Offshore structures under special loads including Fire resistance

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Lecture - 05
New Generation Offshore Platforms

Friends, this is Lecture 5 in which we will talk about new generation platforms.

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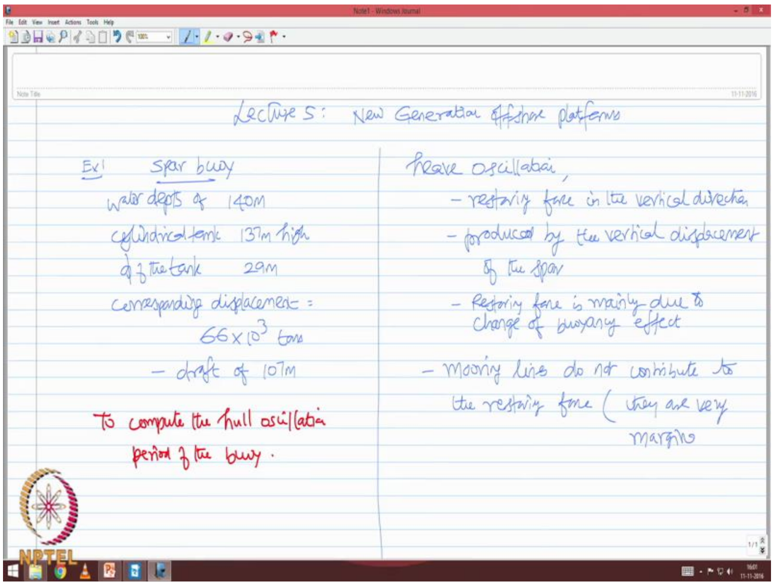

Before doing this let us try to do some quick numeric examples to understand the basic action, stiffness, frequency in period by a variety of platforms for our basic understanding. Let us take one example of a spar platform are spar buoy. Let us say it operates at water depth of 140 meters, it has a cylindrical tank 137 meter height, the diameter of the tank let us says 29 meters. The corresponding displacement 66 into 10 power 3 tons, which corresponds to your draft of 107 meters. What is asked is to compute the hull oscillation period of the buoy.

To calculate the heave oscillation we need estimate the restoring force in the vertical direction. This is generally produced by the vertical displacement of the spar. The restoring force is mainly due to change of buoyancy effect. One may ask me a question what to be the contribution from the mooring lines. So, mooring lines do not contribute to the restoring force even if they are very marginal.

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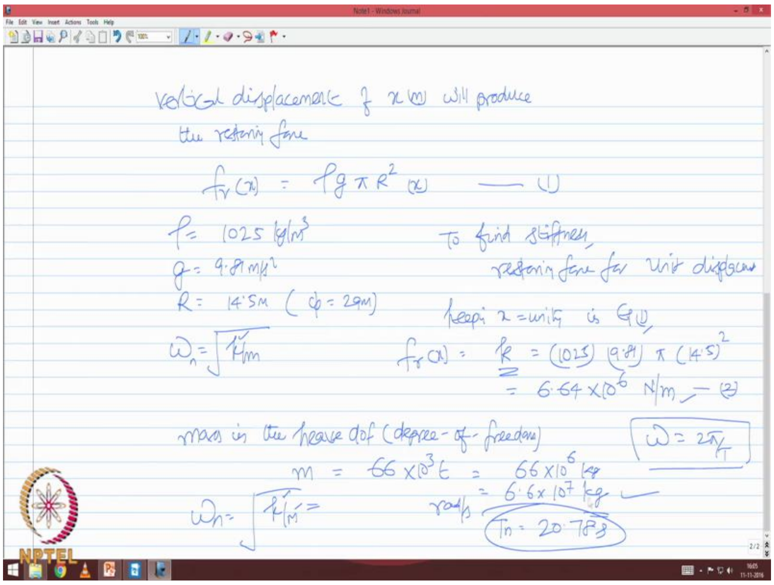

So let us now find the vertical displacement. The vertical displacement of let us say x meters will actually produce the restoring force. The restoring force is given by rho g pi R square into x. Rho is taken as 1025 kg per cubic, g is 9.81 meter per second square, radius in this example is 14.5 meter because the diameter is 29 meter. So, I am interested to find stiffness because you know frequency is actually root of stiffness per mass. So, to find stiffness one can say it is actually the restoring force for unit displacement. So, keeping x as unity in equation 1 I can now call the restoring force actually as stiffness which is actually equal to 1025, 9.81, pi, 14.5 square which gives me 6.64 into 10 power 6 Newton per meter.

