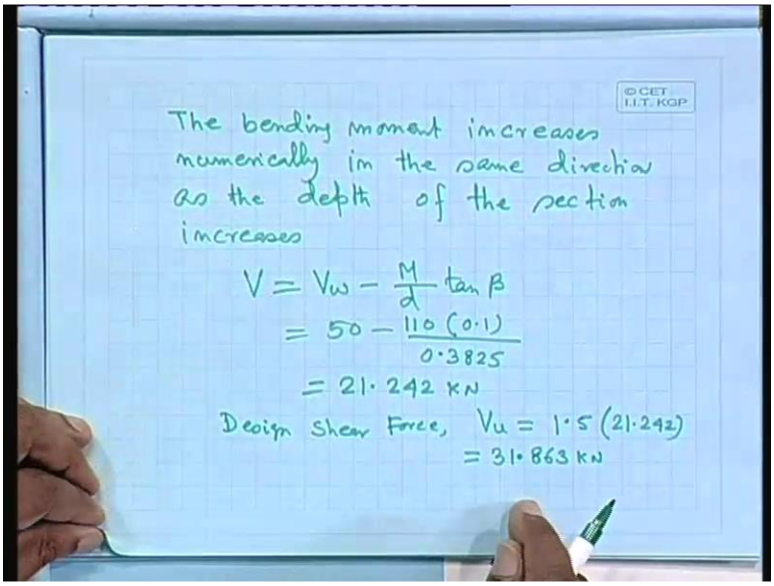

So, this is case a because bending moment increases as well as that effective depth also, increases in this case. The bending moment increase numerically in the same direction as the depth of the section increases. So, we shall get v equal to… so, let us make it clear. So, let us say this is Vw in our case let us say this is Vw because, we are using that formula.

So, Vw minus m by d tan beta equals 50 minus 110 times 0 1 divided by 0 3825 this is the d that is we are converting in meter and which comes as 21 242 kilo newton. In this case, we have applied the load p 50 kilo newton which we can say the characteristics load. So, we have to get in limit state we have to consider that 1 as a design load

So, design force Vu equal to if it is not mentioned anything wind load or load we shall take multiply with 1 5 times 21 242 which equals 31 863 kilo newton. So, this is your design shear force vu which equal to 31 863 kilo newton.

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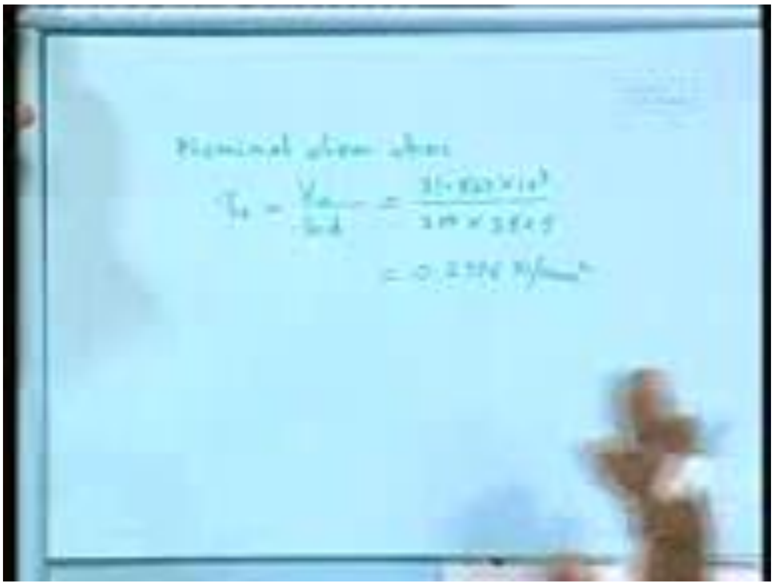

So, what about nominal shear stress the nominal shear stress tov v equal to Vu by bd equal to 31 863 into 10 to the power of 3 divided by 300 that is the width times 382 5 which comes as 0 2776 newton per square millimeter. So, this is your shear stress which is asked to find out in this problem that tov v is not simply what about the shear force we have to modify due to varying depth and then we can do our calculation.

