Offshore structures under special loads including Fire resistance
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Lecture – 04
Offshore Structures: Novelty of Floating Platforms

Friends, welcome to the online course title offshore structures under special loads including fire resistance design.

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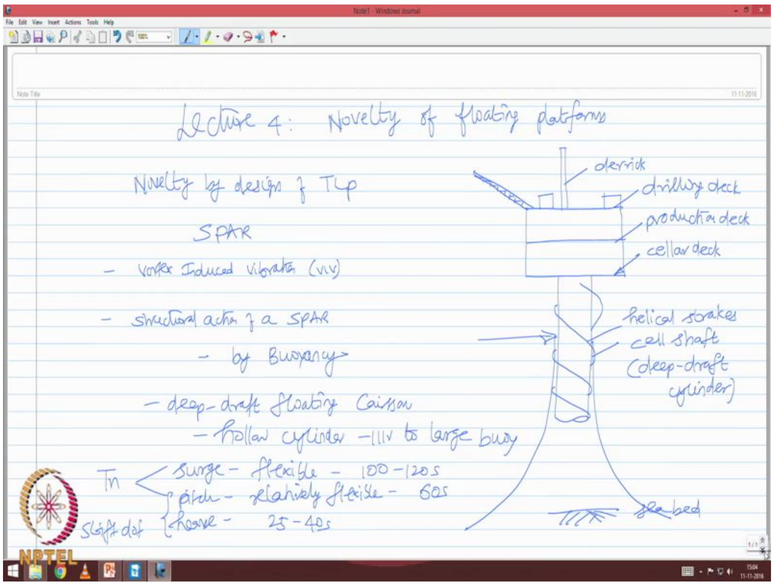

We are now talking about the 4th lecture, which, will be again focused on novelty of floating platforms, just you have a leap over what we discussed in the last lecture. We discussed about the novelty by design of a tension leg platform, we will extend the discussion for a spar platform now before we move to discuss on floating platforms.

A typical spar platform looks like this, which is gone multi level desk, which will have a drilling derrick which will have the flare boom, which may have living quarters another. So, this is may be a drilling derrick etcetera, this is what we call as cellar deck, this we can say production deck, this of course is the drilling deck. So, this becomes the top side detail where all other electro mechanical equipments are housed.

Now, the question is how this will be supported to the sea bed? This is my sea bed; this will be connected by a cell shaft, which is nothing but a deep draft cylinder. Generally because of the extensive length of the cylinder compare to the thickness of the cylinder, it undergoes vertex induced vibration, to essentially avoid this problem they are strengthen with helical strakes. Just to, additionally support this sometimes there can be a mooring line, but it is not necessary.

So, essentially the structural action of a spar is by buoyancy. It has got essentially a deep draft floating caisson which is nothing but this, which is essentially a hollow cylinder, this similar to a large buoy. If you look at the periods of the spar platform, in surge it is very flexible which can go about, 100 to even 120 seconds. Surprisingly in pitch it remains relatively flexible about 60 seconds and in heave about 25 to 40 seconds whereas, if we remember in tension leg platforms these two were stiff degrees of freedom the periods were very very low, where as in a spar they are considered to be flexible degrees of freedom.

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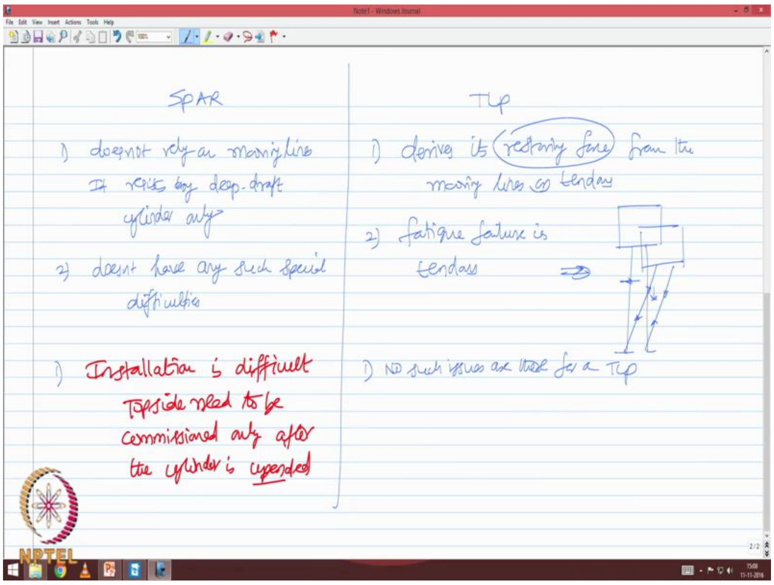

Now, let see why such a decretory difference as been made in the conceptual form of the spare platform compare to TLP. The foremost difference between TLP and spar TLP derives is restoring force from the mooring lines or otherwise called as tendons.

