Structural Reliability
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Lecture –154
Capacity Demand Component Reliability (Part 02)

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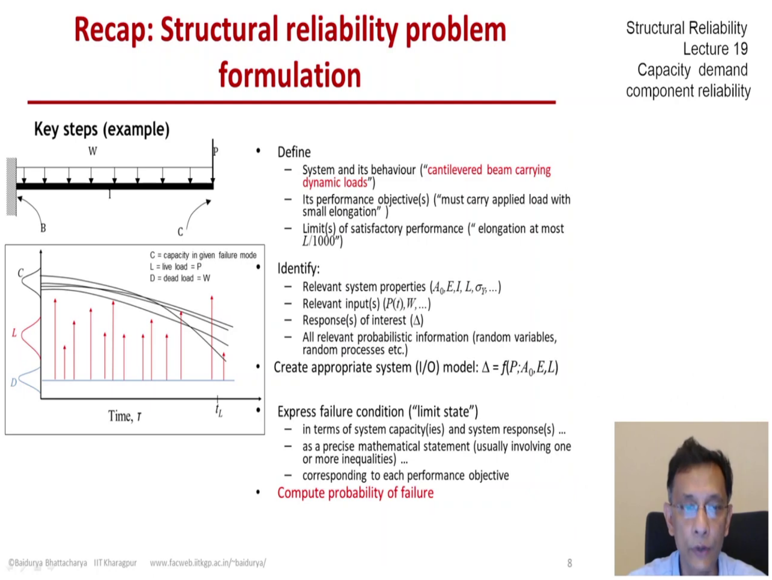

In part B we spent a good amount of time describing how to set up a reliability problem and a structured liability problem in particular. And we had presented a set of key steps and had shown where that formulation of the problem comes in. So, let us continue with that and try to show what we're going to not do now in this part how that fits in the overall scheme and how it advances those key steps.

So, what we started with was a system which we were able to define well we knew what it was supposed to do. We knew what the limit of satisfactory performance was for that system. We were able to identify all the relevant properties all the probabilistic information which is very important and thereby create an appropriate input output model between the response of interest and the system properties and inputs.

And then we expressed the failure condition which is what we spent a lot of time on being able to know what failure is how to convert that into a precise mathematical statement. So, that we can then solve the problem find out the reliability or the probability of failure. For doing that we would need the definition of the limit state which is a precise mathematical statement of the failure condition and together coupled with all the probabilistic information which would allow us to estimate the limit state probability.

So, let us look at some examples we instead of that cable which we had in the previous slide suppose we have a cantilevered beam. So, instead of saying that the tip deflection along the axial loading now we have a cantilevered beam carrying dynamic loads because P the tip load may be dynamic in nature in addition to the dead load which is time invariant. So, likewise here we have the system the beam should be able to carry the applied load with small elongation and we may decide to keep the limit the same as before the length divided by 1000.

So, now we need to identify the appropriate system properties which you see on the on the screen identify the relevant inputs the response of interest all the probabilistic information including the random process P the point load and then an appropriate system model and then have the failure condition the limit state and then we can compute the probability of failure. So, this part in the next few slides in the next few lectures we are going to focus on computing the probability of failure.

Once we have been able to identify the limit state and have gathered all the necessary probabilistic information. We could look at more and more complex problems but the essential feature remains the same.

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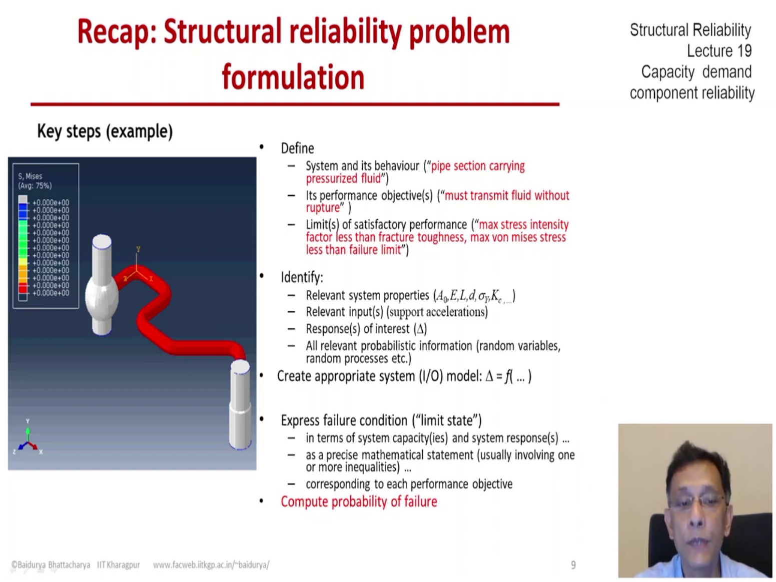

