Computer Methods of Analysis of Offshore Structures
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Module – 02
Lecture – 21
Tension Leg platforms - 2

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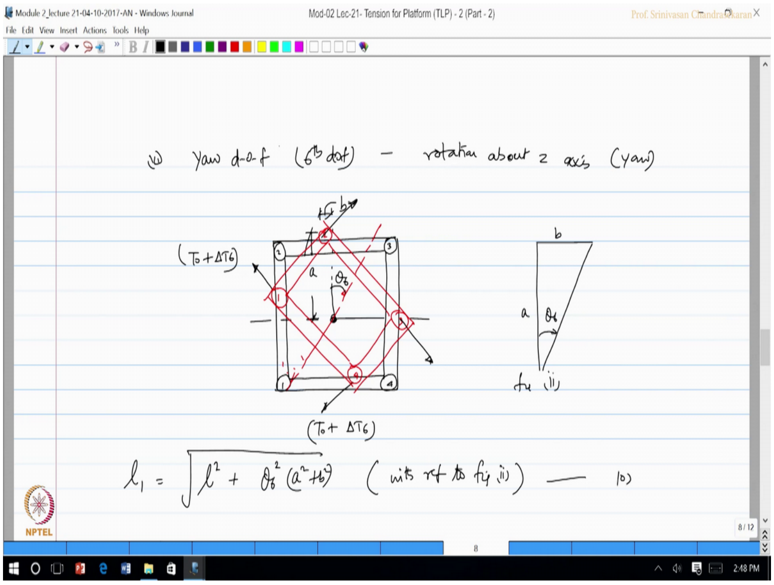

Let us now do for yaw degree of freedom, which is the 6 th degree of freedom go back to the plan again this was the original problem this is the plan, I redraw the plan again. So, there are column corners what we have here the columns.

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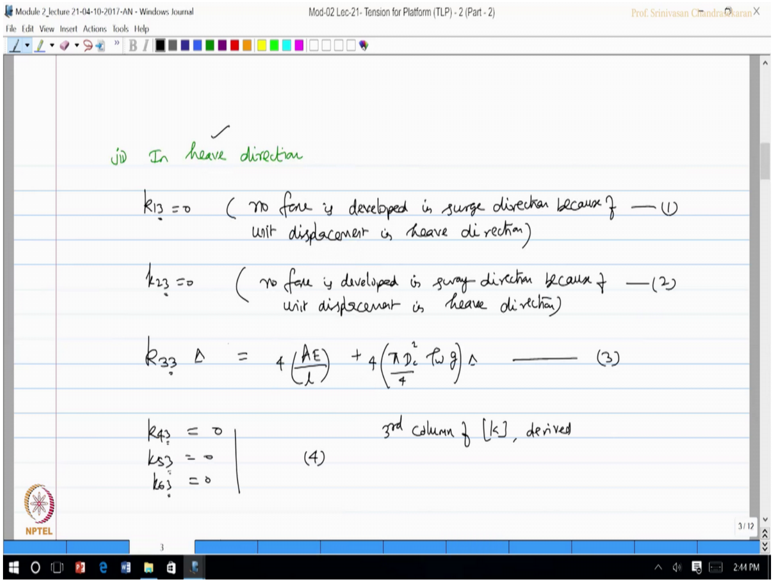

These columns are numbered in the same manner as we have here 1 2 3 4 same style.

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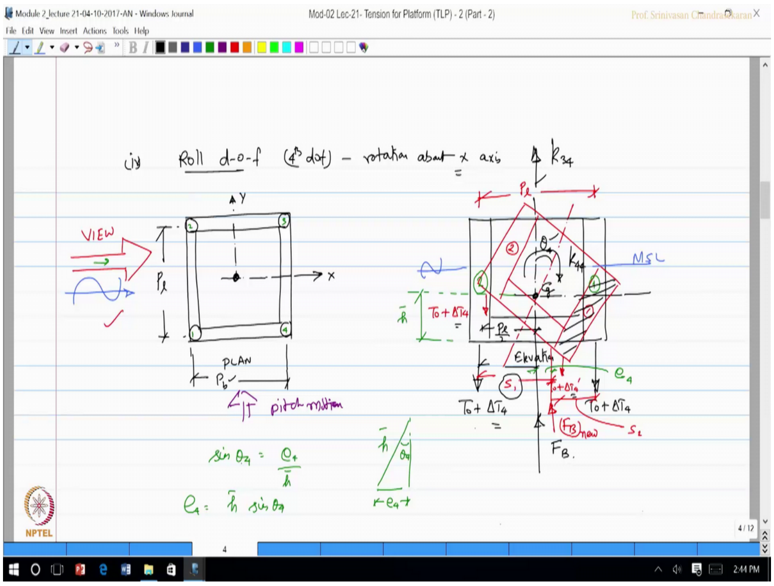

