Elements of Ocean Engineering
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Lecture - 21
Offshore Structures – III

We are still discussing Offshore Structure, now the second point is that is you see here, where is the this is the jacket platform, as you can see. Now, here one thing is to be noted that the piles are given to the fields, these are your piles sleeves, they are called piles sleeves and this are the piles which are been driven. The point that is to be noted that you can see the riser that is your conductor pipes, there are so many number, but they are coming from the centre of these structure.

Now, here actually the water depth is also quite large, say 170 or 150 meter, now you have to cramp these pipes on to the frame, in otherwise they will vibrate, so that is one of the here actually this is not been shown, but in jacket structure you have to do that. So, this is one point that is to remember, and similarly we have here also in the gravity platform ((Refer Time: 02:01)), here also you can see the conductor pipes. See these are your cells that is your case in this is the base, that is the slab and the conductor pipes are coming that is un protected and some conductor pipes are been pass through this columns.

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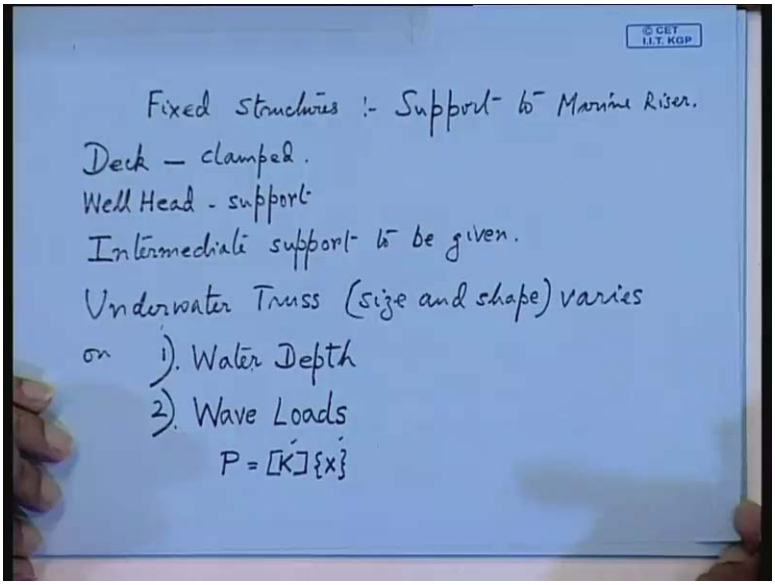

So, here actually the main problem is, all these fix structures is support to conductor pipes, so later on in our will discuss what is the this, so this is support to marine riser. Now, actually at the deck, there is deck is clamped decks support is there and also deck, so this is clamped at deck, and the other one is what is called at the well head. So, these are actually your getting the two supports, well head sub support now beside that, in order to prevent vibration, and because typically it is long structure, length is quite large you have, large deflection in the structure, so intermediate supports to be given.

Now, lots of research has been done into this riser mechanics, in order to prevent failure, so riser failure is to be avoided intermediate support to be given, so this is one point that to be noted in your fixed platform. Now, coming to the other varieties, that we were discussing, so last class I told you how this taken out to be placed on the platform. Now, next is another group of structures, so here you can see this is the same other jacket, but you can vary the dimensions of the truss, you can see the truss dimension is different.

I mean ((Refer Time: 04:22)) here the framing is different, here the framing is different, now the truss, the nature of the underwater truss, where is according to the see the underwater truss, you write underwater truss varies primary with what, that is the size and shape, varies on two prime factors various on number; one basic factor is water depth. Now, since these are fix platforms, water depth is a crucial factor, which determine the size of this underwater truss, your depth is high obviously, the structure will be taller.

Here the tall structure you have large bending movement, the top will be access, because there is the large moment, so obviously, you have to lengthen the base. So, that means, if you have a for large water depth obviously, the size is going to increase, so that is one of the reason why for depths beyond 300 meters, it is not advisable to go for fixed assets, because of this reason. Now, number 2 is wave loads, now there is very excessive wave loads, that is sea is very rough saying the out stand sea and all that, you will find large amount of deck decks is taking place.

