Dynamics of Ocean Structures
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Lecture - 11
Development of Tension Leg Platforms
and Geometric Optimization

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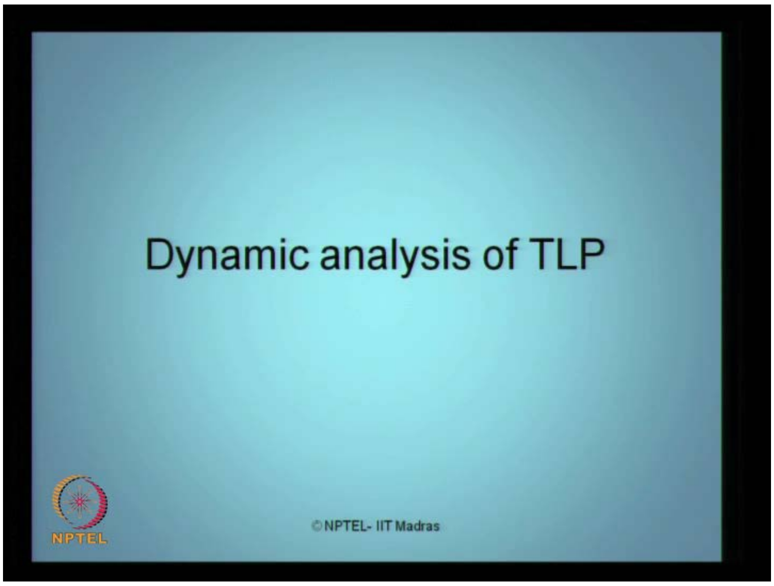

So, we are taking about lecture 11 module 2 on dynamics of oceans structure. In this lecture we will discuss about dynamic analysis of one compliant type of structure which is very commonly used for deep portal of floor exploration which is tension leg platform. In module 1 we already discussed about some of the important aspects of geometric design of TLP, and how TLP restores by itself under the action of lateral lots.

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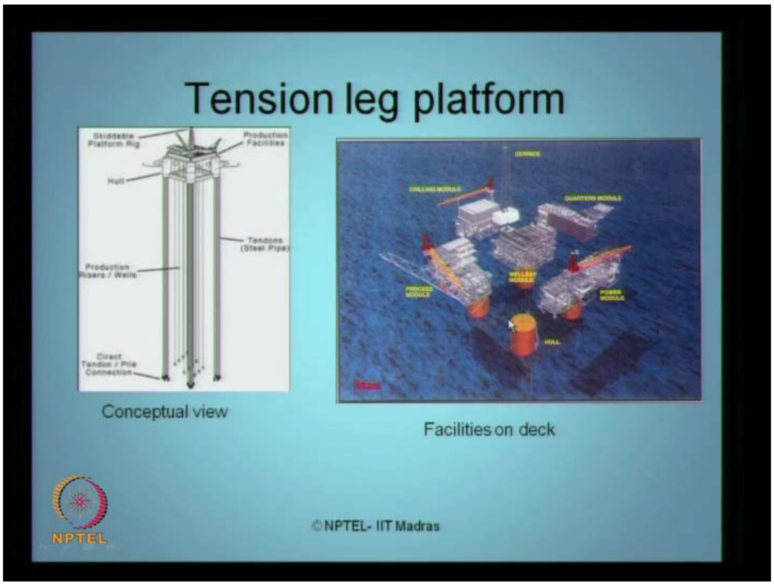

In this lecture we will talk about the dynamic analysis including the concepts of TLP. So, just to understand how TLP looks like just to re-brush what we studied in the first module. Tension leg platforms are shown as conceptual view on the left hand side of the figure as you see here, it contain different components - the components which is holding down the TLP to seabed is what we call as tendons or tethers. And there are of course, risers production riser which are being used for oil exploration and tendons are directly connected to the seabed using fixture type anchors and the top (( )) as lot of interesting facilities is at generally have incase of floor structures.

There are production facilities what we call as a hull these are all members and you can also have a platform rig. Look at in reality how this looks like for a mars TLP, this is actually conceptual view of mars steel it is a very famous production platform using for Mexico. You can see here, these are the 4 legs or the columns of the TLP the hull has been removed and made transparent in the model, you can see here there is power module which is actually supplying power to the whole platform and these are what are called railway modules which is having the derrick being installed in this.

This is type of derrick on the top of the platform you have railings both latitude and longitudinally and the derrick can move on the rail and drill in wherever it want along with the platform. These are quarters module people generally view who are working on top site this is what we call as a drilling module where you call a derrick house in this. Of course, there are different kinds of cranes available; we call them as process module. And you can see that tethers which are anchoring down TLPs legs and these are generally not in single they are in groups and what you see here are all production risers.

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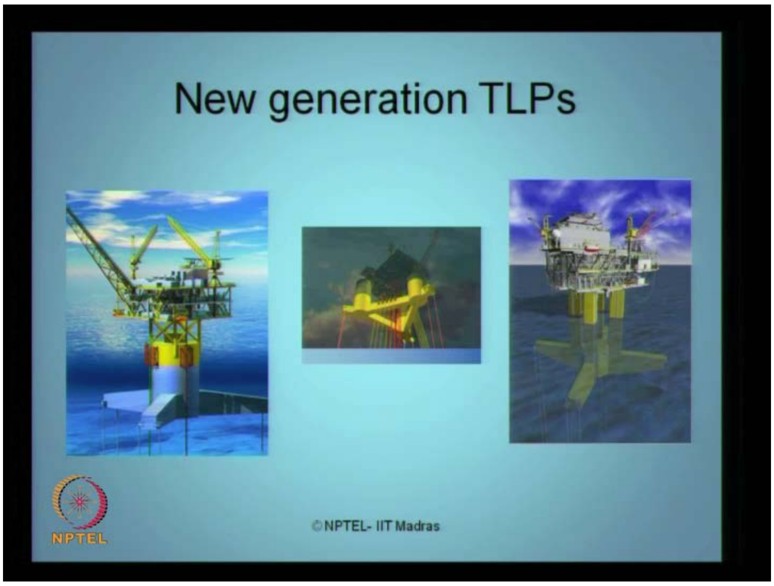

So, it is basically a figure which shows the facilities available on deck of a TLP which is never the less small than what is available on conventional gravity deck platform. Of course, there are new generations of TLP which have been constructed from the Gulf of Mexico for now, they are moving to ultra deports as well. You can see the great advantage what a new form has arrived TLP is that in earlier case if you see actually the tethers were anchored to the column beds directly. Now, what they have done is, they have projected this to increase the buoyancy volume as well as the tethers are taken out well away from the size of the platform so that the production rises have been provided in between with a hindrance. So, that is the great advantage here. So, what we call us Neptune TLP is the picture what you see have you can see at the bottom the legs are extended and the tethers are all provided here. So, it does not have a conventional of a square or a rectangular type the hull is cylindrical and as well as the members extend outside or project outside from which all the legs have been anchored to the seabed using tethers.

