Advanced Marine Structures
Prof. Dr. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Lecture - 4
New Generation Marine Structures

So this is the fourth lecture, we are discussing on the course on advanced marine structures. In the last lecture, we discussed about different structural forms for example, fixed type marine structures, floating type marine structures, which we call as compliant type. We identified that the structural form or the geometric form of the marine structural system vary significantly depending upon its functionality. For example, in marine structural systems depending upon the depth of exploration from shallow to medium to deep to ultra deep waters, the structural form, which has been attempted by the researchers.

In the previous years, keeps on significantly changing so that, the system gets adaptable to the lateral loads to which it is subjected. So we discussed about the functional aspect and the structural configuration of fixed type platforms, we also discussed about different compliant type marine structural systems starting from articulator towers, guide towers, tensional platforms, FPA source. In this lecture, we will take you down to understand drill ships and new generation marine structural systems. So, this lecture will be focused on the drill ships, and new type offshore structural systems.

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The question comes here is, what do you understand by a drill ships? Drill ships actually are navigation ships designed, specifically to carry out drilling operations. So, there are some modifications structurally and geometrically done on an existing ship to make it adaptable to carry out drilling operation, such ships are otherwise called as drill ships. They are specially designed to carry out drilling operations in deep sea environment. A typical drill ship has a drilling platform and the derrick located at the middle of its deck. Drill ships contain actually a central hole called as moon pool, extending right through the hull through which the drilling string is inserted.

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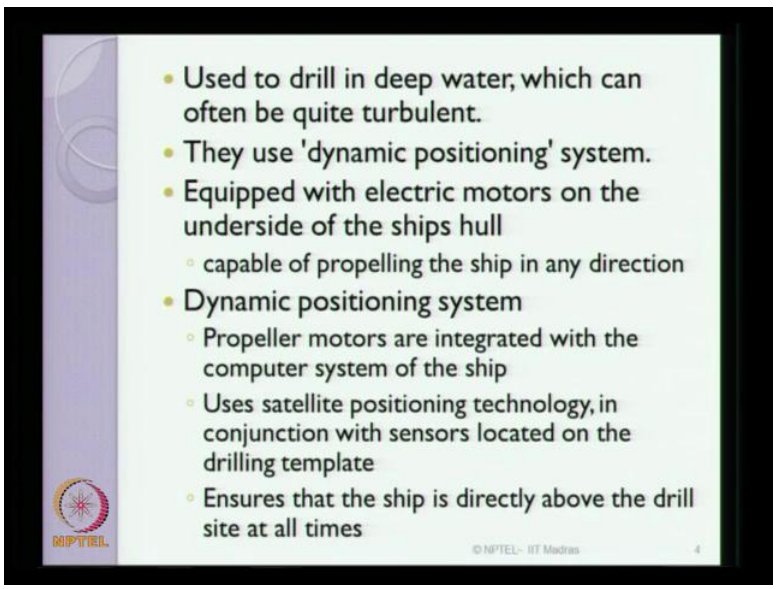

It is essentially used to drill in deep waters, which can be quiet turbulent. Therefore, other kind of compliant systems which you saw in the last lecture may not be suitable for deep waters at least in exploratory stage. Drill ships can be deployed in exploratory drilling stage, and also in production stages, because they have salient advantages compared with that of different kinds of platforms, which we saw in the last lecture. I will highlight those differences in the present lecture for you.

Now, obviously when drill ships are positioned in a specific location for performing drilling operation, they need to be anchored to the seabed and as we talk about ultra deep waters anchoring systems, will become either impractical or will be very expansive. So what we do is, we use what we call dynamic positioning systems, which is referred in the literature as DPS. DPS comprise of equipments with electric motors which are located on the underside of the ship hull.

It is capable of propelling the ship in any direction as you desired to do so; the dynamic position system essentially has propeller motors, which are integrated with the computer system of the ship. It uses the satellite positioning technology in conjunction with the sensors located on the drilling template and therefore, with according arrangements given in the mechanical system design. It ensures that the ship is mostly and appropriately, which is directly located above the drill hole at many times during operation.

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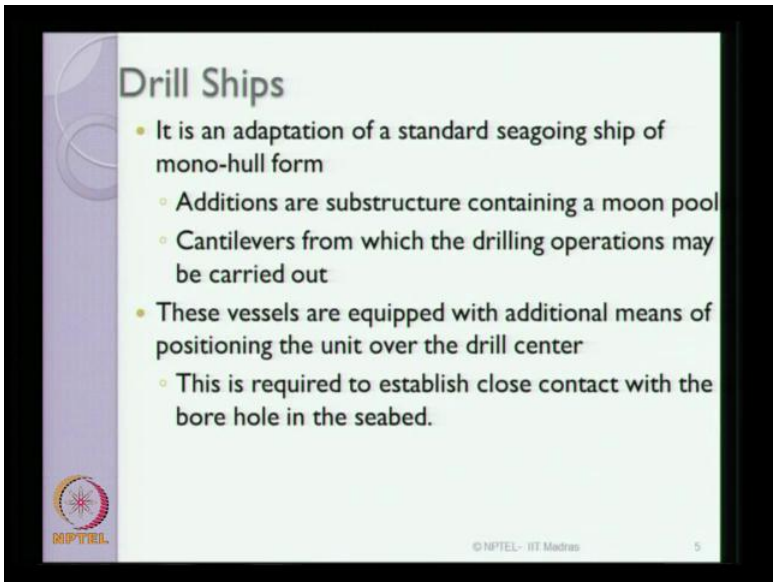

Drill ships, ladies and gentlemen is nothing, but an adaptation of a standard seagoing vessel which comprises of a mono hull form. There are some additions done in the substructure, which contains a moon pool, which enables the drilling to take place. There are cantilevers attached to the seagoing vessel from which the drilling operation can be also carried out in conjunction with that of the moon pool.

These vessels are actually equipped with the additional means of positioning, because they when they do the drilling operation they need to be kept in position and therefore, we have additional positioning devices to hold down the machine or the drill ship exactly over the drill center, so this is essential to maintain a closed contact with the bore hole in the seabed.

