Elements of Ocean Engineering
Prof. Ashoke Bhar
Department of Ocean Engineering and Naval Architecture
Indian Institute of Technology, Kharagpur

Lecture - 14
Introduction to Offshore Structures – II

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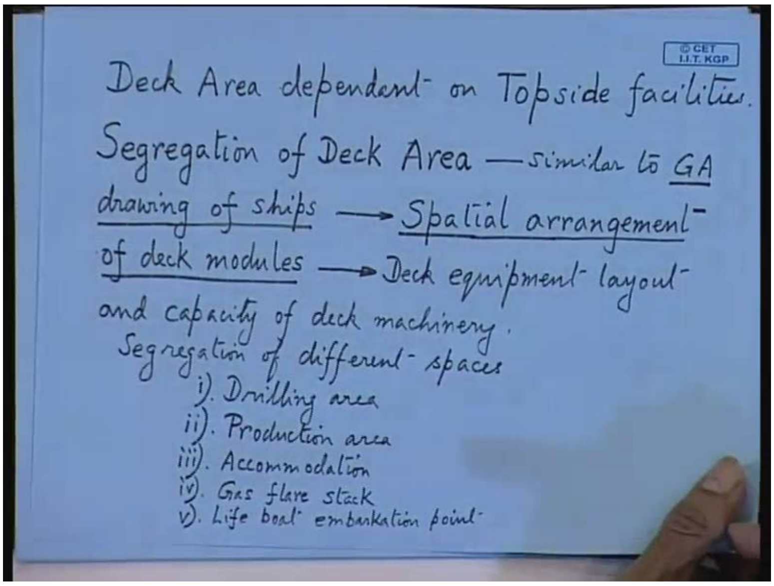

This is the next phase of your offshore structures. So, this deck area decision has to be taken, now this is basically dependent on what is called as top side facilities. So, in this offshore engineering, you will come across this word topside facility, now what are these top side facilities? So, this is basically based on segregation of deck area, now this is similar to your ship general arrangement drawing. So, whenever you designing the deck area of a offshore platform, you should what comes to your mind is your GA drawing, similar to GA or general arrangement drawing of ships.

Now, on what conditions you draw your GA plan, what are the prime considerations, lines plan most of you have done. But, in lines plan, you have done from offset table, not from fundamental ship design principles. Now, you tell me on what considerations, you make your GA plan or GA drawing of ships. So, this is basically the spatial arrangement, how you are going to arrange the various modules on the deck, so spatial arrangements of deck modules, so this is your prime considerations.

Now, this is again based on deck equipment layout, so this is your primary consideration, so in the next class I will give you a list of these equipments, what are these deck equipments, how you are going to lay them out. So, this is primarily done by the chemical engineers or your mechanical engineers they will tell you and the capacity of your deck equipments or rather you write deck machinery. Suppose, you have been told to draw the main deck plan, so what are the items you are going to show.

So, this is similar to that, main deck plan of your ship, so here in this diagram, you can see the various deck modules, but unfortunately the machinery has not been shown. So, here you can see the deck house along with the deck then you have the drilling deck, flash stack, there is a crane, so how you are going to house all these elements on the deck area. So, deck area is a deciding factor on the area requirement of these different modules, not only you have to decide on the area, but also on the distances between the various modules, example I can tell you is the flare stack.

So, you can see the flare stack is far away from your this deck house, because of the heat radiation from the flame. So, you have to keep the crew and the personnel away from heat or from catching fire, so this also has to be farther away from the oil processing and storage facility. So, they have a separate, which is called they make a copper dam, which has not been shown, I will tell you in next class.

So, the segregation of deck facilities, they are not done in a random way, but there is a definite reason on the segregation of the various facilities, because of what, main reason of segregation of spaces of different spaces. So, the different spaces that you will find are, in ships when you draw your GA, what are the different spaces that you segregate. First you segregate the engine room then your cargo space that is your hold then your accommodation.

