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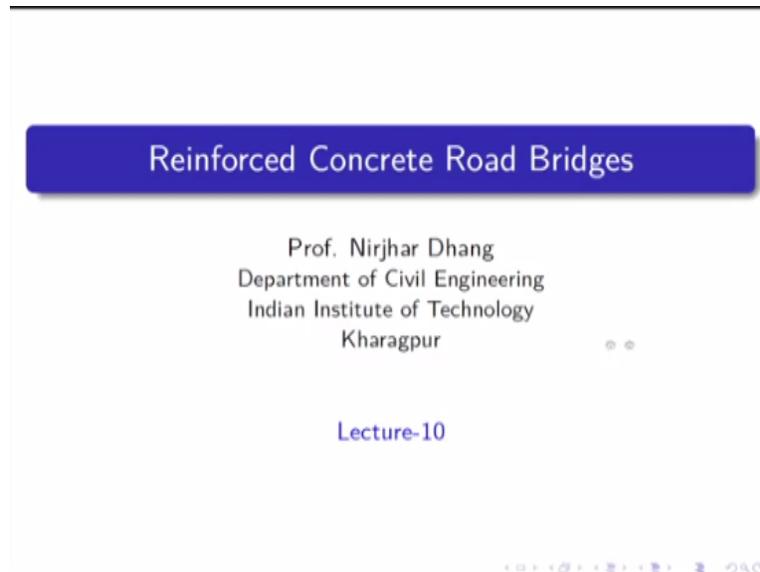
Course
on
Reinforced Concrete Road Bridges

by
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Lecture 10: Design of Slab Bridges (Part II)

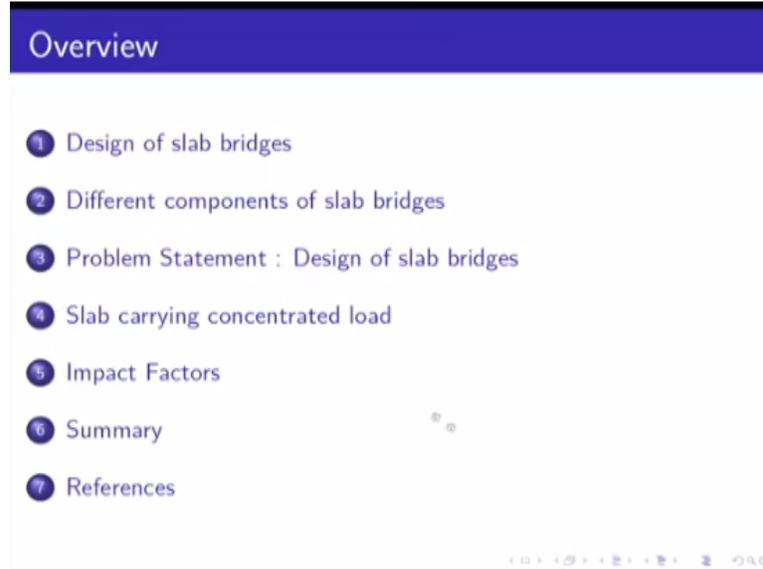
Hello everybody we have started in lecture 9, the design of slab bridges and obviously within half an hour it is not possible just we have introduced that different components of slab bridges starting from the apartment where that super structural will rest and then we are moving towards the problem statement of this particular bridge.

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And that our topic today that lecture 10 and obviously that since it is a continuation of the previous, so this is a continuation we shall actually go to another few more lectures of the half in our module. So that we can understand, we can compute the whole thing that how to design that, particularly main components that we shall see.

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As usual I have told you that we have come up to this one, now we shall start with say problems statement and then slab carrying concentrated load, impact factors, and then we shall find out that bending moment and your shear force. If we can do that one then we can go for the design, for any design we require this one first, that you say that we have to analyze it and we have to find out, whatever way it may be simple one, it may be very complex one that whatever it is that whether you have to go for say your that any software, analysis software, fine element software that also we can use it later on.

But these particular one that for a very simple one, because it is simply supported beam and then we can start.

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Design of slab bridges

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Design of slab bridges

- For design of bridges, two aspects are looked into:
 - **Hydraulic design:** when the bridge crosses the water body, such as, canals, rivers etc.
 - **Structural design:** This is applicable for all bridges, fly overs etc. to provide suitable depth, reinforcement, plate thickness etc.

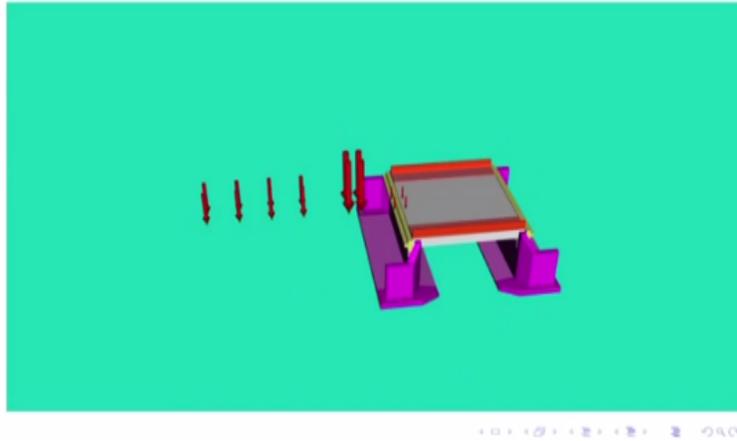
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Design of slab bridges

