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NPTEL ONLINE CERTIFICATION COURSE

Course
on
Reinforced Concrete Road Bridges

by
Prof. Nirjhar Dhang
Department of Civil Engineering
Indian Institute of Technology Kharagpur

Lecture 13: Design of Slab Bridges (Part V)

Hello everybody so we have almost at the end of the design of slab bridges that we would like to conclude today with the checking with the bending moment.

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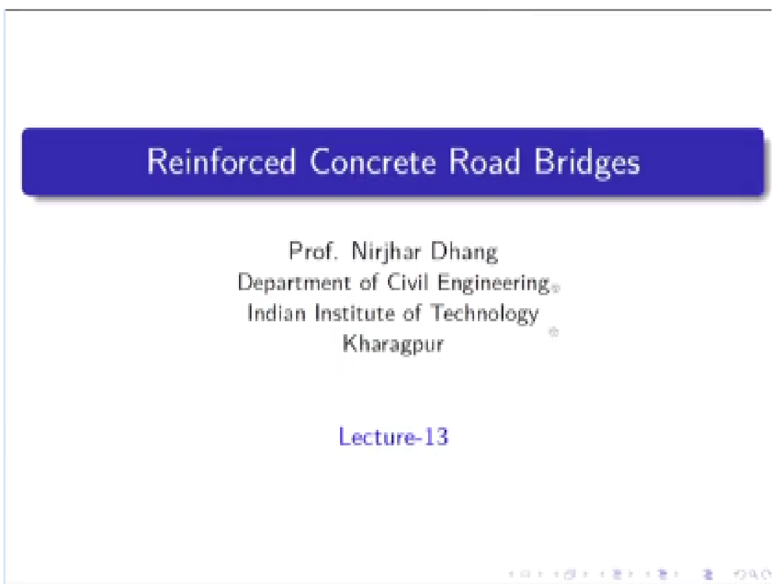

So let us quickly just to go to that one so what we would you like to see this particular one.

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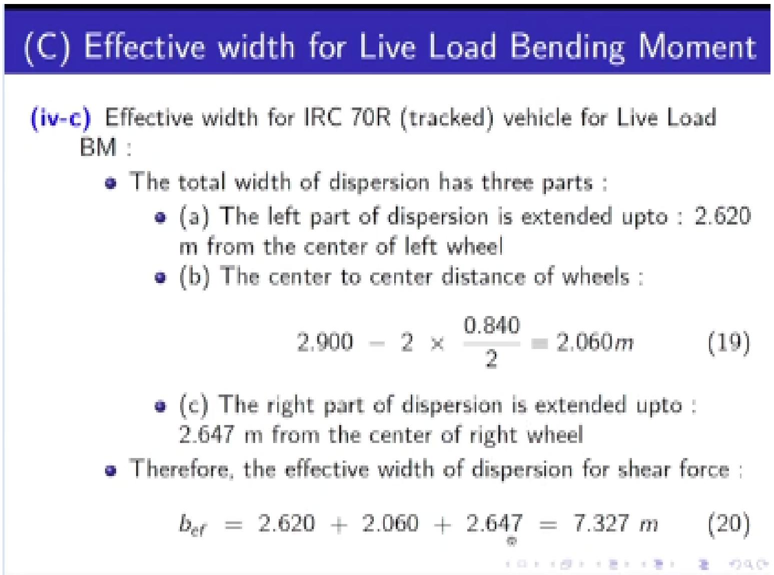

We have got that 7.327 that one we have got it.

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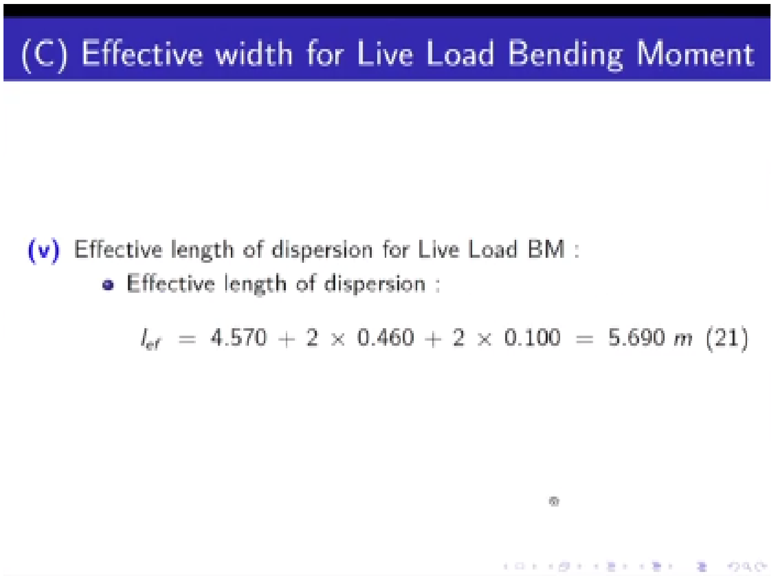

So and also you have got this 5.69 also that meter we have got it so let me keep to the shear, force first.

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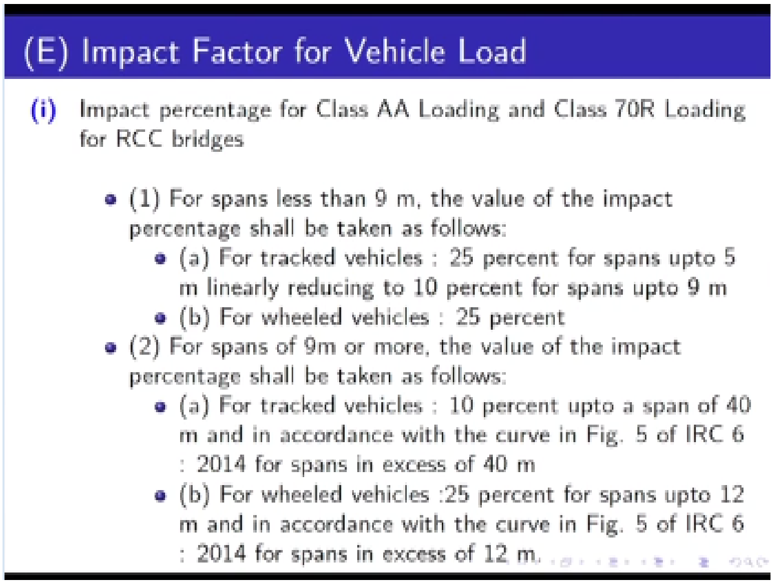

So that one now I shall tell you one more important aspect that is your say impact factor already we have discussed that impact factor and that we have given that one that relevant clauses that we have given here, so impact percentage for Class A loading and class 70L loading for spans less 9m the value of the impact percentage shall be taken as follows, so 25% for spans up to 5m linearly reducing to 10 then, so 5. So, that means here we can consider this particular one 5.9 meter.

So in that case it will fall to this particular category for this is not will wheel vehicle so this is a first case will come case a will come this is for spans of greater than 9m so 10% to up to span of 40 and then figure 5 already we have shown you in one of the that your lecture and then we are having this one so we will show our case will be here this particular one.

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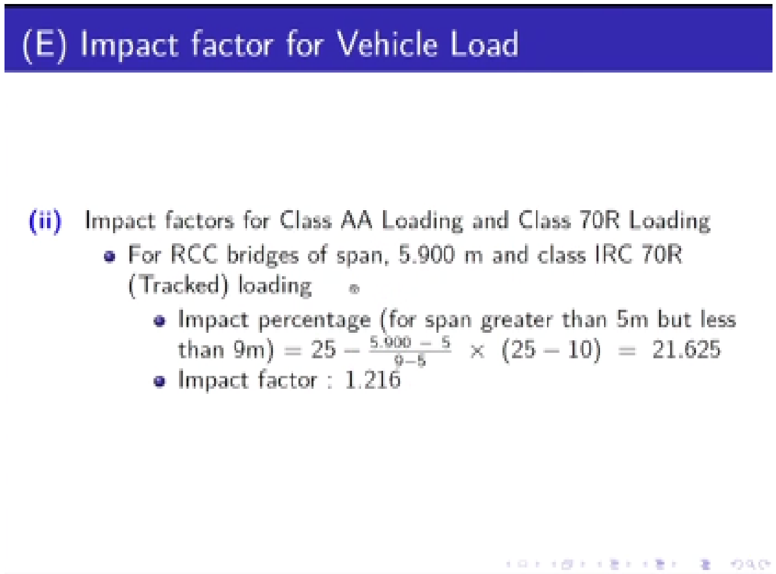

So how it comes let us see so their impact percentage that we can say for span greater than 5 m but less than 9m, 25 – 5.9 – 5 so that means actually you know what we are doing this basically here.

