Elements of Ocean Engineering
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Lecture - 34
Mooring Systems (Contd.)

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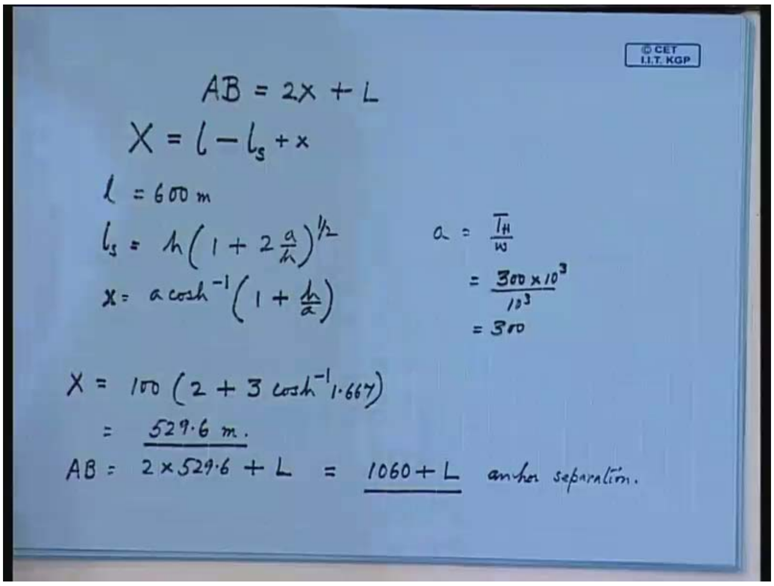

They have an office in Chennai, alright. So, let us continue with this problem. So, we have found out this 1060 plus L. Now the next problem is line tension of the platform. So, find out the line tension formula, formula for T.

Student: T H plus Z t, sir.

So, what is the formula for t, I have given you? Now line tension you put z equal to zero.

Student: T H plus w h.

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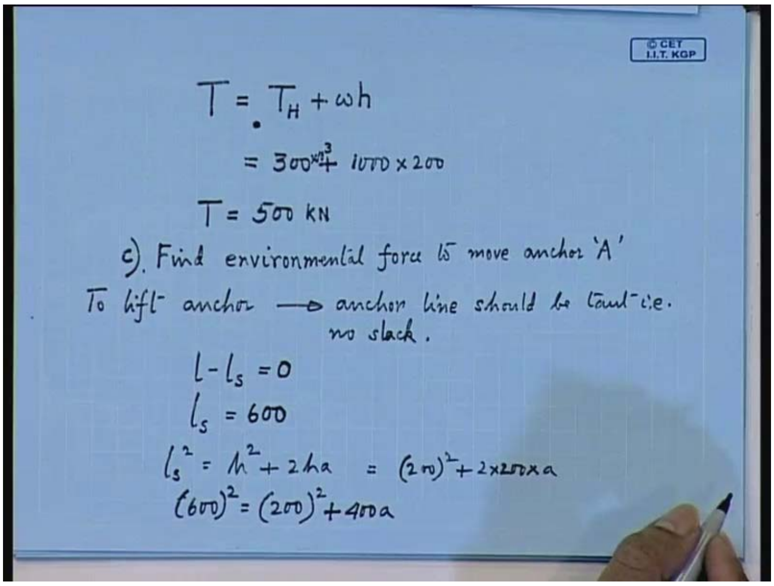

So, line tension is T equals to T H plus w h. The other part actually becomes 0; that row minus what is it? g j z, z equal to zero, so that we will finish. So, this is straightforward, no. So, T H is already given. So, T H is coming as 300, and w how much it is given? So, this is 1000, and the sea bed is 200 meters. So, why, acha (FL), kilo Newton's; so w is, no w is 1000 Newton per meter. Oh, this is 300 line tensions it is kilo Newton. So, this is 1000. So, T how much we are getting?

Student: 500 kilo Newton.

