Computer Methods of Analysis of Offshore Structures
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Module – 02
Lecture – 04
Offshore compliant structures - 1

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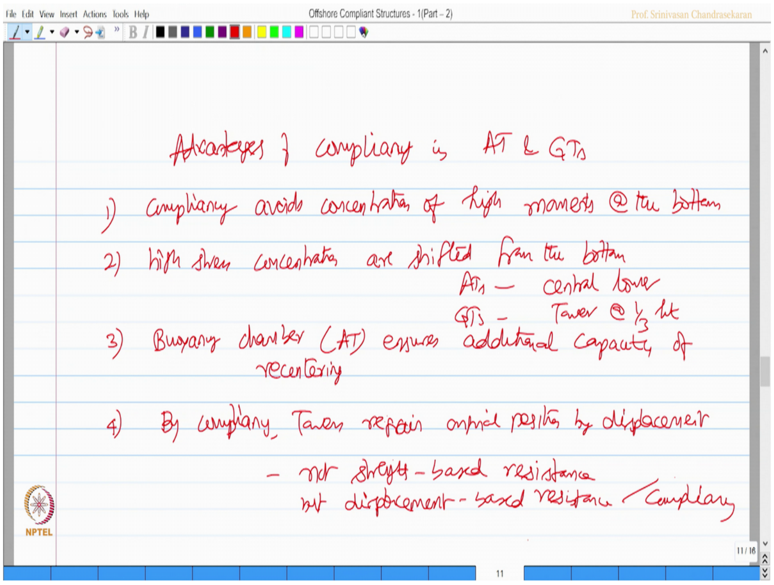

In this kind of towers advantages of compliancy in ATs and GTs that is guyed tower and articulated tower are, Compliancy avoids concentration of high moments at the bottom that is one major advantage we have therefore, high stress concentration are shifted from the bottom, maybe in ATs it is shifted to the central tower, in GTs it is shifted to again the tower at one third height.

The third issue is the buoyancy chamber in particular in articulated towers ensures additional capacity of re centering. So, by compliancy towers regain original position by displacements. In fact, I should say by undergoing large displacement. So, it is not a strength based resistance. But your displacement based resistance what we call as compliancy in addition.

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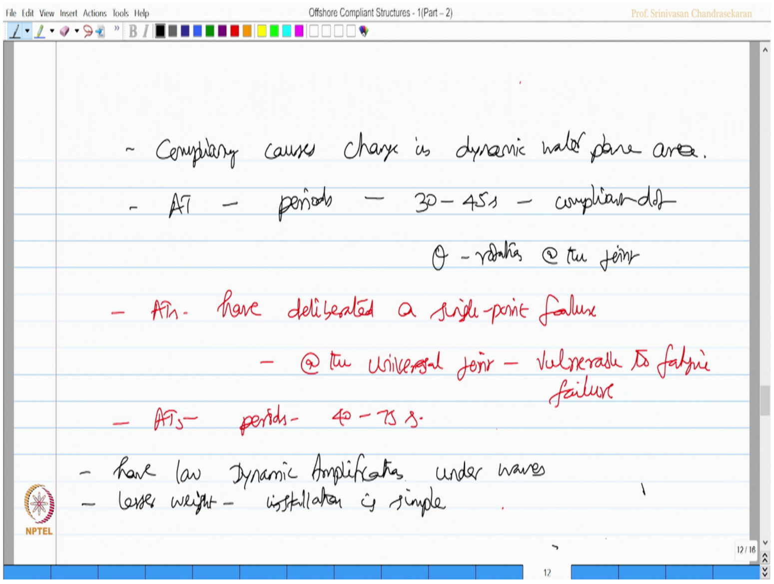

Compliancy causes change in dynamic water plane area. So, therefore, these towers again have periods, natural periods varying from about 30 to 45 seconds in compliant degrees especially the compliant degree of freedom for an AT is rotation at the base.

In addition as we just now saw ATs have deliberately a single point failure, can you guess where the failure would happen? Yeah, it will happen at the universal joint. So, universal joints are vulnerable to fatigue failure. Some designs of AT also have periods extending till 45 to 75 seconds as well. So, as a result these structures have low dynamic amplification under waves.

