**Elements of Ocean Engineering**
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**Lecture - 35**
**Fixed Offshore Structures**

Today we will start on Fixed Offshore platforms, now these are typical actually civil engineers structure. So, your general architects will be a little bit we have to require more knowledge in this career. So, here actually what I wanted to tell you is, before you go to the structural design aspect, there are certain other aspects which you should know, which influence this structural design.

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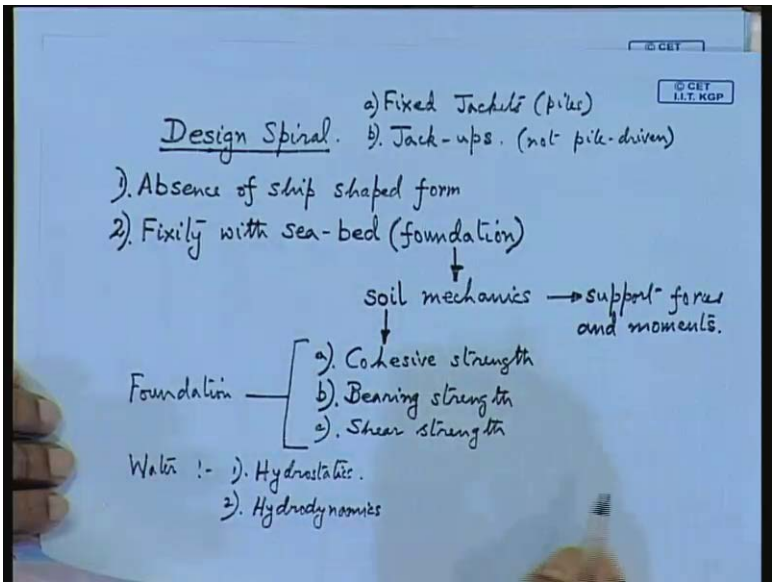


So, first is, number 1 that I have already talked about is the design spiral, so these are actually a specialized structures, as you know. So, there are fixed structure, they do not have any ship shaped form, so these are the ((Refer Time: 01:45)) characteristics of this structures, and other... So number 1 is absence of ship shaped form. So, this is one characteristics, now ship shaped form which is you are already familiar that is, it is the ships and normally symmetric about the centre line all these things.

Now, here actually that centre line concept is not there, so instead of this ship shaped form, you have more geometry is more trust shaped, it is conical etcetera, and all this shape, so that is number 1. Number 2 is, now because of the ship shaped form, you have

all the characteristics related to the form that is, your resistance is less and all these things are there. But you have in the fixed offshore platform, when you are throwing, you have lot of trouble, because of the structure itself.

So, anyway that you will learn in the throwing aspect, so number 2 is the major problem that we will counter is fixity with sea bed. So, this is the major point of departure from your ships that is, the sea bed is your foundation. So, here actually the concept of, what you have learned, that is in ships, your buoyancian stability is that paramount, is not it, so you have to study the foundation mechanics. So, from here actually, if you want to study the reaction, so in case of ships, actually the support is coming from the what, from the buoyancy, buoyancy supporting the wave.

Now, here actually the foundation is your soil, so unless you have sufficient knowledge of the soil characteristics, so soil mechanics is the major consideration for your supporting forces on moments. So, from here, you calculate support forces and moments, so this is another area, which is a departure from your normal ship shaped calculations. Now, if you want to do this, now in this soil actually you should know the number of characteristics, what is the most important is your cohesive strength and the bearing strength.

So, these are the aspects, which is found from lab experiments that is called, so when I discuss about pile, cohesive strength then, we have bearing strength and you also may have another characteristics, which is called shear strength. So, soil actually, the behaviour of soil is different from the behaviour of water. Whenever dealing with water, what are the forces, the water actually is, so when ships that is water, there are two categories of forces which we have more, which we have study in our naval architecture, one is what, one is forces coming from hydro statics and the other is the forces coming from the waves.

These are the two major forces in your study of ships, the hydrodynamics, but in this case, this for the foundation your fixed structure, these forces are important. Hydrostatics is of course important, because the tall structure, the base is have lot of hydrostatic forces and also hydrodynamics coming from waves. So, you remember in case of the fixed structure, so the environmental force, the number of forces is more complex than your ships, because it is coming from these three categories also from the soil foundation.

