Computer Methods of Analysis of Offshore Structures
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Module - 02
Lecture - 04
Offshore Complaint Structures - 1 (Part - 1)

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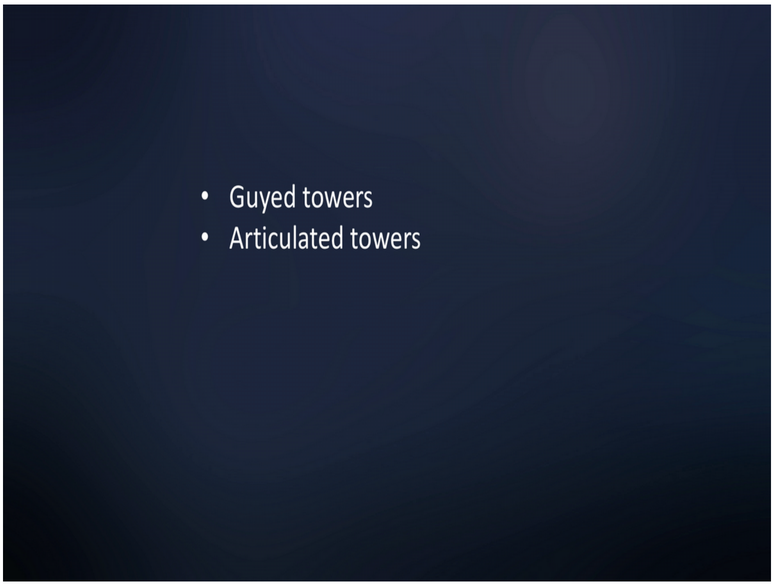

Friends, we are talking about compliant offshore platforms. We said that compliancy refers to flexibility. We also said by design, the platform need not remain flexible in all degrees of freedom.

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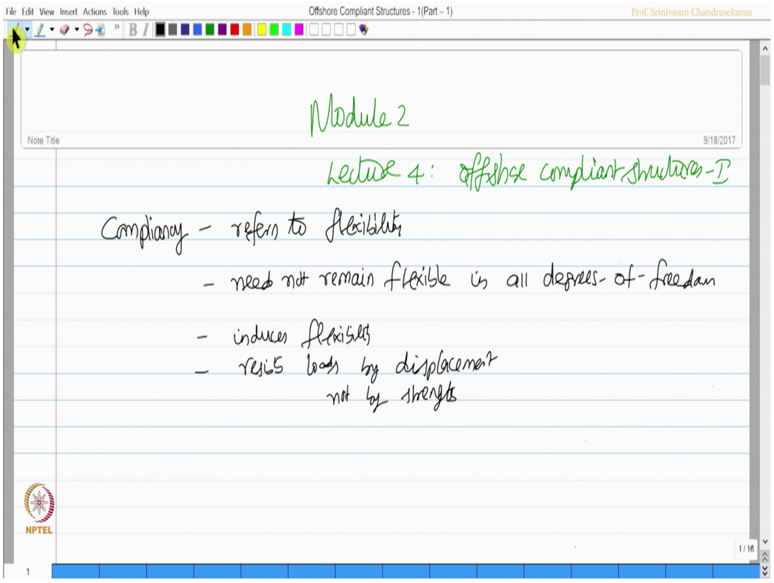

So, compliancy induces flexibility and platform resist loads by displacement and not by strength; having said this there are varieties of complaint platforms which are commissioned from shallow water, deep water and ultra deep waters.

So, what would be the essential source of strength of these platforms? These platforms, very strongly rely on the restoring buoyancy force, this is required to maintain stability and to ensure recentering capability. Now one may ask me a question why recentering capability is required in compliant structures; the answer is very interesting re centering is required, because the system is permitted to undergo large displacements.

So, we must check these displacements to be within the permissible limits. More interestingly these platforms avoid resonance.

