Structural Health Monitoring (SHM)
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Lecture – 57
Part - 1: SHM layout design of offshore structures

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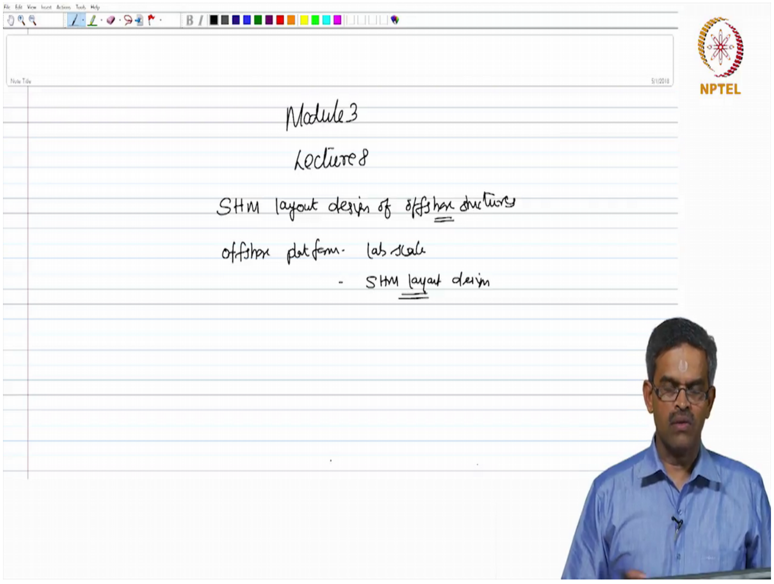

Friends, welcome to the 8th lecture in module 3. In this lecture we are going to talk about SHM layout design of offshore structures. I am going to talk about SHM layout design of a specific kind of offshore platform in the lab scale we will pick up an offshore platform, we will model them in the lab scale.

And experiments are conducted for real time monitoring on the lab scale and some layout design has been done for this. We will talk about the details of acquisition later, but in this lecture and the next lecture we will share some details of how the health monitoring design was laid using both wired sensors and wireless sensors.

What are the configurations? How data acquisition was done? And how alarm generating system was generated? And how the control strategies were applied the design processes, we will talk about that in this lecture. Friends before we understand health monitors of any structural system, let us try to understand more about the details of the system itself.

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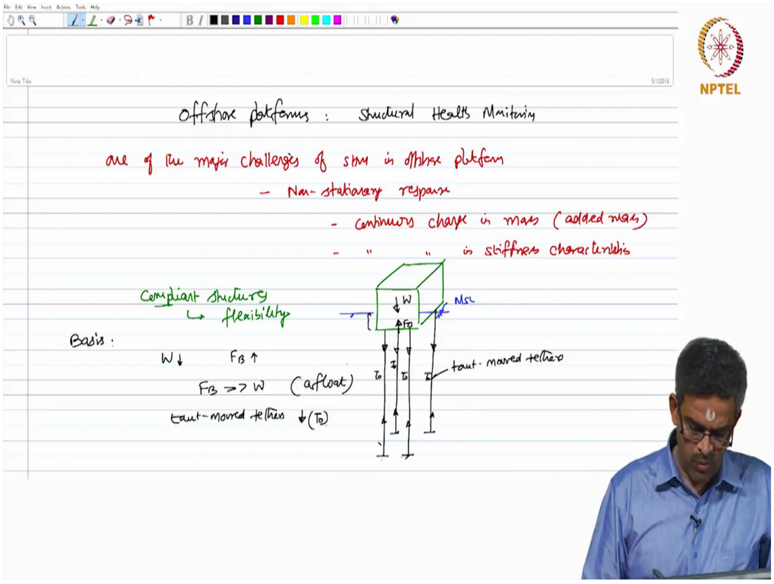

So, we are looking now for some of the primary details of offshore platforms, which are important in terms of it is structural health monitoring.

So, in this perspective let us see what are their importance, if you look at one of the major challenges of a SHM design in offshore platform, it essentially arises from the non-stationary process, which is their response. The response of offshore platforms essentially a non-stationary in nature, it means there is a continuous change in mass what we technically called as added mass and continuous change in stiffness characteristics.

I will explain that very quickly, the study which has been applied is a compliant structure, please beware of the spelling it is compliant; compliant refers to flexibility. So, we are looking for a flexible platform, if this is my water level mean sea level, I look for a rigid box ok. We should remain afloat, but at the same time this rigid box should be position restrained.