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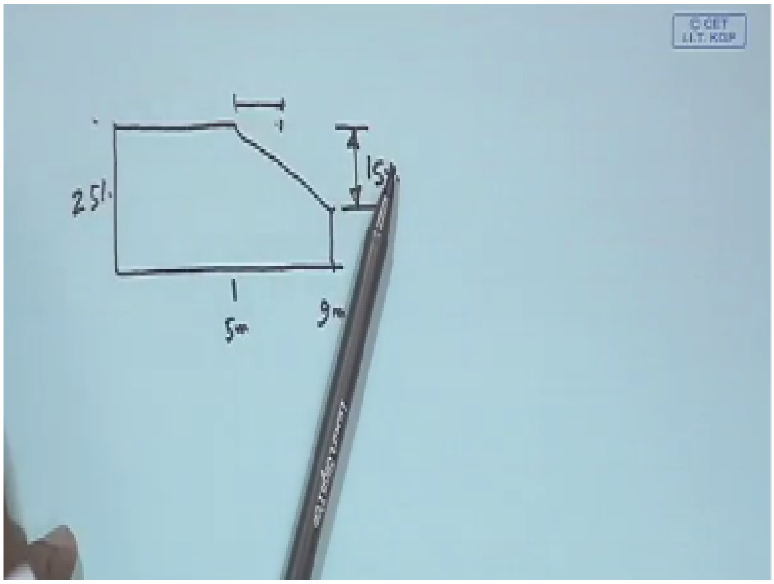

So this is 25% say and up to this we are considering that particular one here somewhere here and which is linearly varying, so this is 5m this is 9 m so how much is this one so it will be reduced to 15%and so for any kind of thing we can find out that how much you are additional one from there you can find out and that is what we have done basically here.

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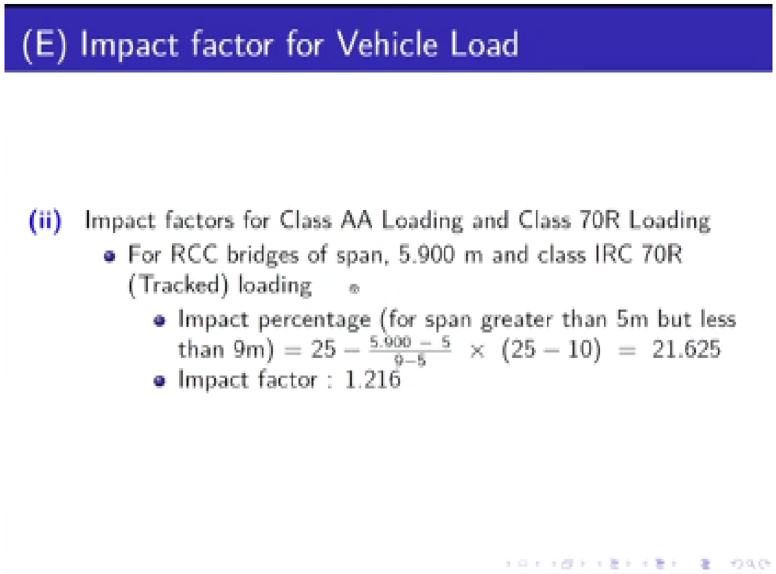

So 5.9 – 5 / 9-5 x 25 – 10 so these particular induction we are doing according to that clause.

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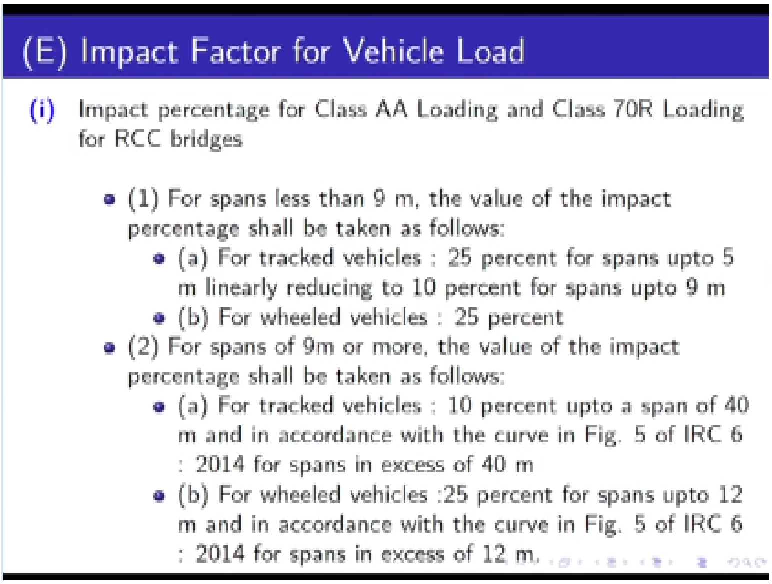

We are following this clause.

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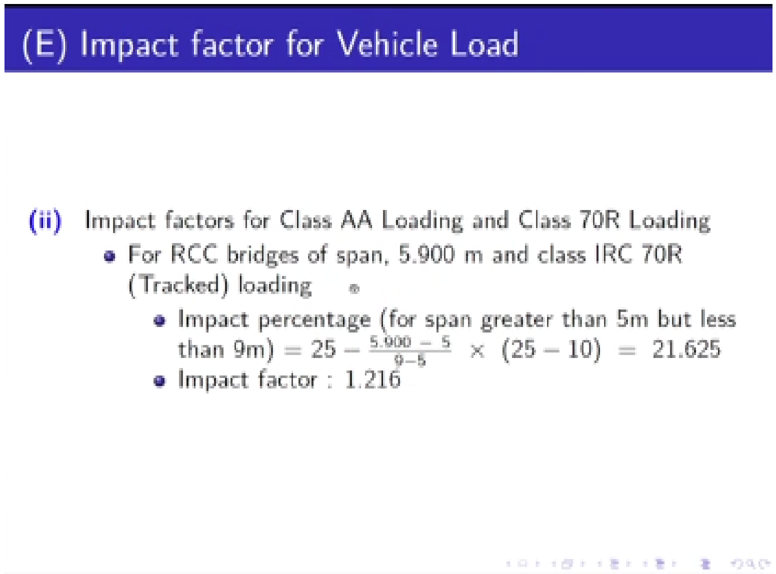

And then we can find out this work role here and which is coming as 21.625 that is in percentage so impact factor will be 1.216 so you will get the impact factor of 1.216 that you can find out here.

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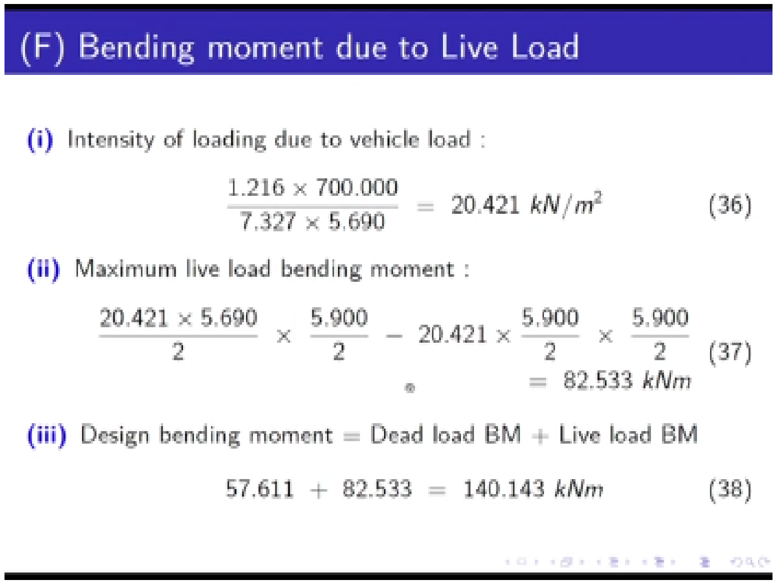

Now intensity of loading then here there is the impact factor into 700 that is the kilo Newton the load 7.327 x 5.69 so 20. 421 so let us add one more thing that I would d like to add let me add it here so that then you can find out that how much we are getting that.