So, similarly here you do a segregation of different spaces, so the primary spaces are drilling area, where you are doing drilling. And nowadays I told you, you can do both concurrent drilling as well as production, you separate your drilling area form your production area. Next is your accommodation, you cannot have your accommodation on top of your deck, so that has to be separate from the drilling and production area and far away from the gas flare.

Next you have lifeboat embarkation gas flare, so that is the gas that is coming out from the oil that is ignited. So, normally if you go into an oil field, you can see the fire, the flame that is coming from the oil wells. Go to any oil field Bombay high, Gujarat, Ankaleshwar in the night, you find the sky is red, because of the flame that is coming from all these wells. So, that is called the gas flare or gas flare stack, the lifeboat embarkation area is also to be separately thought about, so this is the so called main deck of the platform or the deck area of the platform, so you start from that. So, your design actually starts from calculation of the wave loads, the other environmental loads and you trying, which you should not forget is the water depth, so that is the deciding factor for your underwater truss.

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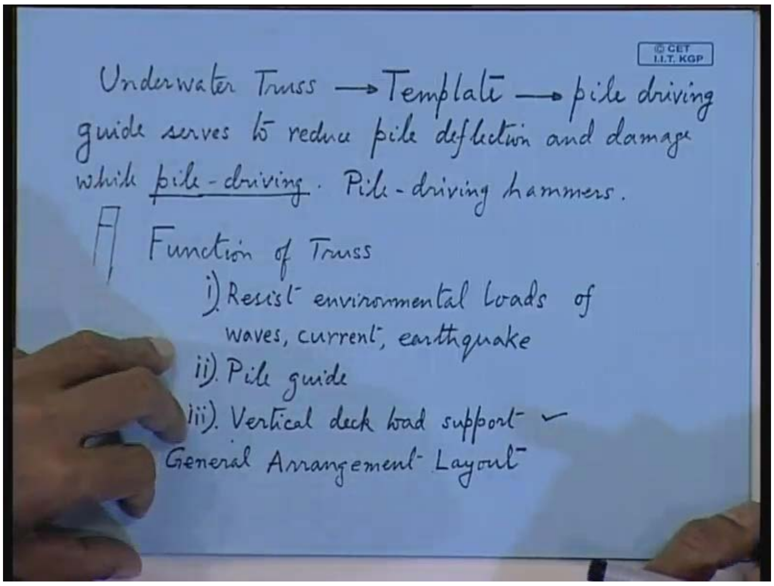

So, underwater truss is also sometimes called a template, so now what is the meaning of a template, underwater truss is also called a template. So, template means, it is a pile driving guide, why is it called a pile driving guide, template is a pile driving guide (Refer Slide Time: 11:00) so that means, you can see from this diagram, example is, this is a underwater truss. So, it is basically holding down the what, holding down the deck along with the deck modules your deck and so for other weight items at a certain fixed location on the sea.

Now, the deck should not vibrate or have tremendous amount of sway, neither should it be swept away bodily from one place to another that is, there should not be rigid body displacement, otherwise your conductor pipes, your marine risers are simply going to tear off from the or separate from the deck. So, the truss should be strong enough to hold on the deck against your environmental loads. So, that is one of the prime conditions and as a prime condition, this template is a pile driving guide.

So, here you can see the sleeves, etcetera, from which you can drive the piles, if you do not have this so called unordered truss or template that means, just like you drive your nail, one pile will go vertically down, the other will go like this, in all sorts of directions it will go. So, the piles are normally driven in an orderly fashion along a fixed direction, so to prevent the piles from going in the haphazard way and finally, breaking down, so this is prevented by the template or underwater truss.

So, it is a pile driving guide and this serves to reduce what, pile deflection and damage, while pile driving, have you seen pile driving, if you go into the site for any large building, you see pile drive is normally done with the help of pile hammers. So, there is a hammer which comes on the top of a pile and your pile is driven down into the soil. So, similar pile drive operation has to be done for offshore platforms, so before you join the deck along with the truss, you have to literally drive the piles through your sleeve or columns.

