Structural Health Monitoring (SHM)

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Lecture – 15
Level of uncertainties in Structural Health Monitoring process – Part 1

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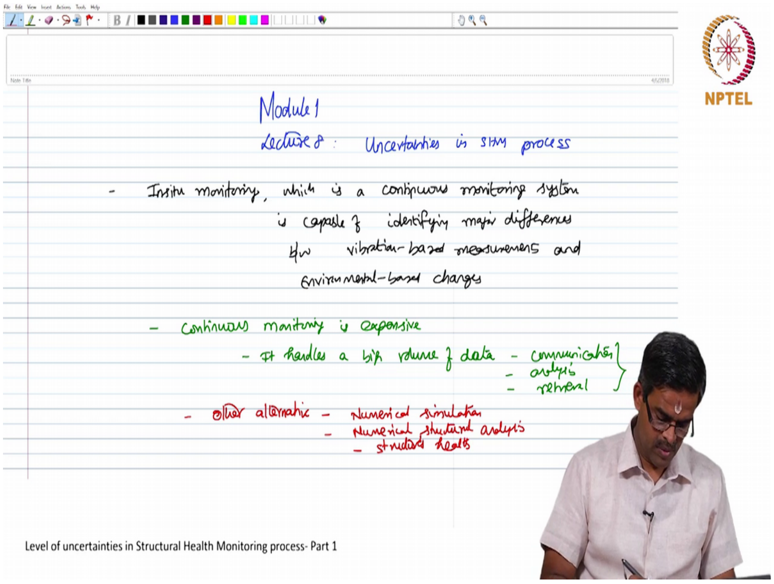

Friends welcome to the 8th lecture in module 1. In this lecture we will talk about the Level of uncertainties involved in Structural Health Monitoring process. We have already seen that insitu monitoring, which is a continuous monitoring system is capable of identifying major differences between vibration based measurements and environmental based changes. Because this is one of the important source of complexities, which actually confuses the data obtained from the sensors to really work into the application of the measured data towards assessment or control design from the system schemes.

But we also know that continuous monitoring is expensive and it handles a big volume of data. So, the data communication, data analysis and retrieval can be a sort of challenge in terms of it is volume. Then certain researchers have also suggested the other alternative for this problem. One of the important alternative to handle the above problem is that, one can go for numerical simulation. So, numerical structural analysis is also used to predict the structures health.

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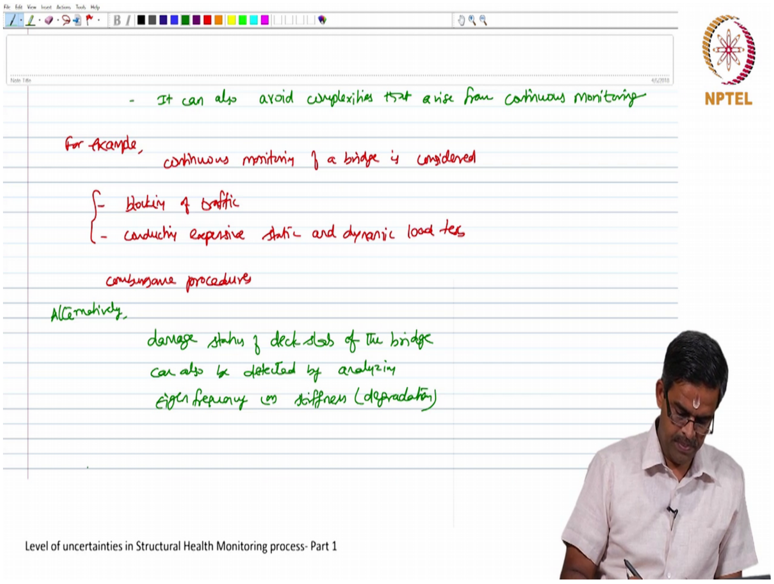

It can also avoid complexities that arise from continuous monitoring. Let us take an example and analyze this, let us say for example, continuous monitoring of a bridge is considered. It may involve lot of complexities for example, blocking of traffic, conducting expensive static and dynamic load test, which are essentially cumbersome procedures.

Alternatively, the damage status of the deck slab of the bridge can also be detected by analyzing Eigen frequency or stiffness, I should say stiffener degradation.