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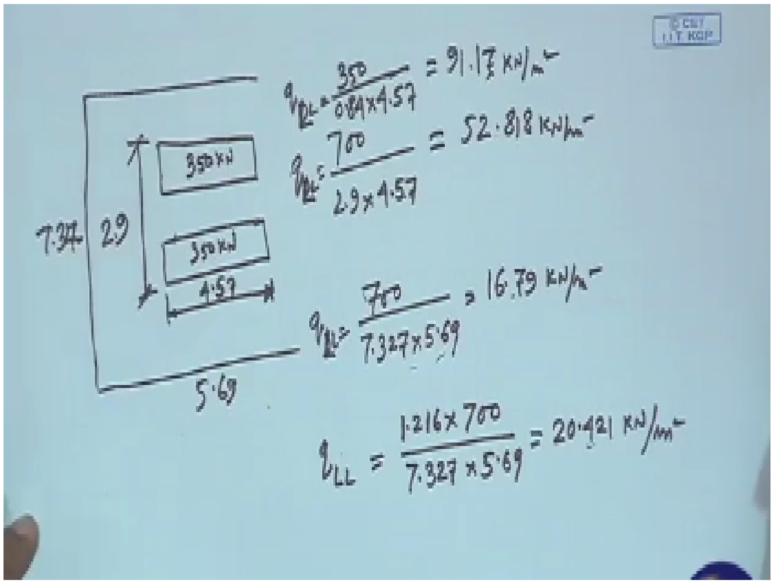

Here we are getting it here so q sorry this will be q live load q live load or vehicle load which will be equal to here 1. 216 x 700/ 7.327 x 5.69 = 20.421 kilo Newton/ m^2 so that means here from these particular one if we come down, so it is coming down this particular one here there so how much if you do this one that whatever section will come you can imagine then if you compare to there to one that considering the both the tracks then coming down to the dispersion final you are going down to a 20.421 that particular one here.

If we consider the effective develop will be little more, so this is the one that we shall consider in our analysis that will find out the bending moment that because one we shall consider here.

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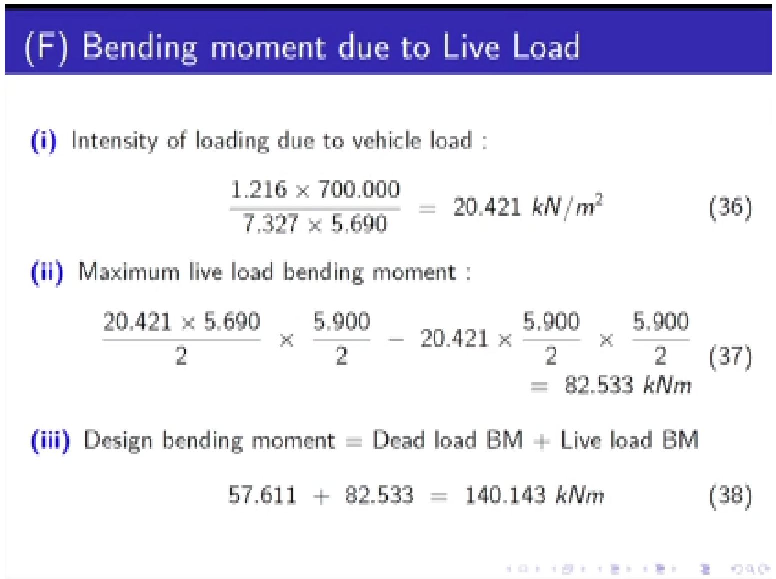

So maximum live load bending moment this is the maximum live load bending moment that particular one we are getting it here, so how much that particular one we are getting it here let us find out here.

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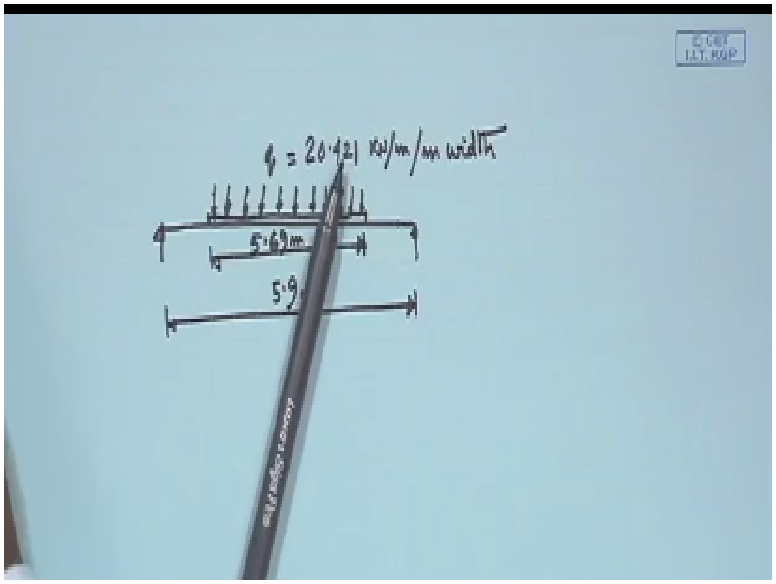

So if you really see this one here this is how much span so 5.9m how much is this one the load 5.69m so if we consider this one here and the intensity we have got it after adding impact factor q that particular one we can get it here 20.421 kN/m/m width so we can get this one q 20.421 x 5.69 / 2 x that movement 5.9/2 – 20.421 so you can get this one here.

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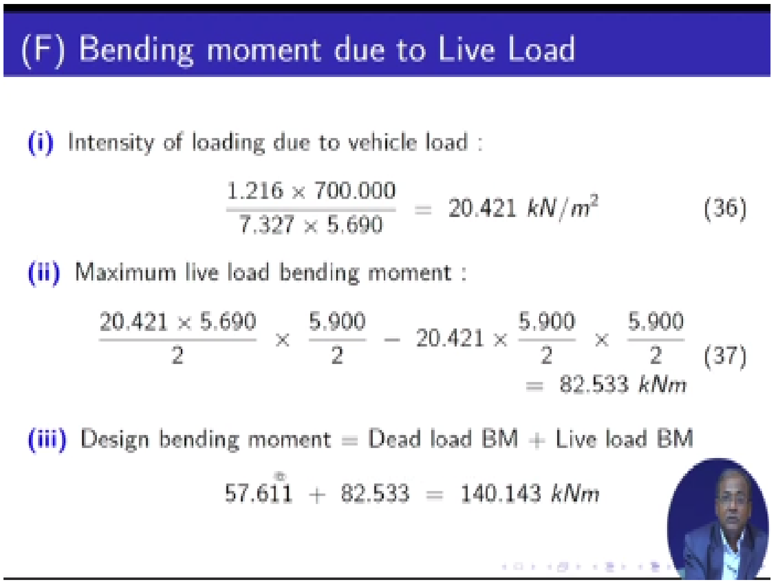

So you can get this one here that particular one here 5.9 x 5.9 that particular one here. 82.533 kNm that we are getting it here this particular one we can find out, so this is the one that we can find out here so design bending moment dead load bending moment, class live load bending moment already we have got this one this class this which is coming as 140.143 kNm, so this is the one the total bending moment that you will get it here, so this is the one we can find out here first you are getting there that means you can find out the reaction and then you can find out that and then you can get the value.

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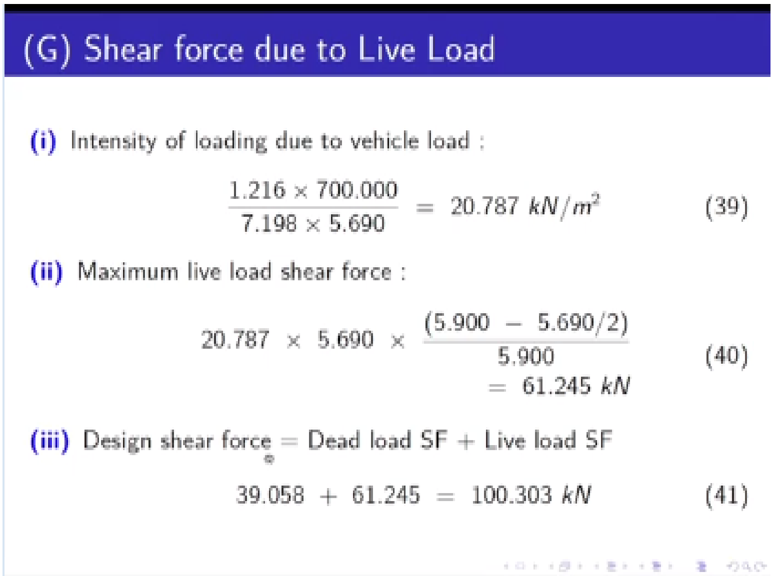

Now coming to this one here we shall come back later on.