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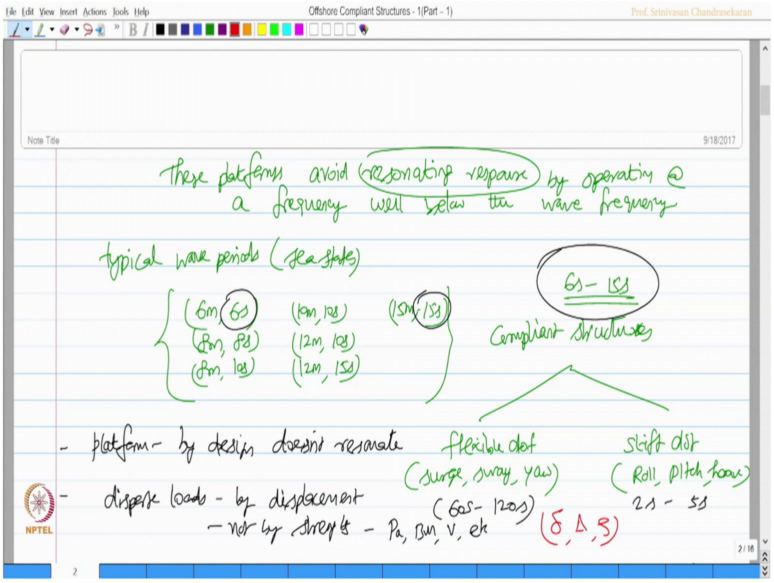

Or I should say resonating response by operating at a frequency well below the wave frequency. On the other hand, let us say the typical wave periods at which offshore platforms are commissioned for different sea states or typically; let us say 6 meter 6 seconds, 8 meter 8 seconds, 8 meter 10 seconds, 10 meter 10 seconds, 12 meter 10 seconds, 12 meter 15 seconds and 15 meter 15 seconds. These are some set of combination of the periods and wave heights, which are operable in different sea states where offshore platforms are generally commissioned.

So, I must select the system whose natural period should not lie in the band of 6 seconds to 15 seconds, so that I can avoid a near resonating response. So, typically compliant structures have two set of periods: one is for the flexible degrees namely; surge, sway and yaw. Other is stiff degrees namely; roll, pitch and heave. So, the typical periods of surge, sway and yaw vary anywhere from 60 seconds to as high as 120 seconds, which is much beyond the bandwidth. The typical periods of stiff degrees anywhere vary from 2 seconds to 5 seconds, which are also beyond the bandwidth of operational waves.

So, the platform by design does not resonate, that is the first advantage we have. The second advantage in response behavior is these platforms disperse loads by displacement or rigid body motion and not by strength so; obviously, friends to be very specific in terms of computer methods of structural analysis of compliant platforms we need not bother about the axial force, bending moment, shear force etcetera, but we should bother about the displacements in x y and z direction. We are going to bother about the displacement control, but not the strength or the stress control design at all.

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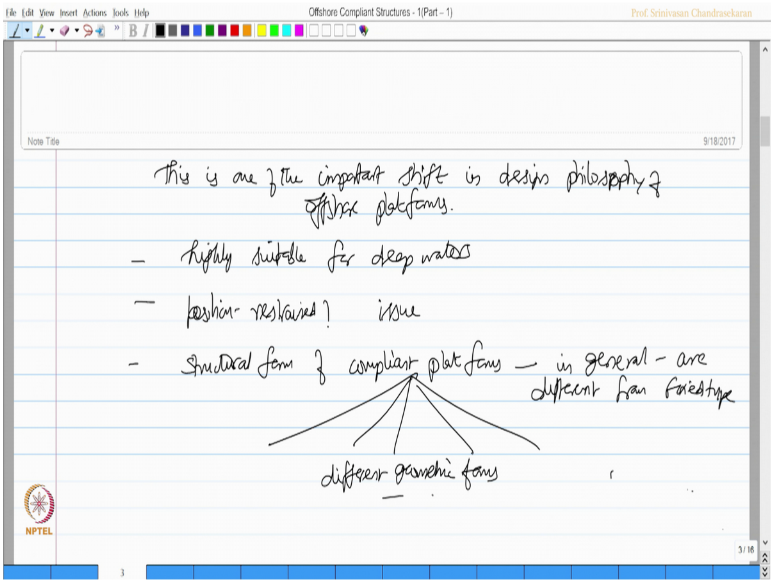

