Elements of Ocean Engineering
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Lecture - 23
Drilling from Platforms

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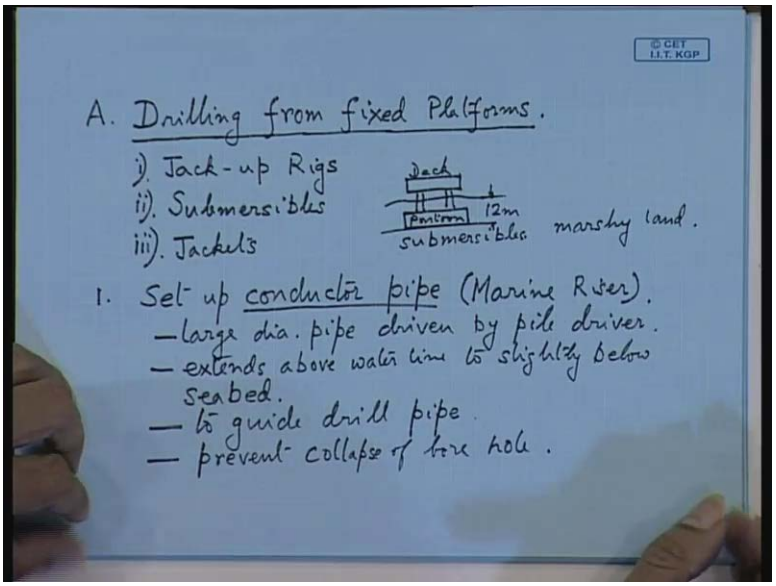

So, today's lecture we on Drilling, so there are two aspect of drilling; one is from fixed platforms, later on we will study about floating platforms. So, from fixed platforms these are the bases, which are basically Jack up Rigs, then you have a submersibles; of course, submersibles are not much of use in the nowadays. Submersibles basically have two hulls, one above the water level and the other on the seabed, so this you remember. So, these are the precursors of a semi subs that means, the bottom hull actually rest on the seabed and here you have the wave, so this is call a submersible.

So, submersibles were used in the 1940's in shallow water, so water depth is around say 12 meter, so this is your pontoon and deck, so this is called a submersible. So, these are not of much used in nowadays still in marshy waters, marshy areas you can find these types of structures. Now, so these are call submersibles and the last category of course, that I was talked about is your jackets platforms, so these are call jackets. Now, jackets are essentially guide for your pipes and they are fixed coastal structures, now the main purpose of drilling is set up conductor pipe, this is set up conductor pipe.

So, this is your prime motivation and this is a large diameter pipe driven by pile driver, so this you must have noticed when you have the pile work is carried out from for buildings. Now, this conductor pipe extends from above the waterline [FL], extends above the water line to slightly below seabed, so this is a extends of your conductor pipe. Now, this is a very important pipe, which transport your oil from the oil well that is down below to your platform, so sometime this is also call a marine riser.

Now, the function is to, primary function of what is your conductor pipe is to guide drill pipe and prevent collapse of borehole, so these are functions where you have a conductor pipe, prevent collapse of borehole. Now, the process of drilling you can see from this diagram, now the processor moral is the same, whether it is from a fixed platform or from a floating platform. So, here I have a diagram and you can see the drilling, so this is your drill pipe.

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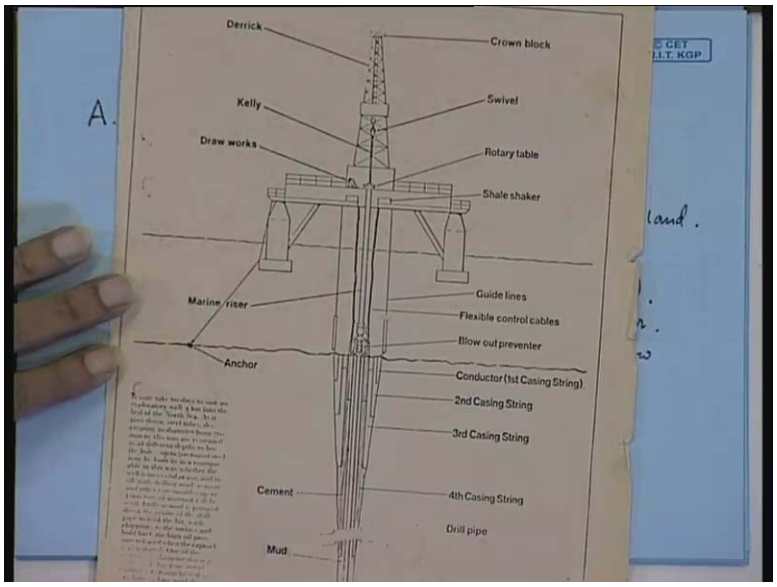

So, that means, so here actually the drilling from the semi-submersibles is going on, these are the various components, now here you find, this is your marine riser or conductor pipe which has talking about. So, this actually is while you are drilling, now through this your drill stream comes out, here you can see this is your drill bit and this is connected to another pipe. Now, this pipe is hollow for mud circulation and this pipe actually comes in 30 fit sections, and there are the screwed at various length, so this is called a drill collar.

