Computer Methods of Analysis of Offshore Structures
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Module - 03
Lecture - 08
Fatigue Estimate of Offshore Platform (Part - 1)

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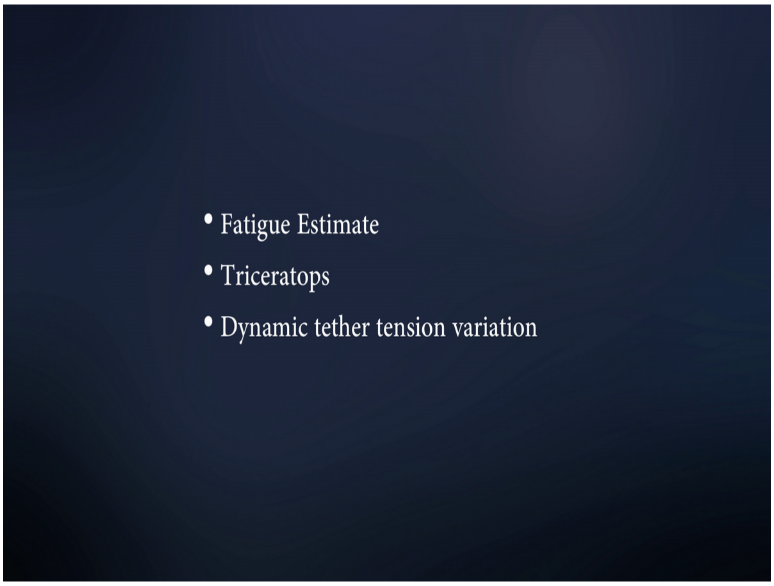

So, friends welcome to the 8th lecture in module 3. We are continuing to discuss the fatigue estimates in the last couple of lectures we discussed the methodologies of the estimating fatigue damage in offshore platforms.

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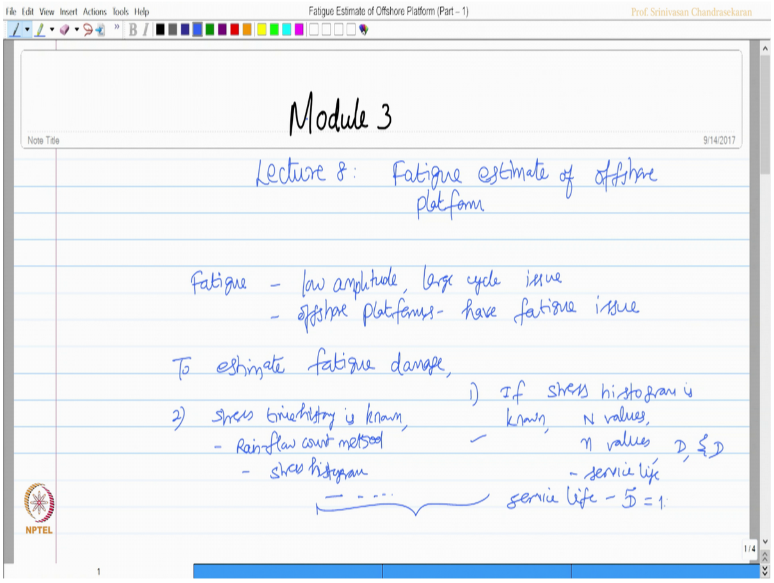

Let us quickly revisit what we learnt in the last two lectures. Fatigue is low amplitude, large cycle issue, offshore platforms have fatigue issue a major concern, we will take up an example and show you today, and how this is important. Now to estimate fatigue damage we have seen two techniques, one if stress histogram is known, one can try to plot the n values estimate, n values from the histogram, and find the damage, find the cumulative damage, then estimate the service life. The second technique is if stress time history is known.

Then use rain flow count to obtain the stress histogram, then follow a same method as we have here, and ultimately one can find the service life for a cumulative damage equal to unity.