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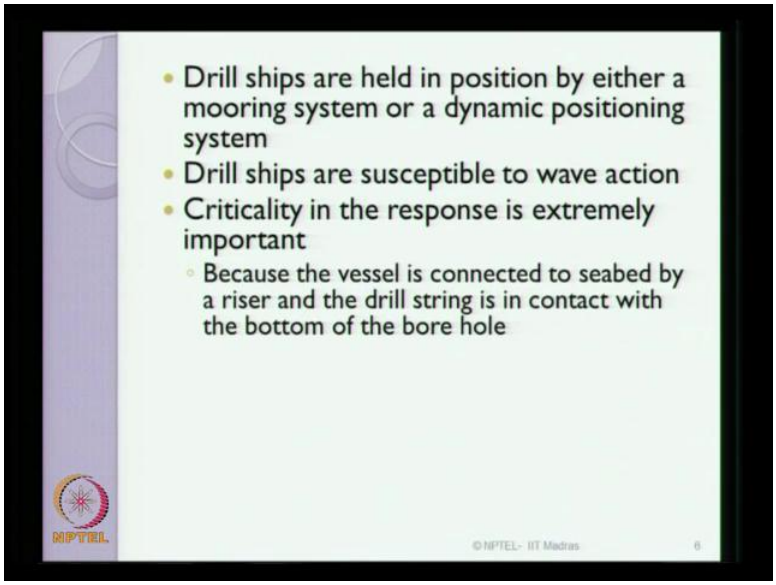

Drill ships are held in position by either by a mooring system depending upon the water depth, where are you operating or when you go for ultra deep water depths then one will look at dynamic positioning system as explained in the previous slide. Drill ships, ladies and gentlemen are susceptible to wave action. A criticality in the response is extremely important to understand how are they be designed, because the vessel is connected to seabed by a riser and the drill string is in contact with the bottom of the bore hole, all the time when the drilling operation takes place.

Therefore, it is very important that such highly flexible systems should remain in position during operation; otherwise it can cause extensive damage to the riser and the drill string which are in constant contact with drill ship during operation.

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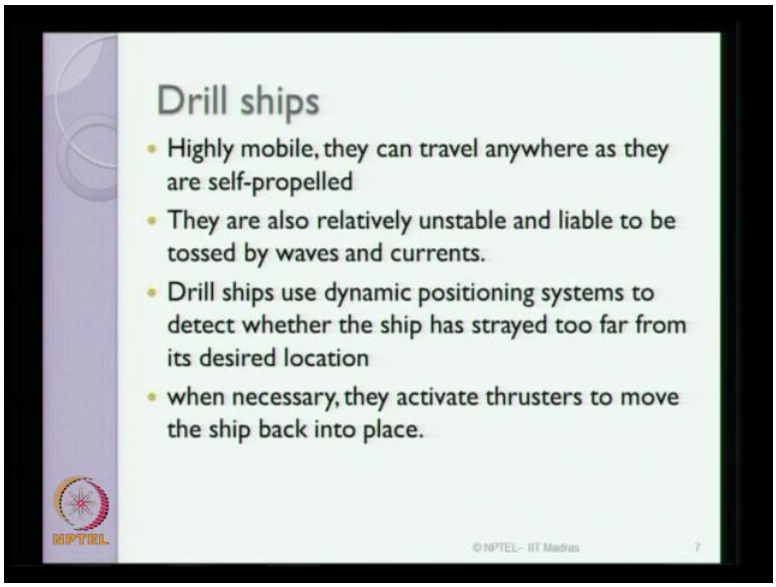

Drill ships can be seen as highly mobile and versatile equipments which can travel anywhere; because they are essentially sea going vessels will self propulsion capacity. But, one disadvantage what the drill ships has is that they are relatively unstable, because they have a very high degree of flexibility, which we call as high degree of compliancy therefore, the relative instability of the ships should be handled with a greater care, because they can be easily tossed out by the waves and current action.

Drill ships therefore, use dynamic positioning systems to detect all the time, whether the ship is exactly above the location of the drilling operation or it is strayed too far away from a desired location. When necessary, these DPS systems activate additional thrusters to move the ship back to keep it in position as desired.

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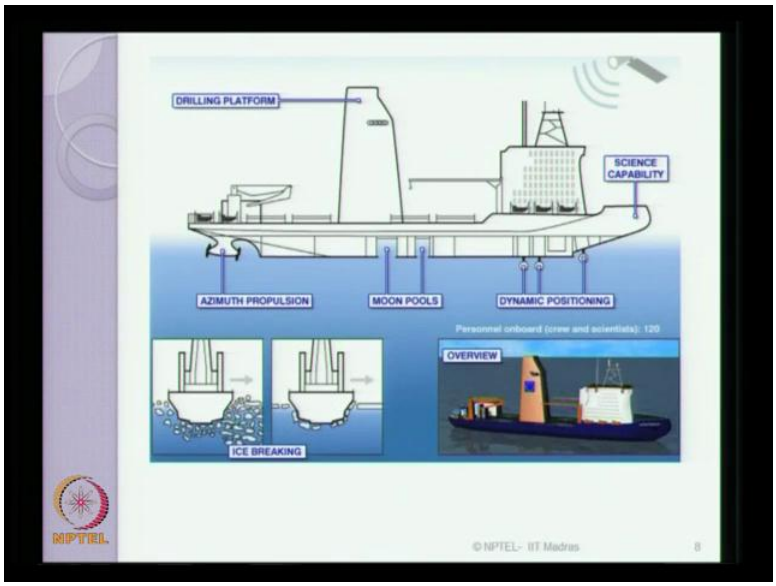

The picture what you see here is a conceptual view of a drill ship, which contains the drilling platform or the drilling mask, which has got a science capability and is got an azimuth propulsion at the rear end. These are the moon pools extend through the hull through which the drilling takes place. And depending up on the position keeping on the drilling drill ships during drilling operation, the dynamic positioning systems activate additional thrusters, which can bring back the ship to the position. So that at all the time of operation the drill ship is exactly maintained over the drill hole to which operation is taking place.

In case of ice breaking, in case of additional requirements as suggested and desired by the designers, you have got addition mechanical systems available in the drill ships as well. It also takes care of the person on boat, because the compliancy offers lot of motion in the soft degrees of freedom of the ship. Therefore, this should be controlled for ensuring a comfortable operational status for the people on boat. You can see an overview of the whole drill ship in position during operation.