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(H) Analysis of reinforced concrete section - WSM

(i) Applied bending moment : 140.143 kNm

- **(a)** Concrete grade : M25
- **(b)** Steel grade : Fe415
- **(c)** Overall depth provided : 460.0 mm
- **(d)** Clear cov8r : 30.0 mm
- **(e)** Dia. of longitudinal bars : 25 mm
- **(f)** σ_{cbc} : 8.5 N/mm^2
- **(g)** σ_{st} : 190.0 N/mm^2
- **(h)** Modular ration, m :

$$\frac{280}{3\sigma_{cbc}} = \frac{280}{3 \times 8.5} = 11.0 \qquad (42)$$

So now we have two design you have to check there are two ways to check that one is that you can find out the depth of the beam maybe you want alternative alternatively you can check that you just you are providing the dispersion of the zip that means I have already taken that one say 460mm that overall depth, so we can find out the effective depth also, so on the basis of that you can find out from the effective depth you can find out that whether the section is alright or not that capacity of the section we can find out that means either you can find out the effective depth and you can find out that your what is called that overall depth.

That we can that way also you can check alternatively you can check with the moment capacity that means the moment applied here we are getting 140.143 kNm and concrete grade obviously M25 steel grade Fe415 then overall the flow hybrid 460 so our objective is that whether this overall depth provided is alright or not that is the one we are covered you have taken say 30mm diameter of longitudinal bus 25mm that we have assumed that means we shall give that one say 25mm bar σ_{cbc} we are considering now working stress method.

That this particular one we are considering here the very simple one that working stress method we are considering here you know that way you can consider that σ_{cbc} which is coming 8. 5 N/ square meter and this one let me tell you again it is according to IS 456 8.5 now here I would like to mention this vector on here that IRC 21 that because one it gives one third of this way that means it will be 8.33 they are very particular they can make it simple one that 8.33 they consider that one and one third of XK they consider here.

So that way we can find out here it will σ_{st} again I have taken according to IS 456190 because the thing is that I would like to give you problem, so that you can compare and you can see that you are from one code to another code with little value of changes how much actually difference you are getting that is more important rather than just using only formula using that certain value not like that you just feel it the particular value whatever we are providing that particular one somewhere they are providing say 0.48 somewhere they are providing 0.58 like that you consider and that particular one can find out here. So whenever we are talking to here, 190 so if we consider that one just to give you idea 190.

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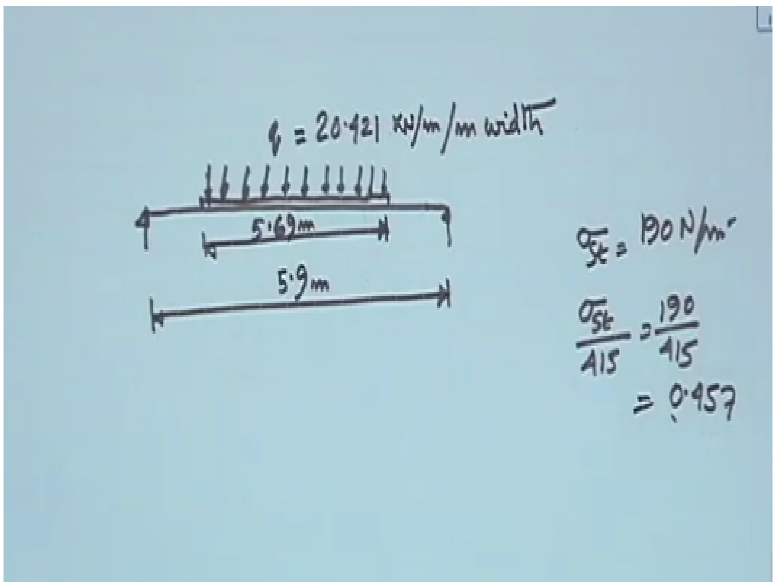

So σ_{st} / 415 so 190 / 415 so which I am getting here say 0.457 so this factor is very, very important I personally feel this factor is more important here that means even shall we consider 0.46 or shall you consider 0.45 so as I have given you that on the fifth lecture that we have told you certain kind of say your probability probabilistic one so this is very, very important here this particular one we have to consider that one, so that means in absence of that without knowing that value is 190 or 200 or something like that.

So if even if you take say 0.45 that is actually good enough that particular one you can consider and on the basis of that you can check the value and you can go ahead with that your computation you will get a reasonable result that we can find out, so the code we shall follow but at the same time you should understand that how much percentage you are using with respect to that FCK Or FY that is more important to me I personally feel that then only you can understand that whether the depth given that it can take care or not this is the one you understand not like that the computer program is giving you certain results.

And it is alright or not that one so you just think of a probabilistic manner hat whether it is coming all right with a small variation so in this case at I have out 0.457 or 0.45 that means I can use 0.45 also for to remembering it easily instead of going for 0.46 like that we can say.

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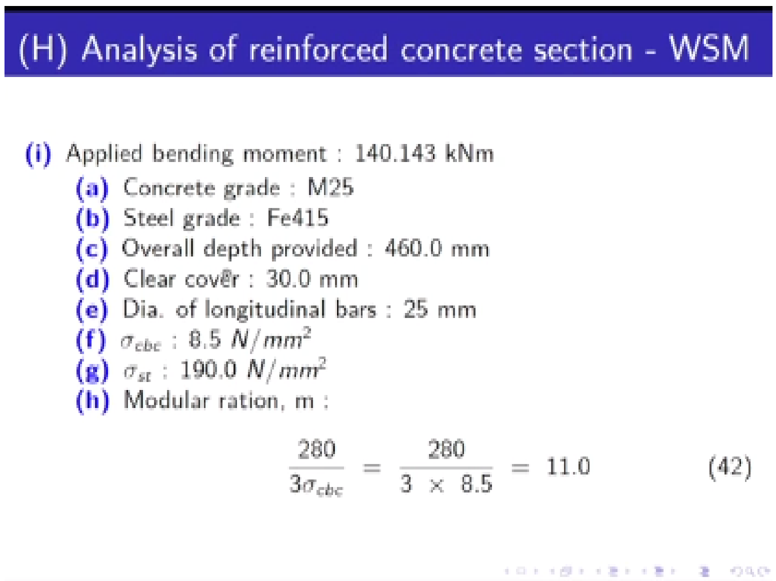

Now coming to this one here modular ratio m 280/ 3 σ_{cbc} = 280/3 x 8.5 so 11 that value we can get it here 11 that particular one here if you consider 8.33 there is obviously a little more that will be come to 11.5 also and this one very interesting thing you can say that as I have told you for IRC code so if you consider that m.

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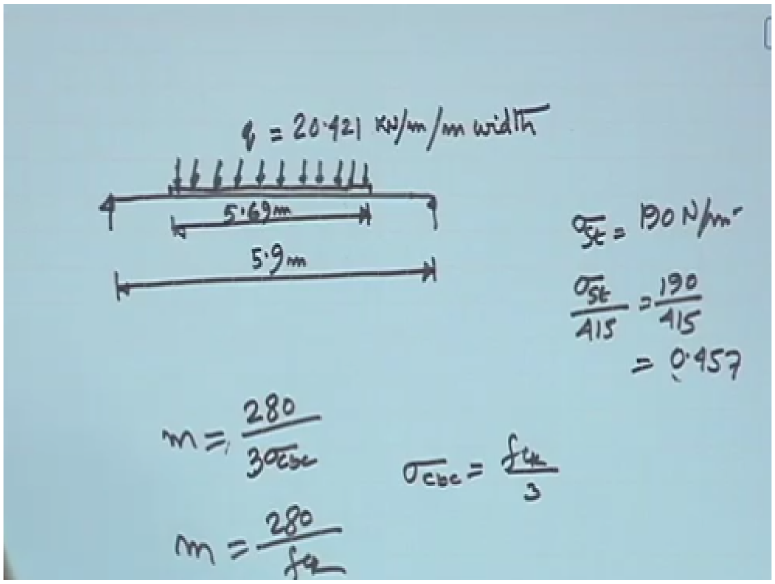

Just to give you idea 280 /3 σ_{cbc} and where as you can see 3 σ_{cbc} = /3 that means m is nothing but 280 by fck so that is the one can consume that means what you can say you can express it in terms fck also initiative remembering 3 σ_{cbc} all those things that means in working stress method also you can go ahead without 280 / fck and on the basis of that everything can be in terms of fck only that is quite possible.