If the columns are ready to be shot by means of a pile driving hammer by pile drivers or this is called pile driving hammers. Now, when you are doing this, there is a tendency, if you do not hold down the pile, then the tendency for the pile to get deflected and ultimately break or damage. So, in order to prevent that, you build this kind of a complicated structure. So, one reason of the truss is of course, to ward off your, to resist the environmental external load. The other is, so functional truss is how many, number one is resist environmental loads.

Now, these environmental loads are many, not simply, the maximum of course is your wave load, which I will give you later on the magnitude, can be in the order of let us say few thousand ton meter. So, resist environmental loads of waves, the primary load then you have current what else, the other is your earthquake. These will come on to the truss of the jacket, resist environmental loads.

Next is, functional truss is a pile guide, now according to the number and disposition of the piles, you have to build your truss, according to also the number of piles. Suppose, you drawn request from the piles then you can reduce the size of the truss or if you have say, number of piles that is more. Here, the main column piles are 1 2 3 4, they have more number of piles, then also you have to increase this and you have to have more columns, etcetera.

So, that will change my structure configuration of the pile, so that is one pile, primary reason is pile guide is also a deciding factor in the nature of the truss. So, next is, 3 is what, vertical deck load or vertical deck load support, so these are some of the functions of the truss. So, the unwanted truss is, the last point is this, what I was talking about is this vertical deck load support. So, if you want to go ahead with this, you have to draw a deck general arrangement layout. Now, simply doing this layout is not sufficient, what else do you require, now remember that, you are building a structure, you are not building something which is not having any function.

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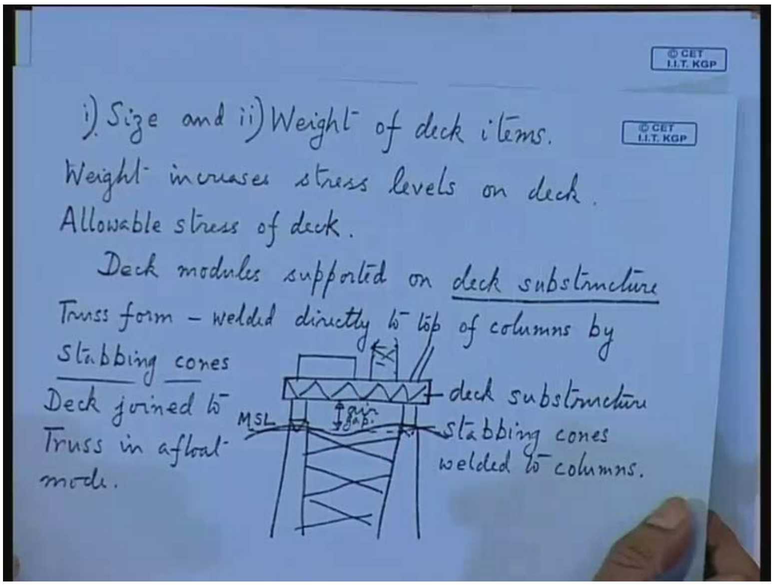

So, the general arrangement layout is basically dependent on two factors, one is size and two is what, weight of deck machinery items or rather you write deck items. Size and weight, they are two governing parameters on deciding the nature of the deck, the layout of the deck and the size of the deck. Now, the weight is an important factor why, because weight increases stress levels on the deck. So, this another governing factor is called the allowable stress, what is your allowable stress of the deck.

So, that is given in various rule books, what is your allowable stress, so similar to your hull girder stress calculation. So, whatever items you are having on the deck, it should not increase the deck stress beyond a certain limit. If it increases then you have to increase the plating thickness and also the supporting structure. So, deck normally you have the modules on top, you have deck modules supported. Now, there is a technical which is called supported on deck substructure, this is called a substructure that is, the structure below the main deck.