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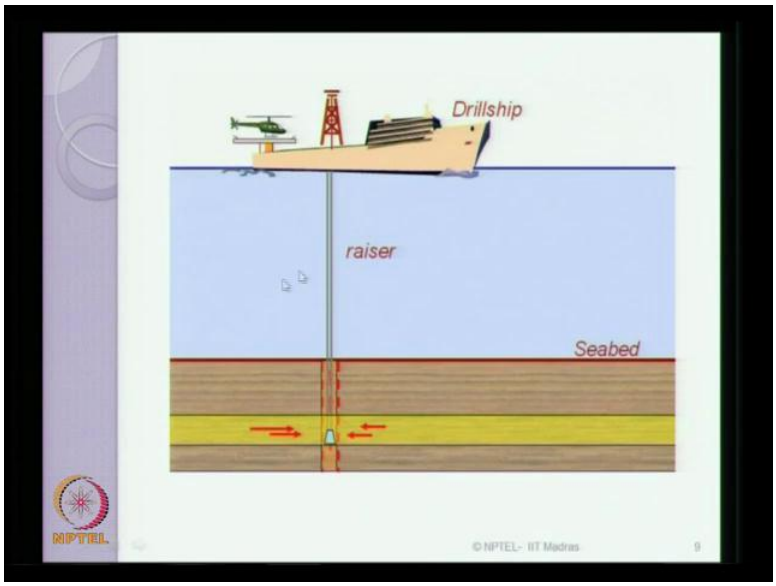

The conceptual figure shows here. How the risers are also connected to the drill ship, while the drill ships is in operation. As I told you, it is very important that the dynamic positioning system should keep the drill ship enable in such a way that the motion controlled is happened, as per the desired value, so that the risers and the drill strings are not disconnected from the drill ship when the drill ship is performing the drilling operation.

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These are the some of the classical photographs of the existing drill ship, which has been deployed in various parts. The photograph what you see here is meant for ultra deep water drill ships. The photograph you see here in the right is a discoverer India drill ship, which is under operation at a water depth of 2900 and 50 meters can see the top side is highly complicated, which contains a very large drilling mass, which also has the drilling rag the mechanical equipments, which are essentially required for production and exploration of oil at greater water depths. The picture what you see here is, the ONGC drill ship the famous Sagar valley which has been deployed by ONGC for deep water explorations.

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These are some of the photographs taken when the drill ship is in operation can see the drill string is passed through the moons pool, which is nothing, but a hole provided on the hull through the hull of a drill ship. Can see here schematic view of a drill ship, you can imagine the dimensions of drill ship as you see here when it has been for repair. This is where the moon pool is actually connecting the drill string to that of the drilling unit, and this is how the mechanical systems and the actuators are connected to the moon pool using the drill string.

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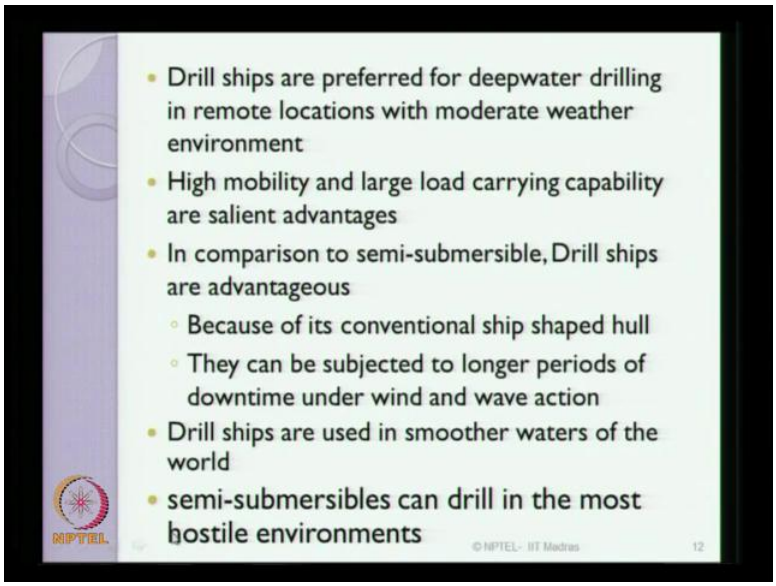

Drill ships are essentially preferred in the literature for deep water drilling, especially in remote locations with moderate weather environment. Now, one can have an alternative of looking at, can I use a semisubmersible or a drill ship for locations, where I do deep water drilling. We will compare them quickly in the coming slides, and look at the salient advantages of drill ships in place with that of semisubmersible. Drill ships have high mobility and very large load carrying capacity, which are seen as salient advantages of drill ships.

In comparison with semisubmersible drill ships are more advantageous, because of the following reasons because essentially drill ships are conventional ship shaped hull, which has sea going capacity; otherwise they are subjected to and they can be subjected to longer periods of waves of downtime under the wind and wave action, because they are susceptible and the design for such wind and wave action for long period downtimes in the sea otherwise. Drill ships however are used or preferred to be used in smoother waters around the world, where as semisubmersibles can drill in most hostile environments as well.

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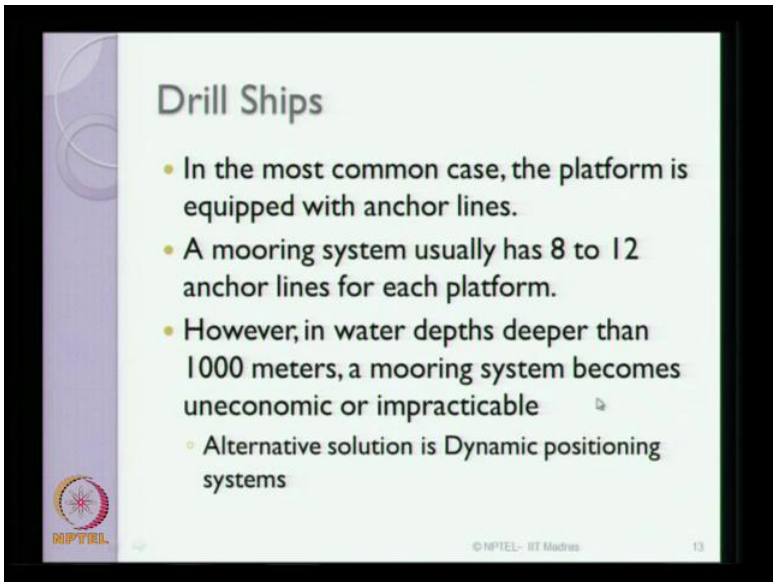

In the most common case of a drill ship the platform is generally equipped with the anchor lines. A mooring system comprising these anchors usually has 8 to 12 anchor lines for each platform. However, in water depths greater than 1000 meters a mooring system becomes highly uneconomical and impractical therefore, people generally deploy dynamic positioning systems for using drill ships in deeper waters practically more than 1000 meters.