And the whole thing from the top to bottom it is called a drill string, so when in the drilling you come across this word drill string that means, it consists of your drill bit, drill collar and drill pipe. Now, this actually your drill string which I will talk about, it is suspended from the derrick, so this is your drilling derrick and it is actually suspended from polish your is call a crown block. So, here it is suspended via is swivel, now swivel is there such as a drill bit, that whole drill stick can rotate, so this is actually a joint, universal sort of joint.

Now, here you find a Kelly, Kelly is a square piece of road, now there are two things which one has to do, suppose you are driving a screw into a wall, so what you are doing you are basically we are applying two forces, one the horizontal or a vertical force and other is a turk. So, similarly here also you wants to drill a hole, say boil hole is being drill, so you have to put a vertical pressure on the drill string however, it would not go down, and also you have to put a rotary turk.

Now, this vertical pressure on the drill bit is actually your weight of the drill string, so drill string is actually way of your 100 tons, and suppose what is done, so normally you will find suppose it is under weight that means, you would not increase the weight. So, what you do, you increase the number of collars, drill collars or here you can put additional weights on the drill string, in order to put vertical pressure is such as, it goes down. And the turk is actually given by this rotary table, say rotary table is given a it goes round and this is actually it made with the Kelly.

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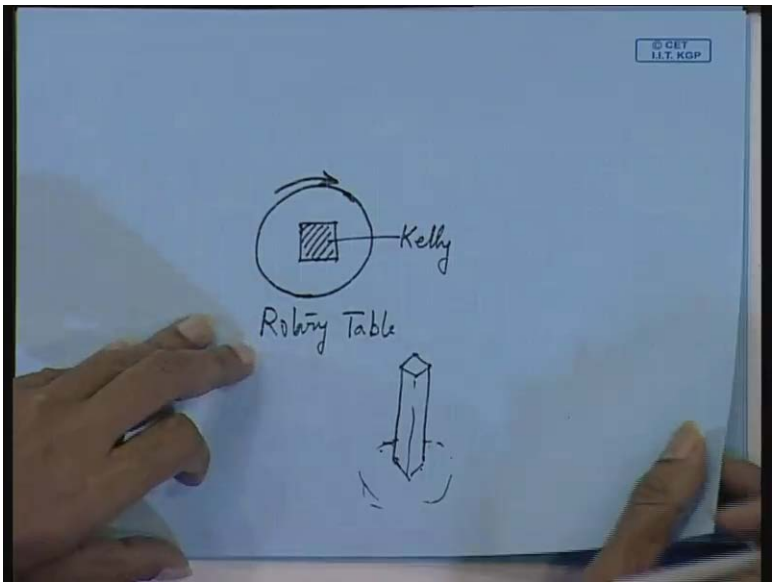

Now, you can see in this diagram that, if you want to have a turk that means, you have to give, so if you look at a plan give of the rotary table, you will find there is a circular disk, circular disk with a square hole. So, this is your rotary table and here you will find a square hole for incursion of the Kelly, so Kelly actually goes down through this square hole, so this is your Kelly. And this rotary table is given a turk, so this is a direction or rotation of your rotary table, so the reason is you have to give turk to the Kelly.

Kelly is a rotary that is why it gives on a square hole, if you make this round then, the grip will be only the friction grip, but here actually there is no chance of slippage, so that is why it is given a square hole. Now, if you see in the process of drilling as the rotary table is rotated, so the whole drill string actually goes down that means, the bore hole goes deeper and deeper. And the one length of Kelly, so that means, the drill pipe actually coming 30 feat lengths, so one length of pipe is going to go down, so that means, it will also drag the Kelly this joint will come here, so it will come down here.

Now, after the whole length of Kelly has gone down, you have to the whole drill string is taken up, so that is why this is actually come from the polish, this is actually here what is called draw works, so what is not shown here this ((Refer Time: 10:30)), number ((Refer Time: 10:30)) is connected to your draw works, by means of wire ropes. So, that means, it is worsted after one length of drill pipe goes down, the whole drill string is hoisted such that, it revise the joint of the Kelly with the drill pipe. So, Kelly if you see, the

Kelly is the square piece of rod, so something like this, so that is joint to your rotary table.

Now, this joint actually is remove is opened up, and another section of drill pipe is joint to the top of the pipe, you remove the Kelly, you joint as a piece of drill pipe with the top of this drill string. And then, again you connect your Kelly and again it will go down, by your Kelly will come here, because you are added a another piece of pipeline, so then again the whole drilling process is continue. So, like this there is a continuous on string of the Kelley additional drill pipe goes on, now so far so good.

