Elements of Ocean Engineering

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Lecture - 19
Offshore Structures – I

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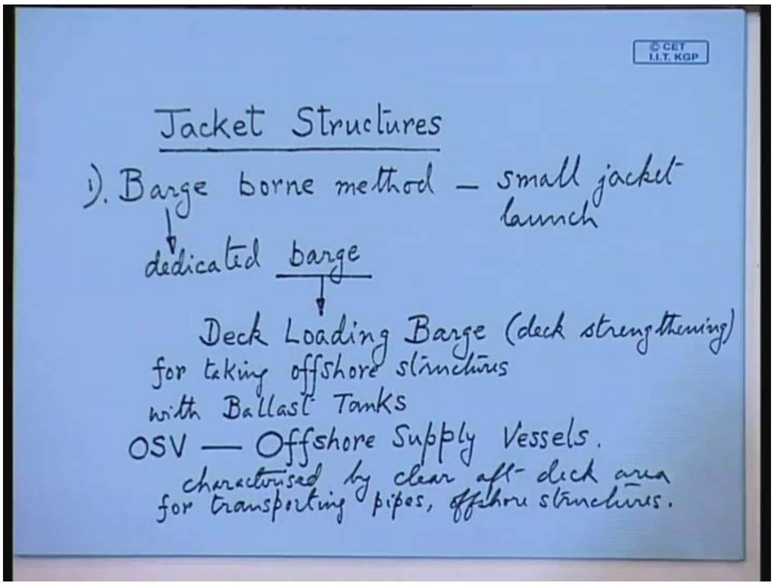

We are starting with the Jacket Structures, on your previous class I was discussing the two types of launch methods, that we are normally used, so one is the Barge borne method, the Barge borne method is normally used for launching small jackets. So, this is actually used for small jacket launch, and this is a dedicated barge, now these barge is the normally called they are not used for carrying carbo, but this is called a deck the barge you have to design is a deck loading barge. So that means, barge is to be specialist strengthen on the deck, this is called a deck loading barge, not for carrying carbo, deck loading barge deck strengthening has to be done.

Now, these you have to do deck strengthening; that means, for taking offshore structures, so deck loading barge with of course, with ballast tanks instead of holed below the deck, you have Ballast Tanks. So, this is one type of this is that is particularly use in your offshore industry have a type that, you will come across is called a OSV, this of course this is not linked with your jacket launch, OSV is another Offshore Supply Vessel.

So, these are special vessels, which cater to your offshore industry, now these actually since this is we are talking about jacket structures, so this of course, we would not talk much, but these offshore supply vessels. They are characterized by clear deck area or rather you write clear off deck area, for transporting normally this is pipes, but it can be also offshore structures, and they are characterized by having very small free board.

So, offshore supply vessels normally they are very small free board, because that will be an aid to your the crane, you can take this structure very smoothly, if you do not have a oil free board and these are the options of anyway. So, coming to this deck loading barges, so here actually you have to do this type of barges, they have special strengthening of the deck, and they have special stability requirements.

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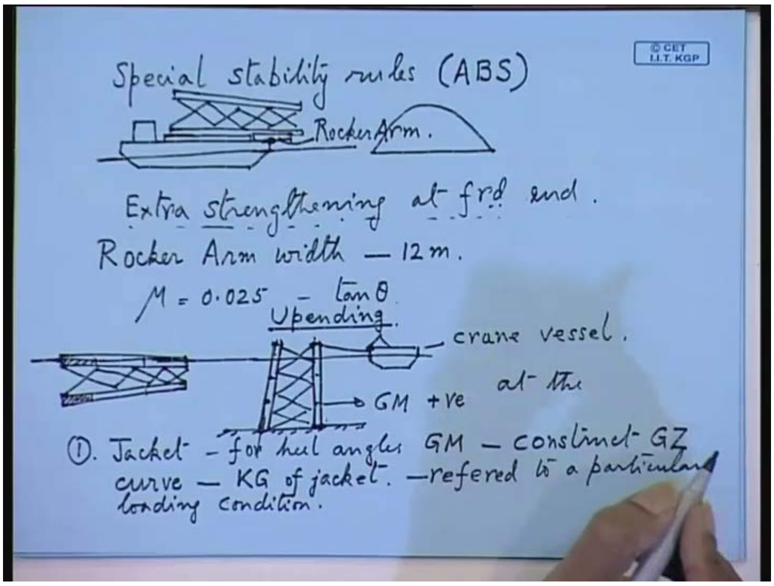

So, this I was talking last class, so this is called a deck loading barge, so you have special stability rules, now those of you who are interested in the stability rules. They can consult you are ABS on deck loading barges move of shipping, what are the dynamic stability criteria for jacket on top of barge that is the most crucial, that is load that is on the barge or they are definite stability requirements, stability requirements means your G Z columns.