So, if TLP is anchor to the sea bed, if TLP moved to the right the tension in the cable or the tendons the horizontal component encounters the wave on the vertical component act to it is straight that improves stability. So, the restoration essentially happens from the tendons, where as spar does not rely on mooring lines, it resists by the deep drop cylinder only. They also said in TLP because of reversal of forces which are axial in nature in the tendons, it can be subjected to a fatigue failure, where as spar does not have any such special difficulties.

But spar as one demerit installation is difficult because top side need to be assembled, let say commissioned only after the cylinder is upended, where as no such issues are there for a TLP. Let us quickly see what advantages spar has compared to TLP?

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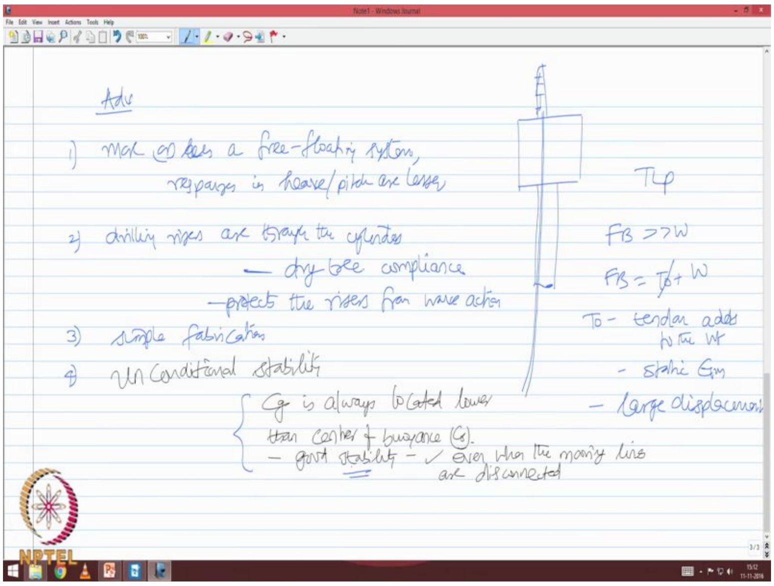

Since it is more or less a free floating system more or less similar to a free floating system, the responses in heave and pitch are lesser.

One major advantage what spar has compared to TLP for example, the drilling line or through the cylinder for example, this is my spar platform, this is my cylinder and drilling derrick, the drilling raisers will be through the cylinder which ensures a dry tree. So, this protects the risers from wave action. So, great advantage it is simple fabrication most importantly it has got unconditional stability, why because the mass center is always located lower than the center of buoyancy, which ensures good stability; in sense the stability is ensured even when the mooring lines are disconnected.

Friends you will realize that this case is not true in case of TLP, because in case of a TLP FB exceeds the weight and FB and weight are compromised with initial tension. So, initial tension in the tether or tendons add to the weight, adds to the static equilibrium therefore, when tendons are removed since buoyancy exceeds the weight, they will have a very large displacement therefore, drilling is difficult; where as in case of a spar platform it has got very high stability, even on removal of the mooring line they will still stay stable of course, spar platforms have disadvantages.

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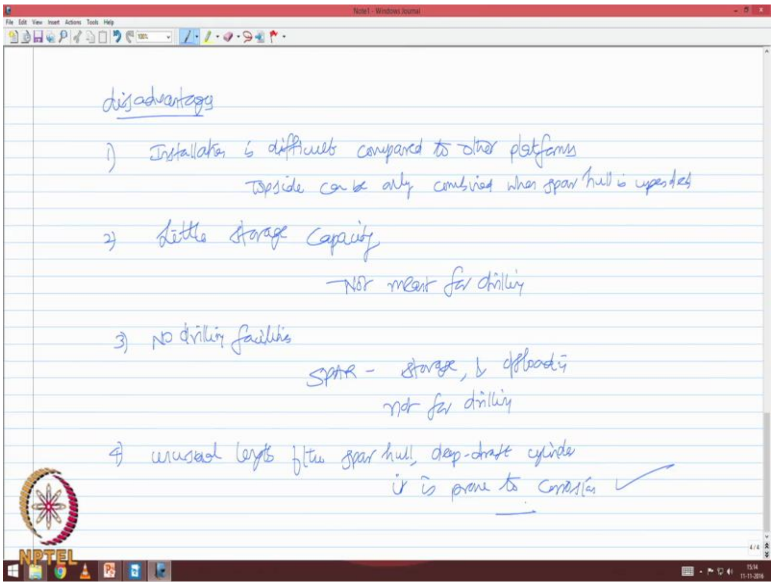

