Elements of Ocean Engineering

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Lecture - 44
Semi-Submersibles

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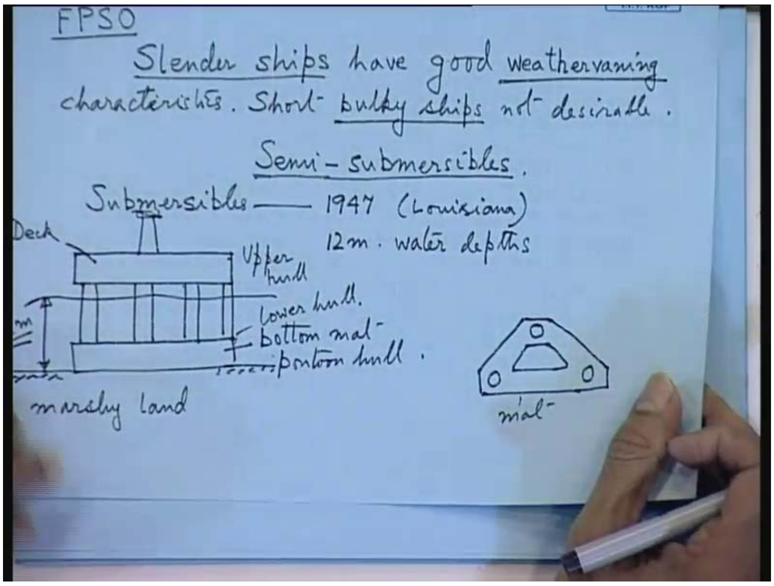

So, today we will begin our discussion on semi submersibles. Now, last class I have talked about FPSO. Now, coming to the weathervaning aspect I told you. But I could not find the f by v ratio. Now, you please remember one thing that slender ships have good weathervaning characteristics; that is l by v ratio is quite large. So, this is one characteristics with FPSO; we have to figure out weathervaning characteristics. Now, in this case characteristics, now in this case short bulky ships not desirable.

Now, whenever you are designing ships apart from your buoyancy and stability. The other points that is to be remembered is for FPSO good weathervaning. That is your CGP characteristics; how it moves about your direct moving; that is your motions and also rotational motion. So, this you do not go for bulky means high displacement ships not having sufficient lengths. So, this will have more motions; if you do not go for that good go for high l by v ratio ships. So, those are called slender ships. So, these are your FPSO. Now, coming to today's discussion about semi submersibles which now they actually evolved from ships which are called submersibles.

So, this I have already told you; this was way back in 1947 in Louisiana. So, this submersibles were nothing but bars type hugs; this water depth was only 12 meters. So, semi submersibles actually evolved from the concept of submersibles. So, this was your upper deck which rested on columns which are supported by a mat. So, this is called a bottom mat. So, this was your wave and this was the seat belt. So, this concept of semisubmersible was there in 1947 actually; before your oil explosions started in the 1970s. So, it was this is 12 meters marshy land. So, this was called a bottom mat. Essentially, a pontoon hull and this was your deck. Now, on this your during daily etcetera we will be position.

So, this is the deck, sometimes this is called upper hull and lower hull. Now, this may actually if we take a plan view it was in the form of a v shape like this. So, at the middle you have a hole or a opening for passage of fuel conducted pipes. And most of the columns are located in this region. So, this was your mat. Now, this concept is been used in Jacob freaks. Actually, there are 2 varieties you will find one is called a mat supported type. The mat is essentially looks like this. And the other is called the independent type anyway.

So, these are coming to the semisubmersibles which are floating platforms. They are actually deviations of this concept of submersibles, but submersibles you can understand. You are only suitable for shadow waters, because of the small this length of column rested on this mat. So, this lower house was flooded busted. Then it is rested in the sea bottom, but when you want to take this out. That means, you have to debug us and also you have to loosen the mud around the mat. So, that is done by water jets will come around here. And move this then you only. So, this was the concept. Now, what has happened in the deeper waters? This bottom mat was split in 2.

