Structural Health Monitoring (SHM)
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Lecture - 75
Part - 1: SHM design by experimental investigations for lab scale model of TLP - I

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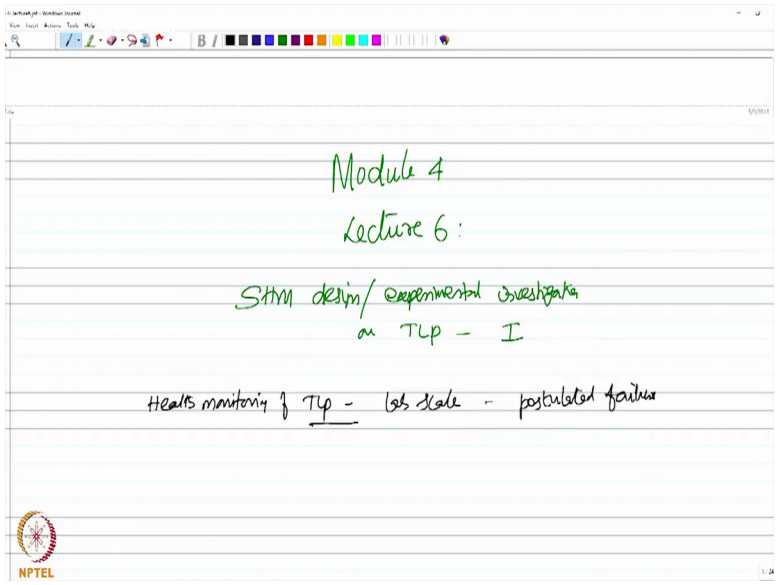

Welcome to the 6th lecture in module 4, in the course on Structural Health Monitoring. We are discussing about the Application of Structural Health Monitoring, their design and applications. In this lecture, we will also try to extend the design of SHM concepts through some experimental investigations. They will take up a TLP on the lab scale model. This will be the first of its kind in the lecture series we are going to have in this module.

Now, the question comes; what would be the application issues of structural health monitoring design and development when you do it for tension leg platforms on experimental scale? Health monitoring is an important issue when applied to offshore structures. In this lecture, we are going to talk about the health monitoring scheme design, especially for a TLP model on lab scale. Obviously, when TLPs are designed they never cost failure; we are talking about the postulated failure case in this issue.

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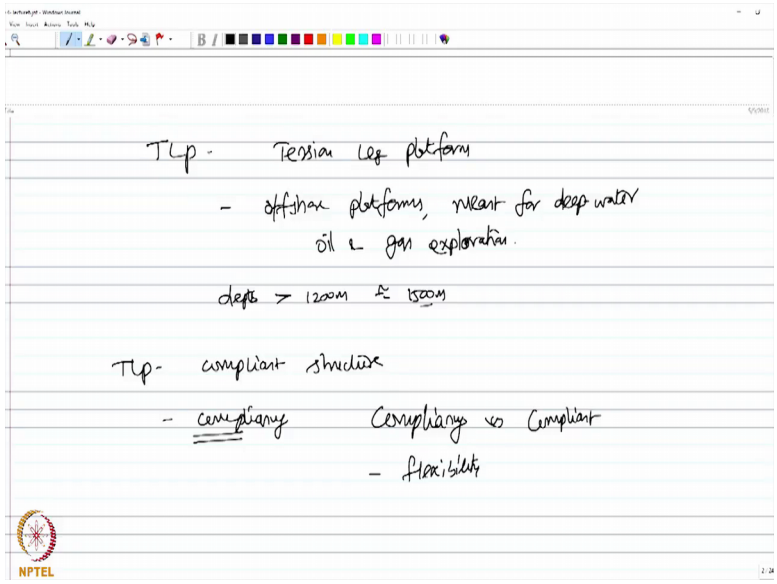

Postulated failure is a failure created on a lab scale to cause a failure and then assess the failure for its health monitoring.

Now, tension a platform is expressed as TLP. Tangible platforms are actually one of the kinds of offshore platforms which are meant for deep water oil and gas exploration. The moment they say deep waters, the depth of water will exceed about 1200 meters, it can go as high as 1500 meters approximately. We are now talking for a platform which is going to be installed in deep waters. TLP are compliant type offshore structures, I refer you to a spell check on compliancy. So, compliant is not complained, it is compliant, compliancy or compliant refers to in general flexibility tential platforms or structural systems which are very highly flexible.

