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

Lecture - 48
SPAR Platform

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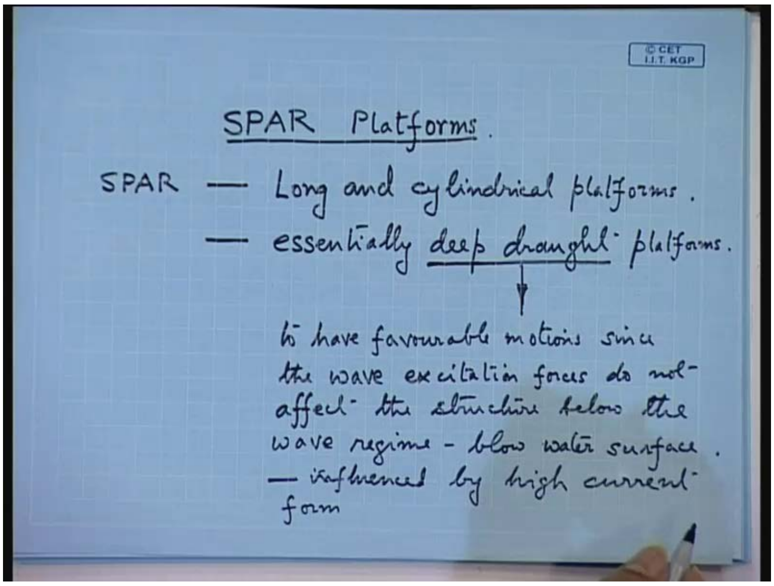

Now, spars are actually essentially long cylindrical platforms. Now, spar essentially a any wherever you come across this word spar with means long and cylindrical. Now, ice spar so; that means, these are essentially deep draught vessels or floaters. In our, this is where the main departure from the conventional T S L P is a semisummational occur that is in the deep draught platform.

So, in some of these platforms you find draught more than say 200 meters, of 400 meters are very very deep draught, now why this deep draught what is the advantage. So, here actually you find the idea is to shallow draught there will be a lot of motions on the, because cleaded by the waves. So, in deep draught you just nullified motions. So, this is there to have favorable motions since the wave excitation forces do not affect this structure below the wave region, wave region is any other surface.

Know below water surface is one of the main advantages, now disadvantage is also there, but this will be influenced by high currents. Current is going to be a clay havoc. So, whenever you designing a platform you should remember that, these are the two types of forces which are going to, come to the platform. Now, spars actually you find that look like this, there are two types. First one is called classic and the other is truss. So, the engineering is actually based on reduction of motion and also the cost of the platform.

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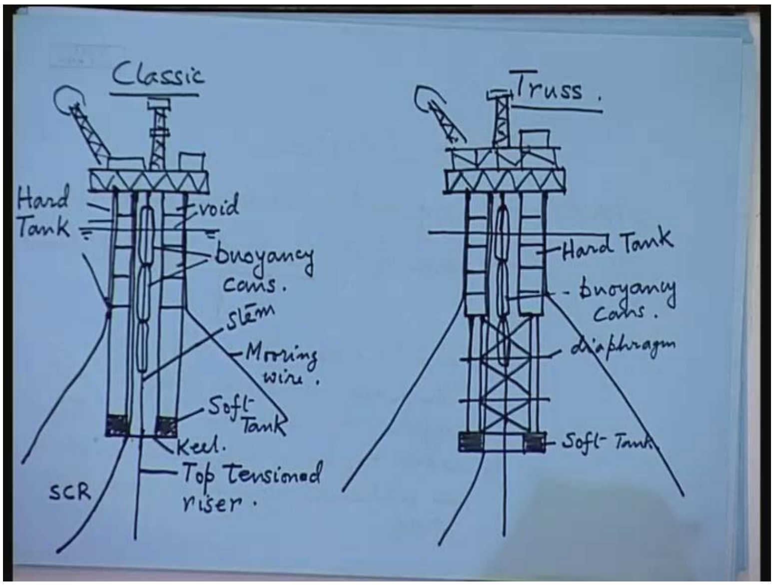

So, there are two types one is called the classics spar and other this called that truss spar. Now, in the classics spar if this is the water line then the deck is kept about the waters line. Now, the deck is more or less an opened deck, you know truss type open deck now, here actually you find the all type deck is not is missing. So, on top of this you have deck produce flares stack etcetera. So, this is your deck, but we are more bothered about the structure below this deck listen it.