So, here actually the trouble starts, so you have to be more conscious when you are designing these kind of platform, because since you have this is fix to the ground. So, ground motions or ground displacements will cause lot of damage to the structure.

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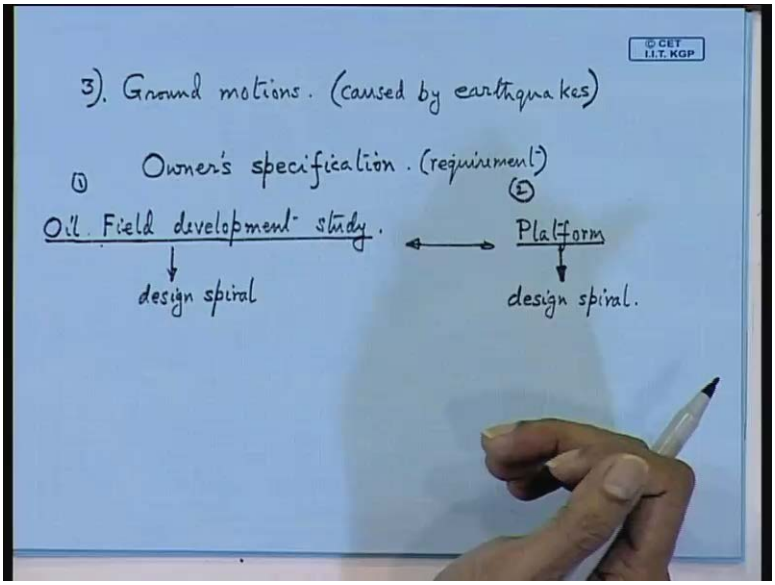


So, here the most important, beyond the study of these hydrostatics, hydrodynamics, cohesive strength, the hydrostatic is number 3 you write, ground motions. So, if you are designing a fixed structure that is, your jacket platforms, so we are studying a fix structures. So, normally we first category will be your fixed jackets, the other type of structures that is, will come in the normally in the fixed category is called the jack ups. Jack ups have connectivity on the sea bed, the rest on the sea bed and also your jackets, but jack ups are not pile driven, there is a major different is, not pile driven.

So, the foundation is not pile base, but here you have fixed these piles, you have to study lot of pile mechanics, if you want to study the foundation. So, this is actually your foundation, so you have to find out the forces and moments for these two types of platforms. So, number 3 is, that is your ground motions is critical, so this is ground motions caused by earthquakes. So, this we will study in your that offshore technology class, this is caused by earth quakes, so we will study all these.

So, I will tell you what are the forces that you have to consider in case of jacket platforms anyway, so this is the gist, and so your design spiral now what you do, you started here platform design, now any design is first you start from this owners

specification. If you want to make a design spiral, owners specifications is the first starting point. Now, owners specification or sometimes we call it client requirement or owners requirement, sometimes it is owners requirement.

So, the owner is also a very noticeable person in this field, so that is taken for granted and the contractor or the vendor of the platform, he has to correspond with the owners. Now, here before you embark on this project that is, you have to do what is called a field development study. What is this field development, now any ship that you are designing or whether it is a carbon sheet container or any ship, they are built on certain designed requirement or owner requirement.

Say, a tanker the owners specify that you have to carry so much of volume, dead weight of crude oil from this place to that place at certain speed, but this now how you start your design. So, this you have to start from the oil field development, field means your oil field, what strategy you adopt for development of oil field, that is a very specialized area beyond the scope of study of your naval architecture. So, but you have to interact with this kind of situation, so oil field development, now here there are two aspects, one is you formulate this oil field development design spiral.

So, here also you have to make a design spiral, now design actually is a very complex study, it is just not one of design, you just make one of table, but that is not the case. Now, this is one design spiral which we have to follow it, next is you come to the platform, here also we make another design spiral. These actually is more, the platform one is more of the ship shaped, the ship design spiral and your ship design class I think those are will be talking about this, here also you have to formulate another design spiral, before you finalize the design of the platform. So, here actually, I told you the problem is more complex than ships, so here actually this one study should be, you should do the study. Number 2 is this study and then, you have to link these two, you have to formulate another design spiral, which will have these two spirals you see, so it is quite complex.