So now, I have the value stiffness which is given by this value of 6.64 10 power 6 Newton per meter. Mass in the heave direction dof stands for degree-of-freedom is given as 66 10 power 3 tons which is 66 10 power 6 kg 6.6 10 power 7 kg. Now I have mass in kg, I have stiffness in Newton per meter; I can always find actual frequency in SI units which is k by m which is going to be so many radians per second. But I am interested in finding the period, I substitute we know periods omega is 2 pi by t. So, period if you do substitution of k and m and get these equation back here the period what you are call is going to be 20.78 seconds.

So, that is the typical period of a spar platform in heave degree of freedom.

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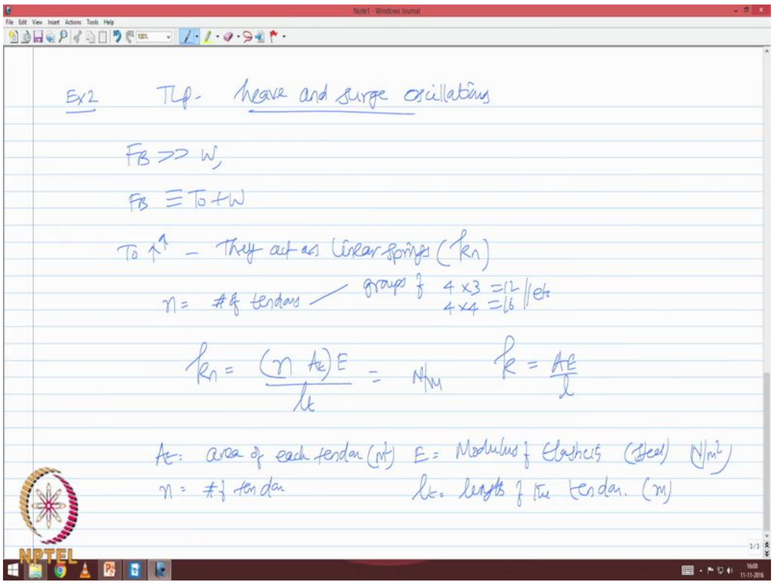

Let us take another example; where I want to find for a TLP heave and surge oscillations. We all know that in TLP buoyancy exceeds a weight and T 0 equalizes this weight to the top buoyancy. So, T 0 values are generally substantially high, they actually act as linear springs whose stiffness is k n. Where, n is the total number of tendons. Generally tendons are not of a single piece they will be in groups of 4 into 3, 4 into 4; that makes 12, that makes 16 etcetera.

So, the stiffness of this spring is given by n A t E by lt, we all know linear stiffness is simply A E by l. So, A t in this case is area of each tendon, n is a total number of tendons, so that makes the total area, E modulus of elasticity; usually steel is used as a material, of course l is the length of the tendon. So this can be in meters, this can be in meters square, this can be Newton per meter square we will get stiffness in Newton per meter.

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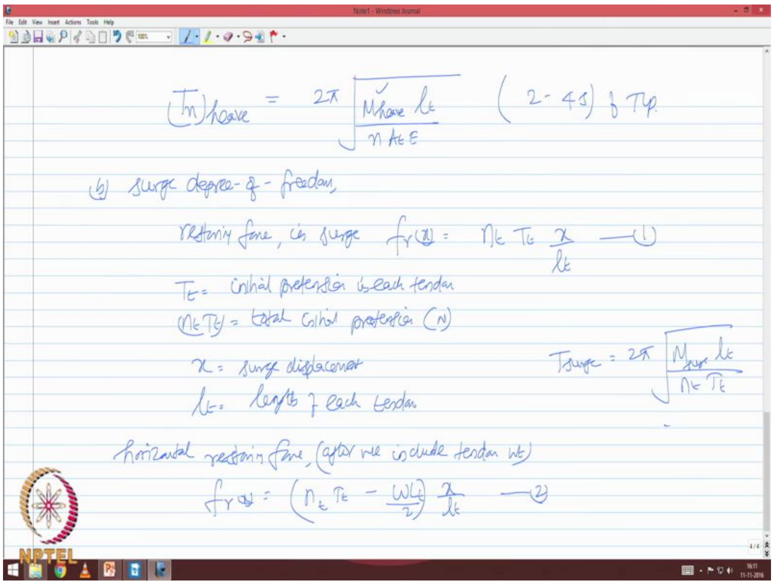

If you want to find the period in heave degree of freedom for a TLP; I can simply say 2 pi root of m that is mass in heave degree length of the tendon by n A t E second. When we know the mass of the TLP participating in the heave degree of freedom I can always find the period in radiance per second or in seconds. Usually, the heave period varies from 2 to 4 seconds of a TLP.