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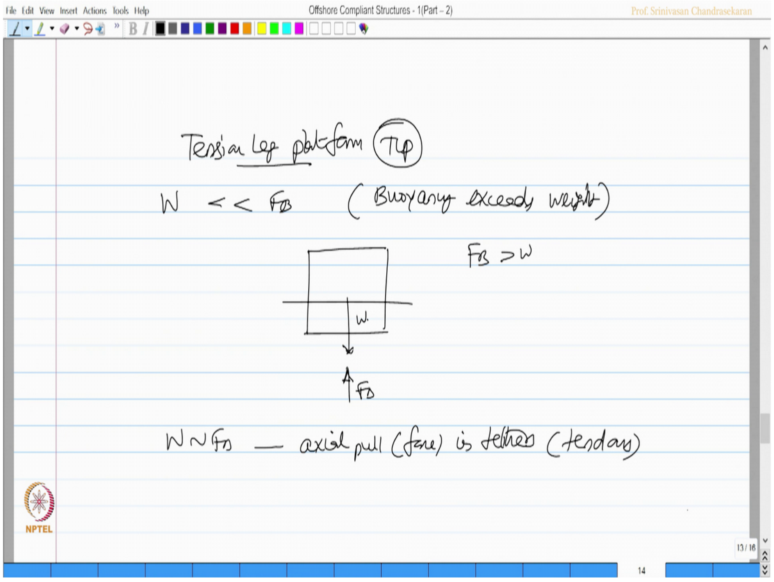

They also have less weight, so installation is simple. The next variety what we can have in compliant structures is tension leg platform TLP. TLPs are designed where the weight is much lower than the buoyancy or buoyancy exceeds the weight by design. Now weight is acting downward, buoyancy will act upward and buoyancy exceeds the weight.

The difference between the buoyancy and weight is to be compromised by the axial pull or axial force in tethers, they are also called as tendons.

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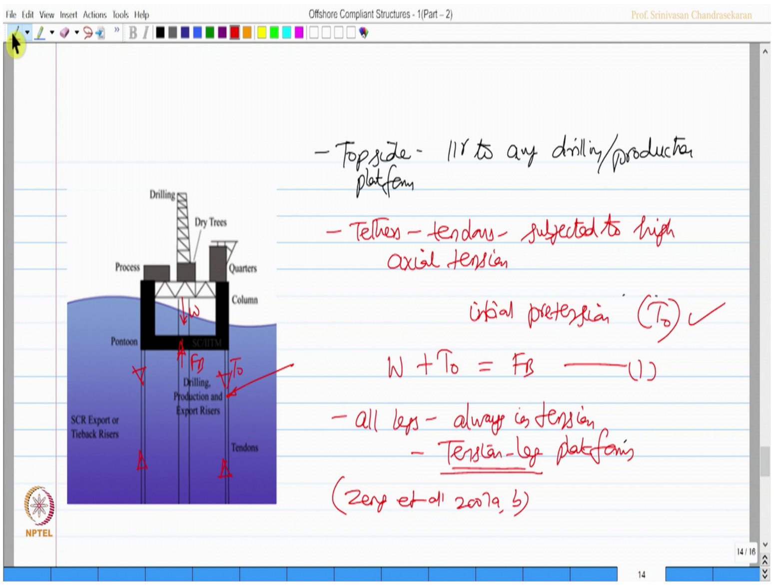

So, the figure shows the typical tension leg platform whose top side is similar to any drilling or production platform. So, now, these are the legs which are called otherwise tendons or tethers. They will be under axial tension, so tethers otherwise called as tendons will be subjected to high axial tension, they are called initial pretension indicated as T 0. So, now, W will have downward, F B will act upward, T 0 will act downward, so W plus T 0 will be F B that is equation of static equilibrium of tension leg platform where T 0 is initial pretension offered.

So, it is very simple a system has excessive buoyancy it will be pushed up to hold it down tethers will pull them down. So, all legs will be always intention that is why these platforms are called tension leg platforms that is the reason why they are call tension leg platforms very interestingly the concept of TLP can be also read at different papers two 2007 a and b by Zeng et al and other literature which he referred in the NPTEL website.

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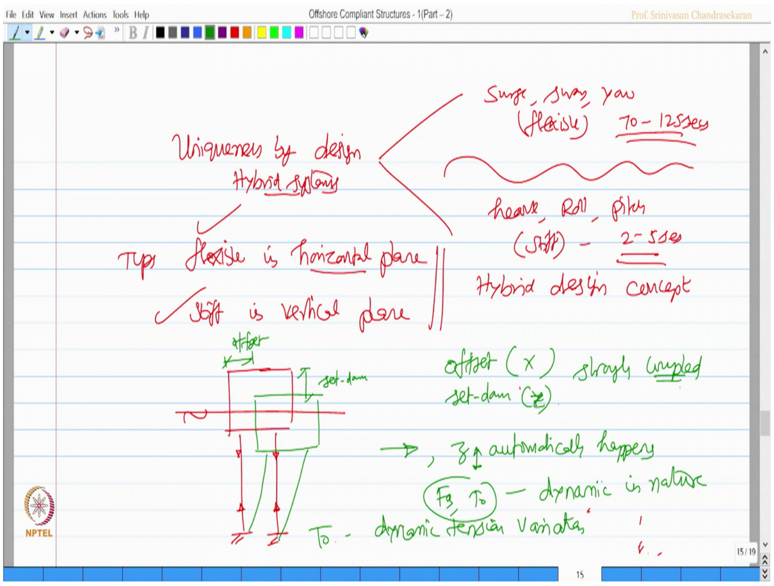