As I said in the beginning, installation is difficult compare to other platforms; it is because top side can be only combined when the spar hull is upended. The second foremost issue is it has got a very little storage capacity, it is not meant for drilling so essentially it as no drilling facilities, spar platform are essentially used for storage and offloading, not for drilling. The fourth demerit is because of unusual length of the spar hull or what we call as the deep draft cylinder, it is prone to corrosion that is the problem.

Let us now move on to the novelty in floating structures.

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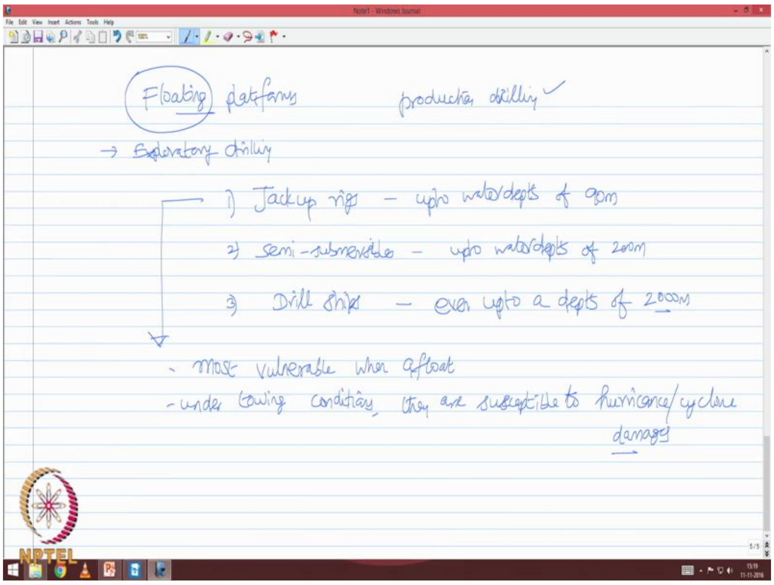

There are other floating platforms which are also constructed offshore; most common platforms are used for exploratory drilling. Friends there are 2 types of drilling one can do; one is called production drilling, once the drilling wells are established and yield is conformed people start production that is production drilling to check whether the well can yield oil people also do exploratory drilling, so there are platforms constructed for exploratory drilling which are essentially of floating type. One famous example which is commonly used for exploratory drilling is jack up platform, they are called as jack up rigs they are suitable up to water depth of about 90 meters. The second type what we use for exploratory drilling is semi submersibles, they are suitable approximately up to water depth of 200 meters; if you want to go for deep water drilling in terms of exploratory purposes, people modified the existing hulls forms of vessel and convert them into what we called as drill ships.

So, drill ships can do an exploratory drilling even up to a depth of 2000 meters. Now let us quickly see what are those difficulties with each one of them, jack up rigs as specific difficulties, they are most vulnerable when afloat.

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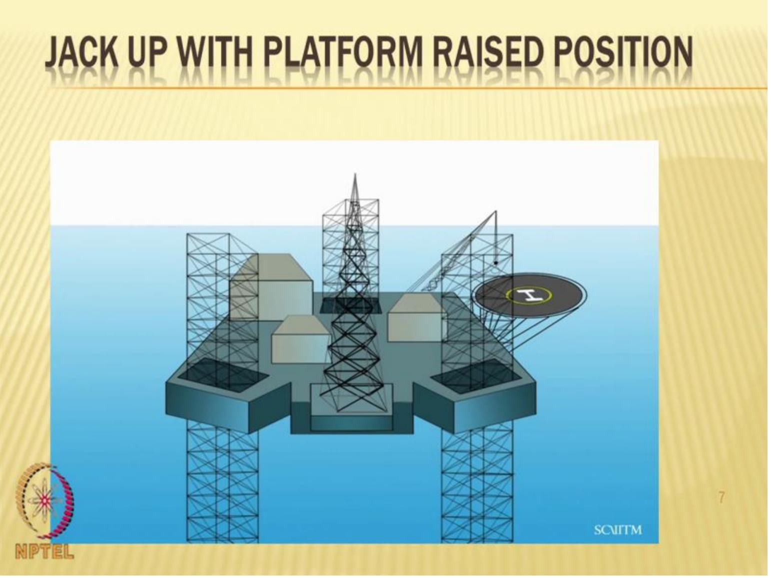