So, we hold tethers to post understand them, which are all initially tensioned and we call them as taut moved tethers. Now the design of such kind of platforms has a basis the basis for the design is if this is the weight of the platform acting down and the submerged volume will give me a buoyancy force which is acting upward.

So, W is acting down and buoyancy because of submerged volume will act up the design is in such a manner buoyancy exceeds the weight. So, the platform will remain afloat.

So, hold down the platform I need taut moved tethers, which will hold the platform down and initial tension in these theaters are all T 0 ok. Now the equation of static equilibrium for this design could be W acting down should be equal to F B acting up plus T 0 acting up, I mean acting T 0 acting down.

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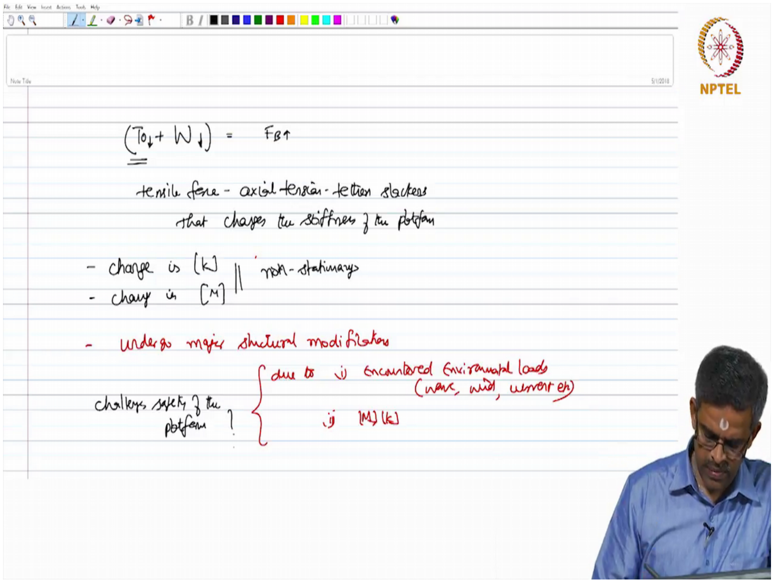

So, now, the difference in buoyancy and weight is balanced by the tension. Now interestingly when the tensile forces or axial tension in the tethers slackens, that changes the stiffness of the platform.

So, that is what we said there is a continuous change, there is a continuous change in stiffness characteristics and there will be a continuous change in mass ok.

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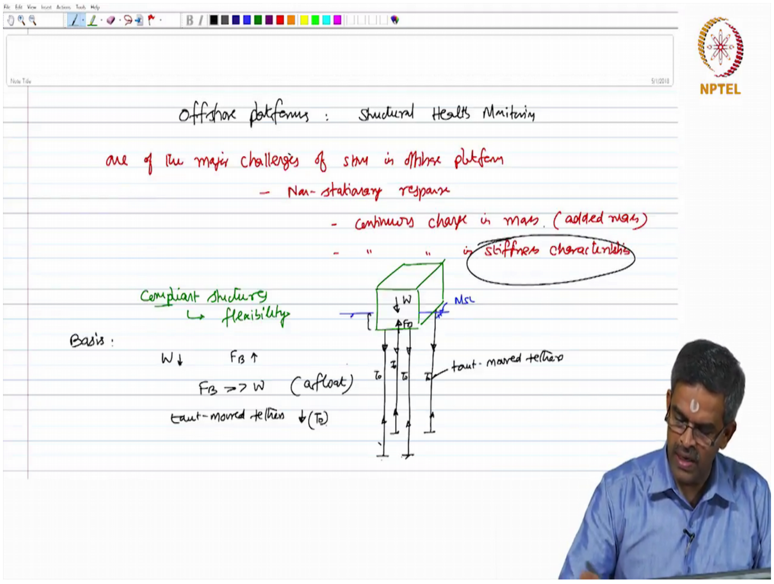

So, there is a continuous change in stiffness characteristics and continuous change in mass characteristics, which essentially are non-stationary. These platforms undergo major structural modifications due to the encountered environmental loads, which occurs from wave, wind, current, etcetera. It also changes because of change in mass and stiffness properties and that sometimes challenges safety of the platform ok.