- We shall take the structural design of slab deck bridge

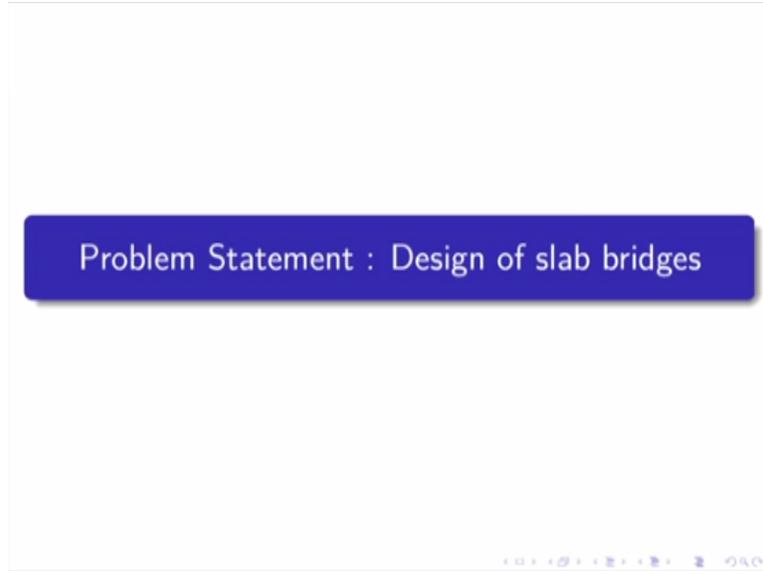
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Different components of slab bridges



So that particular one I shall come back to that problem statement.

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So this is the problem statement of design of slab bridges that how do, what information do you need that is very, very important here. So coming to this particular one here.

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Problem Statement : Design of slab bridges

Problem : 1 Design a deck slab bridge for the following parameters

:

- Clear span: 5.500 m
- Width of carriage way : 7500.0 mm
- Width of the foot path : 1000.0 mm on either side
- Wearing coat: 100 mm
- Loading : IRC 70R (tracked)
- Materials : Concrete : M25, Steel : Fe415



That obviously we can say design a deck bridge for the following parameters. Here I am giving you as a clear span width of carriage way that is 7500mm. Let us follow certain convention and that convention actually helps a lot, because if we follow certain convention then it helps a lot, so that we can understand each other, whatever you are talking, because there you need not actually go, every time you need not go into detail.

Here whatever you shall follow as you can find out that particular one, whenever we are talking meter we shall go up to three decimal places. And whenever we shall talk millimeter we just implicate one decimal, we can actually ignore this one also, that 7500 good enough that is also sometimes we do it. But anyway we shall keep 0.0 also that one decimal.

So that is the convention which we shall follow per meter and millimeter on either side. Width of the foot path 1000.0mm it could be 1500mm also, but I have taken this way so that you can see this problem and later on I shall give you more other problems on the same one I shall give you here. One thing I would like to say and mention here these particular one that notes, actually prepared through computer programming actually, not the one stand that by manually and that we are doing and I have used extensively that python programming language.

Because I am in informing in this required one those who would like to go for it that solving problem then you can use this language rather than going for say, your excel sheet. Generally we find that nowadays that people are extensively used in excel sheet, but there are certain problems we find out who keep the excel sheet that one are not fitted properly. Then problems comes that

formula other things we will not be able to see. And then it is very difficult to follow that how it is done that is your one problem, that particular one.

So that is why I have taken this particular one actually through python programming I have done it these whole slides also this is just to inform you. So that you can understand and you can also take this adventure also. Now we having quote generally nowadays we get just 65mm that is the ones, then also you do a 100mm and loading I have given only one case of loading I am not gone for any kind of combination.

I have seen 70 year tract also I have given and that one given in you say that, IRC6, materials concrete in 25 we generally do not go below that M25, M30, M35, M40 like that we go. Now let us take that one M25, because I would like to say only one design actually analysis means the problem is given and you have solved, there is no such problem that means here. But in design what happen actually we have to choose, because the thing is that what I would like to say the problem step meant only these information first three lines information have a level to you, that clear span.

