Elements of Ocean Engineering
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Lecture - 22
Floating Offshore Structure

Today's lecture will be on Floating Offshore Structure. Now, after that will go to drilling, there are two types of drilling we will discuss, one from fix structure and another is from the floating platform.

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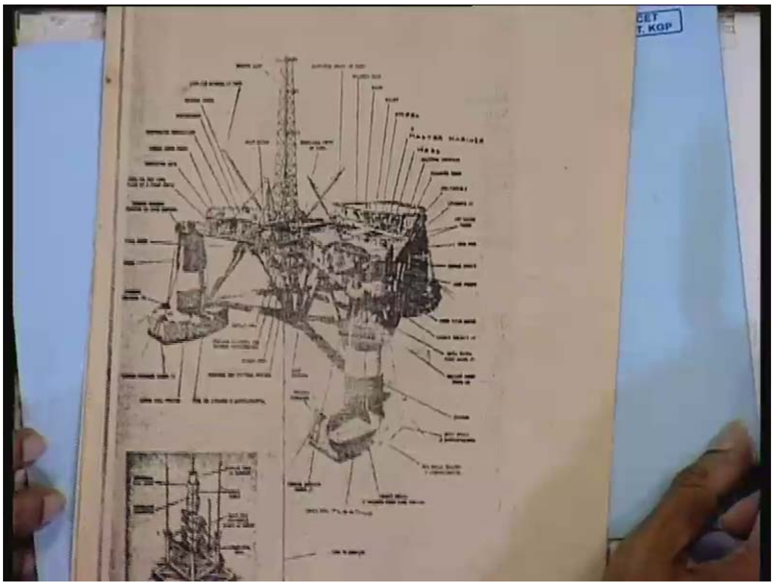

Now, in this diagram, you can see that this is a semi submersible, of course the picture is come out very easy, you can see the trash and the pontoons. Now, what is to be noted is the very small this BOP, this is your BOP that blog preventer assembly, this is down below, so actually your oil is coming through from other ways and it is lead to semi submersible. So, this is your the giving derrick, and here we have your grills stream suspended from the thrown block, now that is going write through this marine riser, this is the typical marine riser, this is going down through the it is connected here to be lower preventer and top to the depth. So, anyway, so this we come back later on, now what is to be noted is the various forms of the floating platforms.

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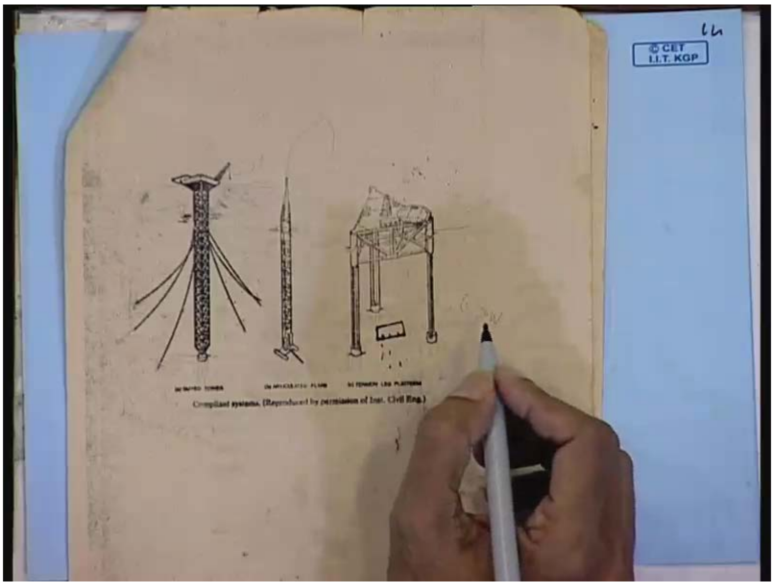

So, already we have discussed three types, that is your articulated flat, now here you note that the three types, there are we already discussed are the guyed tower, then articulated flare is just for igniting your gas, and the TLP. Now, TLP in this diagram you can see the foundations, but what is not been shown is the template, now template will come somewhere here. And that is actually the suspension of the pipes, this is called templates or well head assembly, which suspends your casings.