Now, decks is very large, first of all the cooling is very uncomfortable and also you will have motions in the riser, now riser motions are the deck level too much motions is not advisable, because of there are so many pumps and are stop working. So, here actually the main problem is this P is equal to k x, now if you allow say greater amount of

displacement, say x is more than the structure stiffness can be less. You allows way, you allow displacement, but suppose you want to make the structure absolutely stiff, that is no area going to allow any displacement, there have to make k is very large, for the same amount of load. So, which one do you go for, you have to decide either this or this, so that is one of the crucial engineering designs. So, this decision that has given rise to another class of structures that is complains structures.

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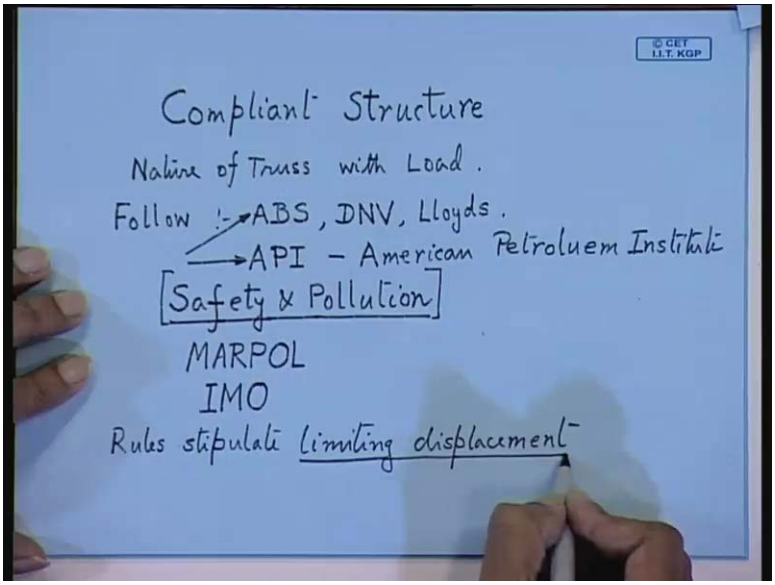

Because of this, so there have lot of engineering consolation here to make if you go for offshore structures, is just now to one of design. That means, you have to do your design spiral taking into large amount of shape of the will first fix structure, whether you go for this kind of truss or other truss of variations. So, obviously, you will have to do, constantly you have to change the stiffness that is nature of the truss, basically you are changing what stiffness, nature of truss you change stiffness with load.

Now, you will find that whenever you are doing any structural design for offshore structures that means, you have to follow certain codes follow... Now, these are the codes that are follows American growing shipping, so these I think you must have come and across varying design that is being subject that ABS, DNV. So, these are the codes which are normally followed in offshore structural design, ABS, DNV, Lloyds also to some extent, so these are the codes to be follows.

And if you go design for Golf of Mexico or for the American course we have to sponsored other course, that is called API code. This refers to American petroleum institute, now actually in the US wherever, now these structures are basically their lifting oil from the sea bed, is it not. So, they have stringent pollution norms, this is institute, so pollution norms, so wherever safety and pollution the most two important aspects is to be taken into account, safety and pollution here very, very important.

So, whenever see if you are doing work for an offshore company, even if your structure and all these things you have design, from the point of view give very large consideration to be marine riser. And how your method of lifting oil from the sea bed such that, to see born recent disaster there in the Gulf of Mexico, the semi submersible got fire you see, the whole Gulf of Mexico is dirty with oil. So, that means, once your got infringe any of this safety and pollution norms, then you had it your life will made help, so all these things whenever you are going to any say ship building company or also your going work for many of these rigs, these are to be studied in great detail.

So, these if you want to study then ABS and API will give you some guidelines, but they decide that you have to concerned other rules, the other rules there are to be follows to MARPOL, Marine Pollution Revolution. Then you have the IMO guidelines international maritime organization, so all these guidelines have to be followed to prevent pollution. So, whenever you design tankers of offshore platforms, you please follow these rules ABS, API, MARPOL, IMO, so these rules are very strict in the pollution environment.