Let us say 1 2 3 and 4. Let us say I have I am also going to mark the centroidal axis of this, now I am going to give rotation about the z axis that is yaw. So, let me draw the new position let me give the rotation, let me draw the new position. We call this angle as theta

6, let us this is going to be 1 2 3 and 4 I have rotated clockwise, let me call this dimension from here as a and from here this dimension as b, in simple terms d of set with a of set will give me my rotation.

These legs will undergo new tension which will be T 0 plus delta T 6, this leg will also now undergo a new tension which will be T 0 plus delta T 6 and similarly all of them that is how the rotation happens. So, now, the cable length will increase by a small amount which I call as l 1 which will be l square plus theta 6 square of a square plus b square the whole root with reference to this figure, I call this as equation number.

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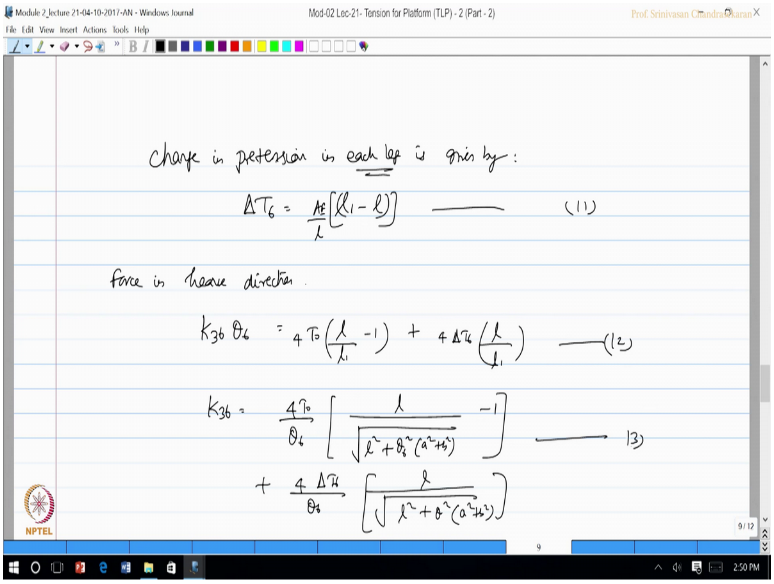

So, change in pretension in each leg is given by delta T 6, because rotation is about 6 degree which will be l 1 minus l of AE by l that is in each leg this is equation number force in heave direction. Due to this rotation will be k 36 into theta 6 which will be l by l 1 minus 1 of T 0 of 4 legs plus l by l of delta T 6 of 4 times, which gives me k 36 as 4 T 0 by theta 6 of l by root of l square plus theta 6 square of a square plus b square minus 1 plus 4 delta T 6 by theta 6 of l pi square root of l square plus theta square a square plus b square.

I call this is equation number 12 and 13.

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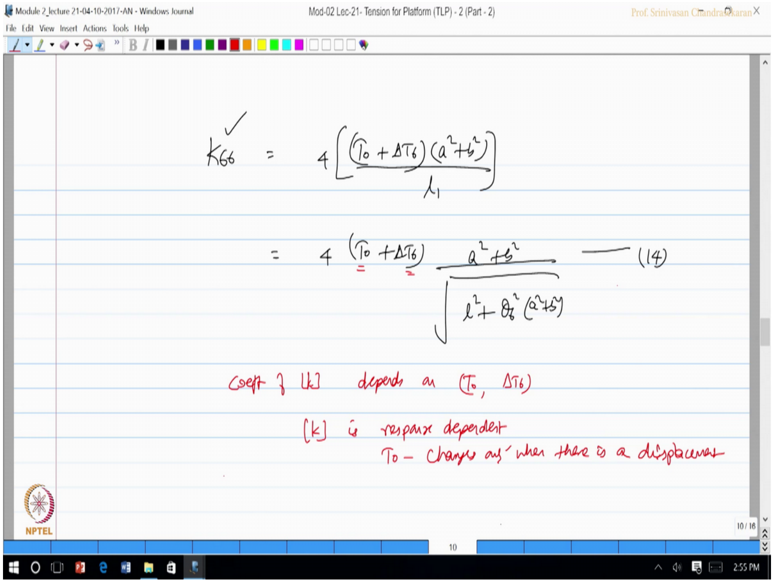