If you look at the screen, a typical sketch of a jack up rig is shown, these are the legs of rigs, the 3 lattice stresses or the legs of the rig then what you see in the gray color is a hull. The hull has all facilities like living quarters, electro mechanical equipments, helideck, crane lifting etcetera. So, usually when the jack up rig is remaining afloat these legs will be pulled up and the hull will be at the bottom and it float as when the legs are pulled up. When the jack up rig reaches the site by extra ballasting, the hull is pulled up at the same time the legs are driven into water that is why it is called jack up rigs. So, this figure shows the platform in a raised position, generally jack up rigs are vulnerable when they remain a float therefore, under towing condition they are susceptible to hurricane or cyclone damages.

Coming to the part of semi submersibles.

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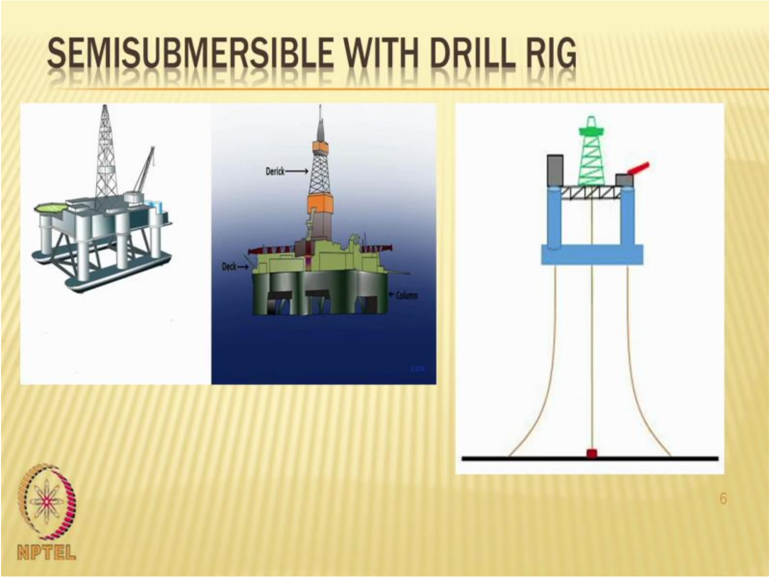

Please pay attention to the figures shown in the slide now. So, typical semi submersibles shown here it as got all top side details as the topper drilling platform, it has got a drilling derrick it has got multi level deck. It has got the flare boom and the cranes, supported on columns and pontoon members which remains it a float, when they reach to the position they will be anchored or move to the sea bed, mooring can be done either with help of GPS that is gravitation position system or one can also use the mooring lines.

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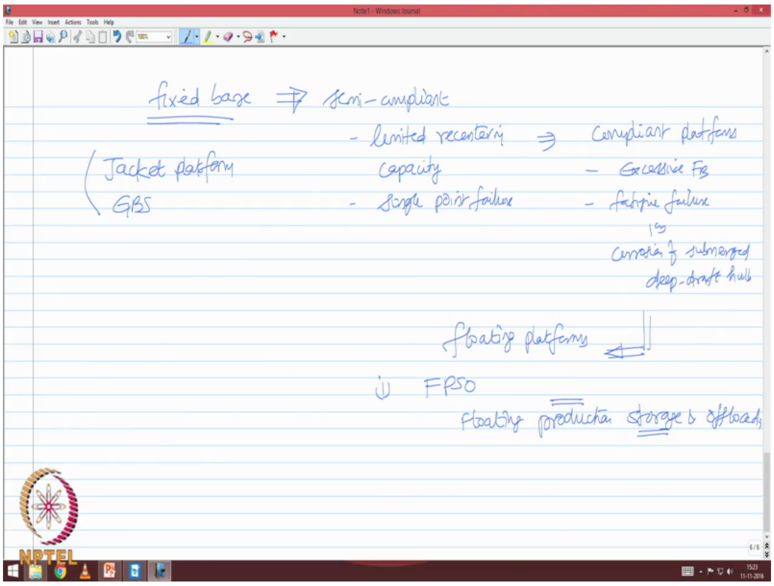

Interestingly as we move forward, we now realize that offshore platforms started with the geometry of fixed base, there were some difficulties therefore, new semi complaint type platforms were launched, these platforms had very limited recentering capacity, they also had what we call by design a single point failure. Then people moved on to compliant platforms, they actually resist the loads by excessive buoyancy, but there were issues related to fatigue failure or extensive corrosion of submerged hulls. Improvement will led to formulate completely floating structures.