Now, TLPs have uniqueness in design there are two sets of frequencies of periods which are connected in TLP therefore, TLPs are hybrid systems which I explained you already. So, surge, sway and yaw which are flexible degrees will have periods varying from 70 to 125 seconds where as heave, roll and pitch will have periods they are stiff degrees will have periods 2 to 5 seconds.

So, the waves which will act on this platform will be in between, which will cause no resonance on the platform at all. So, I should say TLPs are flexible in horizontal plane and stiff in vertical plane because surge sway are displacements along X and Y which is horizontal plane and yaw is rotation about Z axis which is also will happen on the horizontal plane. Similarly, heave is displacement along vertical plane that is Z axis and roll and pitch are rotations about X and Y axis which also happen about the vertical plane. So, for low periods they are stiff therefore, it is stiff in vertical plane for larger periods they are flexible therefore, they are flexible in horizontal plane and put together this is call a hybrid design concept in offshore platforms.

So, interestingly when a TLP is subjected to a wave action TLPs will undergo displacements since tethers are inextensible this displacement along X is called as offset, this displacement along heave is called set down. So, one can now notice that offset which happens along X axis and set down which happens along Y axis sorry Z axis are strongly coupled.

What do you mean by coupling? When I give a X displacement display along Z automatically happens any displacement along Z will change the buoyancy will change T 0 and therefore, the problem is dynamic in nature that is why this T 0s otherwise called dynamic tension variation. So, we have advantages of alleviating the environmental loads by this kind of structural action.

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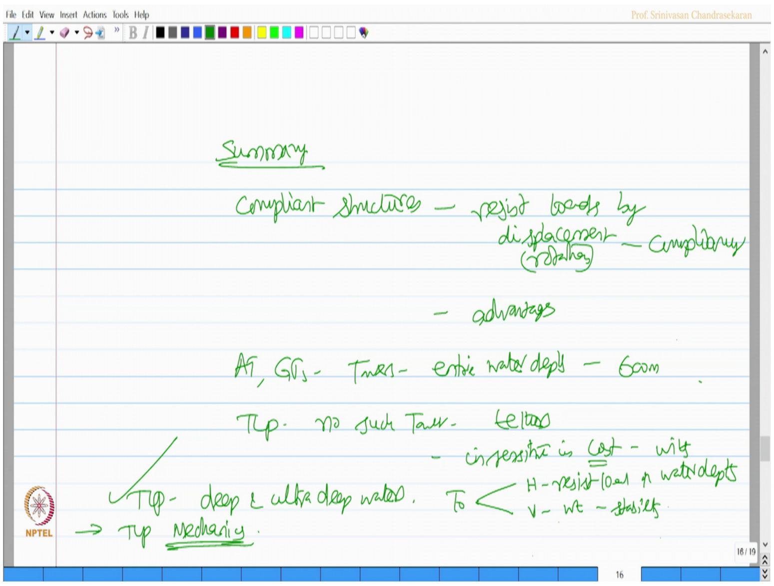

So, one can very clearly understand here that complain structures resist loads by displacement or you can say a rotation it does not matter in general by a compliancy in nature. This compliancy offers many advantages, but in case of ATs and GTs there are towers we need to extend for the entire water depth therefore, they are limited only up to a depth of 600 meters whereas, tension leg platforms has no such tower they are only tethers. Therefore, they are insensitive in terms of cost with respect to increase in water depth. So, therefore, TLPs are preferred for deep and ultra deep waters.

Further we also saw when TLP is subjected to a lateral push the change in tension the horizontal component will offer resistance to the load the vertical component will add stability. So, T 0 horizontal component will resist the load where as vertical component will adds weight which improves a stability. So, TLP has good re-centering capability restoration concept simple in design insensitive in cost with respect to water depth and simple advantage, so this is what we call as TLP mechanics.

So, in the next lecture we will also see some more offshore platforms which are meant for ultra deep waters and new generation platforms which are recently conceived we will talk about their structural action very quickly and understand how these kinds of platforms are useful for deep and ultra deep water oil exploration and production.

Thank you very much.