Now, this deck substructure is a truss form of structure and here of course, you are not able to see this, so this is truss form. And this truss is welded directly to top of columns by stabbing cones, this is not shown in the figure, so actually you have to position the deck, the deck normally comes as a separate module. So, I told you, you have to make the truss and the deck separately and you find that, the deck is then assembled in the ship yard.

The different modules are brought together, say flare stack, drilling and etcetera, this will come and then this comes as a separate deck, this is called a deck substructure. This is your truss and below this truss, you have stabbing cones, now these actually, they are made with the top of the columns of your underwater truss. So, you can see that, this kind of erection at sea is a very tricky affair, it has to be done very precisely. So, this is your truss, so this is your deck substructure, these are called stabbing cones, these are welded to the columns.

So, this is how your deck is joined with the truss and this whole operation is done in the afloat condition, so deck is joined to truss in afloat mode. So, all this is, if you see with your eyes, you see the operation, it is quite interesting, so your waves, your wave height will come somewhere here. So, here the mean wave height you take this, this is called an air gap, you have to maintain certain air gap above the mean sea level. So, this is your mean sea level why, the reason is, the wave should not come and crash on the deck.

Because, it will disturb the deck operations and also it will cause deck wetness that is, the crew will not like to go from one place to another with a wet deck and to be swept away overboard, so that is you maintain a certain air gap. So, this height is also taken care of with the design for your truss, you have to keep the deck certain meters normally I think 10 or 15 feet above the water level.

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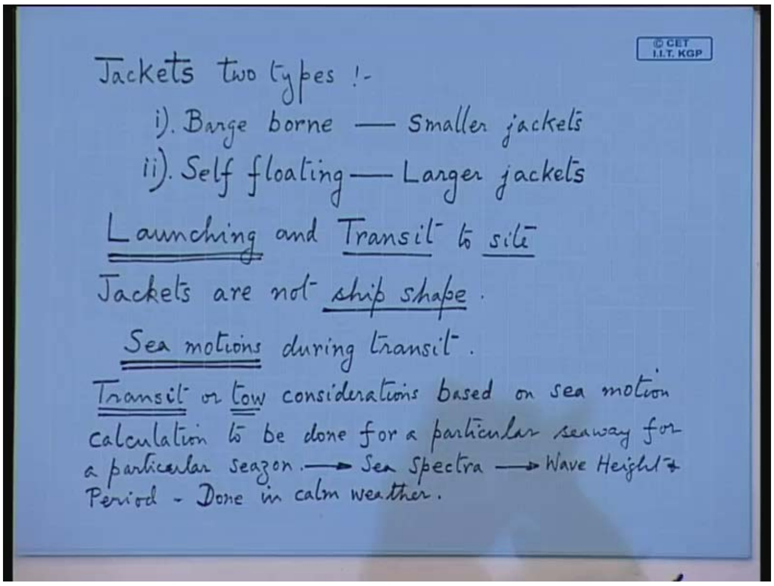

So, deck joined to truss in the afloat mode, now here actually jackets, you find there are two types. So, I told you the water depth is a prime deciding factor on the size of the jackets, so based on that, your jackets two types. So, the first type, there is the smaller one, they call it I think there is a special name, anyway. So, primarily we say that, first one is called barge borne and the other type is called self floating, so distinctly you find these two types.

Now, the barge borne ones, these are the smaller categories or smaller jackets, now the name comes from type of launching that you are doing. Now, self floating are the larger jackets, so jacket fabrication that is, underwater truss fabrication is quite simple. That is, you make the flat panels then you cut the pipes to size and then you weld horizontally and then you rotate it vertically and join. So, this is unlike your ship hull surface, in your ship hull surface you find a lot of curvature on the hull, so that has to be taken care of, which of course you do not find here.