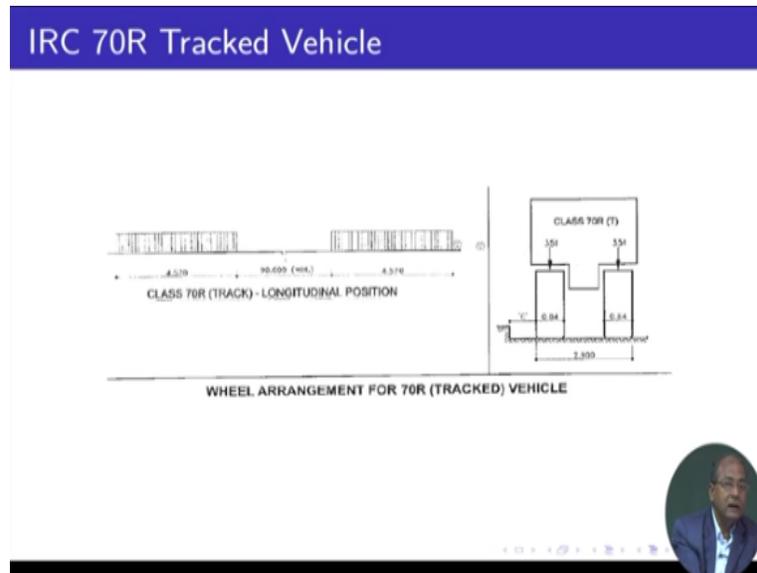
What is in this clear span if it is a river or say your canan it will be dependent on that, you know say drainage also, that let us consider that recover for the drainage purpose also that you can find out, that it should not overflow, that should be like this. So that means what should be the clear span that also is decided let us, we are not going to detail of that required one here, but we are assuming that 5.5m is the requirement and on the result that.

Carriage way of thus it is connected with the requirement for the traffic data that will be decided whether it requires a single line, whether it requires double line so that way we can say. Width of the foot path that is also requirement that plays requirement whether you are having foot path or not. So that require sometimes if you give 750mm, but generally you should give 1500mm and that obviously we can make it is costly or one also.

And anyway we have just taken these partcular data that is these three information have a level to you with wearing coat 100mm we have taken. So 65mm generally we provide, can we say see later on that if we provide 65mm other things that how much actually design is requiring, that also we should know that is overall. We have taken IRC70 are tracked loading and then if it is IRC class A loading what will happen that also we shall compare later on.

Concrete gear M25 and steel Fe415 that I shall show you that require one here and where I could take this is and whether we shall go for higher one or not.

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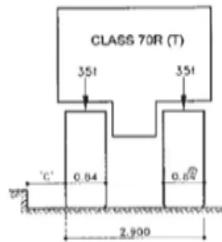


This is the loading available in IRC6 and this track if I feild this is not feild, so one is called field and another one is called track. So if you consider this particular one here say 35 ton load you are having, you are having another dot, I mean so symmetrical loading and that you are having this side 35 tn, this side you are having 35 ton, this is 0.84 and this one total is the 0.9 and then it is certain distance is C, from this end from the card end you are having a distance say C, and this C we have to find over that one.

Then you are having say this is you would say longitudinal direction, so these direction you can see if you look from the back or from the front then I can get this thing. But if I look from this side or this side then I shall get this thing from the field, this particular one, so this is 4.57, that you can find out this is 4.57 that you can find out.

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IRC 70R Tracked Vehicle



- The minimum clearance between the road face of the kerb and the outer edge of the wheel or track, 'c', shall be 1.2 m.
- Therefore, Class 7OR loading is applicable only for bridges having carriageway width of 5.3 m and above (i.e. $1.2 \times 2 + 2.9$)



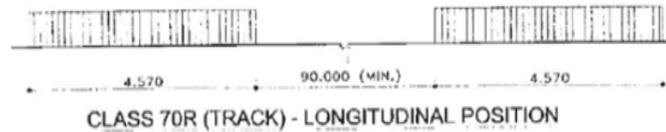
So the cross-section of the vehicle we are having the minimum clearance between the road face of the kerb and the outer edge of the wheel or track 'c' shall be 1.2m. So now it is known to us that how much it will be, so it is coming as 1.2m. Therefore, class 7 their loading is applicable only for bridges having carriage way width of 5.3m how we are getting. So this side 1.2m, this side also should be 1.2m and this one obviously you are having 2.9m.

So considering all aspect you are havng 5.3 meter that means if these which is having 5.3 meter with the minium then only that vehicle can pass according to IRC6.

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IRC 70R Tracked Vehicle - longitudinal position



- The nose to tailspacing between two successive vehicles shall be less than 90 m for tracked vehicle and 30 m for wheeled vehicle.

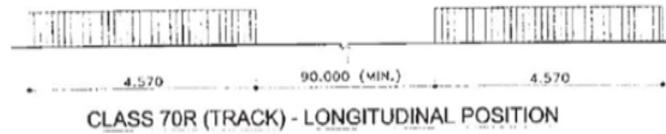
This is the other side already I have told so 4.57 this particular one we are having 4.57cm. So nose to tail spacing between two successive vehicles shall not be less than 90 meter for tracked vehicle. So if it is a tracked vehicle then this 90 meter spacing should be there. And 30 meter for the wheeled vehicle the one if you are using the vehicle in that case we have to say 30 meter for the wheeled vehicle.

So this one will help us to know that whether only one vehicle will be on the bridge or we will have number of vehicles that will occur one here. So that means here we can consider this particular one here that whenever you are talking these particular one the bridge, so whatever we can consider here say for minor bridge, so I mean to say 60 meter one whenever we are talking, so that way we can say that only one vehicle will be on the bridge, on the deck that is the one we are having that particular one.

So that is the very, very good relief also we can say, then because then it will not be complicate aware that calculation that is why you can say.

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IRC 70R Tracked Vehicle - longitudinal position



- The nose to tailspacing between two successive vehicles shall be less than 90 m for tracked vehicle and 30 m for wheeled vehicle.