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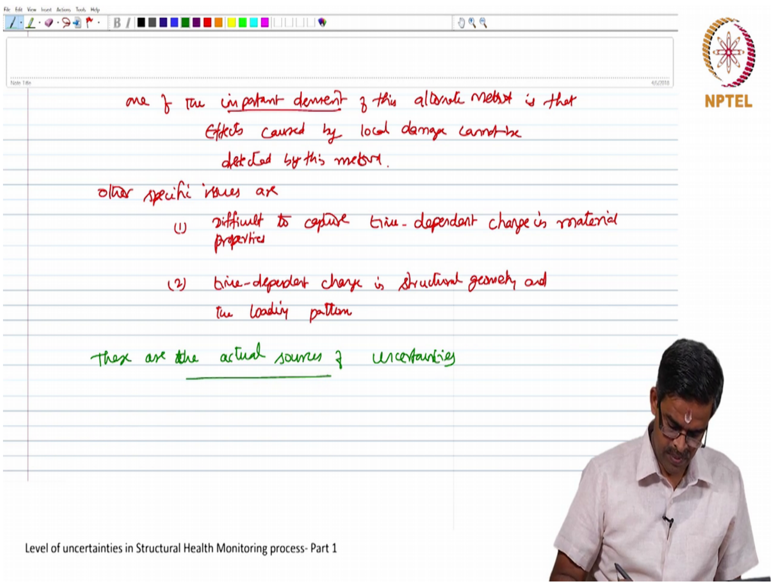

One of the important demerit of this alternate method is that, the effects caused by local damage cannot be predicted in fact, cannot be detected by this method. There are other specific issues there is one of the major demerit the other specific issues are, it is difficult to capture the time dependent change in material properties, it is also difficult to capture the time dependent change in structural form and the loading pattern. So, interestingly these are the actual sources uncertainties.

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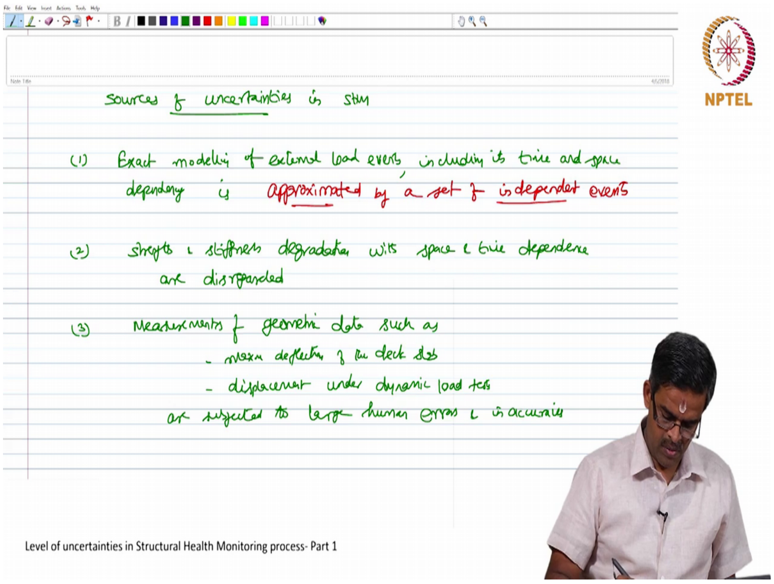

Now, let us see what are the sources of uncertainties in detail when you do health monitoring; one the exact modeling of external load events, including it is time dependency and space dependency is generally approximated by a set of independent events so, that is the first uncertainty we have.

The second one is strength and stiffness degradation with space and time dependence are disregarded, the third issue is measurement of geometric data such as maximum deflection of the deck slab for example, in the case of a bridge then displacement under dynamic load test or subjected to lot of human errors and inaccuracies.