If you want to do this in surge degree of freedom then the restoring force in surge degree of freedom is actually f r, we say it is n t, T total x by lt. Where, T t is initial pretension in each tendon. So, n t into T t will give me the total initial pretension may be n Newton's, x is a surge displacement, l is the length of each tendon. The horizontal restoring force after we include the tendon weight also in that case f r x will be n t T t minus w lt by 2 of x by lt, and period in surge is simply 2 pi root of mass in surge degree length of the tendon divided by n t T t.

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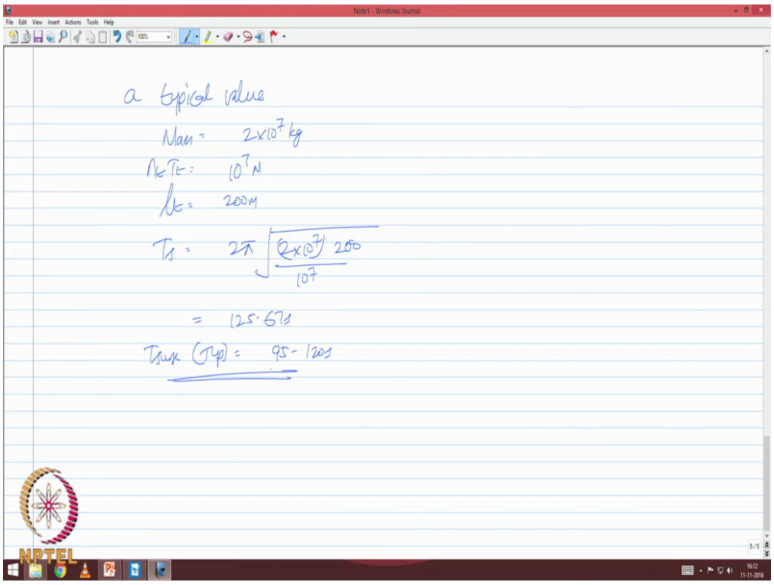

Let us take a typical value. Let us say mass is about 2 10 power 7 kg from the previous example. Let us say n t into T t is 10 power 7 Newton, again from the previous example. Let the length of the tendon be 200 meters, therefore typical surge period would be 2 pi 2 10 power 7 200 meter by 10 power 7 which is 125.67 seconds. Where surge period you surely of a TLP is anywhere from 95 to about 120 seconds.

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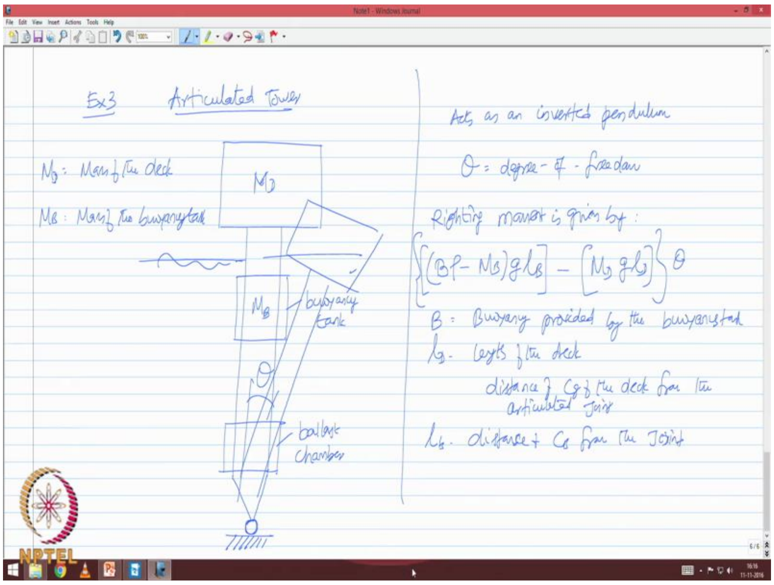

We will take one more example: where we will talk about articulated tower. We all know articulated tower has a top size supported by a tower which is connected to the universal joint to the seabed. The tower also has buoyancy tank and the ballast chamber as we saw. Let us say this is my water level, this is my mass of the deck, and this is my mass of the buoyancy tank. Essentially, this tower acts as an inverted pendulum the degree of freedom this tower has is a rotation about the base. So, theta is the degree of freedom.