Now, beside that is why as engineers you have to give thorough consideration to these ((Refer Time: 12:29)) type of structure, and one of the cause of structure is large displacements. Sometime you will find the rules also stipulate limiting displacement, now actually in a structure engineering problem, you will find that finding out simply the member sizes in your ANSYS are whatever your finite ((Refer Time: 13:14)) methods, that you employed after giving the input files from the environmental loads. Now, the program the ANSYS acts are whatever we have, they will give you the dimensional of the structure they find, but this stage is you have to again consult rules for what is your limiting displacement. Any structure which especially our structure comes under the category of what is call tall structure.

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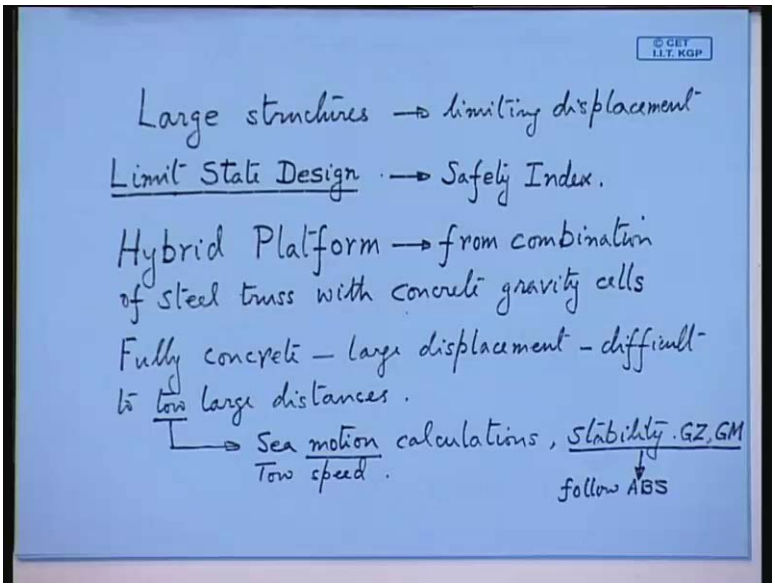

Even buildings you will find for large structures, say large structure have limiting displacement, so this is one category and structure engineering problem for offshore if you go, then you will find you have do what is called a limit state design. So, this actually at the end of class you have the time, then we look into this, this is called limit state design. So, whatever structure mechanics your learning that is the financial method, the design does not stop there, but you have to find out from limit state design, what is your safety index, this will later on in the class you come across this.

Now, this is particularly acceptable to offshore structures, so they are built I told you around the two prime consolation of safety and marine position. So, fundamentally, so this is the problem that we coming across is that, exact if you limit the displacement obviously, you have to increase the stiffness of the structure that is the size will increase. But, you cannot keep on increasing the size at your own views, because that will also increase the cost of the structure, so one example I just giving you just were increasing for large water depths that means, this truss size actually increases.

So, this problem we are coming across, now there are various forms of structure now to get around this problem actually engineers design large, varieties of structures. One verity we have, before I started to discuss about complaint stricture, there is another type of structure this is called hybrid platform. So, hybrid platform actually it is a mixture of your the steel truss, this is from combination of you combine both, combination of steel

truss with concrete gravity cells. Now, why this people they have not gone for a fully concrete, what is called steel type of structure and example of hybrid platform you can see here, so this is your hybrid platform.

So, ((Refer Time: 17:16)) this is an example of hybrid you can see here, now here you can see that your truss is quite large, so this is your steel truss, this is a hexagonal several steel truss first, they made a triangle base you can see write down. So, these are your concrete cells, so these are piled, piled to the base sometime you can piled or by news of it is weight gravity, it is settles on the sea bottom. Now, these cells, that is your concrete cells are connected, first you connect them by a triangular frame, you can see at the bottom there is two tears, for me it is very difficult to draw.