So, friends one can see a very clean novelty which has happened in the structural form of offshore structures, starting from a fixed type which has got TLP, jacket platform, gravity based structure to that of completely floating platforms. The most commonly floating platform is FPSO, FPSO is Floating Production Storage and Offloading, it has got both the facilities production facility and storage facility.

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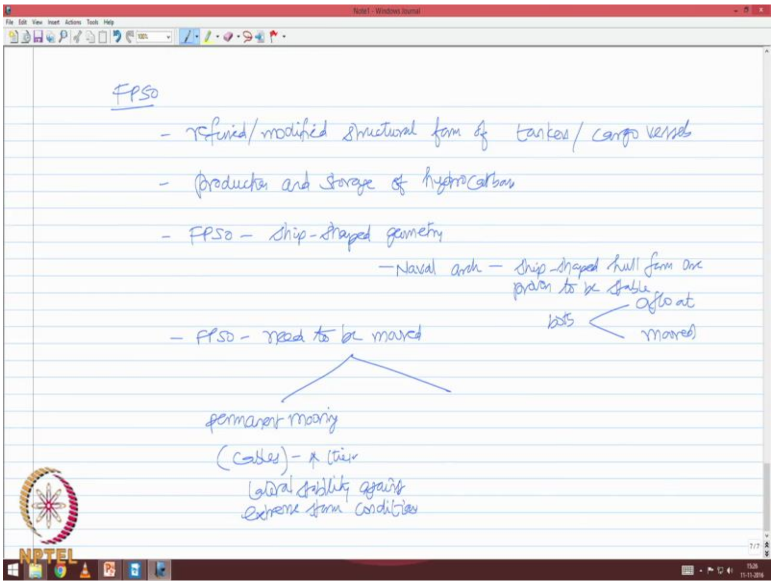

FPSO is actually are nothing but refined or modified form of tankers or cargo vessels. The foremost functional novelty in FPSO is production and storage of hydrocarbon. Usually FPSO’s or ship shaped geometry, one may ask me a question why they are ship shaped geometry because it is very clear in naval architecture, that ship shaped hull forms are proven to be stable both when they are a float and when they are moored. However, when we want to do exploratory drilling FPSO’s need to be moored, there are two ways of mooring them one can be a permanent mooring with help of cables, they help of cables can improved their lateral stability against extreme storm conditions.

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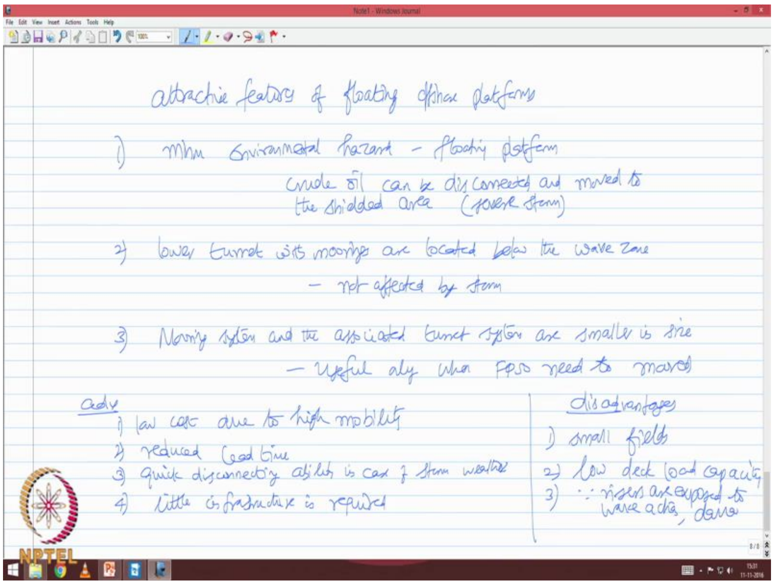

Floating structures have some special attractive features, there is a minimum environmental hazard cost wave floating platform because crude oil can be disconnected and moved to the (Refer Time: 27:28) area, when there is a severe storm. The second advantage could be lower turret system with moorings or located below the wave zone and therefore, not affected by a storm. The third attractive feature could be the mooring system and the associated turret systems are smaller in size; they are useful only when FPSO need to be moored because FPSO can otherwise stay afloat because they are designed to stay afloat in stable condition.