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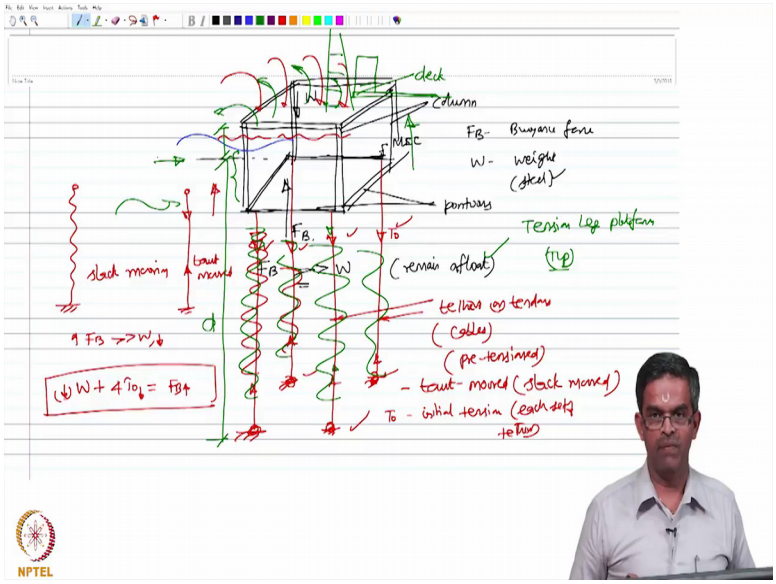

It consists of columns and pontoons has same drawing on the sketch. Now here the mean sea level or still water level is marked horizontal as you see there, it consists of columns and pontoons. I am trying to draw a 3D figure of a rectangular TLP which is now connecting or integrated by different modules of columns and beams.

Now, the structure is partially immersed in water, therefore, it raises buoyancy which is an upward force referred as the FB. The platform will also have a weight which is referred as W W and FB are essentially coplanar collinear and for a symmetric design, they are concurrent, we all do agree that TLP is a constructive a steel. Therefore, we knowing the density and the volume of material of column members, like I am drawing just now and the pontoon members which are horizontal which I am drawing now on the bottom scale, they are integrally connected and welded together of our the structure is transparent and hollow in between they can pass through the structural system.

So, the horizontal members are referred as pontoons and the vertical members are referred as columns. All are hollow steel cubes which are of diameter about 12 to 16 meters as the way passes through, the transparency of the system enables flexibility and recent ring capability for the platform, the wave can pass through the platform as you see in the picture, here, the design concept of TLP is very simple, buoyancy highly exceeds the weight. Therefore, the structure remains a float, so that is one of the great advantages of the design the structure is flexible and remains a float in water.

Now, to hold down this structure into seabed, we need some additional arrangements, these are essentially done by cables or tethers which are anchored to the seabed that is shown in red color now. So, these tethers are connected from the pontoons and column members to the seabed, they are called as tethers or tendons essentially they are wire like structures which are cables.

Now, since buoyancy exceeds the weight by a large value, buoyancy is acting upward weight is acting downward the upward force is small the downward force is lesser. So, the body has a tendency to move up, is it not? I want to bring this body down; I hold this body down by imposing very high pretension. So, all these tendons are pre tensioned and therefore, they are called taut moved the opposite to taut moved is slack moved slack mode looks like this, let us say a body I want the slack moved it there is what slack moved iggy's.

So, there is no pretension in force in the body, I have a body, I want to anchor, it to the seabed, I want to pull this body down, this is called taut moved. So, they are all taut moved. Now if I take T 0 as initial tension in each tethers or set of tethers, then I can write equation of static equilibrium as W plus 4 T 0 is equal to F B because W is acting downward. T 0 also acts downward. There are 4, because there are 4 legs here and F B acts upward, this is my equation of static equilibrium.

Now it is very interesting, the body will be commissioned to the seabed in such a manner that additional weight will be added to the body the body will further submerge, the tethers will be all stuck and they will be connected to the seabed by some permanent anchoring arrangement. Once the anchoring arrangement is complete, these additional weight will be all removed, the body will have a tendency to move up and that additional weight will be transferred to the tendons in terms of axial tension that is how they are commissioned.

So, since all the legs are always in tension, this platform is called tension leg platform ok. So, this is a typical offshore compliant structure which is useful for deep water oil exploration. There are many advantages of the system the advantages could be in case of any lateral load which is hitting the body only this part of the body is submerged. So, the wave action on the body is minimum, because the deck which is on the place where all operational features are happening; ok the derrick their living quarters etcetera all

operational features which happen are above water and there is an inner free board these available for this body. So, that the action of production and drilling is not affected by this splash or where the wave effects on the body number one number two in case of any accidental issues when these tethers get cut off.

