NPTEL ONLINE CERTIFICATION COURSES

Course
on
Reinforced Concrete Road Bridges

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Lecture 5 : Design Codes

Hello every buddy. So let us start with the last part of last week that is the 5th lecture of Reinforced concrete road bridges that is lecture 5.

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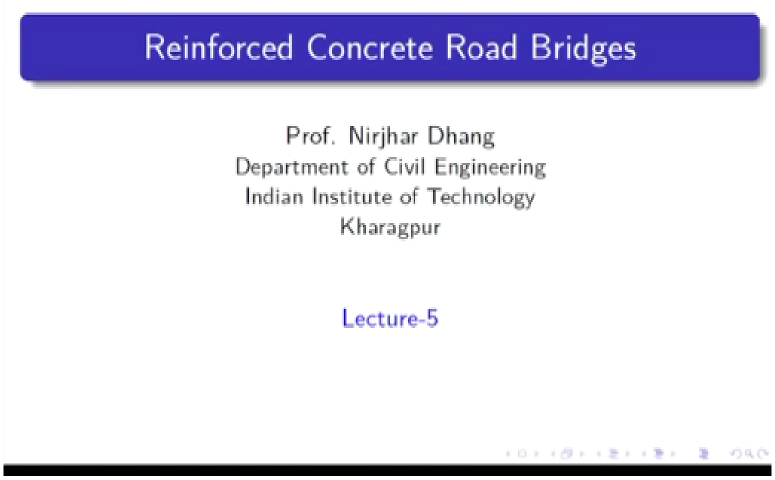

Here you shall consider the design codes.

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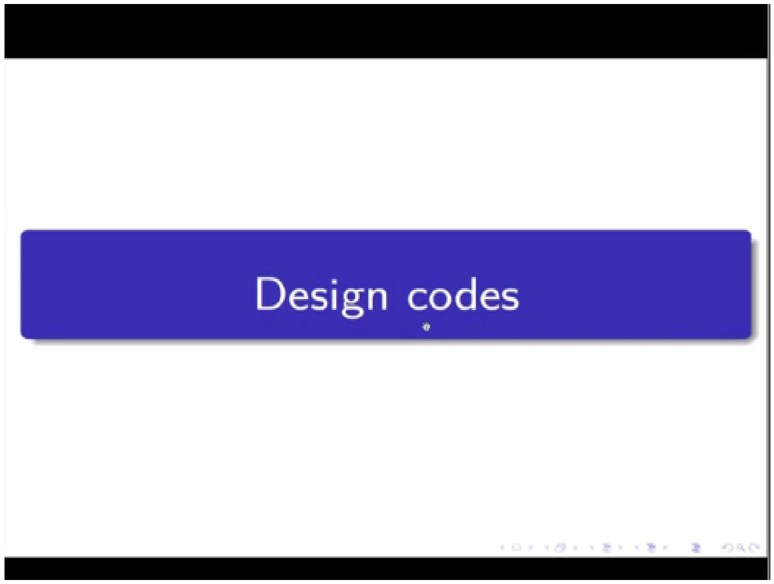

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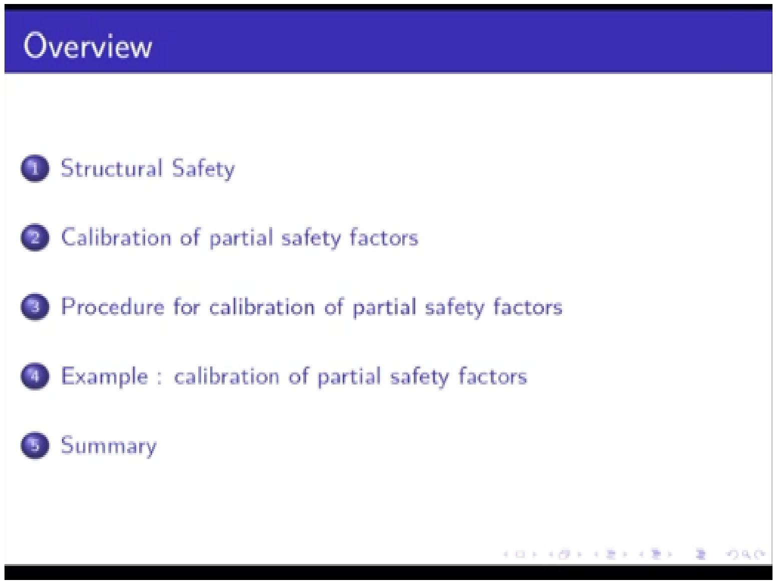

The basic principles of that and we shall consider the structural safety that is the first part, calibration of partial safety factors because we have observe that many times we consider that only multiplied with the different factors how do it come to that one. So I feel that with appropriate to tell something about that you can understand that how it comes that one those factors and certain calibration of partial safety factors we called and one example just simple one is I will tell you today though it is would have time is very tight but anyway since will go to the video so I hope that you can understand that the reinforced.

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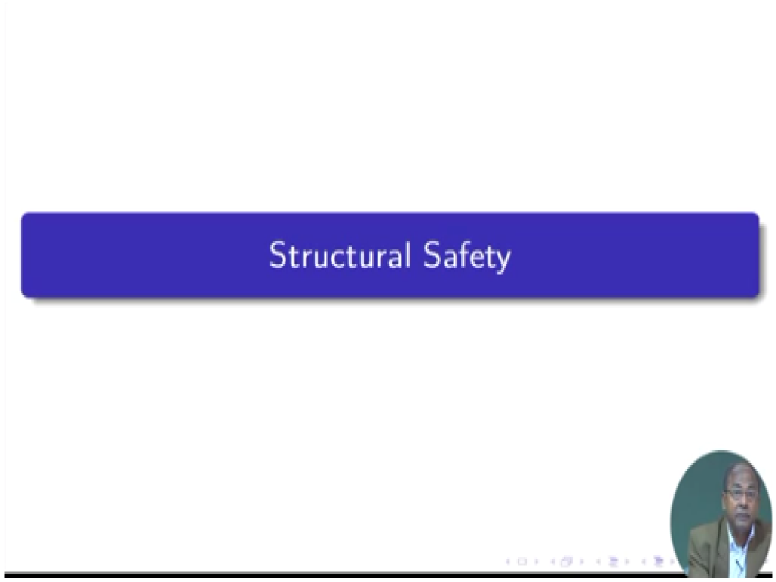

To structure safety when we are considering that.

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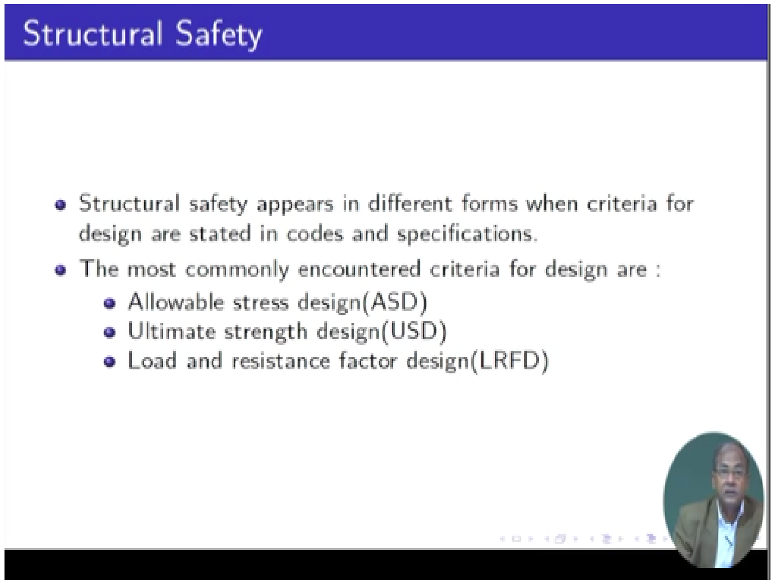

Structure safety appears in different forms when criteria for design are stated in codes and specifications so most common one allowable stress design, ultimate strength design and load and resistance factor design. So inaudible method that these are the one consider here. Let us see first what the basic idea of that is.

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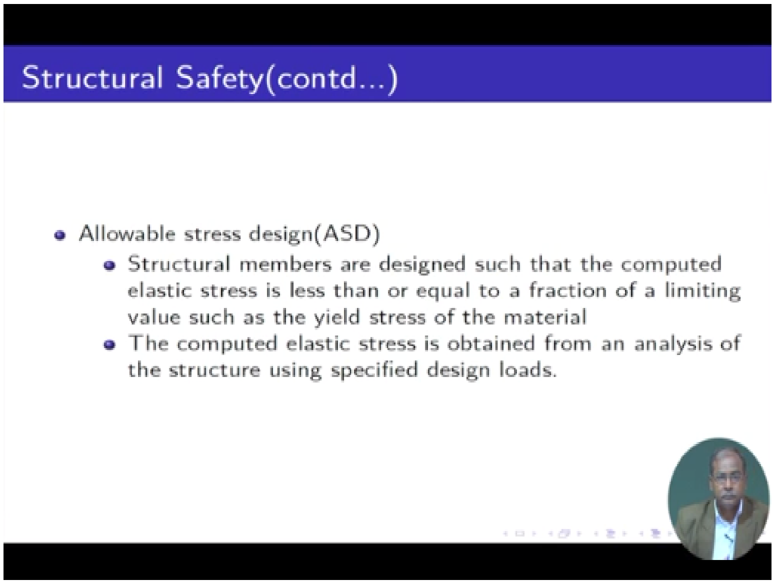

So structural members are designed such that the computed elastic stress is less than or equal to a fraction of a limiting value such as the yield stress of the material. The computed elastic stress is obtained from an analysis of the structure using specific design loads. So here in this case also we are having define design loads then you can retain load that impact factor other things you shall get that one that below which we have to overcome that is the strength of the material, strength of the axon should not be less than the applet force.

So that is the one which is called a resistant and other one you are having the applet load. So the meant so the one can consider the meant and another one consider the supply so divine means that this much load in a formal bendy moment or from a CL force. So that we have to overcome and for that these much exhibits the strength of the xn that we consider and that is the basic one if you know the ill states of particular material.