Now, here actually the point that is to remember usually this type of platform with have ballast here that keeled. So, this is your keel, now here we have solid ballast and near the water line you have your void spaces. So, these are essentially buoyancy cans. Now, in spars you remember that the centre of buoyancy is have you centre of gravity. Unlike ships the C G is above your centre of buoyancy. So, these are void spaces, voids.

So, in T L P, I told you that platform has lot of void spaces because, of the buoyancy now, here you suspend your marine riser. So, this is the centre wave now, the marine riser in some of the spars mostly it is kept under tensioned by giving buoyancy cans. So, there will be large buoyancy cans on the marine riser. Now, these are called buoyancy cans. Now, the moving is from this end the moving where is left from here, this is called scheme scattering no sorry, this is riser. So, this is scheme scattering riser and this is another riser. So, here is having two risers. So, this riser is having support from the side shell of the or side of the wall and this is called top tensioned riser.

Now, moving waves are actually suspended from around it comes from the deck. So, that is the moving are kept talk by being yelled wind losses. So, it will come like this and then it will go. So, this is the figure of a. So, this is your moving wire. Now, this is called a tourney bottom. So, this is your keeled and this is called soft tank where is the boilds then be called hard tank.

So, whenever you come across spar you come across these words. So, hard tank, soft tank and buoyancy cans with risers. Now, here this whole cylinder is, it is enclosed by means of the plate. Now, we can also, alter this design, so, this is your waterline now, some times what they do they discuss with this part that is instead of making covering this portion you can keep it open. So, that is called a truss spar. So, that is the only difference so, right up to the hard tank. So, hard tank limit this is your hard tank. So, this structure is going to be same.

Now, below this you replace it by a truss, but the soft tank is a going to be there now, it you know why the soft tank is given. So, this is your part of the truss. So, you replace the cylindrical shell with this type of truss, but in between we having a diaphragm wall. Now, this is there to dam pure motions and this portion you can give a truss. So, that truss is essentially opened. So, these are the two types of spar you will come across.

Now, here actually the structure will be the same as this one. So, you will have your hard tank now, all these offshore structure and basic thing you should remember that the riser has to be kept under tensioned. So, that acts of the weight. So, you have to increase your displacement or you have to provide sufficient buoyancy for riser support and moving supports. So, this is somewhat your departure from the conventional ship design that we talk about. So, here you can have a flat stack, but the spars you will find that they are not very big platform like your semisubmersible sort T L P or F U S also there essentially smaller compline structures.

So, these structures are called compline platforms. So, that is they move with the direction of the waves you have all these out here. So, this you may not bother now, this is your hard tank region of void space. So, essentially this type of structures have the centre of buoyancy is located very high. Now, here also you have to give support to the riser. So, riser support is in the form of a buoyancy cans. Now, you have to make the structure in such a way that the whole hall of the spar actually slides on the, this is called the stem, on the stem.

So, this is one top tensioned riser, the other riser is coming on the side. So, the structure out here is more or less the same. So, from here the thing is all of because, you have to pass the riser at the bottom. Now, here actually if you close these sides, you will have a lot of enriched water in this column. That is called that can complicate hydrodynamics of the platform at drain water. So, most of you have to do lot of calculations on the autonomic sides.

Now, if you keep this portion free that is the motion becomes much more less because, the water is able two flow otherwise you have n trapped water here. So, this is a diaphragm attorney. So, this actually dams your eve motion, the sort of damping is over. The moving actually will come from the side so, moving is moving chain or wire is let from the top comes down from the side same as the previous one. So, this is your hard tank. Buoyancy cans. So, these are the two types of truss or spars which are at current their prevalent, but again there will be a lot of variations actually. Actually the first spar came in 1960, 63 and some.