So, what is the area under the G Z curve with a jacket on top of the barge, so there are two criteria, whenever you are designing this kind of barge you have to do extra strengthening on the deck, and extra strengthening at the forward end of the barge. Why extra strengthening at forward end, so these are some of the requirements for launch barges, because once you go to sides your jacket is being loaded in this manner. So, it is hanging out, and the narrower end of the jacket will go down in to the water falls, normally that is the case the exact reason I do not know, but they do it like this.

So, this side normally goes down in to the water after you trim the barge, now once you trim it the whole weight of the jacket will come on to this end, so this is called a rocker arm, so this is the specialty of the barge. Now, this rocker arm is not a small structure, so rocker arm width can be as highest 12 meters, this distance can be as large as 12 meters, it is basically a beam over which the jacket is going to slide. So, in the sliding mode the whole weight of the jacket will be distributed on the 12 meter of your rocker arm, so that is why this part of the forward end requires a extra strengthening, because of that.

So, these has to be done, so you calculate your position of friction, so mu is equal to 0.025 with this, you find out the value of tan theta, tan theta is equal to mu from this theta you are tanning, because of this you can calculate the trim angle. You trim the border until the jackets starts like, jacket is going to slide with the narrower first, so and then what will happened so; that means, now the process of launching and then you have to do upend the jacket is not it.

So, jacket has to be in this condition, and in the upright mode after it has been launched, now what you do when it is in the floating mode. So, normally these jackets are not particularly buoyant, you know the other type of jacket is a barge jackets, so they do not have sufficient bouncy in the columns.

So, it might float with very small free board in this manner, now this here to be very careful, so before you start your calculation using max of or multi user, whatever it is you please find out the total buoyancy. So, simply calculating the size of these columns and basing number is not enough why, because your jacket after it is not it has to floating this mode, so you calculate most of contribution to buoyancy. You come from the 4 columns, but also you want this basing numbers contribution hardly said 20 or 30 percent of buoyancy.

So, anyway, but it has to float like this, that means just after launching the whole jacket should go and settle down the sea bed that will be a great disaster, so anyway after this is in the floating mode. Now, there are various compartment inside the columns you know, so these have to be flatted, so especially the wider in columns and the part of the column is wider and you float; that means, the this is always connected to a whenever, you do this type of launching you do not go the jacket to be swept away by the ocean you know.

So, you always try to hold this at one end by a rope or by a, this is called a crane vessel, so we have to requisition these services of a crane vessel, you always steadier it to a crane vessel. Normally, you have witnessed launching is not it last I think, you went Tuesday to Calcutta to witnessed launching, but was the vessel tight to any structure on the this thing, shipyard I do not think it was tight is not it, but there is also quite dangerous you know; that means, you do not have any you control over the.

Now, avoid this is in floating mode you keep on floating these columns so; that means, automatically your G will go down, and your G M has to be positive, now there are two sets of calculations, you have to do. One set of calculation has to be done for the jacket itself, so jacket for various angles of heel, for heel angles you calculate G M, whether you see whether you are having positive G M or not at all stages of upending, so this is called the stage of upending.

So, launching and upending actually goes together, so this is actually your deduction face, so for all for heel angles you calculate G M till it actually settles down on the bottom, now it has to settle that the particular location on the sea bed. Now, this has to be done precisely at the particular location so; that means, not only one crane this is, but there will be other barges except here trying to pull the structure and all different sites.

And then you locate your structure and then in goes down, now after that you have to drive the piles all this is what driving the piles, your water actually, and these will be punctured; that means, these are the these are plates. They will be puncture the water will be pushed out the piles will be driven through this columns, so that is what is done normally, so here actually the never architecture calculation is jacket for heel angle G M you construct G Z curve.

Now, G Z curve is always constructed with what construct G Z curve, now these you should know what is your K G of jacket, G Z or G M that is calculated is always calculated for referred to a particular loading condition. In ships stability particular loading condition and these has to be done, so you have to now loading condition the means the two things they specify, one is a displacement, and other is the K G.

