Elements of Ocean Engineering
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Lecture - 45
Semi -Submersibles & TLP's

We will continue with the discussion on Semi Submersibles.

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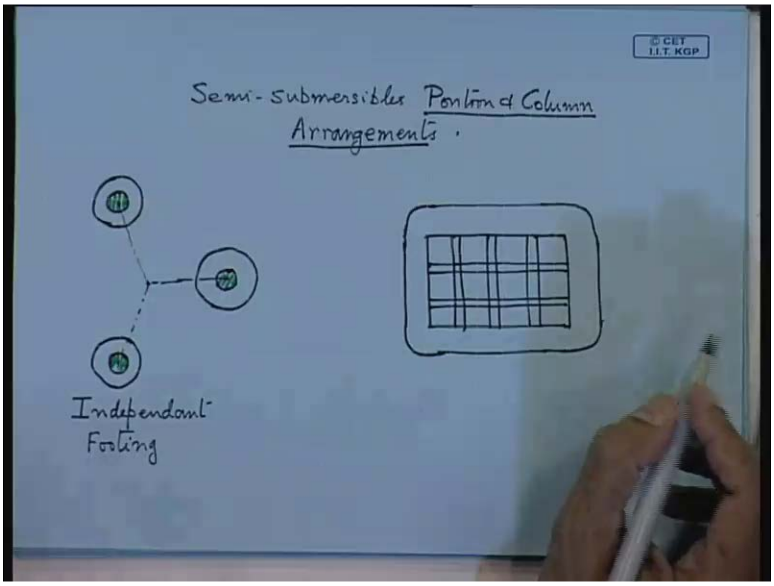

Now, the important thing that we will discuss is pontoon and column arrangements, so how we arrange the pontoons and column in your semi submersible. So, this is a wider issue, now the overriding principle that governs is reduction in the weight force and motions. Now, if you want to do that, there are number of positive and negative points which you come across.

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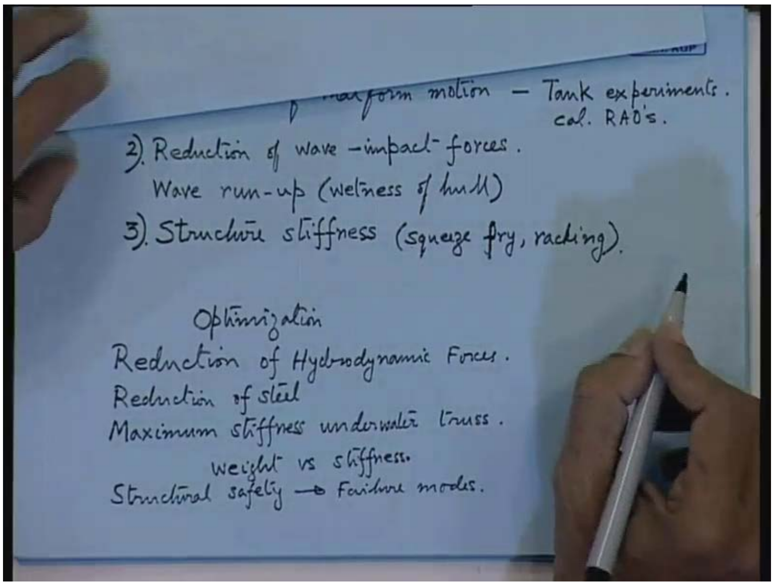

So, first is reduction of platform motions, so that is the your ocean engineering, actually motion calculation is very important. Although we do not do this, now this has to be confirm from tank experiments, which of course you do not do. Now, in tank experiments you calculate what, basically you calculate RAO's in heave piece and in roll motions, so these are you have to find out from tank experiments. So, in other tanks, you are keeping basin, you can do that, so this is one of the guiding principles.

Last class, I told you about this reduction of wave impact forces, actually in our case the hydrodynamic is more important, because the platforms are stationery one place. Ships is not that much important, because it can move from the resistance is another major issue. But, in our case actually, the hydrodynamic forces and motions are very important in these types of structures. The other one is the reduction of wave impact forces and also that is another term, which I have told you wave rum up, this increases your wetness of hull.

So, you have to keep the whole platform, especially the decks in dry mode at all times of the year, so that is one of the fundamental aspects of design. Now, third category is the, third item is structure stiffness, I will tell you the forces which are come up basically your squeeze fry and racking forces. So, the whole structure is designed based on this squeeze fry racking, as opposed to the hull of the bending of your ships, here actually the structure is not particularly wrong with respect to...