So, T is coming as 500 kilo Newton's. Now the cattiest part of the problem is c. c is you will find out environmental force to move anchor A. So, what happens when you are trying to move anchor A? So, this is the situation that is let us say that there is no environmental of course, static case. Now this because of the rise in, say, wind or waves; the ship has started moving in this direction. So, what will happen? So, this is there is a slack in the line; slack is L minus L s. So, this will try to become taut, is it not? See you just conceive in your mind. So, your vessel is actually going in this direction. So, since there is a caternary there is slack, line is slack; this is called slack line.

Now you try to move this in this direction. So, this will try to it is going to try to lift anchor. So, if you do not do anything and this is your connection point to the hall. So, this is fixed. Let us assume that this is fixed; you are not doing anything. So, this will try to assume; first it will try to straighten up like this, is it not. And then finally, it will be in this configuration absolute straight line. So, that means when you get a straight line there is no slack. So, L minus L s, what is the value of L minus L s; so we have to start from this.

So, to lift anchor this anchor line should be taut; that is no slack, but this is actually the hint in the problem. So, that means what is going to happen? An L minus L s equals to 0, but you have not either heaved in the line or paid out the line. Heaving means just winding up the reel, and paying out means you are increasing the length of the line. So, anchor this, anchor either you can rotate in the clockwise or in the reverse direction. Now normally you will find when there is a storm, the captain of the ship actually he has to calculate, right.

So, you will find that you make the line taut; that means the tension is going to increase, we will find out from this problem. You will calculate the tension; you will find tension has increased. So, we have started with tension how much? Tension we have started as 300 kilo Newton's, but once you make line taut tension has increased. So, that is but ultimately how much you can sustain. So, you cannot keep on increasing the tension beyond certain limit. Then there is going to be an anchor line snap; the chain is going to break if it surpluses the breaking strength of the struggling chain cable. So, this you will see how much tension has increased.

So, your ship or platform is drifting in the x direction. So, in this case you put this equation L minus L s equal to zero. So, then what is the value of L s? L s is equals to 600. Now from this can you find out the value of a? So, what is the equation for L s? So, L s I have written that L s square is equals to something, l square plus how much, 2 h a, the one that we have derived. So, this is equals to h square plus twice h a. So, this is equals to, h is of course, the sea bed height.

So, that is normally the same. So, we are getting 200 square plus 2 into 200. Now you find out the value of a? And L s is how much? 600 square, is it not. So, this is out; here we are getting 600 square is equals to 200 square plus 400 a. Now from this you calculate the value of a?

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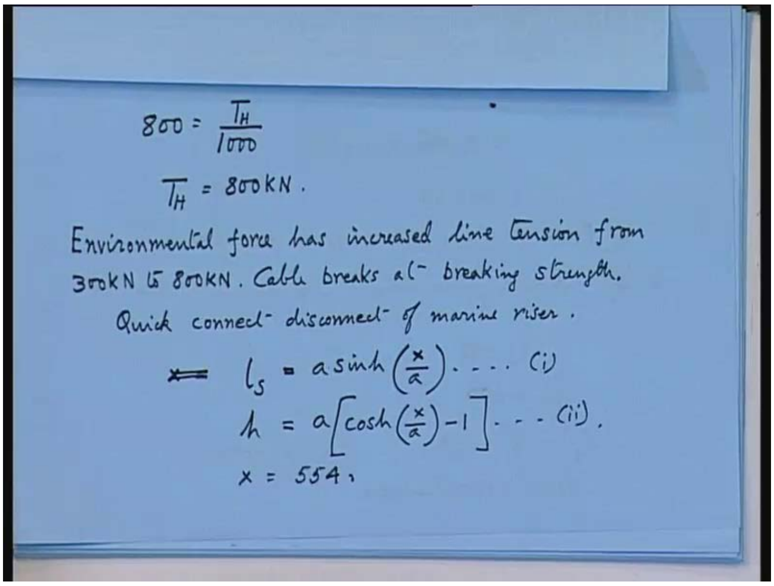

So, a you calculate from this formula; this is coming as 800 meters. The dimension is okay or not. Now what is the value of T H? So, 800 is equals to T H divided by w; w we have already gathered as 100. So, you see how much T H has increased. So, T H you have increased this to 800 kilo Newton's. So, what the environmental force has done? So, environmental force has increased line tension. So, this is going to be an immediate effect from 300 KN to 800 KN. Cable breaks at breaking strength. Now the environmental force increases; suddenly tour T H becomes equal to your breaking strength, your cable is going to break. Then what you have to do at that point? So, this actually you can monitor in the ship itself.