Now, what is done actually, now there are two things is the drill bit, you will find there are number of I will talk this thing in the notes, the drill bit is has a number of variation, in order to drill for hard soil, soft soil. So, after a few hour drilling you will find that the drill bit gets blow out, so then again you have to take out the whole drill string on screw bit and again screw another bit, and again you continue the process of drilling. So, this is a very trivious task and the whole point is that, this bore hole you can see there are number of casing, now casing in here actually it has been shown in the large scale, actually this should fit within the diameter of the marine riser. So, this casings you find this is actually a floating platform or a semi-submersibles, now in a semi-submersibles, you will have the the blowout preventer at the seabed.

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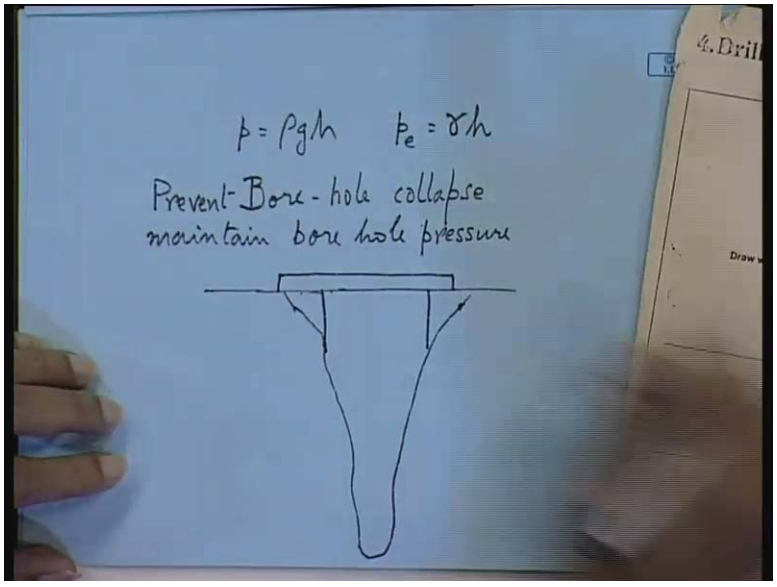

So, this is call a wellhead assembly, so these casings what you have seen out here, it is actually suspended from a wellhead assembly, so here you find number of casings being suspended, and this is your bore hole is going to have this kind of configuration. So, you will find here in this diagram, that is the first casing of the conductor pipe is larger in diameter, because you made the hole size at, first what is actually the hole is made shallow and wide. And then your first casing is inserted, so you can see the first casing the diameter is quite big, so now you go on drilling, as you go on progressive drilling you will see as you drill hole on the wall, progressively the diameter keep on decreasing.

And you have to insert, then more number casing, so the first casing comes out here now inside that you insert another pipe, which is called a second casing, so these are actually strings. String means of course, from the seabed to the top of the platform, you cannot have a one single pipe, but you will have number of pipes which are screwed one to another, so that is why it called a string. So, like this you insert number of casing has the whole gets progressing deeper, now after the certain length in this diagram, you can see that you can no longer insert any more casings.

But, you can see the nature of the borehole has narrowed down from the seabed to down bales, so the these depth can be very high can we as larger as say 3 to 4 kilometer in depth. So, here that means, you do not have any more casings, so you can see the drill string along with the drill bit is boring a narrow hole, now what happens is that as you are drilling, there is a tendency for this mud or blow hole. This is call borehole collapse, now if this happens a borehole collapse is that means, the borehole the mud from the borehole actually comes and blocks the hole this borehole.

So, this borehole actually becomes flatted with mud, so that means, you have not what is called stabilized the hole, so because you are drilling so deeps say 3 kilometers, 4 kilometers there is the tendency of this mud to come and chock the hole of the borehole. So, if that happens, then your drilling is going to stop, either you can remove this drill bit or you can turn the drill string, so that is a that means, the whole process of drilling has to stop, and we have to abandon this hole in gone.

So, in order to prevent that what you do, you give a counter pressure, now here actually all boreholes have to be maintained at a certain pressure, that is call borehole pressure, so which is very important and that also have to be monitored. So, prevent these borehole

collapse, maintain borehole pressure, now as the drilling actually goes on into the deeper and deeper down below into the reservoir, now pressure in countered. Now, pressure will come from the first here the hydrostatic head, then the mud you will see this thing you are always familiar, what is your pressure p is equal to hydrostatic pressure.

Hydrostatic pressure is rho g h, and the earth pressure that it will come across, so p earth you can write the a specific gravity of the soil multiplied by h, earth is also going to exhaust pressure, on the sides just like as your water, it is exhausting pressure. So, these pressures you have to combine, so huge amount of pressure is going to come on the borehole out here, so how to how to prevent collapse is you have to maintained a internal pressure inside the drill string. So, that is actually affected by what is called internal pressure is maintained by mud circulation.