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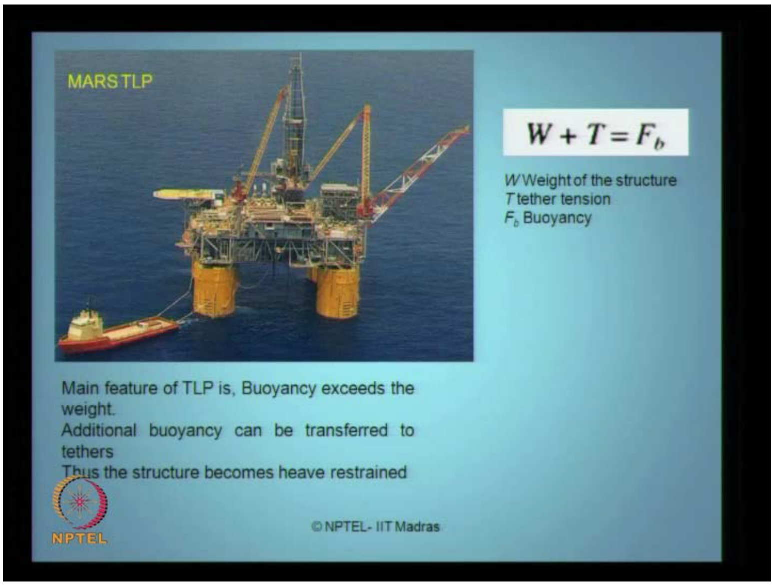

These are new generation platforms where, the facilities essentially made to provide interesting non crossing facilities for the production risers, what you see in red color are the production risers, this is actually the hull. These are all the derricks and cranes etcetera. This is the helipad etcetera, what you see in the figure. So, the new generation TLP has a small modification where the members are extended outs in the peripheral the columns and the tethers are anchored at the extended tip of the members. If you look at the mars TLP it is one of the classical tension leg platforms taken for dynamic analysis and many of the research papers because this has been having extensive research compatibility in terms of studies available in literature.

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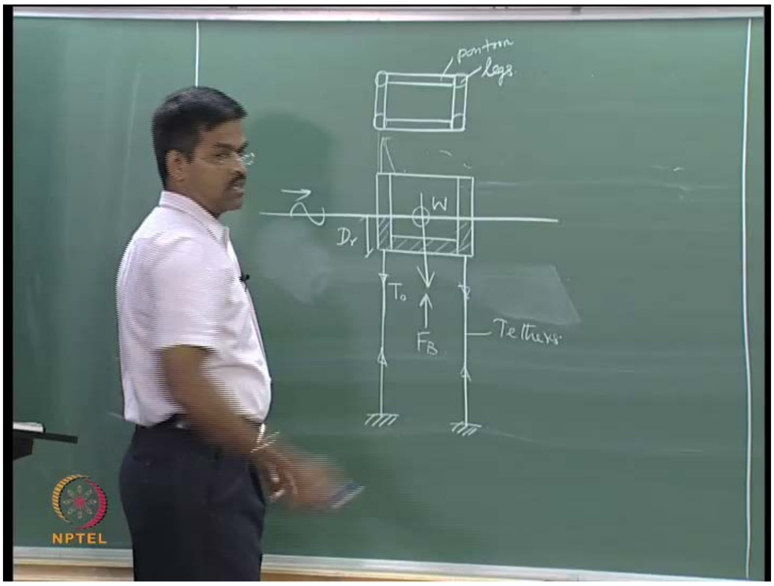

So, the main feature of the TLP what we see here, is very interesting as we understand. Let us say these are column members, these are my pantones. We looked at the plan, these are all the legs, these are pantone members, this is alleviation and these are my group of tethers, this is my green sea level, this is my wave direction. And of course, the top-site has all complications which is sorry, made a direction and of course, to the top sit complications that you see the various case, these are the tethers. So, if you say the various platform acting on a c g which is acting a w and these are t naught which are letters in individual legs and of course, depends upon the immersed volume of the members and depending upon the draft is what we call as draft, depending upon the draft requirement and depending upon the immersed volume of the members I will get the buoyancy force acting upward.

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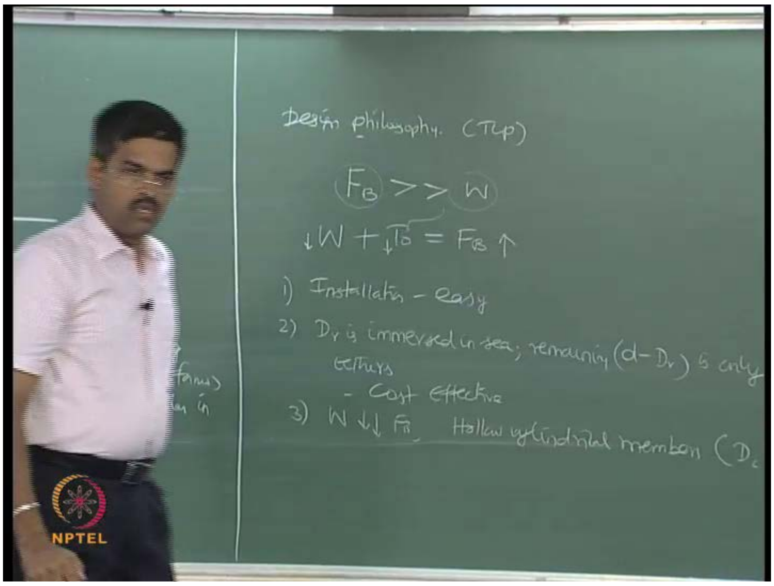

Now, the TLC designed is such a form, the design philosophy for a TLP is that the buoyancy force exceeds weight to a very high value. It means when you tight the platform with this draft in water this is of course, the water depth which indicates a small d and these are the diameters of the members which I indicate with D suffix c which I call D c for the columns and these are nothing but, D of the pantones, generally they are kept same. So, when you have a platform of this size which is installed for specific draft d and r in a deep sea. They design in such a way that the buoyancy force is much more the top of the vehicle platform so, the tendency is always the platform will be pushed up when you install this, to keep it holding down I need tethers or the legs which are holding down that is why they are called tension legs, they will always be in tension. So, the tension which is imposed on the tether to hold it down in position is T naught what we call initial pretension of course, in each tether, I should say each leg because each leg will have couple of tethers may be 4, 6, 8 pairs, so, I should say T naught in each leg. So, the total t naught of the whole platform will be 4 T 0. But, each tether we do not know actually how many groups are there present. Therefore, T naught is initial prediction in each leg. I call as my leg. Not these, these are all groups. I am not drawing all of them here, conceptually the buoyancy force will be much larger than the wave therefore, you have this equation of equilibrium here, static equilibrium W plus T naught should be equal to F B because F B is acting upward and W and T naught are acting down.

So, they act upward and downward. So, the compensation of F B versus W is taken care of by T naught. That is the concept here. Now, one can ask how this is advantages? Very interestingly, I can infer many important critical views from this figure and study what they made, the first and the foremost important is that installation becomes very easy for a TLP. How? Because once the legs are not anchored to the seabed it is a free floating body you can drag it easily therefore, installation and everything become very simple and easy. Two except for D r you want to take down the column member till the seabed. So, actually only D r is immersed, the remaining d minus D r that is, a remaining part d minus D r is only tethers.