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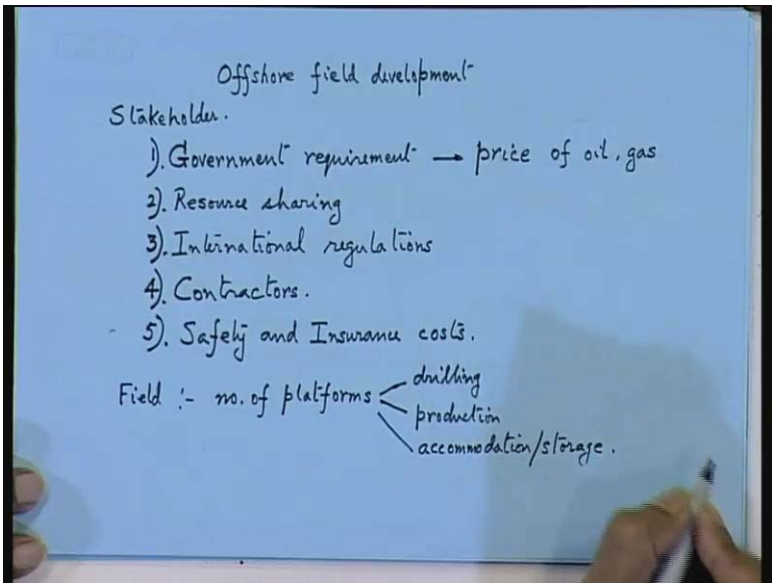


Now, this field development concept, there are lot of, one example I can give you, so here you have field study, you start from this end. So, there are actually we find that, you have to work with lot of other engineers, especially people from the chemical engineering side, mechanical engineering side, geologies, geophysics, now they will give you all the inputs, as how you thinks also it is very difficult for you to complaint at this stage.

So, you start, so this is your what is called your client requirement or what is called initial design, what else still here or owners requirement. So, we start from here, now owner actually he will give you some rough requirement, because he is not making the platform. And remember, this platforms are offshore field development, there are number of stack holders, say offshore if you have go here, offshore field development and you will find normally the fields, as you read in the news paper, the offshore fields are leased out to a party.

So, here actually stack holders you will find, government is a major stock holder, so eventually it is a government of the country, under whose jurisdiction the platform lies he actually dictates the terms, so the first is the government. So, that is why, whenever you venture into offshore field, you have to satisfy lot of government regulations, government requirement. See, the government will tell you that, they are giving certain say offshore field for expectation.

But, they will require that, you give me so many barrels per day of oil at this particular rate like advance of lot of trouble in to gas fielding or oil, because of the pricing on the gas. So, normally you will find the price is normally fixed or this is actually, this is where the whole point comes. Price is normally, price of gas or oil that is, the output from which you get the money, so that is now we fix by the government. So, price of oil gas, so that means, you have to operate within this limit, you have to find out the economics of the platform based on price of oil and gas, as the government dictates.

And also there may be a resource called resource sharing, there may be a resource sharing between your contractor and government or sometimes it may be resource sharing takes place between two governments. So, the contract is very price of oil and gas resource by government, resource sharing, number 3 is of course, you have to organize certain international requirements, international what is called regulations. These have to be compared with, because you will cause pollution in the sea, so that is not desirable.

But then, the government regulations for that company international regulations then, the last category is the contractor. So, these are the stack holders coming into play, so all this people have to be satisfied, remember. So, before you exploit a offshore field, you have to satisfy all this people, so normally you see the bidding of the contract takes a long time, there are number of bids and all these things. And eventually, some price is fixed and the contract actually is, the other part is the safety and insurance, this is a large cost, safety and insurance costs.

So, these also quite large, now your offshore platforms, you will find that the investment is the order of near the nuclear plant, because you are making some structure in the sea. And once you go for field development, you may have the see normally the field conscious of offshore field conscious of number of platforms. Then, you look at the whole project in totality, do not just study one of platform, that is not the concept of field development.

So, you have to derives number of platforms, so number of platforms you have to figure out, configure and some may take care of, say these aspects, say drilling, there are some only production, the other may be these accommodations, storage. Now, all these structures have to be built in the sea, so that is where this is not just like designing one

cargo ship or a tanker, so that philosophy does not hold good. So, here actually you have to look at the whole thing in it is totality, now you start from where ((Refer Time: 19:46)) see here, this owners requirement.

