Structural Health Monitoring (SHM)
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Lecture – 44
Various sensor technologies – Part 1

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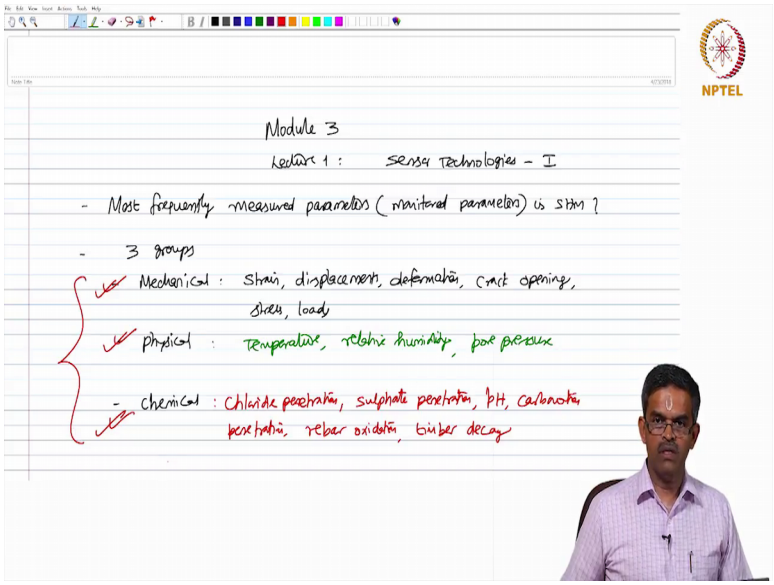

Friends, let us start with the new set of lectures on the course Structural Health Monitoring. This is module 3. In the 1st lecture in module 1 sorry in module 3, we will talk about various sensor technologies in detail.

Before we understand the sensor technologies, let us try to ask a questions; what are the most frequently measured parameters; let us say monitored parameters in structural health monitoring? Because based upon these parameters sensors are chosen accordingly. Let us try to understand what are these parameters.

These parameters vary by enlarge in three groups. We measure mechanical parameters, we measure physical parameters. We measure also chemical parameters. Under mechanical parameters we measure strain, displacements, deformation, crack opening, stress and loads. Under physical parameters we measure temperature, relative humidity and pore pressure.

Under chemical parameters we measure chloride penetration, sulfate penetration, pH changes carbonation penetration; rebar oxidation, timber decay etcetera. These are all biological and chemical processes. These are physical changes which can affect the material and the member.

And these are of course, a measurements required for vibration monitoring of the structures. So, these are the major three groups under which various measurements are generally taken and observed and monitored in an assessment process.

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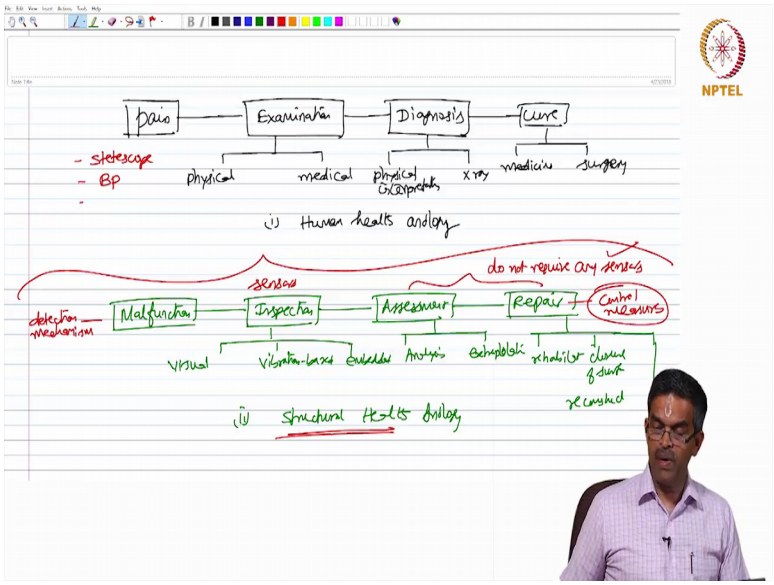

Let us quickly compare the SHM process with that of the human analogy which we did earlier as well. Let us say if you receive a pain in a human body, then you need to undergo in examination.

