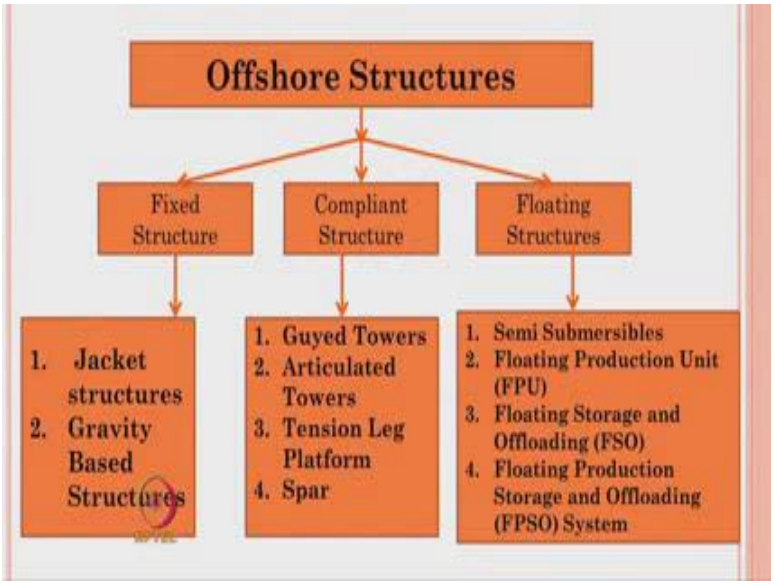
Dynamics of Ocean Structures
Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Lecture – 02
Introduction to Offshore Structures – Cont

Welcome to the next lecture, the Lecture number 2 where we will continue Introduction of the Offshore Structures from the previous lecture. In the previous lecture we discussed about two types of offshore platforms; fixed time and complaint time.

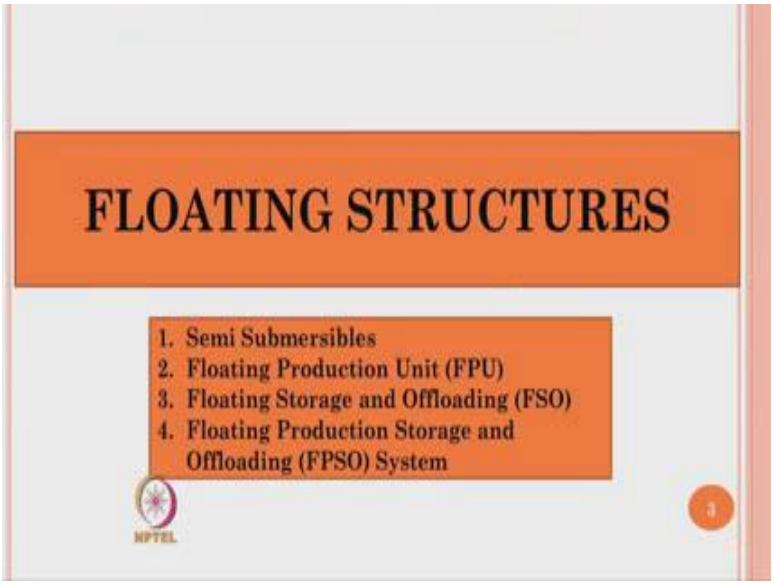
(Refer Slide Time: 00:35)



Just to have continuity offshore structures are essentially divided into three categories; fixed structure, complaint structure and floating structures. Fixed structures have got two verities within them; jacket structures and template structures, gravity based structures or GBS platforms. Complaint structures have four verity within them; guyed towers, articulated towers, tension leg platform and spar platforms.

In this lecture we will focus on understanding different kind of floating structures that is semi submersible. Floating production units; floating storage and offloading units, floating production storage and offloading systems.

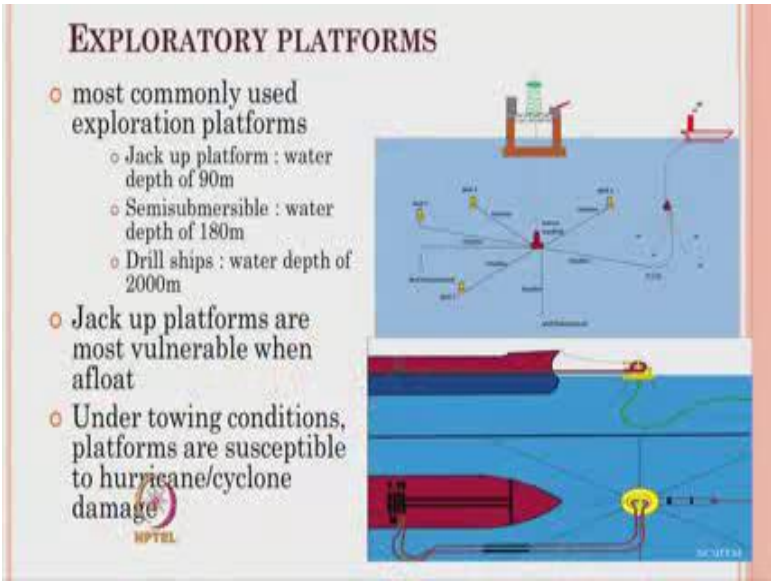
(Refer Slide Time: 01:18)



If you look at floating structures the words itself very clearly say that the structure remains very highly compliant compare to that of complaint type structures. One should understand basic difference between the complaint type offshore structures and floating structures. One can easily understand the differences between complaint of structures and fixed type, because in fixed type it is bottom founded resting on the sea floor by gravity system or by pile revenge systems. Whereas, in complaint type they are not resting on the sea floor they are connecting either to the sea floor by a (Refer Time: 01:58) or the universal joint or (Refer Time: 02:02) to the sea floor simply by moving lines or cables or tendons tethers.

So, now floating structures are entirely different from the tough complaints type. Meaning that the structure remains completely a float only one they have got to be (Refer Time: 02:19) there is a temporary arrangement by which they are been help down in precision when the drilling operation or offloading, transport, production, processing, operations are carried out. Semi submersible, FPU's, FSO's and FPSO's can be under the variety of floating structures.