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So these two information we have got it from IRC6.

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Design parameters

(A) Effective span of the bridge

- Assume clear span by overall depth as 12
- Estimated overall depth of the slab :

$$L_{estim} = \frac{5.500}{12.0} = 0.458m$$

- Overall depth of the slab (assumed) = 460.0 mm
- Assume width of the bearing = 400.0 mm
- Effective span, $L = 5.500 + 0.400 = 5.900$ m

Now design parameters first of all we require next first that means we have got that information problem statement, the first informatin will come from the requirment.

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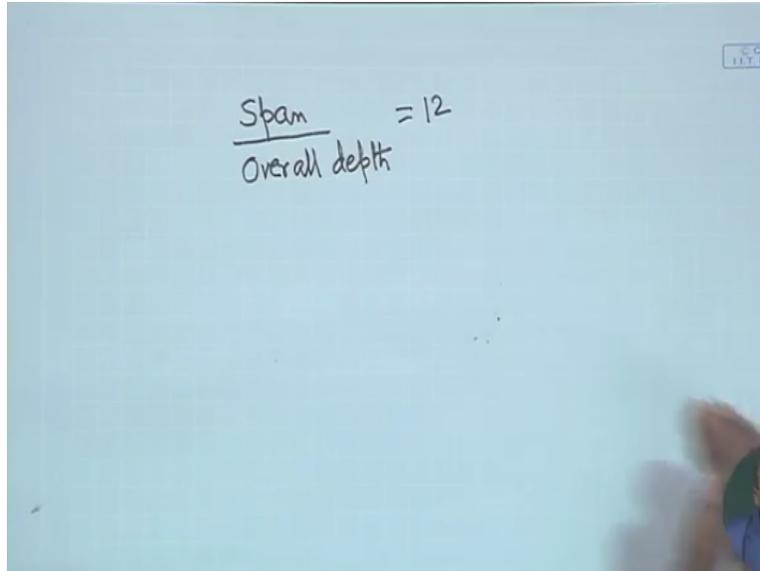
Problem Statement : Design of slab bridges

Problem : 1 Design a deck slab bridge for the following parameters :

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- Width of carriage way : 7500.0 mm
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- Wearing coat: 100 mm
- Loading : IRC 70R (tracked)
- Materials : Concrete : M25, Steel : Fe415

And then next information coming from the design parameters other things that concrete grade, which grade you will use, twisting you provide, so all those things are there. The next thing is coming in the picture that is effective span of the bridge. Now this is a very, very interesting thing I would like to say.

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A photograph of a whiteboard with a handwritten equation. The equation is $\frac{\text{Span}}{\text{Overall depth}} = 12$. The text is written in black marker on a light blue background. In the top right corner of the whiteboard, there is a small, faint stamp that reads "SCE 11.10".

That I have consider one thing span /overall depth the idea is that we have to start some where, how do we find out, because overall depth in the very beginning we required certain depth that we have to know. Otherwise we shall not be able to calculate that dead load or cell point of the deck, cell point of the bridge. So obviously we require that particular one, say that we have to assume something.

Arbitrarily we could assume something and then we can do the whole design and after doing the design itself if it is passes fine, if it does not pass that means, then obviously you have to change the depth and then again we calculate that way. If it is that assume depth is more than the requirement obviously we have to reduce it, so that is the one. Now this one we have taken the span / overall depth as 12.

Now there are many more actually thumb rule also you can say or common sense you can say, but do not say that common sense actually likely, because common sense come from wisdom that means we are having experience, we are having intelligence like that so many things out of that, that common sense come.

So that is the very, very valuable information that we can say. So coming to this particular one there I will be find out the another way also you can find out that somebody says that one let us consider that one your say certain value 80 or 70 or 100 millimeter / meter /meter span that is also another way of thinking that is per meter say if it is 20 meter if you take then on the basis

and then you can find out per meter how much you are taking so rate and then on this we can calculate.

But here following the particular one, because e are very familiar with that, that span by depth ratio that 20, 26, 24 simply supported beam 26 for continous and then cantilever 7 like that. So on the basis of that we have taken certain things, but again I can say the particular one here this is not the sequence sign number, the number may vary it can say 12, it can be 13 also, sometimes it can be 14 also.

So if you are that you are said in pores mental study, concrete stength more then obviously this value also will be more. So like that because depth will come less so like it will come.

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Design parameters

(A) Effective span of the bridge

- Assume clear span by overall depth as 12
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$$L_{estim} = \frac{5.500}{12.0} = 0.458m$$

- Overall depth of the slab (assumed) = 460.0 mm
- Assume width of the bearing = 400.0 mm
- Effective span, $L = 5.500 + 0.400 = 5.900$ m

So therefore whatever we have done considering that aspect because we are spending little more time on that this is very, very important one, but do not say that one that will be the number why you are coming late, why you are doing more, but this is your judgement how we are deciding. Finally when if you are familiar, if you do your design and later on or if you are in the industry then you will have certain confidence, yes I shall follow this particular one and then one that, so that you can find out that it is coming alright.