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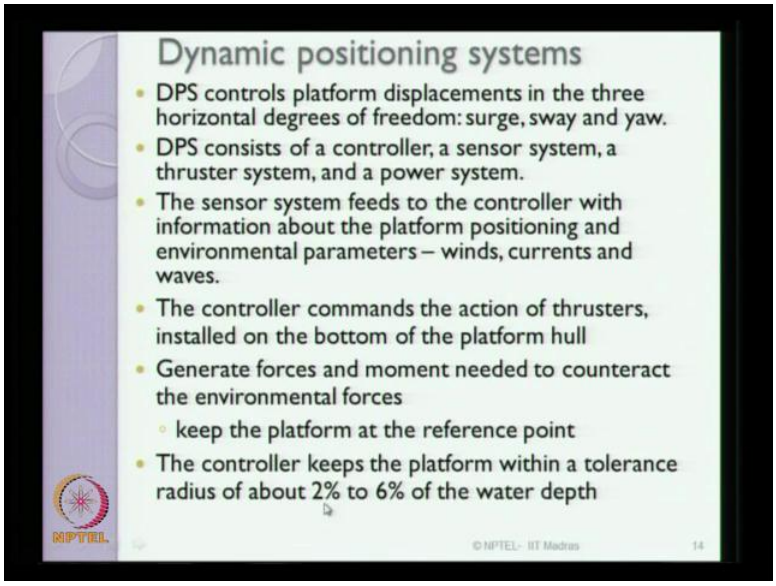

The dynamic positioning system controls platform displacements, essentially in three horizontal degrees of freedom namely surge, sway and yaw. So, DPS actually controls the displacements in the softer degrees of freedom, which we call as comp landings. DPS consists of a controller, a sensor system, a thruster and a power system. Depending upon the actual position, which is being mapped, using DPS fixed on the drill ship. The thrusters and actuators are controlled or activated by the DPS, which brings back the ship to the position as desired by the algorithm. The sensor system feeds to the controller with information about the platform positioning and the environmental parameters namely the wind directional speed, the current directional speed of course, the wave height and wave predominant directions.

The controller then subsequently commands the action of the thrusters, which are installed at the bottom of the platform hull the these thrusters generate forces, and moment needed to counteract environmental forces applied on the drill ship to bring it back to the platform at the reference point as fixed by the DPS system installed on the drill ships. The controller keeps the platform within a tolerance of about 2 to 6 percent of the water depth in terms of its radius.

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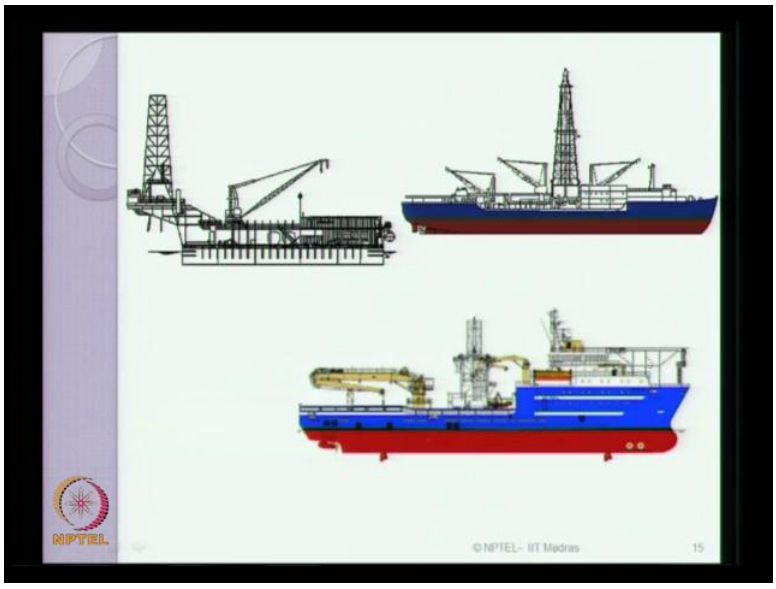

These are some of the views and photographs of a typical drill ship, which consists of all the essential features of classical topside of any platform, which can equip or which can perform drilling operation. It has got a derrick mask it has got cranes for performing

different operations, it has got the flare boom the living quarters and all mechanical topside complexities as desired in case of any production platform, which is meant for deep water drill.

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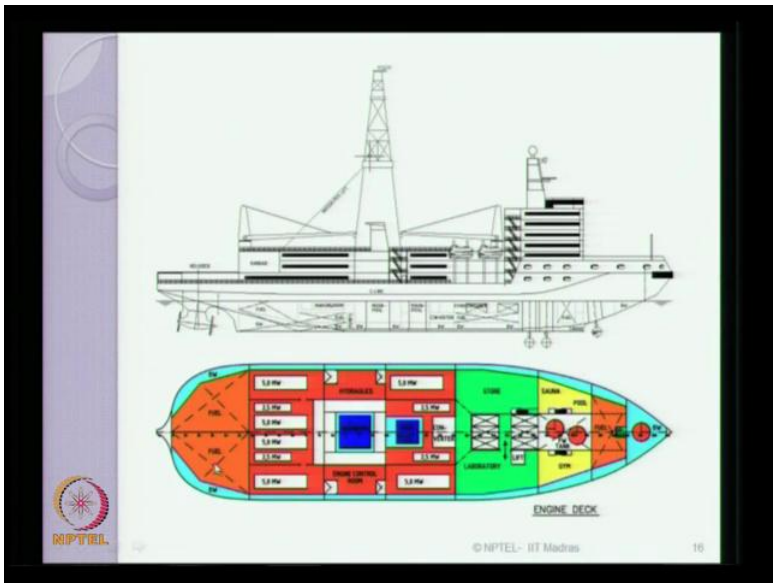

This is a classical topside view of a typical navigation ship, which has been converted to a drill ship can see here. There are two classical large moon pools, which are centrally located on the deck through which the drilling operation generally takes place. Many can see the other complexities or other details are similar to that of any typical navigation vessel as you see in case of a ship.

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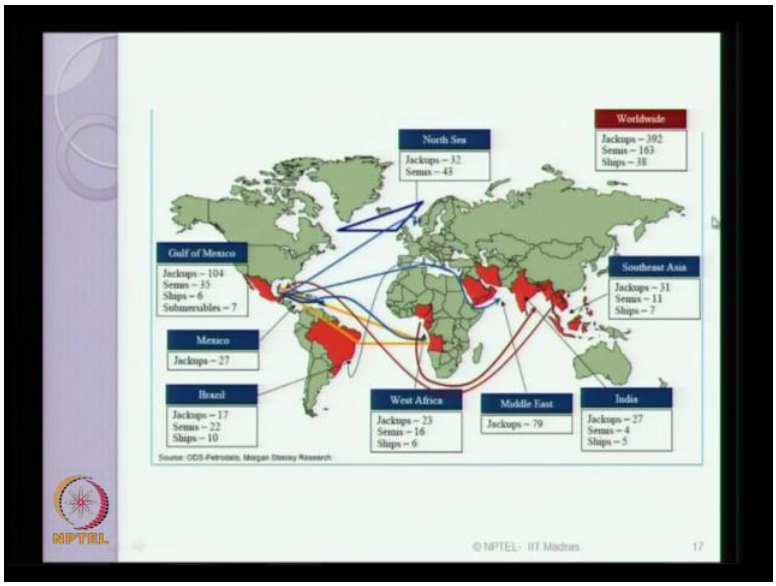

This figure shows interestingly different platforms, which are deployed currently worldwide at different locations. For example, in North Sea you got predominantly jack ups and semi submersibles amount to closely around 80 in number. If you look at the statistics generally jack ups are preferred in larger in numbers for exploratory drilling, where as for production people use semisubmersibles and drill ships, which are also quantitatively very large and comparable number with that of jack up rigs. Of course, in South East Asia people prefer more jack up rigs, and less number of drill ships.