(Refer Slide Time: 02:41)



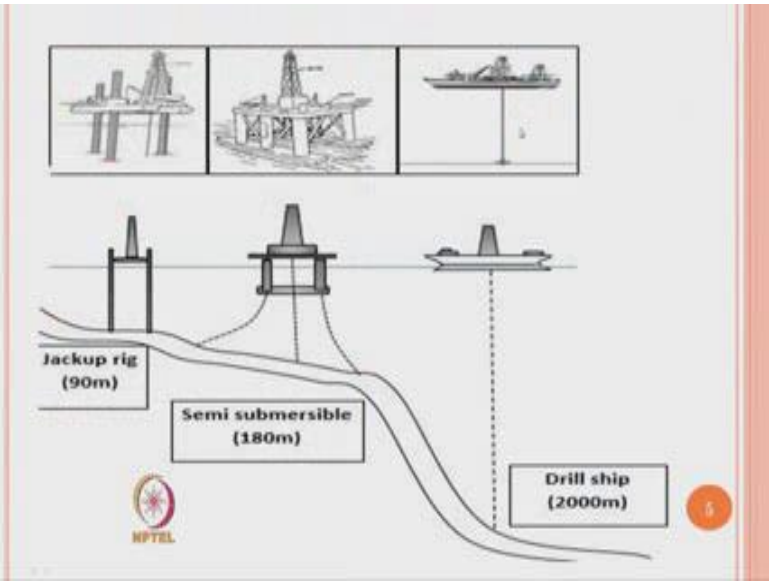
When we talk about platforms meant purely for exploratory purposes then there are varieties of platforms available here. One can ask the question what you mean by exploratory platform and production platform. Ladies and gentleman in offshore structure system design all platforms in (Refer Time: 03:02) analysis are not constructed. For checking the construction viability of any given platform it is important to know whether the designated oil field has got enough yield of oil production, so permanent type platforms and ever constructed in the beginning only exploratory type platforms are first constructed to check whether the platforms is capable of giving or the will is capable of yielding oil of specific return which is cost beneficial.

So, exploratory drilling is a foremost attempt to check whether the yield of the well is satisfactory. Most commonly used platforms for exploratory purposes is jack up plat forms jack up risk. Essentially they are commissioned only up to water depth of about 90 to 100 meters. Semi submersible are also meant for exploratory type, where they are used up to 180 meters. If really want to do exploratory drilling at deep of water depths the best option what we have today is the drill ships, because they can cater exploratory drilling till the depth of 2000 meters.

Jack up platforms or most vulnerable when they are afloat, because under towing condition they are highly subjected to hurricane cyclone damage where instances are shown in the literature the jack up breaks while transportation are very severely damaged

because of cyclone or hurricane effects. The conceptual picture what you see here will show you the connection of subsea system with that of the main platform or with that of the offloading weasel using flow lines and subsea many force. What we will not discuss here in this lecture id the details about the subsea many force and they will layout. We are only talking about the structural systems which are meant for oil and gas exploration.

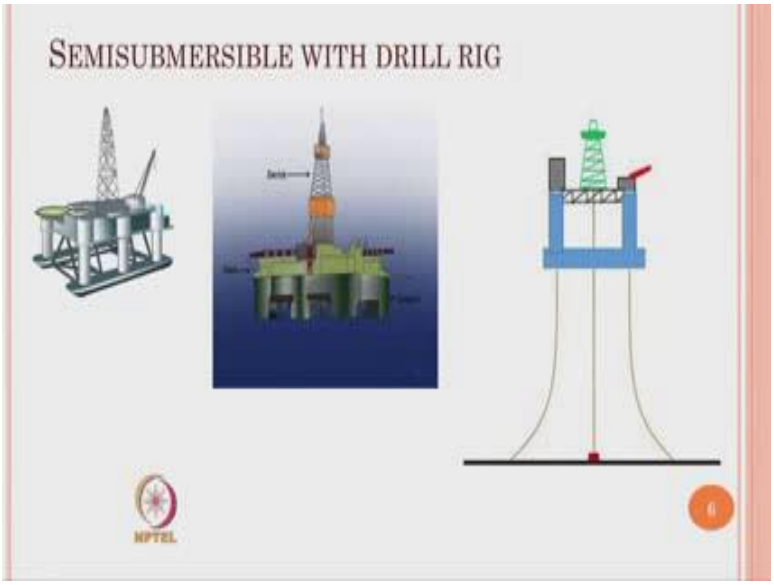
(Refer Slide Time: 05:00)



This figure shows you the conception understanding of what kind platform can be deployed floating type can be d deployed at different water depths up to 90 or save 100 meters one can go for jack up rigs beyond 100 meters one is comfortable with semi submersible up to about 200 meters and beyond 200 or 250 meters prefer to take a drill ship which can also be capable of exploratory drilling up to depth of as deep as 2000 meters.

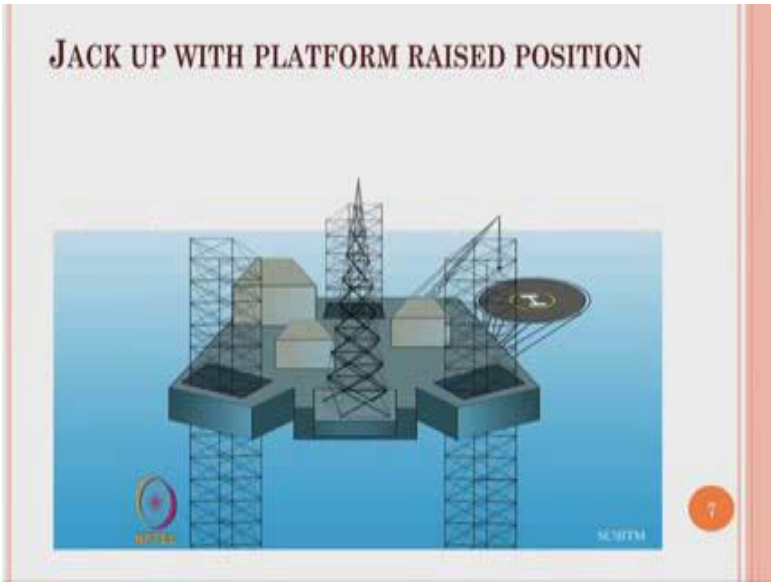
All this platforms remain afloat and their position or station kept in location when the operation is performed. For example, drill ship is completely navigate in vessel which will be held on in the position either by dynamic positioning system or the cables are more in lines, so that the platform or the drill ship reminds in position when exploration is carried out.

