Structural Reliability
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Lecture –91
Reliability Problem Formulation (Part - 03)

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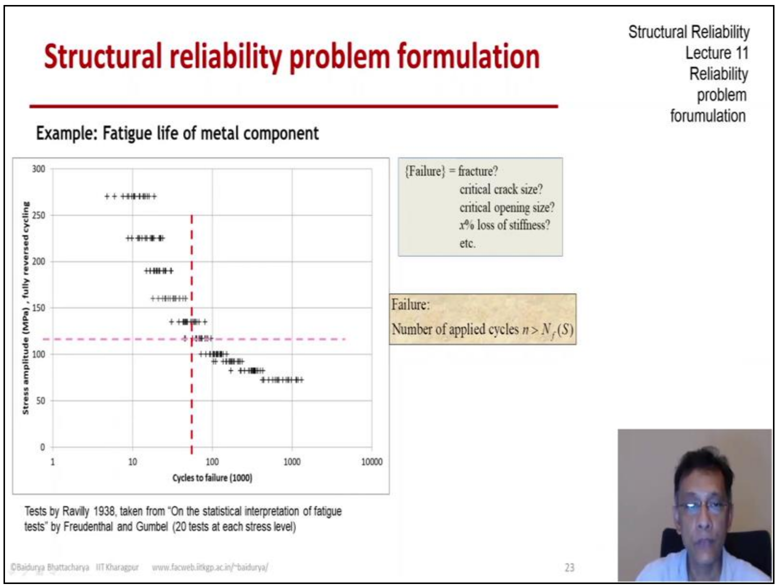

As the first example on how to set up a reliability problem let us take a look at these fatigue tests done way back in 1938. As I was saying yesterday that fatigue was one of the oldest problems studied in reliability. So, these tests were conducted on 20 samples each at each stress level and what you see here are 10 stress levels. So, those markings are the fatigue life of each component tested at the respective test levels.

So, if we were to use this approach or this set of results to set up a reliability problem our first step would be to define what we mean by failure. So, what would these cycles to failure as they are called what actual event do they correspond to do they correspond to fracture or do they correspond to a crack size that is being observed reaching a certain limiting size critical crack size could be 10% of the width could be 30% of the width or some other limit or a critical crack opening size or some specified loss in overall stiffness of the specimen like 10% loss 20% loss.

So, it would be essential to be able to define that condition for failure and then see the number of cycles that are needed to reach that condition. So, obviously the number of cycles at any given stress level to reach failure however it be defined is a random variable and we could define failure as the number of applied cycles small n it exceeds the number of failure cycles at that stress level.

So, for example if we decide to cycle at the amplitude of say 120 mega Pascal roughly then if I were to apply about 75000 cycles it would seem from the data that roughly about 2 or so out of those 20 have failed. So, I could start estimating my failure with that sort of test data. If I want my formulation to be independent of the stress level then I should be able to parameterize my failure condition which with the stress level S.

I could also look at it differently if I had the ability to observe the crack size with increasing number of cycles.

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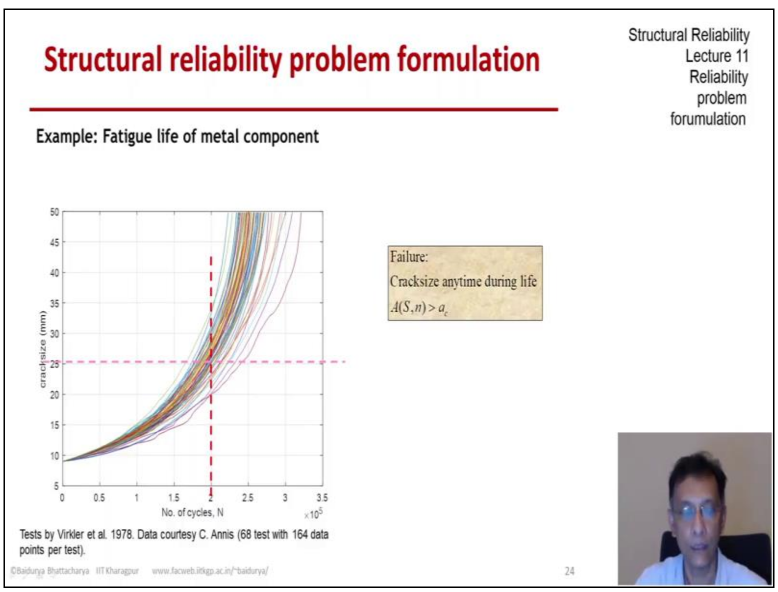

And the next slide shows exactly that sort of tests. So, these are a very famous set of fatigue tests done on aluminum by Verkler et al in the 1970s. So, these were 68 tests done 68 samples and for each specimen 164 data points were taken at pre-specified crack lengths. So this shows the growth of crack size with increasing fatigue cycling. So, I could now define failure as the exceedance of a critical crack size a critical a c.

So, if I knew what the crack size distribution is at a given stress level or given loading spectrum for a given number of cycles I would be able to find out whether failure has occurred or not and what would be the probability of failure and so on. So, for example if my critical crack size is something like say 25 millimeters then I can looking at this I can get an idea about the distribution of the number of cycles required to reach that particular crack size just by looking at those data points at which that red line intersects all those curves.

I could also say that I would have 200000 cycles and it would seem that if that was the number of cycles I was required to perform then it would seem from this data set that almost about half of the of the specimens would have a crack size greater than 25 millimeter by the time 200000 cycles were undertaken. So, this would be the other way of defining failure provided I had the requisite information in hand.