And on top that you make a hexagonal sort of flow type of bottom of the truss and then you keep on there is a trunk it your truss, that is the dimensional keep on decreasing and here you can see that it is supporting a hexagonal tower. So, this is the truss and tower concept is, so here actually the three dimensional truss that is the still truss is more complex in nature, draw than your jacket platform. And we can see that this has been given wide base, these are sort of stair on to prevent this structure from torque; and this type of structure called top size, these are more or less same, whether it be a jacket or TLP or hybrid whatever.

So, in large amount variation you find in the underwater ocean, so this type of structure has been created primary for the hot bottoms, but if you go for the totally concrete type, so that will give lot of load to the bottom. I think this is the reason why they are not go on for a totally concrete type of platform, the other reason behind is at the concrete, fully concrete platforms are having large weight, your fully concrete one that is your sea tank, ((Refer Time: 19:39)) all these design is fully concrete has very large displacement.

Now, if you have this kind of structure difficult to consideration, difficult to two large distances, so you can build your structure in Singapore and to it golf of Mexico. Now, tow consideration is another very important considerations in the design of structure, so this actually comes under your, that is you have to do your two considerations, so these are mainly sea motion calculations. Now, you have to find out which type of structure is having less motions during tow, and also tow speed now that means, the platform has to be tow, within a certain time after it has been launch you cannot delay.

Because, otherwise you need a sceneries, so you should spend too much time at sea, that structure is being tow for Singapore to Gulf of Mexico or some other place in grow. Time is also important consolation and sea motions, that is heave pitch roll stability calculations, where sea motions are calculated, stability consideration is a very important that is your GZ, GM all these things. So, this is where you services never architect required, so always now stability consideration sea motions of course, the rules may not be that much stringent.

But, here again you follow ABS to be on the safe side, DNB coal also has resulted in a few unpleasant disasters, so ABS is a more under safe side, why there is a I am telling you is a most of offshore companies are American companies. Like the Exxon, Exxon you have Mobil, I think only the British petroleum is British, Exxon, Mobil then you have these are American company, so you have more ambiguity to all these American rules.

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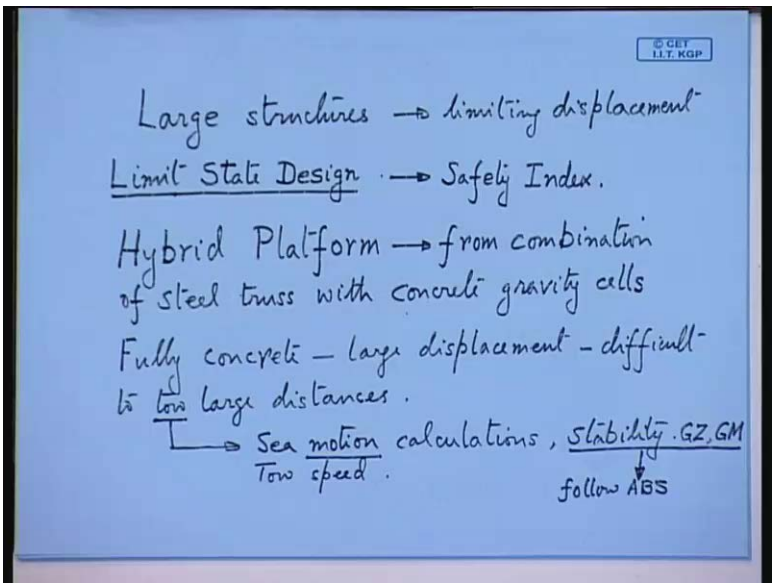

So, there is building structure of Exxon, then you have Mobil, Mobil is another international global oil company, then you have ARAMCO, so these are big oil forms American oil company. So, they are the understand the ABS and API and American rules, more than any rules of this, they will tell you that, these structure is to designed according to this course, so you cannot go with beyond this course. So, this is one of the

constraint in your design, so anyway, so coming to the hybrid category, this an example of a plat forming GOM that is Gulf of Mexico.

So, Gulf of Mexico last class I given you what are the stomps condition, argent conditions Gulf of Mexico is very severe. So, here that means, you have to built most of consider the base of particular very wide in order to take care of the topping moment. So, and other things which has not been to shown here, either you can piled this, but again order one piled sin very difficult. Suppose, you drive piled from here, how do you drive piled, so that is not physical, because your having a steel tower on top. So, those things are remember, so it is better to go for this gravity type of platform.