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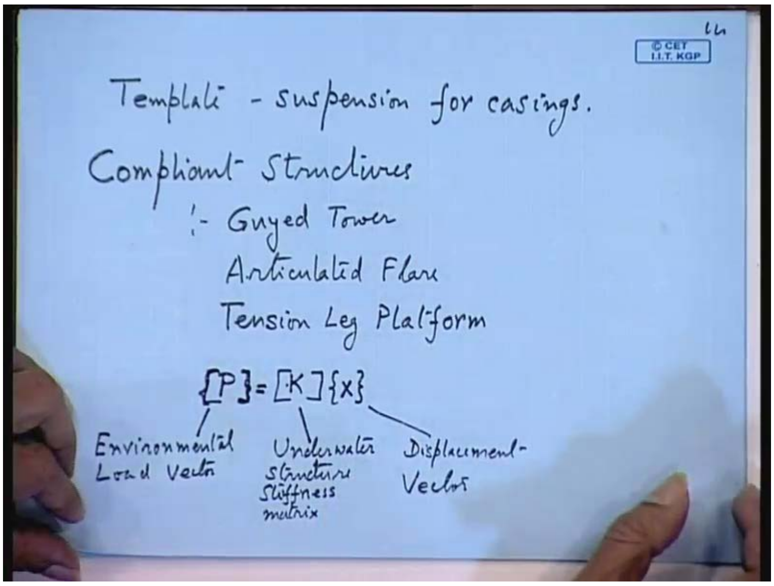

So, your template is actually a suspension point for the casing strange, so these are the smaller type of platforms that is your guyed tower, articulated flare, there is larger varieties are your TLP and semi submersible, which are the most common actually. Now, here the guyed tower and articulated flare, these are called compliant structures and also TLP, compliants category, so these are also floating structure. So, under this head you come this guyed tower, then you have articulated flare, the last one is the tension leg platforms, but do not include semi submersible under this complaint structures.

So, the semi submersible is a fully floating platform, so these are three guyed, now the reason why you go for this equation, and structure analysis you come across this for sometimes, I think in order more appropriative you make this as a vector, k is your stiffness matrix. So, this is your environmental load vector and this is your under water structure stiffness, these are all in matrix form, for any solution to your ocean engineering problem will not be simple one or two line equations. So, this is called a stiffness matrix, the last is called the displacement vector.

Now, if you do that equation you will find, let this environmental load vector is coming from the environment, so this is you cannot change, now what you can change is this value k. Now, you make k small this being the same obviously, your displacement is going to be large, now we have to play around with k. Now, this k matrix there are two things one is this reason, what I told you is how much displacement you can accommodate.

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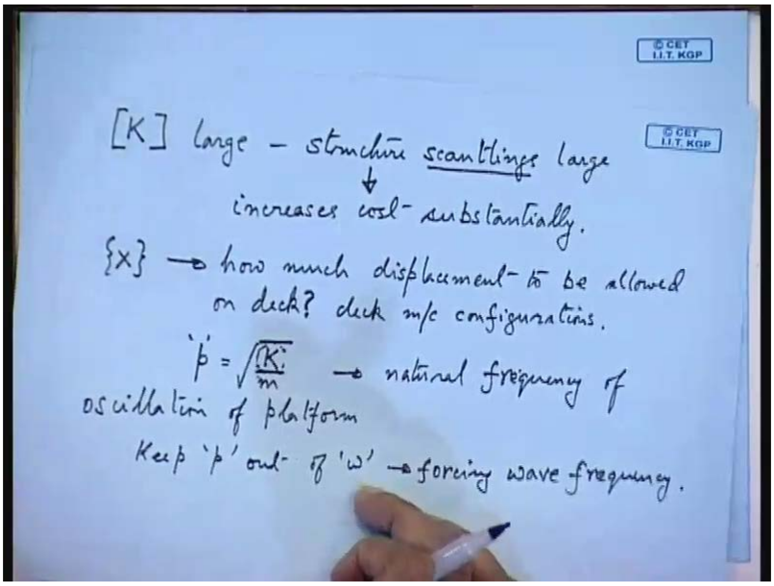

Now, k is the structure stiffness matrix, now k large means the structure scantling large, that is very good this also increases your cost, so increases cost substantially, that is why in very deep water, this preferable ((Refer Time: 07:51)) not to go for a large under water truss. Because, this value of k, k will increase substantially, because this displacement; now displacement or the displacement vector, now this actually how much displacement to be allowed, to where allowed on deck. This is engineering consideration that you have to consider, you have too much deck displacement, as you can see in this structure.

Now, your guyed tower and your articulated flare obviously, there will be no heave motion, but there will lot of flare motion, here lot of slow motion them that will I interfere with your toms on the deck. So, this is another very crucial question, you see how all deck displacement, I will give you some figures of this deck displacement, so how much deck displacement to be allowed that is what you have to decide. So, that basic decision depends on your deck machinery configurations, so there are lot of engineering decision you have to take for design.