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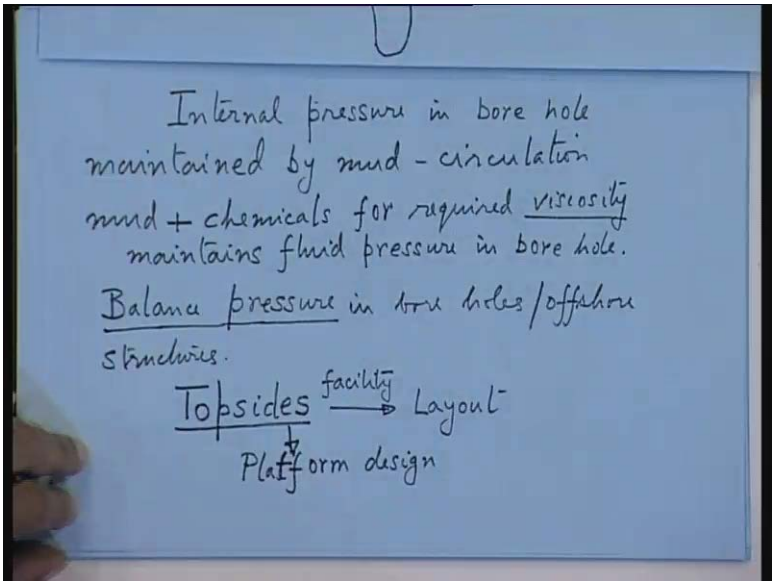

So, internal pressure in borehole maintained by mud circulation, now this mud is actually not the clay that you can see in the soil, but this has mud plus chemicals added to it, this chemical for required viscosity. So, certain amount of viscosity has to be maintained in the borehole, because the flow rate, flow has to be maintained for the mud, so you add certain chemicals. So, this the mud is actually doing required viscosity maintains fluid pressure in borehole is very important.

Now, as you go deeper down inside the earth you encounter more and more pressure, so that means, your mud pressure will has to be increased is it not. So, you have to counter

the pressure coming from the soil and from this region, by your pressure there is inner pressure from the mud. So, the main problem that the out here is I told you in case of gravity platforms in any platforms in deep water, always balance pressure, this pressure balancing has to be done at any cost. Otherwise, you are asking for trouble, the whole structure will collapse if the external pressure is very large compare to a internal pressure.

Balance pressure in boreholes offshore structure etcetera, so this is the problem that you come across for large water depths anyway, so this mud circulation is done I will give you the sequence of your mud circulation. So, mud actually keeps on circulating through your Kelly drill string, now it comes outside through the drill string, outside the bit and here you can see there is a gap between the hole and the drill string. So, the mud actually flows out through this gap, and it comes to the surface through you can see the annulus space between the casing and the string.

Through this narrow space it is led up into the, there is mud pump banner reservoir out here, so that keeps on circulating the mud. So, while you are doing the drilling operation, you are always to supply a mud, the reason is you have to maintained the pressure inside the borehole, and also you have to lubricate the bit. Otherwise, your bit will become worn out in just a 1 or 2 hours, so this is a function of your mud circulation, and here it has not been now, that the other things are not being shown.

One thing you can see this is your drill floor of this semisubmersibles, here you have the shale shaker, shale is nothing but broken pieces of rock. So, those have to be separated from the mud, because when the mud is being lifted up, along with this action your rocks and other impurities are going to be sucked up. So, those again have to be separated by the shale shaker and again mud has been driven down, so here you have shale shaker there will be a pump, there will be a mud ditch and all this paraphernalia will go on the drill floor of the platform.

So, when you are designing a platform that means, the depth has to actually house all those equipments and not only that you have to stack large lengths of the drill pipe, so those are stack on the deck. So, you have to have dekerria requirement when you calculate, so in your not in discuss, but in offshore technology class, what I will come talk about those are call topsides. So, in offshore engineering frequently you come across

((Refer Time: 23:50)) this term topsides, so all these equipments etcetera they are led out on the deck and you have to have space, proper layout of those spacing is required, so those are called topsides layout. So, this is actually a very important in your platform design, because platform design is actually centered around topsides, topsides facility or you can write facility. Now, topsides facility is going to vary, whether you are you are going out for this is exploratory drilling other two types of drilling you come across.