You will say it should not be more than this below. In stress with certain kind of factors of safety we can say. That means if I consider can 100 so I can say okay I shall not go more than 60. If you really consider that I can say in this particular case for limas trite we are getting point for 5 FCK that is the one as per higher scored IS456 so coming to this structural here whenever we consider the design loads that overcome here?

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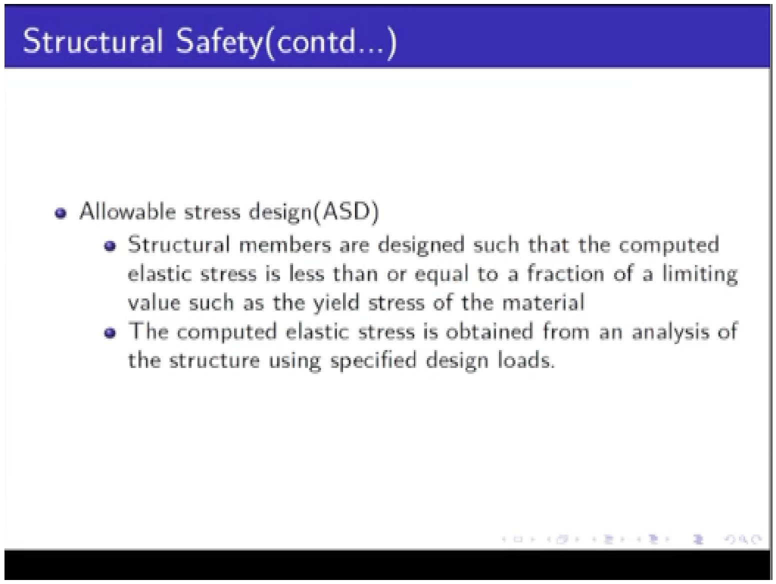

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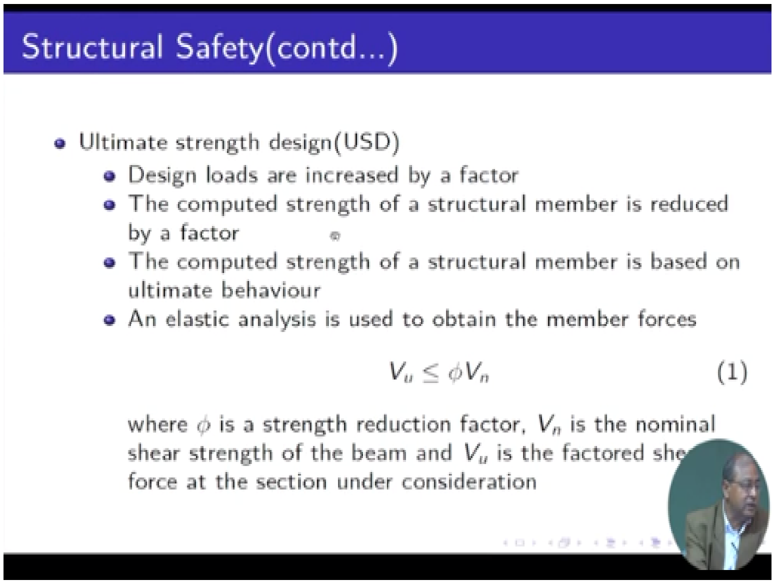

Another one is ultimate strength design, design loads are increased by a factor the computed strength of a structural member is reduced by a factor is very interesting the thing that one way load applied your thinking okay whatever load applied should not be more let us take it. The strength whatever you got it so know I shall take less than that so that is the one you can got it. Computed strength of a strength member is based on ultimate behavior.

An elastic analysis is used to obtain the member forces so V_u<= Φ V_n the nominal strength here one particular reduction factor V_n is the nominal shear strength of the beam and Vu is the factored shear force at the section under consideration so this is the one basic idea of the ultimate strength design.

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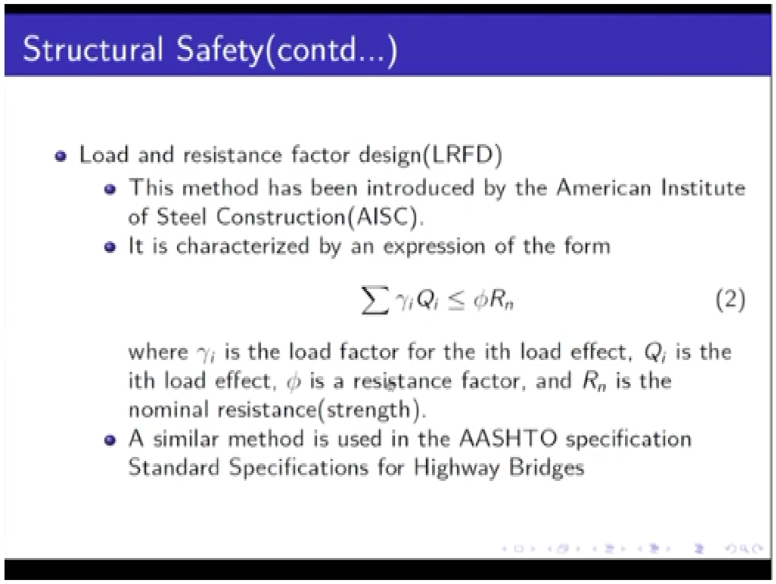

And LRFD method Load and resistance factor this method has been introduced by the American Institute of steel construction. It is characterized by an expression of the form €λQ_i and ΦR_n is the load factor for the i^{th} load effect, Qi is the ith load effect, Φ is a resistance factor, and Rn is the nominal resistance strength.

Generally for the linear limit state function this is the one $\beta = \mu R - \mu Q / \sqrt{}\, \boldsymbol{\sigma}^2 R = \boldsymbol{\sigma}^2 Q$ there is whenever we consider the μR the resistance value and μQ that is the one demand that were we can concentrate here this the one standard dividers but I am not telling that only one mean value here. I am telling certain kind of distribution and there is a that one is reasoning by the standard deviation so those to follows the basic of that linear one you consider that $\beta = \mu R - \mu Q / \sqrt{}\, \boldsymbol{\sigma}^2 R = \boldsymbol{\sigma}^2 Q$ this is the one we consider here.

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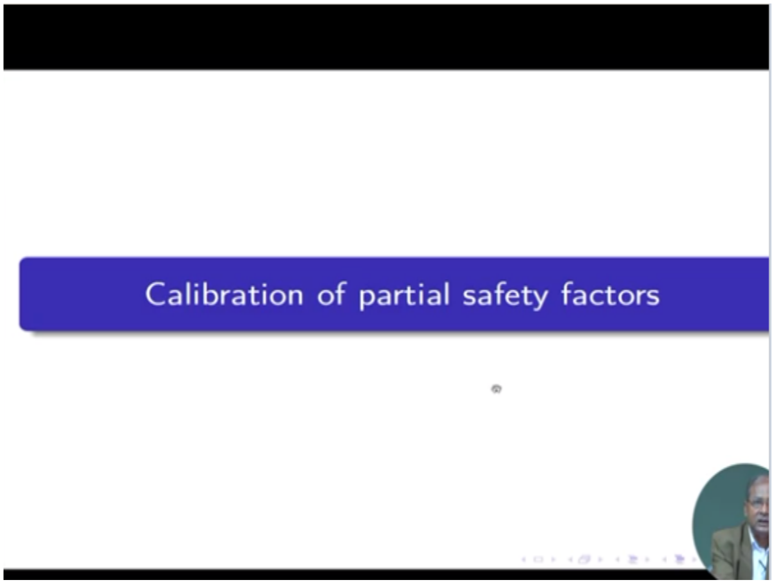

Now I am not because these factor one you can consider as a part of reliability of structures that is separate subject and only I c an taken this futurology code and for reason where who are busy to do it that is a objective just to inform you that hoe it actually works so major part here calibration of partial safety factor.

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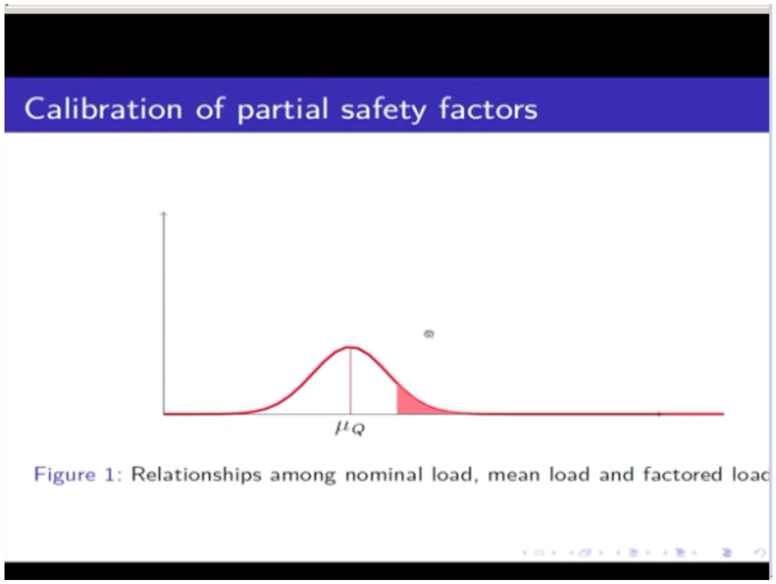

In this case as I told you whenever you having the standard deviation that means it is it not the μQ means this the mean when w required here we getting this. And then you are having certain distribution that means the value whatever you are getting all those things it is having for minus minute to plus minute you can say. So I am restricted that one it should not be more than this value, this is a value this is a mean value and this is the one that I cannot go more than that, so mean value and factor load that means this is the mean value then I am telling that thing factor of that which is coming here upto this.

