Offshore structures under special loads including Fire resistance
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Lecture - 06
New Generation Offshore Platforms – II

Friends, welcome to the 6th lecture on the online course title offshore structures under special loads including fire resistance design.

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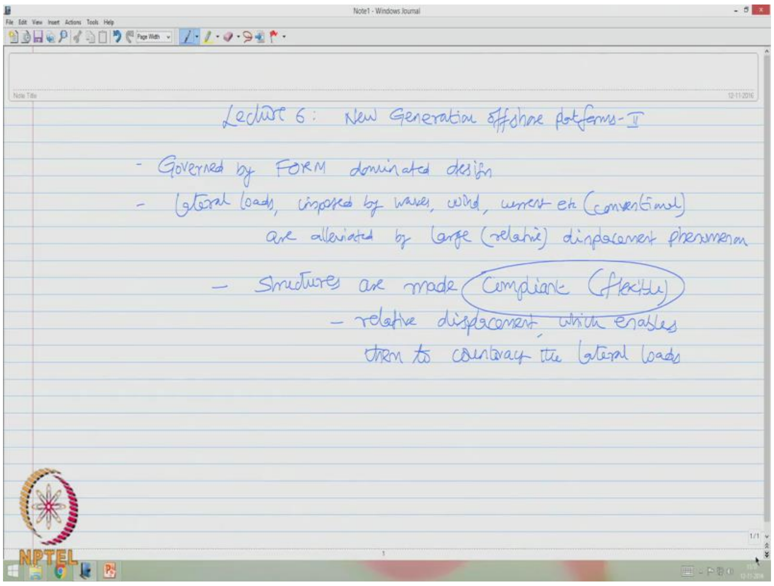

Today in the 6th lecture we will talk about the continuation of new generation offshore platforms. In the last lecture we already said that the offshore structures are essentially governed by form base design, we also said that the lateral loads imposed by waves; wind, current etcetera which are conventional loads are alleviated by large I should say relative displacement phenomena.

That is the structures are made compliant it means flexible, so that they have relative displacement which enables them to counteract the lateral loads. Now the question comes why one is interested to revise the existing compliant structural forms, on the other hand what is the necessity for the formation of new generation platforms?

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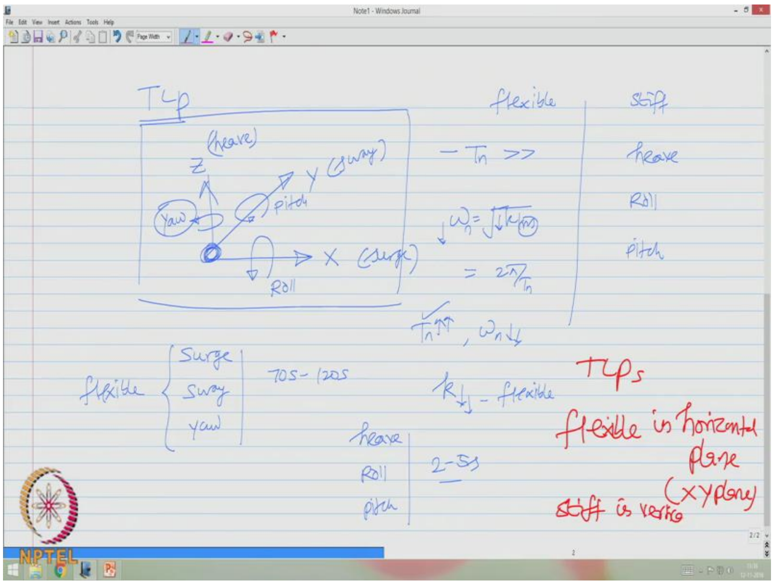

Let us answer this question by understanding the structural action of let say a TLP, we all know that if they are 3 axes under specific point call this as X Y and Z.

We know that the surge is the displacement degree along X and sway is the displacement degree along Y and heave is the displacement along Z direction, we also know rotation about X axis is roll, rotation above Y axis is pitch, and rotation above Z axis is yaw. Interestingly these 6 degrees of freedom are clearly divided into 2 sets; one is flexible degree and other is stiff degrees.

Let say what are these flexible degrees? We do agree that flexible degrees of freedom are those whose time periods are very very large, because we know omega is root of k by m is also 2 pi by T. So, for larger period omega will be lesser, for lower omega for the same mass stiffness will be lesser, for a system whose stiffness is lesser we call that as flexible. So, the degrees of freedom where the periods are very large are flexible degrees. So, we do agree in a TLP surge, sway and yaw have periods ranging somewhere from 70 seconds to 120 seconds.

When I talk about the other set of degrees like heave, roll and pitch, these periods vary anywhere from 2 to 5 seconds, lower the period higher the stiffness. So, stiff degrees could be heave, roll and pitch whereas, flexible degrees could be surge, sway and yaw. Please pay attention to this figure, based on this figure one can easily understand now surge is along X and sway is along Y and yaw is a rotation is a rotation above the Z direction.