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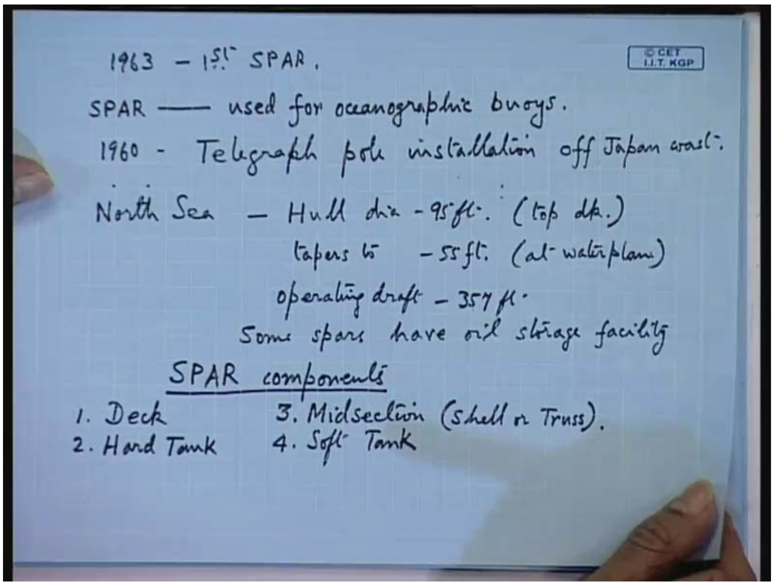

So, that was invented by the Japanese and 1963, it was may first spar. Learned most of these spars platforms of used for oceanography applications that is they measured the velocity of a current etcetera, most of these because deep drop you know. So, here you just how is your current diagonal meter, current meter etcetera it was just calculate current. So, that was the first use of this spar. So, after this actually the oil exponential in 1960 actually it was a telegraph installation. 1960s so, this was a telegraph installation.

Telegraph in the sea telegraph pole sort of. So, remember the Japanese were doing this is 1960s. So, this was an off Japan coast then, after this in the U S to come now, the 100 meter is I am give you the north sea. North Sea hull dia is ninety 95 feet. This is on the top deck just to give on idea in the size now, this tapers to 55 feet at water plane, but the diagrams that I show you varies the more or less lesson the operating draft. Operating draftees around 357 feet. So, this is the just the geometry while some spar have storage facility. Oil storage so; that means, part of these hard tank this type of spar you can have oil storage around here do not store oil near the waters plane.

So, that will raise you G so, that is one of the major advantage. Now, here you find the spar components. Spar components will find the first these you and to design the deck, next is hard tank, next is the mid shift section or sometimes this is called the midsection. This easy a shell or truss and last one is your soft tank. So, these are the four structural components that make of this spar that found. Now, the taken the hard tank, the deck design so, deck design you will find you have to make number of layers, decks number of layers you have to make.

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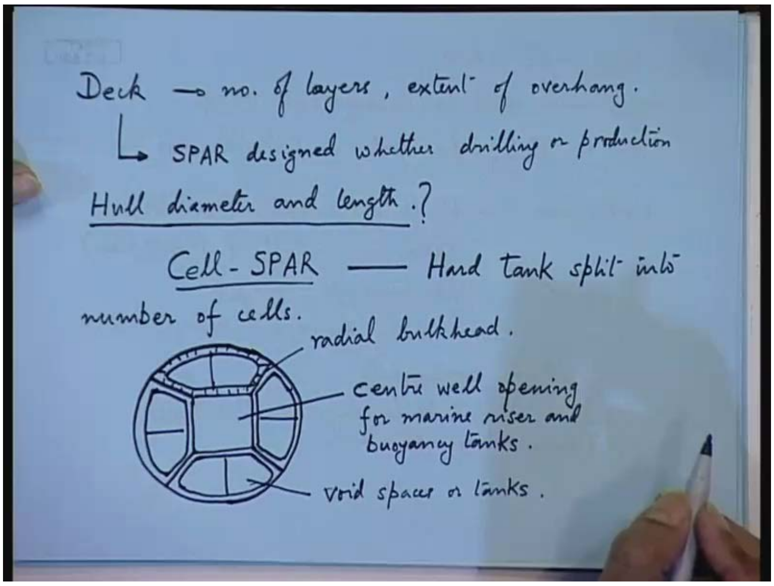