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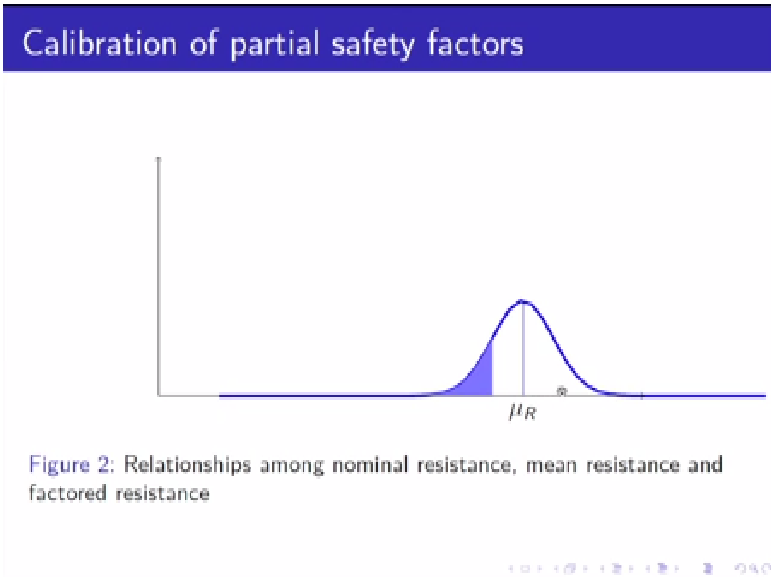

Figure 2: Relationships among nominal resistance, mean resistance and factored resistance

Similarly for the resistance we are getting that resistance these are mean value of resistance and obviously at my strength is reduced I shall never go this side.

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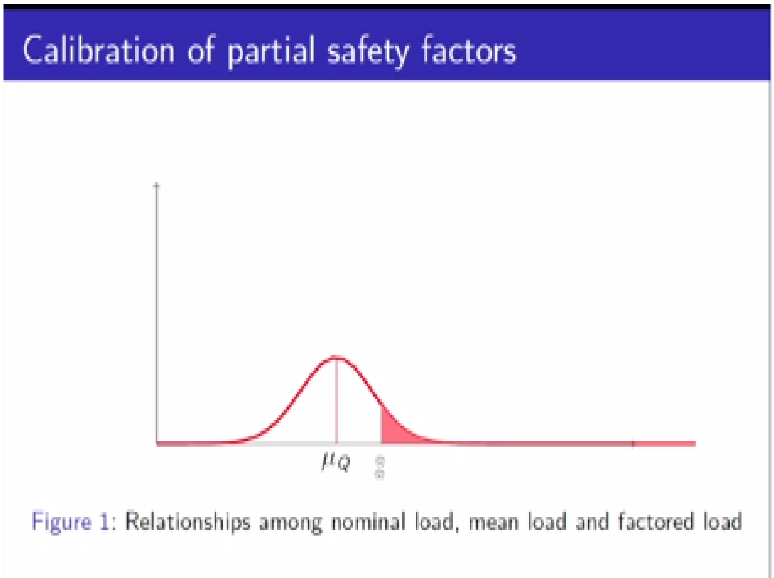

So you can see for load we are increasing that, this is the mean value I am going increasing.

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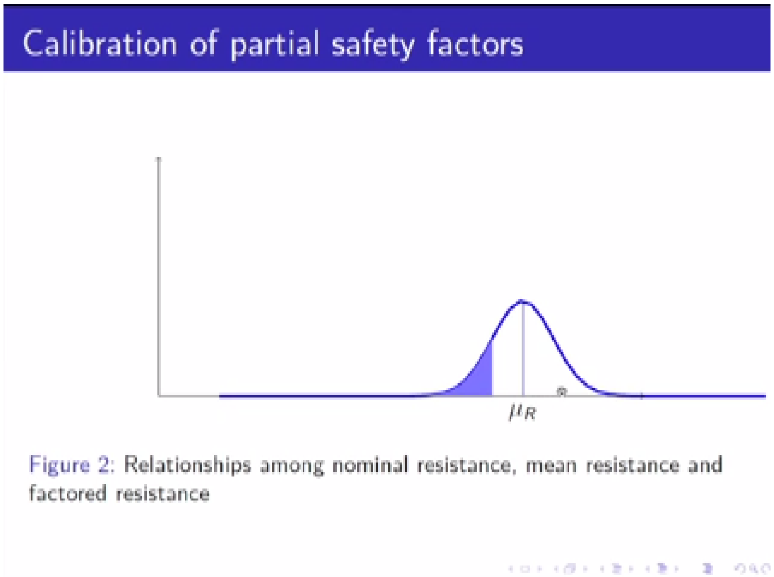

Figure 2: Relationships among nominal resistance, mean resistance and factored resistance

Whereas in the strength one I am reducing that value that mean you are certain factor that mean it should be less than one but whereas for load it should be greater than one, 1.2 1.5 if you remembered those particular value you are getting but in other side you are dividing by 1.5 you are dividing by 1.15 that means still your value is less than 1, so this is the one you are getting it here.

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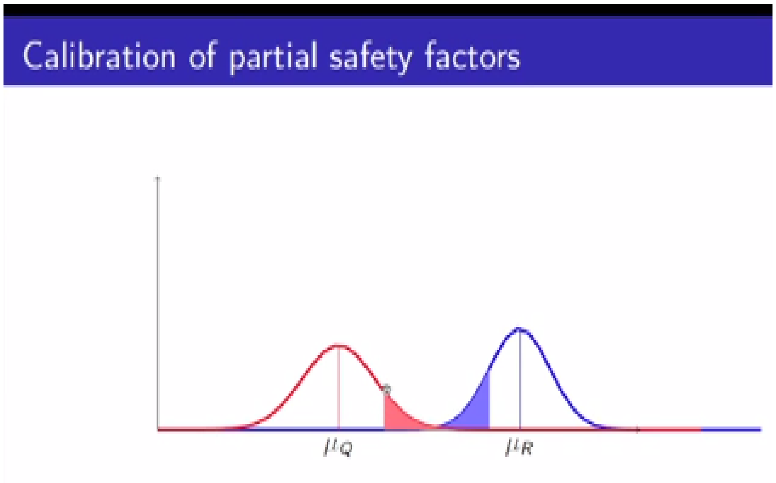

Figure 3: Relationships among nominal, mean and factored load and resistance

So coming to this one here I have increase this value here so obviously it is the very good decision that wherever value you are telling that how much load is coming you have told me something or I am telling you that one this much value is coming but your wise no okay let us take something more so you have taken something more, whenever I am telling the obvious strength of the material I might tell this one this is the mean value I am telling.

Then your flavor that intelligent that you know I shall tell little less so that means here this particular value is greater than this particular value this is the basic idea of our thing that means I have find out these value how much shall I increase how much shall I decrease that factors we have to calculate and that is called that partial safety factors.

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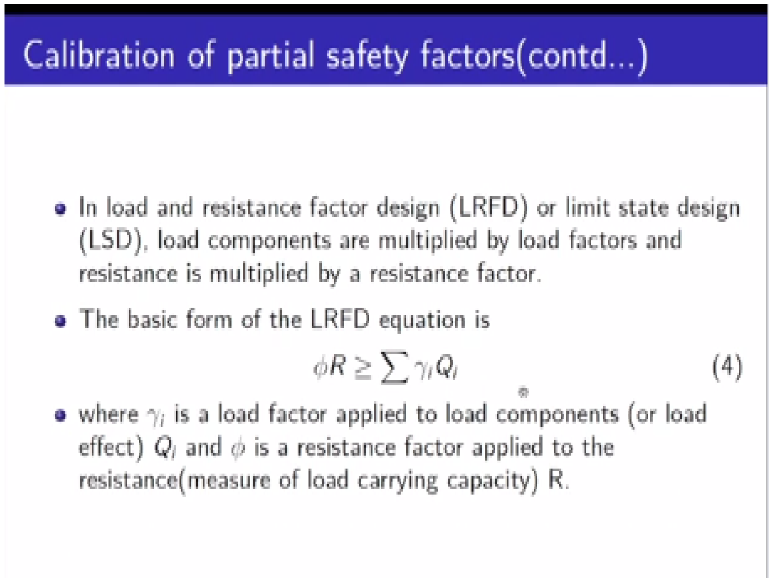

And the obviously there is a basis on that so this is your limits state this one so now the thing is that let me tell you another important aspect whenever we consider the limit state design that allowance state design all in popularly known as say working state design that is also another form of limit state so limit state means actually whatever in a conventional way whatever we are familiar that is not the only one the others also another way of talking that one say limit state here.

So basic form of the elaborated method five here ≥ Σ γ if you guide for define loads your factors should be different that factor one will be there, so γ is a load factor applied to the load components U_i N Ø is resistor factor applied with the resistance so that way we can find out okay.

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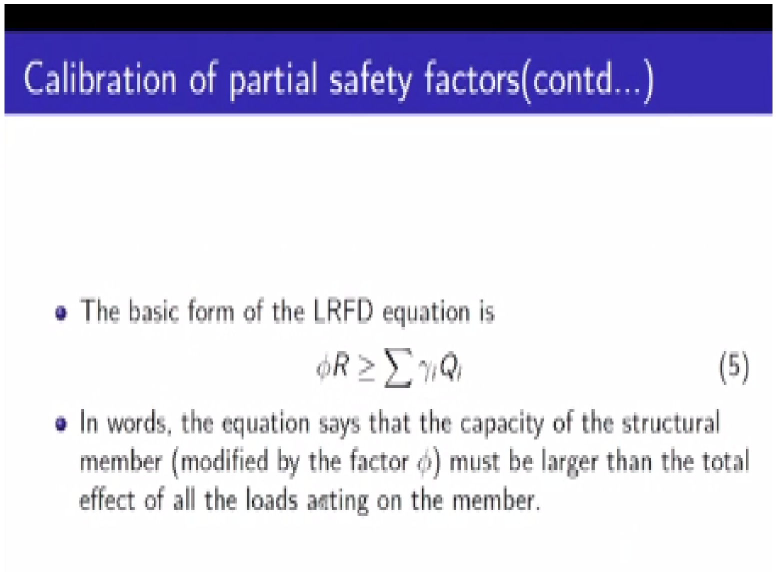

And similarly that particular one equation we are getting it here in word the equation says that the capacity of the structural member modified by the factor Ø must be larger than the total effect of all the loads acting on the member and obviously it is true then only otherwise it will fail.