In India people deploy more jack up rigs compared that of semisubmersibles and drill ships. In Middle East people entirely focus only on jack ups for drilling, where as in West Africa people deploy equal amount of semisubmersibles and drill ships compared that of jack up rigs. Of course, in Brazil people are predominantly preferential use on semisubmersibles and drill ships compared that of jack up rigs, because the deep water drilling is one of the innovative areas happening in Brazil, where as in Mexico people generally deploy more jack up rigs, because more of nature of exploratory drilling takes place.

Ladies and gentlemen, the most important hub of the world of exploration, Gulf of Mexico as predominantly jack ups and semisubmersibles and drill ships being employed for various operations of drill. Now, we have understood different types of off shore platforms or I could put them as marine structures depending upon, what kind of

operation these platforms are going to perform. Now, when you talk about the structural form innovation we have understood that as the drilling operation moves from shallow to medium to deep waters, it is essential that the geometric form of the marine structures needs significant alteration and in site study.

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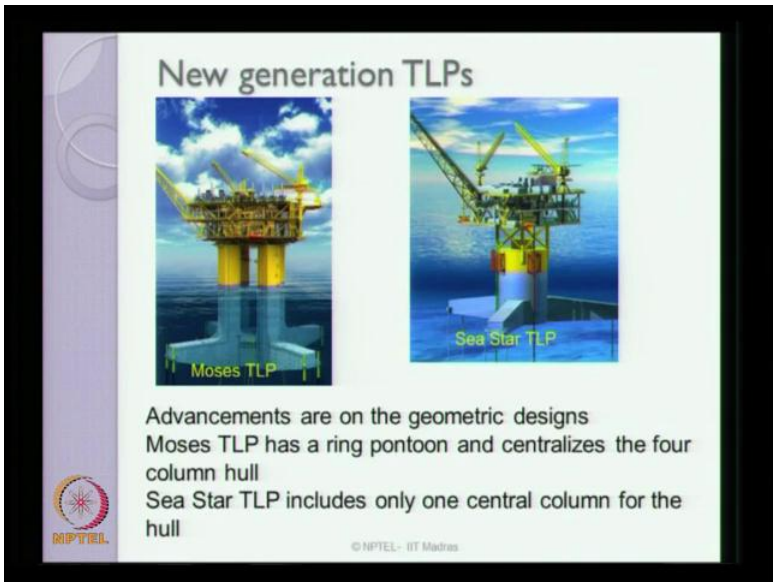

So we know speak about, what we call new generation marine structures. The moment we talk about new generation marine structures TLPs have been modified in a new hull form of TLP the house for greater water depths. For example, the left hand photograph what you see here is, a mosses TLP which has got advancements on its geometric design. Can see here, the bottom members are projected out from the column members, and the tethers are actually connected to this projected area, so the mosses TLP has what we call as a ring pontoon and centralizes as four column hull essentially at these projection points.

The other alternative new generation TLP which is been deployed is a Sea star TLP, which includes only one central column for the hull, so you can see there are new generation geometric forms, which are occurring which are modified versions of a tensional platform, which has been used for ultra deep waters in the region past.

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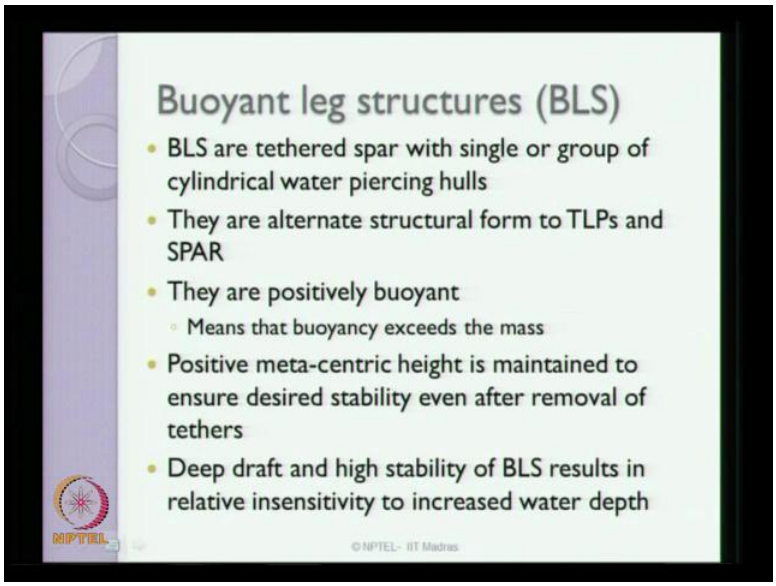

The next kind of marine structure generation touches with what we call as buoyant leg structures. Ladies and gentlemen, as you have correctly understood the term buoyancy talks about improvement in its compliancy, which can make it adaptable to deeper waters, buoyant leg structures are nothing, but tethered spar with single or group of water piercing hulls. They are alternate structural forms to TLPs and spars. These are essentially positively buoyant structures, which mean that the buoyancy exceeds the mass of the platform in a very large number.

The positive meta centric height is maintained to ensure desired stability even after removal of tethers. So, this ensures that these kind of structures stay in position without getting damaged even when there is pull out of tethers, which otherwise becomes a sensitive issue for structures like tensional platforms. They are deep draft systems and they have high stability, which results in relative insensitivity to increased water depth. Therefore in the recent past the literature to use buoyant leg structures for ultra deep water oil exploration.

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BLS, being a deep draft structure reduces the exposed structural part near the free surface. This reduces essentially the lateral forces acting on the members in comparison to that of tensional platforms. As risers are located inside the moon pool of BLS wave forces on risers are significantly reduced which advantage of these kinds of structures. Tension buoyant towers were designed based on the geometric design of buoyant leg structures.