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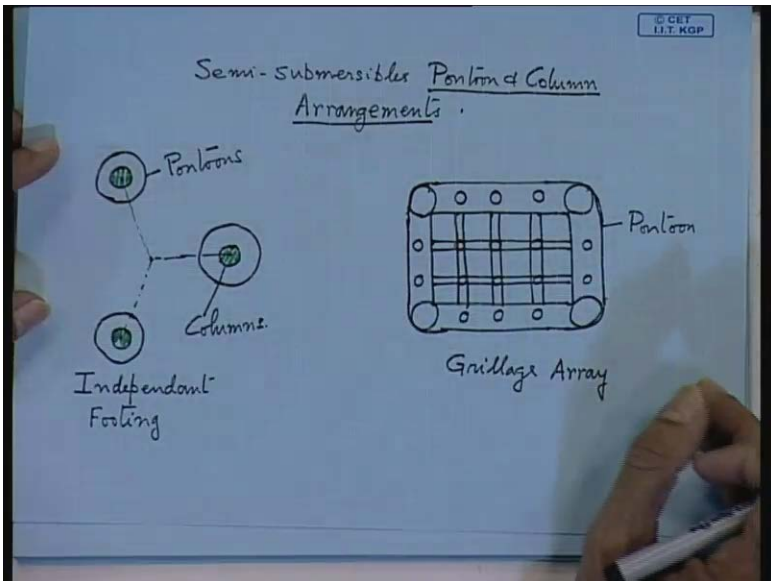

Now, based on this, number of design variations are come up, so in the first you can see the independent leg type. Now, these are actually connected by trusses, which are not shown out here, you can join all these columns, so this is called the independent leg footing, it is a semi submersible arrangement. Now, the next one that I have drawn out here is called grillage, this is called a grillage array. So, here you have the corner columns, now this columns as you see, they essentially giving support to the deck, is not it.

And the other term is, they increase the stability of the semi submersible as such, because the main contribution in the operating mode comes from water plane area of the columns. So, this you have to configure, now this corner columns are giving the corners supports. Now, in between if you want to just span is quite long then, you decide on number of smaller columns. Now, they are located inside the pontoons, so this is your pontoons, so in between you have number of this smaller columns.

So, the main reason for this smaller columns is reduce span of deck, so deck span is reduced by placing this columns. So, here you will have similar, so this type of arrangement is called a grillage array, so this is another type. Now, there are number of other types also you will have instead of, so your pontoon has been in a closed form. In this case it is closed form, where this is these are independent footing, these are the your pontoons and this is your column, so this in the pontoons is very large.

So, this sort of arrangement you can see, is not very favorable for transport of a moment form one place to another, so it is only good for fixed location, neither this nor this. So, the other type of arrangement, which is also there, where you have number of pontoons, but instead of having grillage, you can have this as a linear array.

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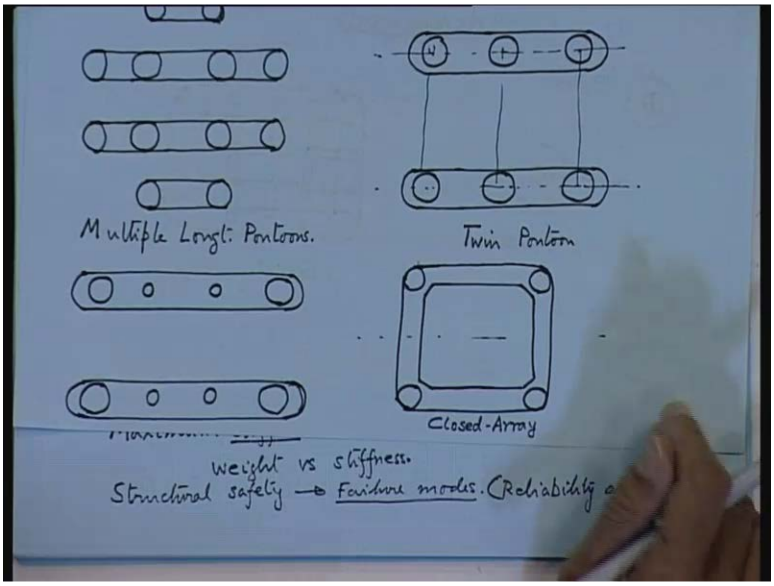

Now, this structure is somewhat amiable to transportation that is, for quick deployment, so this is a linear longitudinal quantum, where you have pontoons like this. Somewhat you have similar to the catamaran hull, but only thing is, in the drilling mode, pontoons are must. Now, you can have so many columns, now columns actually basically I told you, they give decks support. Now, one of the major functions of a column, the other is to give the stability characteristic of the platform.