K 66 will be now equal to T 0 plus delta T 6 of a square plus b square by l 1 of 4 times which in simple terms 4 times of T 0 plus delta T 6 a square plus b square by root of l square plus theta 6 square of a square plus b square. I calls this is equation number. So, friends let us now assemble the stiffness matrix.

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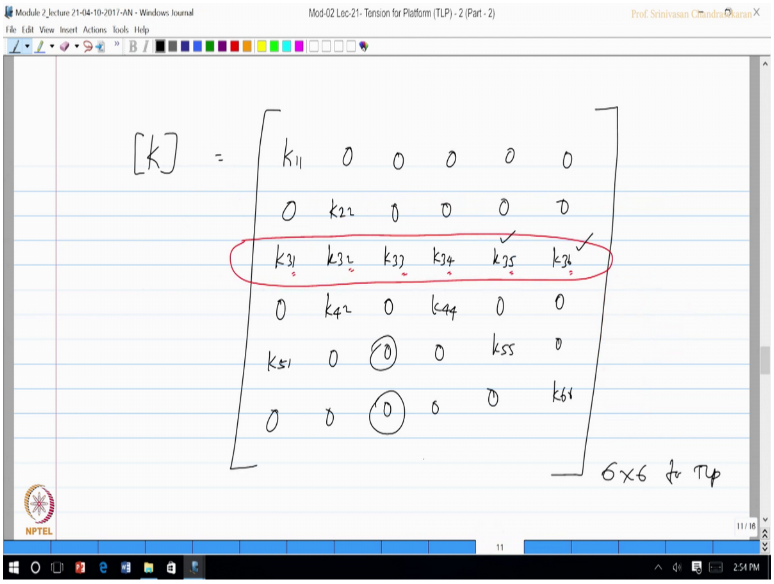

Let us say the stiffness matrix derived from first principles is like this, which is k 1 1 0, k 3 1 0, k 5 1 and 0 0 k 22, k 32, k 42 and 0.

All values of 0 except k 33 in heave similarly in roll we have k 34 and k 44 remaining all are 0, in pitch we have k 35 and k 55 remaining all are 0, in yaw we have k 36 and k 66 remaining all are 0.

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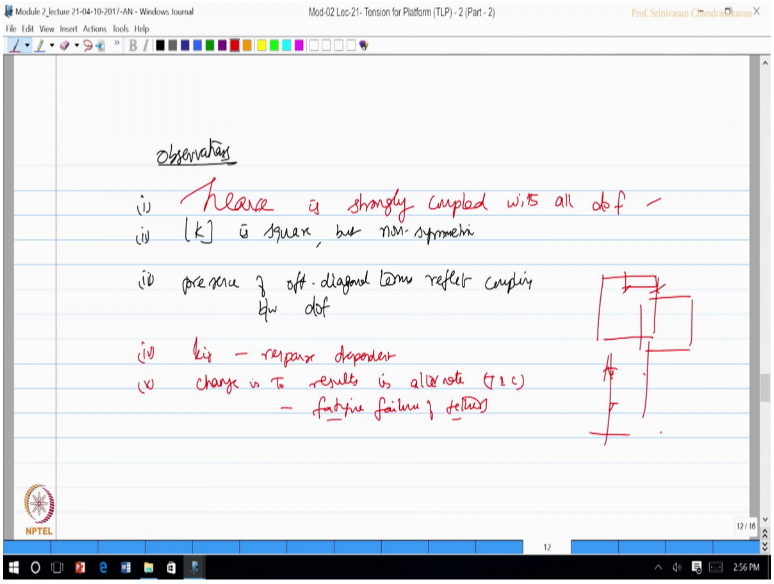

So, that is my 6 by 6 stiffness matrix for TLP one can very easily see some important observations on this for our understand what are the observations we can see from the stiffness matrix first and foremost you see heave coefficients of present in all it means you give unit displacement in surge sway heave roll pitch and yaw.