So, these you always know, whenever you are doing your stability booklet, the stability booklet has to be endorsed by the surveyor. And he is it the first thing that he will asking you is what is the ships K G, second thing he will asking you, what is your ships displacement that which you are doing the calculation. So, these things have to be noted, but this is the operation is normally done and so after the jacket has been sited on the sea bed, then you start driving the piles. Now, this is one aspect the other aspect, I have told you is while launching the whole weight of the jacket comes on the rocker arm, and you should see that the you are doing the operation in calm waters there should be note the any stone. Otherwise, this the barge is going to heel and you will be jacket might come off, so these have to be remember.

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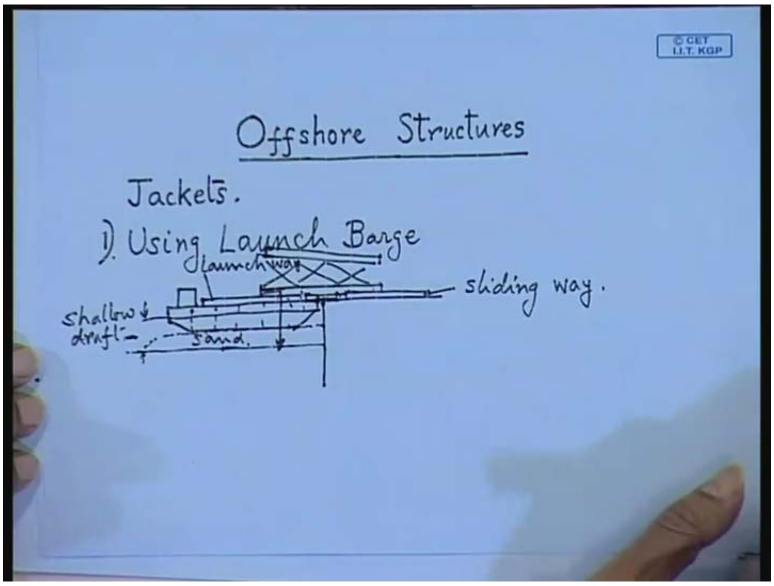

Now, the other this is called barge launching, the other method is called self floating jackets, now in this self floating mode if you go; that means, the jacket is built. Another point I want to tell you is that, when you taking the jacket on to the barge in a here to bring this on at even keel, otherwise you cannot take it, so with the key side or the dock side, so this always has to be at the same level.

So, here actually this is your this is called a sliding way, I do not know you must have witnessed all these ship yard, and this is called a launch way, now the launch way has to be brought at the same level as the sliding way. Now, here actually what you can do now as soon as you take the jacket on to the barge; that means, the portion of the weight of the jacket is coming on the barge, so immediately the Barge will start trimming.

So, the weight of the Bombay high jacket is 1350 terms, so you divide and this plane thing I think 80 or 90 meters when you divide, so per meter how much of the weight will come. So, immediately you will get a trimming moment, so when this comes; that means, the barge is going to tilled and this will lose its alignment, that is the sliding way and launch way this is immediately going to lose alignment. So, one thing you can do is I told you there are number of ballast tanks inside the barge, so there are number of pumps we immediately you tried to change your ballast position in the tanks.

So; obviously, you have to remove ballast water from the forward end is not it, because of forward end you have to give more buoyancy will be shifted to aft, and tried to bring in the throughout water. So, you tried to bring this is not it this is one way and the other easier way is now suppose the next to the dock side, you do not have that much of draft say you are normally at the dock side you will find the draft is pity low.

Now, what you do you try to fill this a dock side with sand, and take the barge on the sand, so that mean you are more sure footing, then you pulled the barge on to the jacket. So, that is another method, so these are the two methods they are normally, but; that means, here actually you should have not deep draft, but shallow draft. Obviously, the draft is very deep you cannot do this shallow draft launch, so this is one method; that means, you can do this, now the other method that was talking about is the bigger larger jackets.

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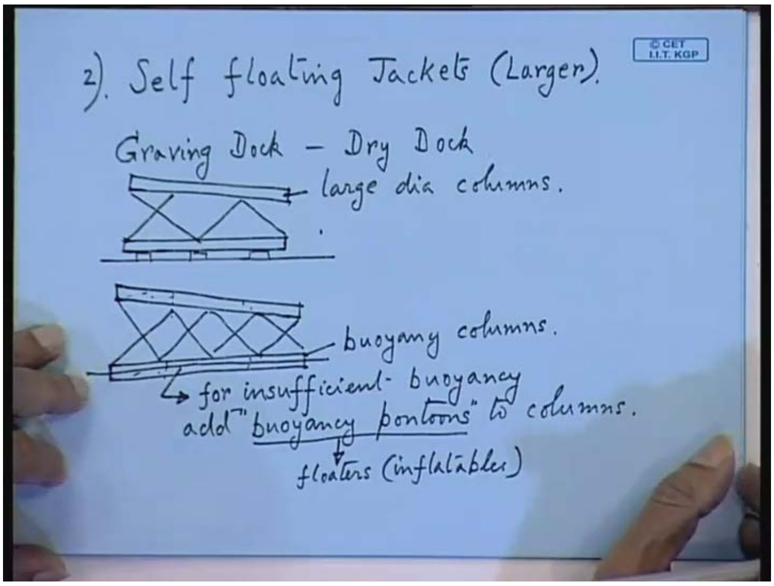