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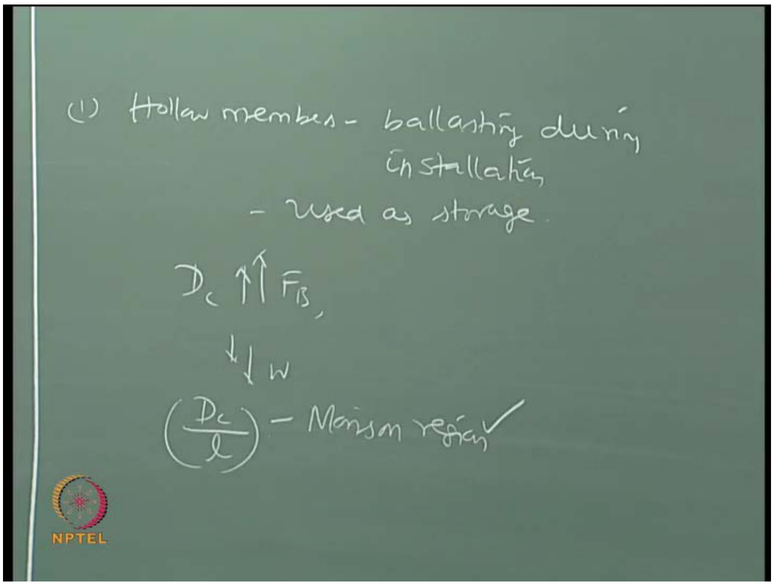

So, what is the advantage of providing such a member here? The advantages here it becomes very highly cost effective. Thirdly, as you want W much lower than F B, as you want W much lower than F B, I will always provide hollow members with an outer diameter D c. Now, the advantage of providing hollow numbers are the following, now the hollow members can be used for velocity during installation that is, one advantage. These hollow members can also be used as storage. The hollow members actually improve their buoyancy but, reduce the weight. Therefore, D c by l can be made to design in such a way that they obey Morison region.

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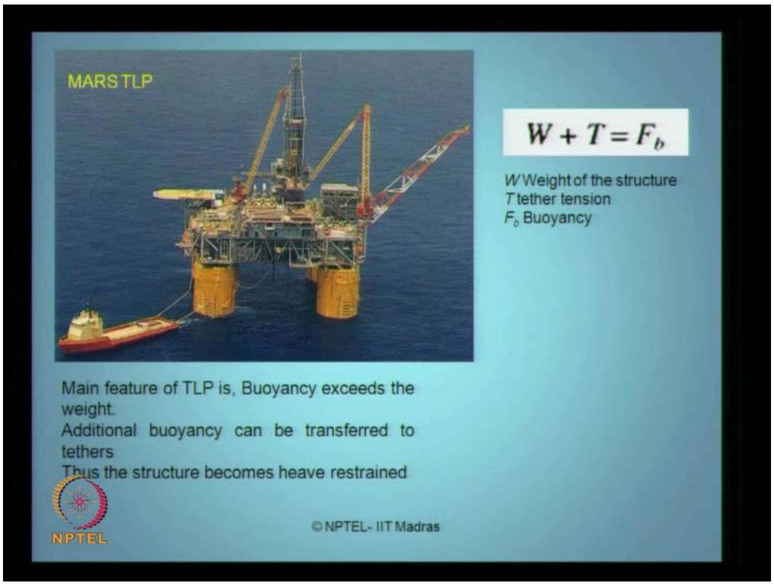

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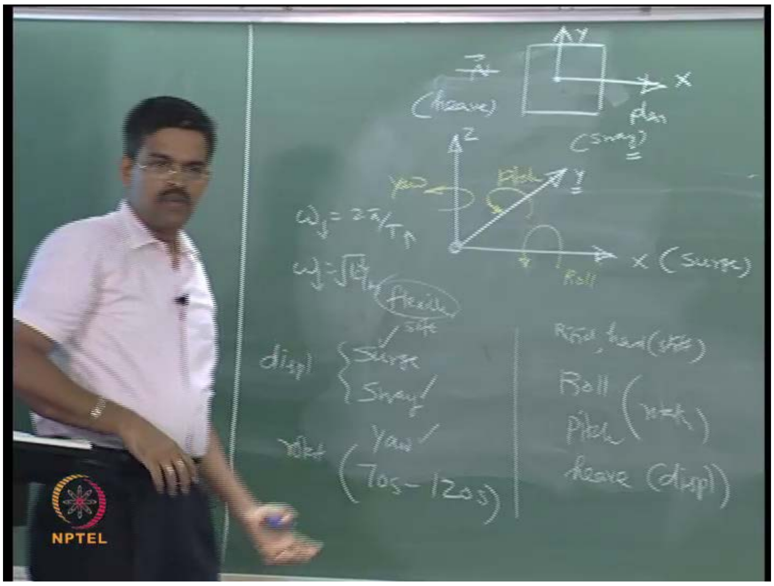

So, we make it this format, you got many advantages. So, the greatest technical and structural advantage what we gain by a TLP is, this point. The structure actually becomes heave restrained, the structure actually becomes heave restrained it means it becomes very stiff in heave degree of freedom. Now, let us quickly see what are the classical degrees of freedom and where are they measured. Now, TLP has got 2 categories of freedom degrees of freedom. Let us categorically divide them into 2; 1 is let us say flexible, soft other is rigid, hard or stiff. So, if there are 3 acts of displacement x, y and z. So, the displacement along x axis with respect to any origin may be a CG or I the center of mass is what we call a surge, the displacement along y axis is what we call a sway, there is a y matches with this y and the displacement along z must be called as a heave.

So, if you say heave restrained, it is stiff in the vertical degree of freedom, it is heave restrained it is heave restrained it does not allow the platform to move much in the vertical axis. And obviously, use your thumb direction towards x and remaining 4 fingers will show the direction of movement. So, if I use it is way this becomes my roll, if I use this way this becomes my pitch, if I use this way this becomes my yaw. So, we got 3 degrees of freedom. One is translations along x, y, z. Others are rotations about x, y, z. So, interestingly there are 2 groups of degrees of freedom: one are translations, others are rotations. Amongst these 2 groups I distinctly divide them to 2 parts for example, I would not say that surge sway and yaw are flexible degrees of freedom it means the platform has a freedom, I draw a plan here; this is plan this is my x axis this my y axis z is normal to the board, this is my real direction. I am drawing the plan here so, this is my x axis and y axis and this being z axis normal to the board.

So, I say that the platform can move horizontally very free so, surge is flexibility. The platform can also move normal to wave direction in plan which is sway; this is again a flexible degree. The platform can rotate about the vertical axis very freely this is what I call as a yaw. Now, these time periods actually vary from 70 seconds to 120 seconds large time period. So, how can we say they are flexible? Omega is 2 pi by T, T is very large, omega is very low, omega is also equal to route k by m omega is very low k is very low for a given mass it means it is less stiff it is flexible, it is flexible degrees. On the other hand, look at the remaining degrees, I have got 6 degrees and I have checked the 3 here and the remaining are let us say roll pitch and heave, out of which this is displacement and this is rotation, out of which these are displacements and this is rotation.

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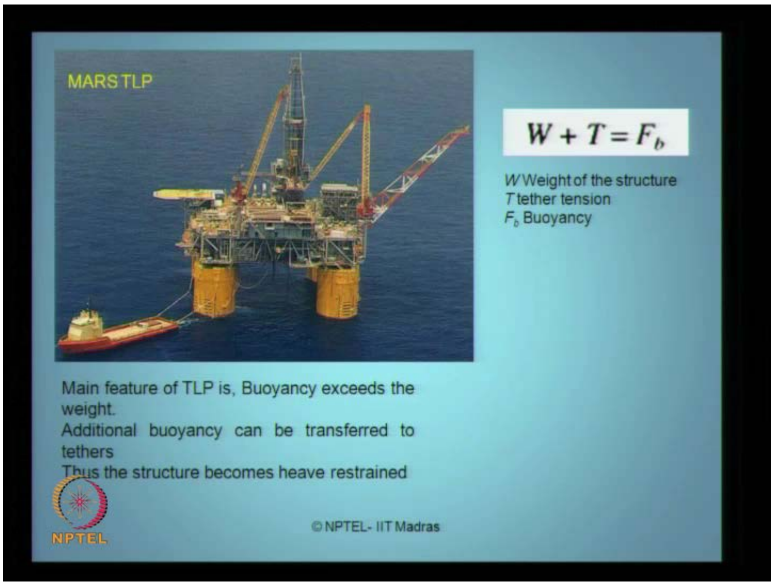

On the other hand, let us try to understand this in physical terms here. When the wave acts on a platform like this, it is very difficult for the wave to rotate the platform about x axis, about y axis and it is very difficult for the platform to move it in the z axis displacement. So, it is a geometric design actually. Now, one many wonder how this is been obtained? Now, the restrained of platform being moving in the vertical direction is being done are opposed but, by a heavy T naught being introduced in the system. The moment we introduced heavy very high T naught value in the system, the platform will not be allowed to move in the vertical direction. Now, look at this photograph here, there is a 4 column restrained tension leg platform which is mars TLP and you can see that top sheet has got 3 levels, which is having the flyer boom, these are flyer boom, these is a crane derrick, this is the drilling derricks, the drilling floor, living quarters, power units, helipad etcetera.