So, there you are getting some relief, but here actually, the more problem with these jackets are, during the launching phase, launching and transit. Now, jacket by itself, they will not be able to move from your shipyard to site, because jackets are not ship shaping. Now, this ship shape has certain advantages, now what is the basic advantage, so it is more resistance friendly that is, the power requirement is there, another thing is you can counter your waves during transit mode.

The transit is an important, the transit is transit to site, the offshore site can be few 100s or 1000s of kilometers from your ship yard. So, you are building a platform somewhere in the Norway and you are transporting the jacket to the Gulf of Mexico, so you have to have the Atlantic ocean in between. So now, the transit mode, this is a mode of a, here actually your naval architectural calculations will come. So, sea motions during transit, what is this, this you have to calculate.

Most of you, I do not think you have done the sea keeping course, you have to do lot of calculations when you are moving the jacket from ship yard to site that is, calculation of sea keeping or sea motions in... Now, the transit is going to take place for several months, transit or this is called the tow considerations. So, the naval architects, they are bothered about, they are more bothered about this launching phase of the jacket and the transit phase of the jacket or the towing phase of the jacket, that is where the offshore companies are going to hire your services.

So, transit or tow considerations, these are based on sea motions or sea motions calculations. Sea motions calculations to be done for a particular sea way, so all your hydrodynamics that you are learning from your waves and all that. Calculations done for a particular sea way for a particular season, at which your jacket is going to be transported or towed, you have to find the maximum wave height. So, this information you can get from sea spectra, we have not discussed about this aspect in your offshore engineering.

So, next we will talk about spectra, which is coming for a particular sea way, now from this, you have to find out your wave height and period. So, normally the towing operation is done in calm weather, you avoid storms, so this you have to get information from the meteorologists, when you are going to tow the jacket. So, wave height period, you have to calculate from the sea spectra for that particular route in a particular season and then you go for transit or towing mode of the jacket. Now, in the towing mode, what are the considerations, tow considerations, you have done practical calculations of tow.

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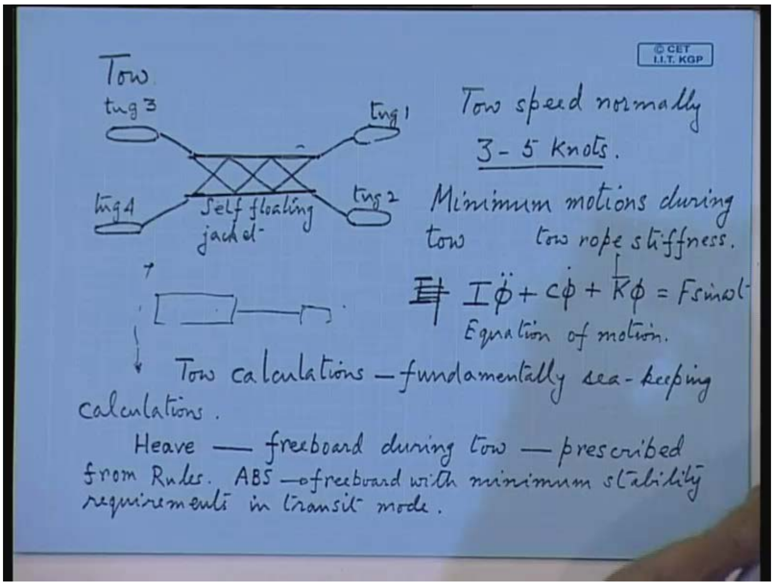

Now, tow is singular to your mooring considerations, say your platform that is, say this is your jacket, it is typically long structure, now are you going to tow it by 1 tugs, 2 tugs, 4 tugs or how many tugs. Now, what is going to be the power requirements of these tugs, so normally, you will find at all the four corners, there is one tug and tow. So, you have to calculate, how many tugs will be required and what is their towing power? For jacket, normally is pretty large, you are towing a large jacket and this is a self floating jacket.