There are many advantages we have under floating platforms, very low cost due to high mobility, they have a very very reduced the lead type. FPSO's can be higher and they can use at different locations, they have a very quick disconnecting ability in case of storm weather. It recovers a very little infrastructure because you know only the existing hull forms are modified. Of course, they have some demerits, they are useful only for small fields large, oil production fields cannot be commanded by an FPSO or any floating platform, they have a very low deck load capacity, since risers are exposed the drilling risers wave action they can be damaged, it has a very little oil storage capacity.

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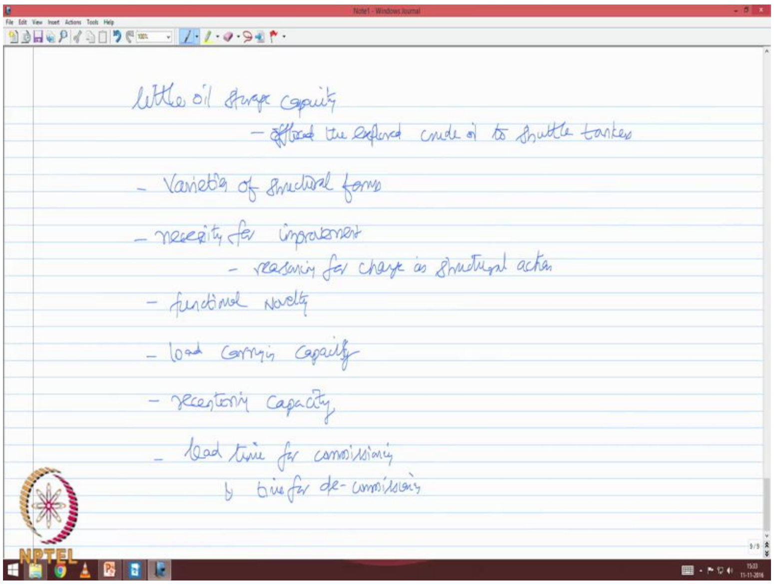

So, unit actually offloads the explored crude oil to some shuttle tankers for further processing. So, friends we had seen different kinds of structural forms, their necessity for improvement, reasoning for change in structural action, their functional novelty their load carrying capacity, their recentering capacity, their lead time for commissioning and time for de-commissioning. Having said this before we try to understand what are those special environmental loads which can cause damage to these kinds of platforms, let us speak something more about specific kinds of failure that happens in complaint structures.

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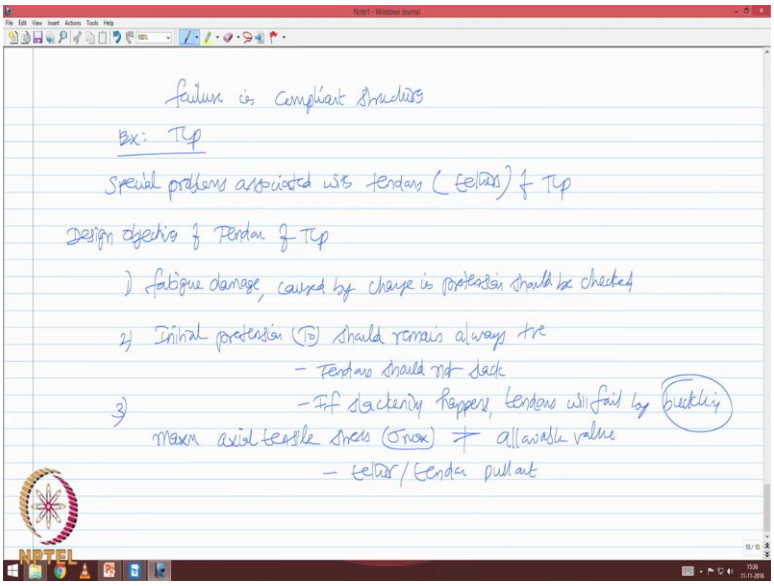

Very briefly we will talk about this; we will take an example as tension leg platform, there are some special problems associated with tendons or let say tethers of tension leg platform. What should be the design objective for designing a tendon of a TLP? Let us ask this question. What are the design objectives of tendon of a TLP? There are 3 objectives.

The first objective is fatigue damage caused by the change in pre tension should be checked, it should not fail with fatigue. Initial pre tension what we say as T0 should remain always positive. What does it mean? It means that the tendons should not slack, if slackening happens tendons will fail by buckling. So, that is the important failure mode what we have in one of the commonly used complaint structure which is just tension the platform, which is the fore most design objective. The third objective as we all know the maximum axial tensile should not be more than the allowable value otherwise it may result in tether or tendon pull out.