Because, you cannot spread out the deck to a large expand because, of the restriction in size of the diameter of the in a hull. Hull diameter reason restriction so, number of layers you have to think about and also extent of overhang. So, this you had to figure out from you processing facility. So, this actually will depend on two factors, spar design for drilling out production. Now, actually in this lecture, I cannot go into either I am experience in that when you deck design. Most of the platforms or based on deck design not deck design, actually the two fundamental aspects of deck design will depend on whether you are going for this drilling or production.

Drilling or production process you rises will actually be different. Your drilling riser will different first production rises and also the functions of the similar different, but in some platforms the can do both drilling and production. So, this actually comes from field experience which is of course, which are not able to give you. So, the base possible knowledge that you can acquired is in the field or in the where it is being made go to a shift here you will see how it will spar are aggregated installed etcetera that itself is the lot of learning. So, this will remembers spar the deck design now, you to start from deck design learning.

The deck design you start from how much oil you’re going to recover in the specified the balance of production per day or you will feet gas that is produced from the day so, produced in the day. So, that in actually this is your production process on the deck. So, there you start laying out and then you go on layering the deck. So, that is not a very easy job. So, that is comes from lot of experience and skill. So, based on that now, you decide the diameter of the next thing is you have to decide on the hull diameter. Now, hull diameter and the length these are you have to find out.

So, basically your spar platform actually the size has increased with the requirement of your oil production the size has increased, but of course, the geometry is more or less single. Now, you will find that instead of having this one tank this diagram you can have number of cylinders in joining together. So, that is called another type of spar that is called a cell spar. So, this has been I will just show you the diagram.

So, this is a, I think this has been built by x on while x on are moving in one of this two oil components. So, lot of thought has been given in to the hydrodynamics in the motion aspects. Now, coming to the A, so, this discussion will be. So, this is the hard tank split up into number of cells this is another type of spar. Actually basically you will find three types; it is classic, cross, cellular constructions. So, here the hard tank; that means the hard tank designs. So, you have to fix this.

So, however going to fix this now, the hull if you here, if you take a cross section across the hard tank you will find that your cross section looks like this. Now, inside you have a rectangular opening for passage of your ricer. Now the construction of this is little bit different from your ships, I am just giving you sketch. So, this is called centre well or centre well opening for what, for marine riser and buoyancy tanks. Now, here these are you give support to the centre well this is a radial bulkhead. Now, here do you make the leap fairing so, your fairing look like this. Centered you have a support and you have your vertical frames long ships you will come across the large frame, but here you have framing like this. So, like this you do for all the cells. So, this is how you lay out your hard tank, hard tank also.

So, hard and diameter is fully dependent on the centre well opening. Next what, so, this is your hard tank layer now hard tanks. So, this is actually your void spaces or tanks. Now, you have to find out the volume of this tanks because, you had to calculate the buoyancy. So, what you will do? So, this now you can see this diagram. So, these are actually your flats or floors that is your so, water type compartments. So, this is one water tight. So, like this you can divide into number of layers say this is one, two, three, four has shown, but for the larger you can go up to seven so; that means, you have seven layers of buoyancy tank. Now, each tank will be this type of configuration. So, here actually you have to find out the buoyancy requirements and then you calculate this width and on top of that you do the so, this is the hard tank layout.