So, this is considered as one of the great advantage, this is one of the important shifts in design philosophy of offshore platforms. So, that is very important to realize at this stage. So, therefore; these structures are highly suitable for deep waters. So, how are they position restrained is an issue? This still an issue which varies with different types of compliant platforms, which we will now discuss; therefore, the structural form of compliant platforms in general are different from fixed type. Within compliant platforms, there are different geometries which all have same design philosophy, but variation in geometric forms which will.

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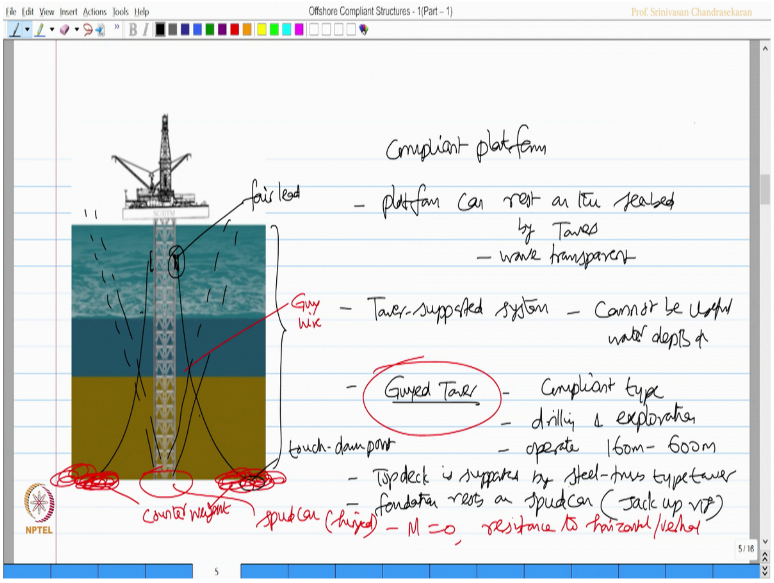

Now, see a typical compliant platform is shown in the figure. You can see the top side of platform and the platform is rested on the seabed; neither by fixed support nor by piles, but a lattice type truss type design tower. So, the platform can rest on the seabed by what we call as towers. Towers are essentially wave transparent, but; obviously, when towers are supporting the deck or the tall towers need to extend for the entire water depth; for example, you see here towers are extending for the entire depth therefore; any tower supported system cannot be useful for increased water depth, because the tower has to go for the entire water depth.

So, we must think of a compliant platform which should not be supported by the tower by some other mechanism. Before, we discuss that let us take a simple example of a compliant platform which is a guyed tower platform the one, what you see here its guyed tower platform, which is a compliant platform, compliant type platform which is useful for both drilling and exploration activities. They can operate in water depths anywhere from 160 meter to as deep as 600 meter, the top deck is supported by a steel truss type tower as you see in the figure, but the foundation is resting on the spud can which is similar to that of a jack up rig.