(Refer Slide Time: 05:59)



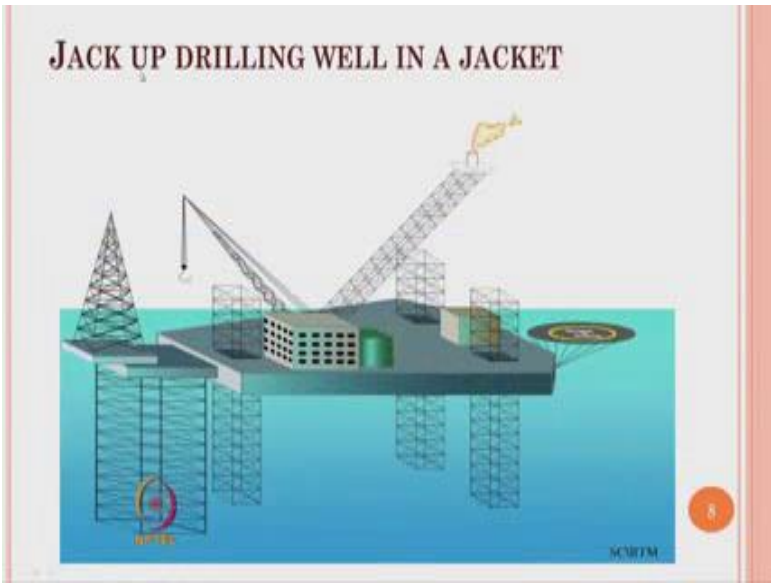
This slide shows a typical picture or a sketch of semi submersible with the drilling rig. Can see this is the drilling the rig which is the used for drilling, whereas this is the semi submersible platform which contains the pontoon on the column members which is as similar to that TLP provided. The difference essentially is that in a TLP these legs will be anchored to the sea bed through what we call tethers or cables permanently. Whereas in this case they are held on in possession only when the operation is being carried out otherwise they are set free float so that they can be moved from one location to another location.

(Refer Slide Time: 06:42)



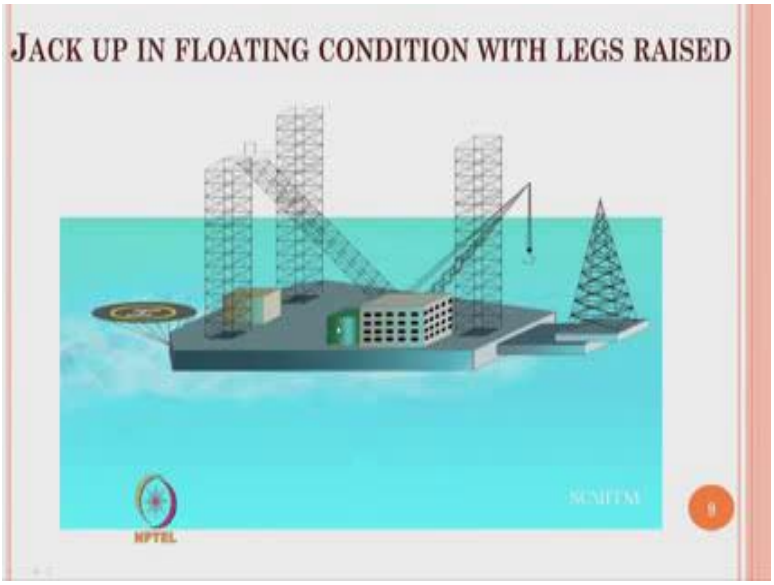
Jack up rigs is meant for exploratory drilling up to depth of 100 meters. The word jack up is very important and very simple to understand it essentially consists of three (Refer Time: 06:54) type tower biased systems which is connect to the depth. When the platform is set the floor these (Refer Time: 07:02) tower will be raised in position. And this becomes a simple sailing vessel which contains all facilities and it is kept on boat and it is allowed to float or navigate like a simple vessel. When the portion or the place is reached for the exploratory drilling the platform is raised up by pushing these (Refer Time: 07:24) tower legs down that is why this platform is called Jack up Rig.

(Refer Slide Time: 07:30)



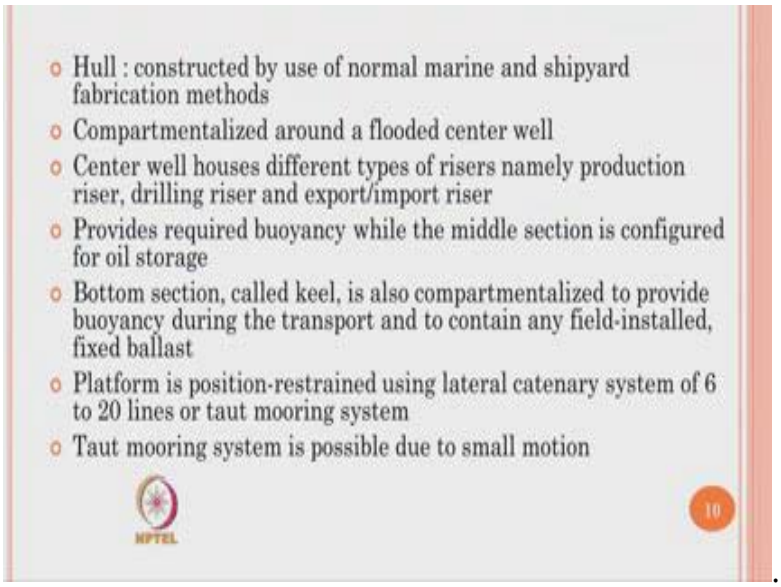
The jack up drilling well is also connected to the jacket as you say in this figure. The jacket drilling also contains the crane arrangement for lifting and other facilities. It has got living quarters for people to keep on boat. It has got electro mechanic equipments. And of course, it has got a conceptual bars or a crane were the flair (Refer Time: 07:53) is connected while exploratory drilling. It is also having a facility like a helipad to off load and on load personal because of safety reasons.

(Refer Slide Time: 08:01)



When a jack up is in a floating condition this how it looks like all the tower like system or the (Refer Time: 08:09) type towers will be kept above the deck and only the deck will made to float like a simple sea going vessel on reaching the site in location the deck will be jacked up. So, that these legs will be pulled down they will connected to the sea floor using the spec scan system as you saw in the case of a simple arcaded towers.

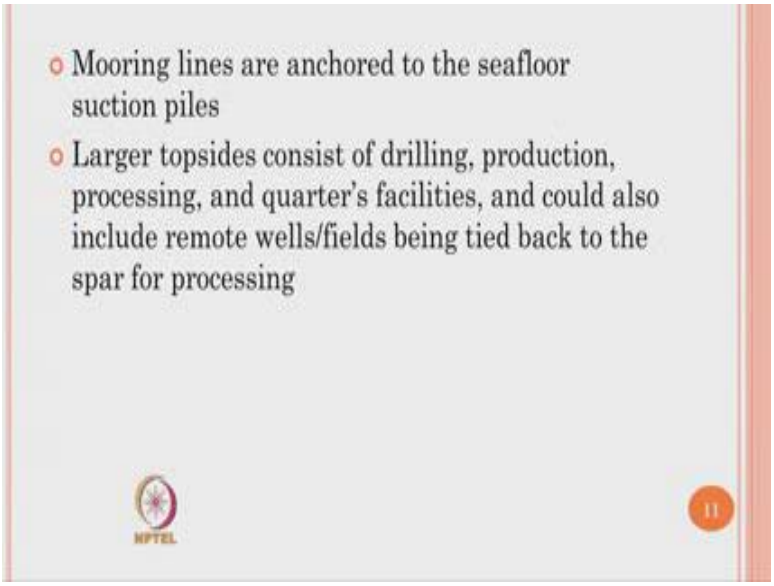
(Refer Slide Time: 08:32)