So, basic equation is this ((Refer Time: 09:35)) the k, we have to clear on with k, so the another reason I will told you is this, that is this scantling of this structure, and the other is your natural frequency is root over what, we have already learned. This is another this k is also influencing your natural frequency of oscillation, now this you keep P out of omega that is the forcing frequency, for rather you write forcing wave frequency. So, you can see this stiffness is very important parameter, both which are related to this P is equal to k is your static, this is called static of set static of set.

So, this x is called static of set, so we have to find out what is the static of set and your natural frequency, so these are from the structure engineering point of view. And for the cost consolation, so this is what I told you is a very too much large K, this is also increase your natural frequency P is equal to, but of course, if you increase k is your mass of the platform is also increase, because your increasing the way. So, this P is related both k and m, but the trouble with k is your increasing the structure size, especially for deep water k is very important parameter. So, this is one of the consolation for your complaint, and later on will find the floating platform.

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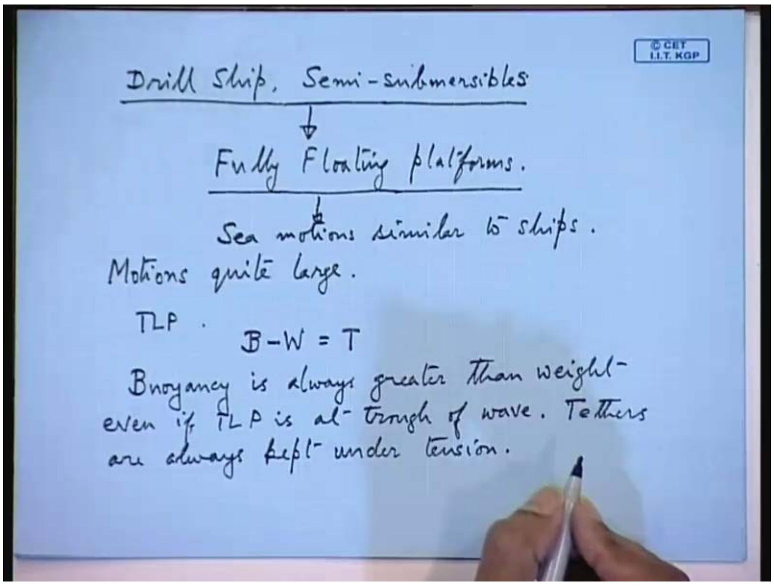

Now, the floating platform, these are the compliant structure your drill ship is a fully platform drill ship semi submersible, there are nothing, they have no connection with the sea bed. You can see your tension like platform, they are trigged down by means of gravity anchors to the sea bed, while this sort of things you will not find in a semi submersible they are fully floating. But, why you go for this a fully floating types rather than the compliant one, these are the fully floating platform.

So, you have no business with this P is equal to k x, so that means, the structure will be like a ship, so this is no more the case behavior similar to ships, so sea motions similar to ships. So, that means, in the fully floating case motions are very large, especially now in

TLP actually we have not heave motion, so TLP you should remember, in TLP this equation is always valid for all cases of waves, that is the different between buoyancy and weight is equal to your tension imitator.

So, buoyancy is always greater than weight, even if TLP is at what at trough of wave, so always some tension in that error headers are always kept under tension. Now, you tell me why you should go for a semi submersible and not yet TLP, because TLP does not have any heave motion, so only motions that you have TLP can have this your sway slide sway which we will have.

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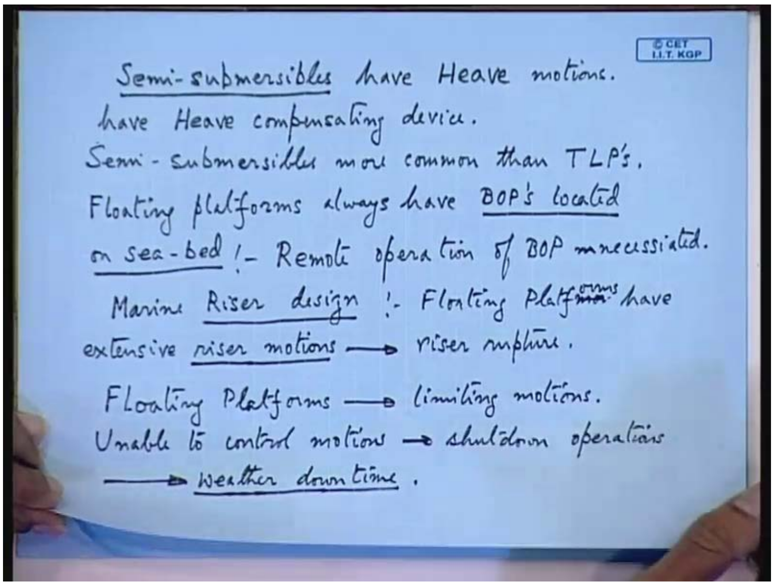