You get forces in heave direction in all the case; it means heave is strongly coupled with all degrees of freedom. You take a box which is floating give a heave displacement it will influence surge influence sway everything. So, heave has got of strong coupling the second observation what we have is stiffness matrix is square and non-symmetric. K 36 is present by k 63 is not present for example, k 35 is present k 53 is not present.

So, stiffness matrix is square, but non symmetric. So, it also says that presence of off diagonal terms reflect coupling between degrees of freedom take for example, anyone specific coefficient let us say k 66. So, the coefficients of stiffness matrix depends on tether attention variation and change in tether attention variation you see here. So, I should say that k matrix is response dependent, because T 0 changes only when there is a displacement.

Number 1 change in T 0 k i j is response dependent, change in T 0 results in alternate tension and compression which results in fatigue failure of tethers. So, friends interestingly in this lecture we have learnt how to derive the stiffness matrix from first principles.

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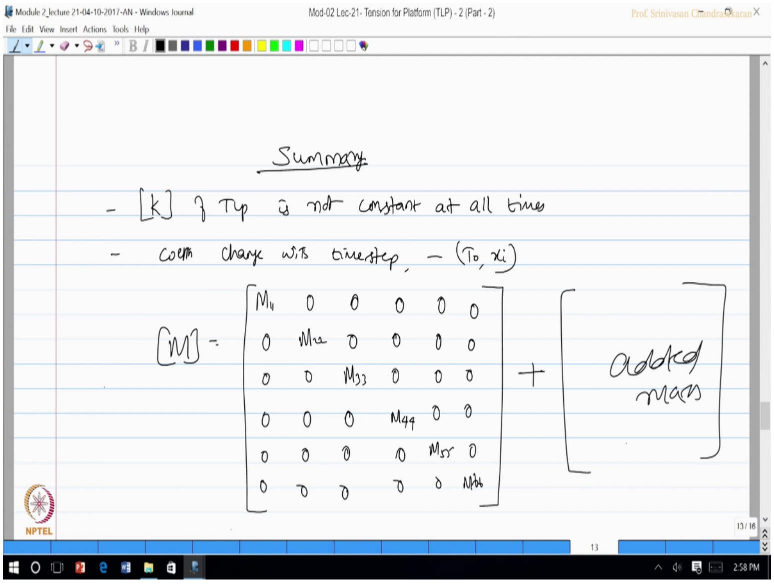

So, one can give a very clear summary the stiffness matrix of TLP is not constant at all times, coefficients change with time step which depends on T 0 and x i.

Let us see what would be the mass matrix, if this is my mass matrix which is again going to be a square matrix I should say M 1 0 0 0 this is also going to be 0 and 0, similarly M 2 0 all zeros similarly all zeros with M thee then all zeros with M 4 or M 22, M 33, M 44 and all zeros with M 55, and all zeros with M 66. This is the ideal mass matrix, but some added mass will be added to this.

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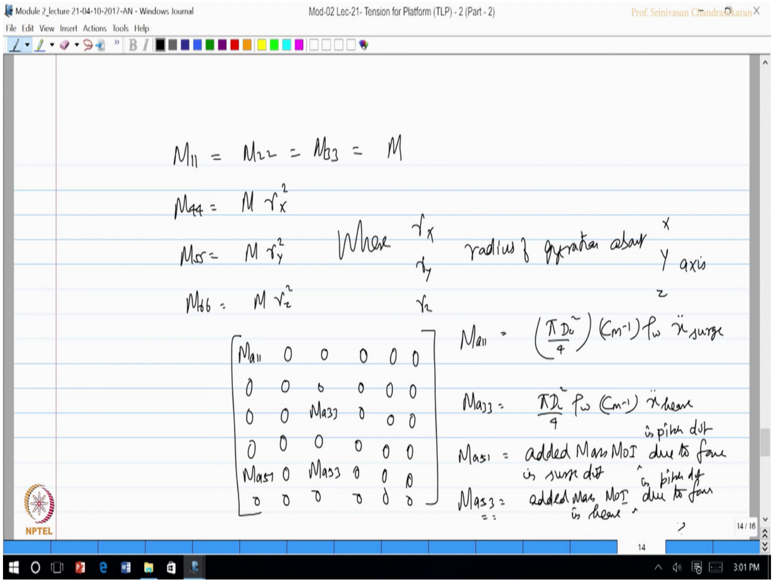