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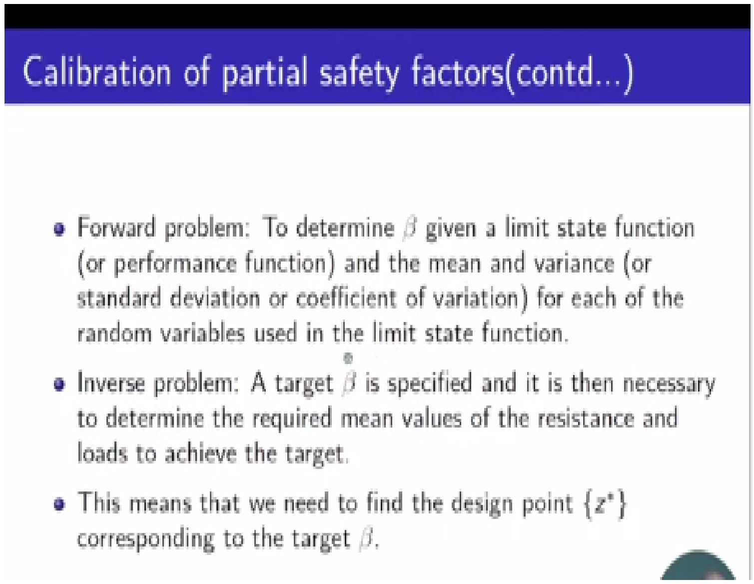

And this is one we consider that one say forward problem inverse problem, forward problem it means that you are giving a you do not know that value whatever value you are getting that you know the mean values standard deviation all those things and on the basis of that you are finding out the reliability but inverse problem it means which is our actual code how it does it, inverse problem it means that you are giving a target ß.

And on the basis of that you have to find out your, that factors different factors, different factors for load different factors for materials that you have to find out that and then.

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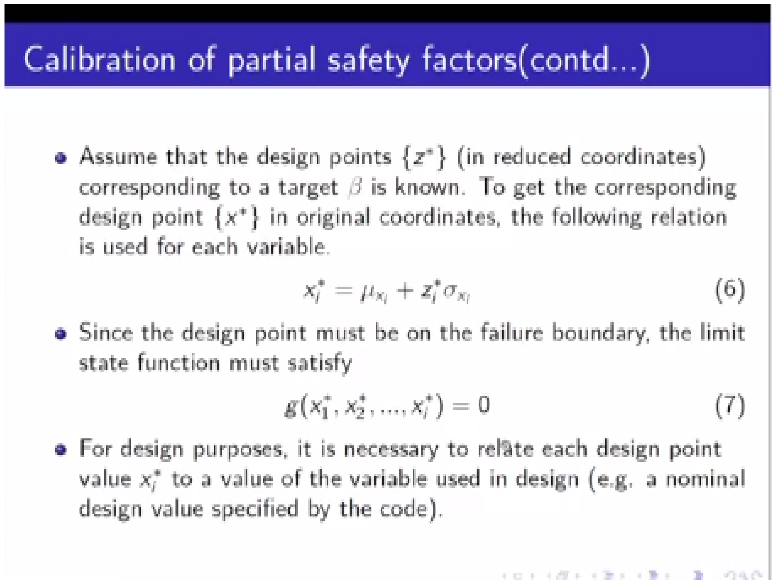

We consider all of them we consider here that $x_i{}^* = \mu_{xi} + z\, x^*\ \sigma_i$ that means I shall assume it is a one process and then this is a limiting factor design point where it works so I have to settle that, that is the numerical solution that you have to do it that means you have to find you can do it in a by guessing also that means I shall take different values and finally I shall get that G the limiting function value that one boundary value once we can consider that one should be satisfied our objective is that, that it as to be to satisfied like that.

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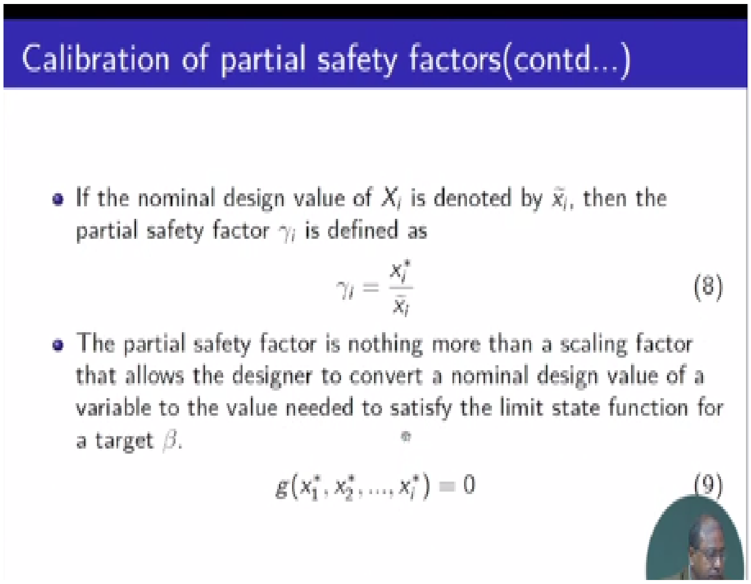

And finally we shall get that γi that X_i^* by this particular one here that design value that denoted by here from where we can get that γi that we can find out.

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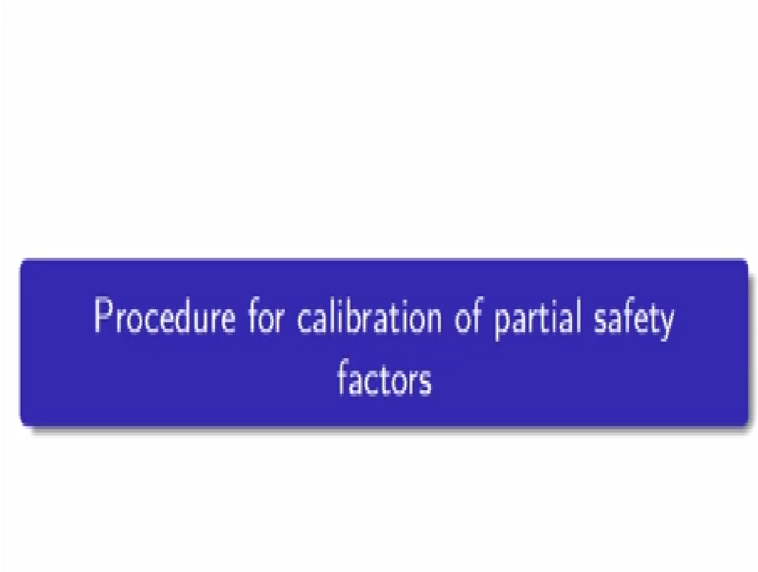

So just because this is the one that we have given so now what we shall do it here.

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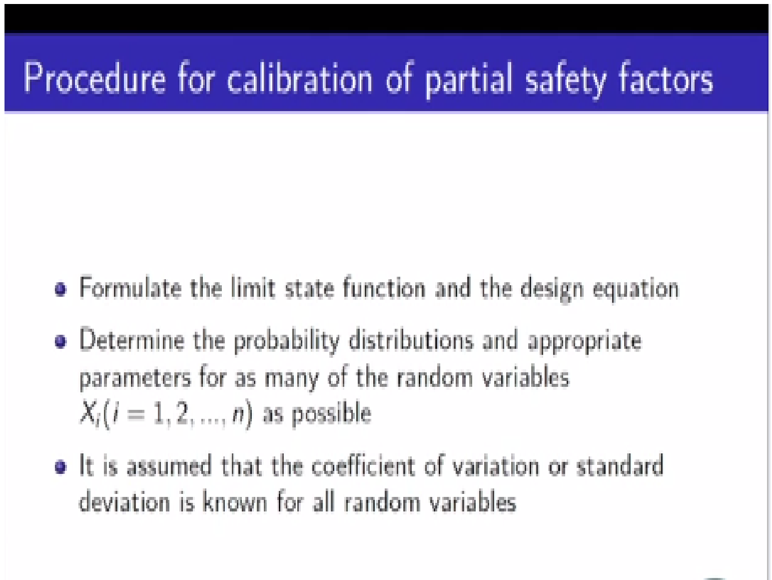

Just quickly let me tell you because it is wise to what to show you that formulate the limit state function and the design equation, determine the probability distribution and appropriate parameters for as many of the random variables, so how many are random variables you just find out let us say length or span so span obviously we shall not consider because it does not exchange much so that during construction it does not change, so width that also it does not change much, D also it will not change much the materials value may change so that one particular construct it is assume the coefficient of variation or standard deviation is known for all random variables.

So out of that which one actually you are deterministic one and which one random that variables we have to find out from that particular one, you need not all of them are not random.

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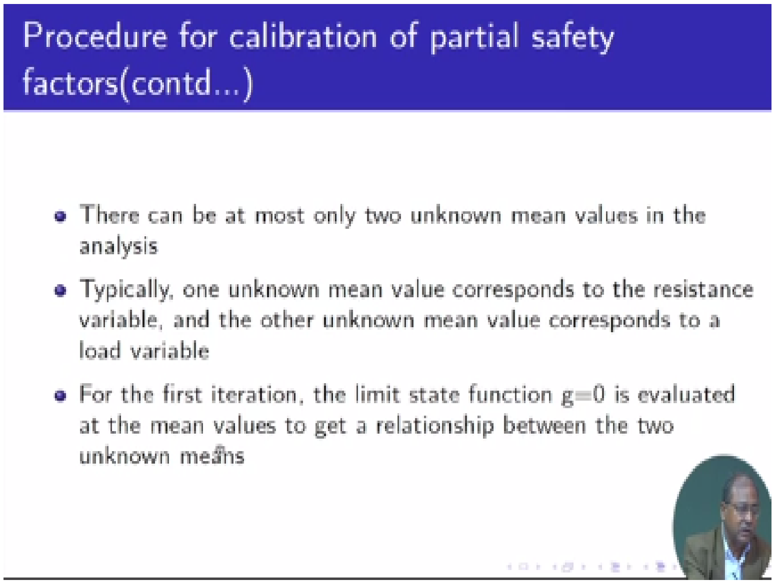

There can be at most only two unknown mean values in the analysis one unknown mean value corresponds to the resistance value and the other unknown mean value corresponds to a load variable. For the first iteration the limit state function g=0 is evaluated as the mean values to get a relationship between the two unknown means, so we can find out that particular one here.