Before we understand further more complexities in terms of estimating of loads on the structures; let us ask the question in case of a tendon, what could be the kind of material used?

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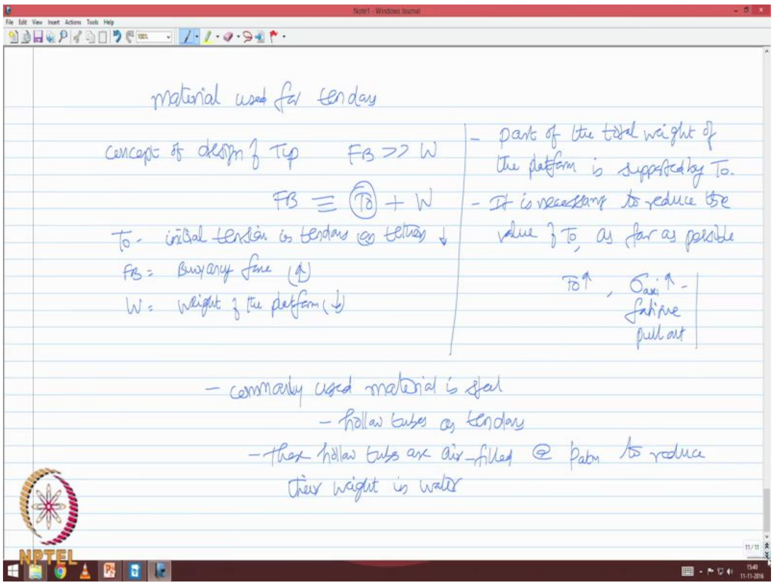

To answer this let us ask the first question, what would be the concept of design of TLP? The conceptual design of TLP is buoyancy should exceed many time by weight. In fact, buoyancy and weight should be equated by initial tension in the tethers. Buoyancy force which act upwards, weight of the platform which act downwards, since buoyancy exceeds the weight T0 also acts downward.

So, what does it mean? This means that part of the total weight of the platform is supported by T0 therefore, it is necessary to reduce this value as far as possible because more the value more this axial stresses, more the fatigue failure, more the pull out. So, what material is generally used? Commonly used material a steel, people use hollow tubes as tendons. Usually these hollow tubes are air filled at atmospheric pressure, to reduce their weight in water.

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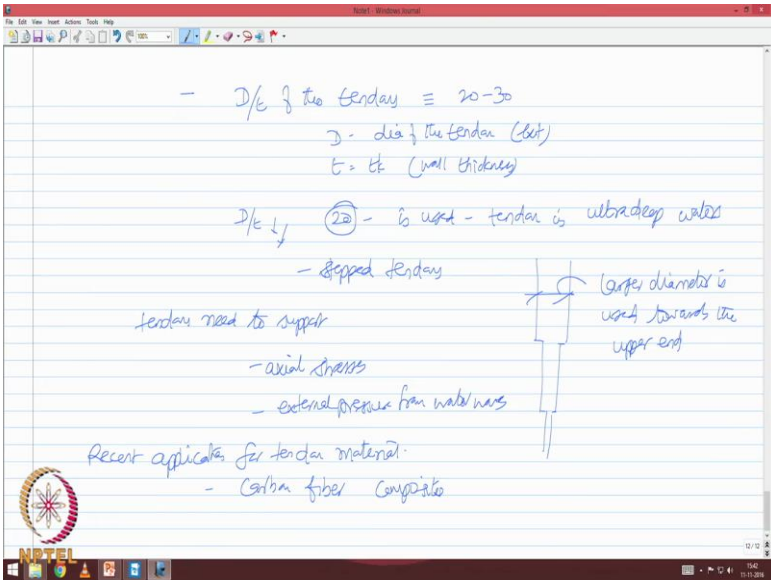

The ratio of diameter of the thickness is usually kept of the tendons; it is usually kept between 20 to 30. Where D is a diameter of the tendon we can say external diameter; t thickness of the tendon otherwise called as wall thickness. The dubitative values are further decreased may be the lower value 20 is used when you go for tendon commissioning in ultra deep waters. People also use stepped tendons, where the larger diameter is used towards the upper end; tendons need to support axial stresses and the external pressure from sea water waves, recent application for tendon material is carbon fiber composites.