So, that mean tov v and then tov c all those things then, again we can continue whatever that we have done in the last class. So, this is the one we shall do it for that to find out the nominal shear stress.

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Let us, go for 1 more problem and that let me eh explain on this problem that how we would like to do it. Let us, do it in total that as well as bending let us take as this as say 2 what is called that brick walls. And over that we are keeping our say beams, that these 2 walls will support beams the series of beams.

So, these are say different beams but what I am telling that, we shall not construct in this fashion just to give you that how we are going to do it. But in actual case that you are other things everything we shall do it will intrigual so, over that the slab will come.

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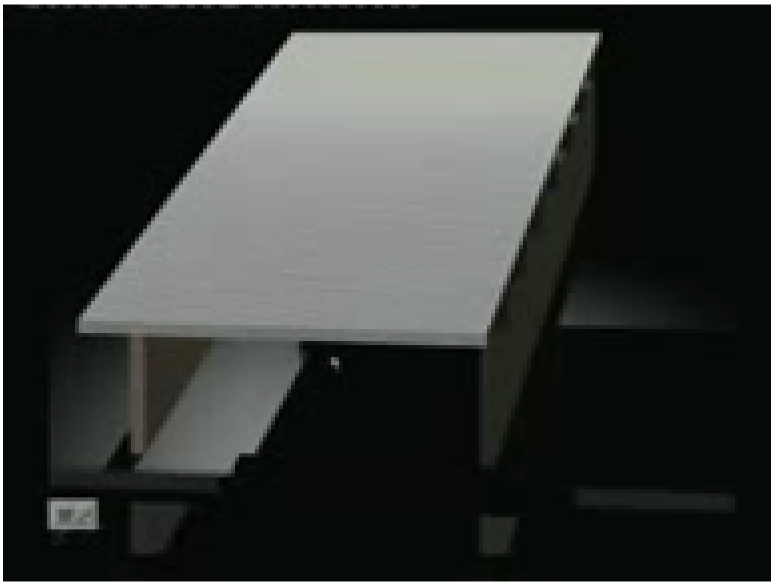

So, we cannot see the beam but that is not the case; our case is that we shall take this beam as well as the slab we shall cast intrugally. So, that we shall get that t section that we can design it as a t beam.

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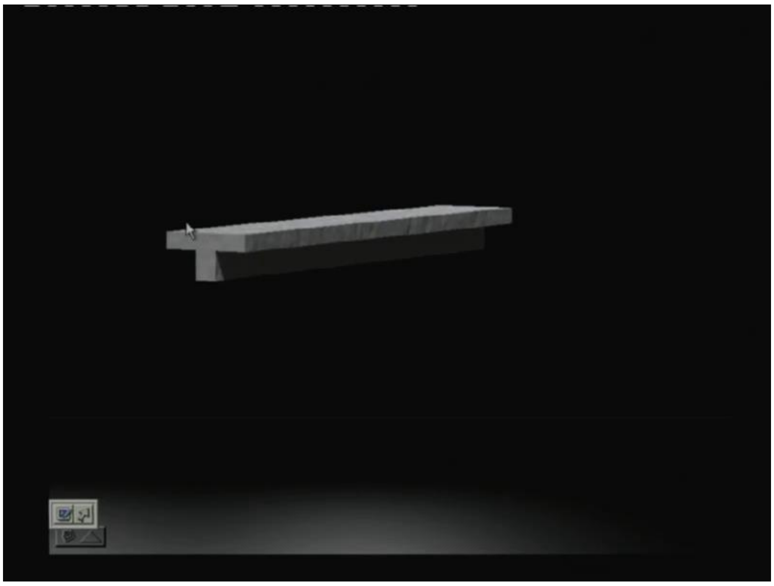

So, we shall. So, that we can design it as t beam so, what we have to find out in this case.