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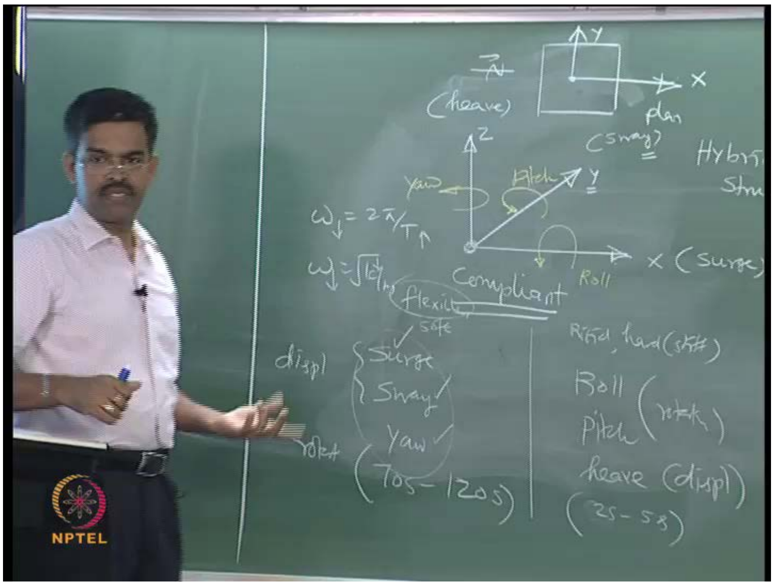

So, if I say that this is my elevation, this is my elevation platform, this is my wave direction for my understanding. The platform as a freedom to move along x axis to move along y axis and to rotate about z axis it is free so, it is floating. Whereas, the platform cannot rotate about x axis no roll, no pitch and no heave no. They are very rigid. So, the degrees of freedom of roll pitch and field varying from the period of 3 seconds or 2 seconds to about 5 seconds. So, very low time period, very high frequency, very high frequency means very high k that is very stiff. Now, because of such unique combination of 2 sets of degrees of freedom, TLP is always addressed in literature as hybrid structure instead of addressing these as degrees of freedom are flexible, people call them as compliant platforms. Please take about the spelling it is not 'complaint', it is 'compliant'. Compliancy means flexibility, compliancy stands for flexibility. So, these are compliant degrees of freedom, these are stiff degrees of freedom. TLP is hybrid combination of both. Now, one may wonder, what is a technical advantage of keeping 2 distinct set of degrees of freedom in a geometric design? What are their advantages? My TLP can have a natural period either very high or very low it means, the wide range of operational waves can be provided on the stage, which is generally larger as you move towards the deeper waters.

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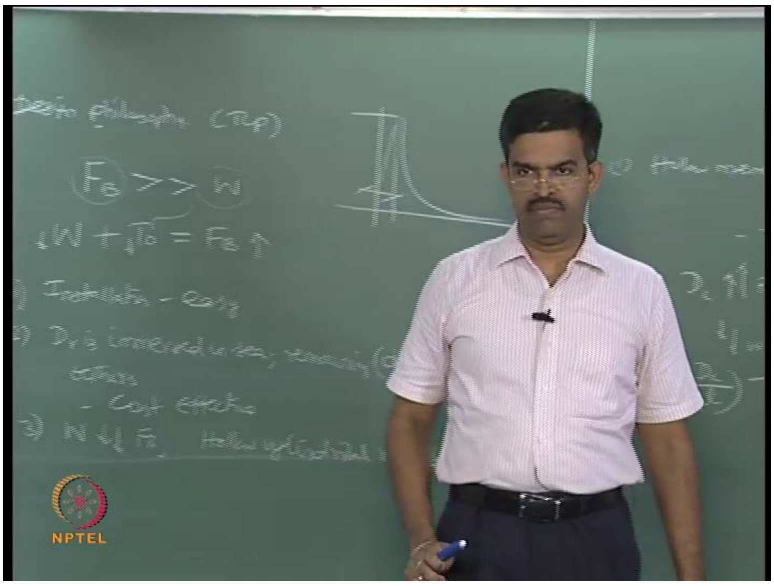

So, TLP now can to wide range or broad band of frequencies which will neither tune with stiff degrees of freedom nor tune with flexible degrees of freedom. Now, one may wonder what will happen to the wind direction of TLP because this is about the wave fine. About the wind direction, wind is always a low frequency phenomenon. If you look at the spectrum of wind you already seen it is a very close frequency and very high amplitude so, low frequency phenomenon. So, low frequency phenomenon can affect certain degrees of freedom. So, low frequency means high time periods, high time period means these. So, the structure has been made flexible in these degrees so that they are relative movement between the wind direction on the platform and the moment of the platform becomes nullified as we saw in the articled towers. So, it is very carefully designed in such a way that those degrees of freedom which are very high team period or very low frequency where wind may become critical are made compliant so that, the relative movement of the platform under the given letter low is less. As we saw it in the same case as the case of multi so it is the same concept being applied.

So, the advantage of the system design will be a good 2 set of combination of degrees of freedom which has been geometrically innovative to alleviate or to counter act the horizontal forces acting on a system for a very broad band of waves as well as wind forces as well. Now, the fundamental question comes under the combined combination of let us say, soft and stiff degrees of freedom, how stable a TLP is? So, mappio stability is one aspect where, stability of floating structures are tested or investigated. So, I will discuss this in the next lecture about stability issues of TLPs, how they have been studied using mappio stability though it is not directed dynamics but, for our understanding we must know that how stability issues are being address in structures like TLP.

Having understood this, let us see how the equation of motion will look like for this and how can it derive the stiffness, mass and damping mattresses of this. Once I know this than I can easily solve this using different methods of value problems, find out the natural frequencies in note slips you can perform investigation on this model and find out the damping ratios once my whole problem is available I know how to find F of t for this given problem under wave and wind, I know all the equations of motion neither in time or frequency and get the response, that is the whole history.