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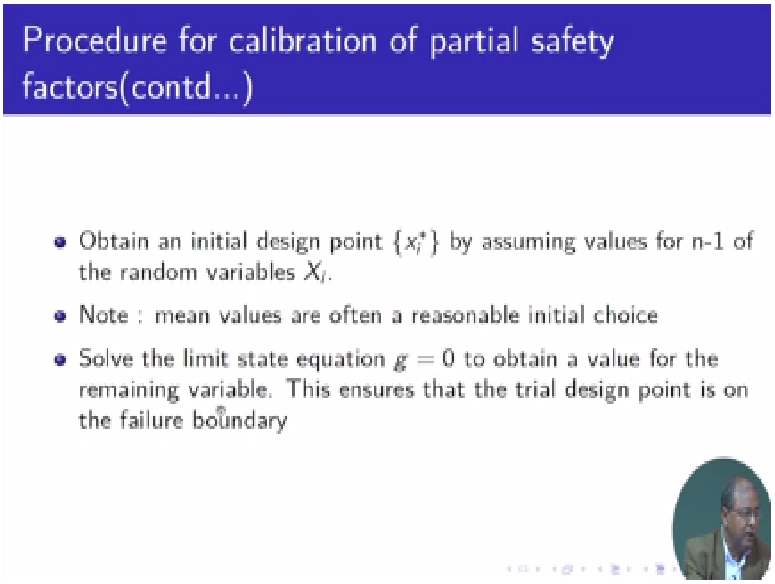

Obtain an initial x* by assuming values for n-1 of the random variables, mean values are often a reasonable initial choice that means I have taking a certain mean value that particular one we are considering and on the basis of that we shall move on. Solve the limit state equation g=0 to obtain a value for the remaining variable this ensures that the trial design point is on the failure boundary that is the one. Again let me tell you though it looks like.

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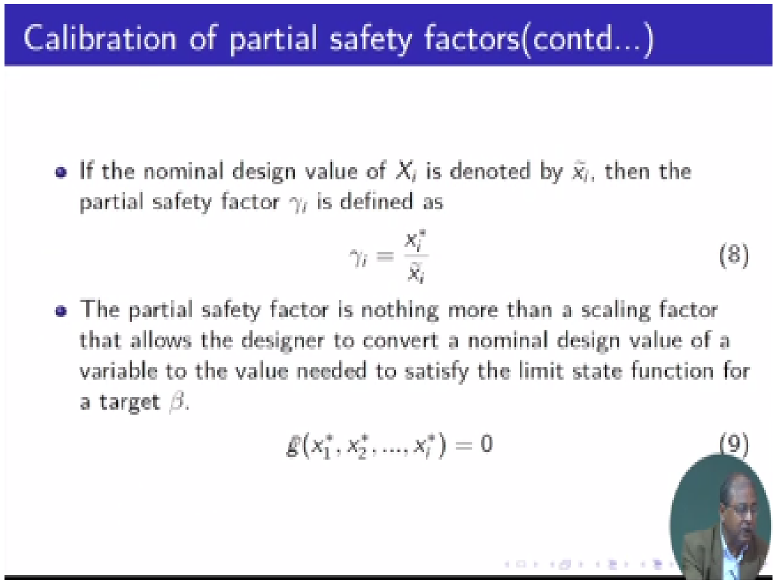

So this is your that function which you have to satisfied.

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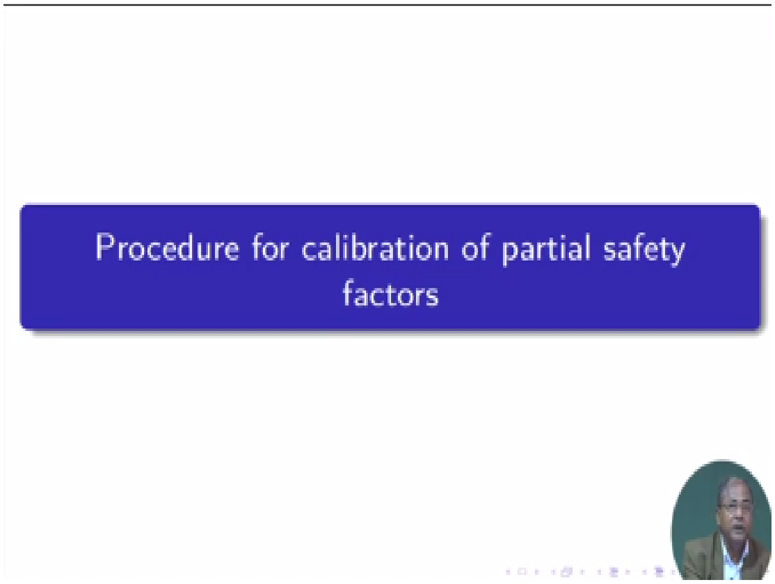

Because your P means there for example you are considering that bending movement and ICR force that particular one we are considering here. This particular case whatever we can consider here that we can say.

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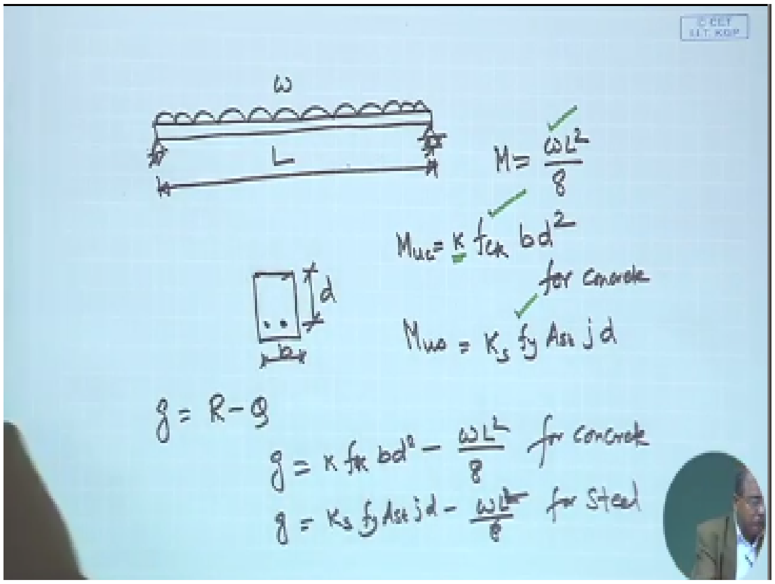

Just let me tell you a very simple one so this is your w, this is your L so M= maximum in the moment and as you know $0.138f_{ck}bd^2$ that is the section we are using so this is your say b, this one your d, this is for concrete. Similarly we can write down say let us say Mu this is let us say M_{uc}, this is M_{us} so K_s this is the one we are getting, out of that length will never actually say length whatever we are considering that 5m or 10m you count that one that it will be not change much.

So that means here in this case we can consider that is W I have given generally we know that point 0.138 $f_{ck}bd^2$ but here you need that you have to find out that value this is your sat f_{ck} and may be that f_y so these are the three parameters that means I can consider this one M and M_{uc} so g= that particular one we can consider just to tell you, so we can consider that g here that value I can consider here so R-Q we can consider g and obviously these case are should be always greater than Q then only I can say that particular one at least.

It should be equal it should not be less than so these one we can say one way I can say G so I can say K FCK $BD^2 – WL^2/8$ this is one or I can say g = Ks Fy Ast Jd – $Wl^2/8$. So these are you are call limit state that mean these limit state and these limit state that one this is for concrete this is for steel and these one to be satisfied and on the basis of that you have to find out that factor how much factor we shall give. So that particular value of β so we shall consider for a particular value of β.

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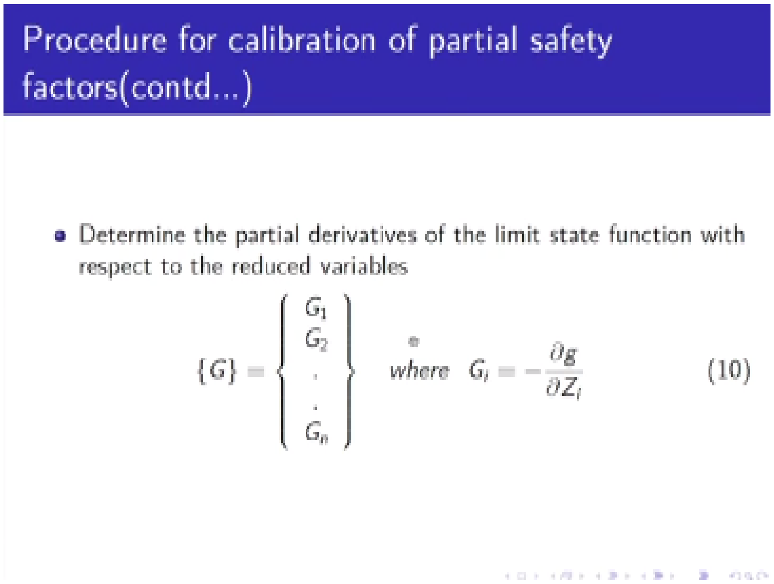

So that is a procedure here I am not going to detail of all those things just to give you an idea that how it works, so that you can understand that one I shall give reference which you can follow.

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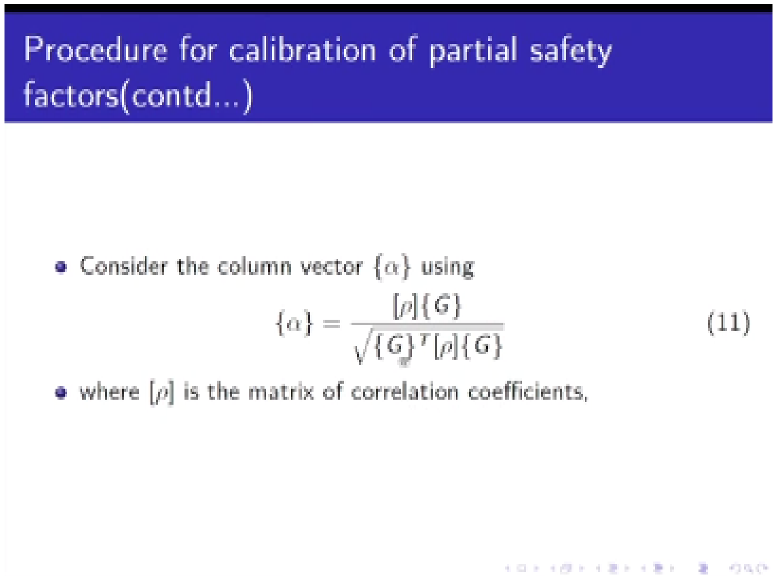

So we can find out certain value here so G is this one and which is actually nothing but the first derivative with respect to the mean value and then you can find out that coordination coefficient we can find out here this particular one this is coordinator.