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Design parameters

(A) Effective span of the bridge

- Assume clear span by overall depth as 12
- Estimated overall depth of the slab :

$$L_{estim} = \frac{5.500}{12.0} = 0.458m$$

- Overall depth of the slab (assumed) = 460.0 mm
- Assume width of the bearing = 400.0 mm
- Effective span, $L = 5.500 + 0.400 = 5.900$ m

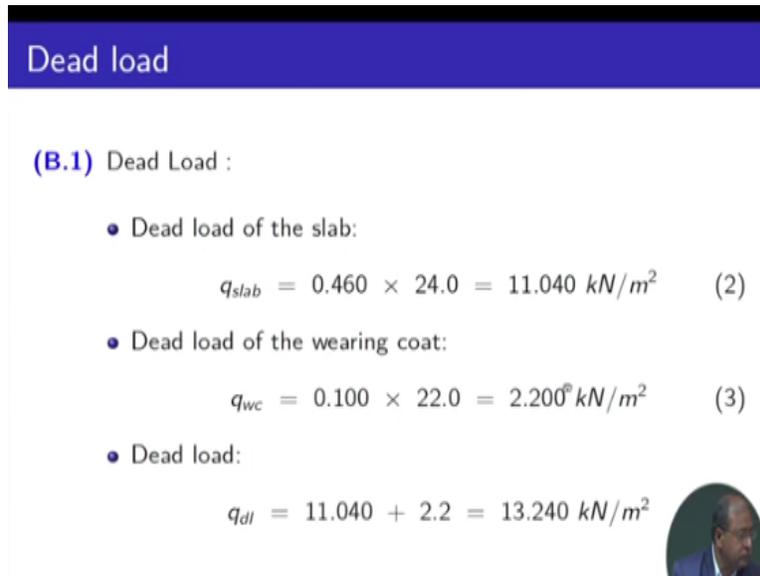
So estimated overall depth of the slab then obviously you can find out 0.458 that requirement here you are getting. Overall depth of the slab assumed that means from that it is another one, there are many ways of thinking that one whether we shall go for 460 millimeter that means whether we shall make it in multiple of 10 millimeter, whether we shall make it in multiple of 25 millimeter, whether we shall make it in multiple of 50 millimeter, that one actually the designers choice that convention that you have to, and also that you say that your body, the body who are affects body or who under whom you are working that particular your self philosophy very much comes into picture.

So if you get the I would say L that one say here we have to compute it, so that is your say D here $5.5 / 12 = 0.458$. Now if we consider that I have taken actually 10 millimeter actually that one it could be 25 millimeter also, because 0.458 and we have taken only whole under 60 that it means it is very, very marginal that we say.

So this is the one and here this one will be Destim deck testing that way that estimated that way I would like to say. Overall depth of the slab assumed 460mm assume width of the bearing 400, effective span L that $5.5 +$ that width of the bearing that support length and which is coming as 5.9 that is another way of doing that particular one here say pier span + effective depth that is also another way of doing that also we could find out from this one for under 60mm and then we can find out say 25mm or bar diameter and then your clear cohere on the bases of that whatever overall that they have assume from there you can find out the effective depth.

And then you can added with that clear span you can find out another span and out of that you can choose that effective span but here we have taken a very simple one, simple one is since that one that pier span + that bearing that width of the bearing that particular one we have considered and one the bases of that you can find out that.

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Dead load

(B.1) Dead Load :

- Dead load of the slab:
$$q_{slab} = 0.460 \times 24.0 = 11.040 \text{ kN/m}^2 \quad (2)$$
- Dead load of the wearing coat:
$$q_{wc} = 0.100 \times 22.0 = 2.200^{\circ} \text{ kN/m}^2 \quad (3)$$
- Dead load:
$$q_{dl} = 11.040 + 2.2 = 13.240 \text{ kN/m}^2$$



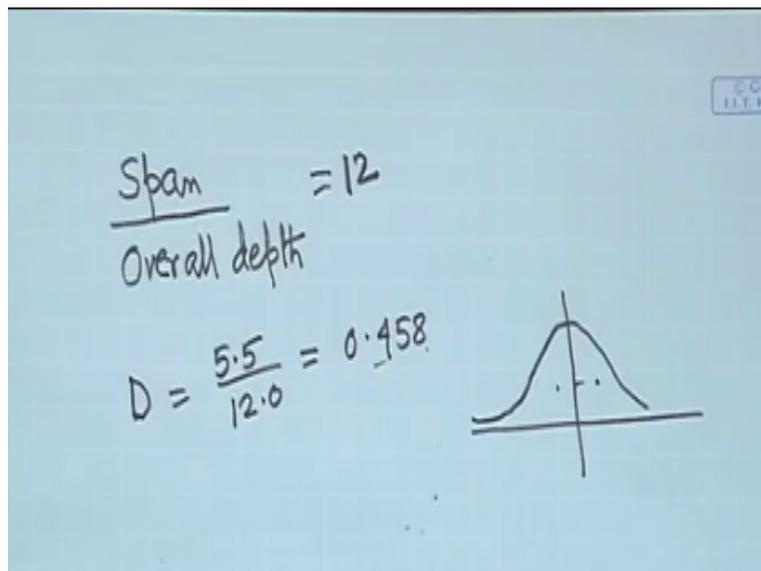
So 146 is the overall depth as you we have been noted down so we can calculate here that particular one here we can calculate here that dead load of the slab that we can calculate so q_{slab} 0.46×24 now question is that one here shall we take 24 or shall we take 25 because we are talking reinforce concrete so we should take 25 also but why I have taken this one 24 and 25 because most of the cases I find that, there is certain confusion.

