Structural Health Monitoring (SHM)
Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Lecture – 14
Structural Health Monitoring issues applied to concrete structures – Part 2

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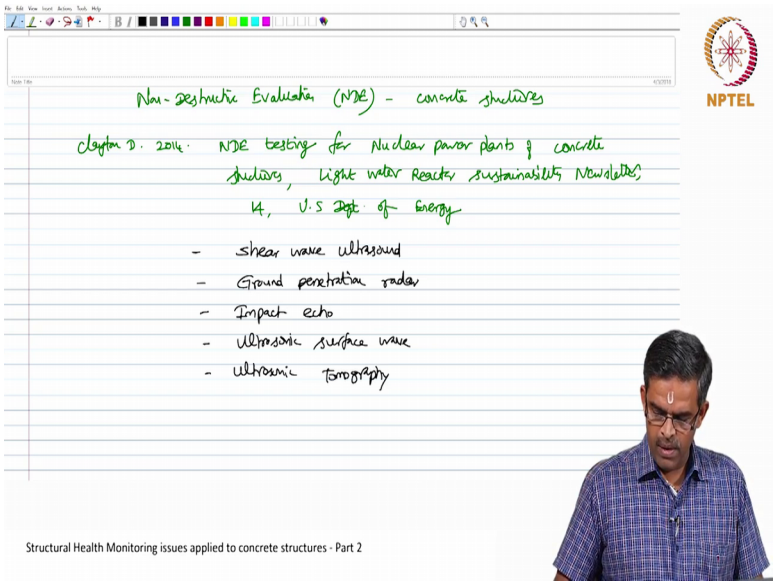

Interestingly, there are many Non-Destructive Evaluation methods, which are exclusive for concrete structures, which can reasonably give you a good health condition of the concrete structures.

So, as referred by Clayton in 2014, nuclear power plants construction members made out of concrete structures has specific problems and they can be addressed using specific non-destructive evaluation methods as discussed in light water reactor sustainability newsletter, 14 US Department of Energy.

Some of the NDE methods as suggested by Clayton are shear wave ultrasound, ground penetration radar, impact echo analysis, ultrasonic surface wave analysis and ultrasonic tomography.

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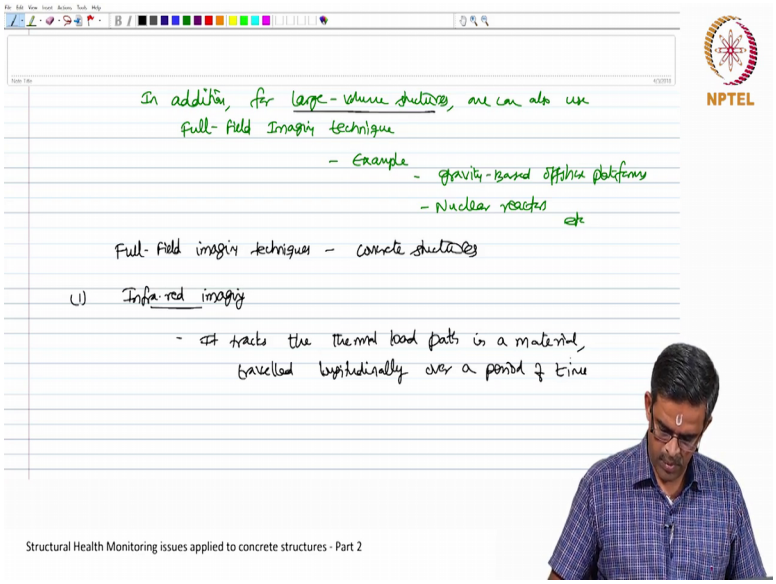

In addition, for large volume structures, one can also use full-field imaging technique. Example can be gravity based platforms offshore platforms, nuclear reactors etcetera.

Let us now talk about a few full-field imaging techniques useful for concrete structures, which essentially can be applicable to large volume structures. The first one is infrared imaging. Actually infrared imaging technique tracks the thermal load path in a material traveled longitudinally over a period of time.