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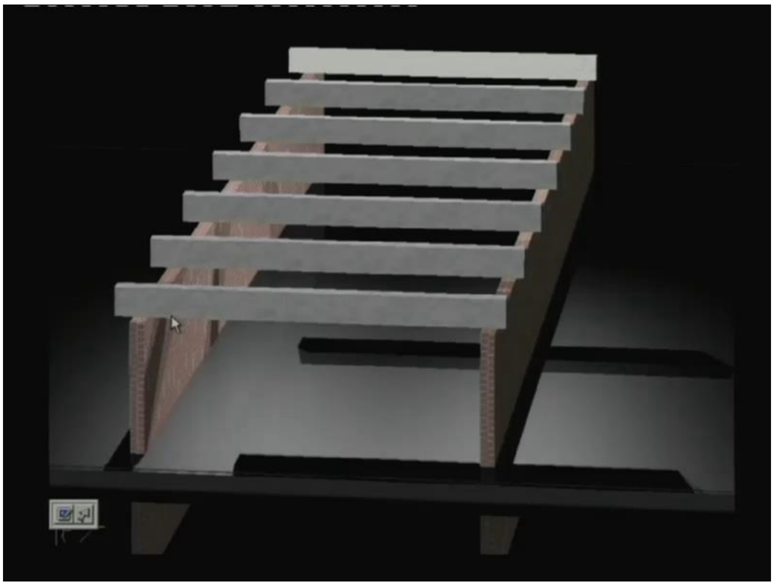

If we take and we are having flange so, it has a particular spacing. We have a spacing and so, let us take 1 problem that having depth that having say flexure as well as a shear we shall take care.

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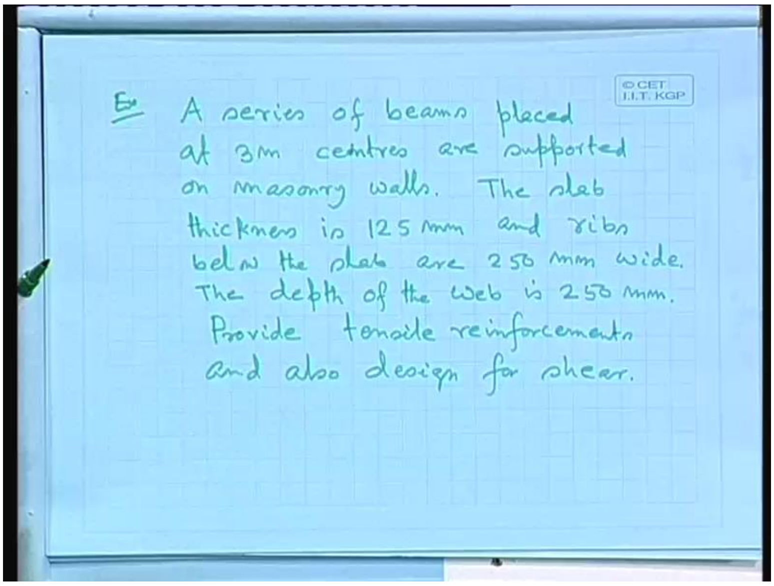

So, let us write down the problem first. A serious of beams placed at 3 meter are supported on masonry walls. The slab thickness is 125 millimeter and the rib below the slab are 250 millimeter wide. The depth of the web let us consider, say 250 millimeter. We are taking that we are assuming, if it is not then we shall change it, but we are taking that say 250 millimeter.

