Elements of Ocean Engineering
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Lecture - 47
Tension Leg Platform (Contd.)

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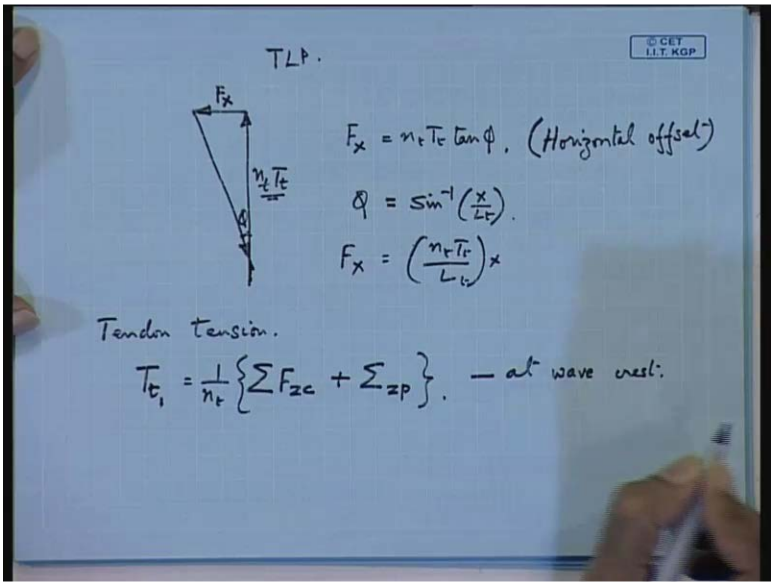

Coming to your the Tension Leg Platform to we will continue try to finish this. Now, you are effects is the horizontal force summation of your horizontal wave current, and the other wind forces. Now, your n t and T t is your ((Refer Time:01:19)), so effects you can write, so tan phi is in this form n t T t tan phi is it ok, so this one effect is n t T t of tan phi, phi is this angle. So, now, this phi is your already calculated as from the previous diagram if you look, so this was sign inverse of x by L t, so you can calculate phi.

So, from this tan phi you can get this is the horizontal off set force, now offset this angle phi is of the order of the 5 degrees. So, you can approximate this into F x is equal to n t over T t L multiply by x, can phi psi phi moral if you can see the same, so this is our expression for horizontal offset. Now, coming to the tendons tension this is more complicated, so tendons tension actually is made of two parts, so the first part you can write T t 1. So, this is 1 by n t you some all the column forces sigma F z c, in the z direction, and two forces in the z direction. So, this is one, so now this is at wave crest.

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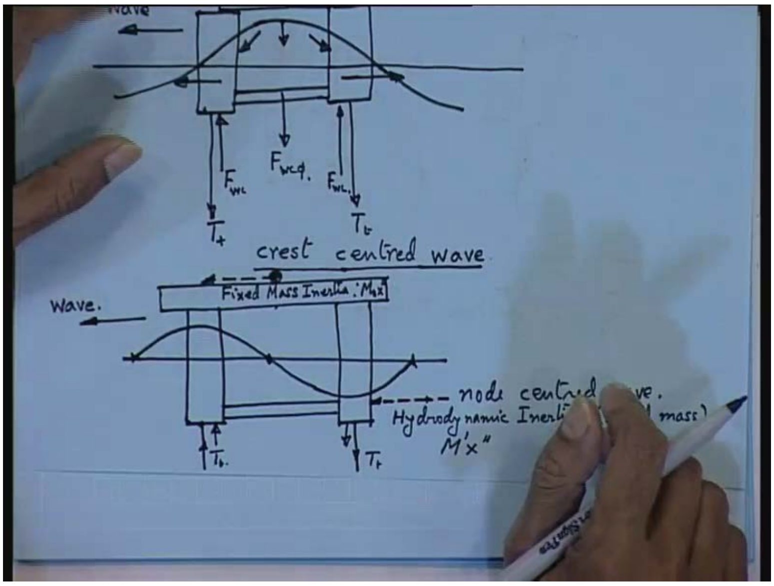

Now, coming to the hydrodynamics part actually this more complicated and a you find that these situation is like this. Say the TLP is writing crest, say this is your still water level and this is the crest of the wave, now you have to calculate the wave particular velocity and acceleration. Now, for all practical purposes use the linear wave theory there are other second order forces, but which will be more complicated.