It consists of a hull, which is constructed by a normal marine and shipyard fabrication methods. It is compartmented around the flooded centre well. The centre well houses

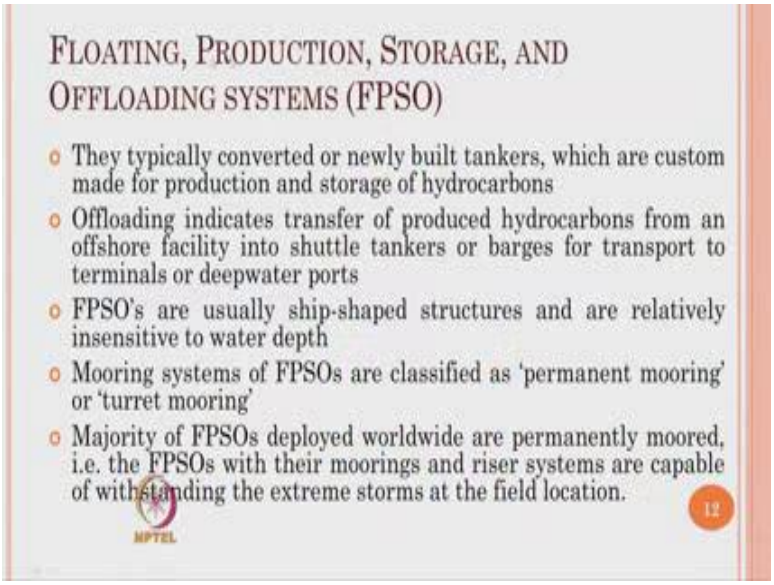
different types of risers namely production riser, drilling riser and export import riser. It provides required buoyancy while the middle section is configured for oil storage. The bottom section which is called as a keel is also compartmentalized to provide buoyancy during the transport of it and to contain any field-installed fixed ballast. Platform is position restrained using lateral centenary system which comprises of about 6 to 20 lines which are taut mooring system. The taut mooring system is possible only due to small motion of the vessel.

(Refer Slide Time: 09:24)



The mooring lines are anchored to the seafloor using piles, which is a suction type pile. Larger top side consist of drilling, production, processing, living quarters, and go also include remote well fields being tied back to the spar for processing.

(Refer Slide Time: 09:48)

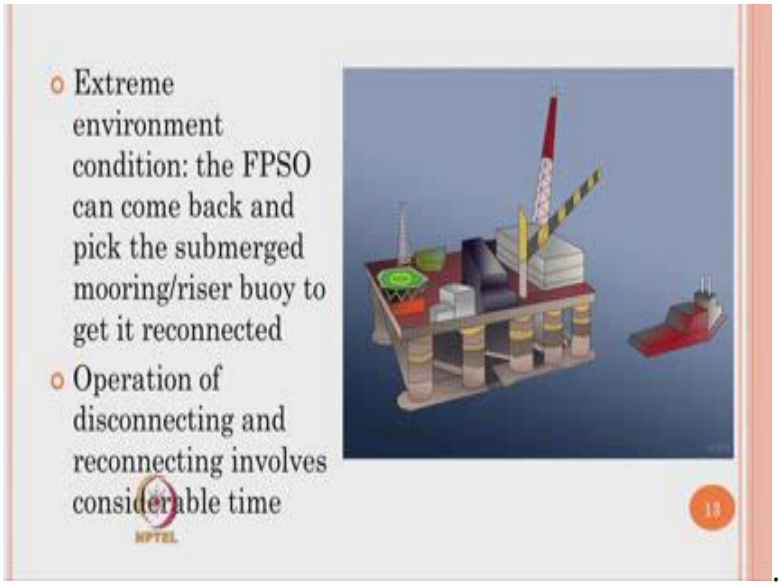


The next variety is floating by nature of geometry, production, storage and offloading by nature of its function is called FPSO. They typically or actually converted type tankers which are custom made for production and storage of hydrocarbons. The essential function of an FPSO is a storage capacity which is not otherwise seen in normal conventional platforms meant for exported type.

Offloading indicates transfer of produced hydrocarbons from the offshore facility to shuttle tankers or the barges form where it is further carried down for processing. FPSO's are usually ship-shaped structures and are relative insensitive to water depth. Mooring system of FPSO is permanent mooring or turret mooring system. Majority of FPSO deployed worldwide are permanently moored, that is FPSO with the mooring system and riser systems are capable of withstanding the extreme storms at the field location.

So, though the platform is suffer floating time, when the platform is located or placed in position using the permanently moored cable system the platform behaves like a complaint type vessel or a platform which is useful for production, drilling, storage and of course this also has capacity of offloading the explode hydrocarbon from the offshore to shuttle tanker as it is requested and demanded.

(Refer Slide Time: 11:18)

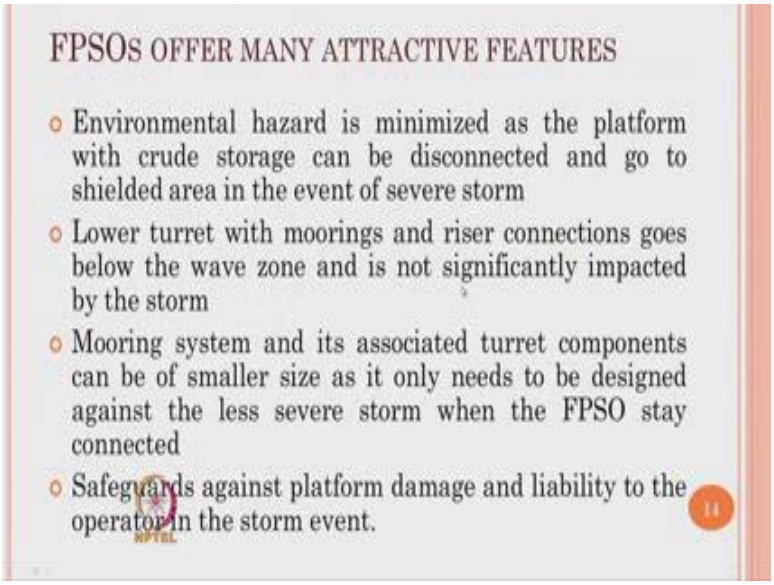


This picture show the schematic figure of a typical FPSO which contains all possible top say details as that of a typical production unit. It is got a flare boom which you see has got a crane, it has got a helipad, it has got a drilling very living quarters electro mechanical equipment, multi triadic system supported by different (Refer Time: 11:45) which are making the system to float whereas we all understand (Refer Time: 11:49) will be larger in a outer diameter (Refer Time: 11:52) inside which will attract or which will enable lot of buoyancy forces which will make the system to set a float.