So, you have so many columns, so this is called multiple longitudinal pontoons, now the problem is, if you have so many columns, it will increase your wave impact forces. Now, here actually the structure engineer, you have to do lot of hydrodynamic calculations and stiffness calculation, that is major work of the hydrodynamic and the structure aspects, they go both hand to hand. Now, the major problem that you come across is, if you keep on increasing the column size and the number of columns, your wave, the effects and forces from waves are going to increase.

And if you have more number of columns then, we have to have column connection between the columns by means of braces. So now, we present scenario design is, try to get rid of the basis, as I given your earlier sketches. Now, the problem is, if you reduce the braces too much, it will reduce your stiffness, the strength, is not it. So, how far you can go down that, so it was always the designs for this type of platforms are always center around and optimization study.

Optimization means reduction of hydrodynamics forces, here actually in offshore if you go, you have to be very efficient in calculating the hydrodynamic forces. So, reduction of hydrodynamic forces, that is one actually and other one is reduction of steel, steel is a major component in the offshore. So, how far steel you can reduce, that will decrease your cost, at same time if you keep on doing this then, maximum stiffness you have to find out, especially of the underwater truss.

So, all kinds of compromise you have to come across, so that is why we have the design spiral and there is a lot of optimization studies we have to do between the, especially weight and stiffness, weight verses stiffness. So, it is not that simple you know, so this is one of the major aspects and the other aspect is the safety of the platform itself or this is called structural safety. If you want to go deeper into the structures safety, you have to study what are the various failure modes, very crucial.

So, one of the failure modes that number of failure modes is I have told you is this, this is not fry, squeeze pry. Pry means you just keep make it, so this is called squeeze pry, so this is another failure mode, so these has to be studied. Stiffness, so when you go for strength failure modes, reliability, anyway this is a separate study by itself, need not go into details on that. And the most common configuration you will find is the twin pontoon hull, is actually very much amenable to your transportation, because you have only...

Now, in the transportation mode actually the floatation is on the pontoons, pontoons come upon of the surface, but in drain mood it is under the water, so this modes of operation you should remember. Now, the pontoons has to the semi submersible has to perform well in the two categories of or two modes of operation, so here we have number of columns. So, this is the most common type, because the client will not to write to waste his time transporting the semi submersible from one client to another. So, the basic design is center around whether the transit time, whether there is frequent transportation on the semi submersible from one place to another or this stationery in one place.

Now, in this stationery involve place you can go for this type of variety, you do not waste so much of time in transportation like ships, more amount of time ships this spending the truck will not be earning, is it not. So, it is always has to be on the transportation mode, so similarly here you have to straighter, which you have configuration best suited to you, that actually your client will tell you. That he wants frequent transportation, especially the drilling the semi submersibles, where you drill at one place to and then quickly go to another place.

So, then you have to this sort of configuration is not be favorable, this type of configuration will be favorable, now instead of having, so this is actually twin pontoon type. Now, if you have the deck very large you can have more number of columns, this a extension of this variety you will have out here, now in some cases you will find the pontoon is going beyond the columns. So, that is called pontoon over hung or the deck pontoons are away from the columns, now what is the engineering impact on that.

So, you can see here, part of pontoon is going beyond the columns, now instead having one column you have two, but smaller once, now the main reason is, in this case the pontoon is longer. So, you have to have deck support, in order to reduce the decks span, you can have two smaller columns, so this is another twin pontoon type, the other is called the close direct pontoon. Now, in this case actually the bracing members have been more this dynamics, but it is a ring type of pontoon.

Now, this type of structure is not very amenable for transportation, but it is good for location at one place, but drilling at one place, so these are the some of the pontoons arrangement you come across. Now, here actually pontoons are not prevent the columns, so this is called a closed array, so if you take training in any offshore company it will find out sort of timings; but, the another point that I was talking about pontoon and deck overhang.