Now, let us suppose this is the situation TLP is writing a crest, now here actually the forces are moreover singular, say this is your TLP. Now, what is happening out here is that at the crest, the acceleration, the horizontal acceleration you write this is 0, now you what are particular acceleration vectors will comes like this at a crest. Now, this will be exhort the out ward force on the column, so this is happening your tendency tension will the acting downwards, say from this end.

What are the other forces, you are out here in the columns you will get a force this is force on that based on the column. The base on the column another force, and here another force will active downwards, so this is actually, the lot of hydrodynamics forces coming into pay. Now, in this kind of situation you will find this expression is valid, this T t 1 you simply add the column as, the photons forces.

Now, the other problem is when it writing a, so this is you write crest center your TLP is crest center. Now, suppose the wave has past the direction of wave ((Refer Time: 07:03)) in this direction from right to left this is wave travel, so add you every time you will not find the TLP this on crest. So, the wave has passed the TLP is no under a crest, but this is called a load, so actually this part of the structure is more from the hydrodynamics side.

So, this is a TLP is now resting this mode, so your force equations will change, so this kind of situation is called load center wave, crest center wave you write. And this one is called, so this is one node, this is another node where the wave crosses the steel water line. So, this is called a node center wave, here actually the you have to very careful in the analysis of the wave forces, this is called node center, now here actually you will find that when the direction of wave travel is the same.

So, this is your wave travel, now what will happened in this kind of situation there be a inertia of force. So, you to calculate the moment of the inertia of forces, and there will be a trip because of the passes of the wave the whole TLP, now this is acting under this is tailor. Now, because of tailor it cannot write the wave as it as few floating structural semisubmersible, so it will trend to trimming action, now how to resist this trimming moment, you trend to capsules.

So, that is counter by or is called the inertia force, so inertia force is going to act in this direction. So, this is your fixed mass inertia, what is fixed mass what is mass of the platform, fixed mass inertia force, now if you want to calculate this you have to calculate this, mass of the platform and the acceleration in the horizontal direction. now TLP you should remember that TLP k g is near the deck just below the deck. So, k g is very high, so that is not good to suitable for you are the stability calculations, so stabilities actually provided by the tensioning the tailors.

Now, TLP mass is somewhere situated say around this junction here, it is shown on the deck level of course, of the top sides I have not shown. But, in diagram it is somewhere here, now there is another force that is also inertia force, that is active at the suitable column. Now, here actually all this calculations in the field if you do then you can gross the problems, so this is called a hydrodynamic inertia of force.

Now, in common term this is called your added mass, which with your more familiar here you have to calculate these forces. And this of course, you have to calculate added mass say in prime multiplied by acceleration, you should always remember that inertia force is always connected with acceleration. So, these are two predominant forces, the other forces will find the tendon tension on the, this column it is acting on downwards, but on the other columns it is acting upwards.

So, your force vector have changed, so you have to analyze the number of positions of the TLP with respect to the wave. And you find out the dispositions of the forces, then you calculate the over turning moments, moment as well as the forces and you have maximum you write, the other term is a he as calculate the moment. So, the first term as given the do this the TLP, on the second term you can denote as T I 1 divided by s n t you have s is the length of a together, s the nodes length of tailor.

So, from the second diagram you calculate all the moments and you divided by the momentum s and t momentum actually, number of tailors and this is your length. Because, you are submitting all the forces, so F w x this is z w try to find out the center of this forces and this is your moment m 0 is the moment and the z j. So, this moment divided by liver arm will give you force and this is dell actually your delta m naught is 0 added mass.

So, this is mass plus added mass and this is your hydrodynamics force, so this multiply by the acceleration, the other one is only force ne columns. So, you try to find out the moment, so this is s is liver arm plus the moment on the photons, all this moments are calculated and divided by the liver arm you get the force. So, this is now you the other thing that you have to find out is maximum tendon tension.