So, there are; obviously, of the self floating variety, now here actually the jackets are actually made in sections, now you need not make them on a slip way, you can easily make them on a graving dock. Now, all these are actually sibling terms a graving dock, because its look like a graveyard, so that is why it is called a graving dock or sometime this is also called a dry dock, now here what you can do is the jackets I told you they are normally constructed horizontally.

Now, you simply build your jackets on keel locks, now these are called self floating jackets, they are invariably these are larger in size, now here the launch barge category. I in this method, I have told you that the two things that we have to make the calculations is hydrostatics and stability, now in the hydrostatics you check your buoyancy. So, numeral architects have to be very thorough about this two methods hydrostatics and stability, they are now it is actually you can take be close to all this software, there is your max of multiuser.

Now, the thing that you have to do is you create a auto cat file in solid works you can do this, and then you just for various drafts you can taught your hydrostatics calculation, and then immediately get you are the volume and the moment of volume, otherwise these structures are not ship shaped you know. So, you have to individually calculated for all the columns and then had an all these things anyway, so this graving dock you build the jackets in this fashion, but these jackets are characterized by large diameter columns.

Columns are particularly larger diameter, the reason is you have got to have buoyancy, so column diameter has to be large, now these are made in such a way that after this is towed away from the dried up, it is able to float on the two bottom columns in this mode.

So, this is your draft, so you have to calculate the buoyancy and stability in this mode, so here the difference, you can see in the launch barge method most of the jacket is after being launched. It is under the water, but here actually most of the jacket is out of the water, so here the bottom columns contribute to your buoyancy, this is your buoyancy columns. Now, you may find that this it is unable to float in on this two columns the whole jacket is going down, then you have to add further buoyancy pontoons for insufficient buoyancy.

So, insufficient buoyancy you might get, now in that is the case add buoyancy pontoons, so normally if you witness this kind of launching you will find buoyancy pontoons to columns. These things you can do or sometimes they call this is a buoyancy pontoons is call floaters, so these are sometimes inflatable drafts or rather you write inflatable's, so these are tied to these columns, and they give you addition of buoyancy followed.

So, when you are upending the same process you do, you ballast the these columns by ballast water, and then it will be upending and he remove the buoyancy pontoons. So, all your hydrostatics and stability calculations, you may have to take account of this buoyancy pontoons. So, that is one way and the other process is the same accepting that these normally these are large jackets, so these are already these are fabricated in sections, so built in sections.

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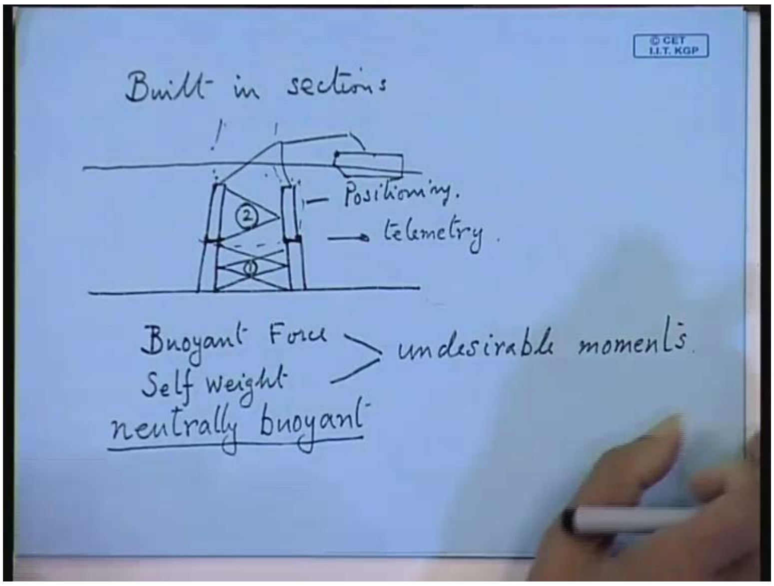

Now, the problem is that say this is your sea level, and this is your sea bed now this is one part of the jacket, you have correctly position at sight, now on this you are going to locate another part. So, this is number one now on this you have to position, this now here actually if you do this very treaty because unless this is position on to section 1, you cannot welled well these are very large structures and slight disturbance in locations will cause you the welding to break at this mode, and this is junctions.