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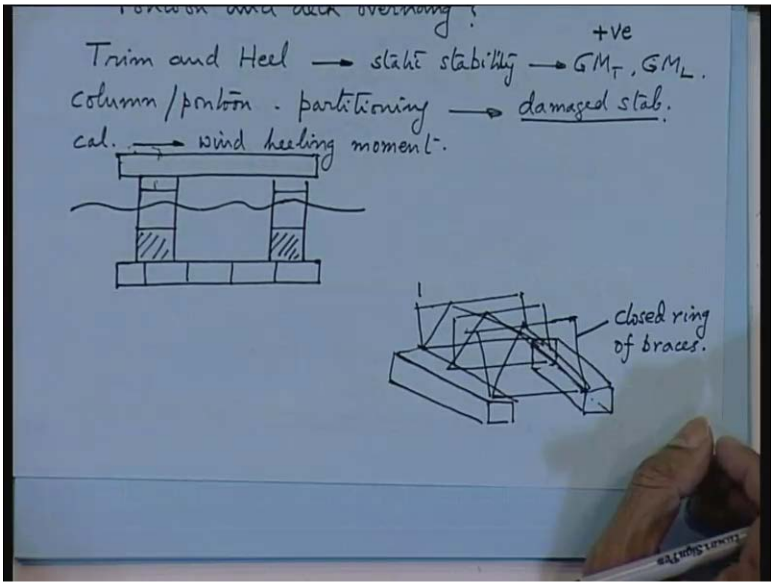

This is why, now the pontoons you some time you will find, they go beyond the extremities or the main termination point of the columns, this is called overhang after the your deck on top will also go beyond the columns. So, that is because, if you want in larger deck area and pontoon are extended, because at the here you will find ballast tank. So, ballast tank of trims tangs are located, so they will give you good amount of decks, ballast tank are located on the extreme end of the pontoon.

So, the twin condition as far as the hydrodynamics are concerned, they will have to do lot of trim and heel calculations, heel is the static stability case. Now, the compartment essential of the columns and pontoons you have to find out from column pontoon partitioning, just like in ships. So, this comes from damage stability calculation as to be done, that it is your flatting calculation and you find out column pontoons percentage, and damage stability calculation you have to find out, basic thing that you have to find out this wind heeling movement.

So, these are floating platforms or some time they called floaters, so this is your newer architectural part, only thing is this structure is, but since they are not ship light, so the columns actually you have to find out where they water integers most probably. So, this is your column, and now column partition if you want do I told you column how is your moving chains, so moving chairs are actually kept in the column, so this is your column configuration. Now, this is the most area which is sub stable to ingrates of water, this reason, so this region obviously, you have to partition.

But, here you can from the deck, your chain table has to be store, so you can compartmentalize like this, this is one of the arrangement inside this you having ballast tank. So, you calculate some of this column is flattered, then what will be your heel and twin, so basically you have find out parallel sinkage heel and twin, and various configurations of the column and pontoons partitioning. So, you have to partition your pontoons and columns, this is for the sake of calculating damage stability.

And static stability what you find out, basically you have to find out this GMT, GML, now as far as rules are concerned have been come across the minimum GMT or GML, but these two has to be positive in all modes of rotation. That is your operating mode, transportation mode, what mode installation mode I think three or four modes of loading conditions, so you calculate all this. So, this is in semi submersible, now the other point is the braces, we are talking about the braces here, there is one configuration is called, these are the columns you can have an array of braces, this is one aspect.

Now, braces if you want to design that means, you have to find out the location or the braces where there will be minimum stress concentration, and you can make a this is called triangular braces you can do like this; there are triangular comes out here, like this you keep on make a number of braces. So, these are called and at the top were you are getting deck support you will have this configuration, now your columns will give the vertical stiffness in this, so you have make a closed form like this, closed ring.

So, this is a brace arrangement, if you have brace arrangement you go modules in this form, so this is one and the other term squeeze pry I think I have already told you and here the diagram on the loading; now the hydrodynamics in this case it is important.

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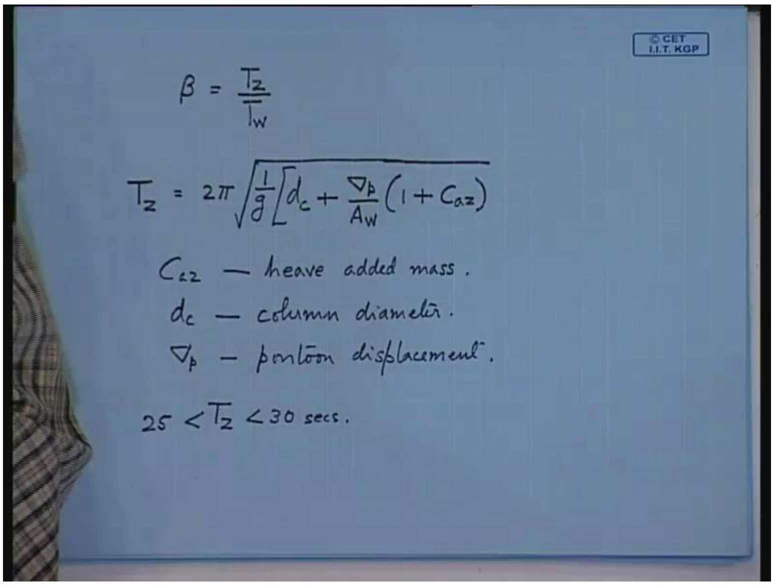