Let us say, they are plugged out because of some accidental conditions the body will remain a float and there is no damage to the body as such that is an advantage here. So, TLP is are actually recommended for deep waters and this is what the water depth we are talking about this water depth is about 1200 to 1500 meters about 1.5 kilometers.

So, now I have a lab scale model of potential a platform which is in fabricated to a lab scale. And we are examining the health of this platform under the given wave loads or lateral loads using or causing a postulated failure that is the whole problem.

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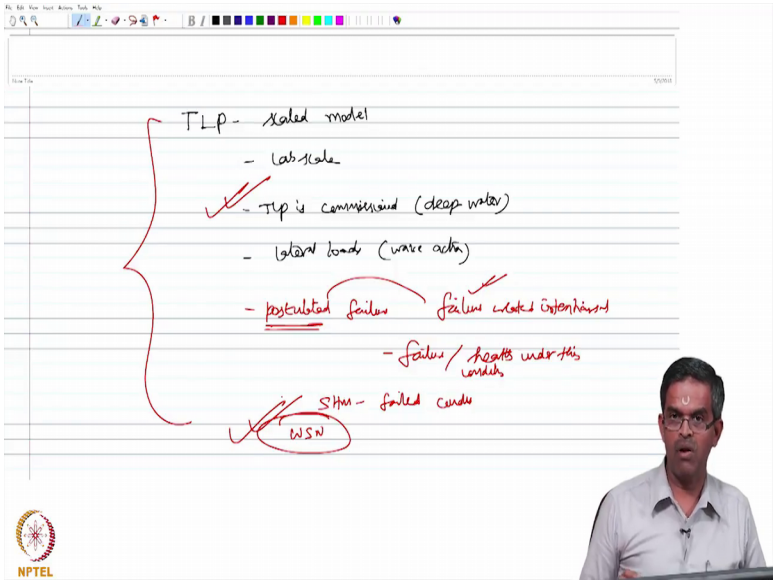

So, we have now with us the attention like platform which is a scaled model which is to be examined on the lab scale potential a platform is commissioned at a specific water depth under deep water condition, it is subjected to lateral loads that is wave action and we create a postulated failure, what do you understand by a postulated failure? Postulated failure is a failure created intentionally. So, when you create a failure yourself you will know the body has already failed.

So, we are now examining the health of the structure under this failure condition. So, that is become the structural health monitoring under failed condition using wireless sensor networking that is idea, what we are going to discuss now in this lecture where we are going to talk about the lab scale experiment of TLP the installation of wireless sensor networking. Then the data acquisition and how do we post process the postulated failure data to obtain the health monitoring on the structure.

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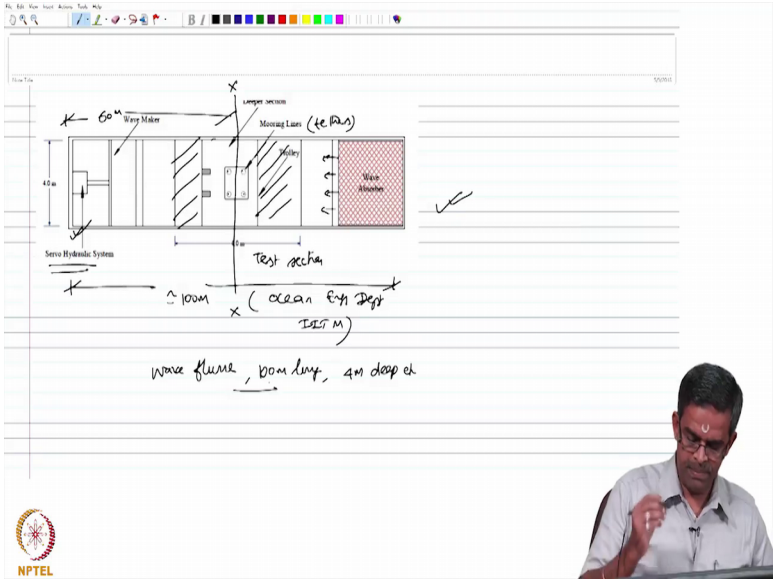

This is a typical wave flume on which the experiment is going to be conducted you can see here the length of the wave flow is about approximately hundred meters which is located in ocean engineering department at IIT, Madras is one of the stated our facilities which is being located in India which is housed in our department in the Institute of Technology, Madras.