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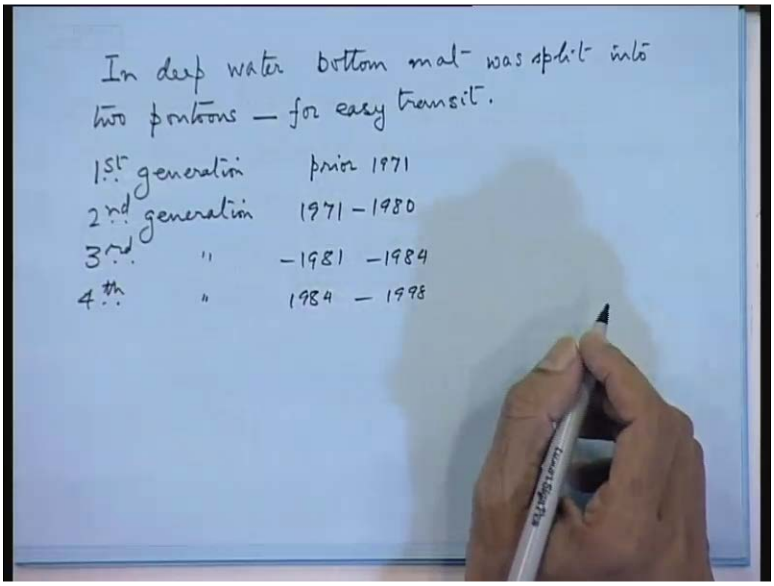

Now, when actually oil explosions started in deep waters; then the bottom mat was split in to 2 pontoons this was for the sake of transit for easy transit. So, this was how the evolution took place for the semisubmersible. Now, coming to the semisubmersible; there are certain factors which are very crucial.

Now, so this actually evolved around this called first generation design. Then you have second generation, then third generation and now we are in the fourth generation. So, the design has evolved over these phases. So, this was prior to 1971 then this is 1971 to 1980, and 1981 1984 and this is 1984. And beyond this is 1998 and still I think no further development has taken place out here; this is how the thing has evolved and coming to the configurations.

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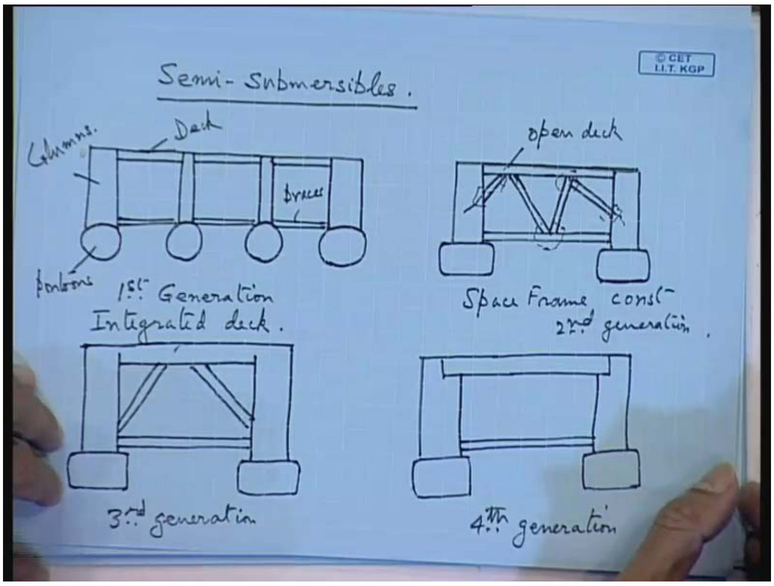

You will find the first generation; actually look somewhat like this. So, these were your pontoons. Then this was your deck and columns. Now, with greater amount of knowledge about waves and all these; so this also started here. And these are called horizontal braces; these are called brace. And then second generation you can see the pontoon waves cylindrical in shape. So, now actually this has evolved in to a rectangular hull with bracing cross bracings. So, this is your space frame construction second generation.

Now, here you can see that the deck is a glass type of deck basically it is resting on this 3 dimensional glass pontoon instead of having circular cross section it has become rectangular. Now, this has further evolved actually in to this type of structure. Now, here you can see the columns size of columns has increased. Now, with more and more knowledge about wave forces coming in to the design phase you find that this was one thing you should note that now the deck of the platform has increased in size.

So, here now instead of having so many bracings have been reduced in number, but still we have the rectangular hull type of pontoon. So, this is another configuration. Now, this system you find that bracings are like this. So, instead of having; so these are the critical joints this one joint another joint fully joints. Now, joints are actually hot spot regions.