But, what is the decision between TLP and semi submersible, semi submersible we will have heave motion, now heave is the most detrimental motion in case of oil platform have heave motion. In order to respect this semisubmersibles have what is called a heave compensating device, actually you will find semisubmersible some more common than TLP's world, more common than TLP's. So, TLP is actually mostly you will find in the North sea, now TLP problem will come, because of this ((Refer Time: 17:11)) tethers, tethers have to be anchors.

So, normally these are gravity anchors, you will find ((Refer Time: 17:18)) the anchoring of this tethers is a big problem, and also you have to un hope this tethers from your base and then, this stomps. So, those are very problematic for your TLP, but the advantages of TLP is there is no heave motion, heave is restricted. So, that is why you will find semisubmersible and drill ship are more common worldwide rather than TLP's, anyway so this is one of the consideration that have the engineering has to contain it, and the other one is the BOP location.

Now, floating platforms, you remember this floating platforms always have BOP is located on sea bed, this is the great disadvantage actually, they are never paste on deck of the platform located on sea bed. So, this actually gives arise to remote operation of BOP necessitated, this is actually very tribalism, because under water operation of BOP very tricky and very costly. So, this is the things there are the cross, and cross of your TLP and in floating on the fix, the other problem is marine riser design, the riser design is not very easy.

For in case of floating platform are showing the figure, because riser have first thing is for floating platforms, you will have lot of motions floating platforms have extensive riser motion, so this is actually leads to riser rupture. So, this is very critical your riser once it rupture, then there will be lot of oil pollution, so riser motion is a very critical area study now a days, now this your floating platforms you will have lot of riser motions. So, these has to be tackled how you can control the motion of the platform around the motion of the riser.

So, the problems for floating platform are essentially motion control, floating platforms the problems are essentially limiting motion, if you unable to control motions, then unable to control motions shut down operations. And this is called whether down time, so that means, you have to build it for a particular extremes sea state, where you have lot of motion. So, this is the one of disadvantages of floating platforms, it suffers lot of weather down time, there is percentage of the time, you are not lifting oil from the oil reserve, so platform is out of production. So, it suffers lot of weather down time, now the other point that is in order, I will give you a deep discussion of three types of platform, that is all three are located in the origin sector of the North sea.

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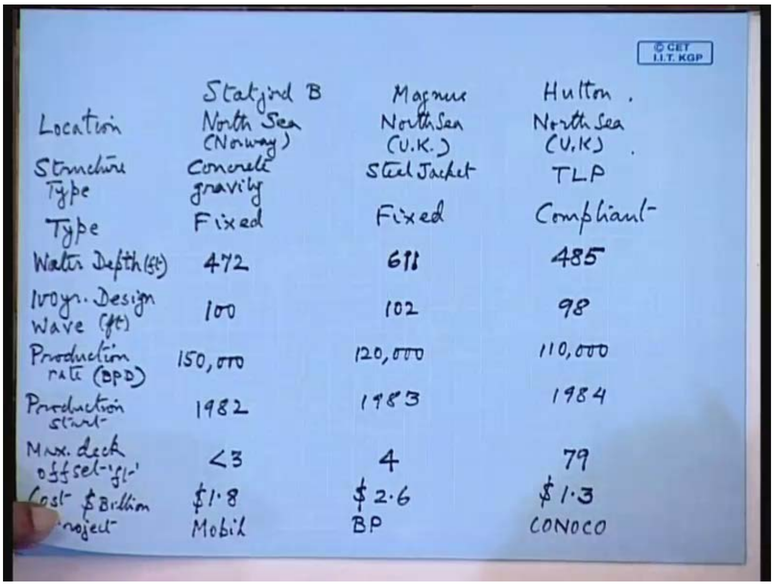

So, this is your statfjord B this is Magnus, the other is the Hutton theorist, so location all are located in the North sea, just comparison between different platforms. So, this is the north region sector of the North sea, this is the UK sector and this is again North sea, North sea UK here you have structure type. Structure type first one is concrete gravity, next is steel jacket and last one is your TLP, there is tension like platform, now here, so these are type or other you can write this is fixed. ((Refer Time: 24:58)) This one is steel jacket is also fixed and TLP is compliant, now you can see the location is more this is the same there is North Sea.