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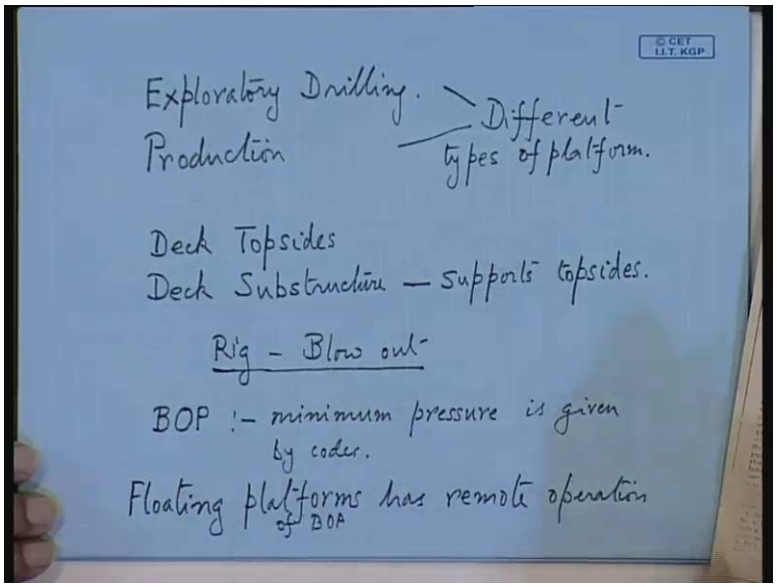

One is call exploratory drilling which has last class I talked about that is call exploratory drilling, and the other is call production. A production of course, you do not have drilling, but you just simply take out the oil from the reservoir, so there are two basic different types of platforms. So, when you go to offshore you come across all these terms, so different types of platforms one is for production and the other for exploratory drilling. So, this is to be noted now what you are doing here is exploratory drilling, so now here you can see this is a floating platform.

The other important equipment that you out here, so all those pump etcetera everything, they are led out on the deck, so those are call topsides. Now, topsides they not only consist of all your equipments mud terms etcetera, but there will be deckhouse which is not shown here, your this things helicopter flash tags and all these things will come. So, the arrangement of all these topsides facility is very important for your design of the platform. So, this actually decides on what is called, ((Refer Time: 26:26)) this is your

deck design, so your platform is basically a deck loading or a deck designed vessel is it not.

Unlike your ships, ships or what ships are actually meant for carrying cargo inside their holes, but here actually when you come from the concept or design, you have to start out from your design of topsides. Now, this is also very tricky, because these topsides if you want to design, then you have to have the nature and the size of these equipments, the weight, area, volume. Of course, volumes are not very critical, because you can go to height, because it is not your the ship you will find it is all the equipments service engineers includes space.

For here actually you get some kind of freedom, and what here if you want to distribute, suppose the distance between all your equipments you layout, and you find that you are not able to accommodate all the equipments on one day, then you have to go for number of decks. And also you can see the distance between the pontoons, they are also detected by the area of deck take it your requirement. So, there are three things, one is you can see these are called the underwater portion, and these are call your topsides, the underwater portion actually, the underwater thrust supports the topsides.

And what you is does it do and also it resists, your environmental loads that are coming from water, that is your waves, currents etcetera, that is taken care of by this underwater thrust. So, in design actually these are two things which are of prime important, so you have to design two separate things one is your topsides, that is your g a drawing and the underwater thrust. The underwater thrust is more of this structural design category, and here also this is being supported by a deck that is call the what, you come across these are typical terms, this is called deck topsides, which has just now talked about the other was call deck substructure.

So, this is supports your topsides actually, so these are some of the common talk you will find out parlance that comes you, here of course, the other things are not shown here. So, in this case these are coming from the floating platform, now in the fixed platform you will find that this BOP instead of being located on the seabed, it is located on the deck of the platform, so that is a major difference. So, fixed platform will have less motions and easy maintenance of BOP stag, because you can readably assess from the deck, here

actually you see bore preventer assembly on the seabed, so if you want to control the BOP.

BOP is nothing but a set of valves, which you have to regular, because you have to regulate the pressure inside the borehole, these actually regulate the pressure on the borehole. So, as you go deeper down there will be huge pressure coming from the all reservoir, and if the pressure inside the drill, that is in your drill string and your borehole is less, then there what is called the rig will suffer, what is called a blow out. A blow out occurs when, there is excessive pressure inside the borehole and you are not able to maintain pressure that means, the driller is has surrendered incent to nature.

So, the whole thing gets substituted, this is blown out along with the rig the whole thing is blown out and it might catch fire also, so that is call a blow out. So, recently one blow out has had occurred in the Golf of Mexico and as you can see the ((Refer Time: 31:22)) that has been in cost, that ((Refer Time: 31:24)) of course, because of this blowout preventer. This blowout preventer the pressure there is a certain pressure you have to maintained as now BOP you will find you just cannot design BOP.

BOP minimum pressure is dictated is given by codes, now the British petroleum in golfo Mexico they knew that this blow out is going to happen, and they kept it as secret, because their BOP was unable to with standard pressure, it was not design for golfo Mexico pressure. So, that lead to the disaster, so this is the function of a blow out, now this blowout actually we have to operate in the case of floating platforms, this you we can see guidelines. So, these are for loading equipments from the deck and also through this guidelines you can operate, remote operation of BOP.