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(H) Analysis of reinforced concrete section - WSM

(i) Effective depth (d) provided :

$$D - cc - \frac{\phi_t}{2} = 460.0 - 30.0 - \frac{25.0}{2} = 417.5\ mm \quad (43)$$

For balanced section, $k_b = \frac{x}{d}$:

$$k_b = \frac{m\ \sigma_{cbc}}{\sigma_{st} + m\ \sigma_{cbc}} = \frac{11.0 \times 8.5}{190.0 + 11.0 \times 8.5} = 0.329 \quad (44)$$

$$j_b = 1 - \frac{k_b}{3} = 1 - \frac{0.329}{3} = 0.890 \quad (45)$$

Effective depth provided D – cc - ϕ t / 2 I we have assumed 25/2 so then you are given 400 17.5 from the service this is the one you have provided for balanced section $k_b = x_d$ which is equal to m σ_{cbc} / σ_{st} + m σ_{cbc} that way you can find out this particular one you can find out here you can do it very easily also you can do it that means here.

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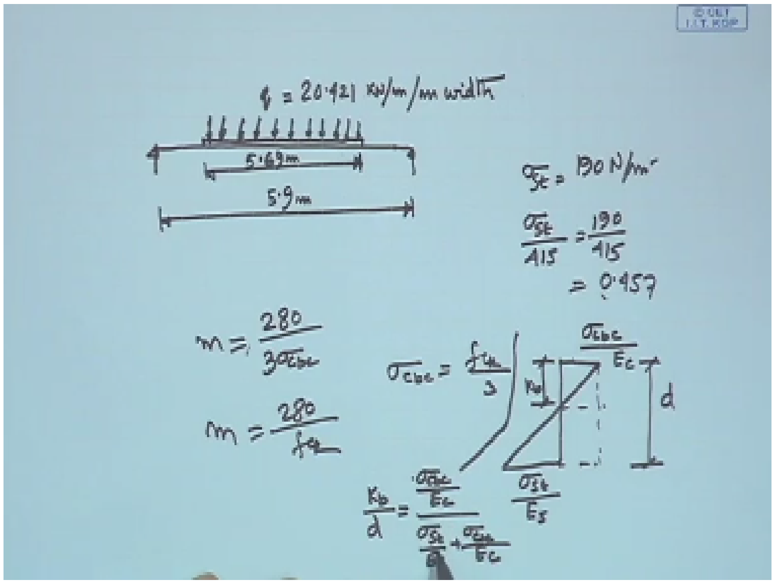

If you really consider this is the one we can consider here so I can consider here $\sigma_{cbc/} E_c$ this will give me the strain this one σ_{st} / E_s this length is k_b and this one is d so you can find out that this one that k_b /d will be equal to this length make this one so σ_{cbc} / E_c / σ_{st} / E_s + σ_{cbc} / E_c and from there you will get that formula which is equal to that way, so that means here what I mean to say you can easily you can remember that no need of going every time that all those things, so if you multiply with the ES / EC this ES will go. So you get that M σ CBC here M, so that means you multiplied with that ES here ES here this ES will go so will get M σ CBC M σ C which exactly this particular value you can get it here.

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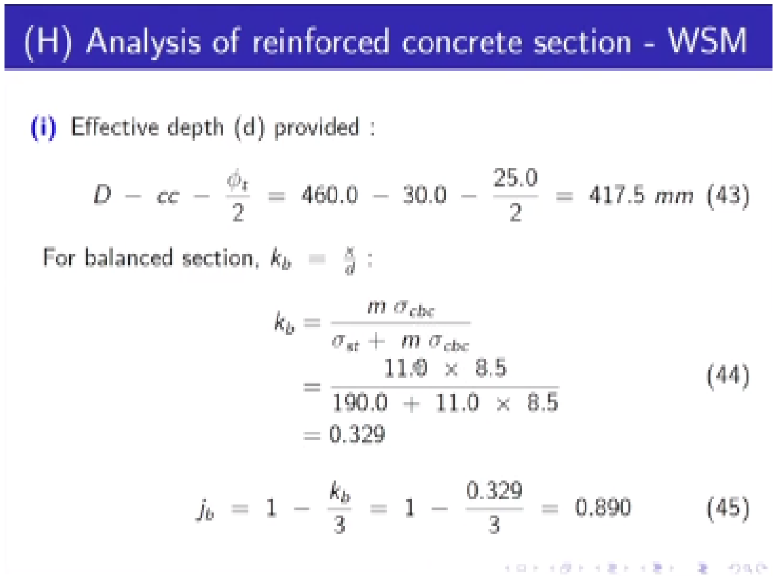

So again very interesting thing again M actually again you can get it 280 /3 σ CBC so 280 / 3 σ CBC I can write down here m2 HT / 3 so that means here it will be in terms of 280 / 3 280 / 3 and that means KB is dependent on σ s T and Jb = 1 – kV / 3, so which is equal to 1 - 0.329 = 3.89 that you can take it that workers.

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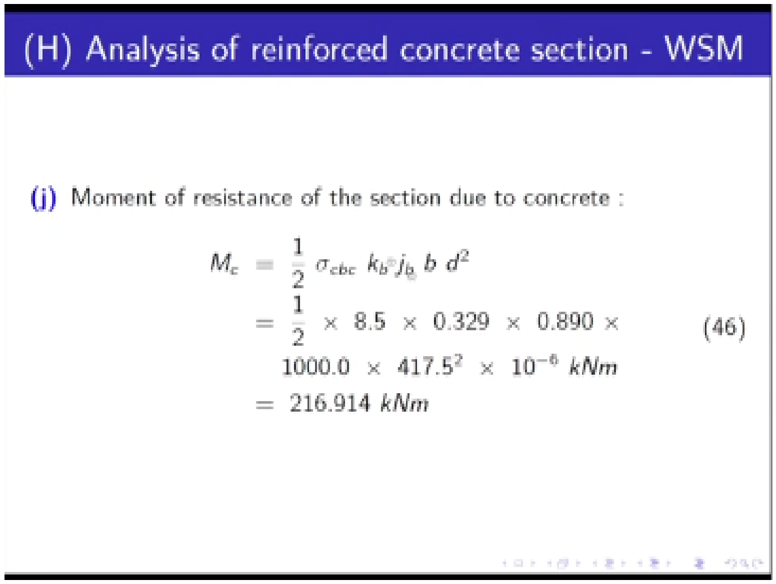

So moment of resistance of concrete 1/2 σ CBC JB JB x $BD^{2,}$ so ½ x H 1 5 x 0.329 x 0.89 x 1000 because I have taken that one say in a parameter weight x 4 17.5^2 x 10^{-6}, so 216.914.

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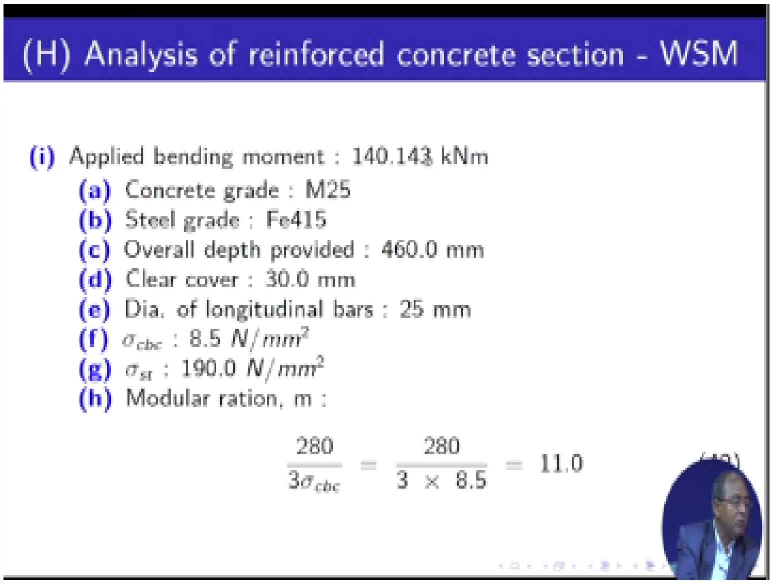

So we are getting here 140.143 and we are getting that moment of resistance due to concrete 216 that particular one is doing quite high that particular one here that way you can find out. So we can consider this vector one here.