Now, you calculate, so this is tug 1, tug 2, so why you require so many tugs, one tug can do the job, tow speed normally 3 to 5 knots why, any tow that is, you are towing a tanker also, you do not tow it at more than 5 knots. One is the requirements of power, of course you will say, you require more power, if you will tow at a larger speed and the other is what, can you guess, you should have minimum motions during tow. Now, your tow force is large, obviously the force would be large and your speed and velocity will be more, so the structure will go at a high speed and will have more motion.

So, you restrict to motions to 3 to 5 knots and ships have been lost during tow also, I do not ships, which have been towed from Calcutta port going to Kandla in Gujarat. When we were crossing Tamil Nadu, the barge has gone below the sea, because the pilot of the vessel or the pilot of the tug, he did not know all these and the vessel is started. So, normally, you tow a small vessel, so one tug was towing and this is started going in this.

That is, yawing in large extent, not only that, it started grooving also, sway and roll was more so much, that the vessel finally, capsized.

So, these are some of the dangers when you come while towing, now these four tugs are given at the four corners, in order to prevent the rotation of the tow, this is similar to anchoring of the vessel. So, you anchor at the four corners to prevent rotation, so that you have to calculate form these equation that is, the moment of inertia that is, I phi double dot plus C phi dot plus K phi, that should be our external force, the sin of the sin form. The K is given, K is from moving via stiffness or tow rope stiffness, so this is a complex calculation.

So, in your sea keeping class, you will be required to calculate all this, so this is similar to your vibration, this is your equation of motion. So, you formulate your equation of motion and find out the displacement and the angle of rotation. So, tow calculations are basically your sea keeping calculations, now this is one example, your fundamentally sea keeping calculations. Now, in tow how many motion are, all six motions will come, there is surge, sway, yowl, heave, pitch will come, but in this case, you do not bother about so much about heave.

Now, the heave is related to what, in this case heave is related to freeboard during tow, now this has been prescribed from rules. Now, when you are going to some offshore company, you look up ABS for transportation of jacket, save floating and on top of barges. Now, ABS gives you the prescribed freeboard, freeboard requirements are given here along with what, freeboard with minimum stability requirements in transit mode.

So, either you have to do your fundamental calculations, you are seeking calculation form equation of motion and you have to check with ABS rules for mobile offshore drilling units. So, heave is related to your freeboard, next all the motions will be there.

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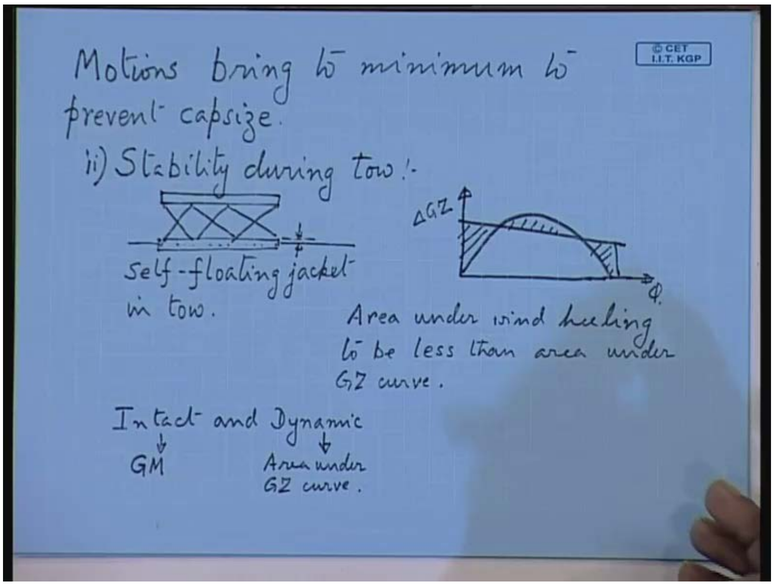

So, motions have to be brought down to the minimum in order to prevent capsize, so this is a very, very important calculation. The next consideration is, the other prime consideration is stability calculation during tow. So that means, whenever you are towing a platform, I think we do not have sufficient time, see this is your self floating jacket, a large part of your jacket will be above the water. You unnecessarily do not submerge a large portion of the jacket below the water why, so this is the self floating jacket in tow.