So, in case of floating platforms the floating platforms necessary should have remote operation of BOP, this is the must, because it is see few 100 meter down below the sea surface. So, this is one aspect in your drilling, this is major difference between drilling from a fixed platform and drilling from a floating platform. Now, for the mud circulation I just now talked about here is the sequence, for your mud circulation.

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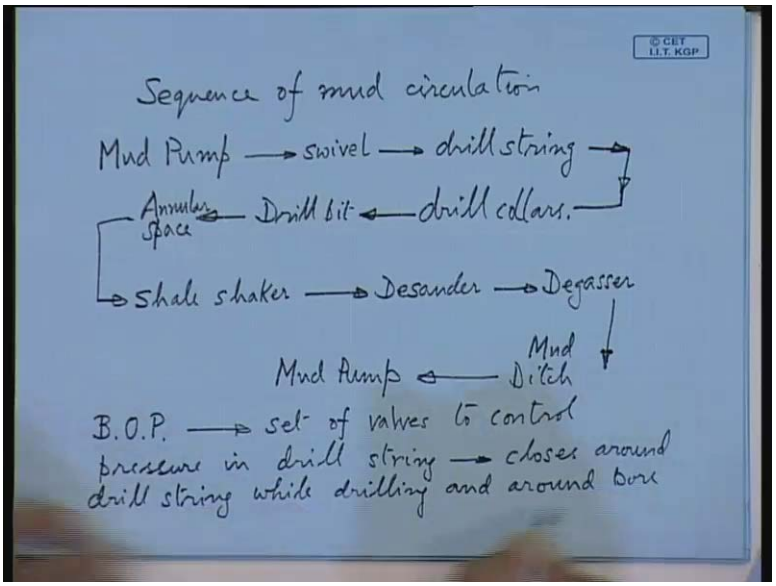

So, you have to have all these equipments, sequence of mud circulation, sequence of mud circulation first you have the mud pump, now from this mud goes to a swivel. Now, here actually what is not shown here ((Refer Time: 34:14)) you can see this swivel, so I told you there is a gap or hole right through the Kelly along with the drill string and out from drill collars. Now, here how you are, we have pore mud actually from this region, so what is done here from the mud pump, it goes through the pipe to this swivel.

Swivel has goes where you can insert your pipe, now these are to ((Refer Time: 34:43)) mud pump through here and out from the drill string. So, this is the swivel, then it goes to a drill string, then drill collars actually I am continuing the loop, so as I am writing like this. So, your drill collars will come somewhere here, then drill bit then out through the annular space, annular space is it is coming from the drill bit and out through here this is call the annular space.

Then it comes to a shale shaker, if shale piece of rocks which have to be shift out, so this is your shale shaker and after that it comes to desander, it is remove the sand, then it goes through a degasser. And after this degasser it comes again to what is called a mud ditch and then, again goes to the mud pump, so the full cycle stops here, so this is the mud circulation I can see so many equipments and so much then mud ditch also that means, you have to have a reservoir for collecting the mud. So, this all this is layout on the deck only shale shaker has been shown out here, so this process actually goes out here, the

next is your blowout preventer, which I have already talked about. Then the blowout preventer is a name which given to a set of valves to control pressure in drill string. Now, this actually closer around drill string while drilling, and around borehole when drilling is stopped.

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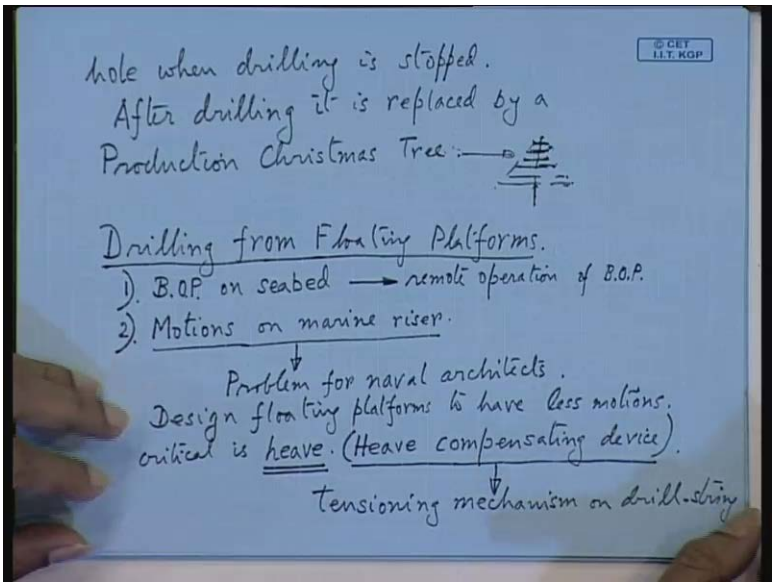

Now, when drilling is over then what you do that means, you have to go for production, so after drilling now there are certain terms which you will find unique, when you come for after drilling, after drilling it is replaced by a production Christmas tree. So, this is to be noted, a production Christmas tree a Christmas tree as you have already know, it looks like this is it not. That means, a set of valves progressively that is your decreasing this pressure in stages from here to here, so obviously the sizes of the valves will go down, because you have lesser pressure as you go from bottom to up is it not.