Now the major advantage of a system like FPSO is like that since it is free to flow mooring is FPSO from location A to location B is very simple even a simple tug boater a barge will be able to guide the FPSO from one location to another. Of course, the single tug board is not sufficient till the seas of tug boards in the aft in the foreside which will drag the FPSO from shift of location of drilling well A to B and so on.

The operation of disconnecting and reconnecting involves considerable time. Therefore, one should always think about marching time involved in disconnecting and reconnecting the device, because the production rises will be connected to the platform and they need be the disconnected before the platform or FPSO is moored from location A to location B for further explanations.

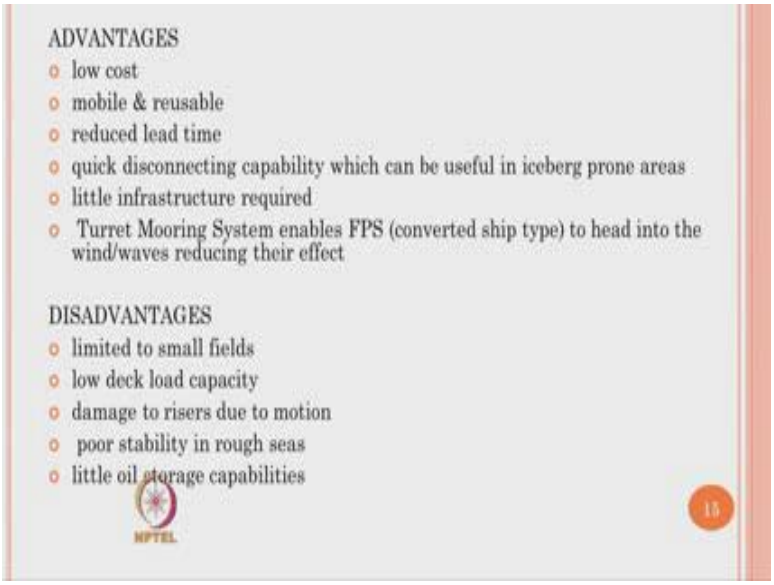
(Refer Slide Time: 12:52)



To look at the literature FPSO's offer many attractive features. The environmental hazard of this kind of platform is as minimum as possible, because the platform with crude storage can be disconnected and taken the shielded area in the event of severe storm. So, failure of this kind of platform and a critical sea states or under (Refer Time: 13:20) sea state are actually not visualized. Because the platform can be disconnected from the riser systems can be moved safely or the production can be upheld.

The lower turret with moorings and riser connections goes below the wave zone and therefore it is not significantly impacted by the storm action. Mooring system and associated turret components can be smaller in size which can involve lot of saving of money. It only needs to be designed against the less severe storm compared to that of FPSO stays connected. It safeguards against platform damage, and liability to the operation in the storm event is minimum as possible. Therefore, in safety perspective FPSO offers lot of attracting features compared to that of a jack up rigs.

(Refer Slide Time: 14:08)



There are severe merits and demerits of FPSO. They have got cost low cost, because FPSO generally can be hired on call. It is highly mobile and the platform is totally reusable. The reduced lead time from marching the FPSO from one location to another location enables the quick production of oil well easily. The quick disconnecting capability of in FPSO from that of a drilling well which can be useful in iceberg prone zones little infrastructure is required, because everything is pre commissioned in FPSO. Turret mooring system enables FPS to head into a wind waves reducing their effects.

Of course, got high demerits as well; it is a limited only small field. Low deck capability will enable the platform only to go far small production capacity. Damage to risers due to motion is also possible, because rises are not protected through the line. Poor stability and rough seas, and little oil storage capability will make the FPS to have a substitute for that kind of platforms.

Now, ladies and gentleman we will move forward in the research perspective understand what new generation offshore platforms are. When you say new generation I am talking about may be the resent 5 to 7 years time. Now we have seen different kind of structural forms, different functionalities, different capabilities of platforms and their cost and functional aspects of the different kinds of platforms. We have understood that oil and gas production is moving from shallow waters towards ultra-deepwater, therefore the structural form which is meant for shallow waters cannot be as same as that are meant

for deepwater or ultra-deepwater. There is a significant change the structural form structural system and the style of alleviating loads compared to the top fixed type with respect to the top complaint of floating type structure.

Now, the question comes in mind is what is the demanding necessity to consider new generation of your platforms.

(Refer Slide Time: 16:22)

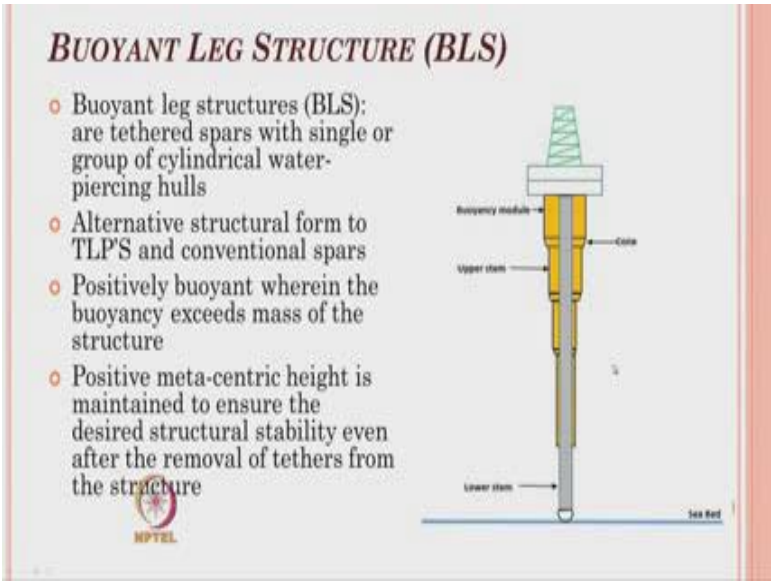
What is the need to identify new generation offshore platform? Due to non-availability of oil gas reserves in medium waters depths oil in exploration is targeted at ultra-deep waters. The movement is say ultra-deep waters I am talking about water depth more than 1500 to 2000 meters. In such situation the encounter wave loads and environmental loads are more severe because of the higher increase water depth. The geometric forms of offshore platforms propose for this kind of deep and ultra-deep waters need special attention. They should remain cost effective; the proposed geometric form should also have improved motion characteristics for rough sea which is not a demand from the previous types of offshore structural systems.

(Refer Slide Time: 17:15)

If you look at summary of different kinds of offshore platforms available as on today for ultra-deep water structures, the figure or the stretch clearly shows different kind. You can name couple of them this is a TLP, because it knows the top side is anchor to the sea bed using thought mooring cable system. You can always understand what kind of platform is this. This can be a drill ship. This is a sea going vessel which is anchored to the sea (Refer Time: 17:47) mooring line for push and keeping them or can even using dynamic (Refer Time: 17:53) system it can be spar platform and so on.