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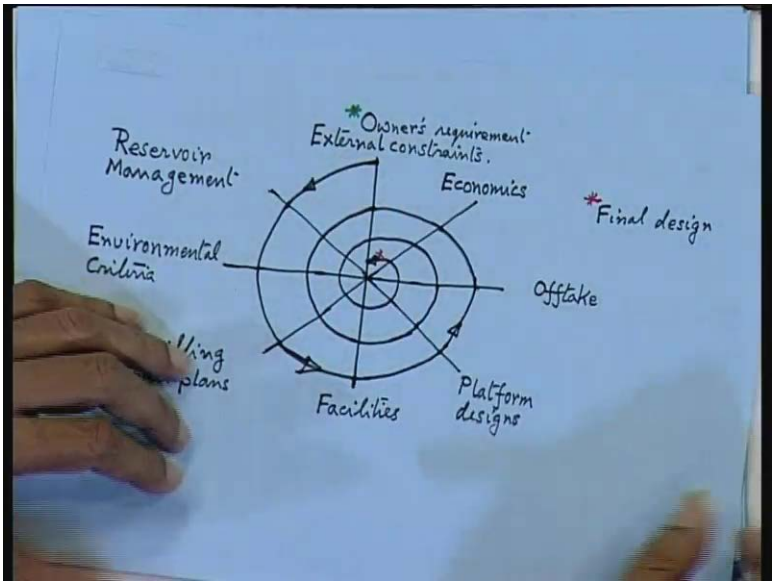


So, owners requirement when you start, so you spiral actually has number of spokes, so I have give you what are the spokes. Now, the reason why I am talking about this is, you will find that, the structural design is a inherent part of the total design. So, you cannot segregate your structural design from the other aspects, the other aspects are also crucial. So, this is your case, now see how many spokes you are having, 1 2 3 4 5 6 7 8 9 10 11 12 spokes.

So, we will start from here, spiral means it goes like this, so after this you come here and then, you can go on iterating. So, a spiral is a process of iteration of the various design sequences, so this is your first iteration is going in this manner. So, after this, this is just only one offshore design, so you go inside the spiral, you come again here. So, this is actually called one loop, this is called a loop, so you are going in this direction. So, here actually made one loop and then, again you went of the second loop, the second loop is actually more refine than the first loop.

So, here you go, second like this, the number of iterations are categorized in loops in the design spiral. So now, ultimately you come right here and you end, where you have started here, so this is your finish point. Now, at this point is your final design, so this do

not have any space to write, so this you write final design. So, you can see, this is a quite complex study and normally you have to have expert staff and expert personal, you can tackle all this.

So, here you start from owner requirement, now next you come what is called reservoir management. So, I told you, we have to start from the field or reservoir, now after this you come to environmental criteria. Now, here you make drilling and well plans, now in the offshore field actually, now if you want to start here, normally it is a experience based design. So, how you start designing an offshore jacket platform, so right you start in ships, you do the design spiral then, you take a basic ship, is not it of course, you have yet starting learning about design.

So, similar thing also will happened here, but how you select the basic jacket platform, say drilling and well plans then, you have facilities then, you have platform designs. So, here actually, it is not only one platform that you are designing, but various different types of platforms. Now, here you have off take, that is your gas and oil offshore, that is called a off take. And the last one is economics, so as a naval architect, you also have to study some economics of this field.

So, these are the number of spokes that you are getting, so owners requirement, reservoir management, environmental criteria, drilling, well plans, facilities, platform design, oil and gas off take and economics. So, you start with owners requirement, you start here and end in the final design, so that is the thing that you will be coming here. Now, under this, you have or as a owners requirement, there is another thing which is external constraints out here, that you should have given another spoke, constants and owners requirement will coming in the same spoke. So, here you will find there are lot of things you have to do, added to your design face. Now, in the external constraints you will find, that is coming under the owners requirement or governmental constraints.