So, after this we come to the complaint category, that is COMPLIANT structures, so here I told you the major problem that you have coming is the displacement and how much COMPLIANT'S comes from the word, COMPLIANT'S to ways external forces. So, that is this structure actually yields, yields to environmental loads, you write the structure yields.

So, basic equation that is coming out here is this one ((Refer Time: 25:34)), that is your P is equal to k x, now suppose you reduce k very large, that is you will have excess displacement, but again displacement is a limiting factor in design, you cannot afford to have large structure displacement especially on the deck, where you having the accommodation and other equipments. Now, this type of structure you can see out of there are three categories, so this is the first one is called a guyed tower, very you can write this called a guyed tower.

You can see ((Refer Time: 26:14)) this is a steel truss, now here you have a universal joint, so this is very critical joint design, so you built a truss type of structure like this. Now, so here you have to pin this down to the base, so this is your join now this you can now this has to be fix to the sea bed is it not, so best thing is drive piles, but again the piled driving is also difficult.

So, any under water activity is very expensive is it not, so that means, your offshore contractor or is the vendor that is he has to very, very careful, otherwise lot of defecation will be there, in their failures. Structure failure giving rise to oil pollution that means, you just have your life out, so this is your depth, you see that is why the most of these

companies are American companies, that is they are wild experience in the international environment.

Hardly you find any this thing, company from the developing company, say Singapore or China or say India doing oil exploration, because of this reason, now this is your guyed tower. Now, this is another example of a compliant structure, so here actually you can see that structure details, now this you will have a horizontal now what is not shown here in that... So, this is your wave wide and this is your sea bed, now you fix this universal joint to the sea bed, so this you can is better to drive pile, and this one you have here is a universal joint.

So, just imagine how biggest that universal joint, now this universal joint will allow the structure to say in all the directions, so it can moving this direction, this direction, any direction it can move. So, behavior of this structure is similar to inverted pendulum, so that means, your structure is out here you can say like this, so this behaving look like a pendulum like this, will behaving as a inverted pendulum. So, the motions of the structure has a inverted pendulum, now you find that if this is the case the two things here, that you have to designed is that these structure has to giving the upright is it not.

The structure should not fall like this of good below the wave, so whenever large wave is coming what is normally done in this structure it has not been shown, you give a buoyancy tank it is preferable, instead of open truss at this reason. So, most of this complains structure have what is called a buoyancy tank ((Refer Time: 30:28)), a buoyancy tank at minister or that say water. So, a buoyancy tank will give the upward force, so you have wave force coming out here, so that is going to till to the structure is it not.

So, your buoyancy that is going to give you the righting moment, so you have one righting moment upward and this is downward, is acting like this is the overturning moment, your overturning moment is your the horizontal edge multiple here, so that is your overturning moment. So, they amount of buoyancy you give and the reaction from here, this the upwards the weight are coming down, so that is your writing moment, so you have to balance overturning moment in the writing moment.

Now, this is not all your buoyancy tank may not be sufficient to give that much a buoyancy, otherwise you have to whole structure you have to make buoyancy tank,

which is normally they do not do it. Because, we have to cut down on the wave because the cost consolations, now what is normally done you fix this type of structure by means of what is call guy ropes, you anchor this to the sea bed by gravity anchors. So, these are called, that is why the name has come guyed tower from this guy ropes, guy ropes are not ropes made of the quire, but the large steel ropes large steel anchor steel.

Rather you write not anchors, steel wires and here you can have gravity anchor, now in offshore normally we use this gravity anchors, gravity anchors very large, the reason they have gravity, they are made of concrete. And concrete each anchor can way much have say 1000 tones, so frequently you will find in offshore use this type of gravity anchor, I do not have the diagram of a gravity anchor, but this is you can take it for tank these are the some of the, so this you write piled base. So, this the guyed tower, now here one type of tower the other one you can see this is a articulated flare, this the articulated flare is actually smaller than your guyed tower, now here actually the tower is studies lender and here also you have universal joint.