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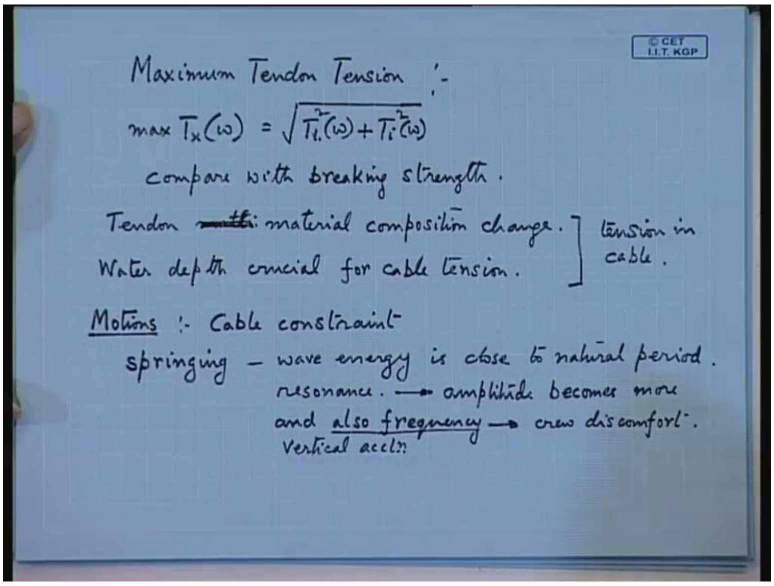

Now, this is very important, so you have to find out the breaking stress, so you should see that, the maximum tendon tension does not exist the breaking strength. So, this will be maximum of T x omega, omega is depends on the wave frequency. So, this is your root over of this T T 1. So, at a particular frequency you are getting this, so you write this square does T I square is also particular wave frequency.

So, this is maximum tendons tendency now this you compare with breaking strength, so you have calculating cable tension is not all the easy, because you have to find this center of all these forces and moments, it calculate the liver arm and then. So, this is as it is now here you will find that if this is the situation, then breaking strength you can go for height and size still, tendon material composition change normally the how you can make of mile still in ship normally use a gradient mike still another.

But, you can come to the tailors tensions and the mile still of course, would not do you have to go for height and side still and now it is they making it of one or two materials the joints together that is called a hybrid. So, this are some of things that are going on same things or riser actually because of this force calculation and the other thing that we have found out is these the water depth, actually important part cable tension and can you figure this out where water depth is important.

So, in our first calculation you can see this the horizontal off set, so this actually depends on l. l is the length of the cable that means, water depth here actually the water depth is coming in to play and effects actually plays a role in, your tension t t cable tension. So, what are depth actually is crucial for cable tension, so these are two guiding parameters for tension design tension in cable. So, this is the this is the peculiarity of TLP as oppose to semi submersibles.

Now, the coming to the motions are actually little bit different from semisubmersible because of cable constants now here actually you find there is a spring motion. Now, this happen when wave energy is close to platform natural frequency or is closed to natural period. So, this causes regimens this is called spring, now the spring first thing the amplitude of response is becomes more and also frequency. Now this actually the frequency cause discomfort crew. Now, how to correct this there is another crew discomfort that will also come, so this is cause of vertical acceleration plat form.

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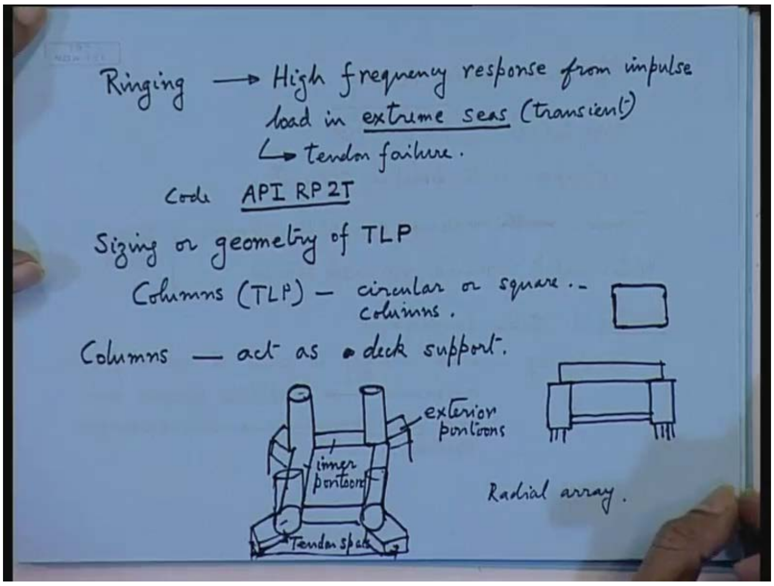

Now, the other phenomena this is called ringing, so this are high frequency response, is from impulse from impulse load it extreme seas. Now, this is transit in nature, so that means very large wave comes and impacts, the platforms that is called ringing. So, this high frequency response the other one is a low frequency one. Now, this actually causes tendon failure, now actually, so that means when you calculating the hydrodynamics load you should know this, extreme seas states they do not occur all the time in the open of ocean.