Let us quickly see what is my M 11 M 22 and M 33, this will be equal to the mass of the platform M 44 will be the mass of the platform into r x square, M 55 will be mass of the platform into r y square and M 66 will be mass of the platform into r z square, where r x, r y and r z are respective radius of gyration about x y and z axis respectively. Now what would be the added mass term? The added mass matrix will be interestingly M a 1 1 0 0 0 M a 5 1 and z0.

Similarly, nothing added in the second column, but in the third column there will be M a 3 3, in the fourth column nothing added there will be M a 33 and M a 53 fourth column then fifth column and 6 th column. So, what is going to be M a 11; M a 11 is going to be pi d c square by 4 that is a diameter of the column into C M minus 1 n rho w of x dot surge.

Then what is going to be M a 33 which is going to be pi D c square by 4 into rho w into C M minus 1 of x double dot heave then what is M a 51 and M a 53. M a 51 is added mass moment of inertia due to force in surge degree similarly M a 53 as you correctly guessed is added mass moment of inertia due to force in heave degree.

So, this is the added mass moment of inertia in pitch degree due to force in such degree similarly the added mass moment of inertia in pitch degree due to force in heave degree that is why it is M a 53.

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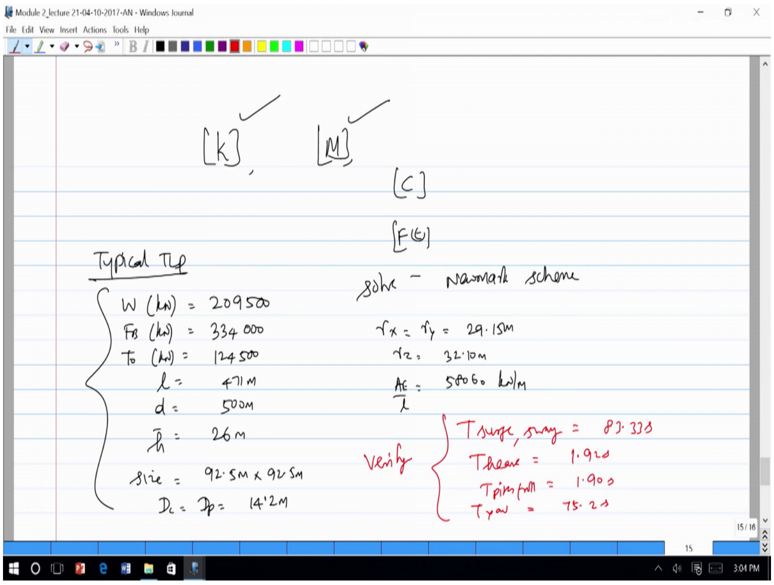

Now, we have k matrix derived I want to use the computer program to find c matrix and then f of T and then solve the problem by Newmark's iteration scheme which we already gave you in the last lecture. It is a typical TLP very interesting data will have weight in kilo Newton's as 2 0 9 500 buoyancy force in kilo newton has 3334 triple 0 T 0 in kilo newton it will be 124 500 for a length of 471 meters for a water depth of 500 meters.

The h bar is generally seen as about 26 meters for this platform, the size of the platform is 92.5 meter by 92.5 meters. Diameter of the column and diameter of the pontoon members are about 14.2 meters, r x and r y are 29.15 meter and r z is 32.10 meter and the axial stiffness in cables is about 5 8 0 6 0 kilo newton per meter. There is a typical example TLP, based on which I want you to find out the mass matrix the k matrix run the software or run the coding which I gave you in the previous lectures, you will find that the period of surge and sway will be about 83.33 seconds and period of heave will be about 1.92 seconds and period of pitch and roll will be about 1.9 seconds and period of yaw it will be about 75.2 seconds.

So, please verify these results using the program of I can solve which we gave you in the last lecture. So, this lecture summarizes how to estimate the stiffness matrix, the mass matrix and of course, the damping matrix for a typical TLP as you see on the screen now.

Thank you very much.