So, these are actually likely spots for cracks development of cracks and ultimate failure of columns. So, here you can see the design has taken place in such a manner that joints have been reduced and here instead of having a trust deck. So, this is called open deck and this one is called integrated deck. So, bracings have been reduced column diameter has increased from the first category and the forth. So, this is your third generation and fourth generation has totally dispensed with the bracings. So, this is called the fourth generation, but column diameter is more or less the same and you have the integrated deck, but here done away with the cross bracings.

So, this is another variety; instead of you can only have 1 horizontal brace? I told you bracings are actually likely spots for failure or stress concentrations; now a days you have various configurations of this category. So, this is your fourth generation. So, actually this is the evolution of the semi submersibles. So, no cross bracings just only 1 tie bracing between the columns. So, evolution has taken place; and now what we have to study is the design.

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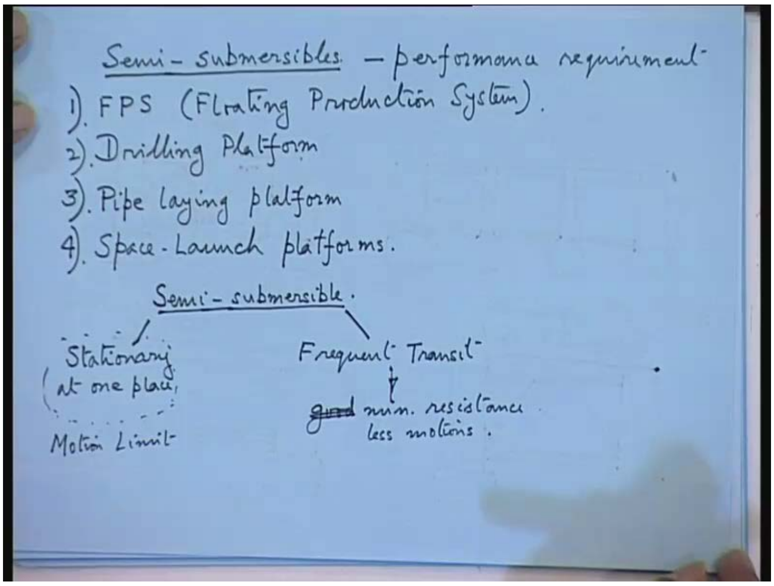

In semi submersible what is the performance or performance requirement? Now, I will give you more variations of the fourth generation. So, what you have seen is only the one time. Now, performance requirement or the work requirement or semisubmersibles can be number of types. Now, it can be employed as an FPS or a floating production system. Now, it can be employed as only a drilling platform. So, these are the very aspects of functional semisubmersible. Number 3 it can also act as a pipe laying platform. So, these are the major uses of semi submersibles pipe laying platform that is the offshore pipelines. So, those are actually assembled on semisubmersibles, because they are large deck area. So, driving what is number one it can also act as space launch platform.

So, that means missiles etcetera or launch vehicles can also be from semisubmersibles. So, these are some of the many users. Now, accordingly there are 2 types semisubmersibles; when you go for semisubmersibles design. Now, you have to figure out whether this is stationary at one place or it can go for transit. So, these are the 2 variants in the design; first is stationary at one place and the other is frequent transit; which one we will go for? So, that depends on the job requirement of the semisubmersible ok. So, there are one design pertain to this. Now, stationary at one place; that means, here you do not require any reduction in the resistant of the platform. Resistance is not the major criteria your major criteria in this case will be motion limitation.

Now, frequent transit; that means, here actually you should have short transit time. So, this should have less resistance our good; that means, minimum resistance motion is secondary of course, less motions. So, these are some of the variants you have to decide on which category this semisubmersible will fall; according to the job requirement or work requirement. So, based on that you have to do the hull form design; so hull form design is actually centered along these specific requirements.

So, based on this the moorings. So, here actually moorings for long term application and for this short term mooring design. Now, what is this long term and short term? So, that means, in your mooring analysis you have to do the you have to calculate the motions of the submersibles. So, here actually you go for 100 years long criteria; it is better. And here you go for lesser amount of time say 25 year maximum year wave height significant wave 25 year storm. So, this is how the thing actually goes. Now, suppose that is when the motions are very unfair. So, you should have quick transit so that means you have to run away from the place of the arrogance say Gulf of Mexico.

So, that means you are getting arrogant is coming; so that means, you have to quickly un hook the errors or unhook moorings. So, that is called quick connect disconnect of moorings. So, these are some of this thing design vary variations in the design. So, here actually you should do long term wave analysis and here short term short term period quick connect disconnect mooring and minimum resistance. So, actually all these things are carried out what is called the sea keeping basin for tank. So, either this you have to find out normally from calculation of vessel arouse. So, here actually in our department we do not do this, but this is a very important area of study source.