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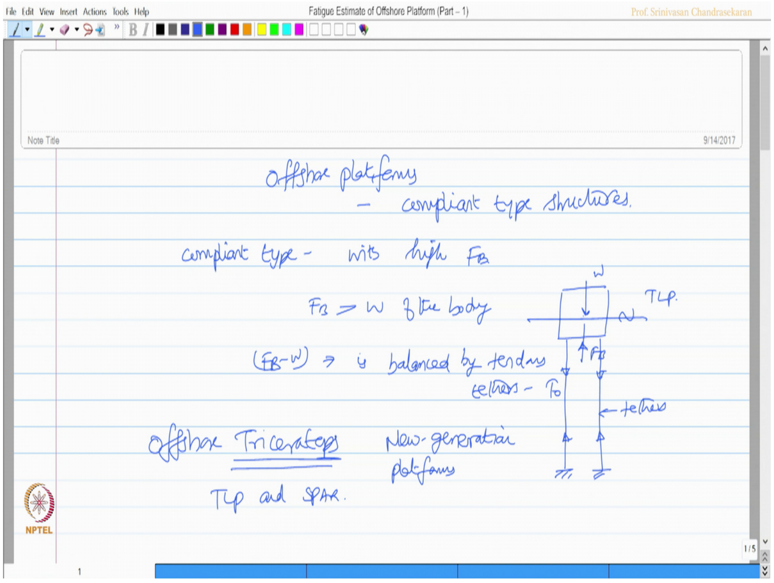

In today’s lecture we will see the application of this problem in offshore platforms. Offshore platforms have special issues, when they are compliant type structures many of you have a background of understanding different types of offshore platforms.

Let us see quickly what is a compliant type offshore structure; compliant type is a platform, which is designed with high buoyancy force, let us take a floating body with large buoyancy force the buoyancy force exceeds the weight of the body. So, the difference between buoyancy and weight is balanced by tendons or tethers with high initial pretension.

So, the body or the platform is anchored to seabed with high initial pretension tethers and we call the system as tension leg platform. In the same order there is a recent phenomena of offshore triceratops, it is a new generation platform which has advantages of both TLP and spar platforms. Let us quickly see some brief overview of triceratops before we understand fatigue prediction on triceratops.

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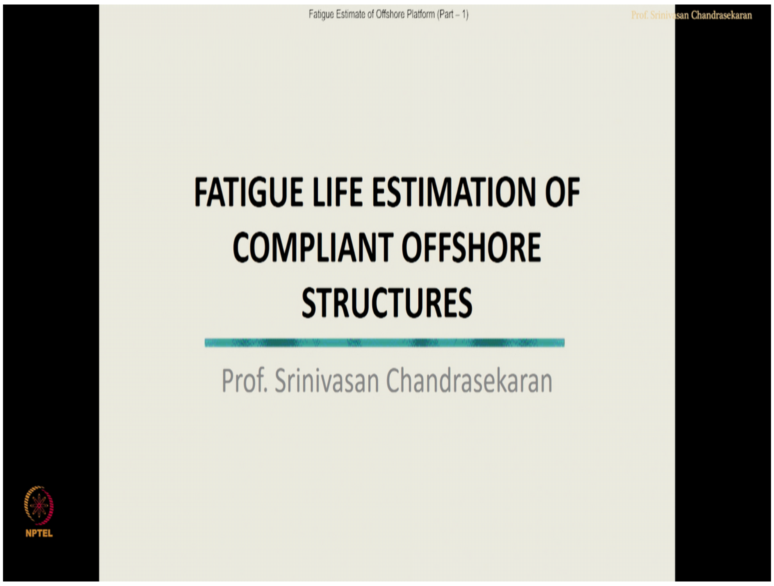

So, complaint offshore structures have special issues related to fatigue life estimates.

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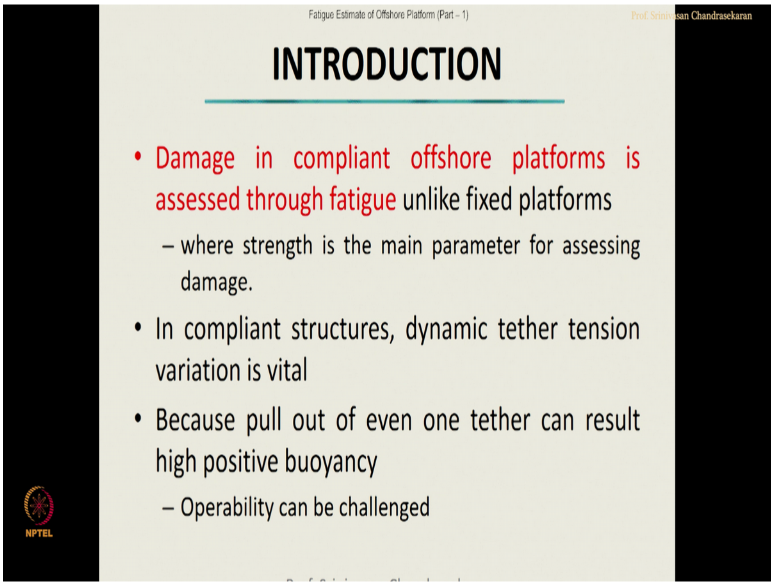

Damage in compliant platforms is generally assessed through fatigue unlike fixed platforms. In fixed platforms strength is the major parameter whereas, in compliant platforms it is the fatigue damage. In compliant structures the most important component which deals with the fatigue assessment is the tether tension variation which is dynamic in nature this is very vital because pull out of even one tether can result in high positive buoyancy which can challenge the operability or functionality of the platform.