Now, the one what you see here is a large kind of platform system or a combination of a different system arrive from the previous one, but catering to that of ultra-deep waters. This is what we are going to see now in the next few slides.

(Refer Slide Time: 18:14)

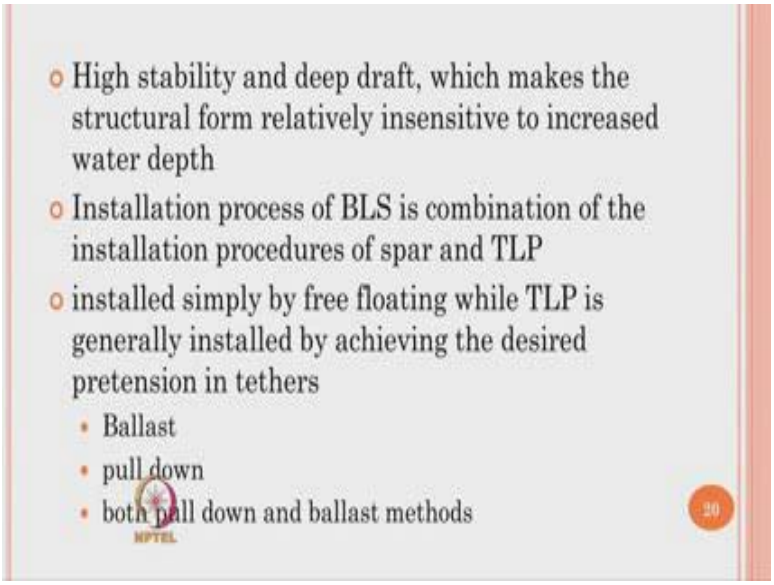


Top on the list in the new generation platform is Buoyant Leg Structure, abbreviated briefly as BLS. A typical tower or stem is connected to the sea bed using a spect scan or a universal joint similar to that of previous kind of an offshore platform. Now the interesting part of this particular type of platform is that there are different buoyancy modules attached to the central tower at different locations so that the buoyancy can be adjusted depending upon sea state.

So, this is what we call buoyant leg structure. They are actually tethered spars which are the single or group of cylindrical water piercing hulls. It is consider as one of the alternate structural form to that of tensional platforms and conventional spars. It is positive buoyant, wherein the buoyancy exceeds mass of the structure. The positive meta centric high of this kind of platform is maintained to ensure the business structure stability even after the removal of tethers from the structure.

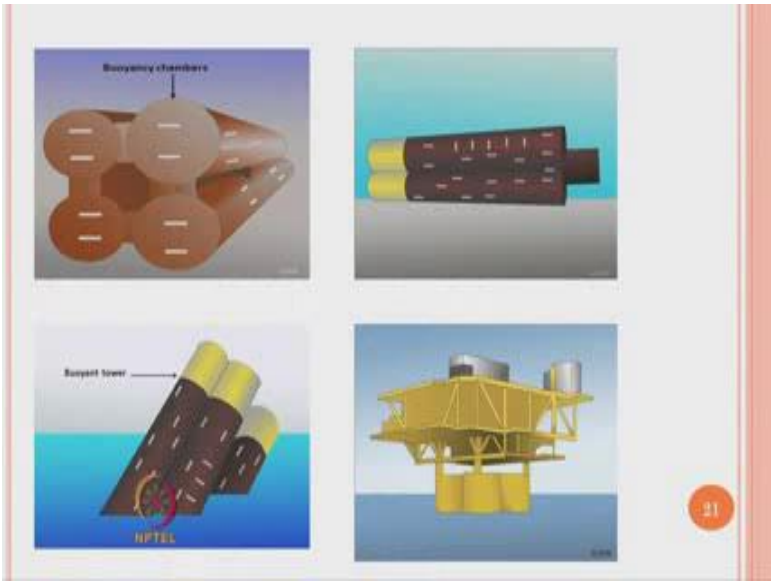
Ladies and gentleman that is the very advantage you have because of the simple reason. When the tethers are plugged off from the systems like TLP they can cause lot of structural instability, whereas buoyant leg structure or analyse in place with removal of tethers as well so that the still remaining tact and stable even though the tethers are removed from the from the structural system. It means these structures do not gain support system from the tethers they are only used as possession keeping systems.

(Refer Slide Time: 20:09)



High stability and deep draft makes these platforms in sensitive for increase water depth. Installation process of BLS is a combination of installation procedure of spar and TLP. They install simply by free floating, while TLP is generally installed by achieving the desire pretension in tethers either by ballasting or pulling down or both pull down of tethers and ballast methods.

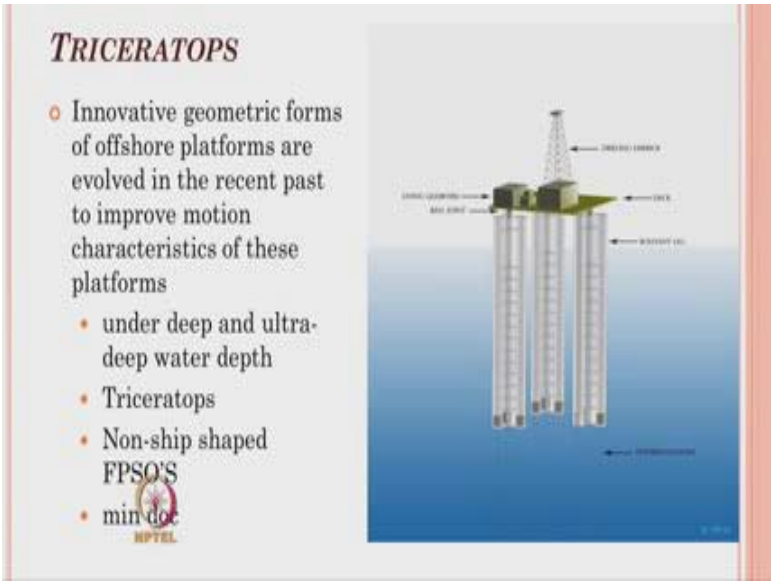
(Refer Slide Time: 20:29)



The buoyancy chambers look like this. This is call buoyancy towers, this buoyancy towers are fabricated, interconnected and placed together on a deck mate system as see

here the whole system is kept afloat and the system is moved for one location to another location.

(Refer Slide Time: 20:48)



The second verity of structure what you see here which is new generation platform is offshore triceratops. The word triceratops indicates there are three pairs of buoyant leg systems. These are buoyant legs which are not interconnected, which are of course anchored to the sea belt using tethers or tendence as in the case of a TLP.