Now, here the water depth, water depth is likely varying, so structure type actually depends on water depth, water depth is a very important factor in deciding on the type of structure, whether you go for fixed compliant or floating. Now, the water depth in this case for the concrete one is 472, now your dimension are in fit this is steel jacket 611, TLP is 485. Now, here 100 year design wave, 100 year design wave is now this is in fit that is your wave height, so wave height is more there is the same, this is 100 fit, this is 102 design wave height, this is 98.

So, environmental load is more or less the same you can see, but you can see that the three different structure have been designed 472 fit, 485, 611, but 611 that is the UK, the British thus have gone for a jacket type of platform. So, here production rate, so you have to take certain engineering decision this is BPD, Balance Per Day, I am not writing the whole thing BPD means balance per day. So, this is 150000, this is 120000, the other one is 110000, so you can TLP production rate is the minimum the concrete gravity, because it has storage facility, it can store large amount oil.

So, BPD is more that is one big advantage, you see these two types of platform that steel jacket TLP do not have storage capability, so this production start, they have started production 1982, so ((Refer Time: 28:10)) this is 1983 and this is 1984. So, this is your Hutton TLP, now maximum deck off set in this case gravity, you can see is less than 3, so this is given in fit. So, gravity platform having the minimum deck off set, jacket for were as TLP is having the maximum that is 79 fit.

Now, this you have to consolation for your equipments, cost in billions of dollars at 1982 price, now this you comparison, this is coming to 1.8, 1.8 is gravity jacket cost is the highest 2.6 and TLP is minimum. So, you can see compliant structure is having the minimum cost and project you write this is first one is mobile, then this is British petroleum and this is Conoco. So, this is a rough comparison of three types of platform doing gravity, steel, jacket and TLP, now there are various casern you can see in this case, jacket is water depth is striking more 611 and 2.6. So, there are certain engineering decision, which you have to take the biggest, is your cost and this deck off set, so how much you can accommodate. So, there is one of the biggest challenges you will find and coming for your platforms types.

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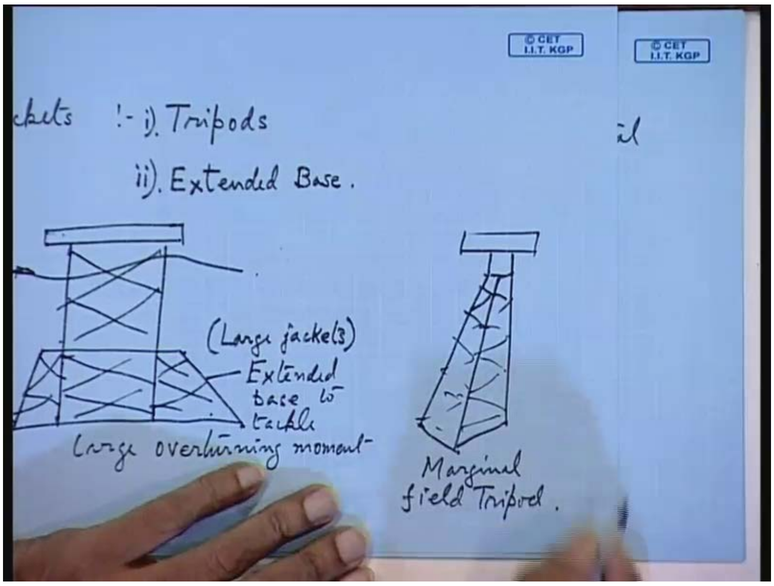

Now, platforms types you have in jacket platform also you will find, there are number of varieties, jackets you have tripods which of course, this is not shown here, then you have this one category, two you have extended base. The other type that I have already discussed hybrid one, ((Refer Time: 31:33)) now hybrid one is coming under gravity platform. So, these are picture of a hybrid one where you have the hexagonal tars and you the casern, there is the cells, cells are looking, but jacket also have tripods and extended base.

Now, extended base of course, here you can see the diagram of a extended base, now this you can see here that, the base is made quite large instead of this thing, being uniform the base has been winded. So, this is the picture of a extended base, now extended base also you can go like this, so you can build your truss. So, ((Refer Time: 32:36)) this is your depth and you can connect it to a extended base, this is called extended base platform, extended base to tackle large overturning moment.