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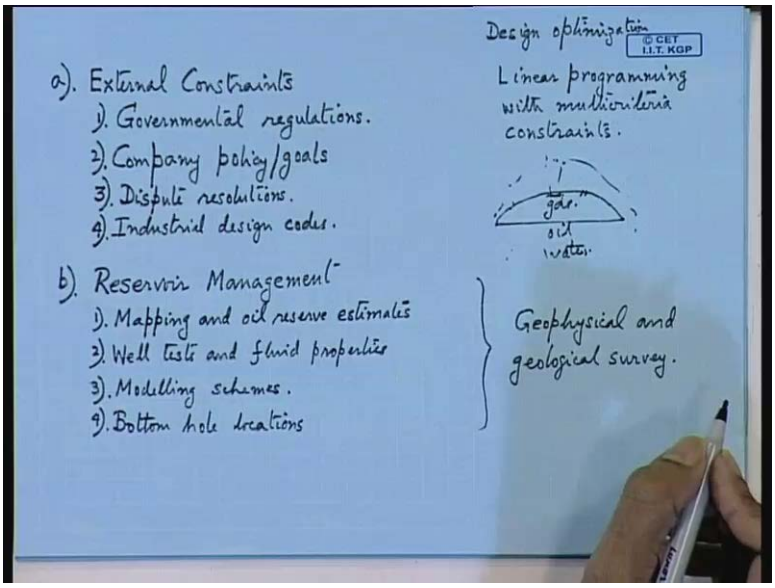


So, what can be your constraints, now any designs you have to do, there will be some optimization with constraints. So, optimization you have studied know, linear optimization, so optimization of various parameters, how ((Refer Time: 27:00)) you give your ship, how you optimize. Other the constant is the ships speed or what speed is normally a constant or that is the minimum speed is the requirement. So, constraints are here, number 1 you find government regulations.

Now, optimization I do not know, have you studied optimization, government regulations. So, optimization is actually, either finding out the maximum or minimum certain point, giving rise to certain constraints. So, this is I do not know whether you have come across this concept of linear programming, linear programming have you done. So, linear programming I do not know whether, but you should, linear programming with multi criteria constraints.

Now, as a designer, you cannot bypass this, so the design optimization, you understand talking my specialization is not in this design optimization, you will come across all these things. So that means, in this may be your design class professor will tell you more about this, so government regulations, what is your company policy, now if a single contractor may not be there, normally in offshore you have multiple vendors, is not it.

So, what are the requirements of these companies or company policy goals, so your interest that one not, usually what happens? The goal of one company will clash with the

requirement of another company, so you will be at longer heads. So, how to resolve all this issues, so government, the contractor will want, obviously you want the maximum price, because you want the maximize price, but the government will also try to get the maximum share from the field.

So that means, the two parties are at cross purpose, so how to settle disputes, so company policy goals, 3 is dispute resolutions. There should be a mechanism who can or arbitration, which can dissolve all the other disputes and arbitration mechanism then, you have to follow the industrial design codes. I will tell you what some of the codes, industrial design codes, so all this comes under external constraints. Now, some dispute has come and the dispute resolution will tell you that, we agree upon this barrels of oil of constraint, you cannot neither produce less nor more, so that is a situation.

Now, next is your reservoir management, so actually our platform starts from the basic reservoir definition or that is called oil reservoir. So, here if you go into the oil field, so this, once you are in the design, so obviously, you have to do all these programming and all these things. The other as soon as you come back then, you have to do management, management of what are you going to manage. First you start from the reserve that is, mapping and oil reserve estimates.

Now, based on this that is, your production rate is decided upon and based again on your production rate that is, the equipment, the size of the equipments, the nature of the equipments have to be decided. Now, once you decide upon the equipment, I told you all these are basically, date type of configuration, date design, you start from the date design. So, structure engineering starts from that, so again you have to go to a root of the problem is your reservoir.

So, you are getting oil from this, so this is normally done by your geophysical survey, so all these is done by the survey, well tests and fluid properties. Now, you have to do lot of modelling, modelling means computer modelling, modelling schemes or scenarios. Then, you have your, where you are going to pears the well, now oil field, I think I have told you, it is like this. You have a capping that is, it is under a doom, where you have the gas, you have in this gas, oil and below the oil, you have water.

So, there is a capping, sort of capping comes like this, all this is done by the geophysicist, so bottom hole locations. Now, in the drilling, why we are drilling, so that

is the top rock has to be pierce at a certain depth. Now, why we are going to pierce, either if you want to take out the oil, which one is the most advantageous location, either at the top or here or here, because here to come from different layers of soil and all this layers of soil may not be feasible to your drilling, you have huge very hard rock then, that is going to bend your drill string or drill pipe, not feasible, is not it.

So, then again you have to explore, you come again away from here, you see that this may be the reason, where you can pierce the rock. So, all this survey work has to be done, so now a days, actually this is geo physicals survey, geophysical and geological survey. These are actually based on geophysical and geological survey, this is quite crucial, so you have to work with this people. Now, after you have located the holes then, the other part is your environmental criteria.