So, let us continue let us say instead of a cable in tension or a cantilever beam under transverse loads. Let us say we have a pipe section carrying pressurized fluid and the requirement is that this must transmit fluid without rupture. And then we may we should be able to bring in mechanics and define failure or define the satisfactory performance in terms of stress intensity factor von misses stress or any other appropriate quantity.

And then go through the process identify and quantify the relevant parameters the randomness associated and then have a precise definition of the limit state and then compute the reliability. Again these two points that I have marked with the arrow they are very important that would let us compute the probability of failure.

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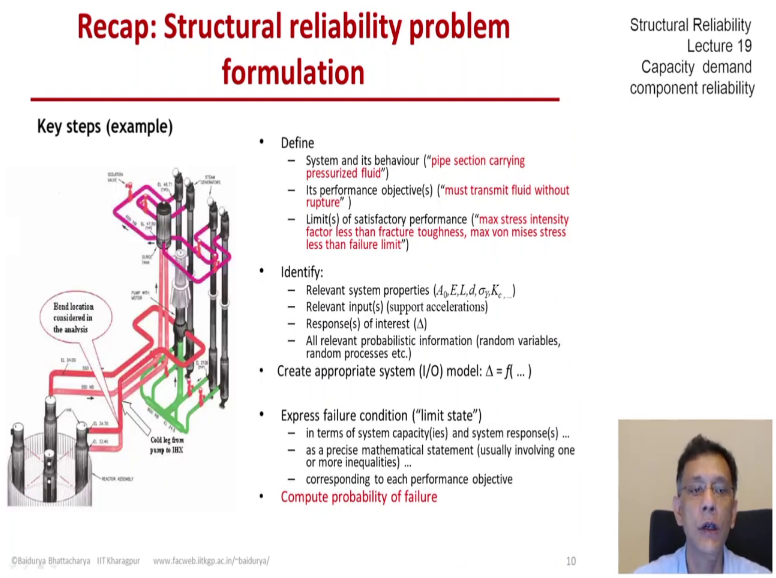

This pipe section could actually be part of a larger system which we need to analyze. So, now we are looking at a more complicated with more degrees of freedom system that we need to analyze which this pipe system could actually be part of a nuclear power plant containment structure.

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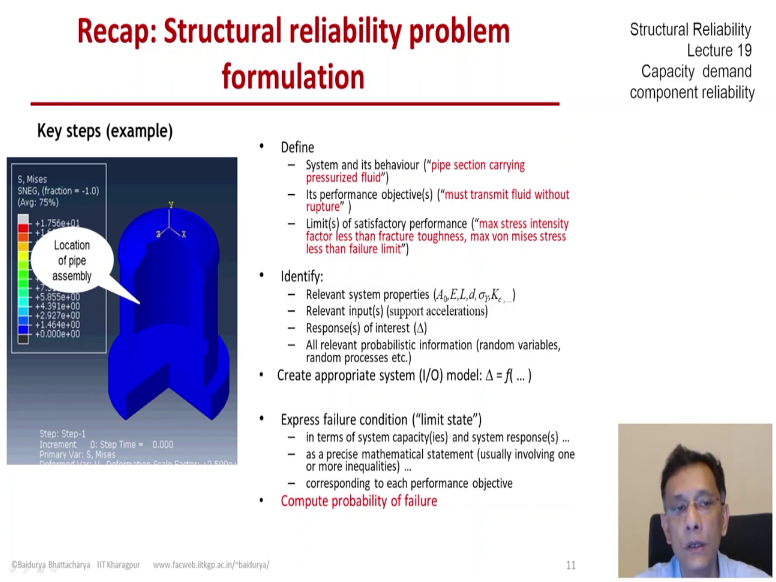

So, the base load due to seismic excitations transmits to the internal structures which is one example is the pipe assembly that we were talking about and the pipe section and then we do the analysis. So, for all such situations we start with a well-defined system. We identify very clearly what it is supposed to do have a mathematical statement of that requirement identify all the parameters that let me write the mechanics of the system.