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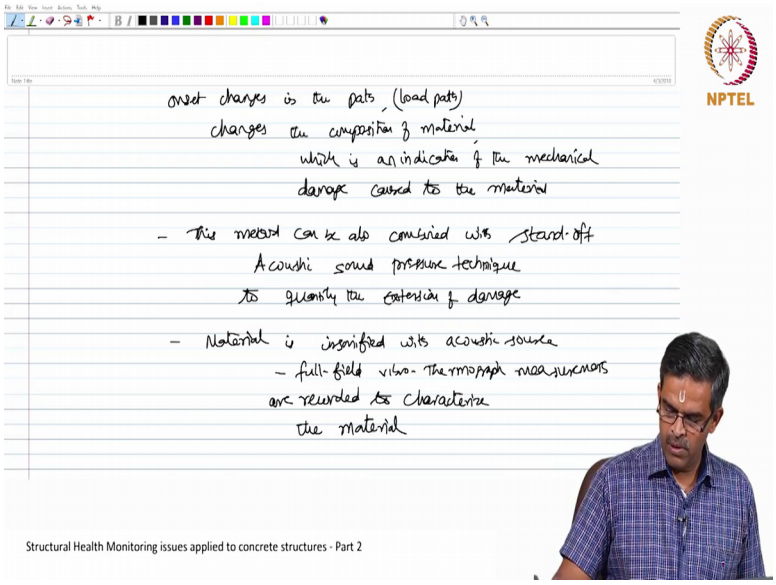

The onset changes in the path, I should say the load path changes the composition of the material, which is an indication of the mechanical damage caused to the material.

This method can be also combined with acoustic source or standoff acoustic sound pressure technique to quantify the extension of damage. In this case material is insonified with acoustic source and the full-field vibro thermograph measurements are recorded to characterize the material.

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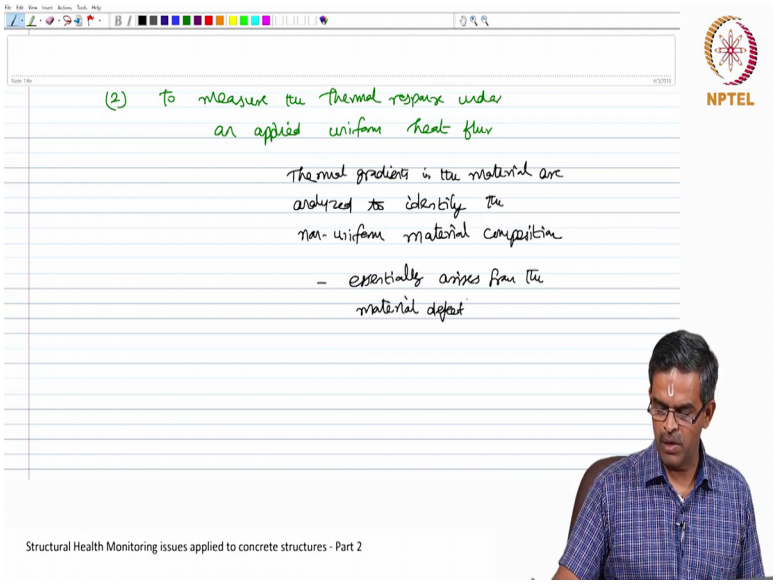

The second method could be to measure the thermal response under an applied uniform heat flux. Thermal gradients in material are measured and analyzed to identify the non-uniform material composition.

The non uniform composition, essentially arise from the material defect which can be then characterized. There is another source or method which can be useful in large volume concrete structures.