So, this complaints structure, because this literally the severe about the base as a inverted pendulum, so you should always have a universal joint, and you can see the export pipe line is being flare. So, this is actually this tower articulated, they are called articulated flare that is they are only servicing you are taking the oil or gas from some other platform and igniting it. So, this is the flare structure, so this is not used for takings a topside waves, top side heavy waves are not there, so this the flare kind of structure.

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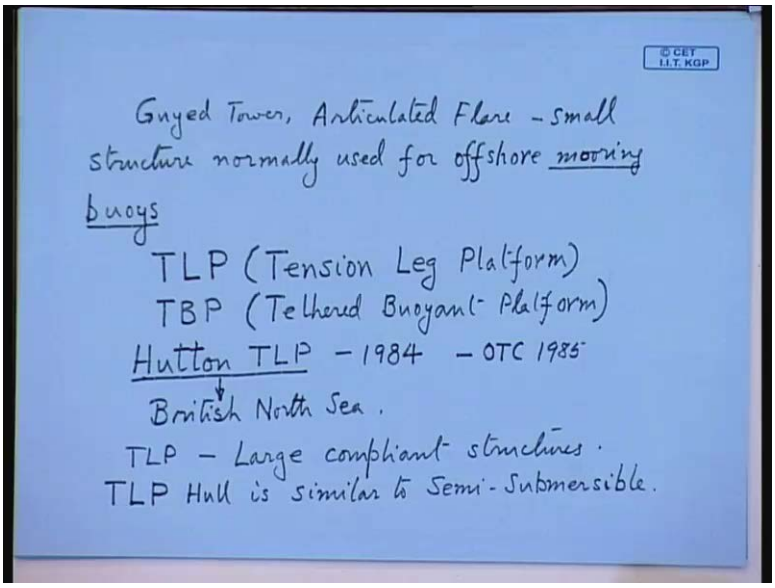

And most of this structure you remember, that is the particular guyed tower, and your articulated flare are small structures, so this structures are actually suitable for, normally used for offshore mooring. And this is what we discuss offshore mooring buoys, later on I will give you various configuration of this mooring buoys, when we studying mooring you will find there offshore mooring buoys, most of this smaller type of structure that gives. Now, the larger category coming to the COMPLIANT type last we discuss your TLP. The TLP is a large structure TLP or sometime, so this is called a Tension Leg Platform, in some literature they are also called tethered buoyant platform or TBP.

Now, the most famous of this platforms is your Hutton TLP note see, you will not find TLP in the Indian Ocean or Gulf of Mexico, Hutton TLP that was constructed in a way back 1984, that was the first TLP design after that do not know. So, this want to have a look some offshore transfer conference OTC, OTC around this 1984, offshore transfer conference was 1985, so this is the discussed of the modality of construction and also the operation of a Hutton TLP.

So, this is in British North sea, British Ocean of North sea. So, this is the TLP they are actually COMPLIANT structures, you can write they are large COMPLIANT structures, this is the basic different between... Now, TLP hull a, sincere architect you may have to design a TLP, a TLP hull is similar to semi submersible, so those of you what you see Singapore you come across the building of this semi submersible TLP's. So, they are

made in, now our country does not make how you offshore platforms, normally you will having Chorea and Singapore they have been building, now one of the forms they have building in your, this form that is the they have a Mumbai office.