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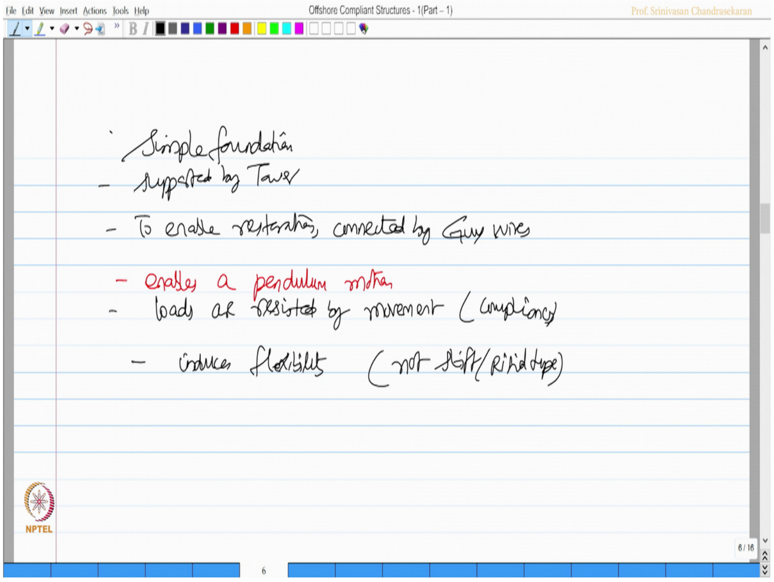

So, simple foundation supported by tower. Now to enable restoration they are connected by guy wires will be connecting the platform. This point where the guy wire connects the tower is called the fairlead. This point where the guyed tower connects the seabed is called the touchdown point; lot of counterweights are added at the touch down points. These are counterweights, to hold down the guy wire. So, this is the guy wire, that is; why this platform is called guyed tower. So, interestingly the platform enables a pendulum motion which is spud can at the bottom, which is more or less hinged boundary condition which takes no moment, but offers resistance to both horizontal and vertical, but no moment.

So, the system actually oscillates; when it oscillates to the left the Guy wire try to pull this back, when it oscillates to the right this guy was there to pull it back. So, this operation is what we call as re centering capability. So, the platform oscillates about the spectrum point and that moment that compliancy that displacement actually resists the loads encountered in this platform. So, loads are resisted by moment which we say compliancy. This compliancy induces flexibility and the platform is not a stiff or a rigid type.

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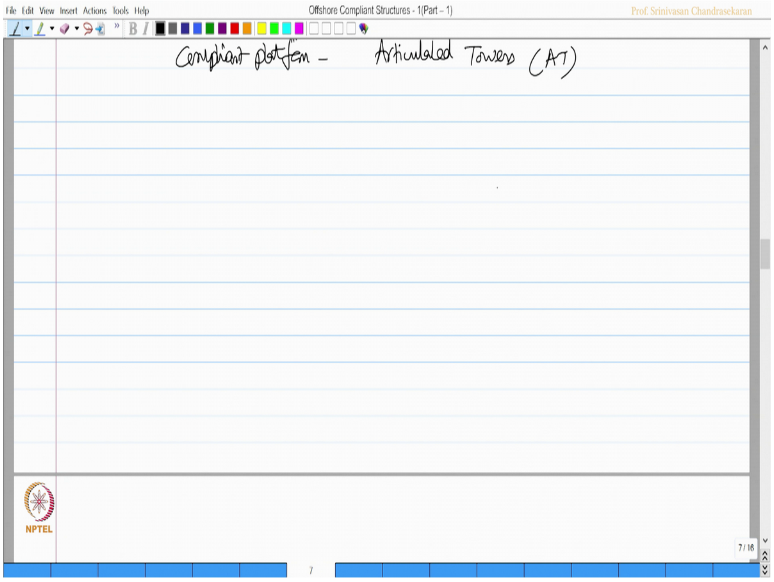

The second type of platform which is compliant platform is articulated towers.