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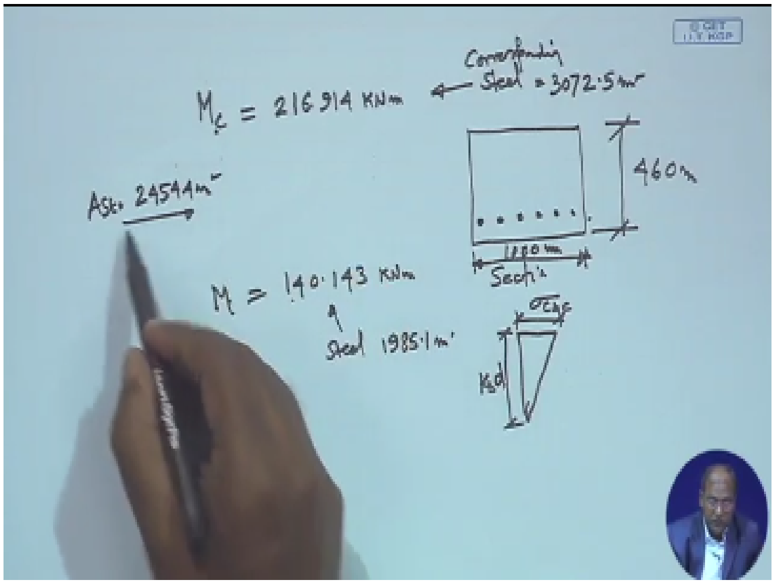

So MC 216.914Knm in which we have got it aim apply it 140.143knm, now we have to provide the steel reinforcement that we have to provide the steel reinforcement later because the thing is that this is the one requirement and this is the one that concrete is giving that the core one here the section we are providing this is the section. So overall depth 46mm and this one 1000 so 1000 mm and 460 mm we are getting it here.

So what we can go do 460 and 1000, now we have to provide that d c--reinforcement and that for that the moments should be in between m and MC in between that moment it should be in between then all I can say get under reinforce it should not be above that it should not be below that the reinforcement provided due to that whatever moment of resistance due to steel that should be in between that particular one here. So coming to that particular one here whatever we can do it here.

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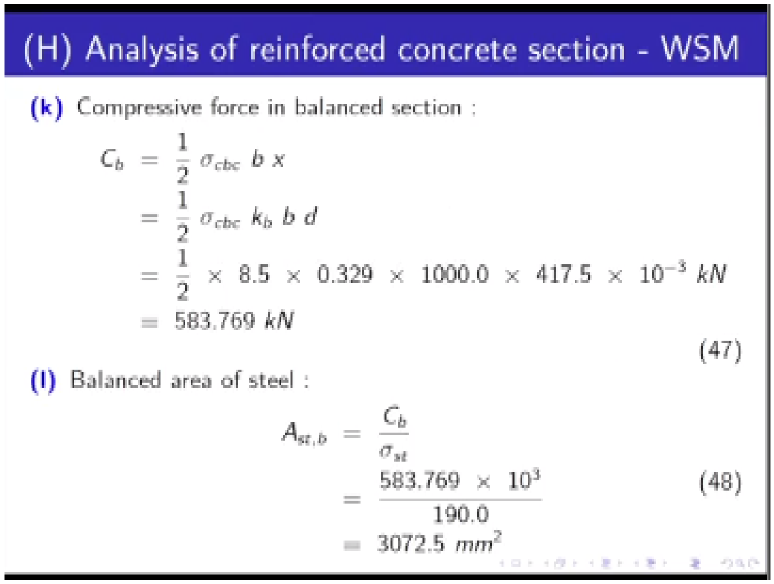

So I can calculate that a compressive force in balance section and which is coming else that because I have taken 1/2 σ CBC B x X because we are considering the section as a this particular one we are considering this is your say KB, this is your say σ CBC and then B so we are getting this per core value here which is coming here into D particular one because 0.329 into that particular one we are getting kV x D that particular one here.

So we can get it here K B x D we can find out here which is coming as 583.769, so from there because the section will be in your equilibrium condition so A_{st} B = 3072 that way this is the one balance percentage of Steel that particular one. So that means 3772.5^2 mm that is the steel required to go up to the valance section that means that time what will happen that your steel in for steel will also take $σ_{St}$ quantity we also take σ CBC that is the balance section.

But if it will if we provide little more of that together then it will become over reinforced that means that case concrete will fail first and which we do not want, so that way whenever you are getting here now e_{st} required for M that we can say roughly 140 .143 in 2006, so 1985.1 that is for this moment we require this much of steel and we are providing 25mm bar. So 1000 x 1985.1 / 490.9 so 247.3mm that is the one let us provide 25mm dia at 200mm CC which will provide 2454.4^2mm.

So we shall provide that one say your steel we are providing 2454.4 $<$ 372 that means that one the balance section or in other way to get these 216.914, we require corresponding steel 372.5^2mm for this moment we are getting steel 1985.1 we are providing in between 2454.4 area of steel 2454.4^2 mm. So that means we can provide this particular one 2454.4^2mm, so which will be in between that much we can say.

So this is the one we can find out actually here that we can we can say that particular one here that we can say that particular one that means the section is shape with respect to bending. Now we have to check the one which we shall get it here for that your shear forces, so let us consider the shear, force part. So that then we can complete that one at this force with the working stress method.

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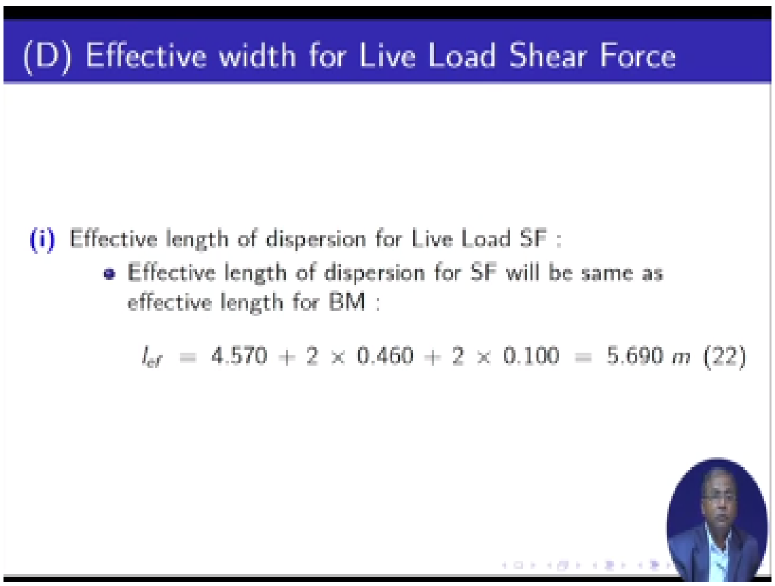

Now regarding shear force we shall equally we shall find out that one say effective length of dispersion for live load that shear force so it will be same actually this one there is no problem with respect to that effective length there is no problem we shall get the same.

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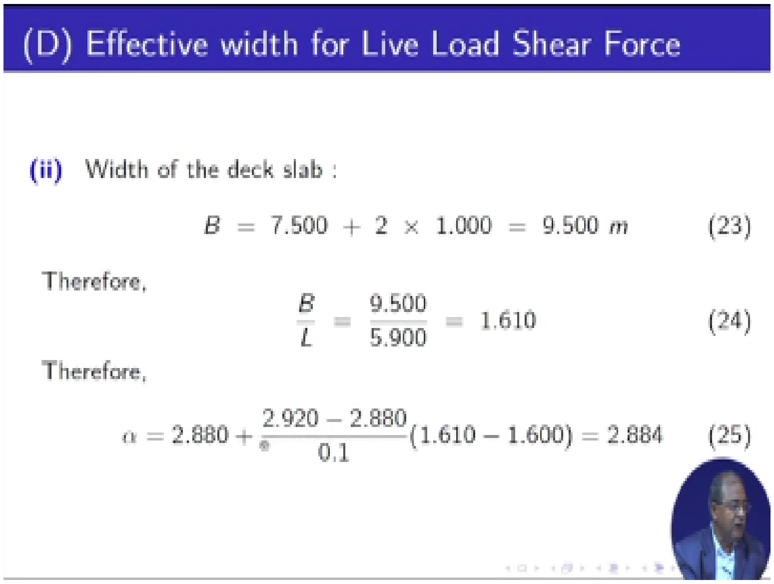

But for width of deck slab that particular one CM α also we shall get same value because there will no change because B / L will not change, so we shall not get any change there this one also shall get the same value.