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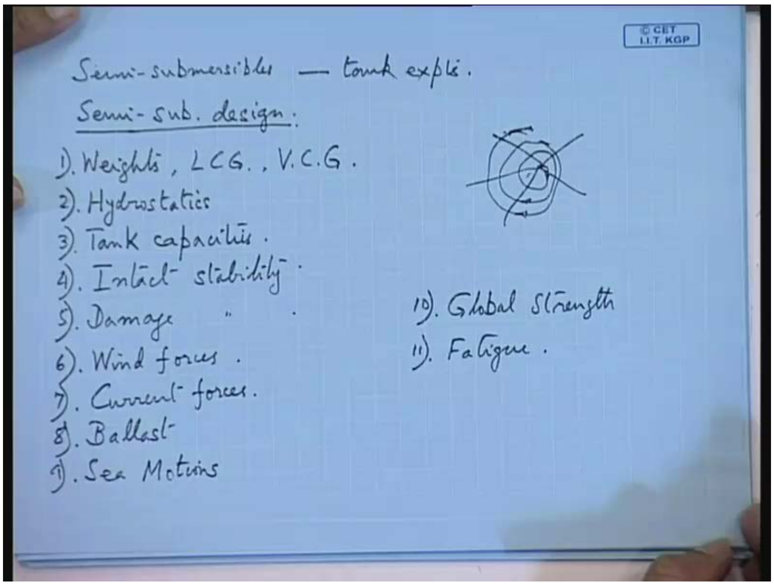

This semisubmersibles you go for this is sea keeping tank experiments IIT madras does this. So, here you calculate the responsible semisubmersible with waves. Now, anyway so now coming to the design phase semi design semisubmersible; there are various aspects of this. First one you figure out weights you calculate weights LCG,VCG etcetera. So, weight summary is very important.

Now, you calculate hydrostatics. So, this actually we have to do we have to find out what is called your design spiral I have already talked about. So, you start from the owner's requirement and go for final design and these are the various folks weights LCG. And all these you go for number of iterations and make the design much more refined calculate tank capacities. Then 4 is intact stability. So, these are some of the numeral architecture considerations what else calculate damage stability.

So, all these you have to do; then wind forces. Of course, we have to find out damage stability probably this you have to do first. This is wind forces; then current forces. Current forces are required, because this semisubmersible is moved at one place ballast. Then sea motions and number 10 is find out global strength and last one is fatigue. So, these are the some of the steps you have to do following semisubmersible design; so 9, 10, 11.

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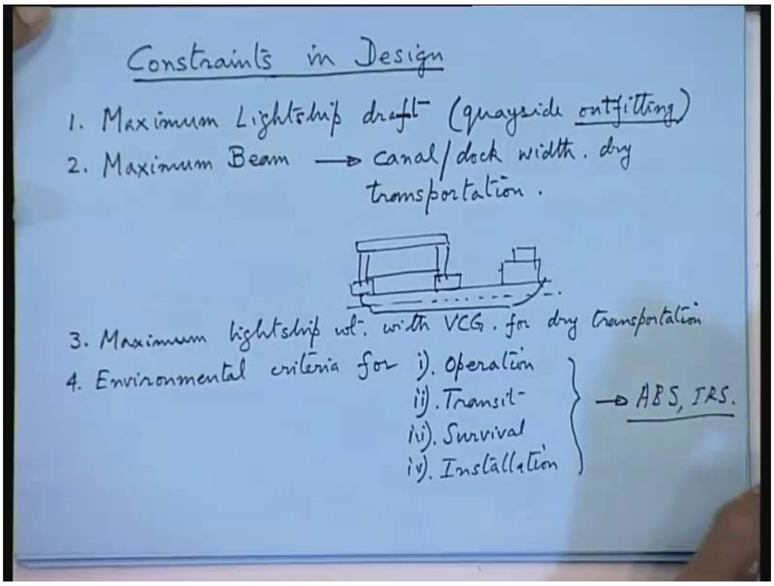

Now, operating conditions Constraints in design. So, you formulate your design spiral with those spokes which I have already talked. Now, what are the constraints? Now, you cannot keep on increasing the dimensions as you like. So, first one is maximum light ship draft. So, from where this will you find out this you can do from key site or quayside out fitting.