Now the captain of the ship is having a crucial decision no. He has to recover oil. The ship should not have a large amount of excursion; this is called excursion, because that will put undue stress in the marine riser. Your marine riser, say, it is your drilling platform is coming out here. So, marine riser also is going to be like this slanted. So, how much slant you can accommodate? This will produce undue tension in your marine riser. It is lot of excursion. Excursion you will be involved tensioning your riser; riser tension is going to increase. At the same time it is going to increase your cable tension also.

So, actually you find that there will be no other option, but the thing is that if you increase this line becomes taut, then the tension becomes near to your breaking strength; breaking strength is around I think 1200 or something, it depends on the steel. So, the captain has to decide on these two aspects whether he is going to sacrifice this marine riser or the chain cable. Now if you want to save the chain cable then allow ship to drift allow drift. If you allow drift then you payout moor anchor chain, keep on paying out and this you allow to drift you will reduce.

Basically what the captain will be doing? He will be reducing the tension to save the chain cable, but now you are paying out. So, you are happily going in the x direction; you are increasing the tension in the riser. So, your riser is getting a configuration like this. So, you cannot do this to a large extent; it is because risers snap is going to take place. So, there is always a limit on excursion. So, you will find that most of the machinery and including your riser they specify a certain amount of excursion.

So, this cable breaks at breaking strength is going to, but normally if you are the captain the best thing you can do is, suppose the storm has come, Gulf of Mexico storm, okay, hurricane has come, what he does is he disconnect your disconnect marine riser. Now marine riser if you look into these pictures you will find it is not as straight as like this. They have some kind of, the marine riser will it may go like this. There is a loop like this, and there are the buoyancy. Boyars are here, and you make a loop such that when you disconnect it is able to float on this boyar actually.

So, you can take up later. So, you can hook it up. It is a hook up mechanism upon the marine riser. So, normally the ship captain has to decide when he is going to snap the disconnect marine riser, allow a ship to drift, allow drift. But at the same time do not break chain cable, and if the situation is unfavorable; that means he disconnects the marine riser.

Either you disconnect the chain cable, because if this is at the water line then you can disconnect chain cable, you go. You go away from the site, you leave the place. Then if you have your own propulsion mechanism you run away you see. So, that is normally done in the most extreme situation. So, this decision actually is taken by the captain of the vessel. So, here actually you will find there is what is called a quick connect disconnect system, disconnect of marine riser. So, in offshore if you go all these situations you will find, and after you are in the platform, say, one month, then you will try to run away from the platform especially if you are located in the south channel sea

Gulf of Mexico. South Channel Sea is very dangerous; that is off the Malaysia Burma coast. So, this is the thing that is going to come.

Now in our case we are getting an increase of 500. So, we have started with 300 kilo Newton, and here just to make it taut we have achieved an increase in 500 kilo Newton's of strength or stress in the cable. Now what is your x value? Small x, not the capital x. So, the small x formula I think there are two formulas I have given; one is the sign hyperbolic and the other is the cosine hyperbolic. Some of you can calculate from the cos hyperbolic and the rest you can calculate from the sin hyperbolic term. So, expression for small x; so small x actually you can calculate form h or from L s, either way you can do it. You see which one is more favorable.

See from this equation that I have already given you. So, this L s is equals to a sin hyperbolic x by a. This is small x not the capital x. From this you can calculate either use this equation or you use h, and these two equations I think I have given you, you just check. But since I do not have a calculator that inverse function you have to find out inverse. 524?

Student: 554.

So, Dhanusa has calculated x is coming as which formula you used? The first one or second one?

Student: Second one.