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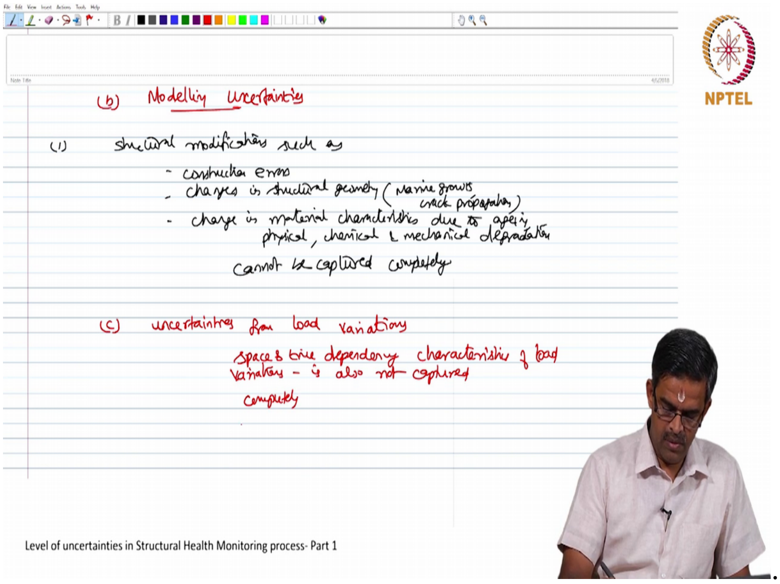

Further there can be uncertainties even in modeling, the structural modeling which indicates the modifications such as construction errors changes in structural geometry for example, let us say the marine growth, crack propagation etcetera, change it change in material characteristics due to aging physical, chemical and mechanical degradations, which we saw in the last lecture cannot be captured completely that is the first modeling uncertainty we have.

It can also arise some uncertainties from load variations, where the load can also vary depending upon the space and time dependency not captured completely, then what is the solution.

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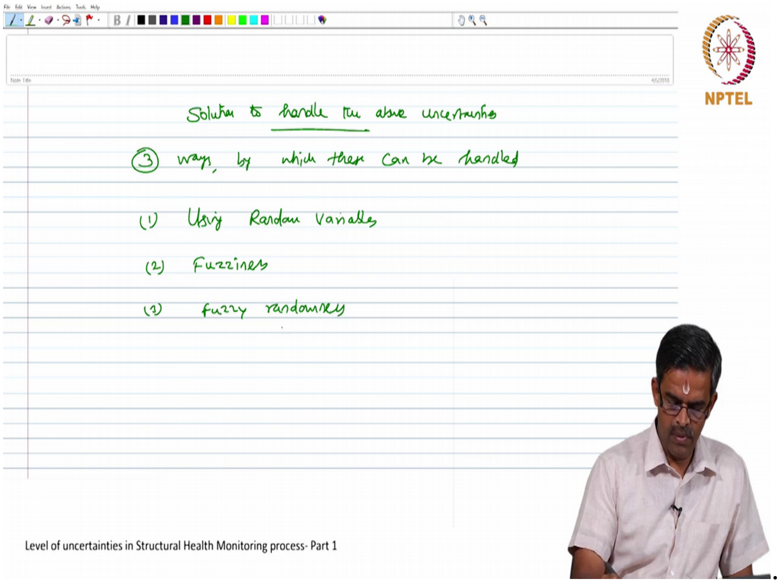

Solution to handle the above uncertainties there are 3 ways by which this can be done one using random variables, to using fuzziness and 3 using fussy randomness. Now, let us talk about randomness.

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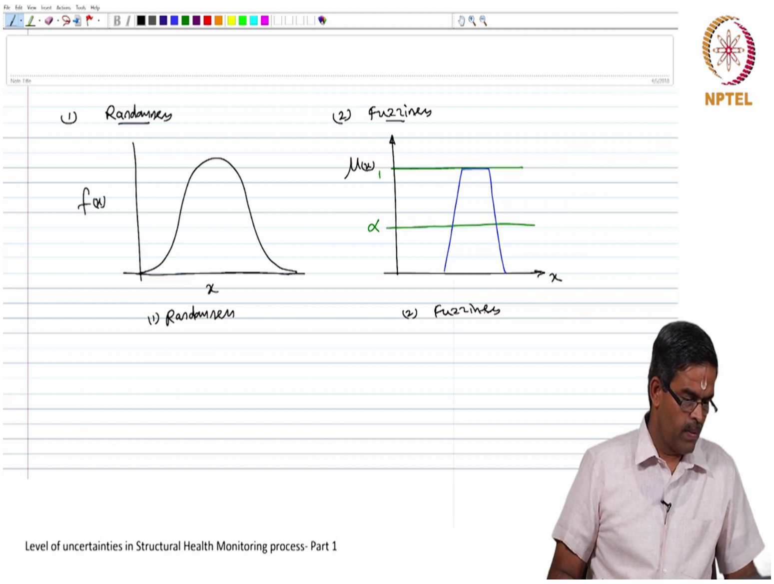

The data can be plotted as a typical power spectral density function they are considering a probability distribution function and the randomness can be expressed as a PDF function.