Provide tensile reinforcement and let us say also design for shear. So, the beam has 2 parts: 1 it has to resist flexure and it as to resist shear. So, we are taking that this problem as a total and if we consider

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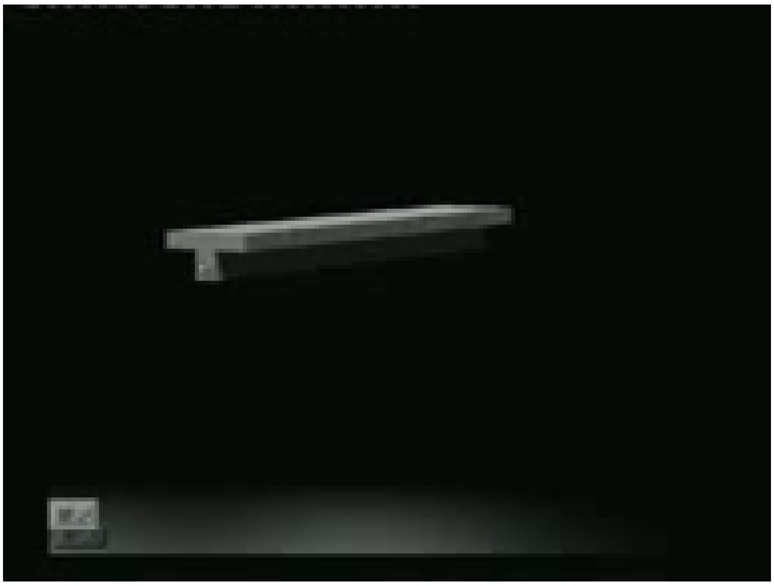

So, we have this rib or web that width that is 250 and depth also we are taking say 250. The thickness of this part this is the part of the slab, this is the part of the slab that we have are taking and that one here 125 millimeter depth. We have to find out, the overall that you say width of the flange also and that we shall get it from the we shall find out from the your that IS 456.

So, if we say a series of beams that is the 1 the series of beams that if we go to that to the previous 1.

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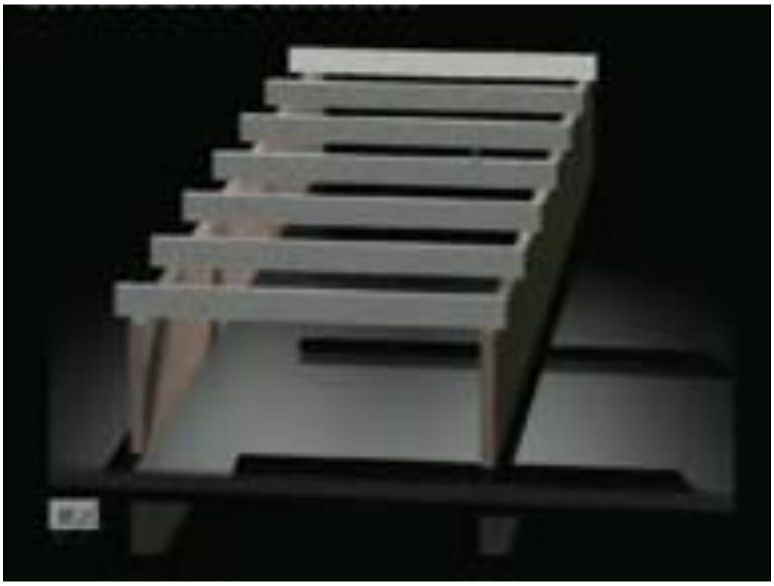

So, series of beams placed at three meter center to centre; that means, each of them having spacing say 3 meter as supported on masonry walls these are 2 masonry walls. We can take say 250 millimeter, the masonry wall.

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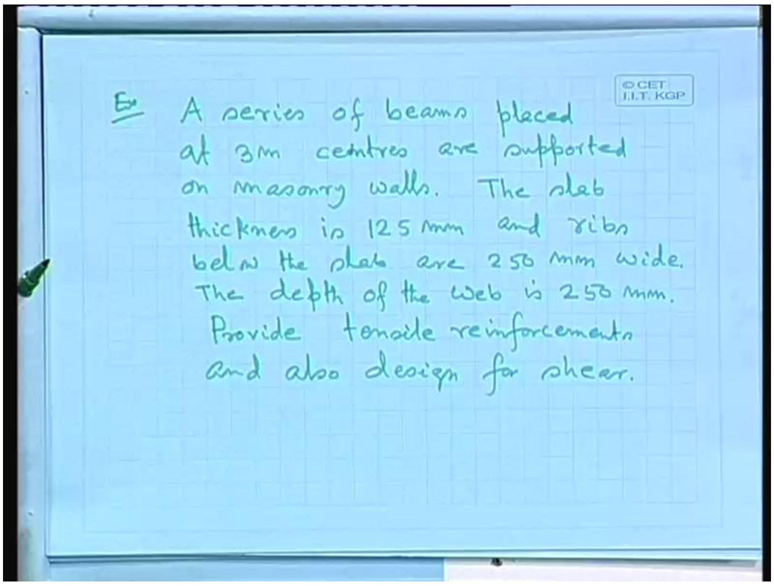

