Structural Health Monitoring (SHM)
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Lecture - 05
Components of Structural Health Monitoring - Part 1

Friends, welcome to the third lecture in module 1 on the course on Structural Health Monitoring.

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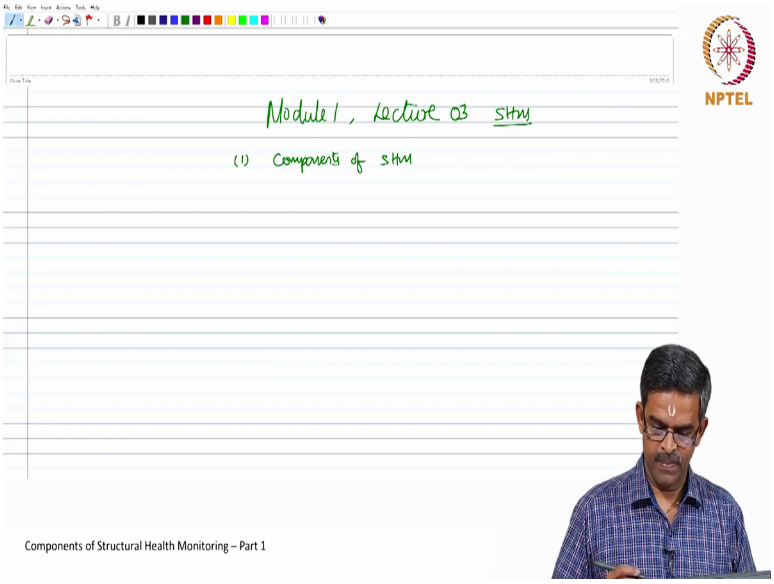

In this lecture we will discuss some of the details about components of structural health monitoring and a few challenges faced by SHM process as applied to various industries.

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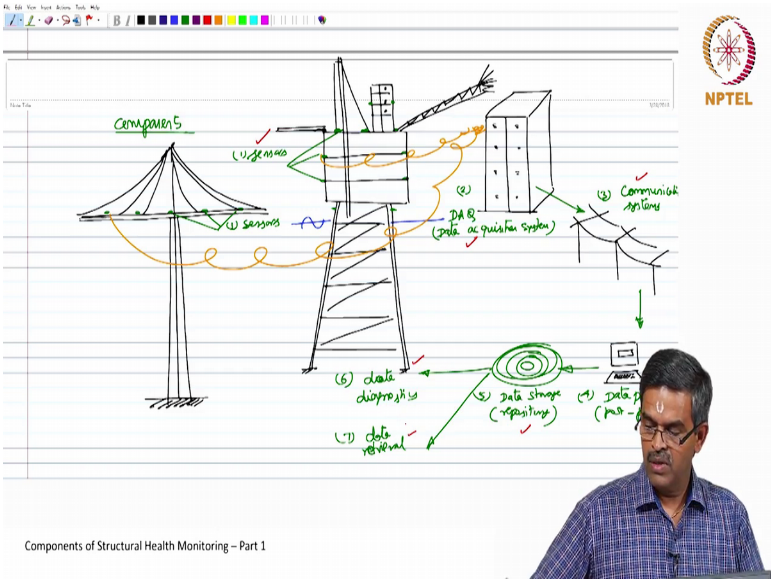

When we talk about the components as we said structural health monitoring deals with continuous monitoring, assessment and then control algorithms to be in place for establishing a satisfactory performance level of a given structural system or any infrastructure.

Considering this as one of the important ideas and objectives of health monitoring, let us say what are the components involved. Let us say I am interested in looking at the health monitoring of a bridge, which will be found at riverbed. There will be varieties of sensors placed on the deck of the bridge. So, all these are the first level components of the health monitoring system which are sensors.

In the parallel, we can also think about in offshore structure, we just got multi tire deck, which has the drilling derrick through a moon pool, which also has living quarters, which has a flair boom, which also has an helipad etcetera. Supported on the template structure, which is founded to the seabed as shown in the figure here, let us say this is my water level. There may be sensors placed on the deck, placed on the living quarters, placed on the deck at various levels and sensors can be also placed above water on the temperate system. So, these are all again a different varieties of sensors, which are the first level components of health monitoring system.

Now, all these sensors need to be connected, let us say to a data access system. So, they will be connected to the data acquisition system which is called DAQ, which is data acquisition system. From there using communication systems, they will be transferred for data processing.