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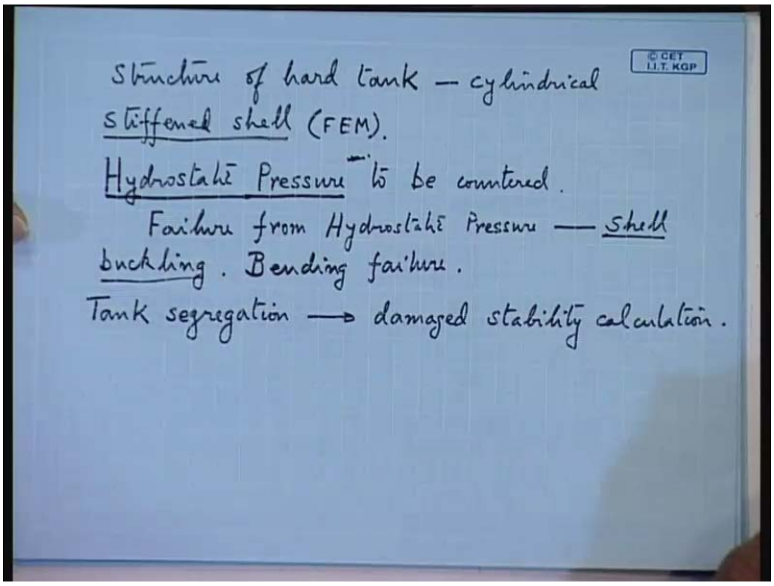

So, the hard tank is cylindrical in shape; that means, at least structural add an event structure of hard tank. Now, you may these are not you are the normal ship ballast tank ship ballast tank is. So, it is integral with the hard, but here actually you can see that it is cylindrical stiffen structure. Structure wise you will, you have to do is cylindrical stiffened shell; I think this is regard your structure actually departs from that of a ship. So, F E M analysis will be shell, shell type of analysis stiffened shell F E M, if you input this as stiffened shell be ship also normally you will find the card part is your curvature is there. So, that is also shell.

So, F E M calculations if you do you have to wear some one bit on the shell type of F E M. Now, here the another point that is to be remembered is when you are designing this structure of hard tank you have to counter hydrostatic pressure. Similar to you T L P because, you are having void spaces now, in a this type of offshore structure you have void spaces suppose; that means, sometimes it will happens concrete gravity columns offshore you void space will tent to buckle your shell because, of this hydrostatic pressure.

So, hydrostatic pressure has to be countered. Now, that is best I do not know your studied the mechanics of this is a curbed panel curbed arch or a panel has most strain that a flat panel buckling listen it. So, all this hoops trace and all this thing will come. So, that is why in the R O V E or in the summary new will find the shell this curbed that is because, of resistance to this hydrostatic pressure. So, hydrostatic pressured is para mold in the design of this tanks because inside your having; that means, inside we are not having ballast, means ballast water was the into some extent the hydrostatic pressure could have been balanced, but there is no balance in the pressure so; that means, this shell has to do the balancing work. So, shell has to be extra stiffened in the hydrostatic pressure. So, hydrostatic pressure to be countered.

So, your structural analysis what is your failure moods that your. So, on the structural analysis based on your failure modes. So, failure modes may be mostly because, of career from hydrostatic pressure. So, you have to do this of shell buckling analysis now, what are the mechanics in shell buckling. So, normally I will try to give you some idea in your offshore technology class. So, the shell buckling is prevalent the other part is bending failure because of the length. So, bending and buckling is the prime failure modes of this type of structure because of the length of the structure.

So, here now in segregate in to number of tanks the other voids of the segregation of this tank is dependent on what, why you have leds. So many water type bal cades now, water type flats. So, tank segregation. The structure is we have designing the shell in buckling this bending, but tank segregation this has to be based on damaged stability calculations. So, in never architect has to be both all over the structures on damage stability for this type of platforms. Now, the other type is the midsession.