Then this leads to diagnosis based upon the results of the examination and ultimately you are advised for a proper cure. The examination can be physical examination and let us say medical or radiological examination.

Diagnosis can be physical interpretation or you can always use like X-rays etcetera also for diagnosis and cure again can be by medicines or by surgery depending upon what kind of diagnosis is proved. This is as far as human health is concerned. Let us compare the same with structural health. Whenever there is a malfunction in the operation of the structure, the structure needs an inspection.

This inspection leads to detailed assessment of the recorded values and detailed analysis. It may then lead to repair. This inspection can be visual inspection. It can be vibration based measurements. It can be embedded technologies. Assessments further can be analysis of the data, then extrapolation of the data. Repair can be rehabilitation, closer of service or reconstruction.

So, this gives me the structural health analogy. So, friends, let us ask a question, where do you actually need sensors? For detecting the pain you need a sensor. For example, let us say we need stethoscope; we may need a BP blood pressure machine etcetera. So, similarly for identifying the malfunction, we need actually certain detection mechanisms to show that there is a malfunction.

Even for inspection, we need sensors which can record different kinds of measurements that are important like mechanical, physical and chemical. Of course, for assessment and repair, we no need any sensors provided the repair is not towards the control mechanisms; if the repair also has some control measures like actuators etcetera, then you require sensors here well.

So, one can see here the sensor requirement is through and through present for the entire structural health monitoring system which is comparable to human analogy.

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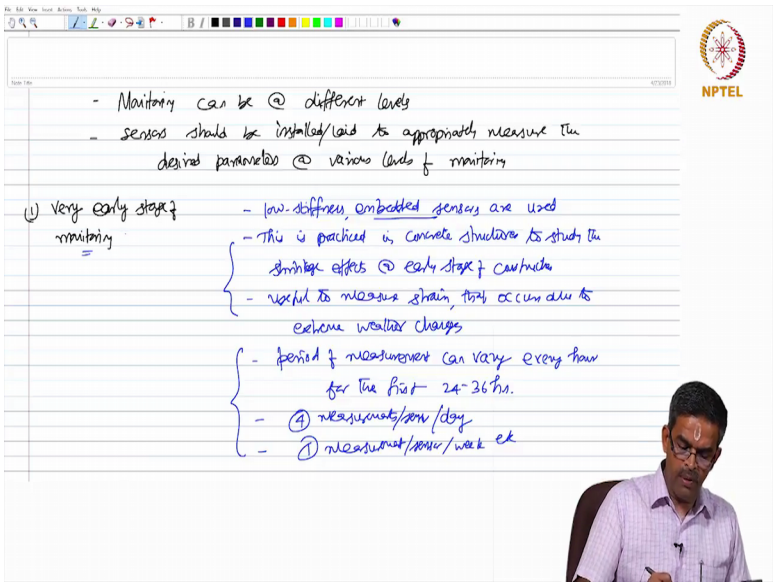

Now, when we talk about monitoring using sensor networking, monitoring can be done at different levels. Therefore, censors should be laid, should be installed or laid to appropriately measure the desired parameters at various levels of monitoring.

So, naturally all sensors do not apply to all levels of monitoring. First let us understand what are various levels of monitoring? One can do what is called very early stage of monitoring. In this case, a low stiffness embedded sensors are used.

Generally, this is practiced in concrete structures to study the shrinkage effects at early stage of construction. This is also useful to measure strain that occurs due to extreme weather changes.

In this case, period of measurement can vary every hour for the first 24 to 36 hours. Then, we can move on to let us say four measurements per sensor per day; it can then later go on to one measurement per sensor per week etcetera.

So, the period of measurement varies depending upon the demand. The type of sensor choice also varies depending upon the type of monitoring; application also varies depending upon the type of monitoring.