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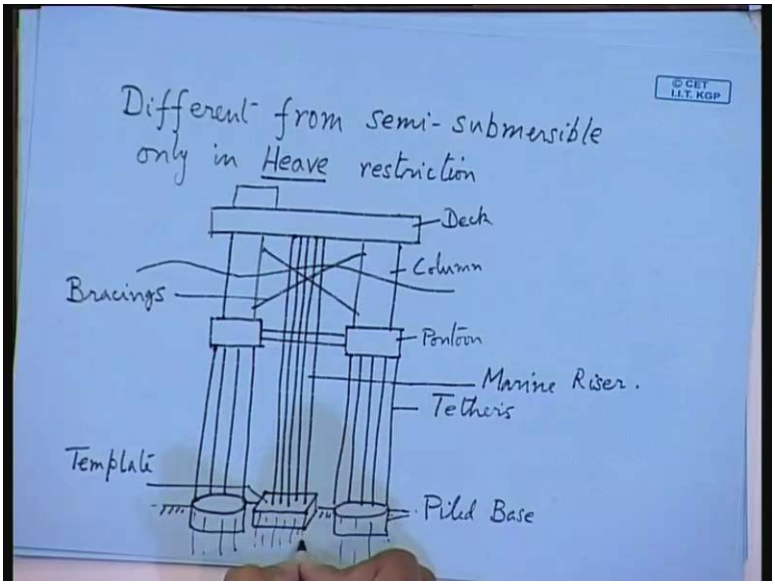

So, this TLP hull is similar to semi submersible, now the basic different of semi submersible heave restriction, different from semi submersible only in heave restrictions. So, heave is actually absent in TLP, literally there is no heave TLP, because TLP if you look at the diagram you will find that is type to the sea bed by tethers, so this is your TLP. Now, those of you are interested you can refer to your, you see the journals in our library, ocean engineering in journals now a offshore conference, whether you having or not I do not know that will also give you here, so this is TLP.

Of course, the deck modules will come here which have not drawn, now here so this is a basically a semi submersible hull, now the structure is sighed down to the sea bed by tethers, so these are called tethers. Now, here you have your the conductor pipes that are being led to your the deck of the platform, these are your conductor pipes, now here you will find is another structure that is quite large, so this is a piled base. Now, TLP the sating on sea bed is very tricky, these are called piled base, the other one is called a template, this template is very important.

So, now TLP hull, so this is your pontoon bracings, it is made up of pontoon columns, deck, these are called your bracings, these are your tethers and this is your marine riser.

Now, this hull that is without the deck modules they are brought to site, so you built to the particular location, but before that you should have make the base ready, base has to be made ready before you bring this structure an top of the location. Then this tethers, tethers are wire loops or leads from the columns of pontoon down and their tight to the piled base, this is one major operation under water operation. Now, next what is to be noted, now the template is also piled to the sea bed, now what is the template.

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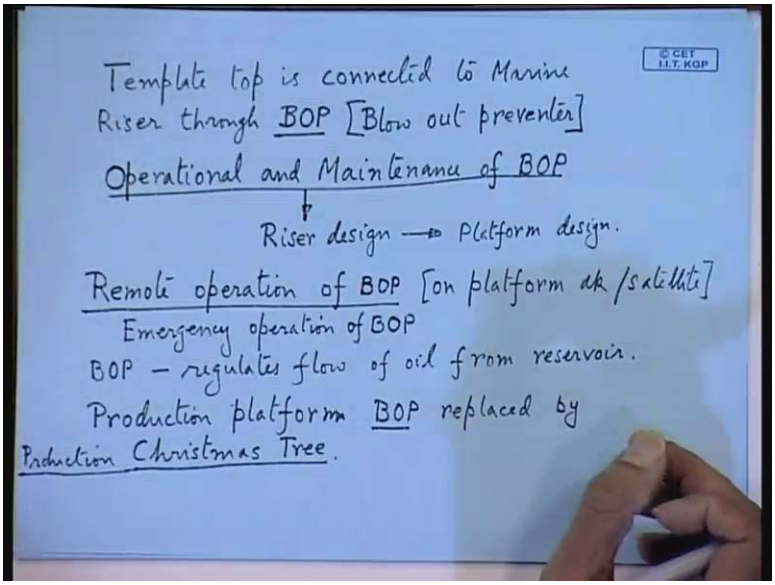

Template is structure; that is the template top is connected to marine riser, through what is call, through BOP, BOP is called this is a very important equipment in offshore, this is called a blow out preventer. So, in Gulf of Mexico what happen that oil pollution is, because of BOP failure, so this blow of preventer will be located somewhere here, so blow of preventer is nothing but a set of hulls which is regulating the pressure of a oil that is coming from the oil reservoir.