So, one can now say very clearly TLPs are flexible in horizontal plane, let say X Y plane because surge sway and yaw motions which are marked on the X Y plane have high periods whereas, on the vertical plane the responses marked could be heave, could be roll and pitch which are very low period therefore it is very stiff in vertical plane; therefore the original idea which as conceived in offshore platform design was a hybrid concept where flexibility is introduced in horizontal plane whereas, stiffness was ensuring about the vertical plane.

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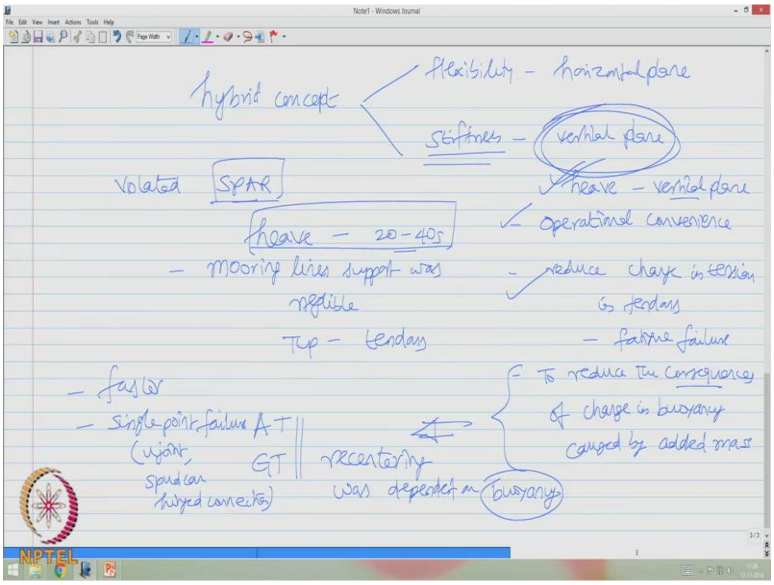

That is the very interesting reason, why this design was conceived. If you look at one specific degree of freedom let us say heave response in the vertical plane, we need to limit the heave response because of operational convenience to reduce the change in tension in tendons because this may cause further fatigue failure, also to reduce the consequences please understand this term of change in buoyancy caused by added mass. Now one can ask me a question that operation convenience because heave motion happens some on vertical plane, if heave response is very high one will not be able to do the drilling operation. So, this is acceptable.

Reduction in change in tension because that is how the change in tension is imposed because of heave motion, you want to reduce that change in tension therefore, you can reduce the fatigue failure this also acceptable for one is not able to agree and easily understand, to reduce the consequences caused by the added mass contribution. So, I want you to pay attention to the articulated towers and the guide towers where the reentering capability was dependent on buoyancy.

So, reentering was faster induce a single point failure may be in the universal joint or may be in the spud can or may be in the hinged connection. So, this effect was to be avoided therefore, people felt that I want to retain the stiffness in the vertical plane; however, the whole design of hybrid concept of TLP was slightly violated in spar platform, because this spar platform if you look at the heave periods, the heave periods can go slightly higher than now let say 20 to 40 seconds and of course, platform did not receive any support from the mooring lines whereas, TLPs where slowly dependent on the restoration happened by tendons.

So, people conceived different idea in a spar boy, by violating slightly this norm on a vertical plane by keeping it heave slightly flexible, but; however, in both this concepts of new designs which evolved in 80s till 2010 etcetera they were some difficulties let see what is the difficult.

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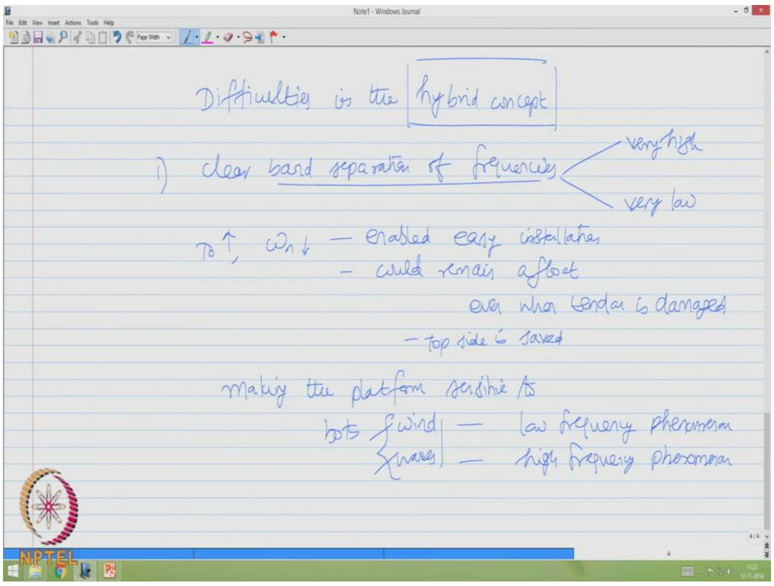