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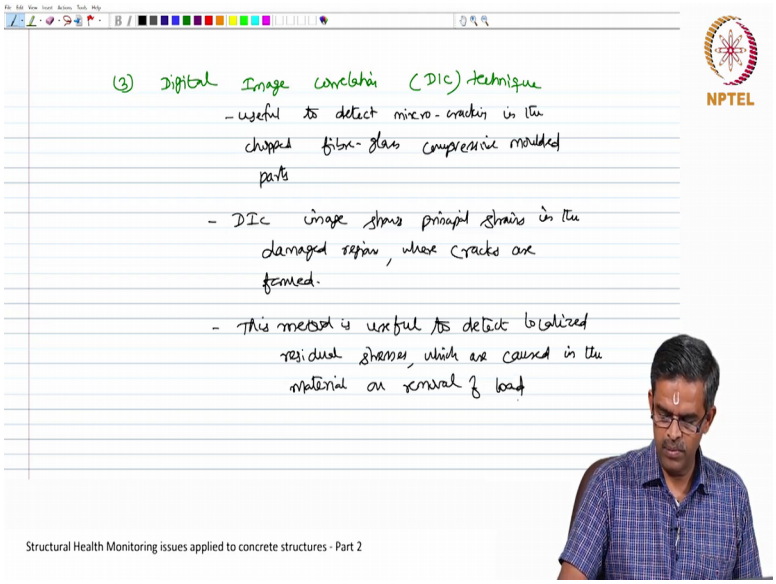

The third method applicable successfully to concrete structures is digital image correlation DIC technique. This is useful to detect micro cracking in the chopped let us say fiberglass compressive molded parts.

DIC image shows principle strains in the damaged regions, where cracks are formed. This method is useful to detect localized residual stresses which are cost in the material on removal of load.

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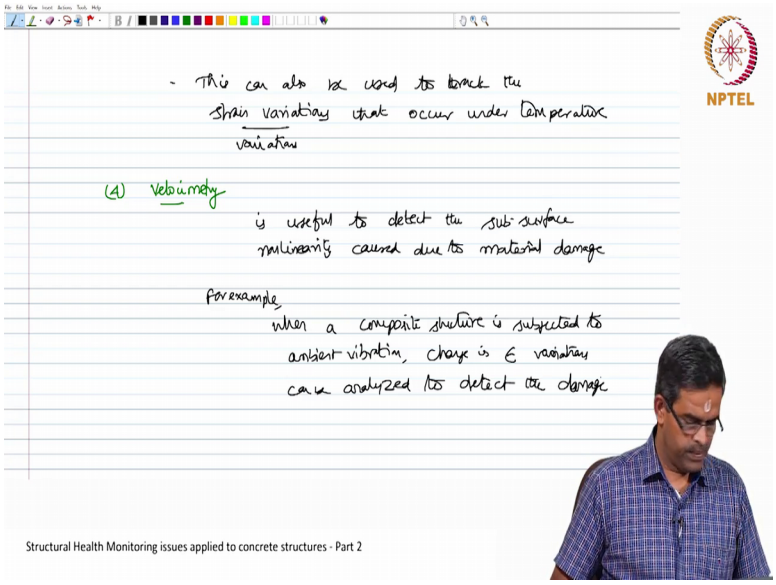

This can also be used to track the strain variations that occur under temperature variations.

The fourth method is velocimetry, which can be useful to detect the subsurface non-linearity caused due to material damage. For example, when a composite structure is subjected to ambient, changes in strain variations can be analyzed to detect the damage.

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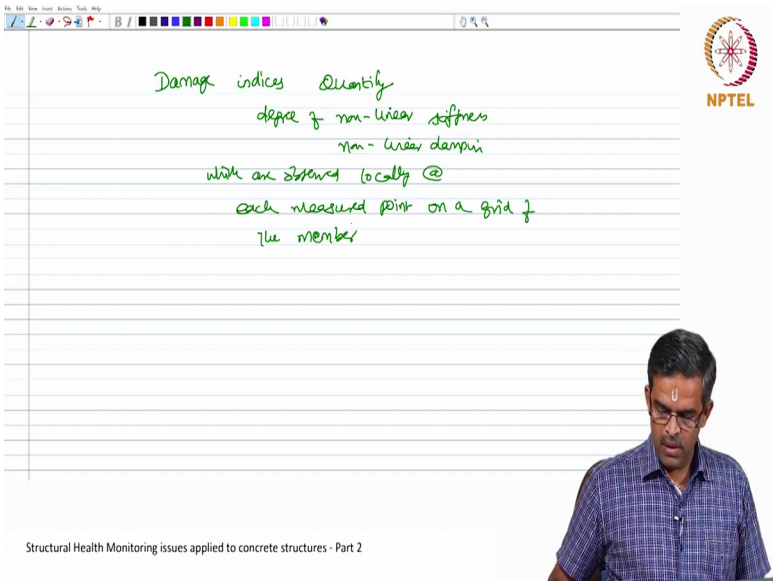