Most of the, whether we shall take 24 whether we shall take 25 because my main objective also here you take this problem and later I shall circulate if it is not possible with this video but we shall circulate that one in as a document that there is no such equipment that how much is the difference with that one kilo Newton per square meter, my objective is that you should feel that, that yes this much of differences is coming.

Otherwise if you just simply go with that 25 only then you will not know that what is the difference you are getting in design that is more important to know that how much is the deviation we are getting as we have shown in the probabilistic design and that we are getting that say normal curve that coefficient distribution normal distribution we are getting in that

distribution we are always telling that particular one here. That is we move little bit that means I would like to say here I am going little bit away.

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The image shows a handwritten calculation and a diagram on a blue background. The calculation is as follows:

$$\frac{\text{Span}}{\text{Overall depth}} = 12$$
$$D = \frac{5.5}{12.0} = 0.458$$

To the right of the calculation is a simple diagram of a parabolic curve representing a beam cross-section. The curve is symmetric about a vertical axis, with a horizontal line below it representing the base. A vertical line passes through the peak of the curve, and a horizontal dashed line is drawn across the width of the curve at a certain height.

That my main objective to tell you that one you feel that particular one so that means if you are here and if we move either this way or this way then how much actually change you are getting actually effect you are getting and finally because main objective here to take that one the call whether I have to increase the depth of the slab or not or whether I have to increase that say reinforcement.

That is the effect that means if I change this particular one little bit whatever it is then how much effect we are getting there and so that is why we have to design such a way that with this small deviation I should be comfortable I should not leave as that I should not have a sleepless night just okay this much of change is there oh! That means that the sky will fall that should not be the

attitude during design. That whenever you have designed so this aspect also should be coming to picture and it should be comfortable.

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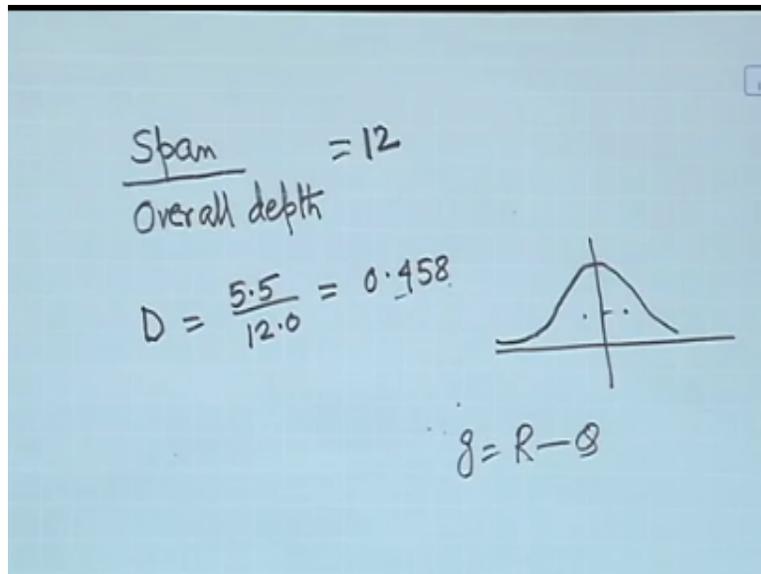
Dead load

(B.1) Dead Load :

- Dead load of the slab:
 $q_{slab} = 0.460 \times 24.0 = 11.040 \text{ kN/m}^2$
- Dead load of the wearing coat:
 $q_{wc} = 0.100 \times 22.0 = 2.200 \text{ kN/m}^2$
- Dead load:
 $q_{dl} = 11.040 + 2.2 = 13.240 \text{ kN/m}^2$

So coming to this particular one here so 0.46 just we have taken very, very marginal one we have taken I could take it 500 also and then I can take the problem and then we can solve it, so but I have taken very, very much marginal that particular one as I am telling your that limit state that limit function you can say that whatever I have told you that particular one here.

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$G = R - Q$, R is the resistance and Q so that means this value is coming very, very close in that particular, that means almost near 0 that is the one you can say. I can say that greater than 0 so that means I can say it is safe but is it enough that is the question and that we should understand that.

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Dead load

(B.1) Dead Load :

- Dead load of the slab:

$$q_{slab} = 0.460 \times 24.0 = 11.040 \text{ kN/m}^2$$

- Dead load of the wearing coat:

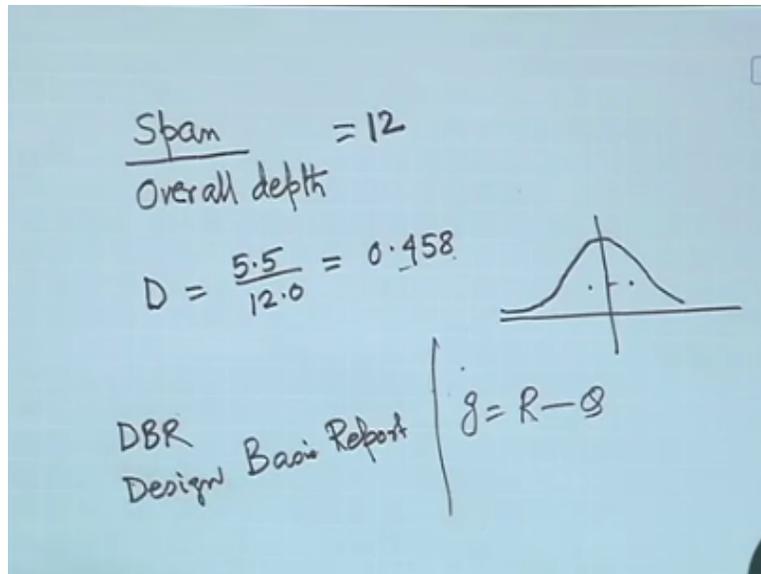
$$q_{wc} = 0.100 \times 22.0 = 2.200 \text{ kN/m}^2$$

- Dead load:

$$q_{dl} = 11.040 + 2.2 = 13.240 \text{ kN/m}^2$$

So dead load of the wearing coat again I have taken 0.1×22.0 so this one we are taking 2.2 but this one we could I am telling you again and again this one actually 0.65 also 0.65 also it is possible in that you will say one and that also we shall say, so that means one thing we are getting here 24 whether it will be 25 next one 0.1 or it will be 0.65 anyway so let us take so these things should be that is the one we call it actually your design bases report.

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DBR so coming to this one here the design bases report that actually if there that what value are we going to take that whatever the value respond the requirement point of view and then for design purpose these are the values to be taken, from this code or this literature or this book we have taken this data if that we should not find anything from the book then we follow certain things from the code also or we get it from the book also or literature also will make it.

But considering all aspect we have to make one design bases report and that report to be approved by the client, yes. This is the thing we have considered for this project and then go through it and approve it so that you can go ahead that is the one we shall proceed your that to be followed for design process.

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Dead load

(B.1) Dead Load :

- Dead load of the slab:

$$q_{slab} = 0.460 \times 24.0 = 11.040 \text{ kN/m}^2$$

- Dead load of the wearing coat:

$$q_{wc} = 0.100 \times 22.0 = 2.200 \text{ kN/m}^2$$

- Dead load:

$$q_{dl} = 11.040 + 2.2 = 13.240 \text{ kN/m}^2$$

So dead load obviously this particular one here 11.040 + 2.2 so that with starting point 240 kN/m² here just I will like to mention this one here actually I have used lactic and python and then lactic and that is why I have given this particular one here that we can find out this particular one here information because in as I told you excel you will only find out this information only and then another column where you will get that once you are unit.

So this particular one, we are having the information so we are having deck concrete deck and then you are having wearing coat these two things we are having and we are taking only casual part. And considering that aspect we are getting that q_{dl} which is equal to this particular one say 13.24.

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Dead load : Bending Moment and Shear Force

(B.2) Dead Load : Bending Moment

- Dead load bending moment :

$$\begin{aligned}M_{dl} &= \frac{q_{dl} \times L^2}{8} \\ &= \frac{13.240 \times 5.900^2}{8} && (5) \\ &= 57.611 \text{ kNm/m width of slab}\end{aligned}$$

So dead load that bending movement we can obviously we can calculate and we have already we know that L, q_{dl} already we have calculated and so we are getting 57.611 kNm/m width of slab so we are getting this information here that we care getting here 57.611 kNm/m width of slab that we can find out here that is the information we are getting that your sake interior.

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Dead load : Bending Moment and Shear Force

(B.3) Dead Load : Shear Force

- Dead load shear force :

$$\begin{aligned} V_{dl} &= \frac{q_{dl} \times L}{2} \\ &= \frac{13.240 \times 5.900}{2} \\ &= 39.058 \text{ kN/m width of slab} \end{aligned} \quad (6)$$

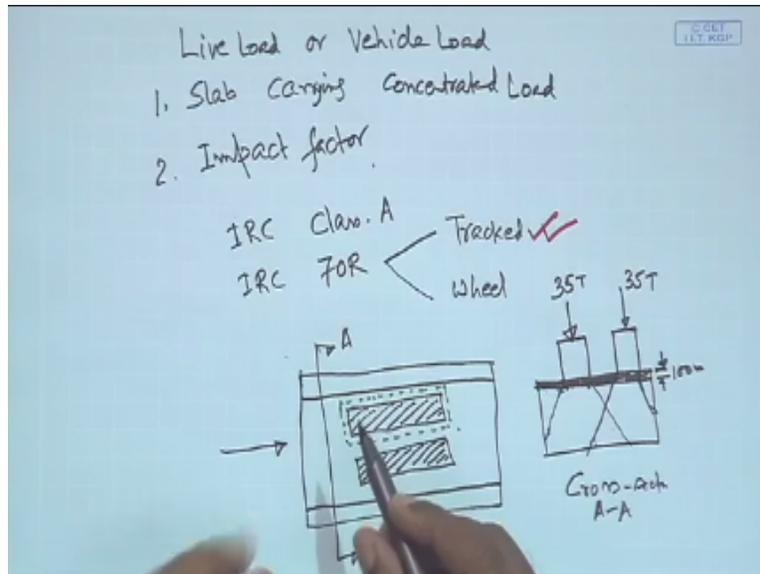
And then dead load for shear force so where dead loads shear force that one we can say $q_{dl} \times L/2$ so then we are getting again 39.058 kN/m width of slab, so this information we are getting from the dead load or cell point of the bridge the deck and that one obviously one slab only, so we do not have any other information or any other load available to us. So this is the one we are getting it here this particular one we are getting it here, so that is a very simple structure and we have got this information here, the next things is coming we will come that is our actual your say.