So, the third component in the health modelling system is the communication systems which will collect the data for post-processing, we call this component is the fourth level component, which is data processing, which otherwise commonly known as post processing. Once the data is post processed then the data need to be stored. So, that is the fifth stage which we call as data storage which is otherwise called data repository from there it will again go back to 2 different places, one will be the data diagnosis and the other will be data retrieval.

So, friends this layout of picture showed on the screen includes various components which are involved in a complete health monitoring system used for infrastructure engineering starting from sensors, data accumulated and collected on a data acquisition system, transferred through communication system to data processing, then data repository, then data diagnostics and data retrieval for further data analysis.

So, if you look at the whole layout of the health monitoring system, we can component-wise divide them as seen in the figure just now.

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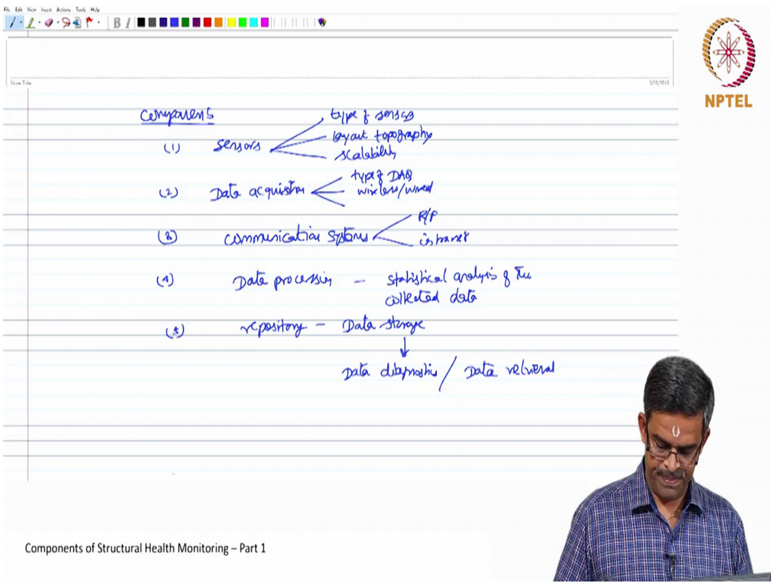

So, the vital components can be the sensors this again have different varieties of sensors like layout of topography, scalability etcetera.

The second level is data acquisition, which essentially depends upon the type of DAQ being used whether it is going to handle wireless or wired sensors etcetera. The third could be the communication system, which can be using either frequency or using intranet etcetera.

Fourth could be the data processing, which will be dealing with the statistical analysis of the collected data, which is then deposited in a repository, which we call as data storage, which also require data diagnostics and data retrieval.

We will start looking into the details more as we proceed further in the coming lectures, we will also understand the application complexities of these kinds of components on various industries like aviation industry, civil infrastructure industry, mechanical industry, oil and gas and petroleum industries by see giving some illustrated examples both on lab scale as well as on real time scale.

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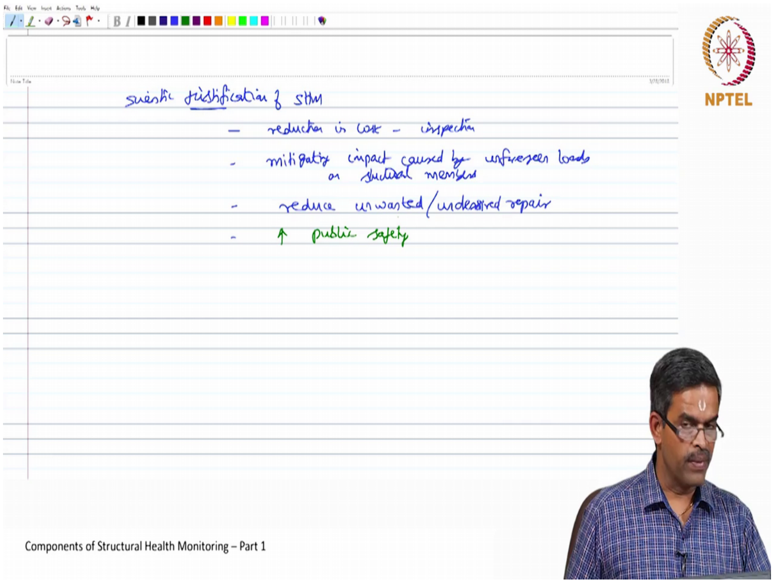

In the last lecture we discussed about the scientific justification of health monitoring, what are the salient advantages of health monitoring on a continuous system? We said that it has got various major advantages like reduction in cost related to inspection, it is capable of mitigating the impact caused by unforeseen loads on structural members. It can also has a capacity to reduce unwanted and undesired repairs, which may arise from a continuous and schematic repair or maintenance processes and overall it can enhance public safety.