So, this is number 2, and number 2 you have to sight just have a number 1, and at the proper locations, so this is done by a method, which is called telemetry, civil engineers they normally do this under water telemetry you have to do, so exactly you have to fit. Now, all this is taken care of by your crane from your launch barge, so launch barge will always be there, the other part that is to be remember this, then when this goes below the water you have you to keep this in what kind of buoyancy as soon as you was this in under the below the water surface.

See buoyancy is you will be encountering a buoyant force is going to act on this part, this structure has its own self weight, and these two forces will give you undesirable moments. The moment is actually the whole cause of the trowel you see of placing this structure on top of one, so these you have to get rid of undesirable moments. So, you will find that the whole structure swing etcetera, and even if you do not have waves or current, because you have not neutralize the moment.

So, this is always advisable, you keep this in a neutral buoyancy mode or it is called neutrally buoyant, this is what the neutrally buoyant is the objective for these kind of thing. Now, these kind of erection problem you are not find in your smaller jackets are more safer, but in this case the positioning is a bit tricky. So, that is the section 1 after that you take section 3 on top of this, and after you have finished it, then the whole the deck module the here is a diagram, this your deck module is transferred on to the jacket here you can see.

So, this is after the jacket has been position on the sea bed, now here that driving piles, so these are very long piles through this columns these are pile have a and now in the next they bringing the deck on to the top of these piles. So, the piles they are staging cone which I have told you, so these have conical in shape, and these exactly fits on to the top of the pile and then you weld this. So, this thing is now we have not transferred the deck mode, in civil engineering they call this a decks sub structure, so this is the method of launching and positioning of the jacket.

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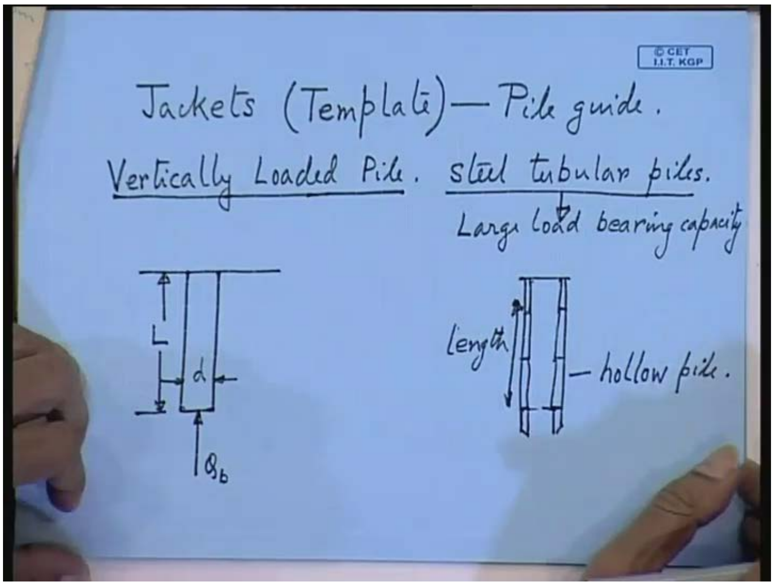

Now, coming to the other category is the piling, now piles actually you come there is various categories of piles, the jackets are normally called piles structure, so jackets is another term for a template. So, what is the function of a template, so these template is actually a pile guide, now piling if you want to do the simplest category is a vertically loaded pile. Now, there are various categories of piles you want that be simplest category is a vertically loaded pile, and if you want to understand the mechanics, you will find that the pile has to be driven the piles bite self not go below the sea bed.

So, suppose this is your sea bed and the pile this, you have driven like this what is what are the forces coming on to this piles, so your base reaction is Q b, and this is your pile length. So, if you want to understand the mechanics, and this is your pile diameter, so this is a actually is you must simplified version, but if you want to go into the details; that means, if you take the section.