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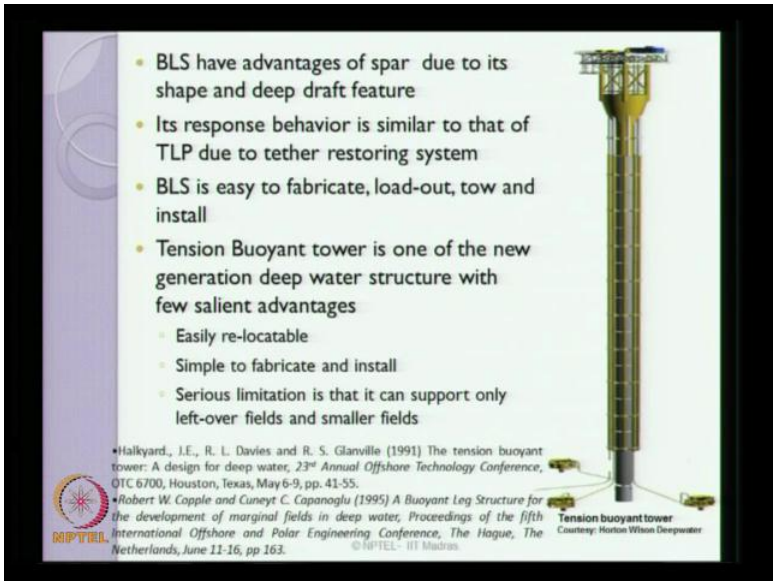

This is a typical tension buoyant tower, which has been deployed and tried attempted a numerical study Hott and Wilson deep water company. BLS has advantages of spar due to its shape and deep draft feature. Can see this shape resembles a classical spar, which has got a deep draft feature. Its response behavior is also similar to that of TLP, because it has got a tether restoring system as comparable to that of a tensional platform. So, ladies and gentlemen BLS is a complex geometry, which derives advantage from a spar system as well as that of a TLP, which is relatively in sensitive for higher water depths.

BLS is easy to fabricate easy to load out to and install and these make BLS recommendable advantage for putting them for ultra deep water oil exploration. Tension buoyant tower is one of the new generation deep water structure with salient advantages, will got easy re locatable capacity, it is very simple to fabricate and install; of course, this got a serious limitation; so that, you can support only the left over fields and marginal fields. You can see interesting references, which has been attempted by the researchers the recent past on buoyant leg structures are seen on the slide now.

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The first buoyant tower CX: 15 load-out infrastructures in Peru's carnival is seen in the photography here, which has been done by especially company courtesy offshore technology.com.

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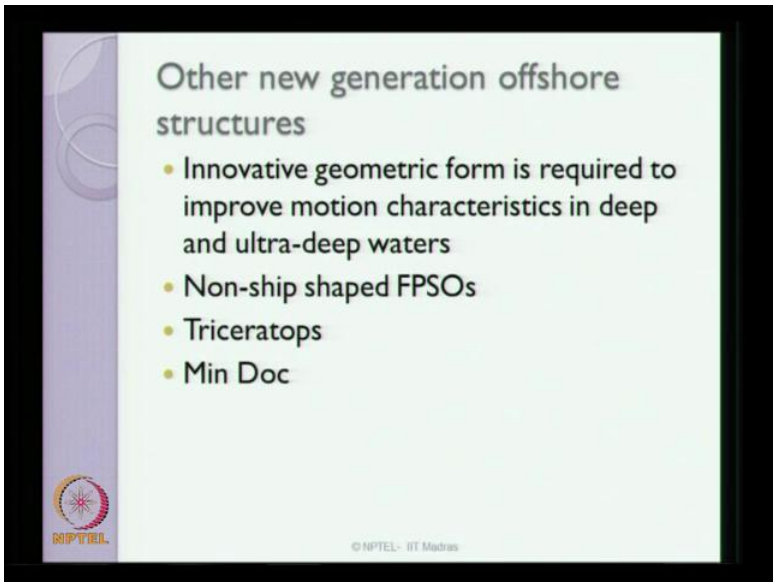

There are other classical new generation offshore structures, which has been attempted by researchers in the recent past. Innovative geometric form is therefore, essential and required to improve the motion characteristics in deep and ultra deep waters. Essentially, this required to make the marine structures water depth insensitive. So, people have attempted non ship shape FPSOs in the recent past people have tried and studied triceratops numerically, analytically and experimentally. People have attempted to study a new kind of platform called Min Doc etcetera.

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The circular FPSO Sevan Voyageur moored at Nymo yard at Eydehavn platform Norway is a photograph what you see on the left.

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On the right, is the goliath the first oil field developed in Norwegian sector of the Barents Sea uses subsea wells linked to a cylindrical FPSO. So, people have essentially used non ship shaped FPSOs also for deep water oil exploration. This production is due by the end of 2013 is a recent attempt made by people.

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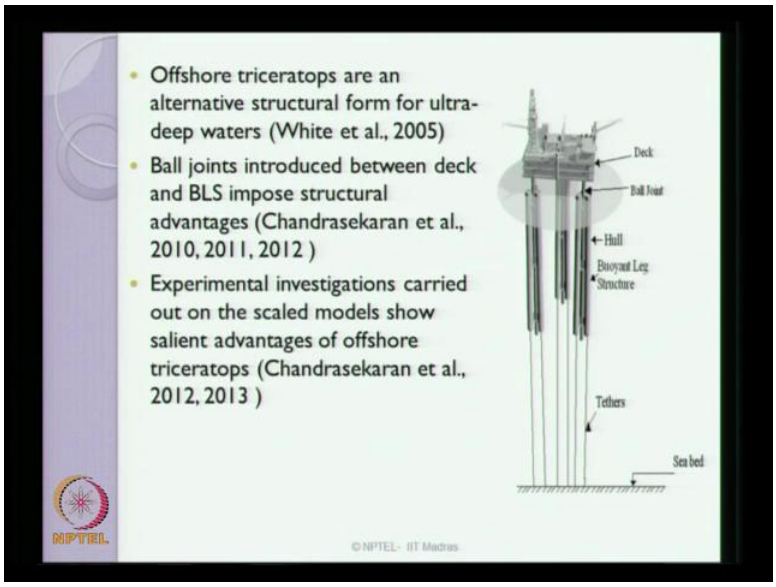

The picture what you see here is the conceptual study extended for deep water platforms, which is called triceratops by white et al in 2005. This is suggested as an alternative structural form for ultra deep waters. Essentially, triceratops has a deck and a hull, which are connected by means of what we call as ball joints. Hulls are nothing, but the buoyant leg structures, which are anchored to the seabed using tethers as similar to that of tensional platforms.