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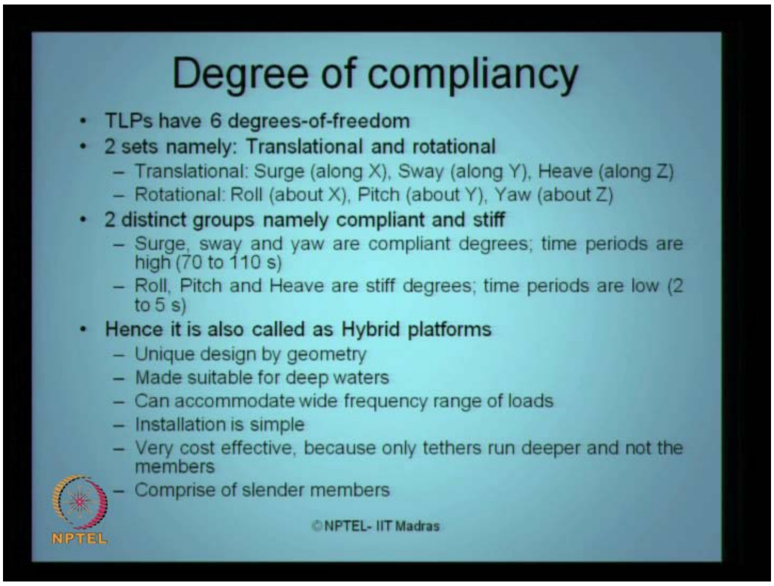

Since, what we are discussing quickly, this for the benefit of the people who are not following the blackboard. So, degree of compliancy is having 6 degrees of freedom 2 sets namely translation and rotational. So, I rotated invert surge along x along y and heave along z and rotation is sway about x about y and about z respectively. There are 2 distinct groups namely: compliant and stiff, surge sway and yaw are compliant degrees varying from 70 to 120 are 110 seconds and roll pitch and heave are stiff degrees varying from 2 to 5 or 6 seconds. Therefore, TLPs are called as hybrid platforms, it is unique in design by geometry, it is made suitable for deep waters because it can accommodate greater waters as we call only d minus D r has to be taken for the tethers where, the cross sections area is very less so, it is very economical can accommodate frequency the range loads, installation is very simple, highly cost effective because only tethers run in waters, it comprise of slender members qualifying marginal equations calculation forming problems because relative movement of the platform with respect to the wave induction is lesser.

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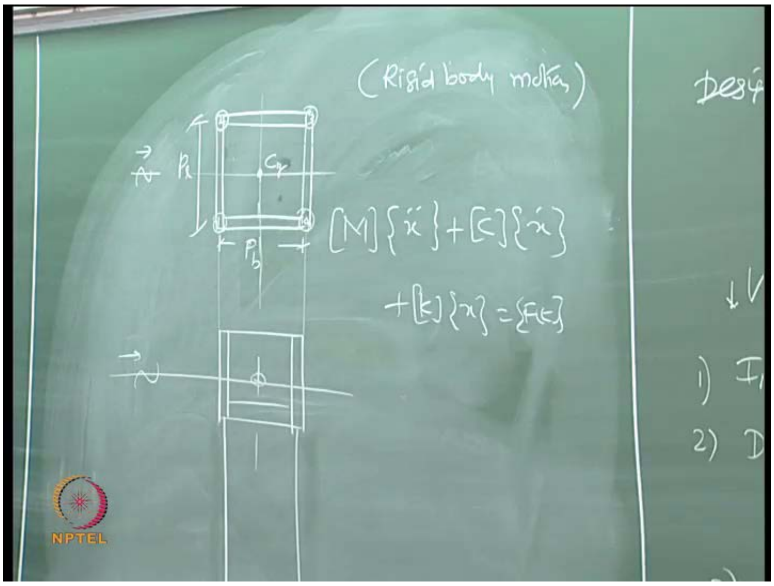

So, let us talk about the equation of motion for this platform, let us say this becomes my geometric center I can call this as C m center of mass, If you are confused then, I call this is C g or C m may also related to initial co-efficient C g. So, this is plan let us say these are all column members which are generally circular, I name them as 1, 2, 3 and 4 this may wave direction and I call this dimension as P b and this as P l and of course, elevation corresponding, as we drew last time, that is where the corresponding center of mass are here. All the degrees of freedom are measured as center of gravity. So, basically it is a rigid body motion. Let us say conventionally, the equation motion remains F of t. In this class, we will pick up k and derive k.

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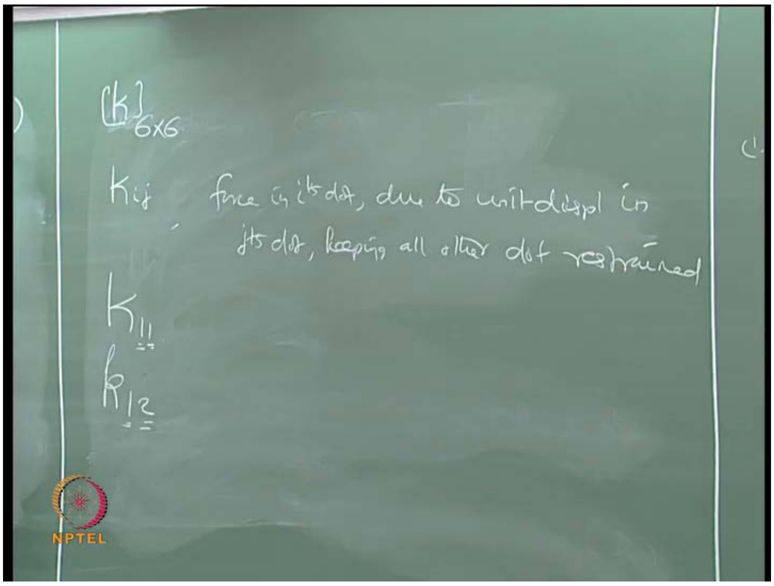

So, stiffness matrix; there are 6 degrees of freedom obviously, respected where matrix will be size 6 by 6. so, if you want to find the coefficient of stiffness matrix k i j it is nothing but, force in height the degree of freedom due to, unit displacement in freedom keeping all other degrees of freedom restrained. So, I found find let us say example k 1 1, I must give you displacement in the first degree and try to find out the force in the first degree. If I say k 1 2, I will use unit displacement in the second degree and find the force in the first degree and so on that is who you generally derive stiffness matrix. So, I will retain this figure. I will remove this.

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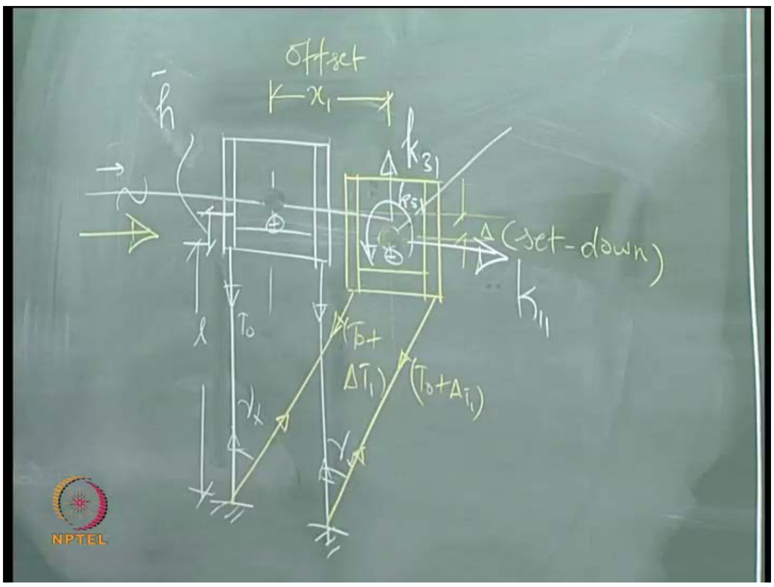

So, apply a displacement in this direction which I want first degree is surge. So, this is the motion which I have given, I call this as x 1 it may be unity but, I give x 1 displacement. And of course, this is what I called as delta which is set down this otherwise called a off-set. The length of the cable on the tether is initially l 0, the angle is gamma x initially, I had T naught in my tethers now, I have different T naught because this cable will have a different tension now, compared to this or compared to both of them earlier. So, the new values will be T naught plus delta T 1, T naught plus delta T 1.