So, your wave height, waves will come somewhere here, so you have to tackle this overturning moment you extend base, so that means, your jacket is become very costly for deep water. Because, of this H, for deep water H will be quite large, overturning moment will be high, again you have to extend the base that means, jacket extended base. Now, so this is basically for large jackets, large jackets the base you can extend of course, there will be piles all these piles remains, now tripod here before we go to tripods you can see here ((Refer Time: 34:29)), there is another sort of structure, this is called a monopolies.

Now, this is also tripod type of structure, you can see at the sea bed there are two cylindrical bases is connected by monopole, and you can call this as a tripod. Now, actually in the article in the North Sea you have structures, this problem we do not have, but in the Arctic actually you come across ice flows.

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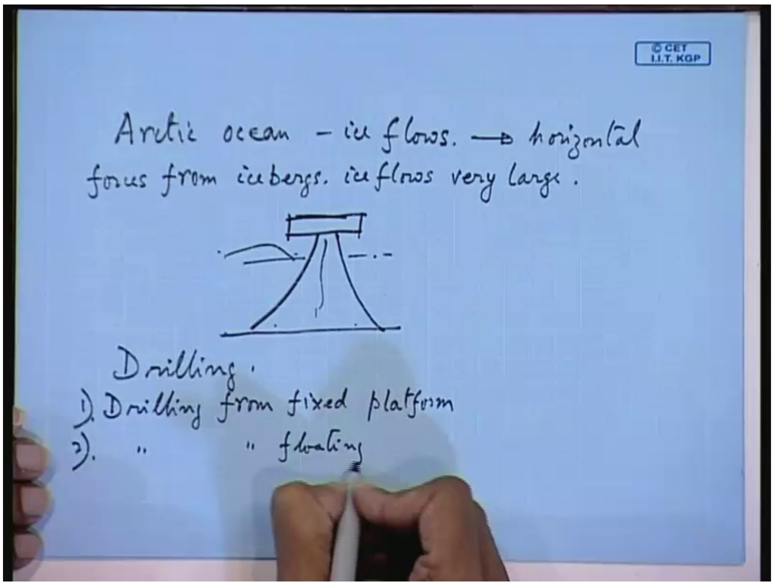

Arctic Ocean in the North sea you will come across ice flows, now ice flows they give horizontal forces, so horizontal forces are very large, horizontal forces from ice bergs, ice flows very large. Now, all these tackle this the structure, under water portion sometime they design this, this is the platform either you can design it in this way, that this monopole tripod variety, this is the steel. Or you can make this structure like this, that this is made of concrete, so there is your ice bergs comes and breaks on the structure.

So, this some of the structure variations you come across, because of variation in the environmental load, the tripod you also can come across for the marginal field, so marginal field tripod will be something like this ((Refer Time: 37:02)), basically you will have three legs. So, your truss will look like this, so this is a marginal field tripod, so marginal field you were the oil is very small you do not have, there is no need to go for a large structure, here you can go for a small jacket structure.

So, these are some of the constitution that you come across, so this is the first one is extended base and then, this is a tripod for marginal field and here also you can go for another, this called a monopole actually, there is a single column supported by a underwater truss. So, here some of the variation in the jacket structure you come across, now next before we discuss about drilling. So, drilling two types, so the number one is drilling from fixed platform, the other one is drilling from floating platform. So, what is your engineering decision for build your structure, now in case of offshore structure.

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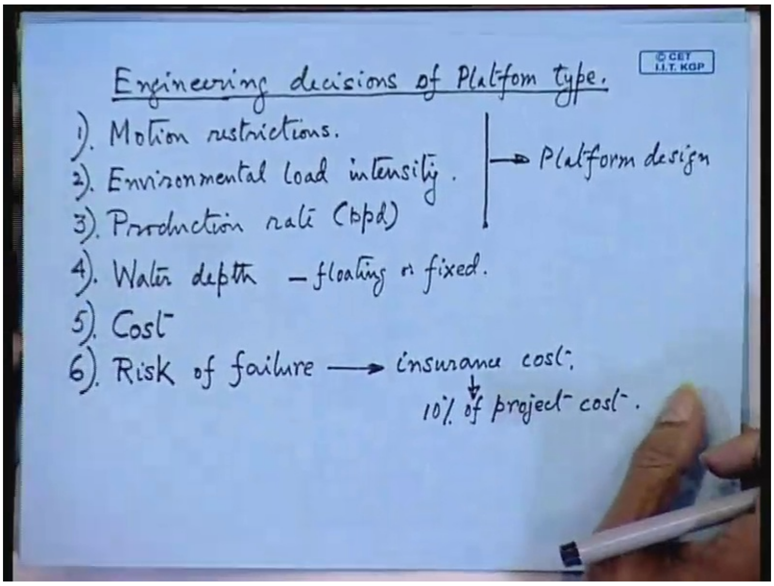

So, these are the engineering decision that you have to come across is, so you are going to be an ocean engineering, you have to make what is called engineering decisions, what are the major engineering decisions. Number 1 the major engineering decisions are motion restrictions, never have to get ocean engineer this is a prime area steady, two engineering decisions of platform design, rather you write platform type. Two is what, environmental load intensity, that is why I talked about the wave that is the wave spectra, environmental load inset motions, environmental loads.