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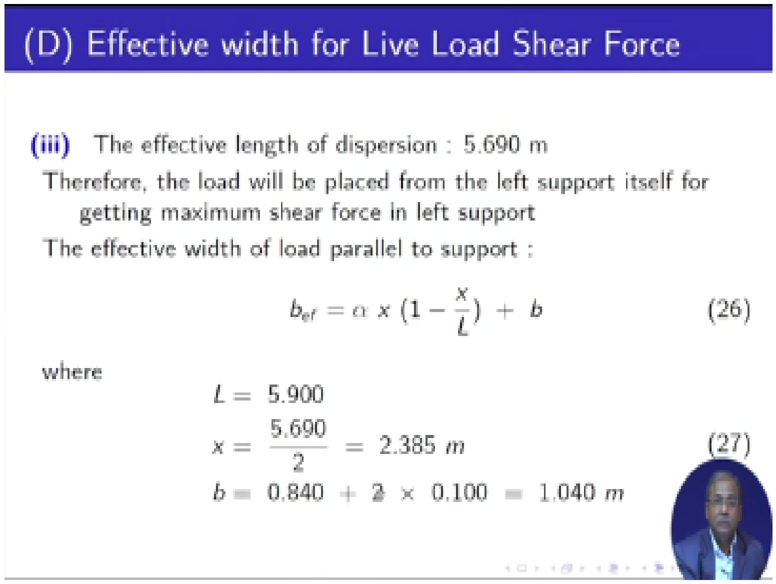

There is no such problem only problem we shall get that x value support because we are considering in the shear, force.

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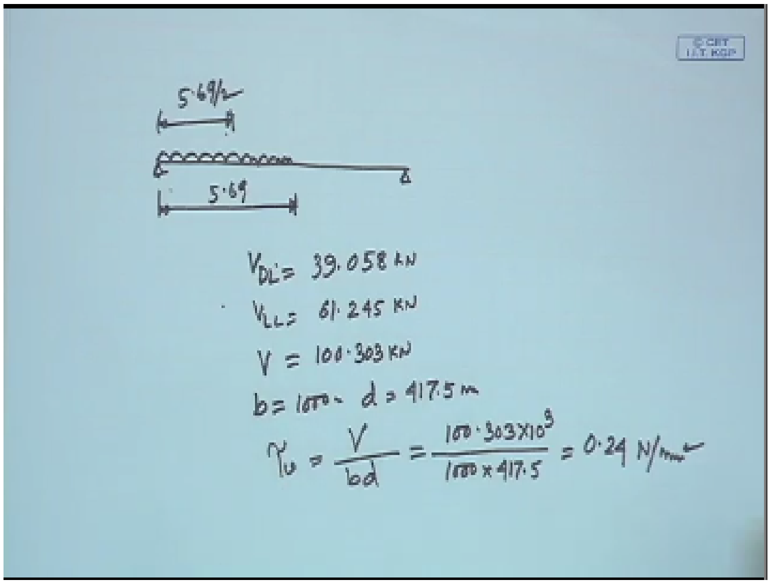

We shall provide that one near the support because then only I shall get the maximum shear force here, so the load will be placed from the late supper whistle for getting maximum shear force in the left support so that X will no longer be L /2 that value will be change with that 5.692 this is the one effective length so that X is reduced, so this is your say 5.69. So X will be half of that so this is the one 5.69/ 2 that particular one we shall get it here, so B will be same.

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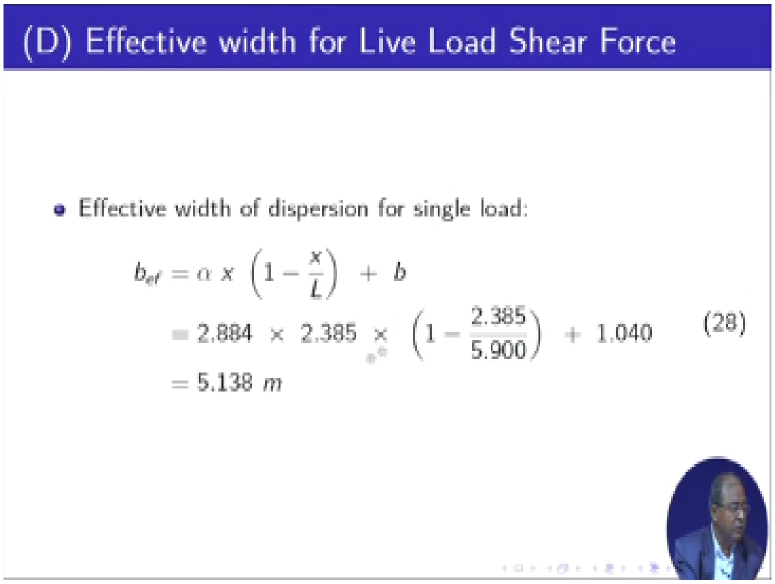

B effective we shall get it here, so that will B effective is now change so 5.138 for a one case one track we are getting here 5.138 we are getting this particular value.

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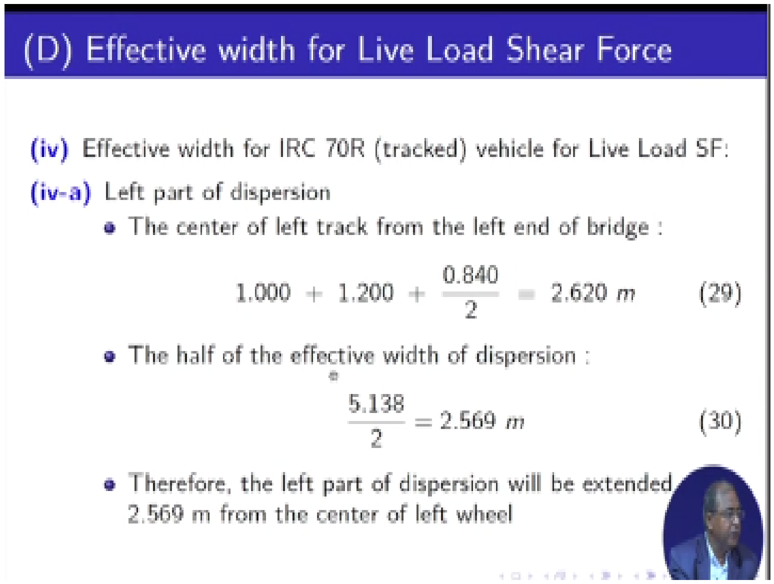

Similarly we can find out the same way we can get it here, here there is no problem 2 .62 that is the one that end from the centerline of that one and I am getting here 2.569, so that means I shall get go to the full extent on the left side we shall go.

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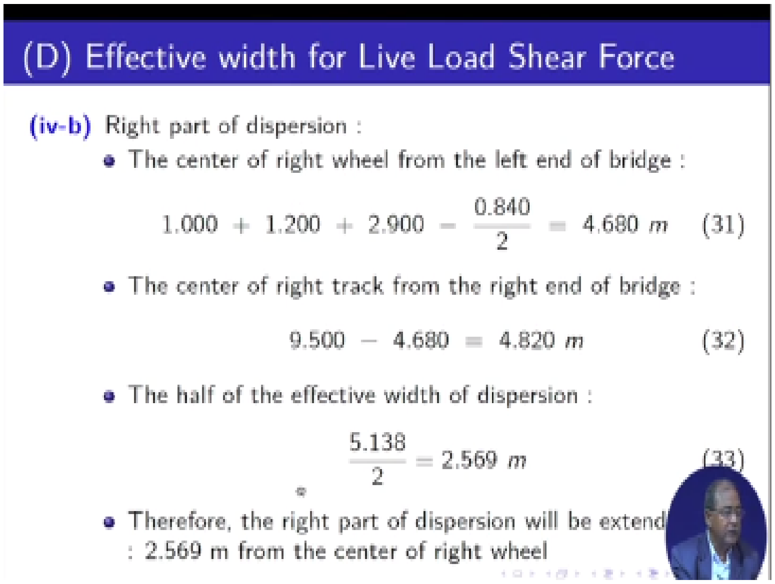

In the right hand side also same passion 2.569 we shall go 4.82 so that particular one we shall go so we can find out the three parts 5.569 in the left side like the previous one this is the middle one this is the one again 5 + so if we add it so we shall get is 7.198. So value that particular one that you are effective with that one reduced a little bit.