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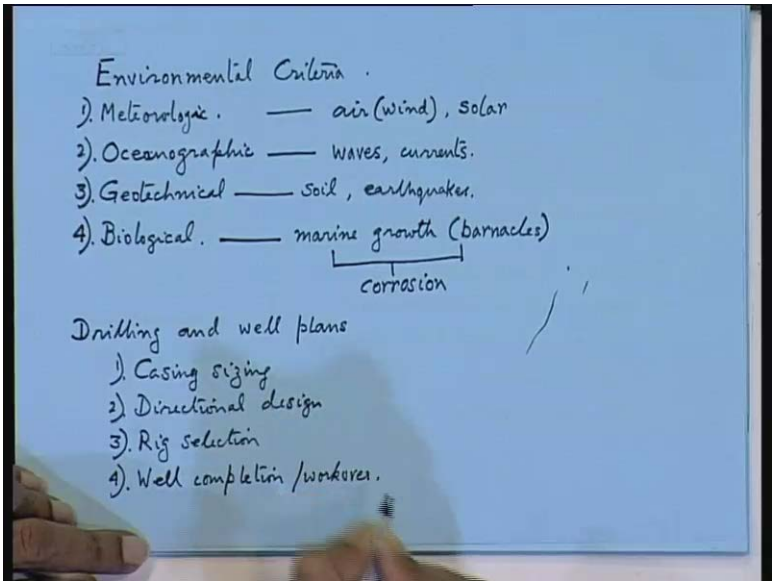


So, you can see the problems are pretty vast, it is almost similar to designing some kind of a nuclear platform, environmental criteria. So, under this category, you have the meteorologic data then, you have oceanographic, but actually here the meteorologic means, half of the water that is, normally the temperature in the wind data. Now, you have oceanographic data, next you have geotechnical, the last one you have biological, this environmental data acquisition is a mass.

So, meteorologic is air, basically it is a wind then, the heat from the sun solar, these are the two most group crucial. Wind of course will be there, but it is not that crucial,

oceanographic waves, currents. Number 3 is geotechnical soil then, you have earth quakes, now what is this biological data, biological criteria. Biological criteria is main growth, this is called barnacles, now there may be lot of vegetation on the sea bed, but just you have to plan pierce, instead of your offshore structures or those you have to got rid off.

And these you study, because of the major aspect is, their coronial structures, corrosion problems, main corrosion is very critical, so these have to be configured. Next is drilling and well plans, now these you have to shift with the chemical engineer and the geologies casing or mining people. So, here you have casing sizing then, you have directional design, so now a days you can drill number of waves from a single wave by slanted drilling, you can pierce those holes by means of slanting drilling like this, drill pipes or drill steels.

Now, three is rig selection, the last is how you complete the well, that is called work over. So now, this is your drilling and well plans then, the other is your facilities requirement. So, facilities is very crucial because so this is that drilling and well plans, so these are happened below on the sea beds.

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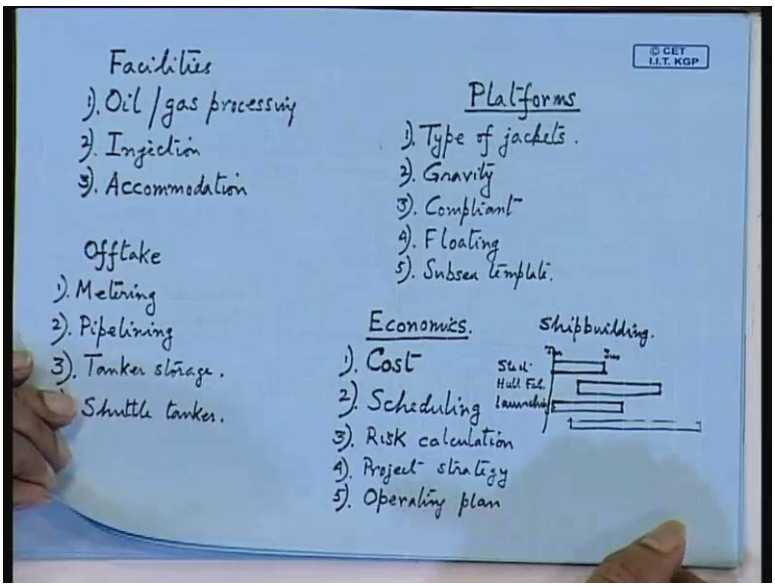


Now, here these facilities are here, deck facilities, so these are actually situated on the deck. So, number 1 you have oil and gas processing facilities, number 2 is injection of gas into the well. Now, why it is done, in order to build up a pressure, so if the reservoir

is depleted then, you inject gas. Now, on the deck you have accommodation, so these are the your deck facilities. Platforms, the next is the more crucial, with which normally you will be associated, so platform design.