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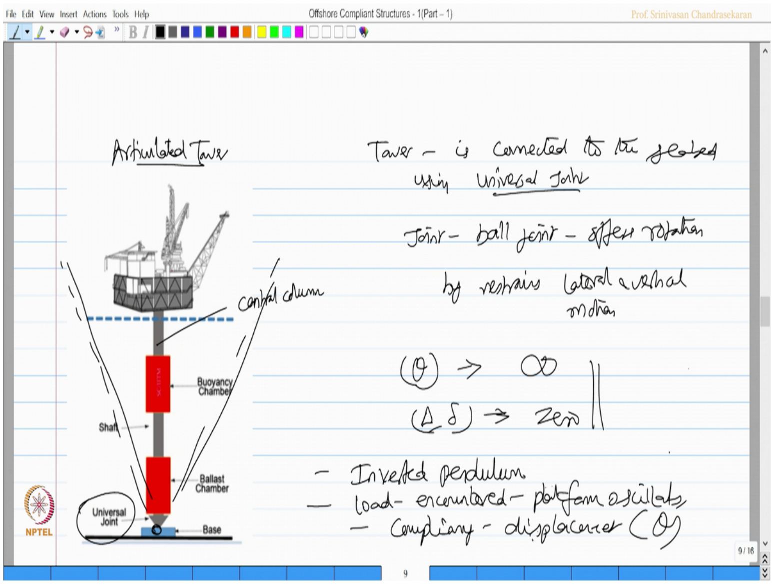

So, articulated towers briefly called as A T. A typical articulated tower looks like this, unlike guyed towers, articulated towers has a central core or a central column which is attached with a buoyancy chambers and ballast chambers, which is connected to the seabed you seeing universal joint. So, the connection the tower is connected to the seabed using universal joint. Universal joint is a joint, which is similar to that of a ball joint which offers rotation, but restraints lateral and vertical motion. So, theta at the joint is practically desired to be infinity, but delta and del at the joint practically is 0, that is ideology of this joint. So, this now acts as an inverted pendulum, because this is a point where and the pendulum is prevented and the platform will oscillate about this. So, again; when load is encountered, platform oscillates, that causes compliancy, because it is displaced the degree of freedom here displacement is rotation about the base.

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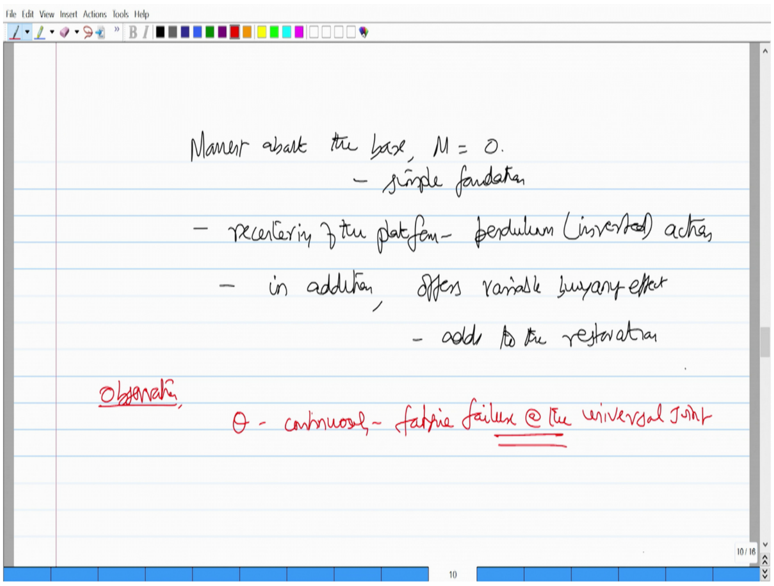

So, this implies the fact the moment about the base is 0. So, this has an advantage this initiates a simple foundation. So, the foundation not complex is very simple; re centering of the platform is ensured by I should say inverted pendulum action. In addition; to that when you look at this platform, the buoyancy chamber and the ballast chamber which are filled with water or oil also offers variable buoyancy effect which also adds to the restoration.

This kind a platform has one important observation. The observation is the platform will undergo rotation continuously which may cause a fatigue failure at the universal joint. So, that is one in important issue as far as these towers are concerned. So, what is the advantage of having compliancy?