Now, coming to the heave frequency or heave time period is given, in terms of first you find out this beta, beat is T z over T wave, so this is your heave period, time period of semi submersible heave over a period. Now, T z is given by this expression, so this is 2 pi into root over 1 by g, this is diameter column diameter is given by d c plus pontoon displacement over water plane area into 1 plus there is a co-efficient, this is called heave array mass co-efficient.

So, this is you calculate heave period form here, now C a z is heave added mass or d c is column diameter and delta p is pontoon displacement, now this heave time period lies between, so T z actually rise between 30 and 25 seconds. So, this is remember, you are asked in interview sector T z is 25 and 30 second in the heave period, now the other important type of parameter is the squeeze pry on the racking force; now, this has to calculate from the way hydrodynamics.

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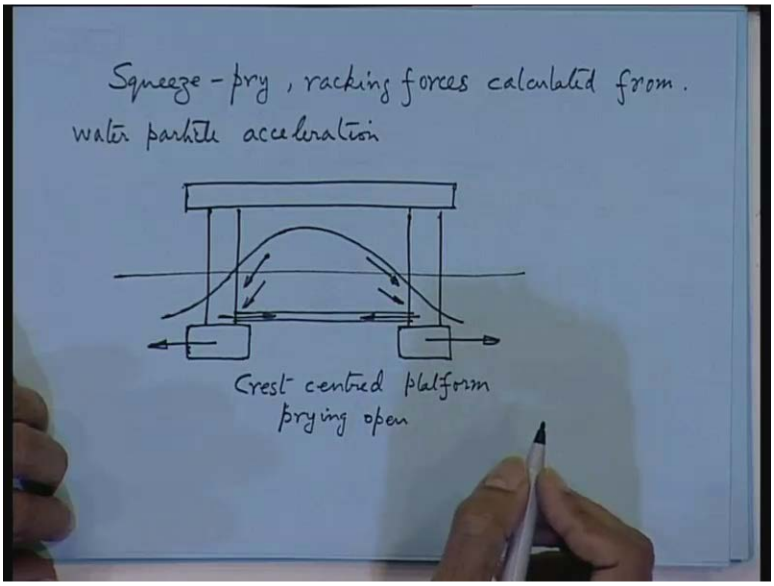

Now, this you have to find out, say this is your wave profile let us tack the liner wave itself, now here you will find a crest and your saying semi submersible is now writing a crest. So, this is your semi writing a cress, now this kind of situation what is going to happen, now here most of the acceleration vector you will find, so this is they are coming like this, water partial acceleration. So, what is happening this is your pontoon, now the hull of the pontoon is more or less rectangular in cross section, so pontoon is also acted upon this force.

Now, force is from the columns may come in this direction, so this is called crest center platform is a occurring, so this is a here you have prime open the platform, prime forces they are trying to spread out the platform. Most accepting the column force, most of all forces coming like this, now here crest center platform prime open, the opposite thing also may come that is the platform may on the trap.

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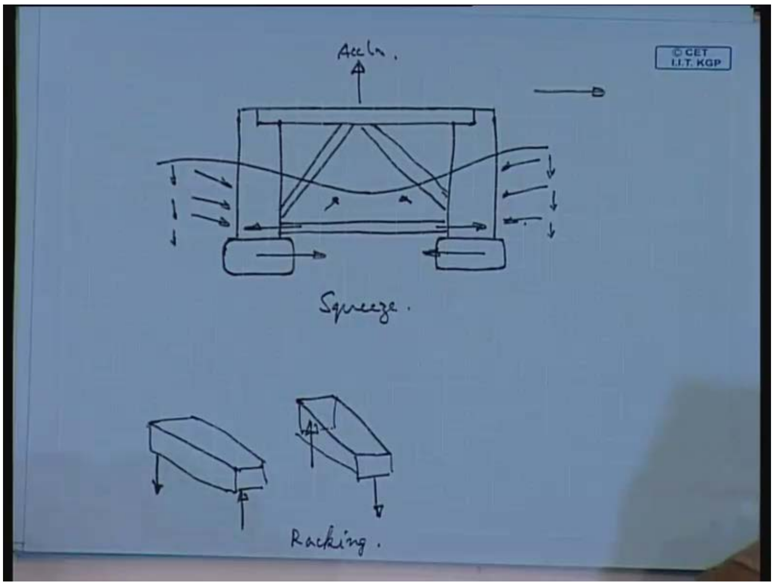