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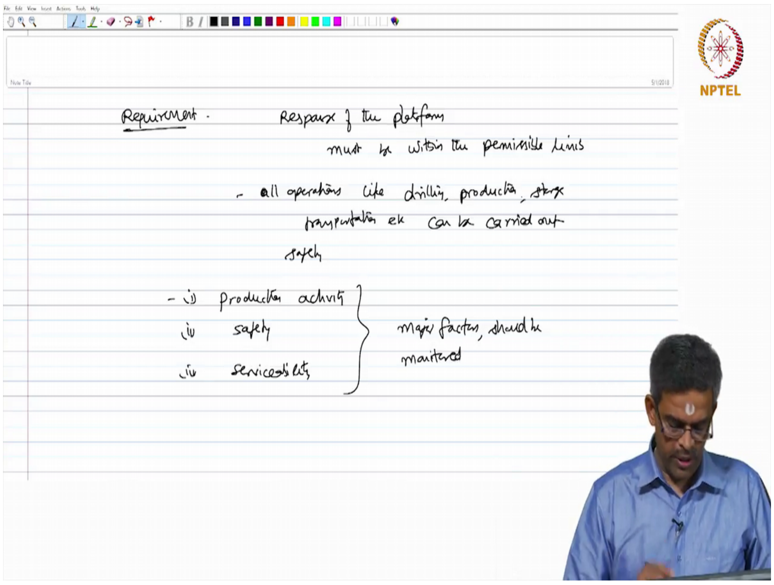

Under this condition the response of the platform. So, the requirement could be the response of the platform within the permissible limits. So, that all operations like production, storage, transportation, etcetera can be carried out safely. We are aiming at 3 values production activity, which should happen conveniently safety of the platform and serviceability.

So, all these are major factors which should be monitored is it not. So, we must first understand what we want to monitor ok. Now as we saw in the previous lectures visual inspection found to be a boon, in many damage identification philosophies.

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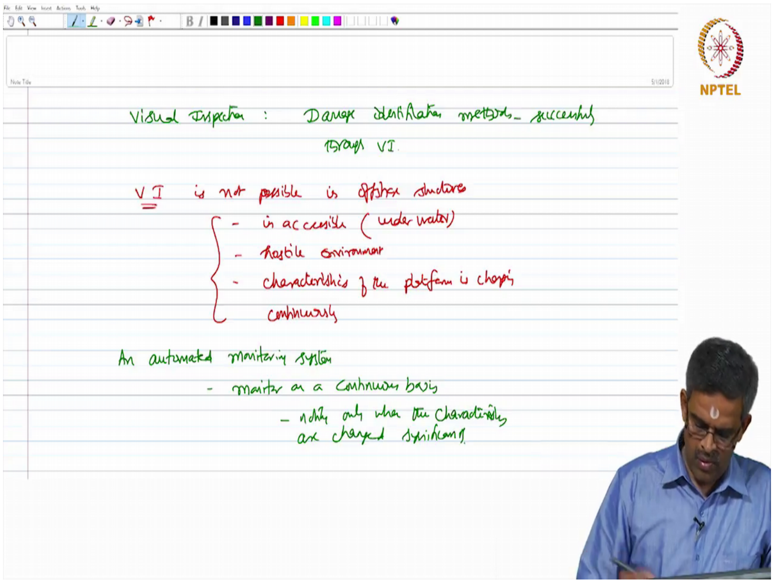

They were done successfully through visual inspection.

But, unfortunately visual inspection is not possible in offshore structures, because they are in accessible, the members underwater. And they are located in hostile environment, characteristics of the platform I am talking about the structural characteristics is changing continuously is it not.

So, therefore, visual inspection at frequent intervals may not help me really to monitor the health of the platform.

So, I need something which is an automated monitoring system on a continuous basis, must notify me only when the characteristics are changed significantly ok.

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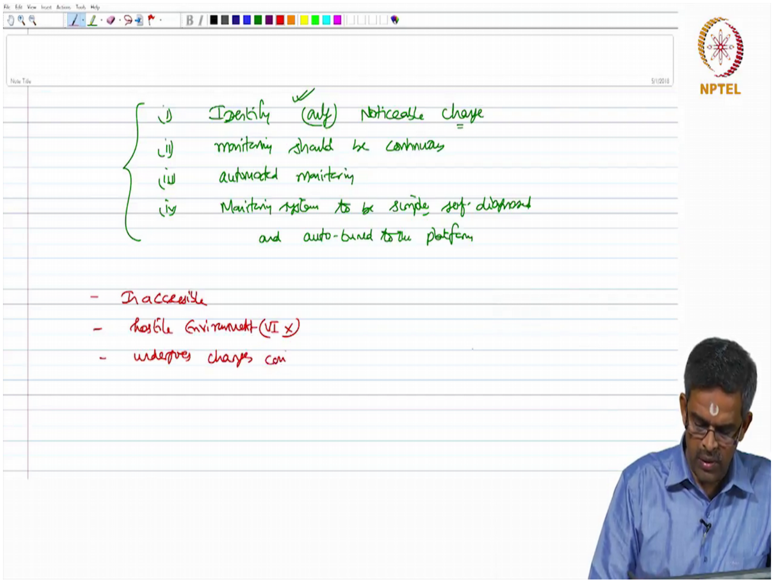

So, we need a conditional monitoring only noticeable change. We know that the Mass and K are changing continuously we are not interested in noting that change, we want to know when those values change significantly then we need to be identified.