Normally, I have shown a section with a uniform thickness, but your thickness is going to vary with depth, you will find actually a steel pile, these are the various as you go the various thicknesses will be there welded. Now, at the bottom of the pile you will find, that you have to drive the pile, so make this sharp. So, this is your cutting edge of the pile, and this is your hollow pile, civil engineering they have various types of piles, but anyway, so we are mostly concern with steel tubular piles they are the presence scenario.

Now, the previous in the previous when nineteen forty seven the piles were not steeled they are made of wood, so they are called wooden pile, but now it is sees jackets or made of steel and a larger jackets. They should have steel tubular piles have carrying capacity large load right load bearing capacity, so this you have to calculate, what is the pile, how much load is going to come on to this pile.

Now, based on that you calculate your pile diameter thickness, the other important parameter for pile determination is the length of the pile, how much is going to be your pile length, so how to calculate this. Now remember that this is what I am calculation that I am telling you is for a vertically loaded piles, but later on you find in your offshore technology class, I will talk of another set of piles, which have called the laterally loaded piles.

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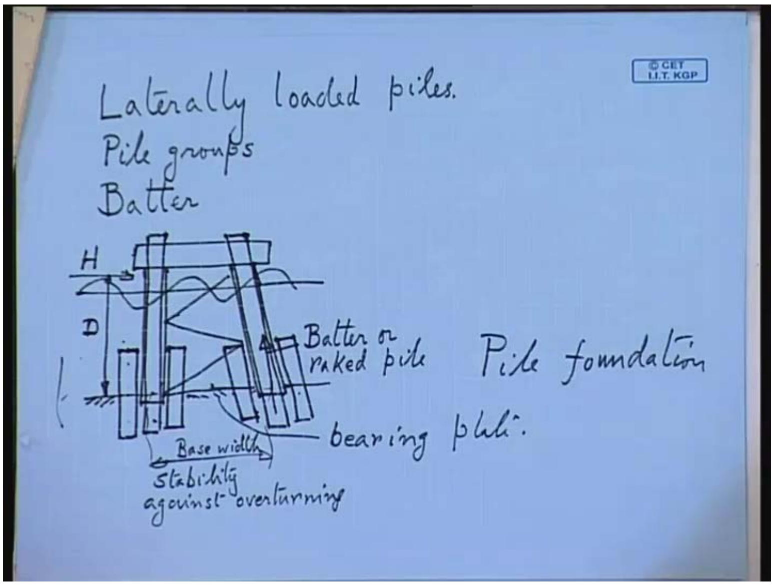

So, this we will not talk about in this class, because that will consume lot of time, so these are called laterally loaded piles, and also your problem is not going to be simple with just one pile, because you will find jackets. They you do not have a just this is a very simplistic diagram that you have it is there so; that means, he has driven only one pile. So, these piles are separated by say ten meters, but here actually the larger jackets you will find pile groups.

So, this large pile will be surrounded by smaller piles, so that is called a pile group, and if you have a pile group there will be interaction between the piles. So, award study in your later class you have to study what is called a laterally loaded piles, pile groups, so this may mechanics you have to understand pile groups, and not only that piles will have a certain batter, what is the batter.

Now, batter means, so in jackets you will find jackets, normally they the jackets are not made of columns, which are vertical, you will find the columns of the jackets are 2 columns may be vertical, but the other column may be slanted. Now, this is called a rake or batter, so actual this jacket configuration may be like this, in actual practice you will find, this now here actually you have to drive one pile which will go through this column. So, this is a vertical, now vertical pile driving is quite easy, but how you are going to drive a pile with the batter or sometimes this is called a rake.

So, problems in our offshore foundation is tricky in building foundations also you have piles, but normally they are vertical piles, and buildings normally the vertical load is the larger one. So, this sort of pile, they call this as a batter or raked pile and so far, so good, and this is your sea bed and here you have still more piles. So, like this it is going to come; obviously, here you cannot have vertical piles, now this is how the whole structure is pin down to the sea bed.

So, you have to study in a actual practice you have to study piles with batter and groups, so you have pile groups, so this is the structure, so these piles will be interacting one another. Especially, when you are driving, suppose you have driven this long piles after this if you drive the shorter piles these are called skirt piles; that means, this is not the same as driving this short pile, just on to the sea bed. There will be interaction between these two piles while you are driving a pile here, so that has to be taken care of and the batter actually you cannot avoid.

Batter and raked pile cannot avoid, because what you have done is what, you have increased base width, now base width has been increase, because of stability against what, against overturning. You can you have to calculate in all these kinds of jacket platforms I told you, you have to calculate the overturning moment coming from the waves, so these has to be massed by a reactive force coming from the piles.