Let us say width of masonry wall. So, we can take this the slab thickness that is 125 millimeter, ribs below the slab that will width 250 millimeter and depth that is 250 millimeter. We have to provide reinforcement, tensile reinforcement were talking.

Because, the other part that 1 say you will be just only say we shall put. So, tensile reinforcement and mainly that 1 in the support because, we can take these beam as a simply supported 1. Because it is just simply supported over the masonry walls it is not there is no moment here; there is no moment developed. But when we take care say you are that columns that time the moment will be developed.

So, frame structures the moment will be developed in at the supports. But here in this case, that you will have that that you have got to say only simply supported. If it happens that one side column and one side say your masonry then, what will happen then it will be you have taken care well. So, here first thing we have to find out let us take that what about the load.

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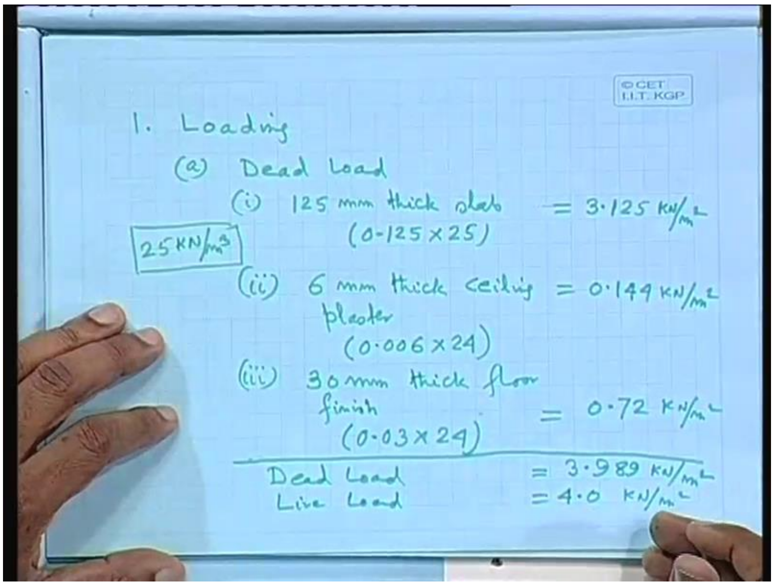

So, number 1 loading. Dead load so, we have 125 millimeter thick slab which comes as 0 0 125 into 25. So, 25 kilo newton per meter cube that is the concrete that we are taking say you the 25 kilo newton per meter cube. So, .0 125 into 25 which comes as 3 125 kilo newton per meter square. We are providing please note, 3 125 kilo newton per meter square.

Number 2 6 millimeter thick ceiling plaster; that means, at the bottom of the slab we are providing plaster at the bottom, at the bottom of the slab and that is 6 millimeter thick. So, what you can see from the bottom that we are providing the 6 millimeter thick ceiling plaster. And that 1 will be 0 006 times here we shall not take 25 instead we shall take 24 because, we are taking this 1 Rcc reinforced and here this plane.

So, plaster which comes as 0 144 kilo newton per square meter. Number 3 let us provide 30 millimeter thick floor finish; that means, at the top we are providing the thirty millimeter thick floor finish. So, which comes as 0 03 times 24 equals 0 72 kilo newton per meter square. So, dead load equals 3 989 kilo newton per square millimeter.