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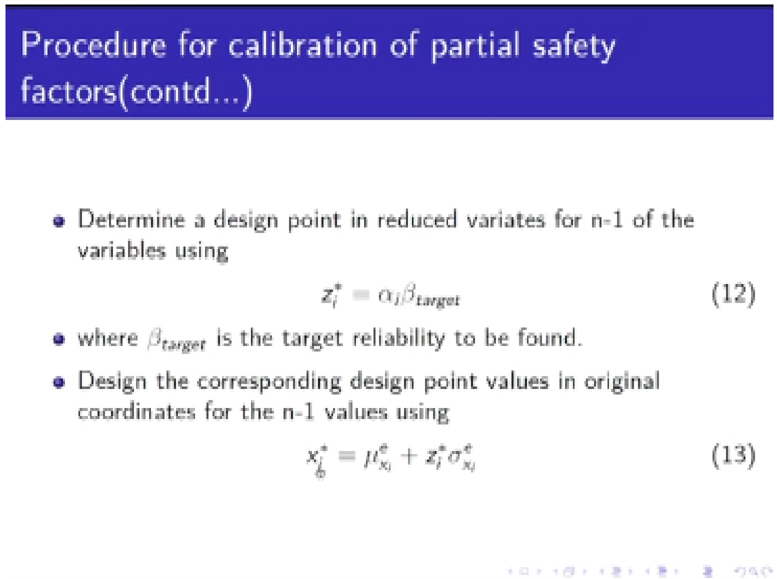

And then you can find out the target value on the values of that I can give the µ value and so then I can get that from the mean I shall get the µ Xi.

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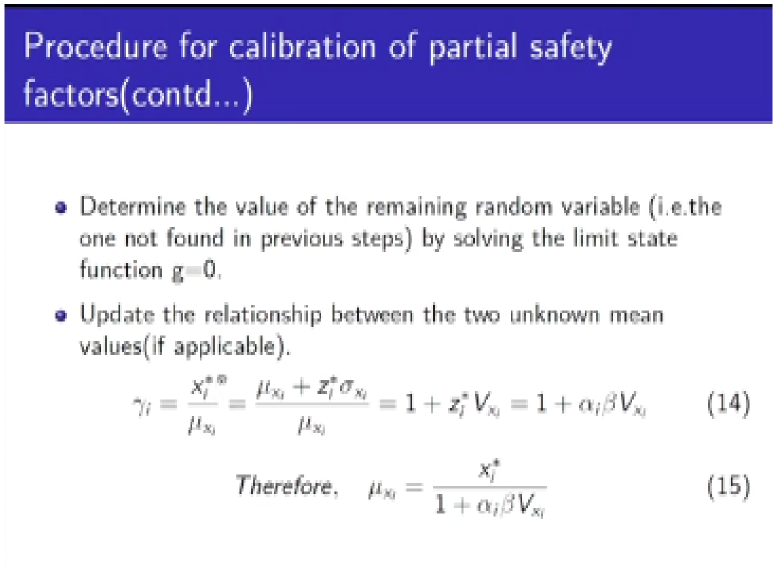

Like that I can keep on doing that particular procedure and then I can get that value 1 + αi β Vi Xi, this is the procedure we will follow, so we can find out that γi that Xi stare by µXi so that means here mean objective is there this β value how much your target that means your deliberative will be that mean say β = 0 that means just only it 0 if you increase that β then only you can find out that I want to say β 2 I want β3 that on the basis of that we can find out.

On the basis of that αi which we have calculated like this so G we have to calculate Gi is nothing but this one that means G is nothing but this one. So and G is the limit state function form there you will get gi so this particular one on the ways of the you are getting α and ρ and then you are getting the µZi considering Zi I can get the µXi* and then I can find out that γ is for individual Xi is there by µXi which will give me that γi that particular value it will give me.

And then we can solve and from there we can find out the value of µx, µxi we can say that we can find out.

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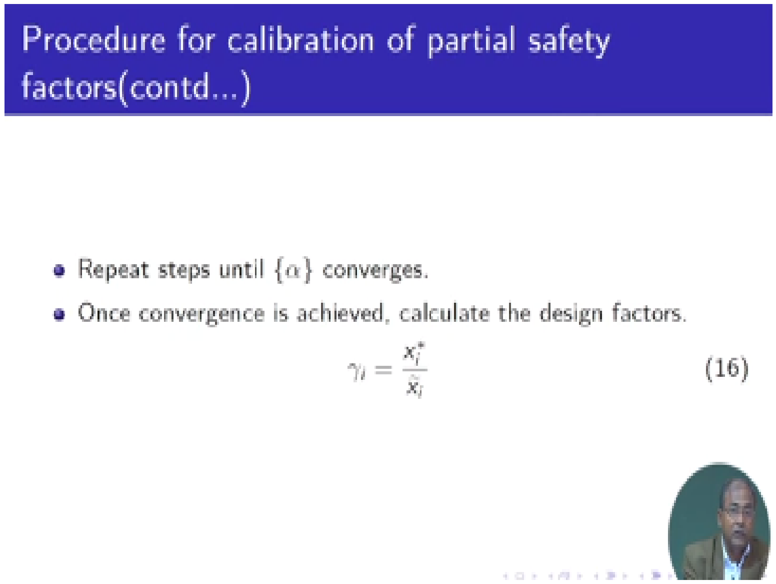

Then we have repeat that one and then when the convergence is achieved $\gamma = X_i^* / X_i$ that we can find out here. That is the one we can do it here so this is the positively follow.

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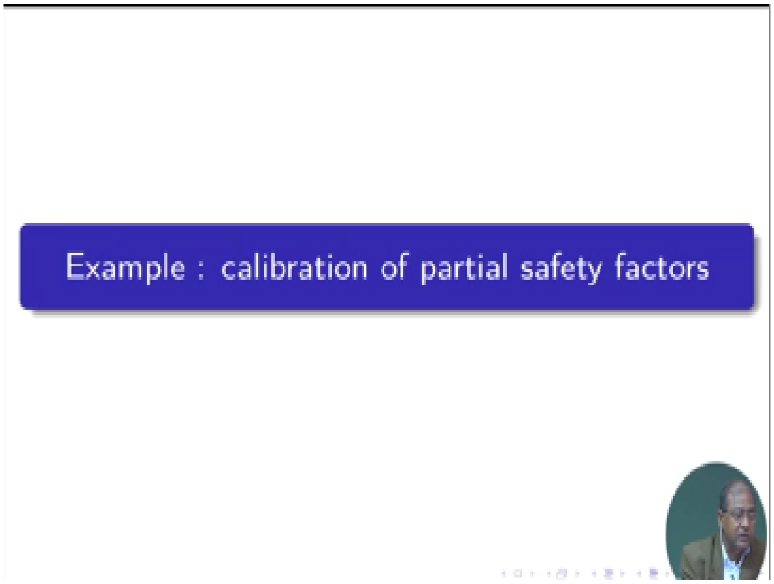

So let us give you one example so it will be clear actually.

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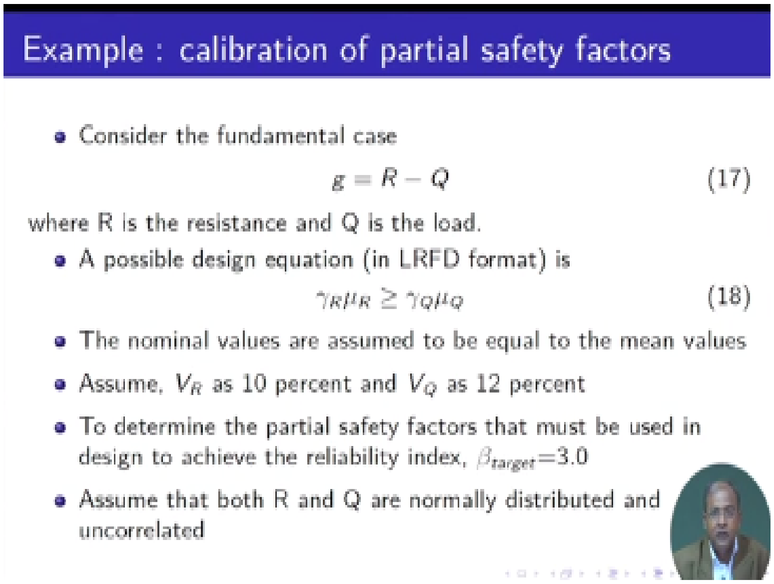

So consider the fundamental case G = R – Q this is very, very common R is the resistance Q is the load are equally demand and supply possible design equation is γR, μR ≥ γQ μQ that is obviously we are having two unknown variables so γR we have find out and γU we have to find out from this particular one the nominal value assume to be equal to the mean values that the first one assume Vr as 10% and Vq is 12% that means there is a variants.

Variants that we can find out 10% and 12% to determine the partial safety factors that must be used in design to achieve the reliability index βt target = 3.0 so generally most of the cases we should consider β actually 3 that will consider you know on the basis of that we calculate those values. So our objective is that this particular one β target we have to find out we have to achieve for a particular value of γR and γQ.

Assume that both R and Q are normally distributed and uncorrelated this is very, very important actually here because a statistically that each of them actually variable each actually follow certain distribution so that distribution whether normal distribution log distribution log normal distribution like that many more distribution available. Normal distribution is very common, so we can find out the R and Q are normally distributed and uncorrelated.