Let us now take an example and see, what are the challenges.

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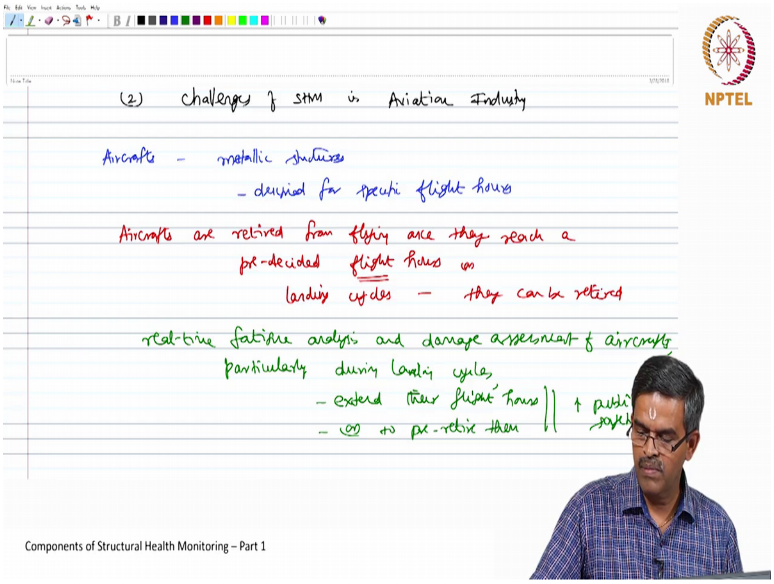

Exclusively we have when SHM is being applied to various industries, we start with aviation industry. Interestingly friends, in aviation industry the vital component of measuring the responses will be on the aircrafts. Aircrafts essentially are metallic structures, which are designed for specific flight hours. Generally, aircrafts are retired from flying once they reach a pre decided flight hours. So, every aircraft is meant to fly for a specific flight hours, once those number of flight hours are completed, those aircrafts are considered to be retired from flying at all. Alternatively if they complete pre decided landing cycles, then also they can be critical.

However, if you really do some real time fatigue analysis and damage assessment of aircrafts, especially during landing cycles, then it is possible to extend the flight hours or to pre retire them both of them improving public safety.

So, what are the various tools by which this can be achieved?

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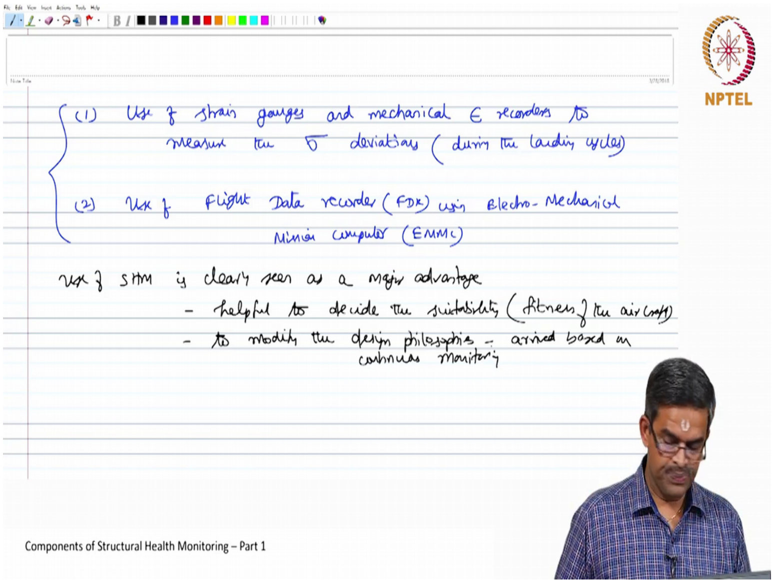

One of the methods by which this achieved is use of strain gauges and mechanical strain recorders to measure the stress deviations particularly during the landing cycles. Second application could be use of flight data recorder, using electromechanical mission computer that is EMMC. Both of them are very useful in estimating the life of an aircraft and it is fitness for n number of flight hours in the future.