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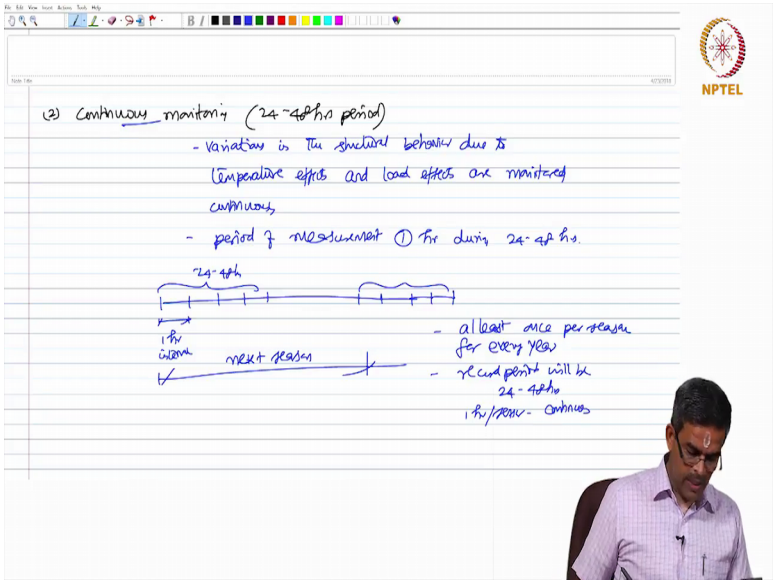

The second could be continuous monitoring which can be generally 24 to 48 hours period; that is what we call as continuous monitoring. It is not 24 into 7 for the entire

lifetime of the structure. In this case, variations in the structural behavior due to temperature effects and load effects or monitor continuously.

Period of measurement can be 1 hour during 24 to 48 hours; that is it can be every 1 hour. So, 1 hour interval for 24 to 48 hours; then, the next 24 to 48 hours can happen in the next season. So, the gap between these two will be the next season.

So, we should say that one should at least record once per season for every year; whenever you record, the record period will be 24 to 48 hours, 1 hour per sensor continuous that is the continuous monitoring period ok.

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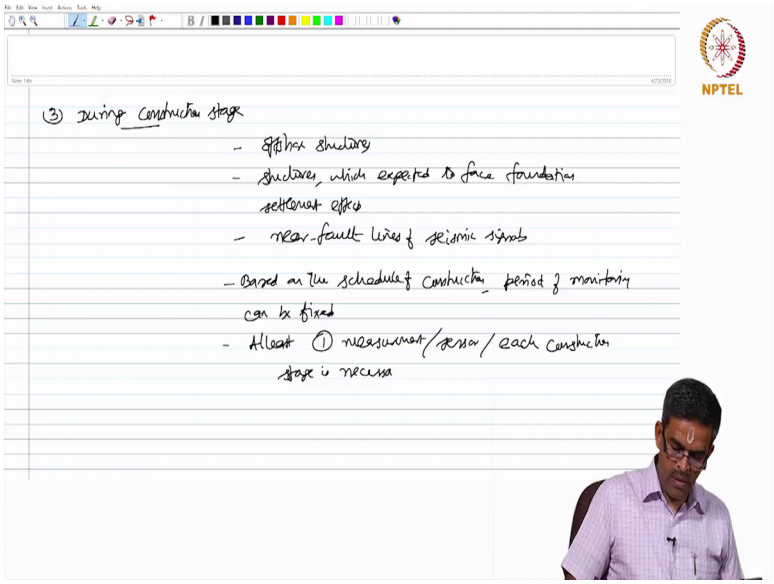

The next level of monitoring can happen during construction stage. This is very important case of offshore structures. In case of structures which expect to have foundation settlement effect. Structures, which are built near fault lines of seismic records.

Based upon the schedule of construction, period of monitoring can be fixed. At least 1 measurement per sensor at each construction stage is necessary.