So, here you have the BOP stack, now newer architect should remember that for floating platforms BOP is located on the sea bed on the template, the semi submersible will also have BOP location on sea bed. Where a for jacket platforms BOP, you can locate BOP on the deck of this structure, jacket platforms you have BOP location will be somewhere on down the, but BOP is essentially is a connection point for your marine riser. So, BOP is very important not only from the point of the location of your marine riser, but there are operational and maintenance requirements of BOP.

Now, this dictates what is called this is influence of riser design, so this is quite complicated stuff, and effects platforms design, BOP location some example, I have given you for BOP ((Refer Time: 48:17)), BOP location is at the base of this structure. Now, there are number of design options that have develop, because of remote operation of BOP, whether you can operate BOP from the deck operate or from satellite, now they also operate from satellite operation.

So, remote operation of BOP is it possible or not, this also dictates your cost of platform, remote operation of BOP on platform deck. And now they are going for satellite communication, so that means, sometimes they can manage from say a North station say in Norway or UK the office, they can man the BOP from that satellite that is called remote operation of BOP. So, your technology is advance to that expend, their some times in case of stomps will coming, and persons have to be evacuated to close down BOP, emergency operation of BOP.

So, your emergency of BOP from, where you are going to do, emergency operation of BOP, because this actually regulates the flow of oil, BOP regulate the flow of oil from the oil reservoir. Now, BOP is more or less used in your, that is in your drill platform and production platform you find the same BOP is replaced by, this is BOP replaced by another set of hull. What is called Christmas tree, you come across these terms frequent offshore this is called a charismas tree, so that means, in your BOP while drilling that is your drill stream go through one of this piled.

But, in your production Christmas tree that is sort of things will not be here, so this is called or rather you can write production Christmas tree, there have nothing where some set of hulls only, but structure will be different from BOP. So, here these are the operations, so remote operations of BOP, so this is another point to be consider, now offshore if you go, you will find that there will be a large platform ((Refer Time: 52:32)) somewhere and you have huge number of pipes coming from a sea bed and then going to the top of the platform.

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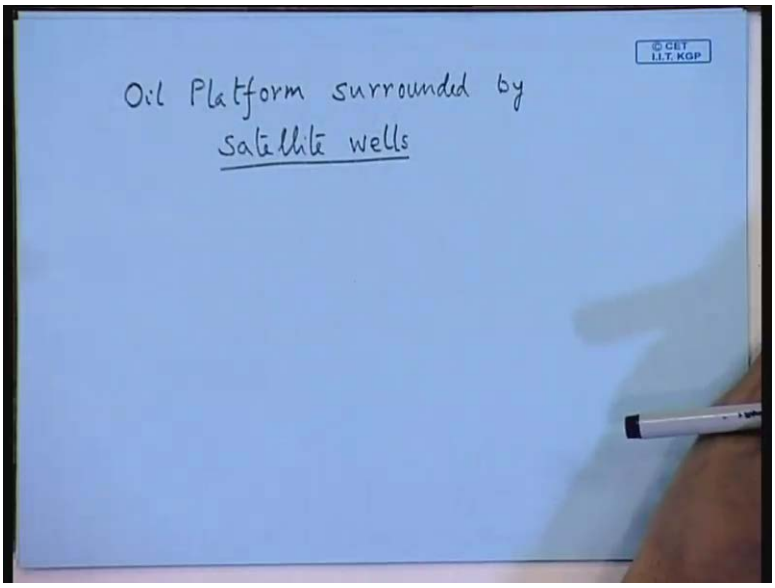

So, that means, a oil platform can be surrounded by what is called, surrounded by satellite wells, so that means, in Gulf of Mexico if you go, Gulf of Mexico you will find the sea bed to be literally cress cross by somebody in pipelines, and satellite wells. So, that is the scenario in your oil explosion of offshore oil, so here after studying your platform you should knowledge about offshore piping are somebody in pipelines. So, pipelines are important connections for platform to a drills, so that bases to end anyway, the other varieties TLP are discussed about semi submersible. Now, what is the different between TLP and then and tell you we give you the formulas for wave length current loads, that includes semi submersible.