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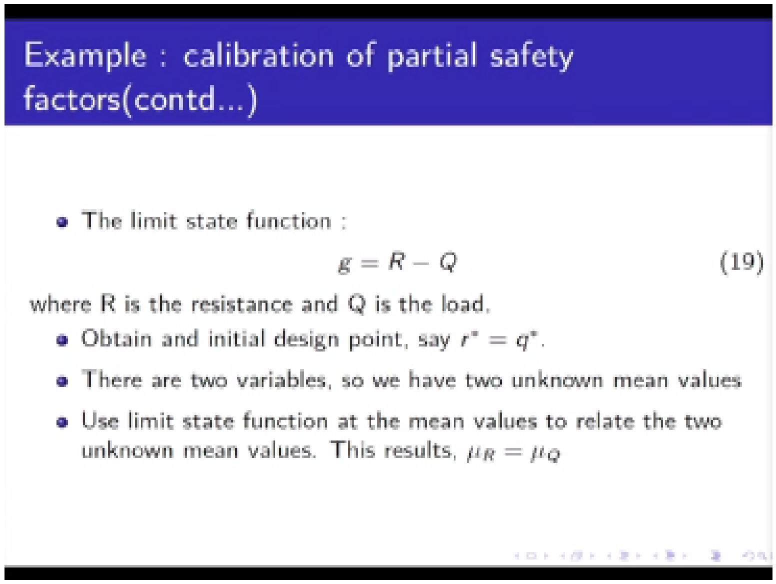

So limit state function as usual g= R-Q. Obtain the initial design point say r* = q* between the value, so we have two unknown mean values. Use limit say function at the mean value to relate the two unknown mean values that is μr = μq. That is the one you can find out over here.

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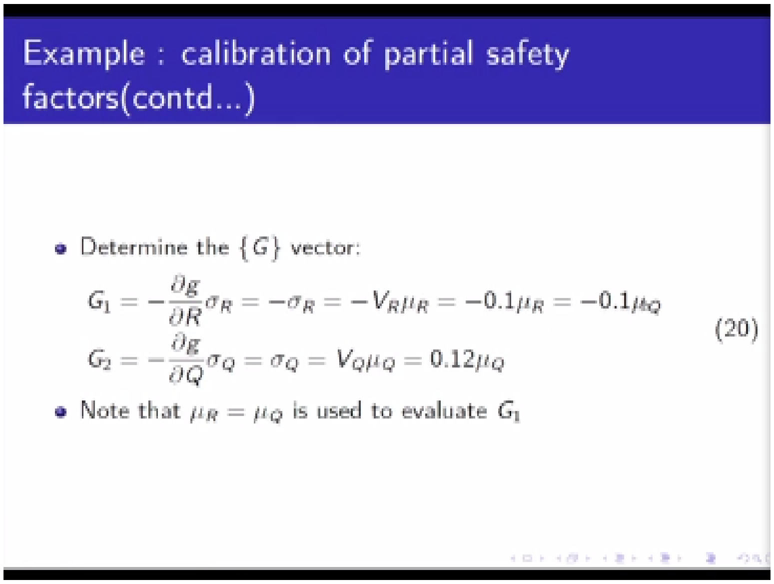

So as usual I can take G1 we can just take the derivative and you can find out these -0.1 μr -0.1. μq. G2 = G1, and then it is used to evaluate G1.So you can consider that the μ1 and μr to evaluate g1.

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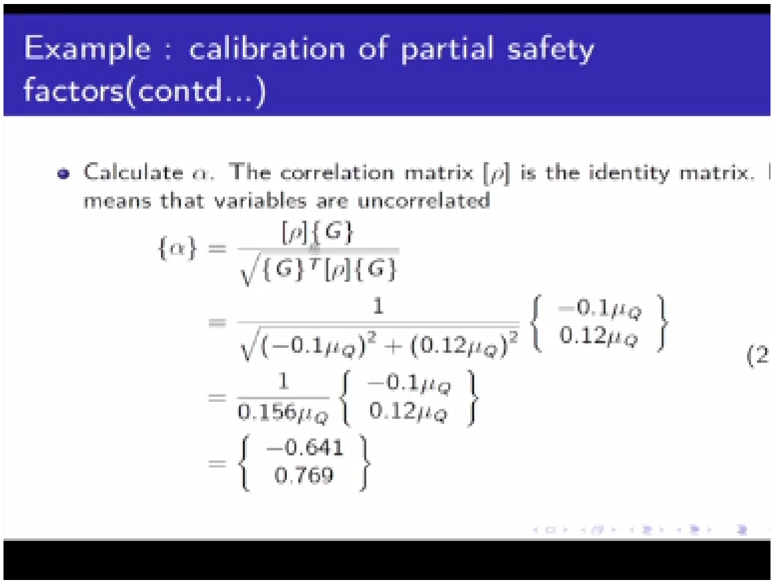

Then calculate α ρ G this particular over here and this is over here and then I can get α=-0.641 and 0.760. This is the one we can get it.

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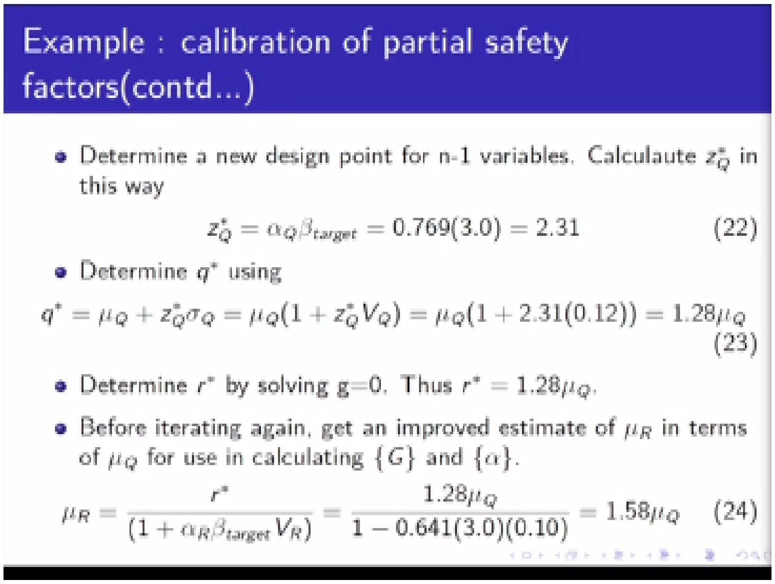

So z*q = this one that is 2.31 q* using this particular formula we can use 1.28µq. Determine r*= 0, r*= 1.28µq and then you are putting this one then I get 1.58µq. so this the one that stepm by step if you do it than I can get the value.

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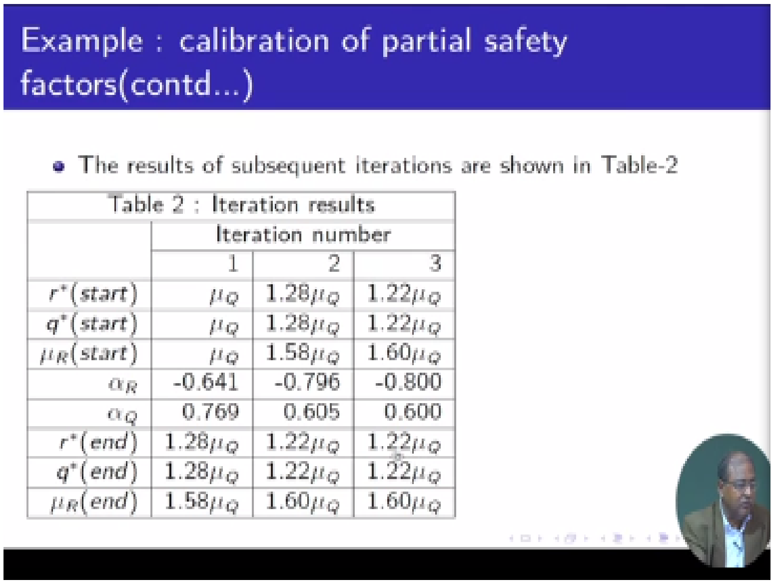

And so it is nothing but actually 1st one we will get like this and 2 set we will get like this and 3rd one we will get like this. So this the way we can find out, so if you start with the value r*,q* µq aplly the value you get the value then this one I am getting it over here this one I am using itr over here. From here to here I am getting 3 equations and I am gettibng the exact value of the particular one.

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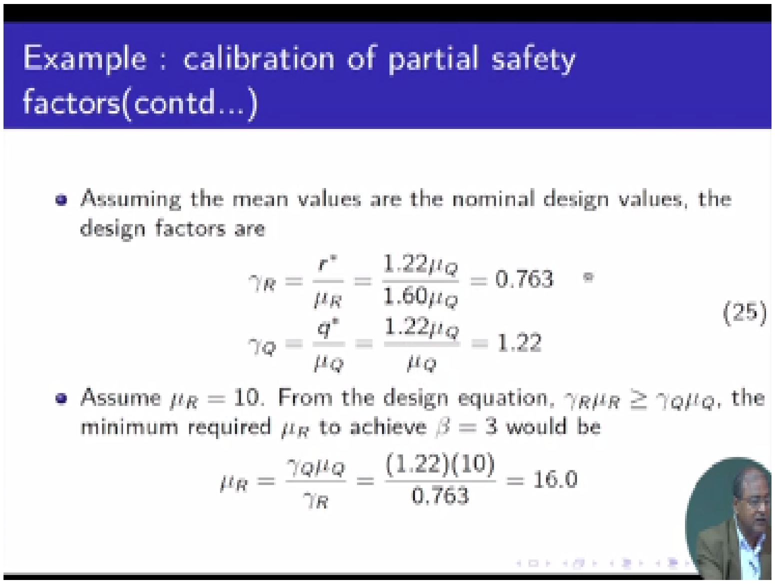

So ϒr = r*/μr s 0.763 ϒq = q*/μq 1.22 μq, so that means I am getting this value as this 0.763 and 1.22 that particular one we arer gettiong thais value that we are can find out and then we can μr = 10 that would be 16.That means we have get the particular one here 16.10 so thease two achieve β=3 I reuired the particular one s 16 that particular one we can considr over here. 1.22 x 10/0.763 then I am getting the 16 that I can find out over here.