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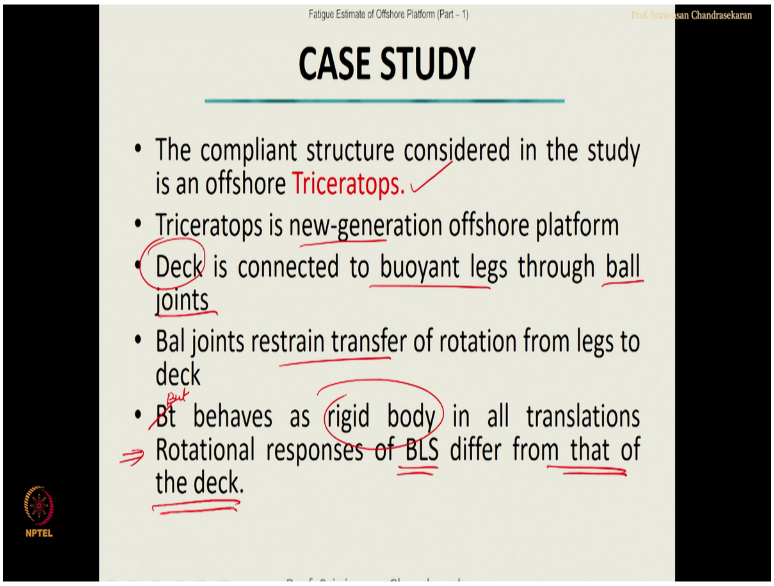

In the present study of the lecture, we are focusing on triceratops. Triceratops is a new generation platform, it has got two important components which are interconnected one is of course a top side which is the deck, which is connected to the buoyant leg the most interesting part in this case is the deck and buoyant legs are connected through ball joints.

Now the ball joints restrain transfer of rotation from the legs to the deck but behaves as a rigid body in all translations the rotational responses of buoyant leg differ from that of the deck.

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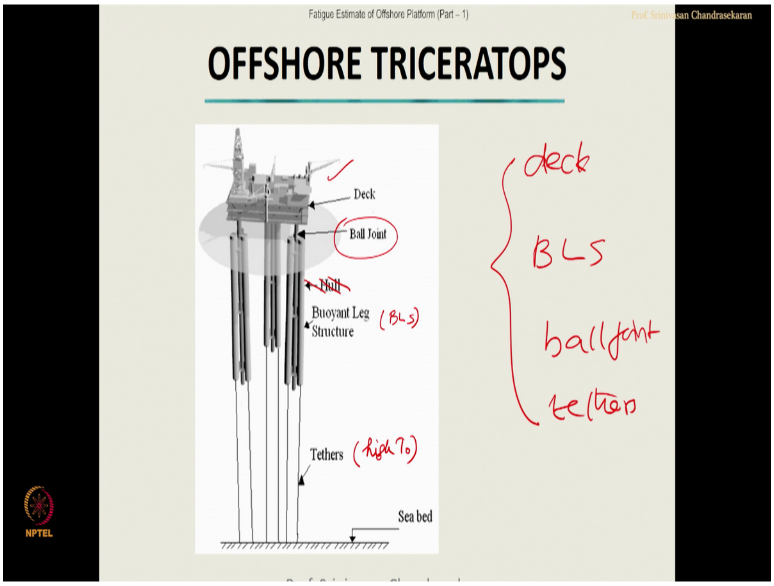

The typical view of an offshore triceratops, as you see from this picture deck has all facilities which are meant for offshore drilling production etcetera.

The buoyant legs are in groups which are otherwise briefly called as buoyant leg structures which are BLS. BLS is connected to the deck through ball joints, and buoyant legs are further connected to the seabed using tethers, which has very high initial pretension, so four components the deck, the buoyant legs, the ball joint, and the tethers. So, this makes triceratop which was a conceived idea in a very recent past.