So, in this case in platform a design, the fluid acceleration and velocity you have to calculate every point of a platform, so how will you do that, so this is normally done by CFD studies. In CFD you first describe the platform in number of panels, and each nodal point you find out these vectors, acceleration and velocity vectors, for this is the acceleration vectors, so that will tell you the force that are coming on these nodal points. So, this is changing is it not, so if you have a good CFD program, say this is our case I thing we have only hydrodynamics what is offshore we do not have.

So, if you have a good sets of programs, you will find the various and in the dynamic forces ((Refer Time: 32:21)), so here actually the other part is coming, so the deck acceleration. Now, if you want to studies this, this is a pontoon it is coming from, the other is coming from acceleration, vector coming from the deck, deck acceleration is coming downwards, so the whole platform is going down.

Now, here the opposite can be happening, so that means, your acceleration with us, now this actually you have number of wave mechanics program, so you have to study the platform actually structures engineering, that is much more require in number of wave mechanics programs will give you calculate only forces. So, this actually you have to seat with a hydrodynamics person, so heave the proper man they should be go an hydrodynamics. So, most of the offshore companies they have specific in house programs, they will find out this, so platform motions and forces, so this is another case which is happening.

So, let us see say tide or another brace, now in this case there deck is having an upward acceleration, instead of a deck going ((Refer Time: 34:26)), deck is having an upward acceleration, and the columns are trying to go out. Now, the wave profile will come like this, now your water political acceleration will go down. So, these are the acceleration vectors, which are coming from the water, smaller vectors will come out here the pontoons reverse of that, so pontoons the reverse of that, from pontoons are again like this.

So, this is what is happening, this is squeezing the platform, squeeze, because of this water political vectors, acceleration vectors, so direction of wave proportion is in this direction ((Refer Time: 35:46)). Now, racking you have like this, so the pontoons, so this is one pontoons, now at one in the downward force, this and the upwards force and again here there will be downwards force, and on this you have an upwards force. So, this is racking, racking out twisting the whole semi submersibles to states, so that is called the racking force.

So, these are the some of the a mechanics you have to study, before you calculate the forces which are coming on the columns and braces.

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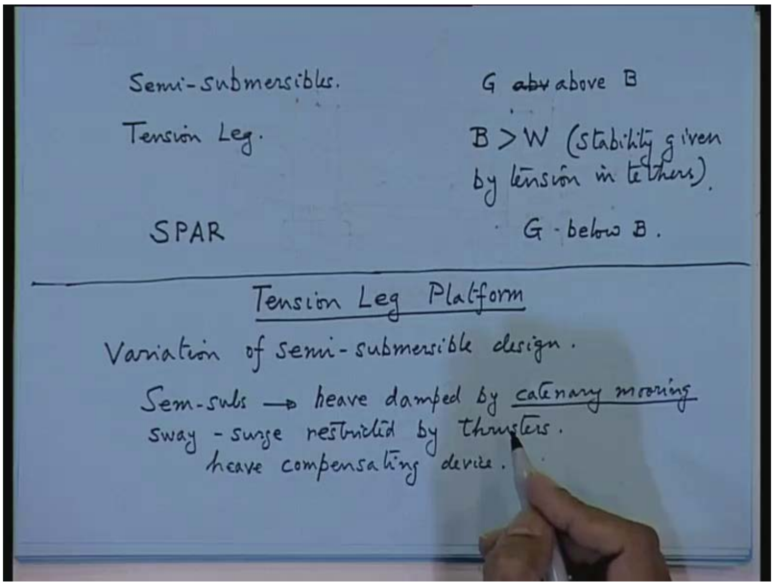

Now, coming to the tension with platforms, now this three cases you say semi submersibles G is floating, what is the position of G above B tensional leg always, this is the... Now, tension leg you find out buoyancy is always greater than displacement, stability given by tension in the tethers, SPAR. Now, SPAR you will find center of gravity is G below B, so these are some of the points always remember design. Now, this semi submersible we have discuss in detail. now coming tension leg plat form.