One difficulty is there is a clear band separation of frequencies, one is higher one is lower; higher in sense very high and lower in sense very low. Though people said interestingly this is an advantageous feature because higher periods with low frequencies enabled easy installation, the system could remain a float even when the tether is damaged. So, therefore top side is saved, but there is a main issue here by having this clear band separation of frequency, you are making the platform viable sensitive to both wind and waves because we all know wind is a low frequency phenomena whereas, wave is slightly a high frequency phenomena compared to wind.

So, now you are making the platform sensitive to both these. So, you have to design to counter act both these kind of frequencies and make the design save you understand the problem now, the complexity of making the platform sensitive to both bands of frequencies essentially arrows because of the hybrid concept conceived with the design of offshore platforms that is the first issue.

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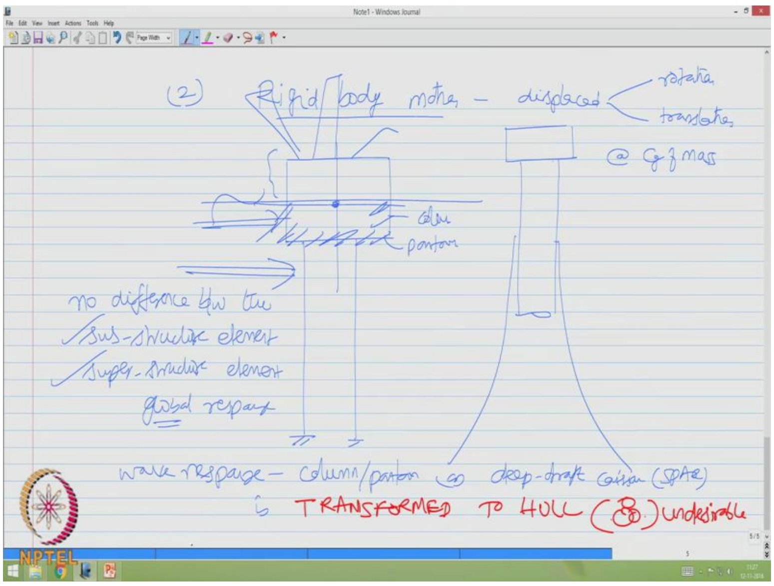

The second issue could be people now focusing on only the rigid body motion, now one may ask me a question what is the rigid body motion? The whole platform; for example a TLP for example a spar boy, which may have or may not have a mooring line it does not matter, has rigid body motion that the whole system is displaced both by rotation and translation at C g of the mass.

So, on the other hand there is no difference between the substructure element and super structure element under the global response. Now what does this statement mean? Let say a TLP as a water level here, I would call this the column and the pontoon as substructure element, the one which is above water maybe including the derrick including etcetera will be a super structure element, both are them undergo the same global response measure about the C g of the platform. So, what does it mean? I have a wave action which is happening on the tether and the members, which are transform to the hull or to the depth. So, the wave response which happens on the column member on the pontoon or the deep draft caisson in case of spar is transformed to the hull.

This is undesirable, this we do not need because the wave response happening on the substructure should not be transformed to the hull. Now the question why it is so? If the substructure response not transformed to the hull, it would be always better that the hull or the top deck can remain operational even under larger responses of the members under water.

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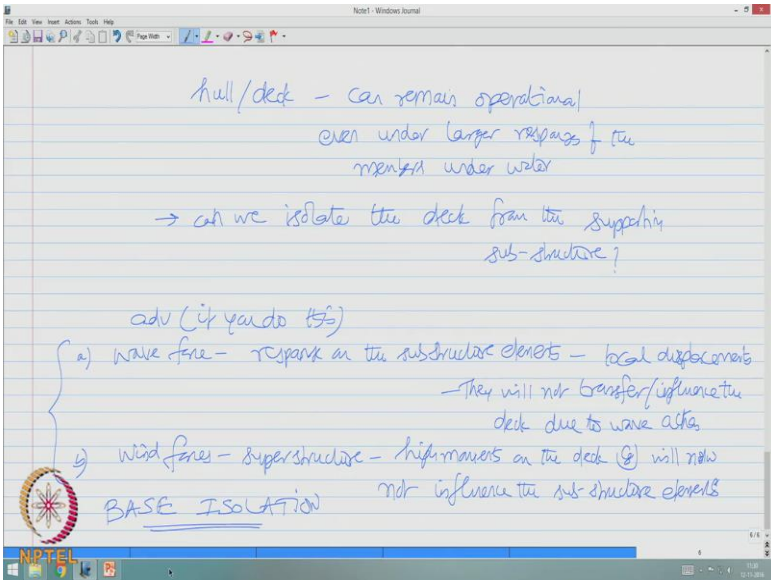

So, the request the requirement is can we isolate the super structure from the supporting sub structure. Before we say can we do it or not, what would be the advantage if you do this? The advantage if you do this could be wave force causing response on the substructure elements, will need to only undergo local displacements; they will not transfer or influence the deck due to wave action, so that advantage we get, alternatively wind forces acting on the super structure which can cause high moments on the deck C g, will now not influence the sub structural elements.