Three production rate BPD, there are three very important parameter, I am telling you this is for platform design, four just now talked about water depth, water depth is also very important parameter designing, whether you go for floating or fixed. Actually you will find all this depends on the engineering capability of the contractor, here you do not have explore floating platform you do not go, because then you will see, the last one is cost. And this goes along with cost is risk, how much it risk you can take, risk of failure of structure, because from this you will find insurance cost.

The insurance cost is very high, insurance cost can go as high as 10 percent of project cost, these are the measure decision you have to take, if you are a platform designer, so lot of technology cost and risk have to be taken into account. So, there are six parameters which will come, now the last one which I am going to tell you is related to your drilling operation.

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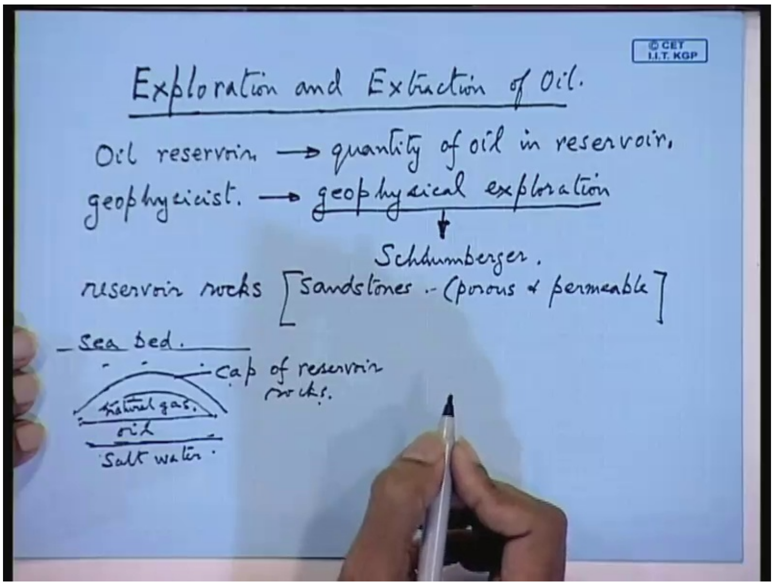

Now, before you going to drilling, we have to study what is exploration, exploration and extraction of oil, so that means, before one goes to extract oil from the oil reservoir, I told you one parameter that is the production rate, you have to decide on the production rate number 3. Now, this decision you have to take oil reservoir, that is quantity of oil, now you can see the price there is the cost I have told you, that is 1983, 1983 figures we are getting something like 1.3, 1.8 some billions of dollars.

Now, if you can projected in 2010, you just can imagine something like 20 or 50 billion dollar or sometime this is goes more than a nuclear plant. Now, who is going to foot the bill, so try to that you have to make lot analysis, now this actually you have to get the quantity of oil in the reservoir. So, this is actually done by geophysicist, now they tell you whether at all you go for oil exploration in deep water or in under the sea or not, depends on the quantity of oil in the reservoir. Now, this is actually done geophysicist or rather you write geophysical exploration has to be done, now there is accompany which specializes in this geophysical exploration.

The oil company have given you the names that is Mobil, Exxon, Conoco and this is a special job this is done by Schdmberger, they are the specially scheme oil exploration. So, now, they tell you about reservoir rocks, so before you take the plants in to billions of dollars or sink billions of dollars in the sea, you have to study the rock formations, this is the oil you find in sandstones porous and permeable. So, I am not telling you in detail, but it is for your information, at these reservoir rocks you will find in this formation, so this is your sea bed and this called reservoir rocks.

So, this is called a cap, cap of reservoir rocks, now here first you will find natural gas on top of oil, oil you will find here and salt water will be below, you will find in this order, but essentially you will oil you will find a cap of reservoir rocks. Now, this geologies is doing survey, survey work as to done before you go for your platforms geological mapping.