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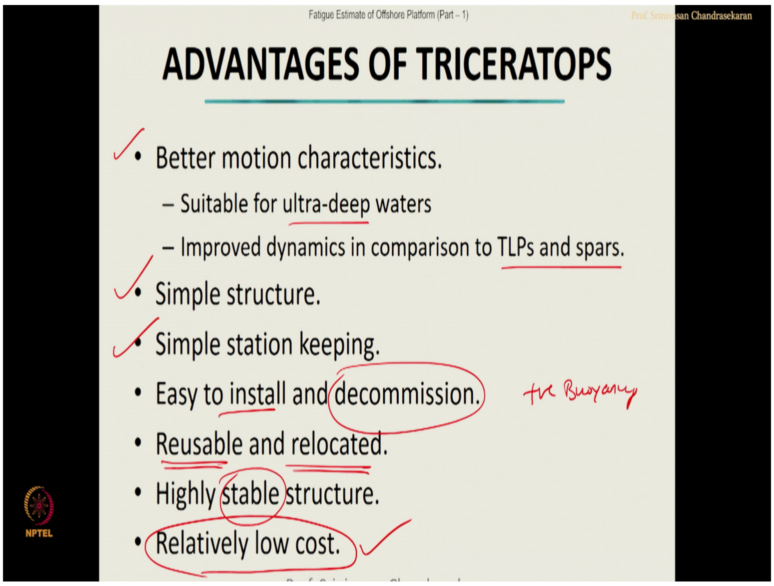

Triceratops have lot of structural advantages, it has got best better motion characteristics therefore, initial studies conducted in triceratops both numerically and experimentally confirm that they are highly suitable for deep waters and ultra deep waters.

They also have improved dynamic characteristics in comparison to TLPs and spars. The structure is more or less of a simple geometric form with simple station keeping processes, it is very easy to install because the system is having high positive buoyancy.

Similarly it can be easy to decommission the system, it can be highly reusable and relocated the structure has got a very high stability, at a very high or very low cost. So, triceratops process have lot of advantages compared to TLPs and spars of course, they are in the conceptual stage and no triceratops are actually commissioned for deep water exploration even till today in the present lecture, we take one such new generation platform as a case study.

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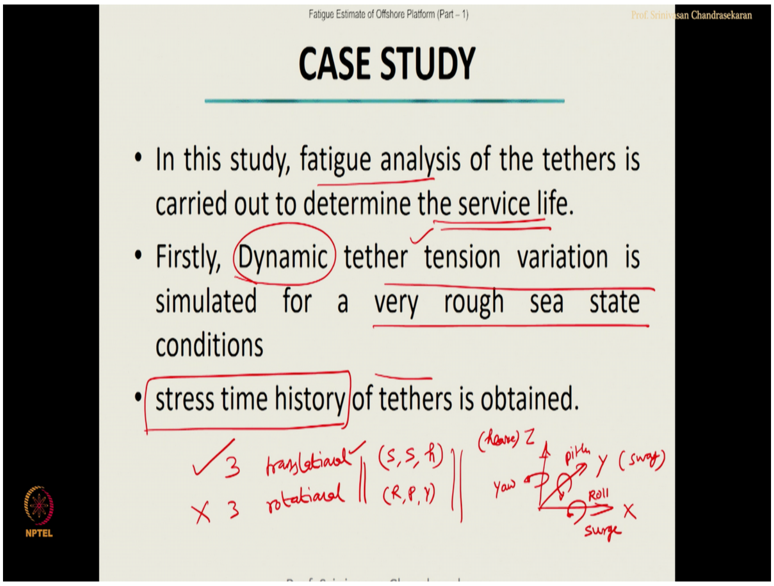

We will take up a traiceratop, we will directly investigate the fatigue analysis of tethers, and then estimate the service life of triceratop.

So, what we are trying to do is we impose the wave loads on the buoyant legs. The buoyant legs will undergo degrees of freedom as per their choice usually 6 in number surge sway heave roll pitch and yaw. So three translations and three rotations for example, this is X axis Y axis Z axis, I called displacement along X as surge, displacement along Y as sway, displace along Z as heave, rotation about X as roll rotation about Y as pitch, and rotation about z as yaw, so 6 degrees of freedom 3 translational and 3 rotational.

Friends please note the translational degrees which are surge, sway and heave, will be transferred from the buoyant leg to the deck. There are the rotational degrees like roll pitch and yaw will not be transferred from the buoyant leg to the deck. Ball joints will restrain transfer of these degrees of freedom from the buoyant legs to the deck whereas; ball joints will allow transfer of these from the buoyant legs to the deck.

When a triceratop is subjected to wave loads, buoyant legs will undergo deformation or displacements, in 6 degrees of freedom. Since the buoyant legs are connected to the seabed you have seen tethers tension in the tether now varies with the dynamic history, we called this as dynamic to the tension variation. So, we investigated a triceratop in a very rough sea state condition and try to generate the dynamic tether tension variation time history for a very rough sea state.