So, in both cases use of SHM is clearly seen as a major advantage. This can be helpful to design the suitability or I should say fitness of the aircraft. It is also helpful to modify the design philosophies, which essentially arrived based on continuous monitoring.

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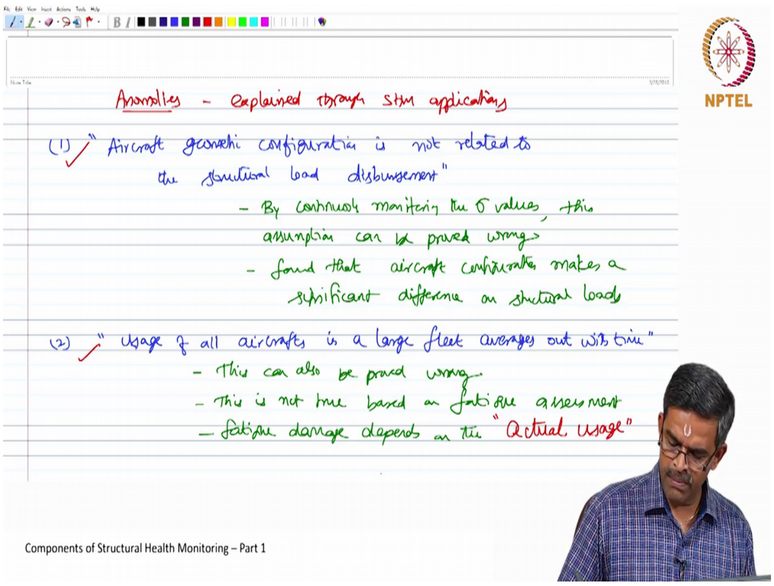

There are some anomalies which can be very well explained if through SHM applications if they are in practice, let see what are they. One there is a statement which is believed in aircraft design stating that, aircraft geometric configuration is not related to the structural load disbursement. By continuous monitoring the stress values, this assumption can be proved wrong. It is found that aircraft geometry or aircraft configuration makes a significant difference on structural loads.

The second could be again the next anomaly saying that usage of all aircrafts in a large fleet averages out with time. This can also be proved to be wrong based on continuous monitoring; because this is not true based on the fatigue damage depends on the actual usage and hence cannot be averaged for a large fleet.

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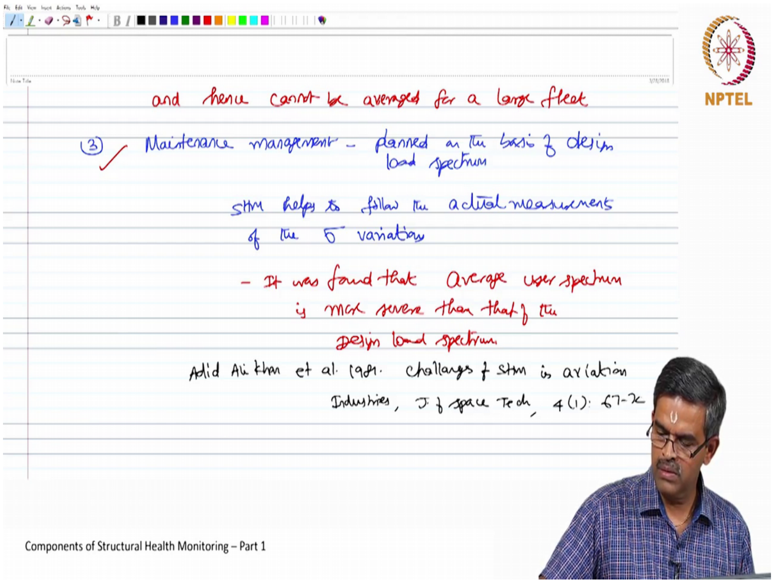

The third anomaly could be based on the maintenance management, which can be planned on the basis of design load spectrum. SHM will definitely help to follow the actual measurements of the stress variations. Based on the fact it was found that, average user spectrum is more severe than that of the design spectrum.

So, friends can very well see a major anomalies as you see in case of geometric configuration, in case of averaging fleet time and even in case of using a design load spectrum, can be easily understood in a better format when you continuously monitor the performance of aircrafts especially during landing and takeoff processes. This can be verified and has been studied in detail Adid Ali khan et al 1981 challenges of SHM in aviation industries, journal of Space Technology 4 1 67.