In such cases the damage indices quantify, the degree of non-linear stiffness, the non-linear damping which is observed or which are generally observed locally at each measured point on a grid of the member.

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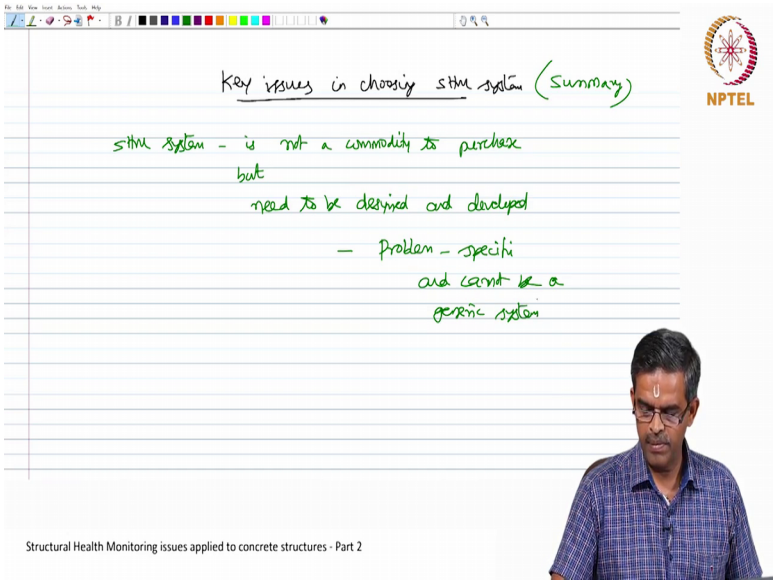

Therefore friends let us quickly summarize what would be the key issues in choosing the structural health monitoring system in general. So, structural health monitoring system this is a summary we are discussing is actually not a commodity to purchase, but need to be designed and developed.

The most important issue is a structural health monitoring system is problem specific and cannot be a generic system.

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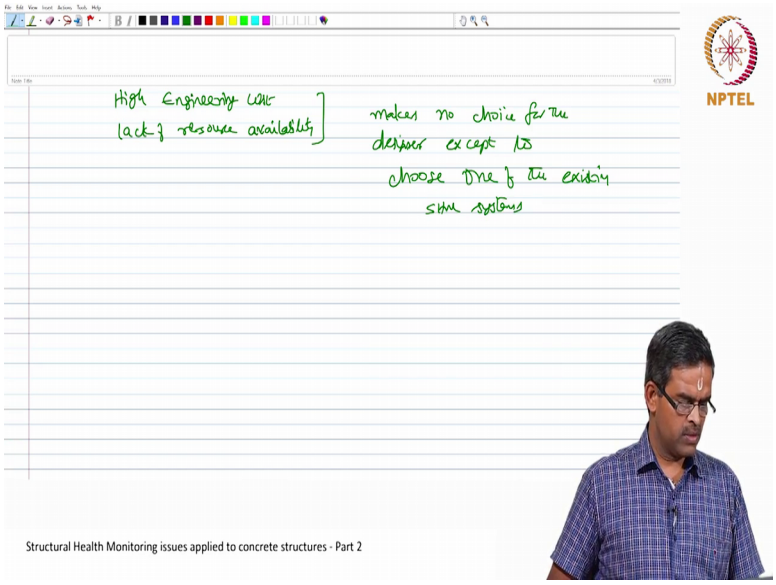

High engineering cost, lack of resource availability actually makes no choice for the designer except to choose one of the existing health monitoring schemes or systems.