Let us say that live load that is say 4 4 kilo newton per square meter 400 kg per square millimeter. Let us say, that we are having say live load 400 kg per square meter. Yes. So, generally depending on the situation I have assumed this 400 kg per square meter, but for a specific purpose that particular building what for that 1 say is made so, on the basis of that we have to assume that, we have to get that value.

So, you will gate in IS code 875 that which I have told in the very first class. So, 875 is the code for loading. So, if is it residential building then you are having 1 particular load; if it is you say public building then you have another load auditorium. Balcony you will find out in the room you will get say your load, whatever load you will get it or else in the balcony because it may be crowded so, that is why we increase the load.

Staircase also similarly the stair case say, if you take say 250 kg per square meter that is in the room load, in the room whereas, you will get that one in the balcony say it may come 300 kg per square meter. Similarly, in the stair case because that also may be crowded so, that is why that one also comes here little more. So, different cases that you will get different load on the basis of that we have to calculate the load.

So, when we shall do 1 full problem 1 building then, that time we shall take care that 1. That what have to do and how to analyze all those things we shall take we shall do it. So, let us assume here 4 kilo newton; that means, 400 kg per square meter that is the 1 say live load. So, we have dead load and the live load.

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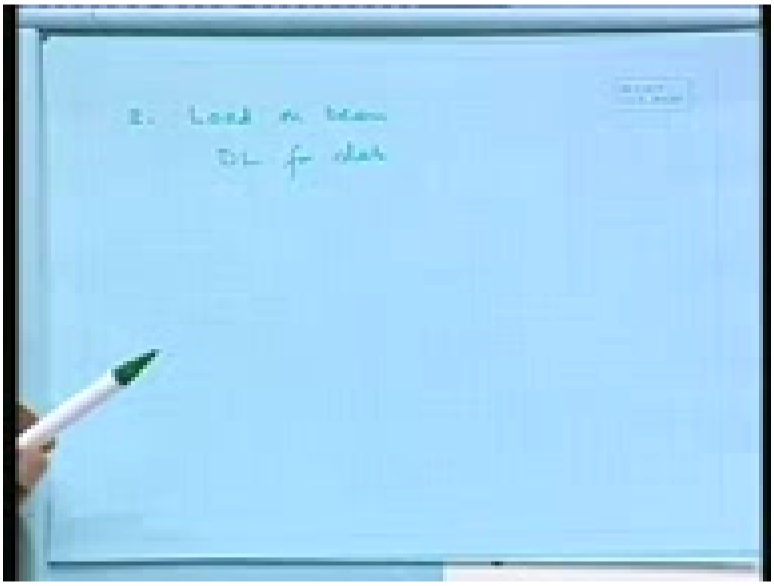

So, number 2 what about the load on beam? Let us say dead load for slab. So, individual beam we are taking say 1 middle 1 what we can do you can take this beam, this end beam the other end beam, the other side those 2 end beams you can design it separately. Because, it will have less load compared to the inner say all these beams this 1 all of them intermediate 1 you will have the more load because, you are getting the load slab load from both sides.

So, dead load of the slab as well as live load so that, you are getting. So, you will get from both sides whereas, this beam and the other end this beam it will have that half of the load. So, you can design it separately; that means, you can design it as a l beam also, but anyway here we are taking say 1 any inner beams we are taking. So, dead load for slabs how much it will be we have got 3 989 that is we can say.