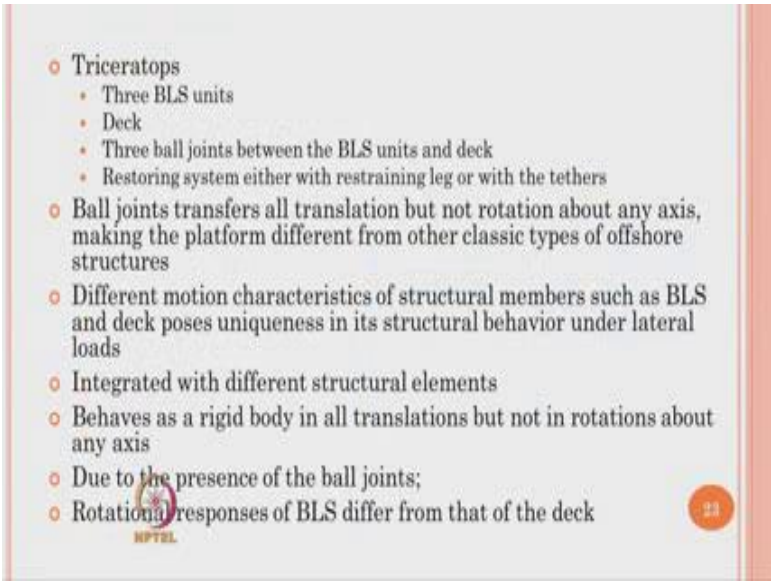
Now, one can wonder and how this BLS will be supporting the deck. Interestingly the BLS supports the deck or connected to the deck through what we call as a ball joint. The ball joints are placed in between the buoyant legs and the deck at every location as you see here. The moment I say ball joint the ball joint is what is own capability of not transferring the rotation from the substructure to the super structure or from the super structure to the substructure.

Now, one can ask me a question what could be the derived advantage of providing a ball joint between the buoyant legs and the deck. Ball joints as you understand do not transfer rotations from the substructure to the super structure, when the super structure rotates because of the arrow dynamics instability or because of the wind loads acting on the derik like structure or derik must as seen here. These movements will not be transferred to the buoyant legs.

On other hand when the buoyant legs are subjected to wave tied and current action which will make these buoyant legs to rotate about this point, this rotation will not be transferred to the super structure. So therefore, this non-transferring of rotation will enable the deck to remain horizontal as far as possible. On the other hand, in the vertical degree of freedom like (Refer Time: 22:50) there is a complete compatibility between the BLS and the deck because BLS is position restrain like a TLP using thought more tendence.

So, in the vertical degree (Refer Time: 23:03) degree of freedom it is a rigid connection. In the complaint degree is like rotation degrees of freedom there is no transfer between the buoyant legs to that of the deck. This improves motion characteristics of these platforms, so therefore these platforms are recommended for deep and ultra-deep water depths they are called as Triceratops. Generally non-ship shaped FPSO's and min docs are also attempted for ultra-deep explorations.

(Refer Slide Time: 23:23)

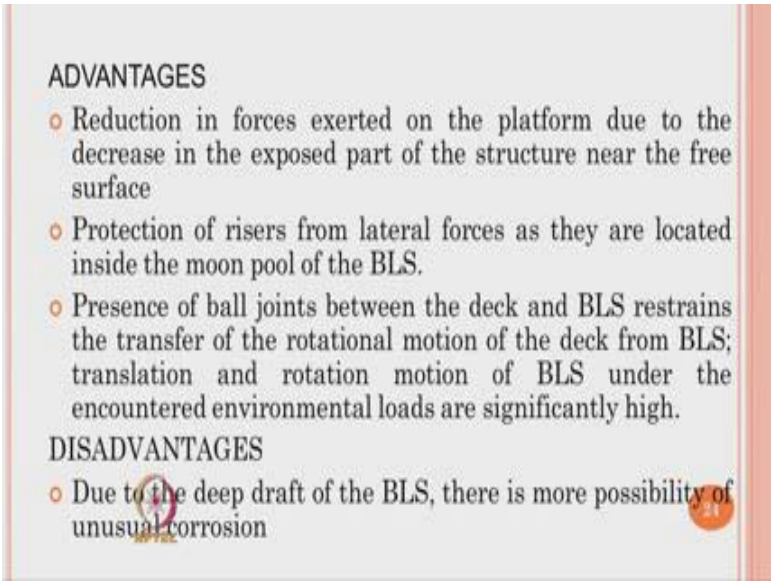


Triceratops has three BLS units, a deck three balls joints between the BLS units and deck and the restoring system is similar to the top a TLP to the top more tether system. Ball joints stands for all translation that is surge sway and (Refer Time: 23:55), whereas no rotation about any axis. So, this makes the platforms different from the top other classical type offshore structures. Different motion characteristics of structural members such as BLS and deck poses uniqueness in the structural behaviour under lateral loads

integrated with different structural elements, but stays disconnected in terms of response behaviour.

It behaves as rigid body in all translation degrees of freedom, but not in rotational degrees of freedom about any axis. This is happening because the presence of ball joint enables this to happen rotational responses of BLS or different from that of the deck

(Refer Slide Time: 24:39)



It possesses series of advantages reduction in forces exerted in the platform to the decrease in the exposed part of the structure near the free surface. Protection of risers from the lateral forces as they are located inside the moon pool of the BLS; presence of ball joints between the deck and BLS restrains the transfer of rotational motion of the deck from BLS and vice versa. So, translation and rotation version of BLS and encountered loads are significantly high. Even though they are very high as they are not transferred to the depth the platform is in sensitive to this kind of large responses encounter with BLS under ultra-deep water conditions.

The essential demerits of the system are due to the deep draft of the BLS, there is more possibility of unusual corrosion.

(Refer Slide Time: 25:33)

The corrosion challenges are very simple. They can be frequently addressed by inspection them using corrosion testing procedures. You can use sacrificial anodes. One can use anti corrosive coatings. One can also use cathodic protection. Please understand that the ball joints are kept above water level, therefore the ball joints are not corroded. Whereas, the BLS can be corrosive media which can be treated as by different methods as explained earlier.

(Refer Slide Time: 26:05)

The other kind of offshore platform which is again the new generation platform is a floating, storage, re-gasification unit.

Ladies and gentleman once the oil and gas explored from ultra-deep water the quantity of oil explored becomes by enlarge high and that needs to be processed immediately. The one way of doing it now is to transfer it to show and then get it processed, but the residue or the remaining ways becomes a very serious problem because they need to be discharged after proper treatment. Now the alternative arrangement people think of is now is regasifying them processing them in the offshore platform itself then take it in the condensed manner and the regasify it subsequently later. Transportation of un-processed crude oil from the exploratory platform to the onshore site involves expensive systems like transportation through pipes, large vessels which make oil production more expensive. FSRU is the more cost effective system which is an alternative to the meet the low demand of LNG than traditional land based terminals.