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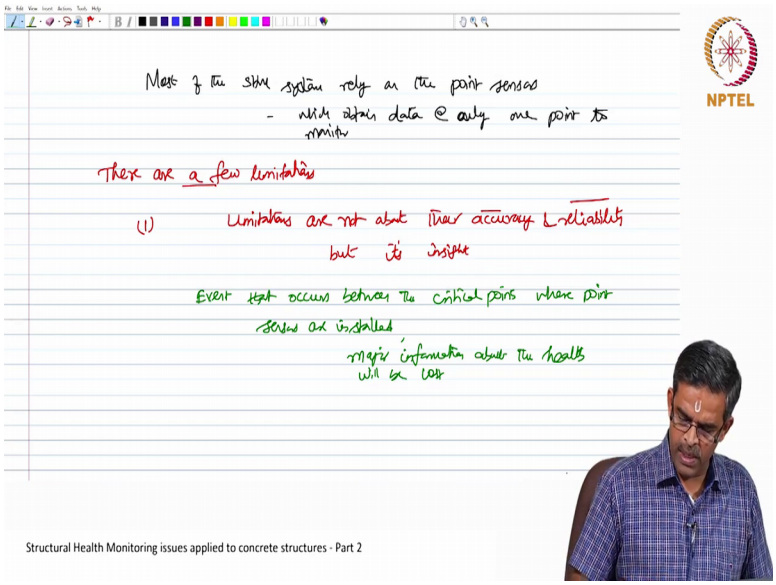

Unfortunately, most of the SHM system rely on the point sensors. Point sensors are one which obtained data at only one point to monitor. They have some limitations. One: limitations are not about their accuracy and reliability. Please understand, point sensors are very perfect scientifically advanced and highly ultramodern.

So, they are very accurate and they are very highly reliable. So, there is no doubt there are no limitations about their accuracy in reliability of the point sensors, but the limitation is its insight.

Very importantly, when there is an event that occurs between the critical points where point sensors are installed major information about the structural health will be lost.

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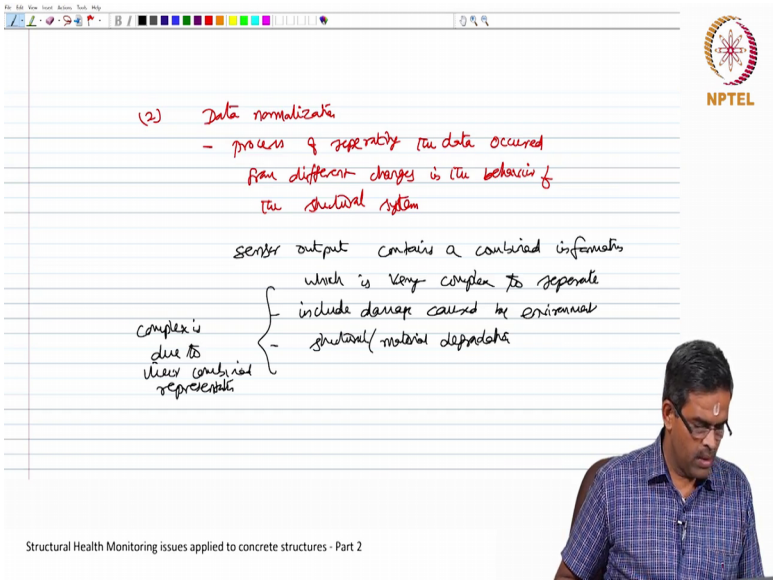

The next issue could be data normalization, that is, the process of separating the data occurred from different changes in the behavior of the system or behavior of the structural system.

Because, the sensor output contains a combined information which is very complex to separate because they will include damage caused by the environment they will include damage caused by the structural or material degradation. When all of them are combined together it makes it very complex, they are combined representation.