But, sometimes they can period have on the platform, so this are some of the points that you, should remember and for this the code that you follow is A P I American petroleum institute A P I report two T. I do not have this reports, but this reports of the American petroleum institute have fundamental design. So, wherever your designing your semi submersible TLP is you either follows, you should follow this both this coded a b s a p I or d m a g a p I.

So, these are some of the characteristics which will come now coming to this hygienic or geometry. So, basically this is your lines spine, now you find that all this plat forms there is TLP semi submersible, they are I mean regular in shapes not like your ships curvature changer and all mole is not there, these are actually prismatic shape uniform cylindrical surface or square pontoons.

Now, debit has exhort values columns can be circular or can be rectangular columns, TLP whether you go for circular or you go for square type columns. So, which one you prefer, now if you go for this circular design, so that means, this structure is reader deal and these are square means flat panels. But, this are actually difficult to fabricates, now square is very easy simple flat panels, but square if you go the corners you have to make rounds.

So, you made in structures actually you will finds you normally ((Refer Time: 24:41)) above this shaft bands or shaft corners you always make round like this. Now, here actually lots of designs have work on this aspect, the circular or square columns which one is true prefer. Now, this is one point and columns I told you, basically act as deck support. So, deck is supported on the four corners by, the four column.

Now, the problem that has come out is regard you find in the simplest of design, that is the TLP deck is resisting on four columns and the four corners. Now, columns are also another point of, engagement of details tailors are also connected to the columns at the base. So, where the columns are located, there you have to locate the cable, it you do not have much choice in this kind of geometry.

So, geometry involve from this now people are also now what they have done they engineers, they have made a provision on the columns. So, this is called if you draw it three d view. So, this is one column now here the pontoon is called a closed e direct pontoon you make a close sort of r a. Now, you still keep the columns at the corners of the close direction, but there is a important difference you will find and why it has done arbitrary.

So, this is the position another column, so another column is coming this is called the close direct you have another column out here, another column out here. now, this is called inner pontoons, now here you make a conclusion you joints smaller pontoons out here, here you can see. Now, why you are doing this according the book you get a, so this is called exterior pontoons, now you can attach at the corners of this exterior pontoons.

Now, the reason is you make a greater tendon specify, you increase tendon specific by this see if you do not have the exterior pontoons, you have to press the tendencies of cable bottom of corner. So, that means, your tendon missing with this, now this is done properly already reduce the preaching of the peach force, preaching income in the situation that I have told you, where in the TLP is writing in the particular node, not at the crest.

But, this case you will find TLP will tend to thought up pull over, so that is called preaching or trading order you have prevent this it does not found that if you increase the this is called the tendencies spray. So, that will reduce your preaching force because you are getting a greater new arm, so obviously, you have force on the tendon will decrease. So, that is one way out the other advantage that your getting is your not distributing the desk support.

If you place the columns at the outer end of these exterior pontoons, then you are the desk span will increase. So, you are not increasing the desks span desk is efficiently supported, so columns are essential points for desk support and you have done this is called a radial I think this is called a radial array probably. Now, in some other design you will find this columns are brought together more closer, but this exterior pontoons are much more longer, in the previous diagram that I have draw, there actually the deck area is not that much required. So, here actually you can alter the deck area or deck spacing without disturbing the this things tendon arm. So, that is one way of the design or TLP, so TLP design actually you find is more centered motion limitation.

