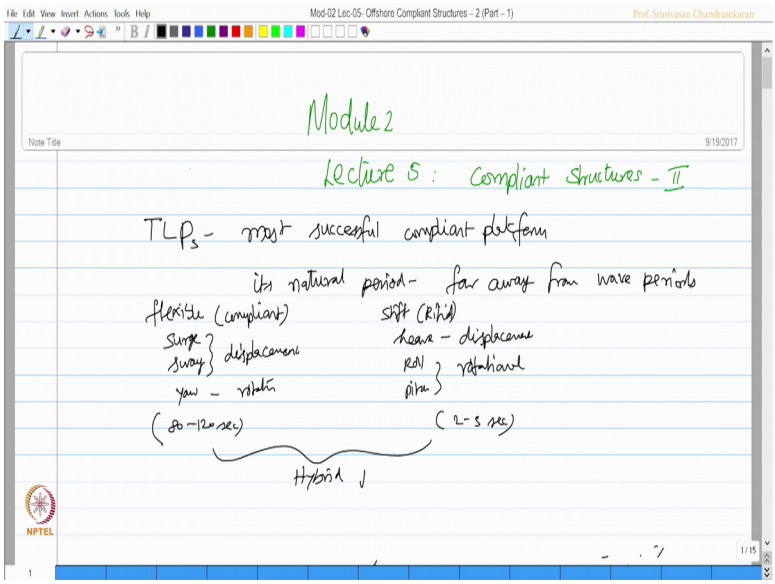
Computer Methods of Analysis of Offshore Structures
Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Module - 02
Lecture - 05
Offshore Compliant Structures - 2 (Part - 1)

(Refer Slide Time: 00:17)

Friends, welcome to the fifth lecture in module 2. In this lecture we will continue to discuss about the compliant structures more in detail.

(Refer Slide Time: 00:37)

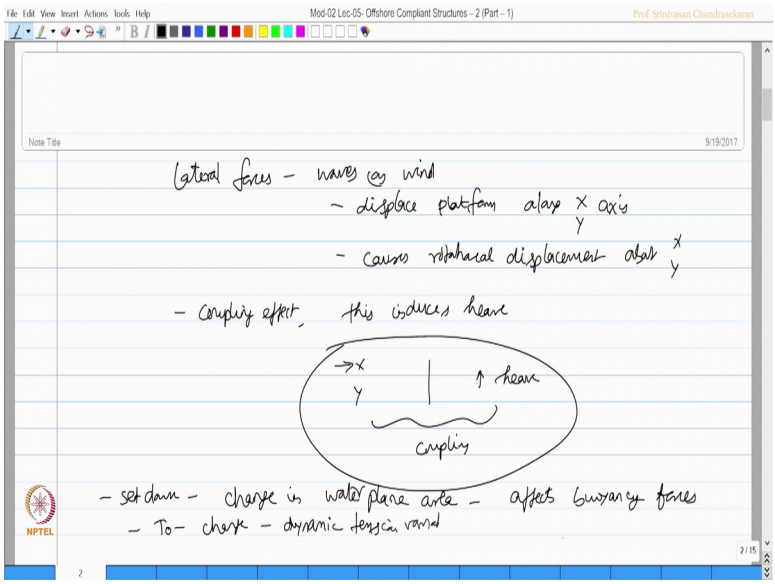


As a summary, we said that tension leg platforms which is one of the most successful compliant platform is designed, in such a manner that it is natural period are far away from the wave period. It has got 2 distinct bands of frequencies, one is highly flexible which is compliant degrees of freedom they are essentially surge, sway and yaw, out of which these 2 are displacements, degrees of freedom and this is rotational degree of freedom.

On the other band of frequencies is very stiff, which is very rigid, they are heave, roll and pitch. Heave is a displacement degree of freedom and roll and pitch are rotational degrees of freedom, a typical periods that we discussed in the last lecture varies anywhere from 80 to 120 seconds. In flexible degrees of freedom and this vary anywhere from 2 to 5 seconds in stiff degrees of freedom.

Since, platform has got an extreme combination of both flexible and stiff groups of degrees of freedom this platform is also called as hybrid platform.