So, you increase the base with so; that means, you have the moment term you increase your moment term, so that is going to give you a reactive moment to counteract this overturning moment. So, this is your overturning moment say this is horizontal load and this is the water depth, so edge these your overturning moment, so these has to be resisted that at any cost.

So, this is the nature and this whole thing is called a pile foundation, so in detail we will discuss this later on, now I have other things to discuss, now the point that is to be remember is that you have another plate out here, which I have not shown. Such that the whole structure does not go below the soil is not it, you have a some sort of a bearing this called bearing plate, bearing plate is this now coming to back to your pile driving.

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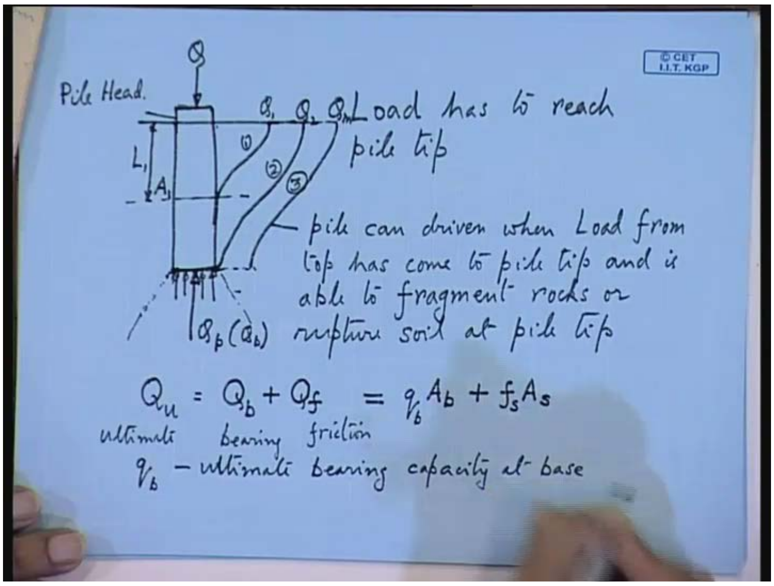

So, here is your pile that I have drawn, now if you want to understand the mechanics you will find that your pile has if you start driving a pile, the immediate the force does not go to the tip, suppose this is the pile shaft say this is coming out of the sea bed. Now, the pile has to be driven by a pile hammer from the top, so you give a load out here that is Q, and at the end you will find the load does not reach the end, so it terminates certain point out here, so this section you call this section as A 1.

Now, if this is the situation; that means, the load that you have given here is taken up by the friction load on the circumference of the pile, the load has not reach the pile tip. So, the basic mechanics is the load has to reach the pile tip, so here actually the whole load you have exhausted in this length of the pile, say let us say this length is l now. So, you keep on increasing the load, now let us call this load as Q 1, you have given now after you keep on increasing the load at a certain instant you will find, the load variation is coming like this.

That means, still at the tip of the pile you are not getting load, but load has increased from Q 1 to Q 2 at sea bed or this is sometime this is call the pile head. Now, in the next case after this you keep on increasing the load, so now, you get some load at pile tip, say this is the load at pile tip whereas, here you have getting pile head load is quite large Q m. So, in these situation now this is the vertical load and there will be another bearing load that is coming at the end, this is called Q p, now this say this is case 1, this is case 2, now case 3 you can pile can be driven.

So, pile will only go down into the soil, when actually 3 is greater than 2, but there is also a certain factor; that means, piles can be driven, when that is load from pile have a wrong, you can see load from top has come to pile tip. And there is another big question and is able to fragment rocks or rupture soil at pile tip, then only your pile will go down.

So, the basic question is you have to break the rock at this region, so your rock strata has to be broken, that is way I have told you in the previous diagram I have given a very sharp edge at this end. So, the main function of the pile is to break the rock strata, or rupture the soil and then the pile goes down. So, these has to be done that is why you increase your load on the pile hammer this is called the pile head load from Q 1, Q 2, say to a maximum will come at Q m. So, these has to be the friction load is not it, so the difference between two this one pile head, and this one is your friction load.

So; that means, the ultimate bearing load of the pile this taken out by two loads, one is called the bearing load and the bottom that is your Q b, this is Q p or sometimes this is also written as Q b, that is the pile base load that is coming from here. This small arrow are your base load last the friction load, now your friction load is going to occur at the surface of the pile not only base end, end of the pile.