Now, you can see from this diagram that, now your freeboard is essentially this much, as self floating jacket. So, this underwater part of the column that is, below the water, that is giving the buoyancy and this is your free hold, because bracing members are, just see that, this is a ship and this is your deck and your deck structure, that is all. Now, here you will find that, a large exposed area is to the wind, your windage area is pretty large. Now, this causes your wind heeling moment, so if you consult ABS rules, you find there is a area requirement, area under the wind heaving arm and the righting arm.

So, this is your, I think displacement GZ and this is your angle, so there is a proportionate area given under this. So, area under wind heeling should be more or less, this is a specialized ratio to be less than area under GZ curve. So, this is of the order of a, ABS I think gives some value, I have forgotten this I have to check with ABS. So, this is the stability during tow, so first is your motion calculation during tow, this is number 1, which I took, do form sea keeping calculations.

Number 2 is calculation of stability, both intact, now this is your dynamic stability, intact and dynamic, so both calculations you have to make. Intact stability is calculation of GM, how much is going to be GM value. Dynamic stability you will find out, there is area under GZ curve, now these are two governing factors. Now, all these calculations, if you are employed by these offshore companies or shipyard, they will tell you to do. The other one is stability and motions during tow and third one is of course, your resistance calculation.

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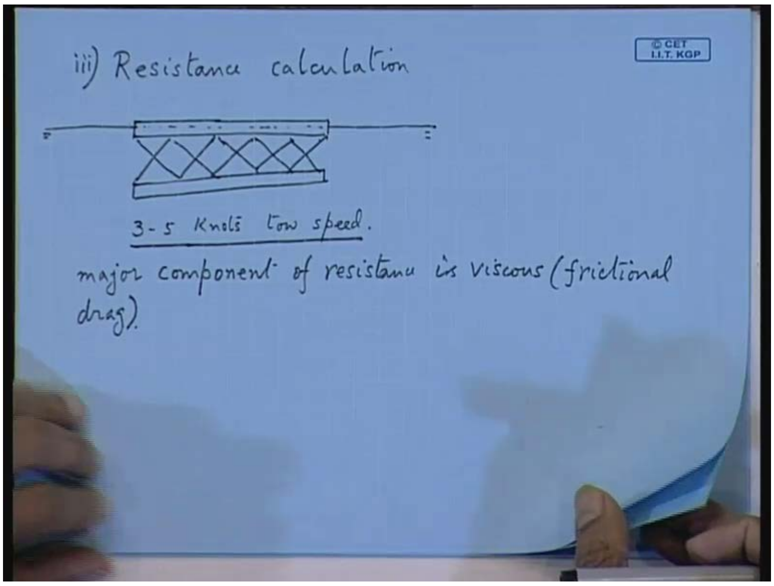

So, all your naval architecture funda is going to be tested, just when you are transporting a jacket platform from shipyard to site. So, resistance calculation that means, you have to do, because the jackets are pretty huge and they are floating basically on two columns. Now, suppose you do not want to tow like this, you want to tow with the larger portion of the jacket jackets submerged, but this is very risky, but sometimes they also do this kind of operation.

Then, You can tow it like this also, smaller jackets sometimes they try to float in this manner. So, you can see from this diagram that, the larger portion of the jacket is under the water. Now, here the risk is, the freeboard is pretty small, here if you tow it like this, even if you have larger waves coming, you can, this is also the buoyant legs or buoyant columns, it gives buoyancy to some extent. These columns are made pretty large in diameter, in order to give buoyancy to the jacket during the tow.