So, these are actually the, what is called the variation of this semi submersibles design, semi submersibles you will find lot of heave motions, so heave restriction is normally done by semi submersibles. You will find this is the motions are damped by large moving systems, especially heave damned by catenary mooring, so mooring were system play an important role in restriction in your heave emotion. Now, what else and semi submersibles have this sea motions, are sway is restricted by sway and surge, restricted by thrusters.

Thrusters you will have semi submersibles are not only by having thrusters, very large catenary mooring systems and a heave compensating device. Now, actually you will find in motions semi submersibles, who have more or less the opposite motions for TLP, where ever you can see instead of here semi submersible going down, there is deck is going down ((Refer Time: 42:09)) you find a TLP it is going up.

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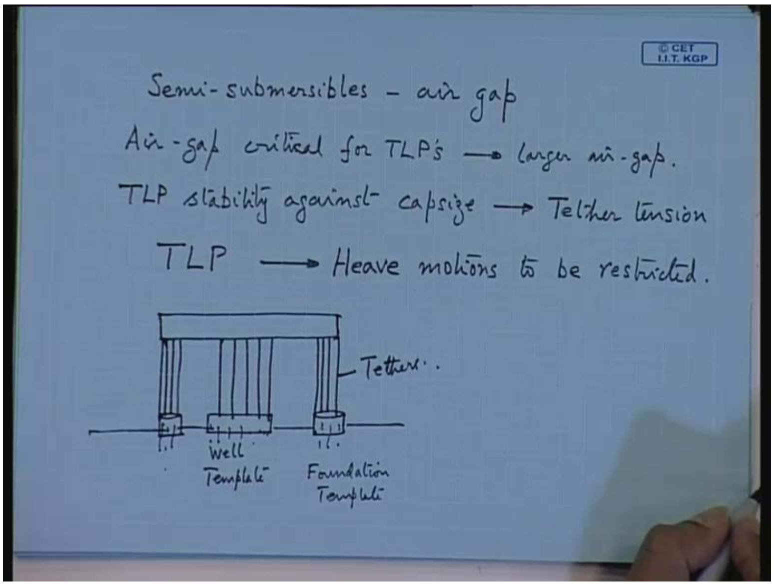

Now, in semi submersibles you will find the air gap issue, air gap semi submersibles, now this is very crucial in yours TLP design air gap, so how you calculate this air gap based on the clearance from the wave. So, if you have the large air gap clearance, you can clear all your waves, but it will increase your CG, so that is for your GM, but in TLP actually since TLP here down on to the bottom. If you have a very small air gap or a gap is very critical for TLP's, so it is always preferable to large ((Refer Time: 43:21)) gap in case of TLP's.

Why because, it is stable, you gave the semis submersible actually rises and goes with the wave, by the TLP is it is held down with the sea bed, now suppose your large wave comes height, then again it is going to crush on the deck. So, air gap critical for TLP's it is always better to have larger air gap, so air gap calculation for TLP is more crucial than semi submersibles. And stability actually platform stability in case of TLP, TLP actually these stability against cap size, this is actually given by tension from tethers or rather you write tethers tensions.

So, this is the most important variation from semi submersible design, tether tension tether actually is vital to TLP stability, semisubmersible stability to some extend you can have on the moving are quite large. So, TLP you go for TLP, where hell restriction is paramount, lot of heave motions are there you cannot control heave, so heave motions to be restricted, there you go for TLP. Now, TLP has other phenomena expecting first thing what you have to do is make a foundation template at the base, so this is called while templates and then, you have foundation template where you are going to tie the tethers.

So, that is not the a easy job, so this foundation sometimes there piled to the sea bed, under water pile you have to do or semi submersibles would not require that, so these are your tethers. So, this is called a well template, now from here actually your marine risers are going, taken to the top of the platform, this is called a well template, and this is only I think this called foundation template. This is the main point of departure from semisubmersibles tethers, so this as ((Refer Time: 46:59)) remember, that stability is coming from the tethers.

And buoyancy is actually not configurations is greater than the weight, so in preliminary analysis of TLP is are the preliminary design.