Now, here actually what you have to decide is, what type of jackets, now jackets you have seen, it is not one type, here you can find out ((Refer Time: 42:43)). So, here actually this is one type of jacket, they are not drained. So, this is a most more conventional category, so here you have the long columns and you have different, you can see skirt piles. That is, each of these legs are skirt pile driven and then, all these piles are go in the sea bed and is fix to the sea bed.

Now, another type of jackets are some where is here, this slightly wider base, but you can say, the base is slightly wider, but this is more rectangular. So, here may call it the sea bed foot print, so the sea bed foot prints are the rectangular category. And in this picture you can see, in the oil field, you do not have only one jacket, so this jacket is probably here, as you can see it may be a drilling or a production platform. Now, it can do only drilling, here you have another production and this is a accommodation jacket.

You may have another platform which may be, so the firing the gas, that is called a fluid structure. So, you can see, when you develop a oil field, you have to take into consideration of all these platforms and these are all connected by sea bed pipelines. So, pipelining is a very crucial part of offshore engineering. So, here this is one type of the platform that you can see, the other type is called a extended, say here the lag. So, this is probably in the Gulf of Mexico jacket, you can see is a very tall structure and you can see the number of piles is all around the periphery of the jacket.

So, this is actually a very crucial in your structural engineering work, what we have to do, we have to start with the foundation mechanics. Now, here you decide what type of structure you are going to do, now how you price you going to select and all these things. And sometimes, the most the load that are coming is your wave load is coming at the top, current will be there, so the large part of the wave load is giving rise to your coupling environment.

So, there is a side shift, lateral shift along with the coupling moment, now the problem is the water depth is a very important criteria, why? Because of the momentum, s, unnecessarily if you increase the momentum, you find the coupling of moment is also

quite large. So now, what you do, in order to resist this, you have to make increase the stiffness of the underwater truss. So, you have to make this truss and the usual this thing option is to increase the increase the diameter of all these columns.

So, if you increase the diameter, it will be stronger, but the problem that you will have is, out at the surface, where you have the wave loads, there will lot of the diffraction loads will come, because of increase in member sizes. So, again the whole thing is going to increase that is, the coupling moment is also going to increase. So now, this is a, say offshore structure design, you have to be through on the hydrodynamics aspect, whether you are giving the waves in the sea.

How to make the truss structure transparent to the waves, you have to make it transparent, otherwise the problem is, you have large amount of overturning moment. So, this is the ground reaction that is coming and your reaction is normally the resisting moment is coming from the sea bed. So, you have to play around with the configuration of the base of the structure, now base you can see, you can either go for this rectangular base or a square base or sometimes they have another base you can find, that is called a extended base platform. So, here the, I think they do not have, I will show you the picture of a extended base. Now, they are actually the structure is completely redesigned you know, the underwater part, because of the large base, anyway.

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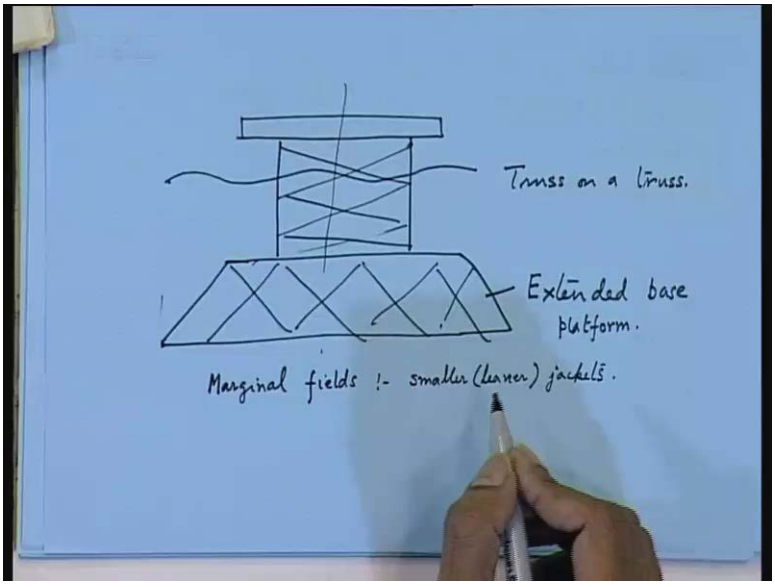