So, the model will be installed at a specific test section this is my text section where the model will be installed here the water depth of this is about four meters and it is approximately about 60 meters from the wave front where the wave is generated using servo hydraulic system as the way passes the body. The wave is absorbed at the dead end by a wave absorber to avoid any reflection of this wave back to the model a trolley is been housed a trolley is being housed here, so that during examination, the body can be investigated for all the measurements on the system.

So, the mooring lines are connected at every corner of the deck as you see here. And mooring lines are nothing but the cables or the tethers which are holding down the deck to the seabed by taught more axial tensile cables that is the test setup, what we have as far as the wave flume is concerned which is about 100 meter long the test section is about 4 meter deep etcetera, ok.

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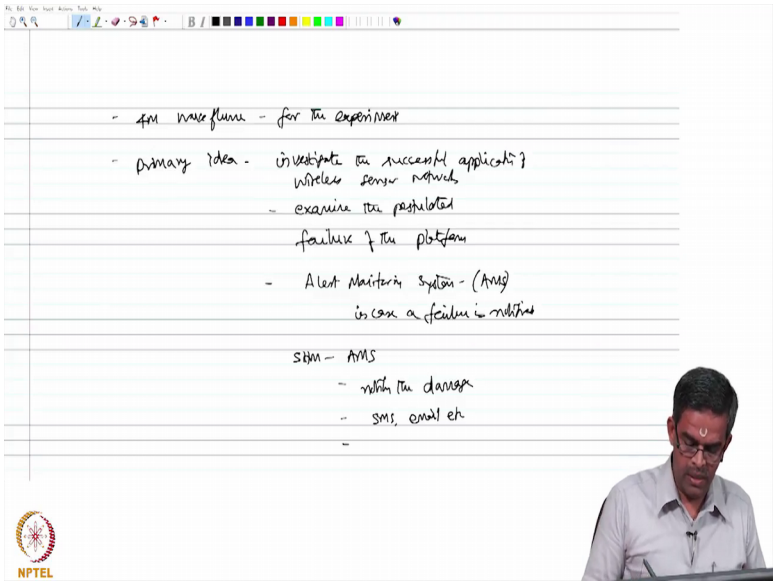

The experimental investigations; we are going to use your 4 meter wave flume for the experiment, the primary idea is to investigate the successful application of wireless sensor networking which is going to examine all which is going to be useful in the examining the postulated failure of the platform. We are also going to apply the alert monitoring system concept in case a failure is notified, the structural health monitoring system integrated with alert monitoring system should be able to notify the damage and also send SMS, email alert, etcetera to the affected or to the client server to indicate the type of damage being caused to the model on the lab scale that is the whole idea and the design now, ok.

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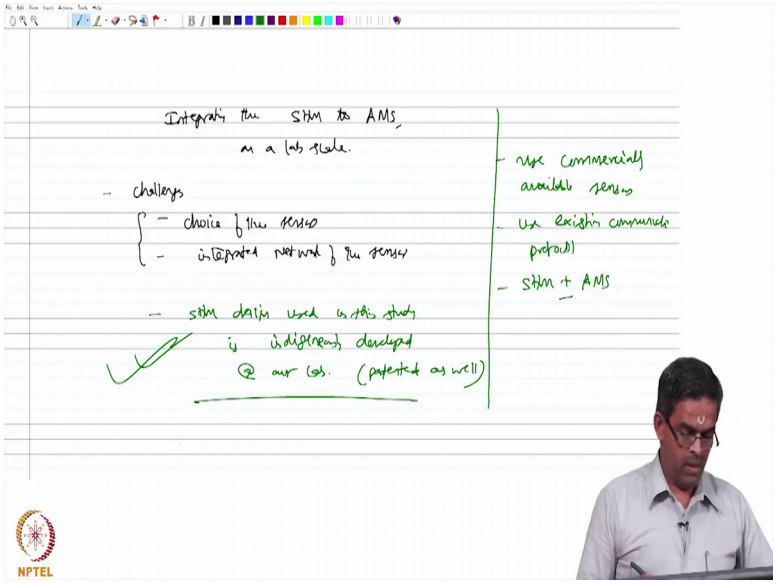

Now, we are integrating the structural health monitoring to alert monitoring system on a lab scale that is the whole issue we have here ok. Now the typical challenges are choice of the sensor; what type of sensor we should use, then integrated network of the sensors which we should use for the provided design. And we are proud to declare that the SHM design used in the study is indigenously developed at our lab and it is patented as well. So, it is indigenous development.

So, the object is began the design is use commercially available sensors use the existing communication protocol to develop SHM integrated with alert monitoring system that is the objective; what we are looking for at this moment so the experimental setup.