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Slab carrying concentrated load

Concentrated load or that quill or that load whatever will come that particular one here.

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And for that particular one what will be the effective width so slab carrying so this is our topic that we have to find out that particular one we have to consider this is one aspect and another aspect we have to find out because these two things are coming from the live load or vehicle load and since the loads are moving at certain speed 50km/hour, 60km/hour so like that we are having 70, 80, 90 generally we will find out 60, 80, 100, 120 km/h that one.

So obviously that is, it is a dynamic so there should be certain of impact factor, so there will be certain kind of you say impact factor that you will have. Now whenever we are having these particular one say your impact factor that you are having and that we have to find out and that one will be applicable for you say vehicle load. And in this case we are having two types of load that is one say IRC clause A and IRC 70R, 70R again we are having tracked and 70R we are having say wheel.

In this problem we have considered this one, so we have considered tracked vehicle that we have consider and for this load we have to find out how much will be you say effective width that particular one that we have to find out and also we have to find out you say impact factor that we are going that means here.

If you see the plan of the bridge I am looking from the top plan, I'm looking from the top vehicles are moving like this there is one portion where it will not go it may be that your say foot path or other things, now this one the track vehicle this is the track vehicle at the top of the deck,

top of the deck means there is one part is called concrete another one is called that we are in course, so it is over wearing coat.

So we are at this level say slab I am taking this one say cross section this is plan this is cross section, cross section means like this over that we are having wearing coat and then we are having this vehicle tracked wheel, so how much it will disperse like this that we have to find out, how much it will disperse that we have to find out and then we can find out that means here according to these we are above 100mm I can consider this one as $4\frac{5}{8}$ that we can consider $4\frac{5}{8}$ so that means I shall get this one, then we shall get for one wheel how much it will disperse then we can find out for the other wheel how much it will disperse that is the over level portion.

So like that we are having this particular one here from there we shall get the stress, that whatever load we are applying here this one we are giving here 35 tonne and this one we are giving here 35 tonne and that load finally the 70 tonne so obviously if we take the 70 tonne and then for that if we do it with the limited length then obviously the load will be more, so to avoid that one we have to find out the dispersed one and here in this case as I have told you in the very beginning there are two methods one is that effective weight method another one is that Piegeaud's method, effective weight methods for the one way slab because the slab is supported in two opposite sides, so we shall consider these method and on the basis of that we shall solve the problem.

So for the slab carrying concentrated load this one also as I have told you earlier that again that why I am always referring back twice four, five, six because that you are the first code for civil in your under graduate that you have come across that IS456, so that way you are familiar and then we would like to show you that what modification to be done whenever we are going for applying for your say bridge that is your say that or that IRC code that is our thing that I would like say.

So then I can tell you here in this way that very simple that means I shall get this is the actual one then I shall get certain kind of dispersed area I shall find out in both direction that means I shall get it in this direction also as well as in this direction also, so that means I can say effective width which is parallel to the support and effective length along the span, so both the lengths that we have to find out and we are having certain formula and on the basis of that actually we can do it.

So this is the theme that we have to find out and that again we shall follow these particular one we shall follow the slab carrying concentrated load that we shall use it from IRC21 and then impact factor again for that we shall go to IRC6. So these two things if we do it then we shall find out our whatever load is coming from there we shall get how much load is coming per meter width of the bridge and then from there we can find out that bending moment and CR force and then we can solve the problem.

So this is the thing that we are going to do it with the that your say that your for the vehicle and that is applicable again as I have told you that one will for IRC clause A loading also, IRC 70R loading also but here we are only taking care now to be that one say IRC 70R tracked one that we are considering here. And then when we shall get that bending moment and CR force then we can check that with the, we shall added with that dead load bending moment and see only dead shear force and then we shall check whether the section is alright and that we shall follow with that your working state method again limit state method according to IS456 and limit state method according to IRC112 that we shall solve and we shall do this problem that we can do it here.

So these particular one we would like to make it here, but again I am trying to say this particular one here that few numbers that whether we shall take it say 24, whether we shall take it say 22 that I mean to say 24 kN/m^3 or 22 kN/m^3 those things in the very beginning we have to decide that what are we going to follow and for that obviously we are having different codes and from there we can again make the design basis report.

Another one you try to make it that particular one here you can use excel also, you can use metalab also and as I have told you that the language python that is very, very popular nowadays that also you can use it you can download it and you can run that particular one so that you can see that how the problem, how one can design that one and then it is very easy to change the parameters and on the basis of that you to check whether the results are coming alright or not whether design is perfectly alright or not that way you can find out that is the thing we can do here.