So, the base itself is a separate truss, you find the thing is like this, so this is your normal jacket, that diagram is not coming out, you make it rectangular and here is the deck. So, you build a truss like this, now this is actually situated on another truss like this, this is a huge structure, so this is called a extended base platform. So, the reason is because if you give an extended base then, the resisting river is more, your resisting river will be somewhere in this way.

If you want to topple the structure about one end., so your resisting river arm will be more, you increase the resisting. So, all kinds of configurations you have to play around with, so this is better be the truss on a truss. So, this is a another structure engineering configuration, so wide with extended base platform, now the thing that I want to tell you is that, now all this you have to think about the feasibility study of this platforms.

How much money you are going to invest, whether you want a large jacket type of structure or now in case of marginal fields, where there is not much oil in the reservoir, there is it feasible for the timer huge structure to be commissioned. So, marginal fields will require smaller jackets or linear jackets; that means, you try to reduce the structure size, because that will cut down your cost. So, all kinds of options, you come across this whenever I think the extended base is last one, so it is not clear.

So, that is your ((Refer Time: 50:22)), other is your basing configurations, you can have different basing configurations, you can see normally these are the x basing and these are call the diagonal basing or key basing, this will come back later. So, anyway for this matter, you have to just let me finish what I am doing right here, we have the design spiral, so this just an example. So, drilling and well plans, the other is your processing facilities, so facilities you decide based on your platform.

Platforms is type of jackets that I have told you, first is jacket type then, you can also think about gravity platforms then, complaint structures. So, if you find that, that you are not getting sufficient oil production from the well of from the reservoir, you try to abundant jacket project. So, you go for this complaint structure then, it is your floating structure or not. So that means, if you find that the cost is prohibitive for a jacket structure and you are not getting sufficient oil, use this is sequentially he is going down to the floating category.

Then of course, the last is your subsea template, so these are the platform considerations which we have to take then, the other one is off take. Off take you have metering then, you have pipelining then, you have tanker storage or you may have shuttle tanker. So, which one you have to decide, so whether the output you can store or you can push it to store facility, so that is deciding. The last one is economics, so those of you are going for the management part, we can see if you are in offshore company, the amount of risk involved is very high, that itself is a management challenge.

So, first one is the primary driver is cost, cost is the most important criteria, because the offshore field is going to truss billions of the dollars, so who is going to foot the bed. Now, next is, the most crucial is scheduling, this is also very crucial when you are ship building. So, when I was in the ship yard, so we use to make a schedule or a production schedule you have to make. So, normally that is done in by, the easiest one is the bar chart, say this is your steel plates are coming here, you are acquiring steels same on the January to June then, you have hull of fabrication will start from here, go like this.

So, when you go, you have to design of this, so this is hull fabrication, you have to make a bar chart like this, so this is called scheduling. In ship yards, you go for training, you will see this is thing they are doing. So, there are number of, you have to split normally your ship building or fabrication, ship building is normally split up into various options, various length of times, time runs then, you have this may be your launching, now this is your job, remember that.

So, you have to, say here somewhere here, you will find this, they actually killing it, all starts from the killing. So, right from killing to delivery of the ship, you have to make this kind of flow chart or bar chart ((Refer Time: 56:20)) and the bar chart. So, this is called scheduling, so scheduling is a very important part of the fabrication or ship building process. Now, here you have the other parts of economics is scheduling then, risk calculation, whether this huge amount of money is at all justified or not, so that is based on risk of failure.

This is because of environmental loads then, you have pipeline, snap fire, etc and this risk is covered by the insurance companies then, project strategy. So, what strategy we are going to use, because there are number of contractors or vendors, who will be working there simultaneously. So, you have to formulate a strategy of completion of the

project. So, that of course, that is your, the last one is operating plan that is, after your completed the installation face then, the operation face. So, this brings us to end of the design spiral and the spokes, may be since we have not much time, the other part is talk about this later. I think one more class, one or two more class, before we go for the detail design, structural design.

Thank you.