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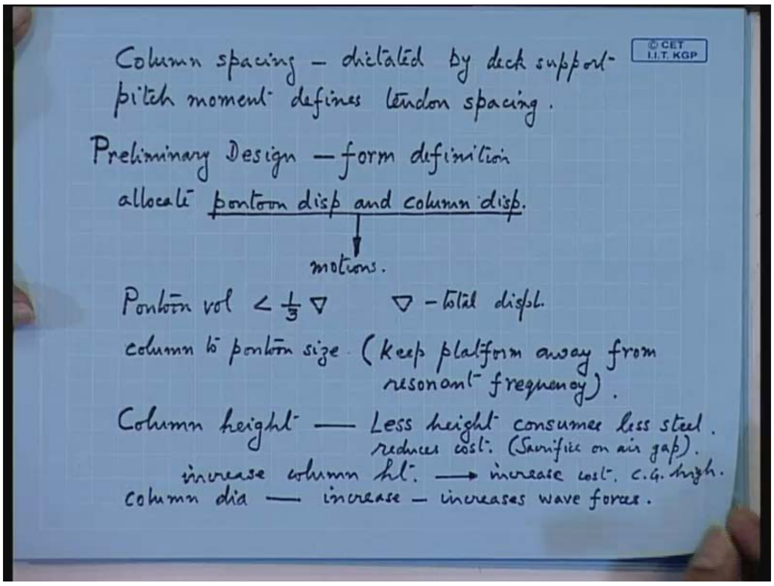

So, columns spacing you will write dictated by deck support, now if you find that four columns are not sufficient, your 1980's design you will find another column at the you can place another columns on the a center of this pontoons. But, you will find the deck there is no support at the there is this kind of close structure does not have any braces or supported at the center and without braces.

So, essentially your TLP you have to design without because at the same center you have some opine for your conductors piles to pass. So, conductors basin on the deck that will also govern the size of the inner pontoons, I mean the gap in the in between the inner pontoons. So, this is called the pontoons specifying and this is the column spacing, so this are some of the column spacing dictated by desk support and a peach moment this is an important area, peach moments defines what defines tedious spacing.

So, lot of mechanics actually you have to calculate, now coming to this the phenomena design, where you have to design the form you basically your form definition. Now, here you have to allocate pontoon volume or pontoon displacement, and column displacement binding this are in the initial design you have to work this as separate. So, how much pontoon displacement you have to allocate from the total displacement, now what precious govern this, so this you find these based on motions.

So, there is the relation between pontoon volume and total displacement, now in mostly the find pontoon volume will be less than 1 3 rd of total displacement. This delta is total displacement you really do not go for random sizing of pontoon and the column, just increasing the volume will increase the motion that will be a disaster. So, this is called columns to pontoon size, keep platform away from resonance zone or resonance frequency.

So, here actually the ratios of the column radius and the pontoons he has not be given, but that is also relationship, now column height. So, this actually less height consumes less steel, so this is point to be remember you give less column heights consume less column diameters are very large, columns heights consume less steel, so reduces coast. Now, every time you will find that you have to optimize between different parameters, you are not free and you are doing this you reduce try to reduce the cost by being on the column height.

Now, here actually you have to sacrifice air year gap, now air gap I am telling you very crucial internal. Because, TLP has the set down with the passage of wait the TLP actually when there is the offset that delta z will come, so then end the if you are not having sufficient air gap, the whole way you come and crash on the deck. So, this, but at the same time you have to try to optimize between this two that is column than the air gap, you do not go and if you increase column wise what will happen.

Suppose, you find that you want to give very high air gap, high air gap can given by increasing the column height. Were here you find first of all you increase the cost no doubt, from the mechanics point of view you will find that C G has grown up, so that will cause a water the stability will be a problem because of your G N criteria. So, this is you have to strike a balance between this two, column diameter if you have sufficient diameter. So, that will give you sufficient base area for support your deck, but column diameter if you randomly increase, this increases wave forces that is another problem you will find. So, you cannot arbitrary increase column diameter, so this here actually the ratio are not given, but you find when you design you better you go for similar TLP's.