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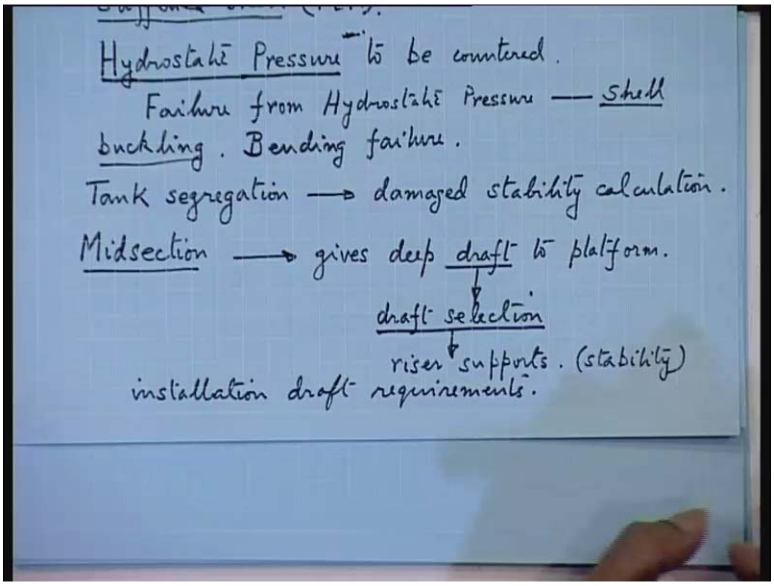

Now, this is all the details of your hard tank. Now, I coming to the mid portion, this is your midsection. Now, what is a function of this midsection? The midsection actually gives deep draft, you increase the draft. So, a lot of thought has to be given into the motions and the mechanics of the platform. So, this may trick actually these dependent on drafts selection.

Now, draft selection is based on what how select the draft, ships is easy to select and draft were you go through the pass through the channel, how you select the draft? Spot draft. So, your draft selection will be depending on basically this depends on riser supports. How much riser you are going to support and also it depends on also knew stability characteristics, installation draft requirements. So, the lot of ever log picture calculations would be down there, calculating your G alone here. Now, here you find that the installation is the reason why you have given the soft tank. There are actually, if you take the free body diagram. Your free body diagram will be this is F B D look like this.

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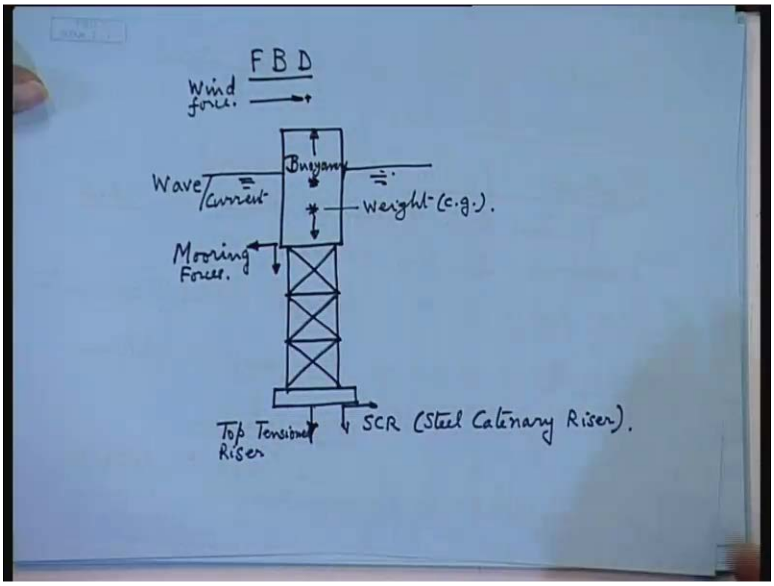

So, spar is nothing but another type of via. So, this is a trust part, I am going to draw free body diagrams. So, the all they have two drew somewhat different. Now, your wind force is going to act somewhere here. Now, wave sent currents will be acting in this region on the hard tank. Current actually also here it will be written these waves current, but current will act much more downwards in this, then mooring forces will come here correct. Now, here is a main difference from ships.