Now, the buoyant leg structure is connected to the deck using ball joints, which has been introduced between the hull and the deck and they have got many salient structural advantages. They experimental investigations carried out by the researchers on the scaled models of triceratops show lot of advantages, which are not discussed in this specific lecture; because it is out of the scope of this lecture, but I urge you to look into the references given in the literature.

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Now, let us look at the structural advantages, which these kinds of new generation platforms claim in comparison to historical platforms, which exist in the deep sea. They have better motion characteristics; they are suitable for deep waters; they are improved dynamics in comparison to TLPs and spars create them advantageous features. The wells which are within the protected environment create additional support, because they are laterally supported by the system. It is a simple form, which can be easily installed; it has

got very simple station keeping characteristics, which keeps them as advantageous compared to conventional marine structures.

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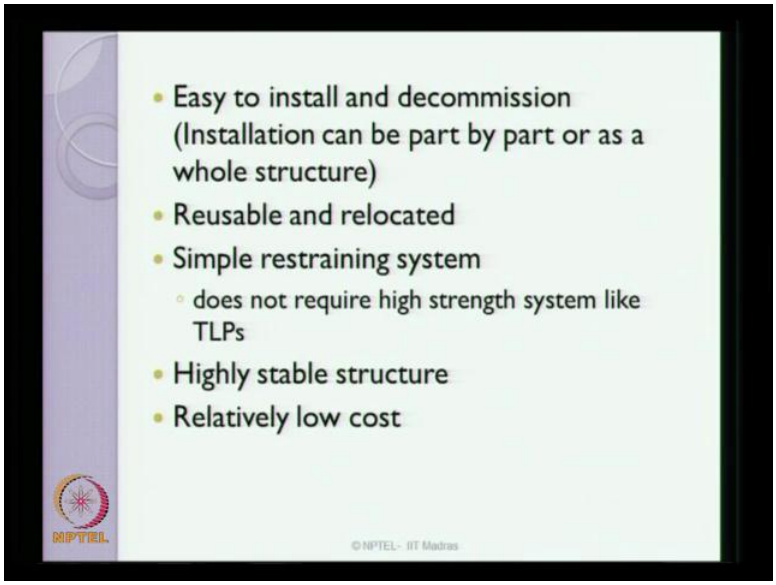

They are very easy to install and decommission, installation can be a part by part or as a whole structure. Most importantly ladies and gentlemen, they are reusable and they can be easily relocated. They have got very simple restraining system, as compared to that of a TLP and most importantly they do not require high strength structural system of tethers like TLPs. They are highly stable structure, because the experimental studies made by the researchers show that even when the tethers are pulled out they have stable floating characteristics, they have relatively low cost and relatively insensitive for increased water depth.

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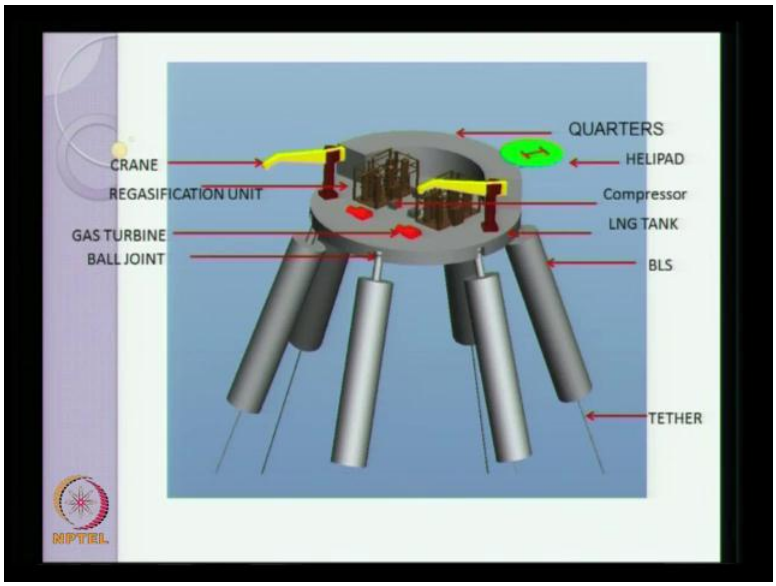

The recent invention also talks about floating storage re gasification units, if we call as FSRU in the literature. The FSRU is having again a sector hull connected by different buoyant leg structures, which are then subsequently anchored to the seabed using tethers FSRU of the ship is still a conceptual development happening in the recent past with the researchers, which houses all facilities as you have in conventional marine structures. It has got living quarters, it has got helipad, it has got the compressive unit, it has got the LNG tanks and it has got the gas turbine and the re-gasification unit, which are otherwise required for essentially processing the explored oil.

Ladies and gentlemen now, the floating gasification units are very important because transportation of crude oil from the drilled side to the onshore side becomes expensive. Because, laying of pipe lines and maintaining these pipelines in deep water conditions becomes very expensive therefore, in the recent trend people have started using re gasification itself in the floating systems in deep sea conditions as system. So, you can see here, the new hull form with the circular in shape, which can be insensitive to wave directions or then supported by the buoyant leg structures placed in different directions, which are then subsequently connected by the ball joints.

As we just now saw, the ball joints give advantages of not transferring the rotations from the subsystem to the super structure. Because, they absorb the rotations whereas they give the relative displacements they transfer the heat. So, in the degree of freedom the

platform becomes monolithic whereas in surge or for example in pitch roll degrees of freedom they are independent. It means water may be the translates the rotational degrees offered to these kinds of sub-structural system they are not transferred to the super structure or on the other hand, the rotational responses given to this super structural elements, because of wind forces do not get transferred to the sub structure. It means the ball joints filters the rotational transfer from the sub structure to the super structure, which claims to be a deep critical and serious advantage of these kind of new generation structural form.