So, out fitting is normally done on the quay next to the ship yard. So, what is the draft over there? So, that means the semisubmersible should have a large draft for out fitting on the draft side. So, from this you calculate draft; next how you will find out the maximum beam? Now, this you find out from canal width, canal stroke dock width. The other one is dry transportation; what is this dry transportation? Now, dry transportation means the whole semisubmersible is transported on a supply vessel.

So, semisubmersibles are not very friendly towards the resistance part or co it is not co friendly. So, that means you have to load the semisubmersible on a barge or after supply vessel and take it to the site. So, that is called dry transportation; now whether you are having sufficient beam or very large beam for dry transportation. So, the semisubmersible is literally carried on top of it see offshore supplier vessel for a barge like this; we have semisubmersible somewhere here positioned.

Now, you have to calculate the stability of the barge with semisubmersible on the deck. This is how it is carried. So, this is like your I told you like you carry transport jacket on top of a barge. So, this is semisubmersible carried on top of the barge. So, this is dry transportation. So, maximum beam you find out maximum light ship weight. Now, in this case you cannot increase the size of the semisubmersible or the weight of the semisubmersible; you sink the barge is not it? Sink or capsize the barge.

So, there is a maximum light ship weight with what; with VCG this you have to calculate for dry transportation; this you have to figure out then environmental criteria. Now, semisubmersibles develop actually 3 or 4 operating modes; one is the operation that is as in the production or drilling. Number 2 you will have transit and 3 is survival storm survival. The other one can be installation. Now, ships actually you have calculated your g z or g m for how many loading conditions.

Basically, you have calculated for 2 loading conditions is not it? The light ship and loaded departure or light ship wherever whatever? See, semisubmersible will ask you for all this. So, you have to calculate your g z curve for all this conditions. So, all these conditions we have different drafts with different g m and g z values and different giving arms and all that. So, this you have to give it to the approval approving of it say ABS then IRS and all these they will ask for this document. So, you can see it for. So, offshore if you go the criteria is much more vigorous anyway. So, these are the loading conditions and here these loading conditions will give you, now this kind of offshore structure.

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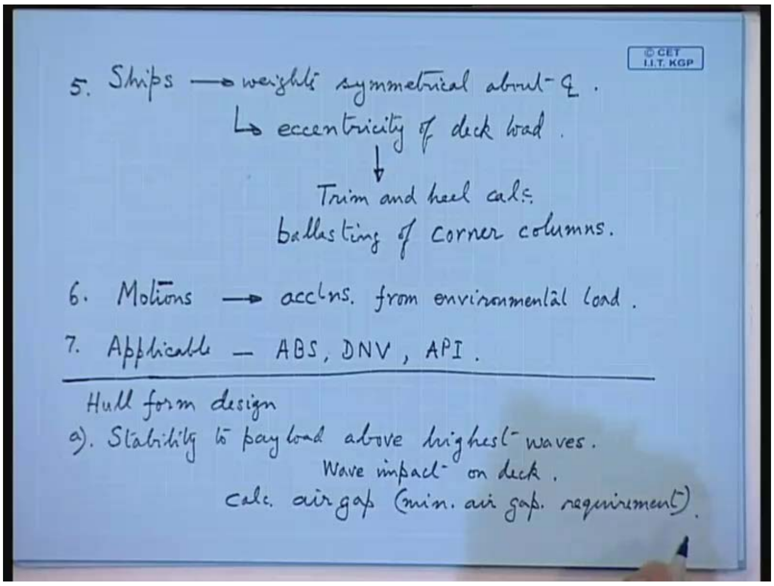

Now, ships basically you will find they are what? That means, weights are the weight configuration ship is symmetrical about central line more or less have you seen. Ships are actually about the center line doing hull form is similar. And also the weight distribution is symmetrical about the central line that is normally you calculate the weight about make the NCG and VCG. And that is the what you have done the calculation on before that. So, the NCG is important, because of trim.

Now, in case of this type of ships which I have the bridge is quite large you also have to do the transverse center of gravity, but in this case you have to find out what is called eccentricity of deck load. Now, your weight distribution on the deck may not be it is evidently it is never symmetrical. So, this is called eccentricity of deck load. So, that means that one end you will have a crane the crane saving will something like 200 tons.