So, this is Q b plus Q f is your Q u is your ultimate load, this is called Q b bearing load, and this is called friction for now the equation for this is the Q b small Q b is your bearing capacity they called multiplied by the area of the base that is your A b. And skin friction is this is called units skin friction f s multiplied by what multiplied by the surface area of the pile, so this is your equation for a vertically load loaded pile. If you want to note this down, so this is called ultimate bearing capacity, so all these things you come across this is just the starting point of the pile mechanics.

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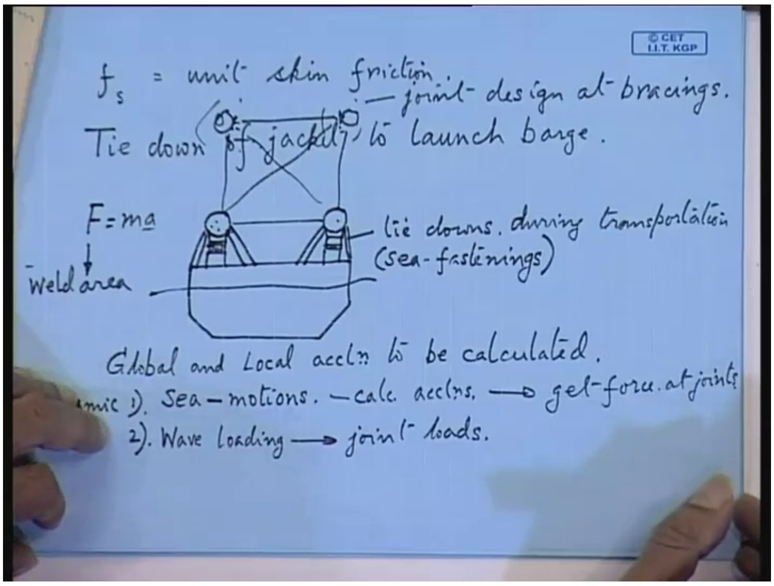

Now, the other point is your f s is called units skin friction as per unit area, so these points we will remember. Now, after this we will go on to the other aspect is of course, the tie down mechanism during transportation, so this is called a tie down of jacket to launch barge. Now, these I told you now when the jacket comes on top of the barge, you know the barge will have its own this is called launch girder is not it, now you have to launch.

So, this is your launch girder, and say this is the column of the jacket, so these will come down here. You have to make some kind of a shoe like this, and here there will be wooden wood will be there and this things, so this is your jacket, so the whole jacket which I have not drawn out here is something like this. Now, here actually so; that means, there will be continuously, there will be heeling will be going on heeling and trimming will be going on, because of motions coming from the barge.

Now, this if you simply keep it like this it will just fall off from the deck, so these you have to have a tie down mechanism, so these are normally pipes which have secured to the deck, so this side is icon draw. So, these are called tie downs or sometimes these are called sea fastenings, now these you have to calculate that is what should be the amount of sea fastenings and tie downs, so tie downs during transportation of jacket.

So, how to calculate this now first thing is you calculate acceleration at this point and you find out the forces, so force is equal to mass into acceleration, and this acceleration will be different for different locations, because of motions coming from the sea. So, again you have to take be close to your sea keeping analysis, so from this after you calculate, this force then try to distribute.

This over weld area you have to do the amount of welding, you see how much of weld area you require to have this force, so that will decide on the amount of sea fastening that is required, so this is the calculations that you have to make. So, we have to make both global as well as local load calculations, global and local acceleration have to be calculated, so lot of mechanics is there, so all this in motion engineering is not all that simple.

You have to calculate global and first you calculate global acceleration and transferred it to local acceleration find out all the local forces, especially at these joints. Now, these joints are important, because you have to make your tie downs and calculate the weld area, but also these joints are also important, because you can see there the farthest from the deck. So, that will give you the motions will be more at this point, so here if you are not careful then this will start cracking.

So, in offshore engineering actually joint design is very critical, this joint design at bracings, now this you should not forget. Now for that you have to do a number of calculations particularly the calculations, which are important in sea motions giving rise to acceleration next you have. So, this is during transportation, number 2 you have during what, during the life of the structure that this wave or wave loading, so here calculate accelerations, from these get force and prefer the at joints.

And this is one calculation, you have to do wave loading will also give you joint loads, so joints are very healthy stressed regions in offshore structures. We have just two simple loadings have told you one coming from sea motions, here this is a both loadings are dynamic in nature, so here you can see that instead of static loading the more important loading is your dynamic one. So, that is why you come across in this type of calculations anyway, so with this we finish the jacket platforms next we will come to the gravity structures, so we will have a break of a few minutes you can refresh you.