Structural Reliability
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Lecture –186
Capacity Demand Component Reliability (Part 34)

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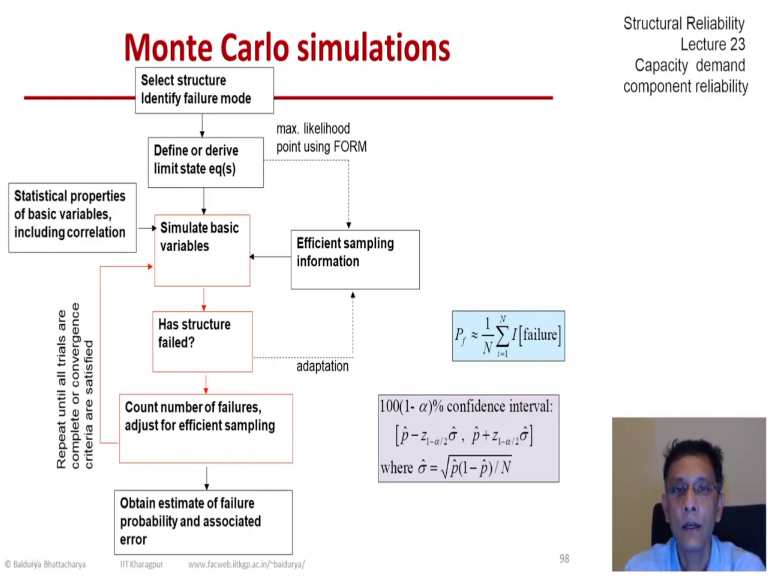

Now that we have a good random number generator that gives us an abundant supply of IID standard uniform deviates and we have the ability to transform them into any non-uniform deviate that we like we are in a position to solve structural reliability problems. So, here is the algorithm in broad terms. We select the structure identify the failure mode that's the top box that you see in this flowchart and then we define the limit states we have gone through these steps but putting these together once more.

We simulate the basic variables and then ask the question or verify has the structure failed obviously there would be could be hidden very detailed finite element analysis and which would take a lot of time in some cases. But once we do that we can count if failure has occurred or not and we can keep count of that and then repeat the loop that you see on the left with the red arrow and once we are out of the loop we can obtain estimates of failure probability.

On the left you see the need to input the statistical properties. So, that is something we need to keep in mind and then once we are done with all of this the estimated failure probability would be the average of these counts and if we are interested in confidence interval how much how many samples to run and so on. So, that answer could be obtained from the confidence interval or the coefficient of variation of the estimate.

You could have another side loop there where we could use efficient sampling information which is something we are going to look at in the next lecture. So, we could enhance this direct Monte Carlo or basic Monte Carlo, Brute Force Monte Carlo method by bringing in efficient sampling information which could be a biased sampling like important sampling which could be an adaptive sampling and so on.

In fact if you do all of that then that simple P f as the average of the eye would not work in most cases. So, we have to keep that in mind also and that is why you see in the last red block we have count number of failures adjust for efficient sampling. So, that is the reason that we have that qualifier. Now let us solve a couple of examples the first one would be the safe stopping problem that we solved earlier in this course.

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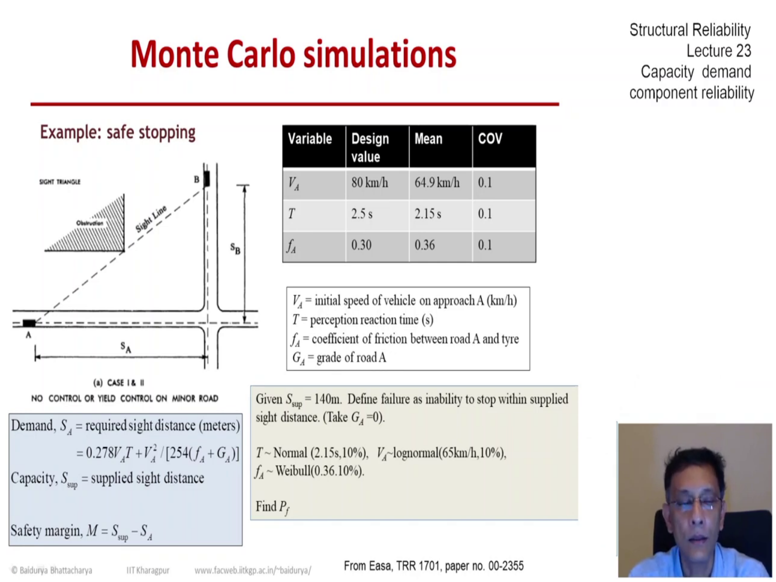

So, here is the problem statement we have a vehicle traveling at a certain speed on a road and it must be able to stop within the distance provided otherwise there is going to be collision. So, this is the demand and capacity description the demand is an empirical formula in terms of the speed the reaction time the friction coefficient the grade and so on. And the supply distance is what is given as part of the geometry of the of the road design.

The safety margin is a supplied minus s demand and here are the definitions of all these parameters some of these three of these actually will be treated as random variables in this exercise and here are the numerical values both the design values and the distribution parameters for the three random variables in question V A, T and f A. And now the question is given a particular value of the supplied side distance which is 140 meters what would be the probability of failure when failure is defined as inability to stop within that distance. The three random variables T is normal V A is log normal and f A is viable with the parameters defined in the table at the top.

So, let us solve this with multicolor simulations and the code is in the next slide and I am going to go line by line through that code.

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So, let us first define all the parameters of the problem. So, the supplied side distances in meters the mean of the speed the cov of the speed from which we get the lognormal parameters. We have to be careful in defining these and you will see that instead of using function calls in MATLAB or equivalent programming languages to call and directly get the desired random deviate in one step I prefer to write out and use the more basic commands.

Partly because this way we can take it to a new language which might not have that same function call for one and the other it is easier for the student to follow what is going on. So, we have to find these log normal parameters next we define the parameters for T. Next we define and then derive the viable parameters which we just go through these few commands to get the u and the k the shape and the scale parameters of the viable distribution.

So, now we are ready to start the loop. So, the count is the counter for number of failures we have one million Monte Carlo trials that is what we have set. So, we start the loop and. So, it is a FOR loop in MATLAB we run it from i equals 1 through nmct. So, we first generate the V A the speed which is a log normal random variable. So, we first generate the standard normal rand n and then scale that with sigma log and then add the mean log and exponentiate the whole thing that gives us a log normal V A.

Next we generate the normal T again with the random command and then we generate the variable f and there also we have used the inverse cdf approach. So, with all of these we are now able to compute the demand through that empirical formula and once we have the demand we can compare with the available side distance. So, there we have the; if block and if block make sure that failure has happened or not. So, if the demand exceeds the capacity the failure count is incremented by one.

So, that is the end of the; if loop and that is the end of the for loop and we can count we can estimate P f as the average of the indicator functions count divided by nmct. And the answer that we get from this exercise I run the code the estimated P f is about 0.0025 which is small enough probably and the cov of the estimate we can estimate that as the square root of 1 over NP and that turns out to be a very small number 2%. So, we should be able to accept this answer.