So, when I give unit displacement of the surge direction I have forces in k 1 1 of course, there is an effect seen in the heave degree. So, I will have force k 3 1, I am marking the arrow direction as positive to the degrees of freedom. And of course, in case of this axis about y in plan, I will have also a rotation. How? Because they will have now vertical component, this vertical component will create the movement about this point. So, I call this as k phi 1 because that is the fifth degree which is rotation about y axis. And of course, the distance from heave here to my C g, I will call C g here this is what I call as ‘h bar’.

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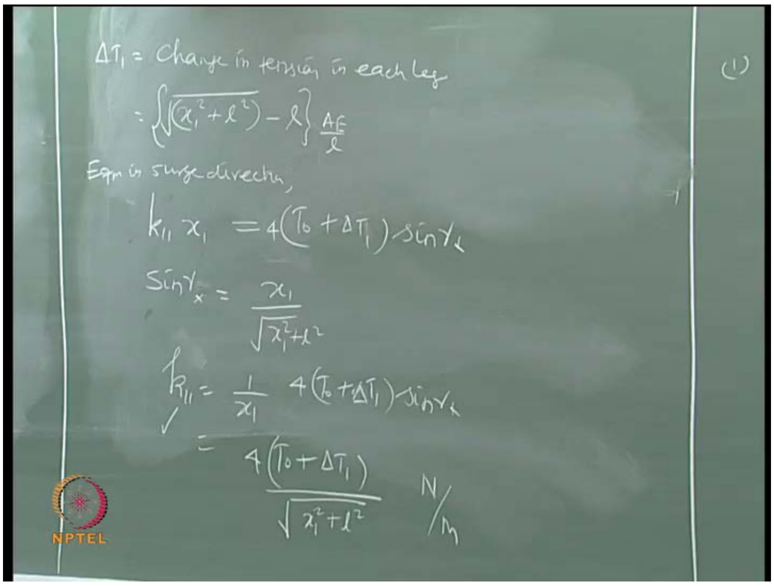

So, delta T 1 that is a charge in tension in each leg, simply given by x 1 square plus l square i minus l square or minus l minus l of AE by l. Is it ok? If you write equation of equilibrium in the surge direction, I should now say k 1 1 x 1, k 1 1 is force per unit displacement is neutral by multiply meter I get the force here I am writing the force equation in the surge axis which will be equal to, this is got to be restored by the horizontal components of these tension by an angle of gamma x. So, it is nothing but, T 0 plus delta T 1, delta T 1 sin gamma x of 4 times, this 4 stands for the value of this for each leg. There are 4 legs in plan you will see there are 4 legs. And also from the figure I know sin gamma x, from the figure sin gamma x will be equal to x 1 by route of x 1 square plus l square. Therefore, I can easily find k 1 1 as 1 by x 1 of 4 T naught plus delta T 1 of sin gamma x and sin gamma will substitute here, I will get this as 4 T naught plus delta T 1, this is delta by route of x 1 square plus l square. Even the compatibility is also there because delta T or T is a Newton there is a force and of course, this is in meter so, that is my stiffness. Say as you see in this elevation when its right to move the platform in the x axis there is no movement in the y axis which normally to the board ok.

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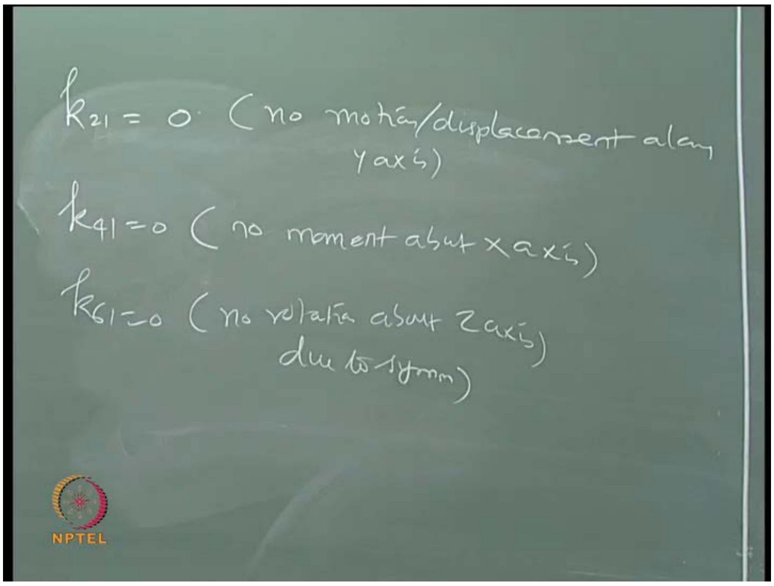

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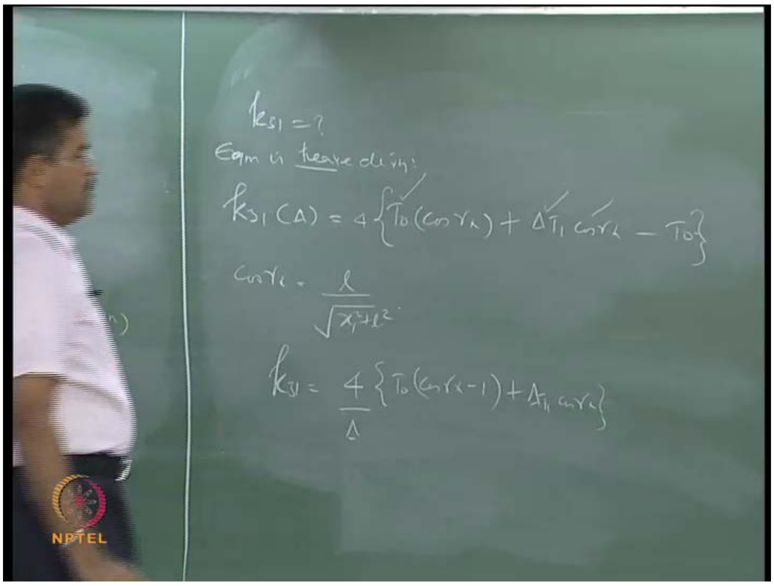

Therefore, I should say k 2 1 is becoming 0 because no motion or displacement along y axis so, k 2 1 will be 0. Since, there is no movement about y axis, the rotation of this force about y axis this is pitch is also 0. There is no roll; there is no movement about the x axis. Of course, the platform is symmetric therefore, there is no rotation about z axis k 6 1 is also 0 due to symmetry. Now, the k 1 1 are the surge displacement has given an off set of x 1 which has inherently caused the set down of delta. So, k 1 1 or x 1 has given influence of forces rising in the heave direction. So, let us try to find out k 3 1, I will remove this shall I remove this? So, to find k 3 1 let me write the equation of equilibrium in the vertical axis.