Second monitoring should be continuous and we recommend automated monitoring. And above all the fourth one we want the monitoring system to be simple, self-diagnosed and auto tuned to the platform. We need more or less an automatic system for health monitoring here, because the platform is in accessible, it is present or located in a hostile environment, where visual inspection cannot be done, and the platform also undergoes changes continuously.

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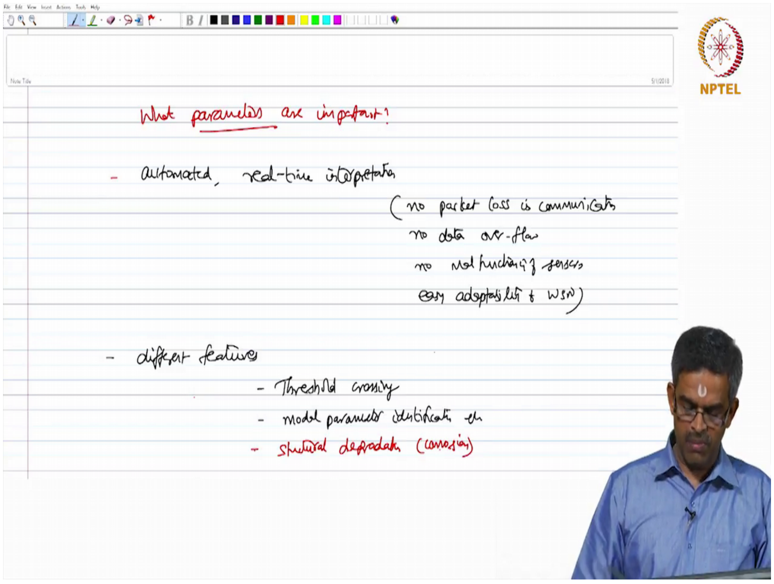

Therefore, under these conditions what parameters are important? Let us talk about that an automated real time interpretation. It means no packet loss in communication no data over flow, and no malfunctioning of sensors and easy adaptability of sensor networking.

So, that they can do real time interpretation automatically different features, because we just now said mass and stiffness characteristics keep on changing. So, vibration based monitoring is circumscribed with these 2 values. So, we are measuring them continuously, we are not going to do anything important as far as this monitor is concerned.

So, looking for different features namely threshold crossing only when these changes cross a threshold number there should be a communication threshold crossing change in model parameters. So, model parameter identification the identification should be also focused on structural degradation, if any because corrosion is a severe issue as far as these platforms are concerned.

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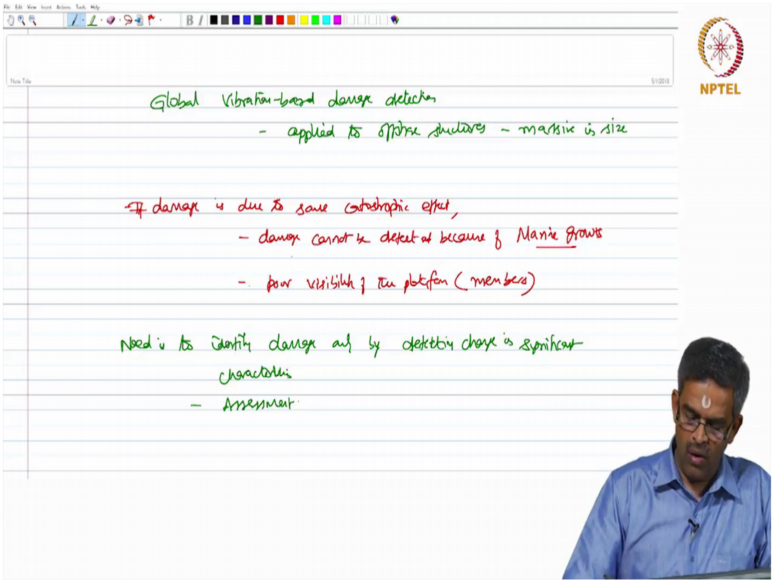

Now, there are methods available in the literature for such structures in general. Let us say global vibration based damage detection. There are successful methods to do this they can be applied to offshore structures for a simple reason these structures are massive in size, but there are issues. If the damage is due to some catastrophic effect, the damage cannot be if the damage is due to catastrophic event, damage cannot be detected because of marine growth.