Second one you have used. So, she has got small x as 554, 554. So, how much x has increased? Previously what was our value of x?

Student: 529.

529 no. So, x is increased by certain extent.

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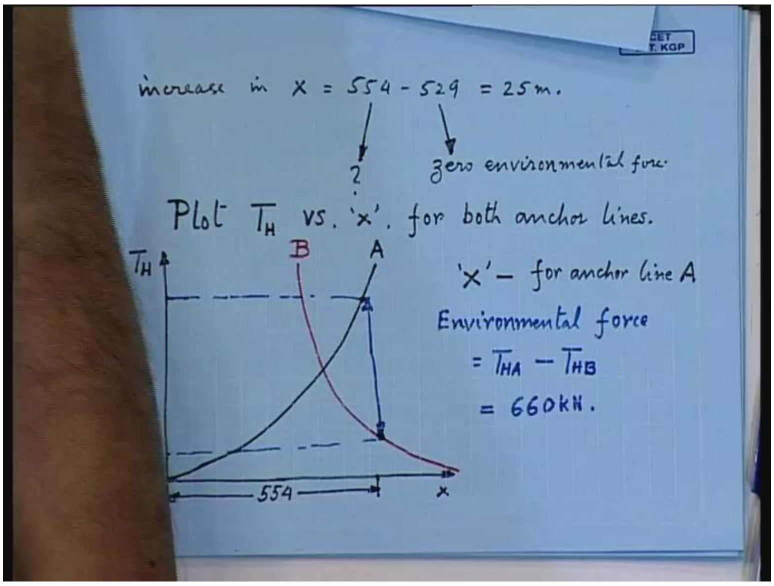

So, increase in x you write 554 minus 529. Sorry, this is 25 no.

Student: yes.

But you have to find out this environmental force. Now here actually this how much environmental force you have taken? Zero environmental force and this is you find out this. Now if you want to this you plot. Best thing what I suggest is plot T H value, T H, say, versus small x for both anchor lines. So, you will get a graph, say, for cable tension, say, anchored a line what should be the nature of this graph? So, this is your small x. This is T H; you get a graph like this. So, this is cable tension; it is your A line. Now you just tell me what will be the B line? Now x, mind you, what is it x? Which anchor line you are taking? X you write for you are measuring tension in chain cable B, but x is for anchor line A; it will look like this or some other.

Student: It is almost.

So, you will find your graph is going like this, but for the same values of x, x is for your A line. Now what you do what is our value of x that 5, the second value of x that we have got. So, you take 554. So, this is your anchor line B. Now you take, you have told me you have calculated as 554. So, this is 0 point. Now you are getting it. Now if you draw a vertical you will get two points, one out here, the other out here. Now here you find out the value of T H. So, this is your T H A minus T H B, but you have to plot a graph, otherwise, you cannot find out.

So, from the value of x; so if you plot a graph. So, this comes as, this you can do it in the hall. So, this is 660 kilo Newton. You just work out in your hall; you put some values of x calculate T H for A and B, and plot these two graphs. Take 554, find out the difference. So, this is how the problem is solved. Now the remaining portion since we have some time I will just give you some idea of the equipments, and that brings us to the end of the mooring system. Now here actually we have anchor windless. Now when you go for training this comes under the head of deck machinery.

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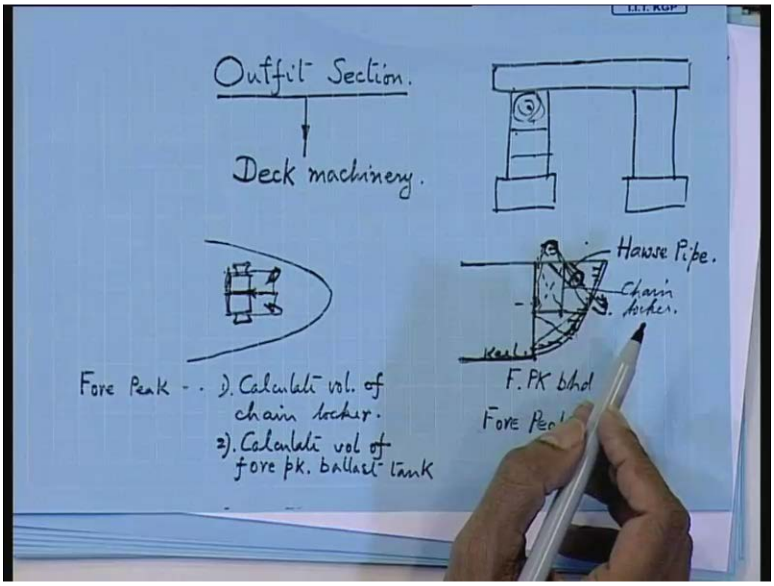