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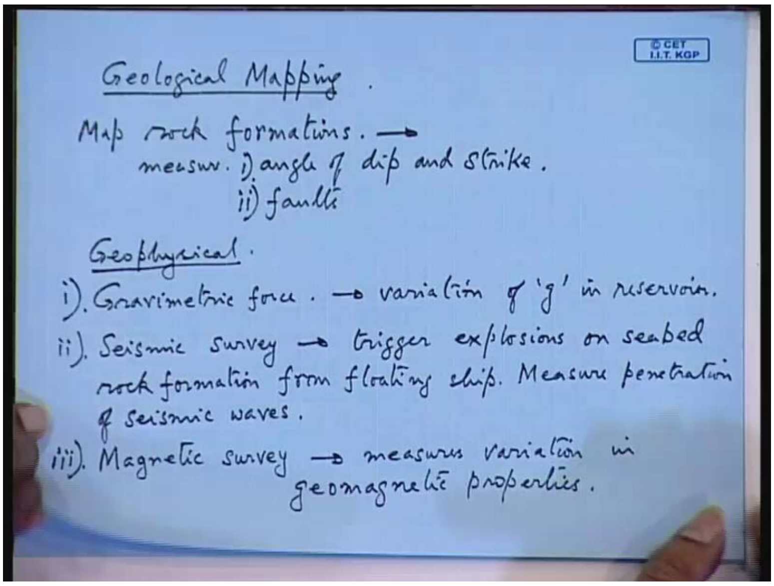

So, map basically you have to map rock formations, so these are done by aero plane they make a survey, you measure this angle of dip and strike, these are the rock formations. Number 1, number 2 oil is to be found in faulting, faults in the rock formation anyway this is geological mapping, the other type of mapping that is done is geophysical, geo physical you measure what is call gravimetric force variation in the of g reservoir.

Finally, if you find that there is variation of g in reservoir, then that show there is presence of oil, other one is seismic, this is call seismic survey explosion from floating ships. Or rather you write trigger explosions on sea bed, on sea bed rock formations from floating ships, measure penetration of seismic waves, so like this you can map the rock formation. So, this call a seismic survey, the last survey is called a magnetic survey, these are the different forms of survivor which is normally done.

So, this actually measures variation in the geomagnetic properties, now after all these is done, now basically now a day's always information is lead into a computer.

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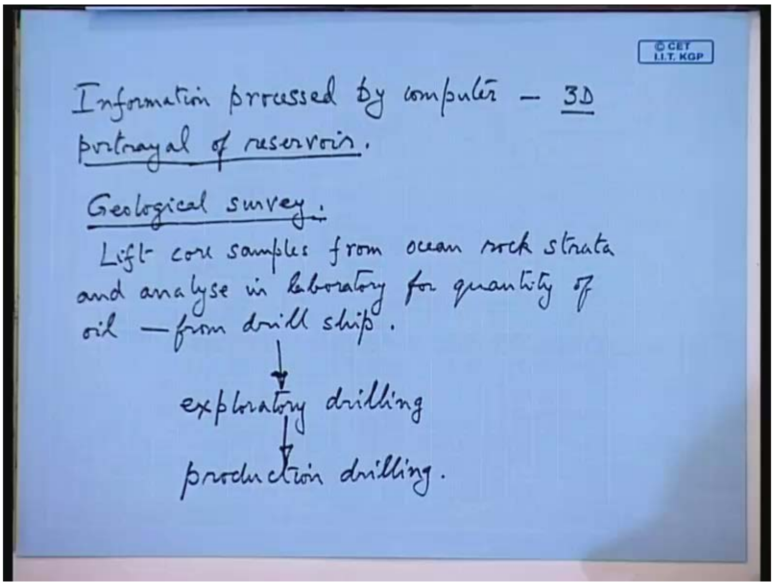

So, information process by computer, now this computer you get the you can get three dimension portrayal reservoir, so this information is separate by your geophysics by doing always these three kind of survey, gravimetric seismic magnetic. So, your computer you will get a 3 D flat of the reservoir, after this you do what is call geological survey. So, remember all this survey has to be done, because your pumping billion of dollars of money in to the sea bed, and better it would be sure geological survey that is lift course samples from ocean rocks strata.

And analyze in laboratory for quantity of oil, now this is done from drill ship, so this is the last survey that is your geological survey, so all these various stages of survey work have to be done, before you go for the next stage. What is the next stage, so this stage is called exploratory drilling, after this you go for production. So, in the next class we will discuss this, there are two methods of drilling, so this is how you go for, you have to lift oil from your sea bed.

Thank you.