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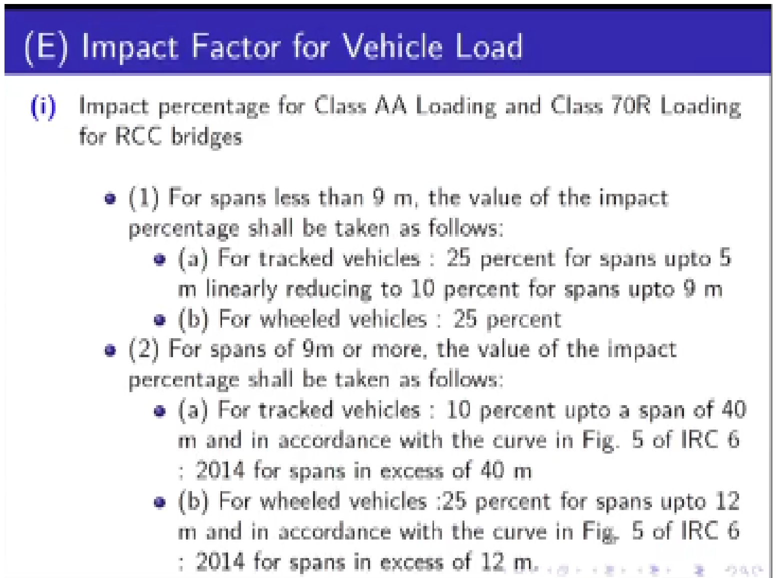

So coming to this particular one here we can find out.

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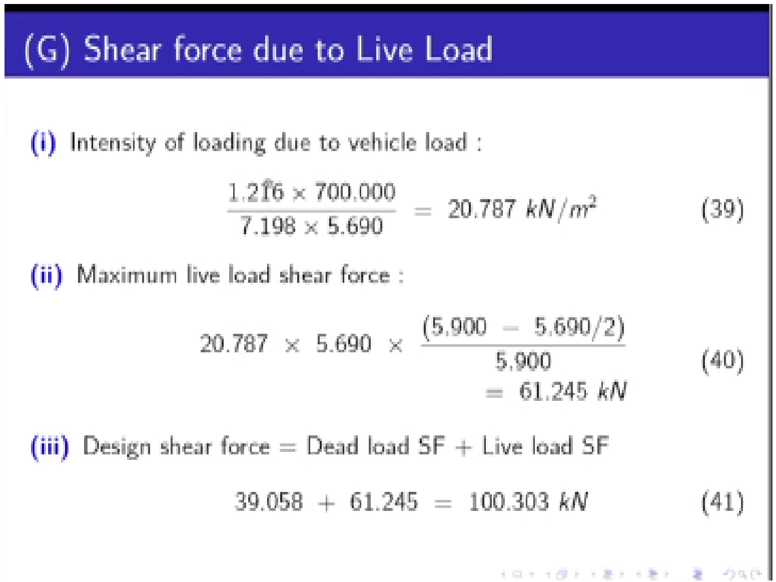

So this is the one we are getting intensity of loading due to vehicle load, so we shall get this much for the shear force 7.198 x 5.69 maximum line load shear force so then we shall get it here 61.245kn design shear forcing of dead load shear force which already calculated live load shear force now calculated so this is coming as 100.303 kn. So we are getting here V_{DL} which is equal to 39.058kn V_{ll} = 61.245kn and V = 100.303kn B = 1000 D = 417.5mm.

So τ_V V / BD = you can say 100.303 / 1000 x 417.5 x 10^3 kn, so we can write down here 0.303 / 417.5 0.24 if you go back to the stable and with respect to the percentage of steel you will find out this value is very less so that means we do not require any shear reinforcement. Now coming to this particular one here that is the other two checks we generally do it for the slab which that main reinforcement we provide that overall depth we provide mineral crystal wood and we check the shear, force.

Now there is a present trend you will find out that one that people used to give that reinforcement overall depth list and if you give the overall a list they obviously that effect would be that in the shear, force or shear stress and in that case whatever we do whenever we consider for the shear stress whatever we do here their per color one here then we have to provide the share reinforcement.

Now this is the one designers choice and generally that it happens for the slab we avoid the slab we avoid giving actually shear reinforcement if it is at all required that one then we provide but it is better not to give actually your shear reinforcement in slab whenever you are considering that vertical slab if we consider this one as a beam then obviously you can provide that one say shear. So that means slab means only bending and beam means bending and shear.

So this is the totally a design philosophy that how you are considering that whether you will go for only bending that means it is created a slab and you provide your reinforcement accordingly and if you consider that one as a beam that means you are providing again shear reinforcement and that also you have to provide. So considering that aspect that is the thing there is a designer choice but I personally feel actually that it is better to give up for your just to give you IDI to is better to go for on your say load more depth then you will have more cousin.

So that it will be more cousins with there with respect that enforcement the basic objective is that it is this one.

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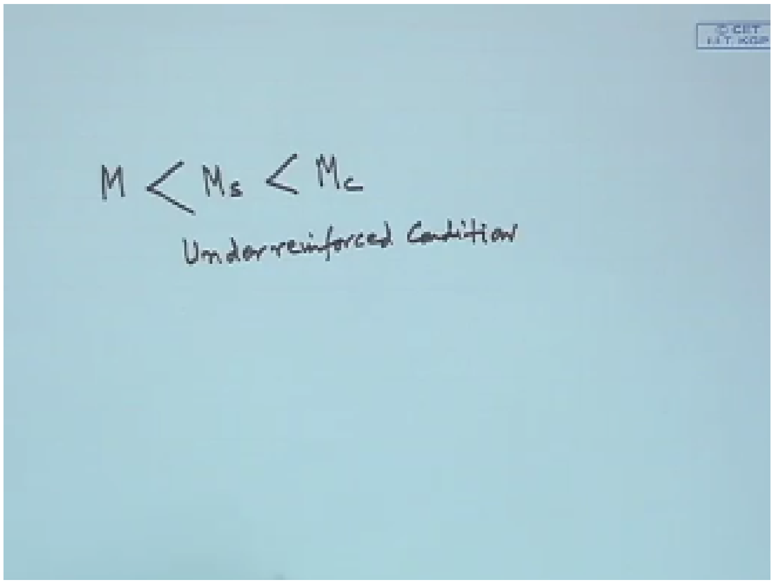

Then you are getting M_s and then you are getting M_C, so then only your under reinforce case condition can be full filled. So this is the one just we have given so we shall solve we shall give few problems also we shall give on the other methods also easily we have taken little more time on that to elaborate that because I would like to give you idea that how we feel regarding design is not like that a formula or using any software you just try to fill it and then it will then you can understand that whether the structure is safe or not.

There are many more other things also just quickly I would like to give you just will be getting the slab whenever you are talking slab.

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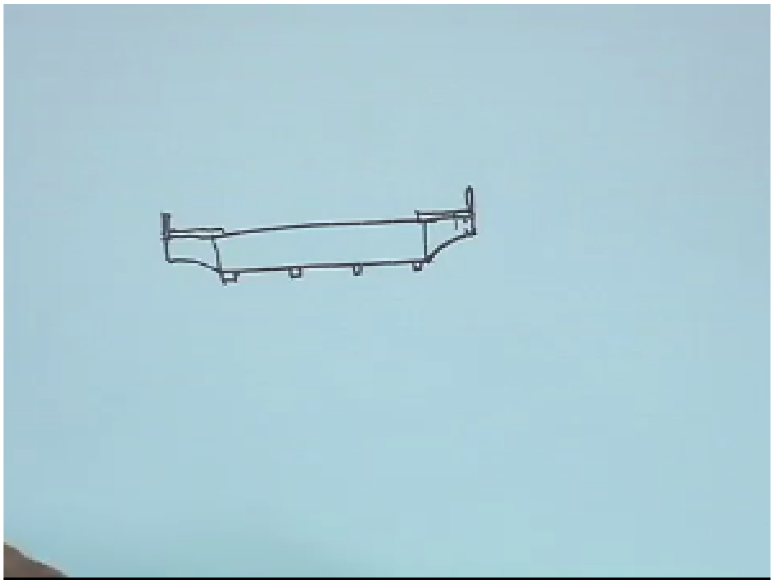

Just I am taking the cross section here there is certain person the middle portion where that you are say carriageway other the load they can load more you can also design like this also let mean this portion here the bearing the two ends it may be like this so these portion that your footpath other things are there which can come here and these portion may be after second level it can come and where the load is less.

So we can also design in that person that and it will look very good also that is also another but that case if this portion will become actually a continuous function it will not be your say longitudinal via these portion is longitudinal and personal, so that will be the another one it can happen and one can think of it also that how can you do it. So with this we conclude this particular one, so thank you very much.