So, the shipyard if you go they have you will find there is a section that is called an outfit section. Now in the outfit section if you find yourself in this section then there is a section which does your deck machinery layout. These are the normal ships, but you go for offshore platform T is more vigorous. Because normally what they do, you have huge anchor chains. In your offshore platform you will find there are huge anchor chains, and these are normally stored in reels in the columns, because your offshore platforms center is the mooring system. So, they have the columns, they have these reels; either they are positioned in the columns or if you do not have space in the columns you can locate it on deck.

So, columns is used for reeling purpose and storage in these columns chains, but in ships actually I think this you must have studied and your Professor Monul must have told you this. Ships if you visit then you find at the forward end there is a bulkhead, and this is called a forepeak bulkhead. You come across this in your these ships I think they normally do it in ship structures, or now here you find a chain locker just forward of forepeak bulkhead. When you go to the shipyard and you happen to visit a ship which is being built or constructed you can see this. This is called a chain locker. Now on the side shells of the ship you will find there is a opening through which you take in the anchor chain.

An anchor actually comes from out here, okay. Now there is a pipe which goes through the ship. This is called a hawse pipe, hawse pipe. And here you will find your windlass is located. So, basically your windlass what it is doing? It is lifting chain from the hawse pipe through the hawse pipe, and your chain that is anchor chain comes and it is fixed to the forepeak bulkhead. There is an attachment to the forepeak bulkhead where the anchor line is hooked or it is clamped. So, your anchor line is coming in this fashion. So, this anchor is stored in the chain locker. So, if you see the deck layout and I will show the deck layout; you will find normally there are two anchor chains which are serviced by a single wind glass.

So, a wind glass will be here. This is called the top stun where you can root wind your mooring ropes. Now here you will have the opening on the deck, and this is your wind glass. This is how it goes. Now you have to design this part of the ship. This is called a forepeak. Now forepeak design is essentially taking care of the storage of the chain, and what else you can have in the forepeak? So, here you will find lots of heavy stringers are given like this, and there is a stem bar. I think all these terms you must have come across in your study; have you seen the stem of the ship? When you go to a shipyard you will see how the forward end is made, the hall shop or the ships which are being built.

So, they have a stem bar on which your side shell is wielded, and if you come at the bottom this is wielded to the, this will go down right like this to the forepeak bulkhead, and then you have a keel. So, this is connected with the keel, followed. So, this is how the construction. So, basically you have to calculate the volume of the chain locker if you want to design the forepeak design. So, forepeak designs if you calculate the capacity you calculate the capacity of the chain locker which will accommodate all your chain.

Now if you take this there will be two chain lockers. Now you have a chain locker, you have a partition at the center line. So, there will at least be two chain lockers just below the deck, because you have to keep our heaving the chain from the port side and also the starboard side.

So, you have to calculate capacity of chain locker, what else you can do? Forepeak conception; now fore peak is not very comfortable for your accommodation. You cannot have any accommodation out here, and you have a lot of structures, and you will find Brest hooks, thinner plates, stem bars, chain locker is there. So, obviously, accommodation is ruled out. The other thing you can have if you want to decrease bow trim is tanks, tanks space; the void space you can fill by vast tank. So, forepeak design, forepeak first thing is calculate volume of chain locker. Now remember this; all this things you have to do in GA drawing, calculate volume of chain locker.