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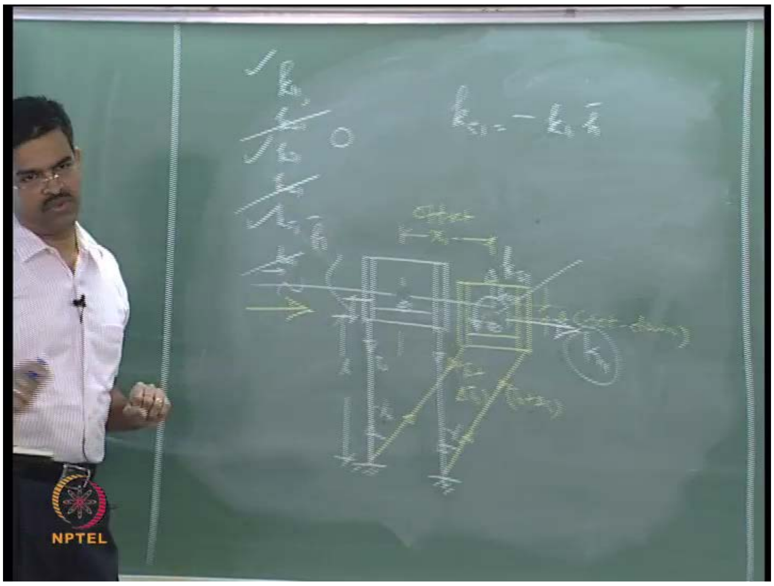

So, I should say equilibrium in heave direction, k 3 1 into delta because that is the action in the heave should be equal to T naught cos gamma x. Is it not? T naught gamma x that is in the y axis or that is in the vertical axis about here, plus delta T 1 of cos gamma x that is, the change in tension because of the displacement given minus original T naught because original T naught is anywhere there, I am looking for the change only, all this multiplied by 4 because there are 4 cables and cos gamma x is given by l by route of x 1 square plus l square.

So, in this equation T naught is known to me already it is initial tension available in the cable, delta T 1 already we have given you the equation, gamma x is known to me. I can easily find k 3 1. So, k 3 1 will be this divided by delta. So, I got the first column of the stiffness matrix now available to me, which I have derived k 1 1, k 2 1, k 3 1, 4 1, 5 1, 6 1 out of which k 2 1, 6 1 and 4 1 is 0. k 1 1, 31 and 5 1 is what they have here.

Now, I will derive k 5 1. Now, the vertical component of this dissolved values of these will right have the movement about this point which are counteract this. So, on the other hand the horizontal component of this, the horizontal component of this is nothing but, the effort of k 1 1. We said k 1 1 multiplied by h bar that means, the movement about this point. I can simply say k 5 1 is k 1 1 of h bar with a negative sign because it is opposite it is a restoring force. So, I got all the first column coefficient of stiffness matrix now.

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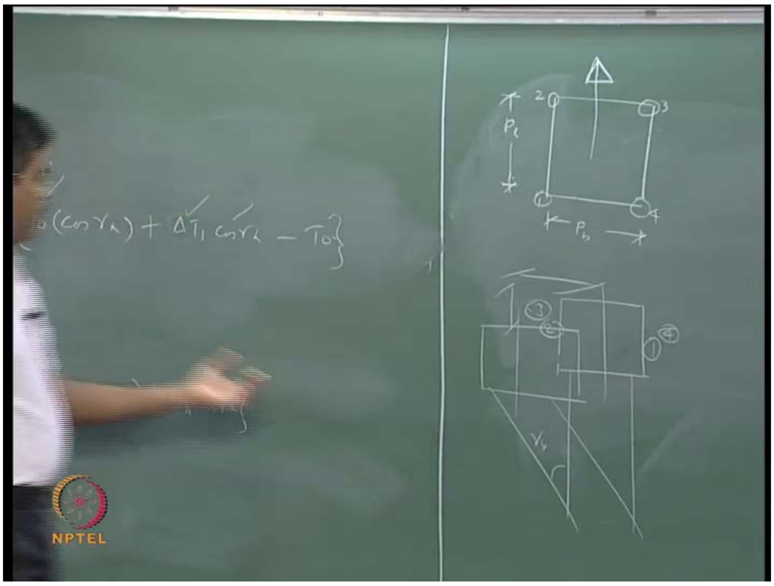

Similarly, so let me explain in sway degree very quick. Let us see this is my plan view, I am just drawing the plan again. These are my 4 columns; I name them as let us say 1, 2, 3 and 4, this is my P b and this is my P l, that is a notation you can u use anywhere this is plan breadth plan length that is the meaning of this. So, when you are doing an elevation from a surge degree freedom, if you want to replace this diagrammatically in this view here, I must say these are 1 and 4 hidden at 2 and 3. Is it ok? Similarly, if you want to do for sway degree of freedom, I will draw the same figure except that this will become 2 and 1 and hidden will be 3 and 4. I am viewing it from here; sway is this direction in plan. So, I will draw the figure like this, this is my original body and this is my new one sway positive is this way. So, I should say this is my 1 and 4 is hidden, this is my 2 and 3 is hidden this becomes my set down and this become my off set and this becomes my gamma y, everything will remain exactly identical.

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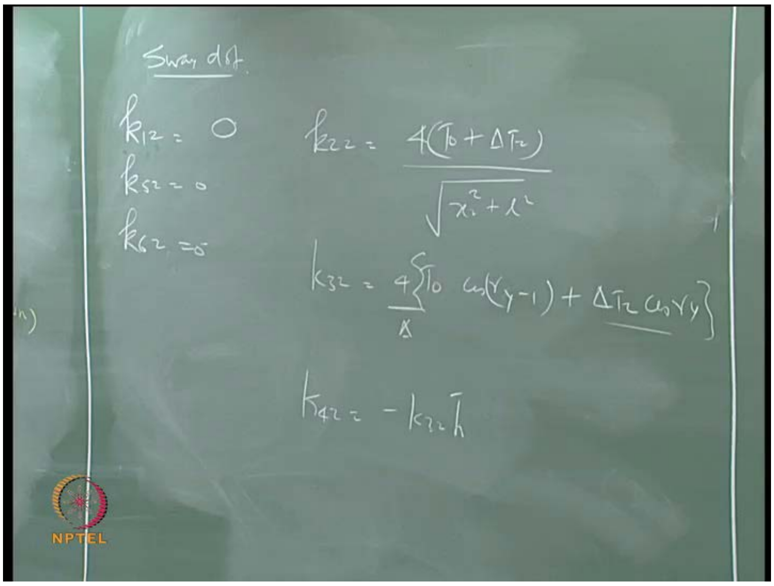

Now, let me write down the second column identical to this, I will remove this. So, as we apply force in the sway direction I will effect on the side therefore, I will see that this is in sway degree of freedom. So, I must say that k 1 2 force in the surge degree because of heave displacement given in the sway degree will be 0. When the force in the surge degree is 0, the movement force above the axis will also be 0. It means, k 5 2 will also remain 0. Is it not? There is a moment about the y axis, there is nothing but, pitch. Due to symmetry platform will have no yaw rotation that is also 0. So, k 2 2 is simply same as the top k 1 1 which is nothing but, 4 T naught plus delta T 2, there is a suffix change in here, divided by route of x 2 square plus l square. So, k 1 1 was identical to this which we have it here and k

3 2 because, heave is affected when you give displacement of sway degree because there is a set down happening here, the set down happening here. In the same line as the top k 3 1, I can write this as T naught cos gamma y minus 1 plus delta T 2 cos gamma y of 4. In the same line I can write k 4 2, as minus k 2 2 of h bar. Is that ok?