The second way of doing it is using fuzziness, which can be done by reporting the data using a fuzzy logic algorithm, which can have a variation as alpha and unity and the variation can be modeled typically I shown the screen. So, this is what we say as modeling using fuzziness. The third one is a combination of these two.

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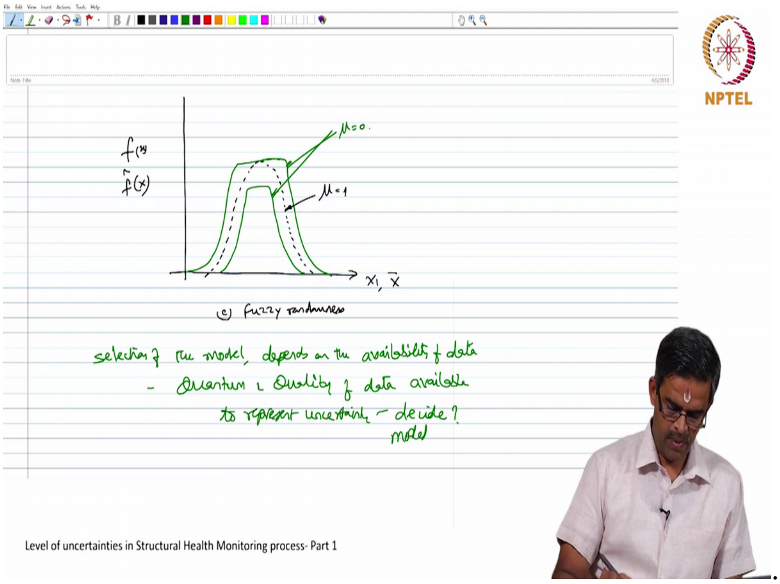

Which can handle fizzy randomness which I say X 1 and X bar and typically f of x and f tilde x, for a specific band fuzziness operator and randomness is chosen within the band. So, I should say that this process has mu equals 1 and these 2 has mu has 0.

So, this is what we say as fuzzy randomness interestingly friends selection of the model amongst the 3 depends on the availability of data, because these distributions and these models are very strongly data dependent. So, what is the quantum of data and quality of data available to represent uncertainty so, this will decide what model we should select.

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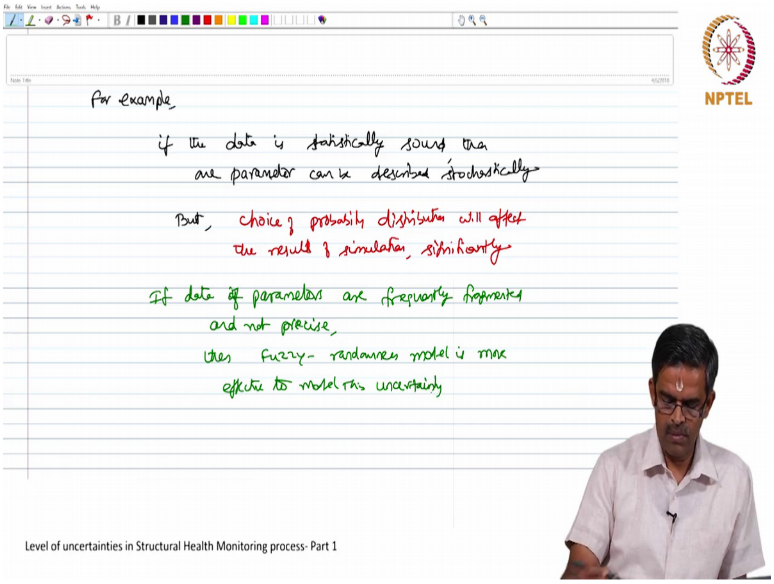

For example, if the data is statistically sound then one parameter can be described stochastically, but even in that case appropriate choice of probability distribution will actually affect the results of simulation significantly.

On the other hand if data of parameters are frequently fragmented and they are not continuously distributed and they are not precise, let us say you have a doubt on their precision itself, then fuzzy randomness model is more defective to model this uncertainty.