So, this is call a Christmas tree, so this you find, now here I just talked about the process of drilling, and the absolute condition actually there is a number of points which you have to remember. So, the first one which has talking about is drilling in the from fix platform is not it, so I was started by talk about drilling from now, drilling from floating platforms. Now, this diagram you will see I think this is taken from the Daggers book, here this is upside downwards, so here in the left side you will find this is a drilling from a fixed platform.

The right hand side is actually it is not shown here, and this diagram I have shown that in a form of floating platform. Now, here ((Refer Time: 41:06)) you can see a drilling from a fixed platform and you can see the bit hole of course, there is only one casing, you can see this is your surface casing and the dark portion that you see is the cement. So, the cement has been grouted in order to stabilize the hole, so the hole mud is coming out from the drill string and going from this and though the.

You can see the BOP stack is above the water level this called a sealed deck of the platform there the BOP out here, so this is your conductor pipe. Now, here the problem in the fixed platform is less, because the conductor pipe will have less motions and your BOP assembly on the deck, so that is a major advantage. Now, a fluid is drilling from floating platforms see is more difficult actually why, first is BOP on seabed, so this similar that is in the floating platform BOP on seabed.

And this actually intense remote operation of BOP, and the next major technological challenge is motions, motions on marine riser this is where you was never a great, you have to reduced motions, so these are major problem for novel architects. So, how you are going to reduce riser motions, motions are individual is it not, is for floating platforms. So, one thing you can do is design floating platforms to have less motions, so this is why the TFP concept has come from this, design floating platforms to have less motions, this is not easy.

One is a platform of deflator itself has to be designed to have less motions, the most critical motion is what, critical is heave, a heave at any cost has to be restricted, because that will give your the alternate tension and compression on the drill string. So, this has to be registered by a mechanism, which is called a heave compensating device, a heave compensating in all cases of floating platforms, whether it be a drillship or semi submersibles you find a heave compensating device.

So, this is a tensioning device on the drill string, this is actually a tensioning mechanism on drill string, now this has to be maintained if you do not maintain tension, then what will happen your whole drill string going to collapse. That is then, we are bending failure, so drill string has to be kept taut otherwise, it will get a curvature like this.

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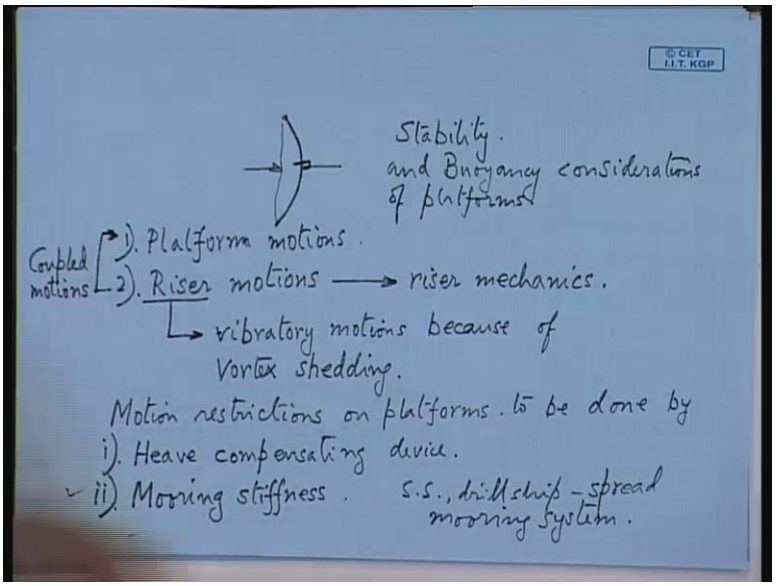

Now, you this distance is too much it may lead to bending failure, on the marine riser, so riser mechanics, so for the naval architects they have to studied this ((Refer Time: 46:22)) platform motions, riser motions. So, next you have to study riser motions, now this is actually a very separate studying itself, these are related to higher branches study which is called riser mechanics. So, those of you, who are going into research and on these things you come across all your offshore engineering forms they are into this, platform motions and riser motions, so all these two motions have to be limited.