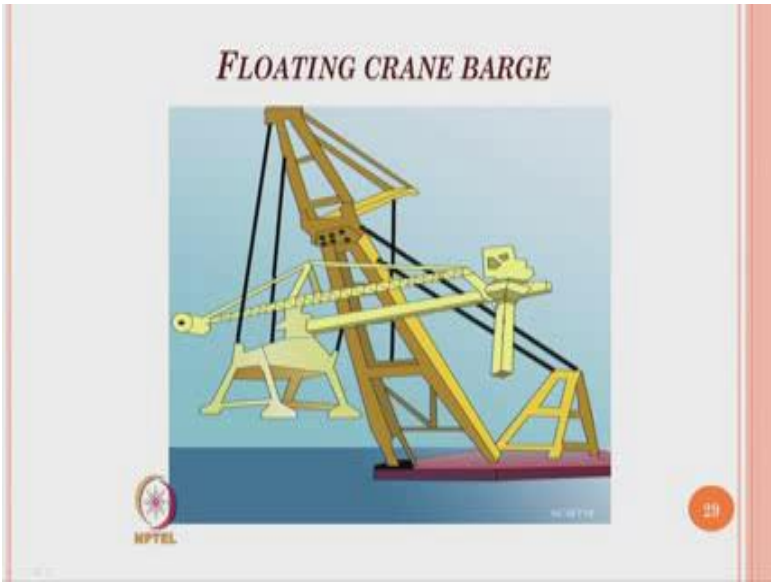
Now, in this lectures ladies and gentleman we gave a comprehensive review of different kinds of offshore platforms varying from fixed type, complaint type and fully floating type. In addition to that we also see some additional features of new generation platforms. We have understood how the shape of the structure the structural forms is geometry arrangement of members, its connectivity, its position keeping characteristics, its functional use, its production capacity, its storage capacity, its mobility and construction aspects of different kinds of platforms has a very short review.

So, this idea will unable to people understand a variety of offshore structure before they carryout detail dynamic analysis of anyone of similar structural systems. Now, as brief introduction will also talk about offshore construction equipments which are used because very important for knowledge sake.

(Refer Slide Time: 28:22)

The photograph what you see here is semisubmersible crane barge. Now we can understand very clearly that a platform which is not tankered to the sea bed or connected a sea bed using piles that is semisubmersible needs a crane barge which is used for uploading or transferring oil from one vessel to the another vessel or shuttle tanker.

(Refer Slide Time: 28:53)

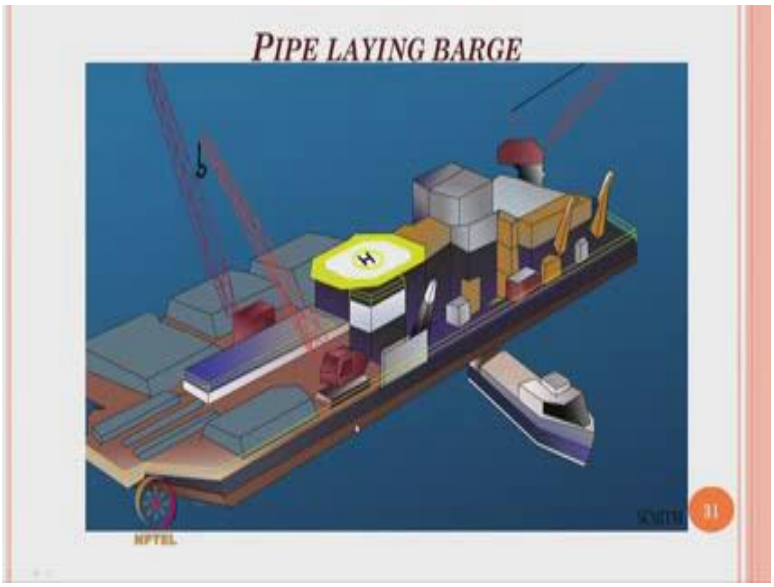


This picture shows floating crane barge which by itself floats and can be moved from one location to another location as the system demanded.

(Refer Slide Time: 29:03)

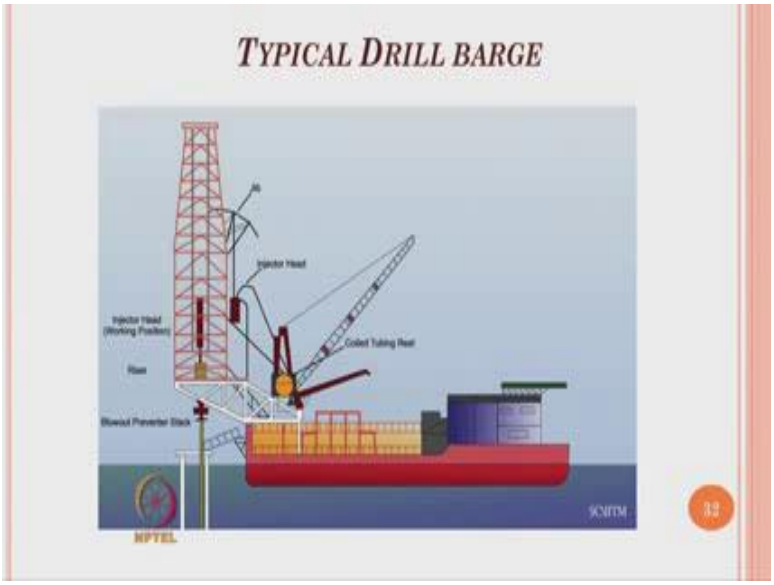
Offshore mast crane AHC it is a typical example of a very large floating vessel which has got different capacity, different bloom length and different crane hook capacities of cranes of different locations which are used essentially in offshore production systems.

(Refer Slide Time: 29:22)



Pipe laying barge is another kind of large floating vessel which essentially used for lying of pipes. Pipes can be used for transporting oil from offshore to onshore locations.

(Refer Slide Time: 29:34)



A typical drill barge looks like this for a drilling rig is offloaded or completely kept away from the vessel (Refer Time: 29:43). We got a riser we got a (Refer Time: 29:47), and of course, got other cable arrangements which will also pump or suck out the drilling mach from that of the drilling stack.

(Refer Slide Time: 29:58)

Lifting barge is one of the common facility being used for installation and commissioning during essentially during the top side installation what we call as a (Refer Time: 30:08).

(Refer Slide Time: 30:11)

Large barges are also used for loading transporting top side equipments, because you know modular construction is enabled in offshore platform design.

In the present lecture we understood different kinds of offshore platforms followed by lecture 1, therefore it gives a view of different kinds of platforms meant for production, exploratory drilling, storing, offloading, etcetera.

Thank you very much.