So, for this you have to do what in order to counter this you have to always do trim and heel calculations for different disposition of the deck load. So, that is called deck load eccentricity. So, this will give you adverse trimming and heeling movement. So, this has to be countered by that is why you require what is called ballast. And ballast ballasting of what corner columns. So, at the corner of the columns you will find large ballast tanks. So, essentially they are called trim tanks. So, this is the job.

So, anyway so that is lateral eccentricity; now calculate this is 3 environment 4; so this is 5, 6 is motions. So, motions are actually very important for this type of ships more than your say cargo ship or passenger ship, because of the reason of rise up break down rise up break up conducted pipe snap. So, all related to motions. Now, motions calculations you have to do from environmental loads and accelerations. Basically, you have to calculate the accelerations from environmental loads. So, this is the and then the last one is of course, applicable rules.

Now, whatever you have to do you have confirm to say ABS, DNV. These are some of the rules. So, these you have to be followed the other one is API American petroleum institute. So, based on this the semisubmersible has to be configured that is your hull form hull shape configuration or rather hull form design; you can write after you have done all this study. Now, this if you want in boils down to numbering a is stable stability to payload.

Now, this is another very important criterion in hull form design; that is the life span that you will be withdrawing. That is basically you have to figure the column height and the length and breadth depth of the pontoons. You have to keep the deck always above the highest waves; otherwise you will find that the your deck is going to be wet all the time not only that wave impact on deck. So, this can have up to your production and driving operations. So, this is essentially done by calculate air gap or you will find out minimum air gap requirement. Now, this is very crucial, because otherwise your deck is going to become wet and you will have lot of wave impact loads coming on the say quarters living quarters driving and all that. So, that because your major operation is on the deck.

So, the crude and all that will be operating the various Ralphs pipelines etcetera on the deck and you get washed away. So, this is minimum air gap requirement is a fundamental criteria of design. Now, next here you have so this of course, the other smaller item is wave run up on columns. So, this is called wetness; suppose a weight comes I mean impacts on the columns then it goes away, but your column is going to be wet is not it. So, that is also to some extent I mean this is a minor issue where you have to do all the painting cores and production, because of this. So, this is called wave run up on columns and wave impact. So, you study. So, this these are very crucial wave impact, wave run up. So, lot of hydroponics is involved is involved at the free surface. So, response to waves; so this is one of the guiding lines for form description.

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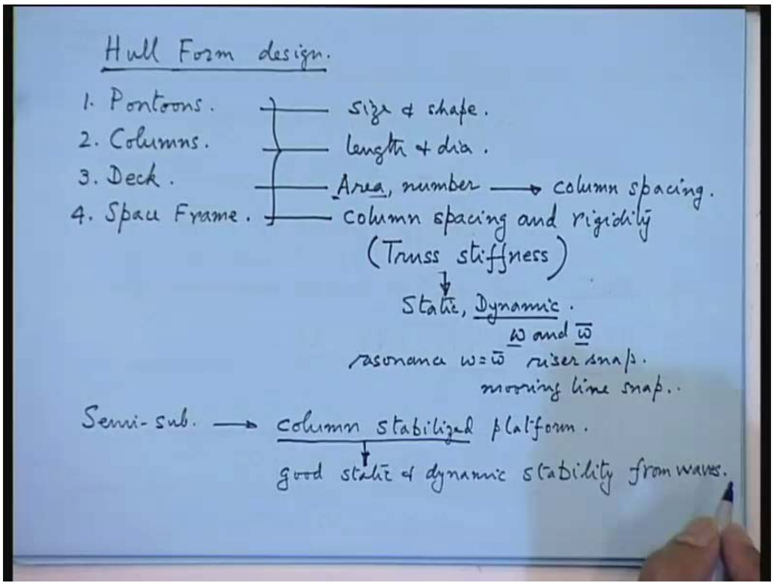

Now, form basically you have to split up hull form into 4 categories. Now, in ships what you do? Ships is just 1 single volume, is not it? Normally, you fix up your length between perpendiculars; and then you breadth molded breadth, molded depth block position draft.

But here actually you have to do independent design of first you do for pontoons; next you do for columns. Next number 3 is deck last one is what space frame. So, actually what is more from your ship design? Because you have to independently design all these 4 categories. So, I will give you one of the description pontoons what is the configurations of your pontoons. There are various types of pontoons first is first 2 types I have told you one is cylindrical; the other is square shape with rectangles. And all that next you can have a ring type of pontoon. I will show you some of the designs. Now, columns actually pontoons you fix up size and shape, columns length and diameter deck depends on what?