Now, here actually you will find they are not independent of each other, but you have what is called coupled motions cause it is more complicated is it not, so coupled motions would be platform and the riser are going to take place. So, here the problems are coming and also risers you will have to find there is what is called ((Refer Time: 47:53)) shedding or these are vibrations are very large, vibratory motions. This is call because of it is phenomena which is called vortex shedding, so this another important area of study.

So, naval architects namely concern about these two for floating platform motions, riser motions the others, they are normal in naval architects is before that stability, platform stability, we have already done ship stability. So, those are have to be stabilize, stability and buoyancy considerations of platforms, so these are normal that is your ships stability and buoyancy g z curve, g m and all this things are come out here, more important is this.

So, motions restriction you can do by a heave compensating device, what is can you do motion restriction on platforms to be done, so heave compensating device what other thing can you do, number 2 is mooring stiffness. So, in cases of floating , whether I thing you TFP have already discussed that is, their TFP is actually moor by tellers, vertical tellers to the seabed, semisubmersibles will have what is called a ship drill spread, and semisubmersibles they are spread mooring system. They are called this are discuss after your mid sem exam you have called is spread mooring system, so these are very important.

First you have to restrict motion on the riser and then, you have to restrict motion on the platform by a effective mooring system, so moorings are very very important in case of floating platforms. You will find a mooring cable of line say 8 kilometer for water depth of around say 2 kilometer always an 1 kilometer water depth. So, mooring constitute a large volume of your platform, because you have to stored all the mooring change in the platform itself semisubmersibles columns they stored, and also you have to keep this mooring intention, so do the particular important in case of platform design.

So, platform designs are centered around so many things, first I talked about your topsides facility, your topsides layout then of course, the underwater part which takes care of your wave loads. Then these platforms are also design for a suitable mooring, that is a mooring system what kind of mooring you are going to give to the platform. So, moorings actually contribute to a large portion of cost.

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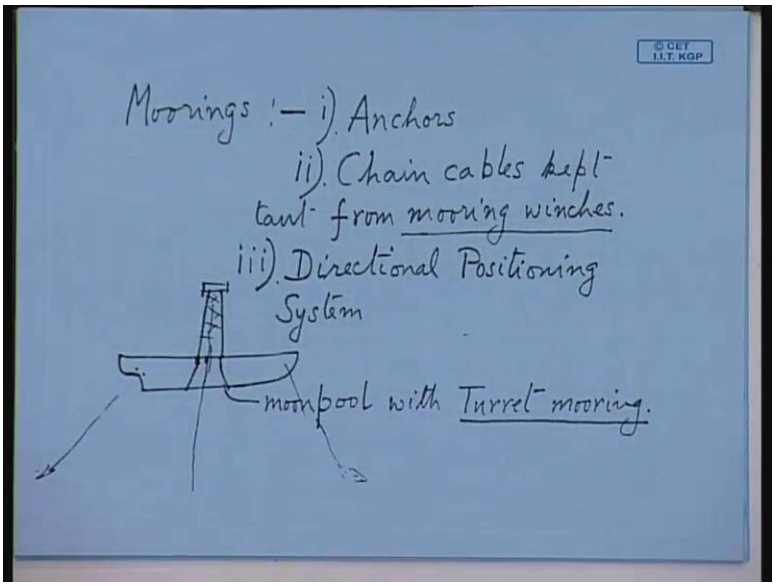

Now, moorings you will find this is a separate area of study, moorings are actually consist of the what are the components of ship mooring fist is your anchors, so in case of floating platforms you will find large gravity anchors, which are connected to chain cables or anchor chains. Anchor chain, chain cables kept taut from mooring winches, I do not know in ship design you come across all these terms, if not able to use some notes on this, how to design all this. Because, in ship also you come across mooring cables, mooring winches what else is require, anchor, chain cables, mooring winches.

And other things that will come is number 3 is a feedback and control mechanism, which is called a directional positioning system. These are the major factors of a mooring system in a ship, now say your this is your drill ship, a drill ship normally have all these systems. Now, a drillship or semi submersible you will find the moorings actually come from a hole in the ship, which is called a moonpool, so these are typical terms in offshore engineering from which the drill string comes out.

So, here actually you will find your drilling derrick, from which your drill string comes out from here, now the whole ship actually rotates on the moonpool. So, here also you can have anchor chains, mooring anchors, large gravity anchors will come out here moonpool with what is called turret mooring. This actually after your mid sem I will talk about, so this will come turret mooring is normally in offshore engineering, you come across this turret mooring about which the vessel rotates.

So, vessel will always have freedom to rotate about it is mooring system, so the mooring system is very costly it takes of around 50 percentage of cost of a floating platform. The next most important is the marine riser, so moorings and marine risers constitute large proportion of the cost of the platform. So, next class at 10.30, we will meet, tomorrow I will try to finish this, there is a diagram of the marine riser which is little bit different from your fixed riser. So, tomorrow I will give that, and I will give you some notes on the current and the winged.

Thank you very much.