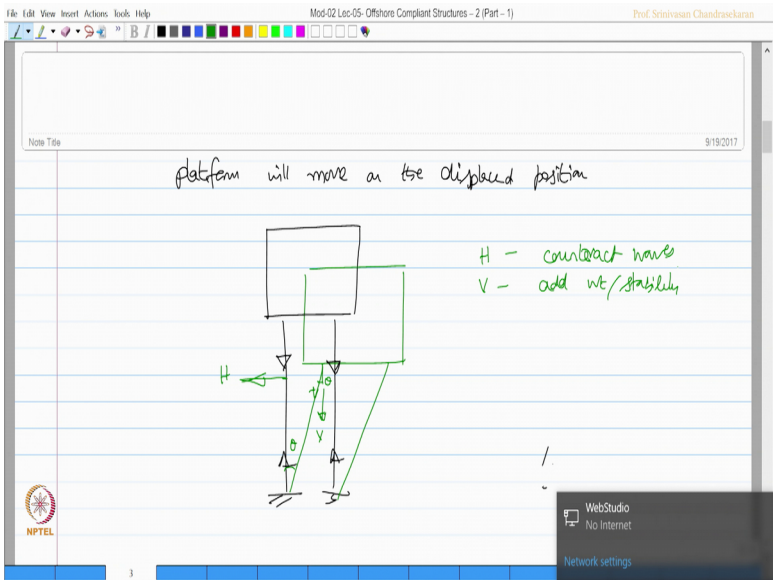
(Refer Slide Time: 02:28)



And extending the discussion further, the lateral forces acted upon by the waves or wind essentially, displaces the platform along x and y axis, as a case maybe it also causes rotational displacement about x or y axis respectively as the case may be. So, due to the coupling effect this induces heave motion. It is very interesting friends to realize that force are applied across x or y, but displacement happens along heave this is actually a strong coupling effect.

So, when we do an analysis of offshore platforms of this nature we must take care of this concept in the analysis that, there is an interdependency of degrees of freedom in the analysis we must remember this when we do the analysis for tension leg platforms. So, set down causes change in water plane area, which in turn effects or influences the buoyancy forces. Now, as a result the initial pre tension t0 will now change that is why, it is called dynamic tension variation.

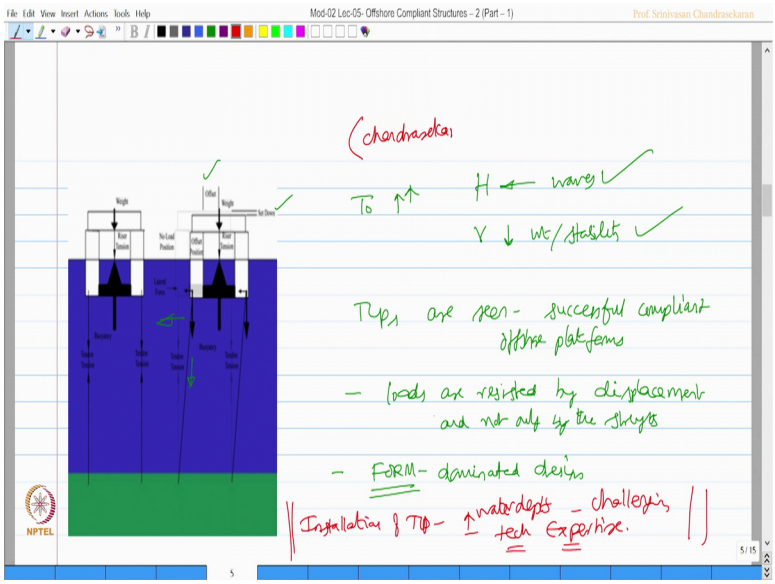
(Refer Slide Time: 04:15)



So, now the platform will move on the displaced position so when, I have a platform which is initially tethered to the sea bed, with initial pre tension of a very high value when the platform displaces to the right as the tethers are inextensible, the horizontal component of the tether and the vertical component of the tether, the horizontal components of the tether will counteract waves.

The vertical component of tether will add weight and it will improve stability. So, this is what we call as TLP Mechanics, and this offset this displacement is call offset and this displacement is called set down which is explained in this figure very clearly, that how the offset and set down induces horizontal and vertical component of the forces and these forces are very large, because t0 initially is very high, t0 value is very high. Therefore, the horizontal and vertical component will counteract the waves and this will impose weight and improves stability.

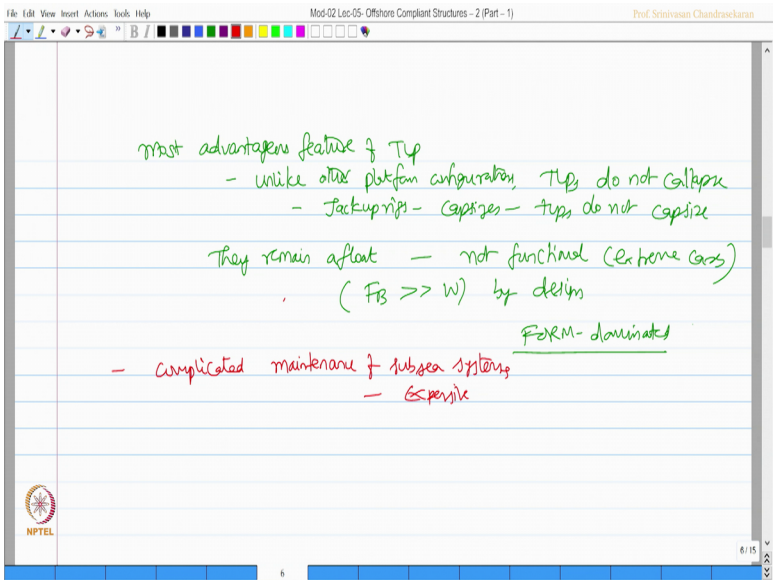
(Refer Slide Time: 05:29)