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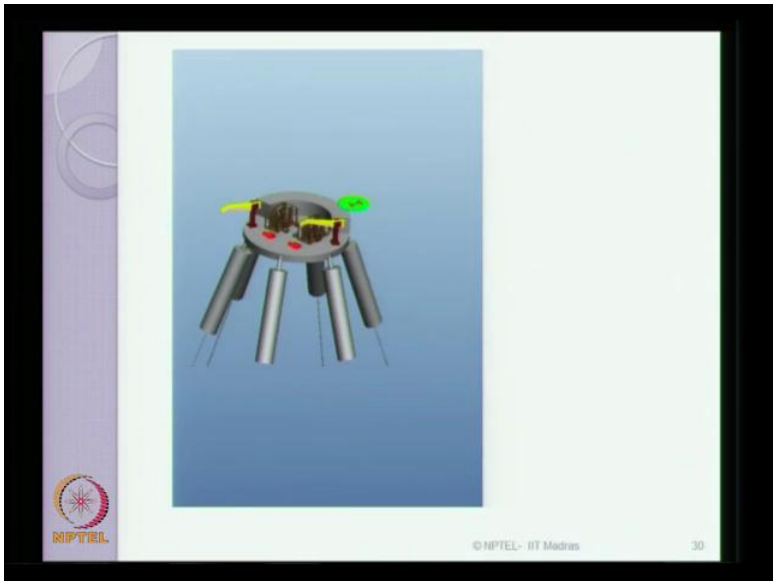

Now you can see different views as they have been conceptually installed in attempted in numerical analysis studies carried out with the researchers in the recent past, this is a typical view which shows how these kind of FSRUs will be installed in deep water conditions.

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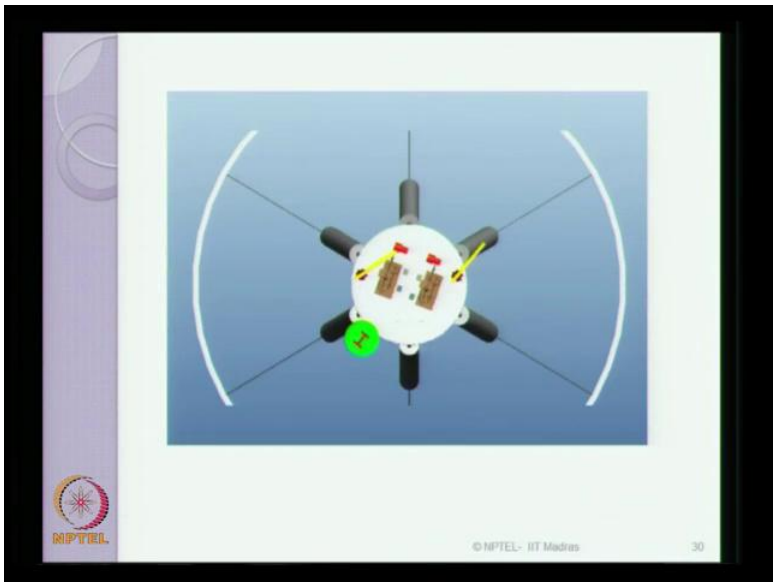

This is the plan view or the top view of the FSRU, where the BLFS are extended out from the circumference, and this shows the outer peripheral of their lay out of the tethers as you see in the picture here.

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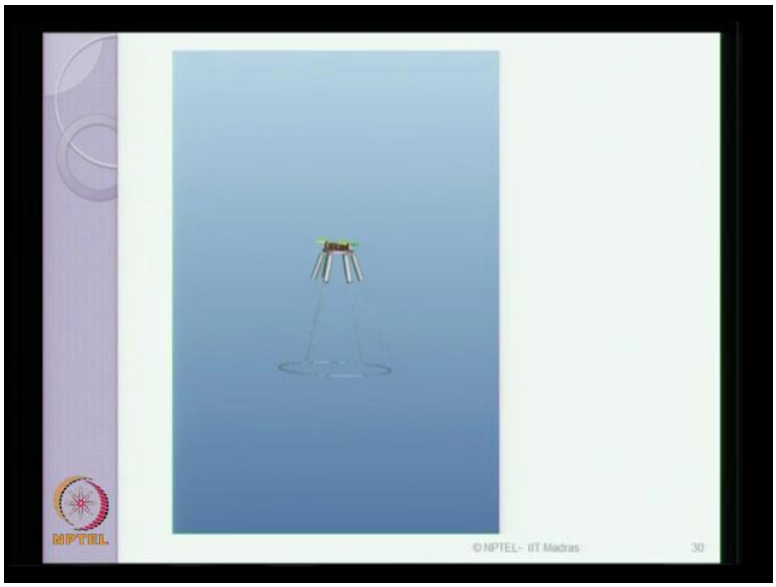

This is a typical front view, which shows the installed FSRU in terms of the tether restraining system.

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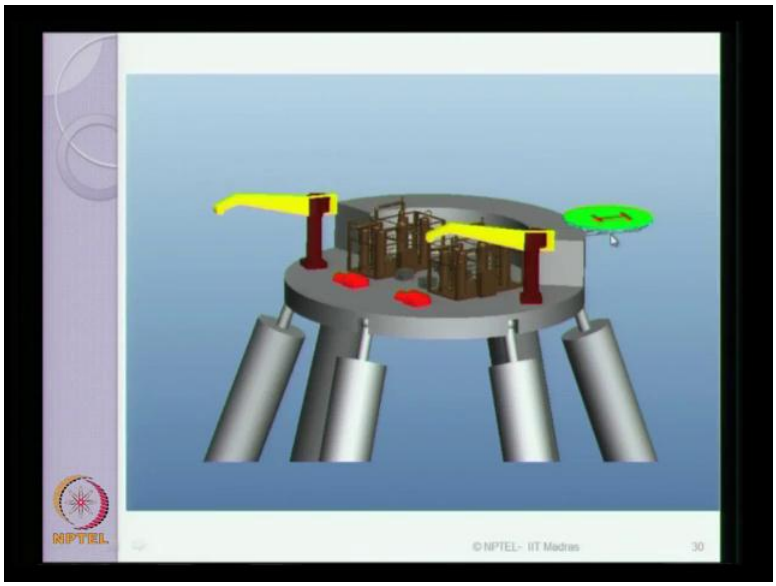

This is closer view of a typical FSRU, which is now being attempted as a new generation platform for numerical analysis in the literature. So ladies and gentle men, we have now attempted to understand different kinds of offshore platform or marine structural systems, which has been attempted by the researchers in the recent past as you see in the references shown in the slide.

So the geometric form the innovation in the structural format the degree of flexibility, the compliancy, the stiffness or the flexibility the structural system in its design in the form. In the dynamic positioning system, the reusability, relocate ability, commissioning installation, easiness for installation etcetera or different factors considered by the researchers and engineering advisers. So that, new generation platforms of marine structures are being evolved.

So, in these four lectures we gave the interesting summary about different kinds of marine structures, which are commonly deployed for deep waters or varying from the water depths of shallow to ultra deep waters. In the next lecture, will talk about different kinds of environmental forces, which are acting on this kind of structural system before we understand, how to perform in a ultimate load design and talking about plastic analysis of these kind of marine structures.

Thank you very much.