In that case the variable summer gens changes for the new position of the platform, therefore I should say the righting moment is given by B rho minus M B into g into l B that gives my buoyancy tank value minus M D g l D multiplied by theta. Where in this case B stands for the buoyancy which is provided by the buoyancy tank, l D is the length of the deck in sense distance of C g of the deck from the articulated joint, l B distance of center of buoyancy from the joint.

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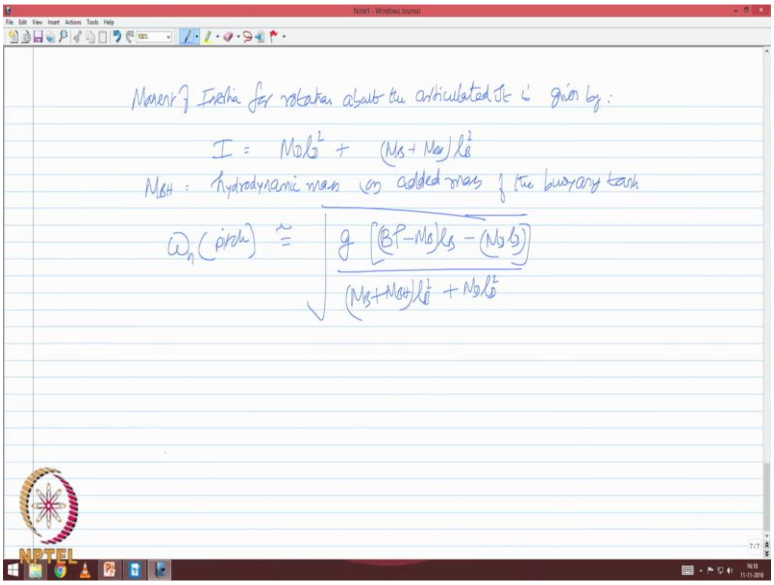

The moment of inertia for rotation about the articulated joint is given by M D l D square plus M B plus M BH of l B square. Where M BH is the additional hydrodynamic mass or what we otherwise call added mass of the buoyancy tank. Now the frequency n pitch degree because we talking about rotation is simply square root; I should say approximately g times of B rho minus M B into l g minus M D into l D divided by M B plus M BH of l B square plus M D l D square.

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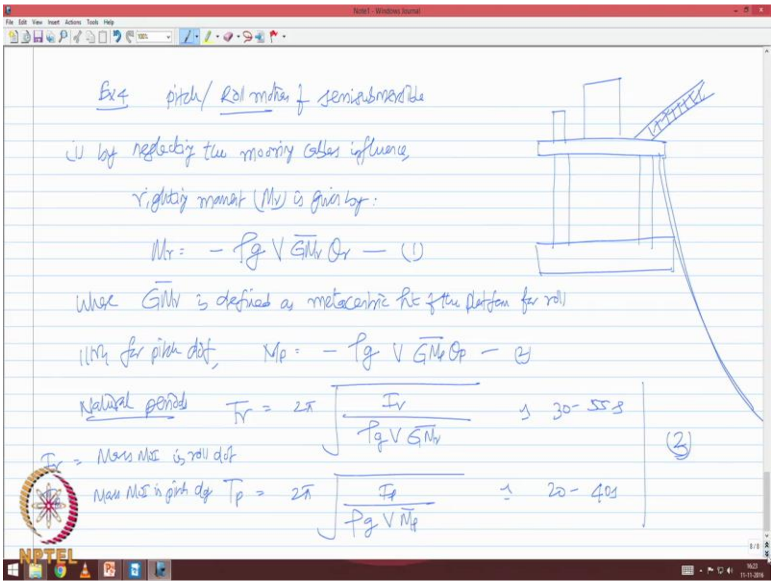

Let us do one more example. I want to find the pitch and roll motion of semisubmersible a typical semisubmersible has a deck supported on columns, rest thing on bottom pontoon with all top side, with the risers connecting. Now, by neglecting the mooring cables influence righting moment, I should say M r is given by rho g V G M r theta r; V G M r. Where G M r is defined as metacentric height of the platform, let us say for roll degree of freedom.

Similarly, for pitch degree of freedom M P the righting moment will be minus rho g V G M P theta. Hence, the natural periods in roll could be simply 2 pi root of I r by rho g V G M r which is approximately 30 to 55 seconds. In terms of pitch this 2 pi I p by rho g V M P which is approximately 20 to 40 seconds. Whereas, in the rolls expression I r is mass moment of inertia in roll degree of freedom and I p is the mass moment of inertia in pitch degree of freedom.