So, there is a poor visibility of the platform and a few members of the platform for sure at least. So, the need is to identify damage only by detecting change in significant characteristics, which needs a demand of assessment of offshore platforms.

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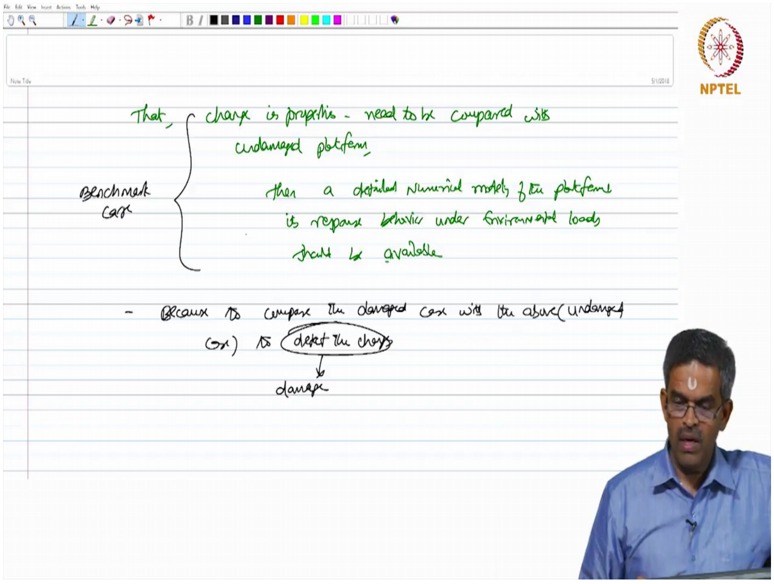

Change in properties need to be compared with undamaged platform, then their detail numerical modeling of the platform and it is response behavior under environmental loads should be available. One may ask me a question why it is required? It is required, because to compare the damage case with the above, which is undamaged case to find the changes is it not whereas, changes can only tell me the damage.

So, to find the changes I need to compare the damage case with the existing standard case, what we call as the benchmark case.

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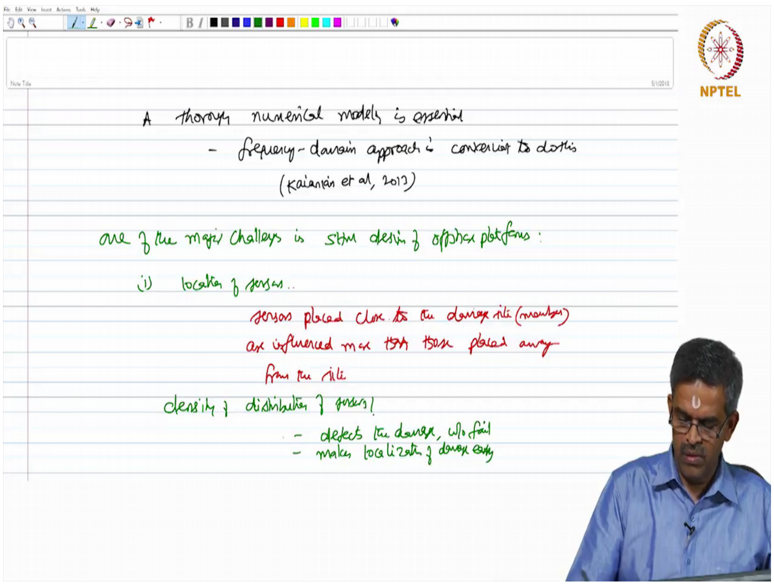

So, I need to compare them it means a thorough numerical modeling is essential. So, generally people use frequency domain approach to do this is convenient to do these Kaianian et al in 2013.

One of the major challenges in SHM design of offshore platforms is that relocation of sensors. Sensors placed close to the damaged site or member are influenced more than those placed away from the site ok.

Therefore, the most important issue is the density of distribution of sensors. How are you going to distribute the sensor that is a major issue here? So, that it detects the damage without fail to it makes location easier or localization of damage easy. So, these are my 2 requirements now.