Now how you calculate the volume? You simply take these sections around here. Now line slam you only have drawn up to forward perpendicular. There are no sections between, say, at this forepeak bulkhead you have not drawn any section neither you have drawn between these two. So, you have to draw at least two or three stations out here sections, then you symphonize. So, that is how normally you calculate volume of chain locker and you find out this. Calculate volume of what? Volume of forepeak ballast tank. So, these are normally the spaces to be allocated forward of forepeak; this is one thing. So, windlass is taking care of this thing chain locker size, and aft peak calculation how will you do? So, this of course, is not in the relevance of ocean engineering, but this is all practical calculations you have to do.

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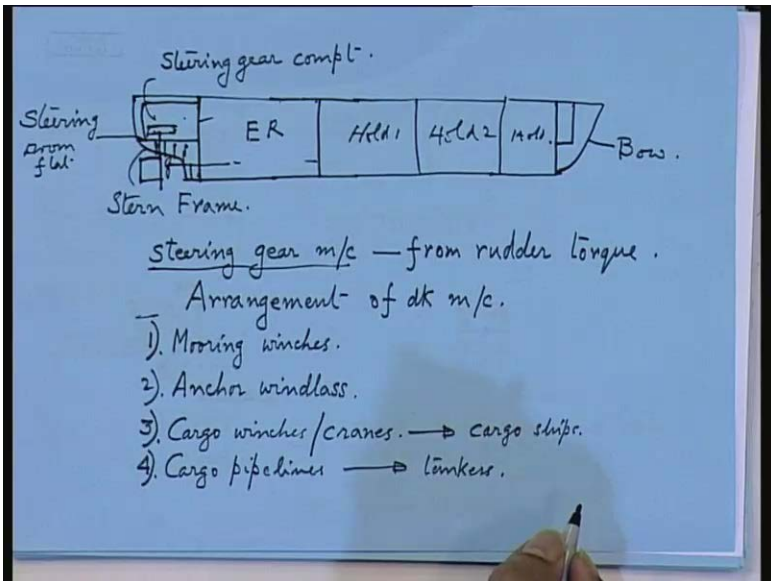

Say the portion of the ship which is away from aft peak away from the bulkhead, engine room bulkhead; have you thought about this? There is always a bulkhead at this region. So, this is your engine room. So, the engine room is basically housing your main engine, is it not? So, how you design this space? Forepeak design I have just told you. Now engine room and forward of this you will have number of holes, and in the forward section this ship will look like this. Aft peak how you are going to do? So, your shaft tunnel is coming out here. So, this is your propeller end.

Now aft peak if you look into I think you have done that croissant ship construction no. So, here you will find also storm frame. Now these are huge structures storm frame like you have ship bow you have a storm frame, and there will be heavy structure out in this region. These are called deep floors. Then you have your deck guarder will come out here, and inside this what is this space for? Now just after this propeller you have your rudder, is it not. Your rudder position is going to come out here. So, this is called your steering gear compartment.

Now as a naval architect what you have to do is you have to order steering gear machinery; from this normally they will teach you in ship maneuvering, but this you calculate from rudder torque. Then this you have to give indent for steering your machinery. So, this is accommodated in the steering gear compartment, and this is your rudder machinery. So, this is the volume, take care of that. So, this is called a steering gear, steering room flat. So, when you go into the ship invariably you will find a forepeak bulkhead beyond that chain locker, aft peak bulkhead, steering gear compartment. Rest of the space is occupied by engine room, holds, say there is a hold one, hold two, like this it will go on. So, this is a thing you should remember.

Now, coming to the deck you will find arrangement of deck machinery. This you have to do in ships outfit department. If you go to your design office in measurement of design office you will find that this is an outfit department forward design. So, arrangement of deck machinery you have to do. Now mostly this there are mooring winches, then you have anchor windlass. What are the other deck machinery items? Basically mooring winches, anchor windlass, and if it is a cargo ship you will have cargo winches, cranes. This of course is right; I am not taking in ship design, they should take care of this. So, these are the items of deck machinery.