Now, either you have to go from deck to columns or columns to deck. Now, deck area you have to find out area, number; you can have more than one deck. And this will depend on column spacing space frame, of course this will depend on column spacing and rigidity. Now, this you have to calculate from structural what is the rigidity of the structure or some the stiffness of basically you have to calculate truss stiffness. If I had the method that you are studying this you have to calculate this stiffness matrix.

Now, this you have to do both for static as well as dynamic. Yes, the static analysis you get the static forces and dynamics you calculate omega and omega bar; that is the wave frequency and the response frequency. So, remember this type of platforms you always keep it out of the resonance frequency range semisubmersible or TLP are very crucial; otherwise it will be a disaster and mooring. The first thing is in case of resonance what will occur I am telling you; if this is the situation of omega equals to omega bar you will have riser snap; this is quite dangerous. And you can have mooring line snap lower structure as a whole will remain as it is, but these 2 will go.

So, in order to prevent this very accurate calculations have to be done for dynamic analysis; this omega and omega bar find out natural frequency from your Eigen value calculation. And also your resonant the wave frequency. So, anyway; so these are the some of the hull form design. So, here you can see the design is more complex than that of a ship. Now, basically you have these pontoons columns this space frame and the deck is actually area based. Now, area based actually you have to figure out what are the type of equipments weight they are weight configuration LCG, VCG and all that.

So, those data will define your deck. Now, columns actually you find your semisubmersible is called a sometimes they are also called a columns stabilized platform; you come across this in the literature. Now, what is the meaning of column stabilization? Now, from the structural engineering concept this you call structural stability is; that means it will not buckle. Basically, buckling the failure against buckling is called the column stability, but in this case column stability actually means your that never architectural stability. This should give good static and dynamic stability from what from waves.

So, columns are essentially the volumes which give your static and dynamic stability, because your pontoons are wave below the water surface. So, pontoons are not in the operating mode. So, there are actually number of modes they are in the transit mode actually the columns are?

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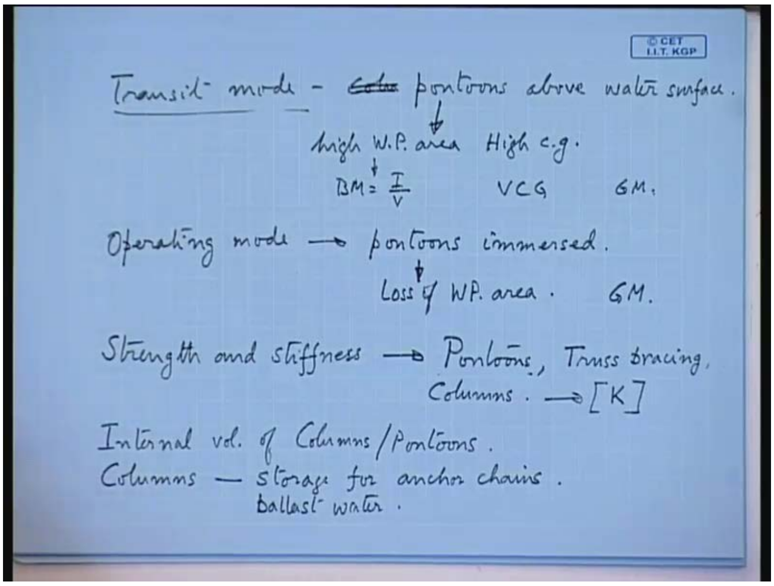

So, in transit mode transit mode what happens columns are above the water surface sorry not columns pontoons above water surface. Now, in this case you are getting very high water planar area. Now, this is a case of high water planar area good for stability, but at the same time you have high c g; which is detrimental to your g n, is not it. So, everywhere you have to do all these calculations of c g high water planar area. So, high water planar area this is good for your B M is equal to I by V.

So, you have to find out this moment of inertia of the columns which is giving you B M. And here you calculate your V C G from this you calculate G M; G M calculations are very crucial. So, this is in transit mode. Now, in the operating mode; now here actually the semisubmersibles floats on these pontoons are immersed or submersed you can say. Now, so here it is actually it is loss of water planar area. So, water planar area is lost. So, this will reduce your B M.