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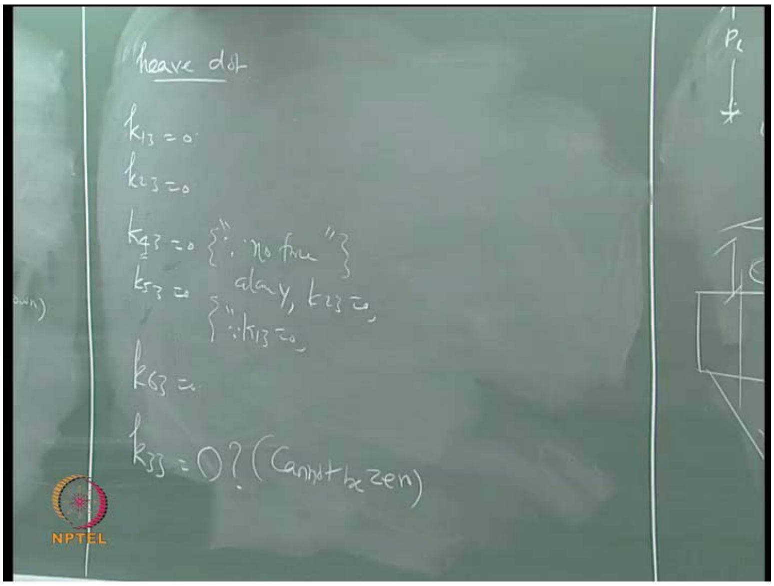

So, I got the second column of the stiffness matrix also. Let me take the third column. So, in a slide the heave degree of freedom now, I have to give unit displacement about the vertical axis in elevation. So, when I purely give displacement only in the vertical axis that is about z axis in heave direction, k 1 3 will remain 0 because they have no effect. You may wonder sir, when I give surge heave is generated, when I give heave why will surge be not generated? This nothing but, the restorations problem of a TLP, how? When a since, TLP is floating because of its buoyancy excessive buoyancy when I push TLP to my right or to my left as you see in both the figures, when I push there is a change in buoyancy happening the draft changes, the draft the change in draft initiates change in tension, change in tension restores it back. Therefore, surge and sway are coupled with heave. If I am going to give only heave there will be only change in buoyancy T naught will not be there. Is it not?

So, k 1 3, k 2 3 will remain 0 and of course, k 4 3 and k 5 3 will also remain 0. Why? Why k 4 3 will remain 0? Can you write the reasoning here? Why k 4 3 will remain 0? I want a specific correct reasoning here. Yeah. Why k 4 3 will be 0? What is k 4 3? k 4 3 is the force in the roll axis or roll direction because of unit displacement heave direction roll means it is about x axis, I am saying it is 0. It means since, no force along y that is k 2 3 is 0 this will be 0. Similarly, if you want to say, how k 5 3 is 0? Since, there is no force along x axis that is k 1 3 is 0 this will be 0. So, under service you give a proper reasoning for a derivation and definition these all will go shear waste, you will not understand anything of this, you will only repeat it in the exam or in your definition later by looking at the literature or the books or looking at my notes, you will never ever be able derive single coefficient in your life for a new geometry. Remember this very carefully. If you do not understand the reasoning of why I am putting them 0, take it granted you will not derive stiffness matrix for any of new geometry in your life, you will not be able to do it. You will only know how I am deriving that is all, you can be a good spectator, you cannot be a researcher. You must know why I am saying this as 0.

Now, let us work out what is k six 3? It is 0. Why? Why k six 3 is 0? Sorry, what is that, somebody said something why k 6 3 is 0? That is rotation about z axis is 0. By giving unit displacement along heave direction that is the meaning of this is it not physically. Why is it 0? I mean come out with some reasoning. Why is it 0? You must tell. Yeah. So, it is not because of symmetry, it is not because of symmetry in this case. Since k 1 3 and 2 3 are 0 there are no forces, the moments about these forces are unbalanced moment about these forces about C g will remain 0 because there is no activity.

So, only thing which we have here will be k 3 3. Can this be 0? Why? Why k 3 cannot be 0? Sorry. There are 2 reasons for this. No, No, No. There is no question of half answers you have to give me very full answer; you are saying something about restoring force. Let us try to work out on that particular comment. Why k 3 3 cannot be 0? There are 2 reasons for this. Sorry. Decrease the restrain, it makes a tether flexible but, tell me from the physique of the geometric design of TLP, why k 3 3 cannot be 0? There are 2 reasons.

We are attempting only the first reason; I am not seeing any one to attempt the second reason. Sorry. No. You are not attempting the second reason k 3 3 is 1 of the leading diagonal element of the stiffness matrix, if is the leading diagonal element is 0 the whole row is 0. Is it not? So, how can you invert this matrix? So, leading diagonal element of stiffness matrix can ever remain 0 technically or mathematically. And k 3 3 is nothing but, the change in buoyancy or the change in draft, the change in draft are always buoyancy on additional force from these members which will be a force acting on a vertical direction cannot be 0. When you a force in a vertical direction, the buoyancy changes. Why?

Because the depth of draft now changes so, the immersed volume of the members change therefore, the buoyancy will now change, that buoyancy will be transferred to only to T naught. So, it has got to have a stiffness coefficient in the vertical direction, cannot be 0. So, as you said the restoration cannot be happen is it not then, you can keep on sinking the platform till the seabed. The whole geometry concept of higher buoyancy versus weight is lost.

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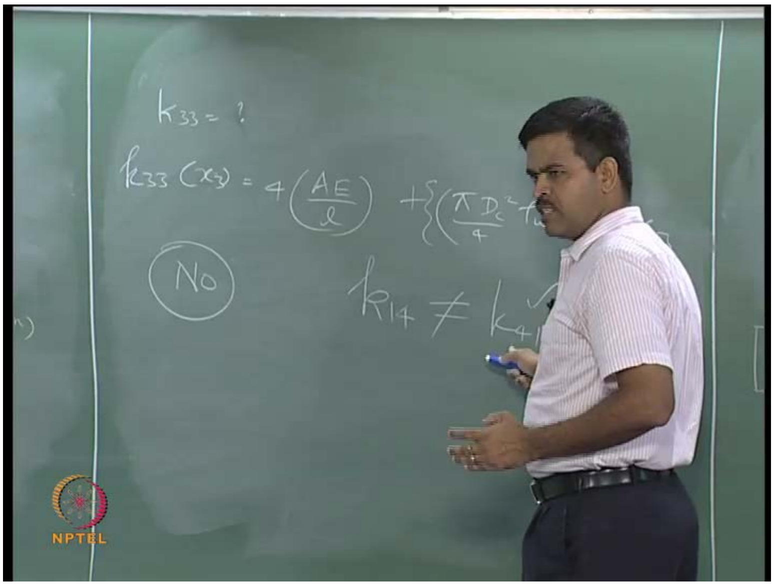

So, what is k 3 3 now? So, I want a point k 3. So, I should say k 3 3 into delta, delta is nothing but the set down effect or not the set down the displacement what to give. I can even call instead of x 3, I can even call this x 3 also. Is it not? Which will be the change in tension of the cable now, of 4 there are 4 cables plus pi d c square by 4 rho w g of 4. What is 4? These are all the column members which is immersed now, D c is the diameter of the column additional immersement. And I must multiply this with what, x 3. So, this will give me k 3. So, I derive the third column of the stiffness matrix now. How many columns are remaining? Can it be symmetric, can I simply say k 3 1, k 1 3 is as same as k 3 1 and so on? Do you have to remain; do you have to derive the remaining things, what is your opinion? Yes or no? You have only 1 minute time. We will derive it later. Yes or no? Can I use the symmetric characteristic of this matrix and say I have certainly derived the left triangular part of the symmetric? Can I simply replace it and say it is symmetric? Yes or no?

The answer is no, I cannot do it. Why? If you say this argument, you mean to say k 1 4 is never equal to k 4 1 in your understanding because k 1 4 is displacement force in this surge degree because of rotation given in roll which can never be equal to force displacement given in surge because of and get the rotation 4 because this we got, this we got. Not 4 may, be we got 5 what or maybe. So, you mean to say rotation and displacements cannot be combined ever. Is that your argument? Since, they are 2 different degrees of freedom one is displacement, one is rotation I can never get this. Is it your argument? If that is your argument then, you are wrong. That cannot happen it can drill still remain symmetric. Think it about, why it cannot be symmetric?

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