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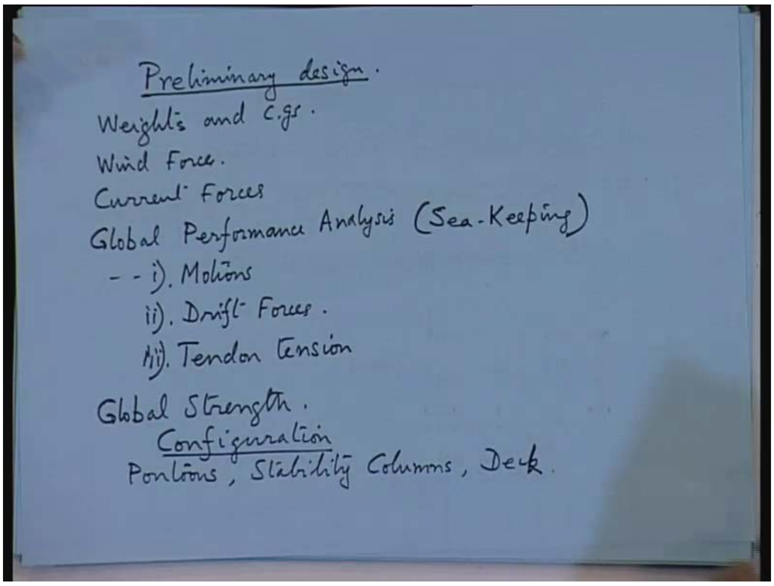

You calculate this, now this we have done for semi submersible also this is weights and c g's that you calculate wind forces current, this you have to find from ocean graphic studies, global performance analysis as we got motions. Then you can have drift force tender tension, now after this you find out global strength, so this is mainly sea keeping, mainly accepting the last one that is tender tension tendons; last category is global strength. So, this all these done from preliminary design, so after this you go for various iteration, then you figure out the configuration.

Now, configuration of pontoons stability columns, now what remains is your deck, now sometimes you will find that the sketches are out here, this is called extended leg TLP.

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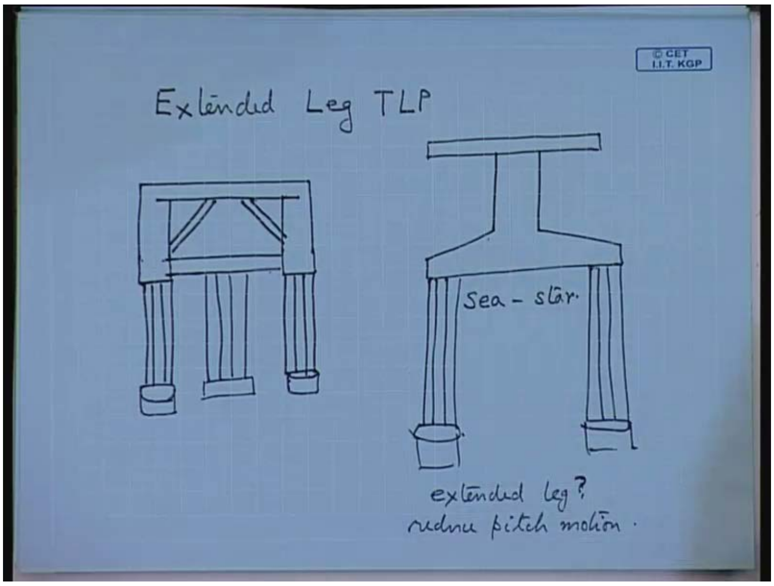

Now, in normal TLP's you will find there sort of the ring shape of box shape, you will find a deck supported on columns and since, the TLP are require to be stationary at one place, you can have ring area of pontoons. So, that means, you can have a the columns can put below the pontoons, so pontoons can comes again essentially here, so you are not bothered about the resistance to the transport of the platform, so because it is fixed in one place. So, this is one variety, now in which you will find the tethers are connected at the corner of the platforms, and the corner columns, this is the most general design.

Now, here actually lot of variation in design have taken place, so here this is your foundation, what is called foundation or tether foundation you can call, and this is your wield template, this is your normal design. But, variation of this you can have, see one single column being supported on pontoons like, this is called a sea star design. Now, here actually you will find the tethers coming at the extolment of the pontoons, you have one single column.

Now, sea star design either you can have one column or you can have one or two or three also, but we are hiding somewhere, but basically you will have extended leg as usual. But, this is why, now this is mainly done to reduce pitch motion, because that means, in this case of platform you are doing reducing both the design and pitch. So, the design is actually center around I have told you, in case of this platforms is reduction motion, primarily reduction motion is the major design criteria, because your platform is going to rest one place.

So, here actually the structure calculation is somewhat difference from your ((Refer Time: 54:13)) bending, and if you want to go deeper in the analysis, then you have to be first thing is you have to know the failure moods platform; this is our squeeze prize, ((Refer Time: 54:26)) will come, because of that... So, fearer mode very, very crucial, based on the fearer mode you do your structure dimension a structure you cannot do it, now without calculation of platform hydrodynamics, hydrodynamics structure will go hand in hand.