Now, the buoyancy will be acting at this region. Now, wait will be below the buoyancy weights c g. So, from this you will get a upward force, here is acting downwards. Now, at the bottom you will find riser force, normally these are two rises. One is called the top tension riser and your S C R is coming somewhere here, S C R is steel catenary risers so, you try to find out the mechanics. Now, this type you have soft tank hard tank coming out here.

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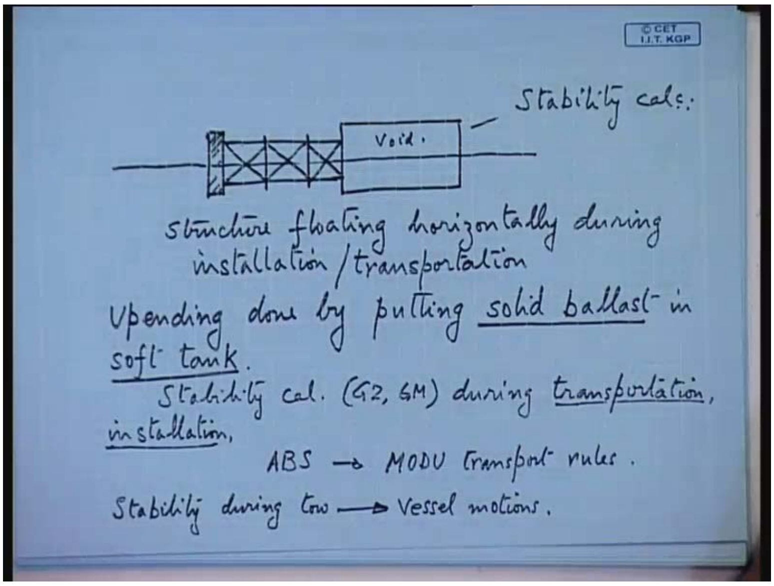

The reason I am telling you is this because, in the installation mode you will find these structure will be lying like this. So, this is in the installation mode. Now, we have to calculate you are the G Z, G M etcetera, in this mode; this is your hard tank. So, what you do if you structure installation mode or structure floating or horizontally. You know this is also the more for transportation, you transport in the structure horizontally on a barge like this and then you try to float it of rolled over the boiled from the, onto the see it will loads like this. Now, you have to append the structures now upending is actually done by putting solid ballast.

Now, this is why the solid ballast in soft tank and this time is to remain void. So, that is main reason of the having the weight concentrated in the soft tank. Now, dewing another length of hard tank that I have told you. So, this hull diameter told you to calculate from this and length of hard tank you write. Hard tank length it is dependent on this thing enclosure to buoyancy cans. So, buoyancy cans are actually totally enclosed through the hard tank.

So, hard tank length is, this is what parameter, the parameter is the amount of writing on you can get from the hard tank your G Z. So, that is here you to do your stability calculations. So, never argued, if you go to offshore companies you will be asked to do stability calculations. Stability calculations especially your calculation of G Z, G M during transportation installation so, all the main reason why, never are you take the job.

Now most of these platforms they are transported or the deck of offshore supplying then. You do not transported it like this because, this will create a hull off truss can transport for small distances, but not in rough seas. So in order to be safe you transport it on top of a offshore supply ratio and their area have two follows strictly you are A B S requirements know, wherever you go to shipyards contracting from you look of A B S mobile of shear during the M O D U transport rules. So, all these manuals you will find in the offshore companies, they have all these A P I codes. So, when you go to the companies you will have to recap all these rules.

Now, this is, but you have to do the stability calculations during installation and transportation. Major part of calculations is for never, the other part that will come during from the, how you transport from a semisubmersible or at A P transport. So, toe edge stability during toe is a very important consideration, but here you have to find out vessel motions. So, these are some of the challenging areas you will come across in off shore transport. This is a offshore you will find the structure is literally very large were spar actually you will find the depth of this spar region is actually 400 feet. So, that is more than 100 meters the 100, 200 are huge, our problem is transportation of very large structure.