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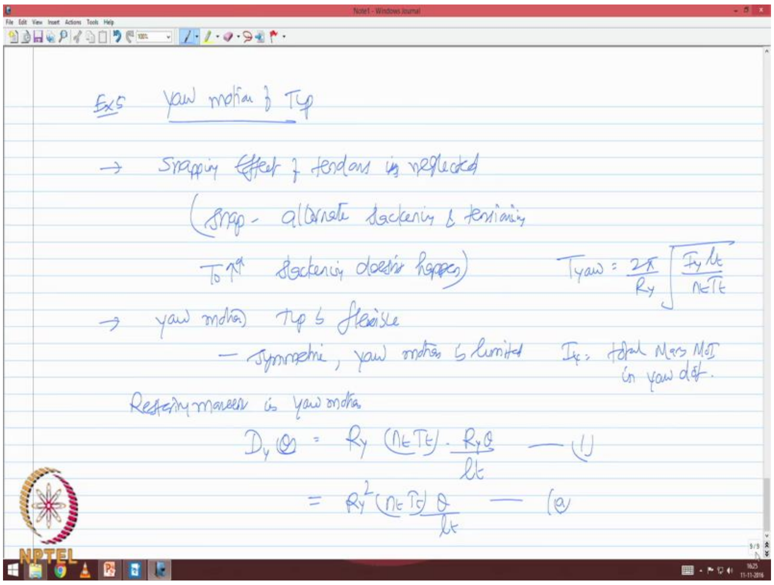

Let us try to calculate yaw motion of (Refer Time: 25:41) platform. While calculating so, the snapping effect of tendons is neglected. What is snapping effect? Snapping means alternate slackening and tensioning. Initial T 0 is so high slackening does not happen. We also agree in yaw motion TLP is flexible, but the platform is define symmetric. Hence, yaw motion is highly limited. The restoring moment in yaw motion is given by which otherwise and period in yaw is simply 2 pi by R y I y lt by n t lt. Where, in this case I y is total mass moment of inertia in yaw degree of freedom.

So friends, in this lecture we are trying to understand through simple examples and equations how we can estimate the restoring force, the initial stiffness, periods of vibration for different verities of offshore platforms under simple normal free vibration conditions. Now the question comes what is the necessity for the new generation platforms.

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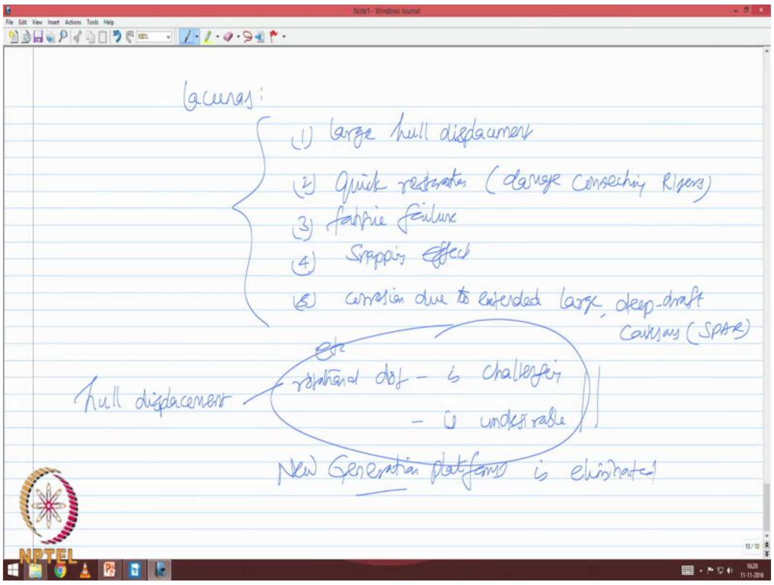

There are some lacunas which the existing platforms had: one, a very large hull displacement, very quick restoration which can damage the connecting risers, initiating fatigue failure, snapping effect, corrosion due to extended large deep draft caissons in case of spar etcetera. In all these cases you will see that the hull displacement essentially in rotational degrees of freedom is challenging, actually it is undesirable. So, the new generation platforms are conceived in such a manner that this primary problem is eliminated.

So friends, in the next lecture we will talk about those conceive geometry of new generation platforms, how are they conceived in idea, and what would be the efficiency of this platform in terms of eliminating rotation responses under normal environmental loads.

Thank you very much.