Having said this, TLPs are seen as one of the most successful compliant platforms, one can very easily see here loads are resisted by displacements and essentially not only by the strength. So, strength may not govern the design of such platforms, so we call this as form dominated design. So, the structural form or the geometric form of the platform is very important. It is conceived in such a manner that the displaced position forces counteract the lateral forces and induce the stability and recentering capability in the given system.

Adding to one more point installing TLP, at increased water depth is more challenging it needs a high technical expertise, it is due to this reason one can say the TLPs are expensive when you go for higher or greater water depths, that is the reason why they are expensive. Because construction or installation of TLP at higher water depths needs high technical expertise which is expensive this was reinforced by Chandrasekaran et al., in 2008, 2011, 2016, 2006, further it is also enforced used by Donley and Spanos, in 1991.

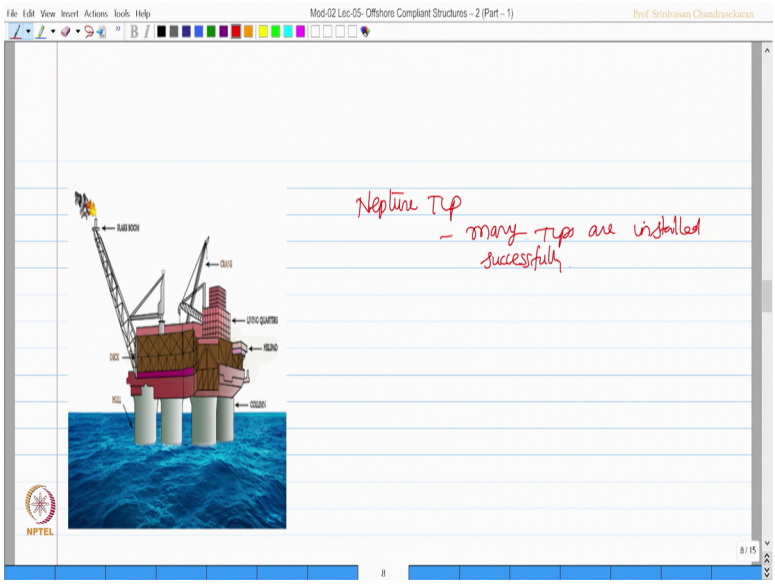
(Refer Slide Time: 08:30)



The most advantageous feature of TLP can be seen as, unlike other platforms or platform configurations TLPs do not collapse, like in case of jack up rigs which capsize TLPs do not capsize.

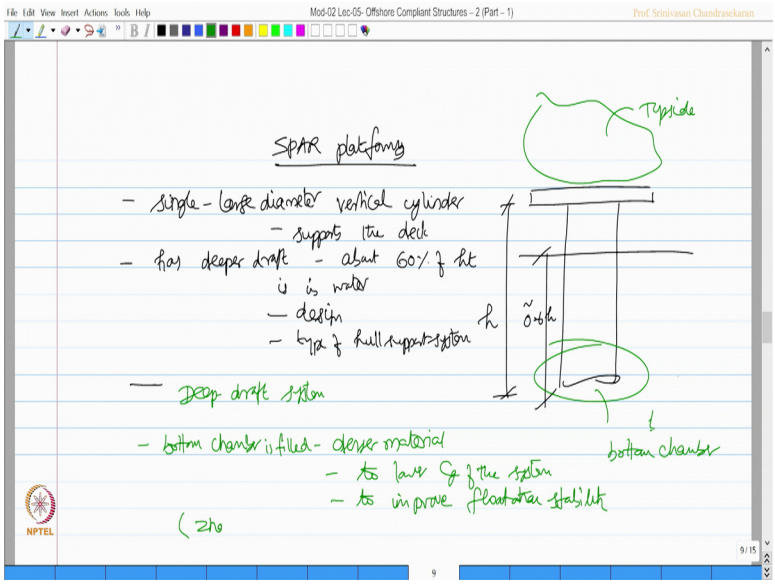
Then what happens to them they remain afloat, they may not remain functional under extreme cases, but they will remain afloat. Because buoyancy exceeds the weight by design so that is why we said it is form dominated design. One demerit it has got it has got a very high complicated maintenance of subsea systems which also makes it expensive.

(Refer Slide Time: 10:13)



So, there are many TLPs built across the world in different locations for completion sake this is one picture of Neptune TLP the other picture, so many TLPs are constructed successfully. So, TLPs have shown advantages in terms of restricting or dispersing the lateral loads by large displacements.