So, this concept is not new in conceiving structural geometry we design, this concept is otherwise being used in structures under earthquake engineering what we call as base isolation. So, the idea here is isolate the sub and super structure by a media, by a layer which then does not transformed the undesirable activities or responses vice versa.

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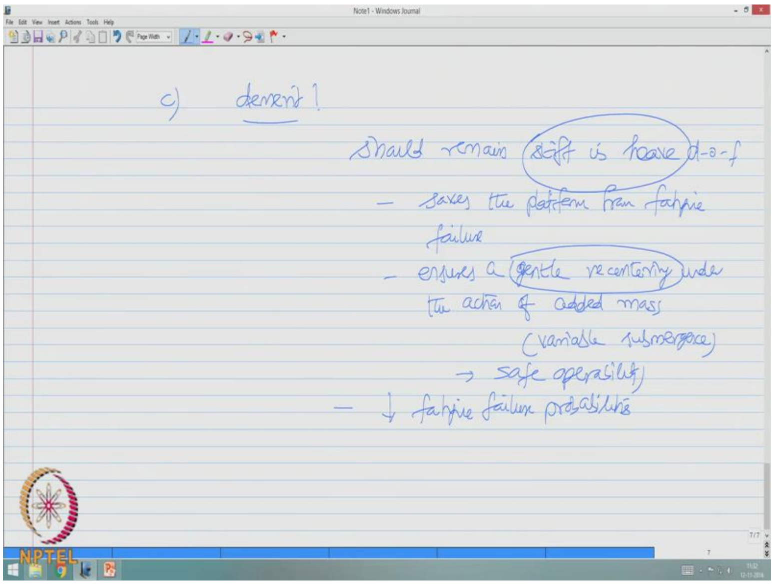

By doing so we have one main demerit, what is the demerit? The system should remain stiff in heave degree of freedom.

We already said why it is required to the main stiff in heave degree, because it saves the platform from fatigue failure, it ensures a gentle reentering under the action of added mass, what we call as variable submergence. The catch here is it ensures a gentle reentering, which confirms safe operability of course we also know if the system is more and tendons supported, it will reduce fatigue failure probabilities. So, we need to ensure even in the new concept of design, that stiffness should be maintained in heave degree. Can we have a platform of this type which has been conceived by people, in offshore engineering which is still in the research development stage that no such platform in constructed in prototype physically, but lot of research work is happening around the world, to see the feasibility of study this kind of geometry and it is possibility and viability for the an ultra deep waters, that is what we say as new generation platforms.

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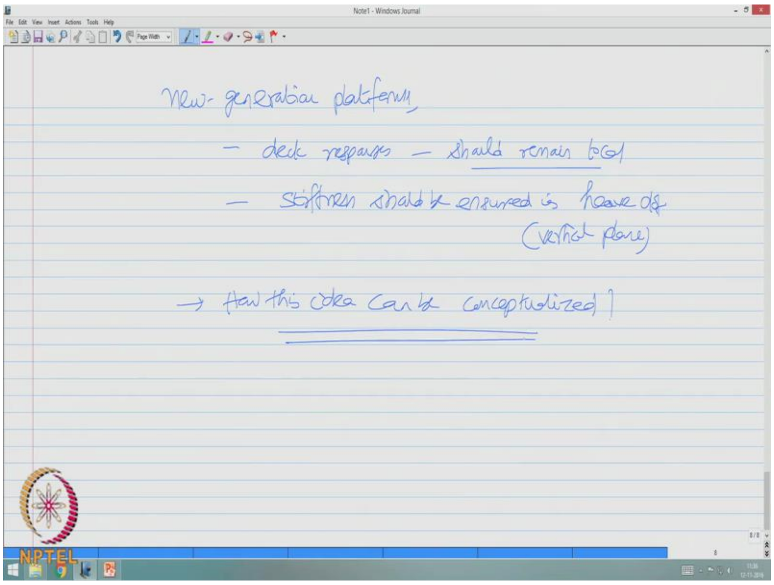

Now, let us see what are these platforms all about. When you talk about new generation platforms, we need to keep in mind that the deck responses should remain local, what do you mean by local? So, deck responses vertical plane.

So, let us see the next lecture how this idea can be conceptualized.

Thank you very much.