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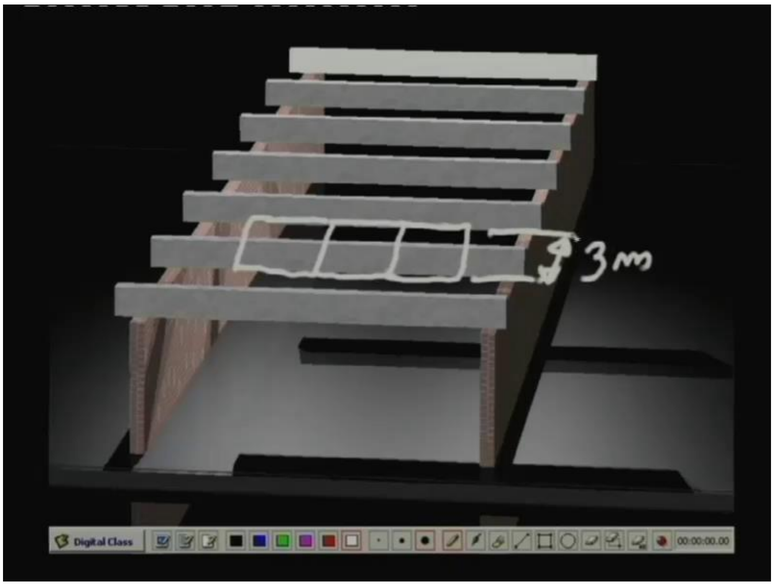

So, this is the square that means, 1 meter by 1 meter. So, like that it is going when you talk say your beam it should be per meter that udl whatever it is per meter. So, whatever load we have got that is your 3 989 or 4 kilo newton per square meter. So, along this length we will get and what about this distance half of this half of this that is equal to 3 meter isn't it? this 13 meter because, that spacing of beams.

So, we can find out that per unit length that per unit length it will be 3 989 times 3 which comes as 11 967 kilo newton per meter. So, our load along this length you are getting so, multiplied by this width. So, I shall get 11 967 kilo newton per meter.

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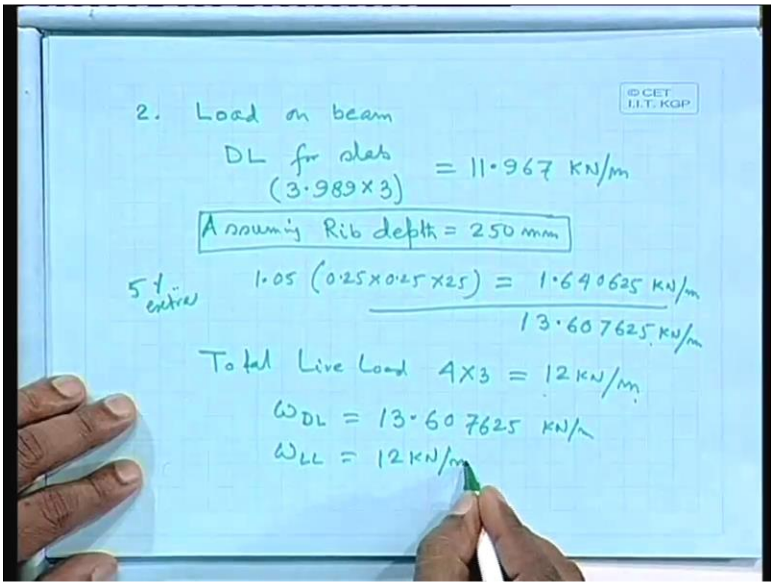

Similarly for the live load , but before that I have already assumed already given of course, that rib depth last beam it will be only this side half the that 1 5. And if there is no overhang that means, if it ends the slab ends at the here say this is no overhang if we assume then it will be just multiplied by 1 5.

But if it happens that something say 0 3 meter this side also, then that also you have to take that is 1 5 plus 0 3, but anyway generally we can say half of that. So, rib depth let us say 250 millimeter and so, we can get and let us say 5 percent extra. So, 1 05 times 0 25 times, 0 25 times, 25 equals 1 640625 kilo newton per meter. I have taken five percent extra for finishing other thing we have taken.

So, we can get 13 607625 kilo newton per meter. Total live load 4 into 3 the similar fashion which comes as 12 kilo newton per meter. So, this is so, we are getting let us say for dead load we are getting this much and for live load we are getting this much. So, Wdl 13 6076 25 kilo newton per meter and W live load 12 kilo newton per meter. I think we have to stop here, we shall continue the same problem in the next class.