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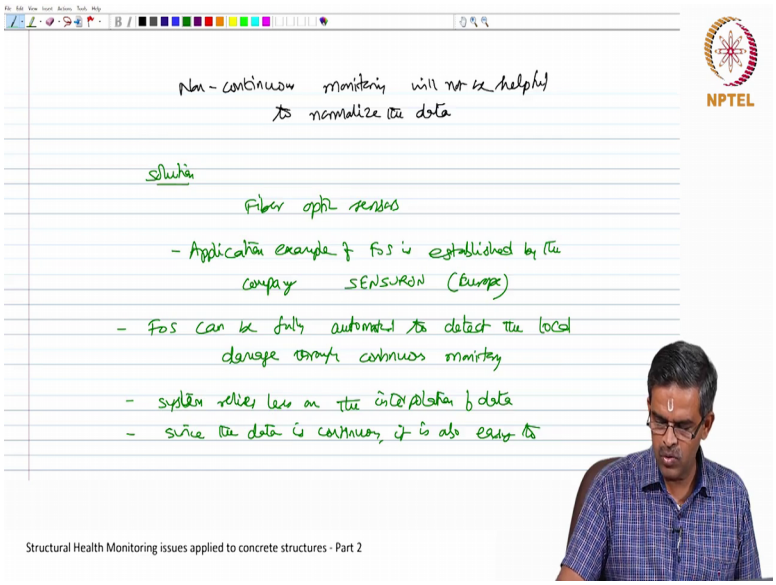

Therefore, non-continuous monitoring will not be helpful to normalize the data. Then what is the solution? The solution could be one can use fiber optic sensors. One of the application example of fiber optic sensors is established by the company SENSORON in Europe. Advantages are FOS can be fully automated to detect the local damage through continuous monitoring.

Therefore, the system relies less on the interpolation of data.

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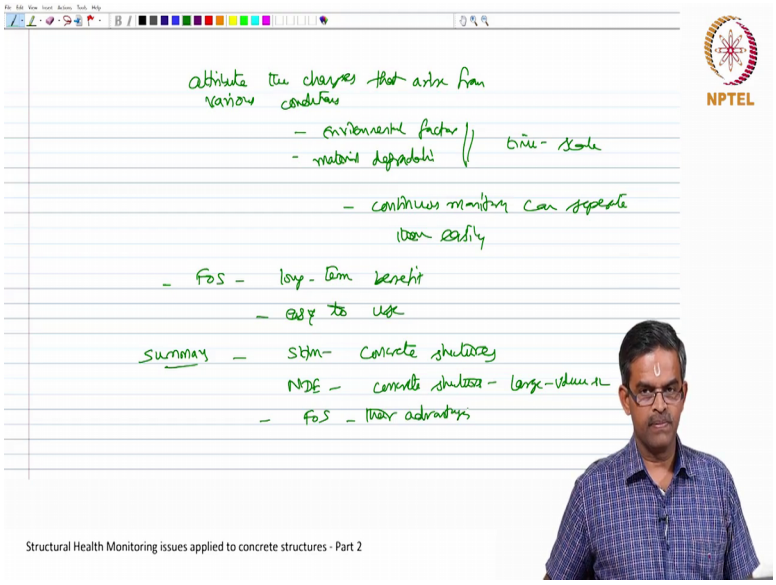

Since the data is continuous it is also easy to attribute the changes that arise from various conditions like environmental factors, material degradation etcetera, because all of them have a different time scale and when the monitoring is continuous can separate them very easily.

So, therefore, use of fiber optic sensors have long term benefit and they are very easy to use. In the case study next module, I will show an example how fiber optic sensors can be useful in detecting the damage in concrete structures.

So, friends, in this lecture we discussed about the application issues of SHM on concrete structures. We have also seen different NDE methods, which can be used for concrete structures and large volume structures; we have also seen a brief introduction about use of fiber optic sensors and their advantages in structural health monitoring.

Thank you very much.