(Refer Slide Time: 11:03)



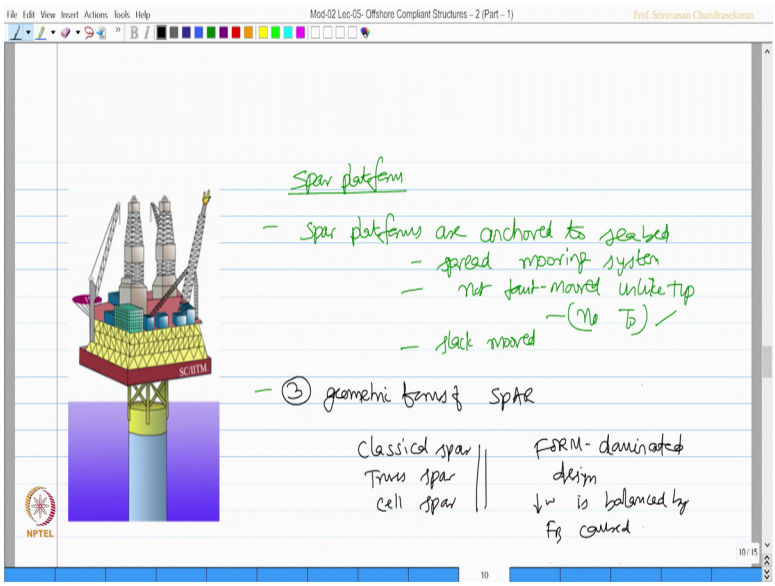
Alternatively, the next structural form which was chosen as an alternative to TLPs are SPAR platform, it consists of a single large diameter cylinder, this cylinder actually supports the deck. So the deck is there and it is supported by a single large diameter

cylinder, the cylinder is having a deep draft. It has deeper draft may be about close to 60 percent of it is height is in water. Let us say this is h this is about approximately 0.6 h.

Of course, this is governed by the design and type of the hull support system etcetera. So, essentially it is a deep draft system. The bottom chamber of the cylinder, the bottom chamber is filled with denser material; this is essentially done to lower the centre of gravity of the system. Because topside hull, has got lot of superimposed load to compromise and compensate that the bottom part of the chamber is filled with denser material, so that the C g is lowered to improve stability.

So, this was a concept which was verified by various studies conducted by Zhang et al., 2017, Ran et al., 1996, Agarwal and Jain 2002 and others.

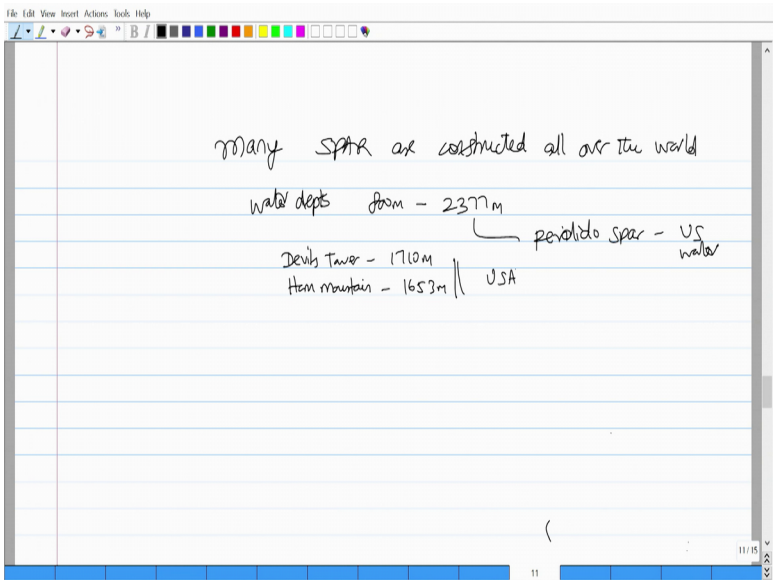
(Refer Slide Time: 13:33)



So, that is the typical structural form of a spar platform. Generally, spar platforms are connected to the sea bed by spread mooring system. These are, actually not taut moored unlike TLPs.

So there is no initial pre tension in this tethers they are slack moored. There are 3 types of structural forms of spar platform essentially classical spar, truss spar and a cell spar. So, again one can say this is form dominated design because the top weight is balanced by buoyancy caused by the cylinder draft.

(Refer Slide Time: 15:50)



Many spar platforms are constructed all over the world in the recent past the water depth where they are installed varies from 800 meters to as deep as 2337 meters, 2377 meter is the Perdido spar commissioned in US waters. Alternatively, you have Devils Tower which is at the depth of 1710 meter. You have Horn Mountain which is the depth of 1653 meters. Again both of them are commissioned in USA.