So, we are now trying to get a stress time history of your tethers. I want to reemphasise that fatigue analysis can be conducted by two ways one, if we get a stress time history from the stress time history, do rain flow counting method tried to get the stress histogram from the histogram used minus rule, tried to find the cumulative damage and estimate the service life.

The other method what we saw in the last lecture was the stress histogram is directly obtained and given to you from the histogram try to get the damage. So, in the present study the stress histogram is not given, but the stress time history which is directly obtained from the study. Is investigated, and then the stress bins are calculated from the stress time history directly.

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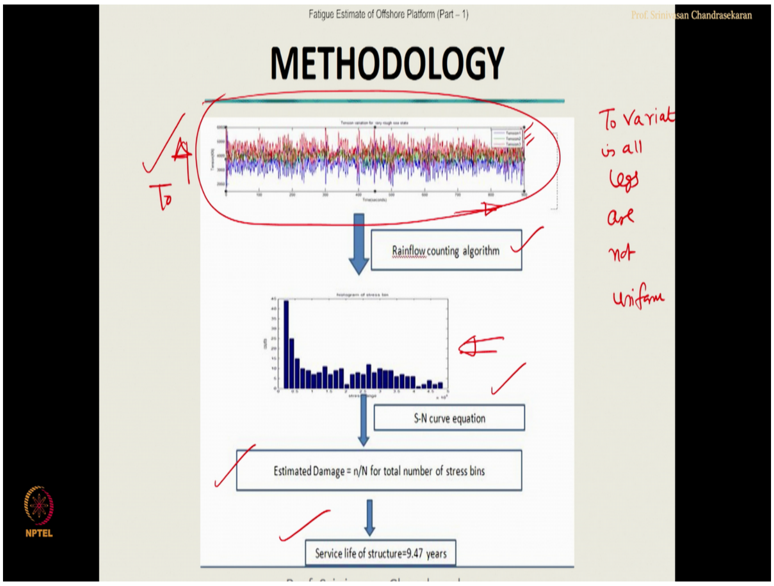

So, a typical stress time history is what you see in the sketch is shown here is a typical stress time history, so the variation is on time history in the X axis and the Y axis is the T 0 variation. Since the variation is respect to time we call this as dynamic tether tension variation. Now there are three different colours the legend show variation in leg 1, leg 2, and leg 3 independently.

So, one can very easily see here the T zero variation, in all legs are not uniform that is a very important observation we have here all legs they are not uniform. So once I have this history, from the history apply rain flow counting algorithm try to get the stress histogram, from the histogram using a S-N curve equation get the cumulative damage from the cumulative damage estimate the service life.

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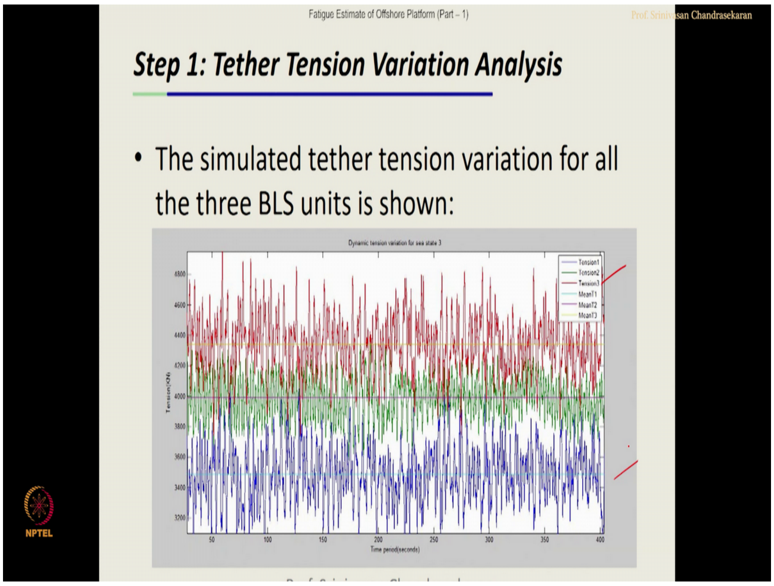

So, let us closely look at the stress history variation in a larger perspective the simulated tether tension variation is shown in all the 3 legs separately. We can see here the red one indicates tension at leg 3, the blue one indicates variation in leg 1, and the green one indicates variation in leg 2. One can see the mean of all the three are not same, so they are varying we will take up any one leg for our investigation and try to see how the fatigue damage can be estimated now.