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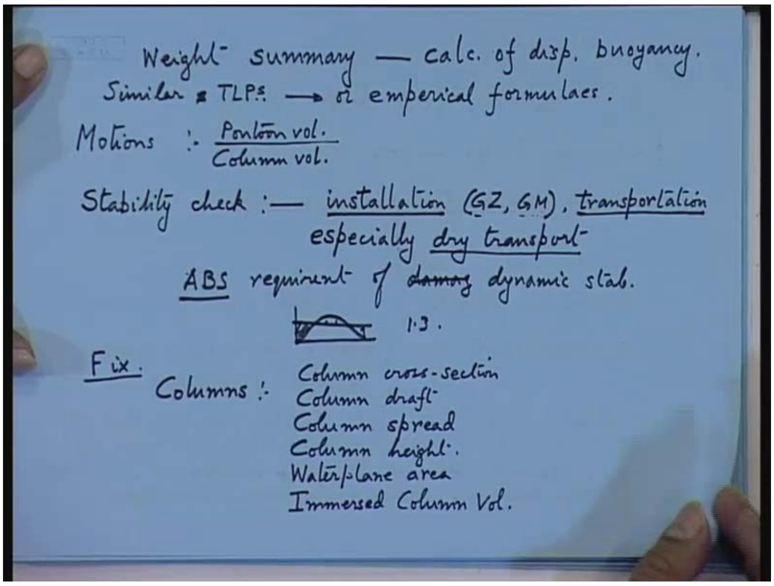

Now, here the problem that I have told you is that you have to remember design for first thing you make a weight some module. Now, this is very important for calculation of displacements and buoyancy hydrostatics you make a, but weight somebody at the initial stages how you do, you do not have data. So, here actually what has been done normally you find from similar ships, if you have weights some body or similar TLP's or tap records to some formulas empirical formulas based on column diameter upon do length and all this thing.

So, there is the quick thumbnail for adding at the displacement, so once you find out of the diameters of length diameter is another next job is find of this displacement. And then you have to work out the buoyancy, so buoyancy should have gives sufficient tension in the cable, your cable at all times should be touched it should not be loose or having some curvature, then play have up then you have lots of motions. And cable will try to get twisted with one another that is what working will come, there platform you will try to do rotate.

So, that is quite very dangerous because that will be two cables, so here you take recalls the impose formulas you decide on the displacement. So, this is the first part of sizing, now the second is the motion calculation, so motion are I already told you, the motions you find the most important is the pontoon volume by column volume, these are the ratio is determines the heap and the search motion that the data I have not got. So, I cannot give you, now.

And the next is stability check, so these are the important arms of your preliminary design, the spokes in the design by road piles. Now, stability is very, very important during this installation, now here you find your G and G Z G Z, G M over everything has to be calculated. And the other point is during transportation is specially what especially dry transport, so this the installation and transportation face actually determines easy of the platform.

Now, when you transporting the TLP say or a offshore burgee, so; obviously, you cannot keep the G very high, there definite rules on the areas will give you definite guideline for this sort of thing transportation, this is called dry transport you look up it is requirement on damage stability not damage stability, dynamic stability D Z curve, what is the proportion of this area to the area, here ratio you enter in some 1.3 I think criteria.

So, this is just look of the areas criteria dealing transport, dry transport or installation specific procedure given to G Z and Z M calculation. Now, after this by this time, but here actually the installation and transportation, if you find that your G Z and Z M not favorable because this are again optimize values. You will depend on your column length, column height, pontoons all this things we cannot very much.

Then you do not transport or installing rough weather, you always try to install and go for transport fare Wellers. So, whether actually this is important criteria during the installation and transportation spacing, now so here the decision that fix these items, after you preliminary design columns. Now, you have already fixed column cross section, now in ships actually what you fix preliminary design, then bread, draft and all that.

So, similarly here your column cross section is one important parameter then comes column draft. Now, next is columns spread, so this are some of the important parameters, which you have to find out after preliminary design, column height, water plan area. Now, water plan is given by the column cross section, so water plan area is very important for each calculation, and last is the most is regards to columns are of course, column he must column volume. So, this are the parameters to be found for the columns after you fix your displacement.