Identify all the relevant random behaviour all the random variables stochastic processes. Then once I have all of that i can compute the probability of failure which of course is a demanding exercise but that would be the next logical key step in the process.

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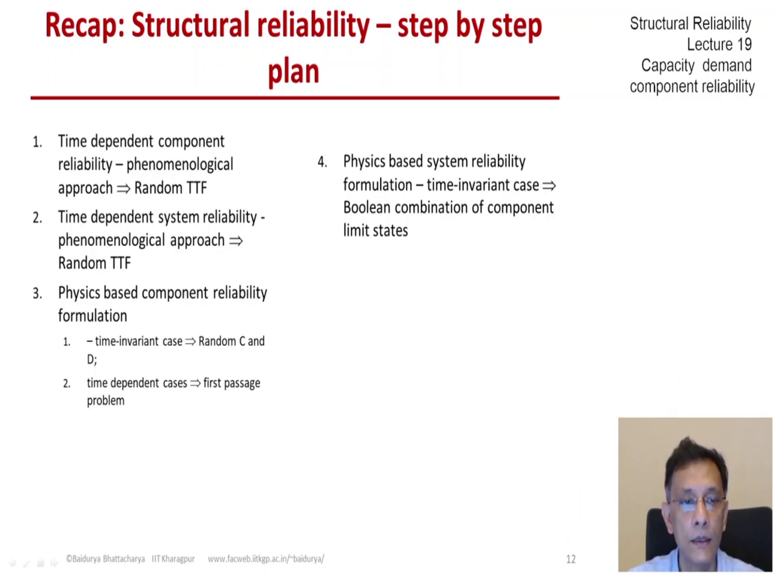

So, these are the four steps that we had discussed how we are going to approach the formulation and the computational reliability in part b this was presented. So, let us recap this we said there will be four distinct steps one was the time dependent component reliability which we have already finished that is a phenomenological approach giving me the random time to failure continuation of that into systems.

So, again the TTF based approach to system reliability without knowing the underlying failure mechanisms or the mechanics and then this is what we are starting now the physics-based component reliability formulation and we will look broadly into two types where the quantities are time invariant. So, the capacity and demand for example they are time invariant we will have one case there and then three more cases that come under the time dependent cases and we will approach that step by step at the end of part C.

We are going to look at the same physics based system reliability formulation. So, instead of element which is the subject of part 3 we are going to look at the system which would be the last thing to take up in this part C.

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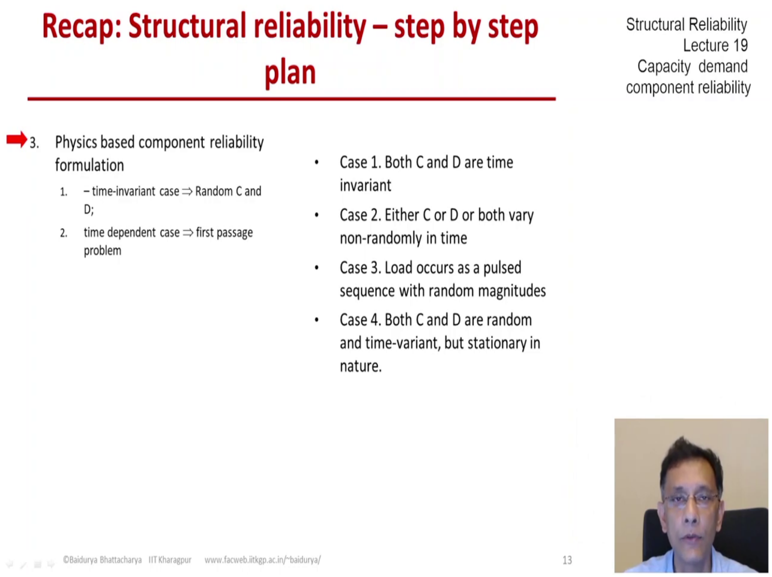

And to give more details to the third step that we are going to take up now is we are going to look at one case where both C and D are time invariant. As I said and then three cases where is time variance the first is the simplest the capacity or the demand of both varied non-randomly in time the third case is that loads are now random coming as a pulsed sequence with random magnitudes. And we will see different kinds of occurrence models.

And finally case 4 which is the most complicated the most advanced type is both C and D are random and time variant but in the language of stochastic processes they are stationary in nature. So, that is that is our plan for this part of the course.