So, at the same time, but you are, because it is the G will go down, because probably you have biased it, is not it. So, this you have to find out G M in both categories operating mode as well as transit mode. So, you have to decide the hull form design is basically centered around your stability calculations and your space frame. Now, your structure that is the strength and stiffness; coming to the structural aspect strength and stiffness. So, these are normally given by this comes from major strength part is your pontoons bracings of the truss or other you write truss bracings.

And, last is your columns structure; if you want to calculate first you calculate from pontoons truss bracings. And then columns you have the thing main structural items from this you calculate your this stiffness this K matrix. This you have to decide from the structural point of view the draft has there are 2 more of this draft that is transit and operating mode and calculation of internal volume of columns pontoons. Now, how you calculate this? Now, columns actually storage for anchor chains; so your semisubmersible we will have huge anchor chains. So, a few kilometers long.

So, those have to be hold up by means of which is stored in the columns. So, columns have sufficient volume to accommodate anchor chains. Next ballast water can be in columns corner; columns are provided with ballast water for trimming eccentric load coming from cranes and other deck load. So, those you have to trim by means of varying the ballast water in the corner columns.

Now, what else pump room columns may have pumps machinery. So, all these require space volume. So, you have to provide all these volumes inside the columns length of column is dictated by what air gap mainly your air gap requirement. And your draft is again a crucial issue for deciding the length of columns now pontoons also same thing will come.

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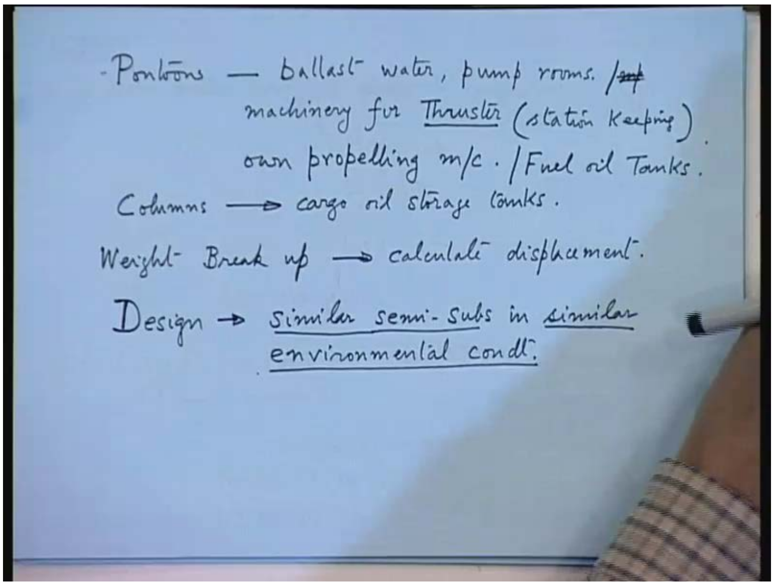

Now, pontoons you have ballast water, but pontoons you do not store chains. Mainly pontoons have ballast water pump rooms. Then you may have what else ballast water pump rooms. Then you may have this machinery rooms sorry machinery for thrusters. So, pontoons are normally provided with bow and stun thrusters in case of semisubmersibles, because in order to change the orientation or station keeping. Basically, for thrusters these are required for station keeping.

Now, some of the semisubmersibles may be provided with their own propelling machinery. So, these are to be housed inside the pontoon. So, you have to give sufficient volume and space for all these fuel oil tanks; if you have machinery you have fuel oil tanks. Columns can also act as cargo storage; if it is found necessary cargo oil storage tanks. So, this is the volume calculation of your semisubmersibles. So, you have to calculate all these tank capacities. You calculate volume of all the machinery tanker chain all these requirements will be there; you will find out columns pontoons columns. And then your space frame is normally your this thing giving the stiffness to the structure. And all these is actually all these performs is from the support to the deck.

So, deck support is coming from the underwater part; next is the motion calculations and you calculate the mooring. So, you have to calculate basically find out semisubmersibles displacement; after you find out all those weights weight break up. I think I have given you now weight break up from this calculate displacement. Now, so how do you start your design semisubmersible design? You follow the principles of your ship design. This will start from similar semisubmersibles; in similar environmental conditions. This is very important. So, with that is the starting point of your design spiral. Now, each site will have its own environmental keep on changing the parameters till you come at converge at the correct value. So, basically…