So, this is the major part of the self floating jacket, now whenever you do this, here it is being towed in this fashion that means, there is not sufficient freeboard or sufficient impact falling above the water surface. Here, there is tendency for the jacket to sink in case of adverse weather, but sometimes if favorable condition is there, the rolling motion is diminished, because above the water exposure to the wind is not there. So, this is one favorable condition, but your resistance is going to be high.

Normally that is the reason, why you do not tow the jacket for more than, say 3 to 5 knots, 3 to 5 knots tow speed. And resistance in such a slow speed, you obviously will not be having much of wave resistance, but major component of wave resistance will be viscous resistance, resistance is a viscous. So, there is a lot of viscous drag, viscous means frictional drag, now these here you find out from experiments or you to calculate from surface area or speed, etcetera. Now, these are complex calculations, so these are some of the considerations that you have to do before you are transporting the jacket. The other calculation that you have to make is launching calculations.

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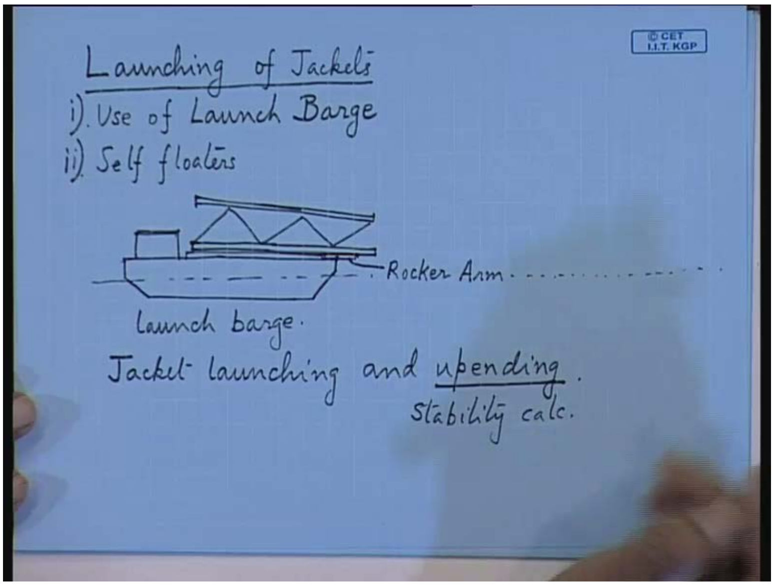

Now, launching, I have told you, there are two types; one is the barge bone variety that is, use of launch barge. Now, launch barges have certain advantages, now what is that advantage. Now, your jacket is not ship shaped, you are transporting an object which is floating in the water, but it is not having, neither it is motion friendly nor it is resistance friendly. Now, if you transport it on the top of a barge, you are getting this advantage of this ship shape.

Say this is barge bone, but the problem with this is that. you have to dedicate barge separately for transportation of the jacket. Now, normally one end of the jacket will be sticking out of the barge, you do not make a barge, which will accommodate the full length of the jacket, so this is an example of a launch barge. So, first you will have to bring this jacket onto the barge and the jacket goes to site then you have to tilt this barge, otherwise your jacket is not going to come out with your barge.

So, there are certain mechanics that you will have to calculate during, this is called jacket launching and after you come to site, you have to do another operation, which is called upending. Now, in this diagram if you see that means, you tilt the barge, obviously the jacket you cannot take off from this end, because of the willows of the barge. So, the jacket normally slips of the barge from this end and this is going to tilt about a beam, which is called a rocker arm.

Now, this narrower end of the jacket, is where you have to, the deck is normally welded at this end, but this end you will be going down to the water first. Now, if you are not careful that means, this end is going to strike your sea bed, if it is shallow water. So, this end normally, you tight by means of a rope onto a crane barge. So, this end will go down and then this end has to be brought out of the water, so that process is called the process of upending of jacket. So, again in this mode, we have to do your stability calculations, so next class, we will talk about this, what precautions you have to take.

Thank you.