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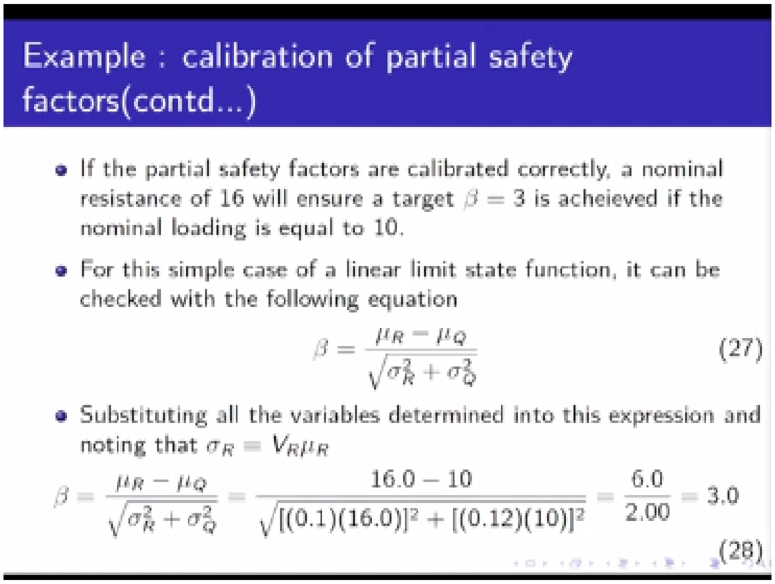

So even the partial safety factors are callibarted correctly, a normal resistance of 16 will ensure the target β=3 is cahieved if the nomianl loading is = 20. So that maens I can get the particular one here 16 and that one is 10 that we can find over here. So as I have shown you earlier β=μr-μq/ σr2 + σq2, so then we can find out from this β16, 10 0.1(16)2 so which I am getting it = 3.

So I can get the value of three that we can find out what ever the traget we have taken 16 and 10 we got it as it here. This is the one how do we calculate callibaration factor because I thought this is what I have to show then I can show the different in steate, that you say srevice limit state extreme limit satete there are different kinf living state. Each of them having there certain objective that we consider.

On the bsais of that we can find out. So coming to this one here one may say that one just to give you an idea that how it works with the calibray method and this is the simple one you can try these the same thing you can try with the other load cases, say for example that one I have shown you thes particular one here.

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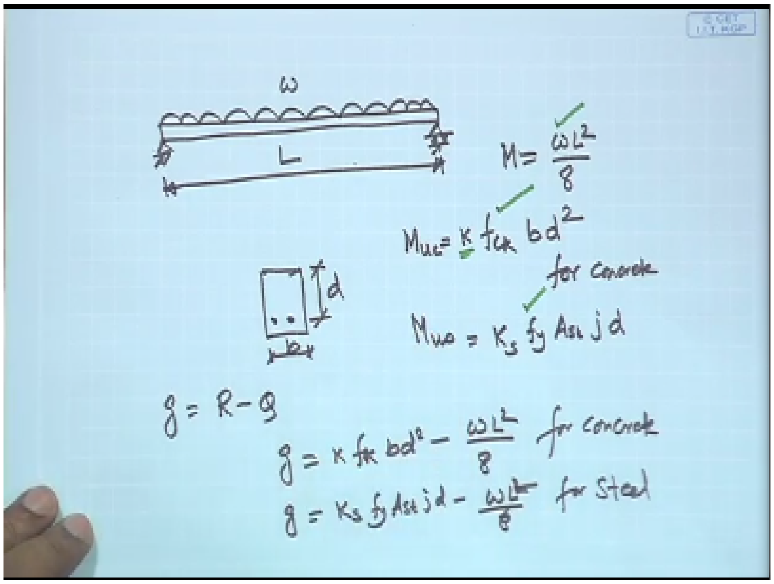

This is very intellegent intresting one from the we are talking from the desigh quetes from the interview for that is equally possible to make it for the health monitring then means thsat you having the particular structure for that and what the lability of the structure that also you can find out in that one .

In this case we will actually fore or method in this case what you are giving we are β=to 3 and you are trying to find the corresponding factor so that I can get that so the ablity is but in the other case when ever we are intrested the particular structure in the gone for the inspection the monitoring you have done they are finding the distuinsh of the stage of the quaslity .

And the other thing bending on the quality is the system we are calculating the βfollow are m,ethod that what ever the value we got it we say our the βis greater than 3 that means it is alright if the βis less than 3 then it is not alright then we will go for the β=to 2 β=to 4 that way you can find outin the changes in the loadside of that.

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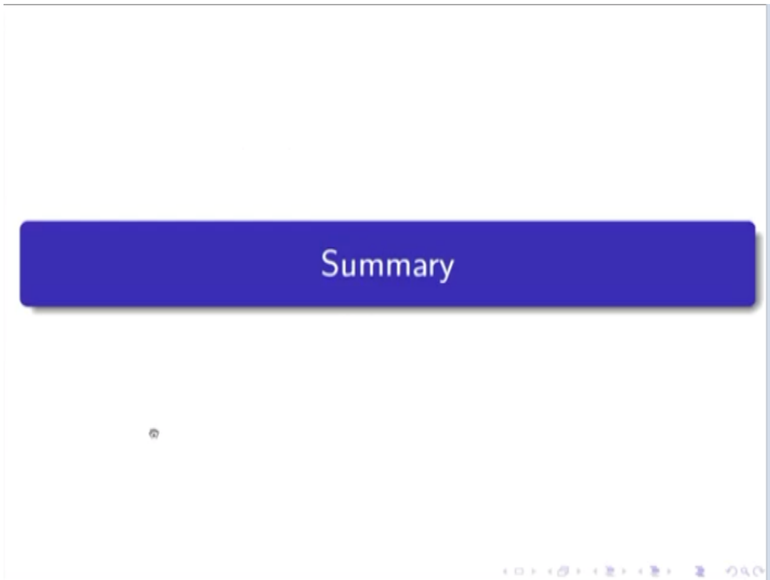

So this is the one I would like to say the the particularly here that would like to conclude that is one do so that particular one will be good one is the .

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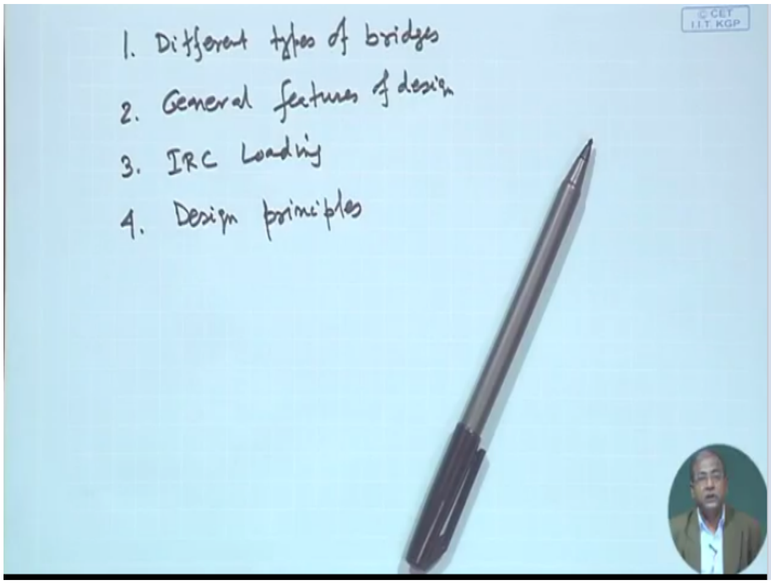

And this is different types of bridges then we are considering the particular lads we have say the general features of desighn number three I have seen the the loading the desighn code and the desighn pinslidwes and how could be it calbriate I have you told you the desighn pines that how to calbriate the parcel in the factor actually in the more important that one then we will find the different states again I like to say that the linit states that one we will do.

The desighn equally in the really seethat working states is nothing but the another kind of living state bbut it longally considering stress similarly we are having the state method of collapse method visiblity like that I can have in the kind of things and what else we do now in that in the next week that from 6 lecture number 6 on wards we shall concrate on that the desighn of complete elements and we can go through the different elements concious.

First of all you told the particular one the nothe only one method it is solved it by in the method then whats happen if we decide it by the living method let us say the high score then how I can see throuh it if you desigh as per IRC so that the new code then also what will happen different aspect consider and which we shall find out define aspects find out coming through these spectum here .

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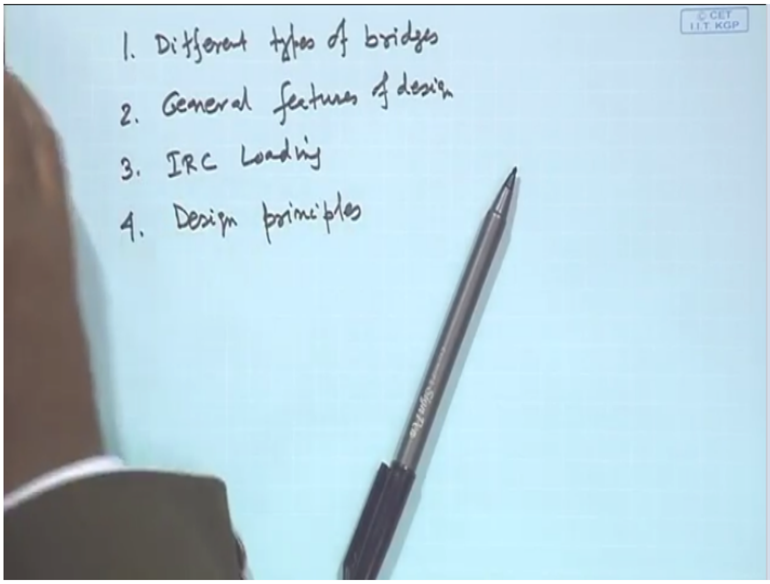

I have like to say that here the basic thing things of desigh codes are disussed here and in the whole week we have discussed types of bridges vand finally you an focused on the rein force concrete and the road bridges and that on and RCC T beam thank you very much.