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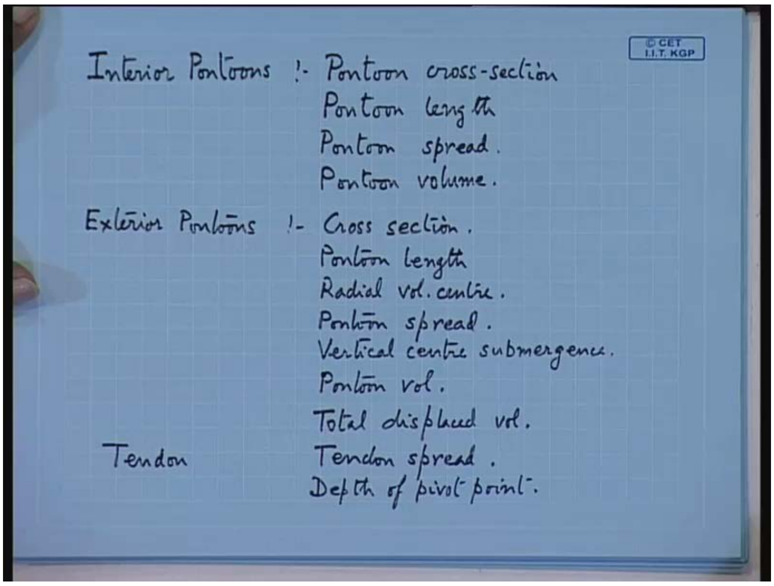

Now, if you have interior pontoons, so; that means, you can see you have to fix, so many parameters in ships are the you find therefore, 5 or 6 parameters. Now, you have to find out pontoons cross section, pontoon length, so you see the columns and pontoon are different. Now, what has to be pontoons spread their distance between the two calculus pontoons that is called pontoons spread, now pontoons spreads is actually dictated by columns spacing then of course, pontoons volume.

So, all this items have to be calculated then comes if you have exterior pontoons, again cross section, so similarly pontoons length. So, this will pontoons length will depend on radial volume, volume central, because exterior pontoons are this is basically your location center of gravity. Pontoon spread vertical center that is your VCG. Now, why this is important vertical centers submersibles, you find this vertical center of the pontoons is actually location point for you tendons the cable actually. So, pontoon volume I already talk about pontoon length you calculate pontoons volume, and total displace volume. And before you finish you find out tendency spread and depth of pivot point, so this are the some of the parameter which you have to fix your preliminary design.

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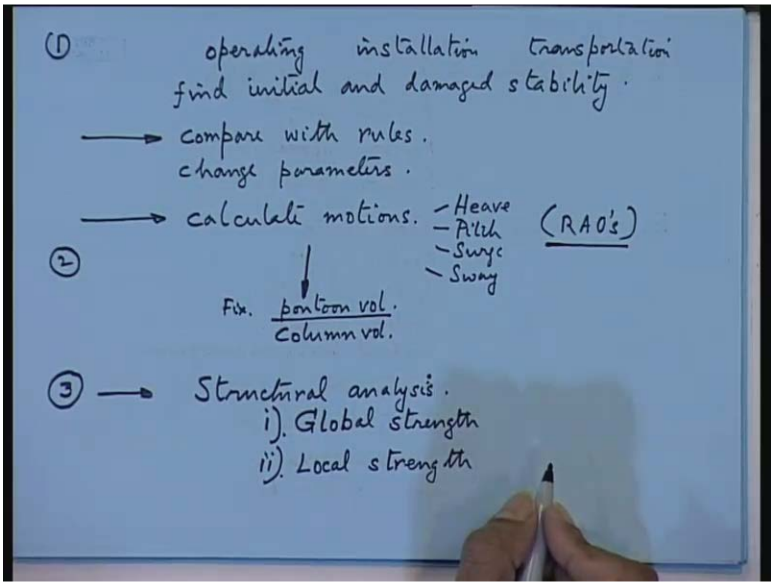

Now, the limitation first thing that you do here is your design spiral first at every stage at told you installation, transportation and operation mode you find this out operating, installation, transportation you find initial and damage stability, your this are the three basic load criteria, load stability. In this three mode you have to find out your G M G Z curve damage G Z all this things you have to do, now you have this you can do it your max of you can find you can do it.

Now, this you compare with rules, now you have first job now next job is based on this you change, if you do not have this sufficient stability then change parameters basic job. Next calculate motions rows have to be calculate, this are normally what the do is you make a module and do tank placed, you have to determine this base done in the c p tank which of course, we do not have. So, this is now here you fix if you have favorable motions, fix pontoon volume by column volume.

So, your parameters are guided by specifically this two conditions, a last is your structure analysis. Now, structure analysis there are two types, one you have to find out global strength, the other is called local strength this are discuss later on, so after you do all this three calculation when then fix up your parameters with that we finish preliminary design, so after this you go for detail design, let me end here because...