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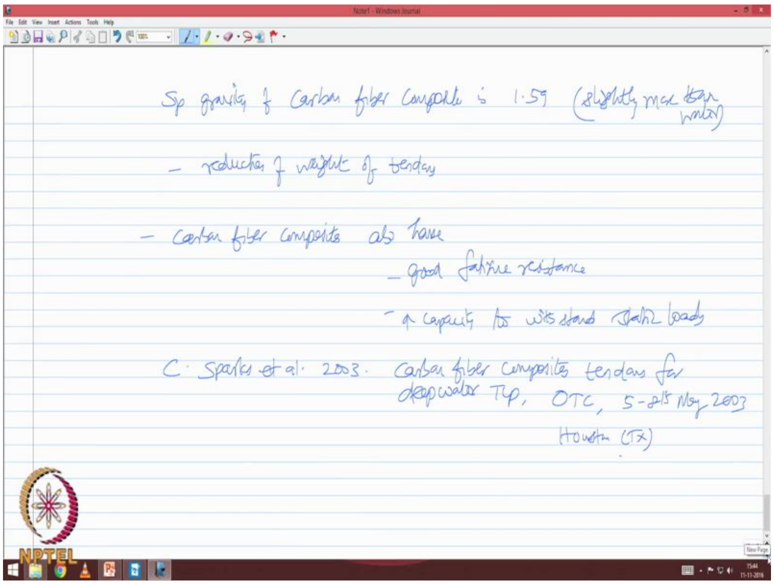

The specific gravity carbon fiber is about 1.59, which is slightly more than water. This enables reduction of weight of tendons; the carbon fiber composites also have good fatigue resistance and high capacity to withstand static loads. More information can be seen from recent studies conducted by C Sparks et al 2003; carbon fiber composites tendons for deep water TLP, offshore technology conference 5-8th may 2003 Hustle.

So, friends we are slowly now understanding different structural forms that are required for offshore platforms to stay in position. What are the kinds of loads generally act on these platforms, which are conventional for which these members are usually designed with international codal provisions. However when special loads acts on the structure, their behavior is entirely different which even challenges their existence in even normal (Refer Time: 44:41). So, our intention in this course is to make you understand what are those response behavior novelty of this platforms under special environmental loads including fire resistance, which is one of the important agenda and objective of this course.

However, without understanding the structural form and conventional behavior under normal loads, it is not advisable and interesting to really know the response behavior under special loads. As a matter of fact we should do couple of exercise problems to really understand how to compute the natural period, the restoring forces, the stiffness offered by the cable and mooring lines under these kinds of platforms by simple example which we will do in the next lecture.

So, in this lecture we summarize then we discussed about spar platform.

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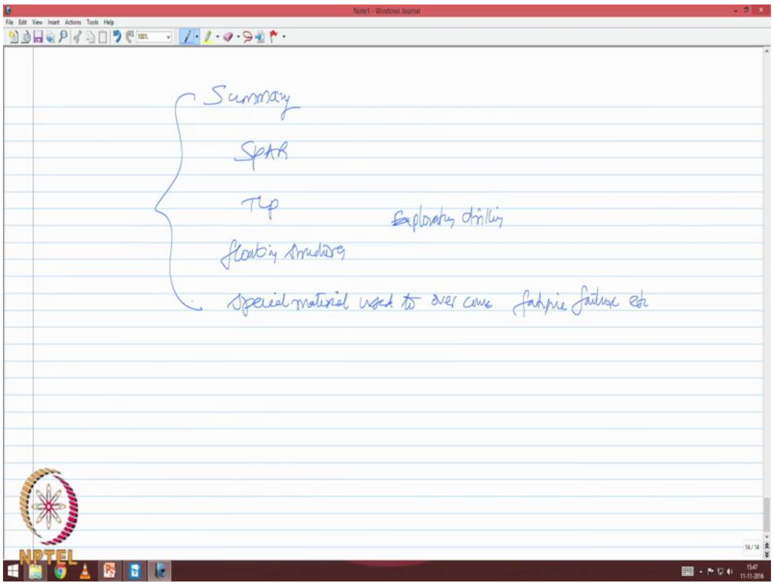

We conceptually extended the comparison of spar with tension leg platform, then we moved on to floating structures, there we discussed about platforms which are used for exploratory drilling, we also understood what would be the special kind of material used to overcome fatigue failure etcetera in this lecture.

I hope we are able to now understand different structural forms used for offshore production and processing under normal loads in normal c states how do they behave. So, we will take up some examples to understand them numerically, then we will move on to special kind of new generation platforms which are again redefined, modified structural forms, which are more advantageous than these conventional platforms.

Thank you.