Tankers you have, cargo pipelines. Tankers of course, this is for cargo ships, cargo pipelines, tankers. So, GA drawing has to take care of all these arrangements basically, but arrangements you have to have some kind of a pattern, or you have do it in a scientific manner, is it not. Just haphazard layout will not help. Now if you want to do this the mooring this thing mooring arrangement you will find there is a diagram which you can see end of your my file you can see.

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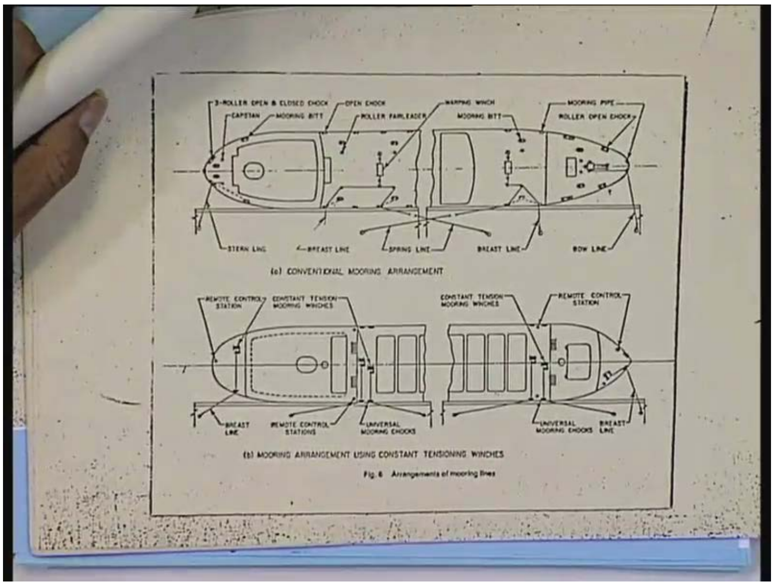

So, this is the example of the layout of the mooring arrangement. So, this is there are two types you can see out here; one is the conventional, and there is a constant tensioning winch. So, this is the conventional approach. This is called breasting thereby means of a spring line. Now spring line may call that is the ship, the whole mooring system has that kind of a spring system; that means when the ship goes in this direction it will try to draw it to the winch spring stiffness. So, here you can find this is the windlass; this is your windlass actually. And from here I think he has not shown, the hawse pipe has not been shown out here.

But here you can see that is the bow itself is given by a bow line; the one bow line, another bow line is coming like this, and this is your warfare jetty. So, all these mooring ropes are tied to the bollards at the jetty points. So, this is one bollard shown out here in another board line, but this line actually it is in the cross direction. One is coming in this direction; the other is coming in that. You have warping winch; warping means this ridge, tensions this line and also there is a tension in this line is tensioned by warping on this increasing the tension here. And this line is also tensioned by means for another warping winch out here. So, now the ships you will find you have to arrange symmetrically on these lines.

So, you can see the windlass, the warping winches are always positioned on the center line. You will never find windlass to one side of the center line, rather towards the port because the same windlass has to service both the anchors. So, either this anchor or these anchor the warping winch. Now the ship is brought on the, say, this is your starboard side. Now if it is brought on the other side you should have the same system on the reverse side. So, the mooring arrangement has to be symmetrical about the center line. So, there was a number of bollards and roller chock where which the mooring rope is passed, etcetera, aft line on both sides you will find, and these are the bollard positions, bollard mooring bits.

Now here that is a stern. Now ship has to be now you are basically mooring the ship on a forward end. This is your mid ship or the parallel middle body part. In the out here also to prevent these stern from having motions you are just hooking the. So, these are your deck machinery items which you have to draw and which we have to position on the main deck of the ship, besides you it may have other the cargo pipelines and all these things are there. So, normally you can draw this in AutoCAD.

Now this constant tensioning winch is that they maintain these winches you can see they are on this direction, but this winch is in the reverse in this direction actually. So, these are actually better this constant tensioning winch because they provide the uniform tension actually. Either you can pay out or take in this line, the same thing the same work that you are doing out here, but constant these are called constant tensioning winch.

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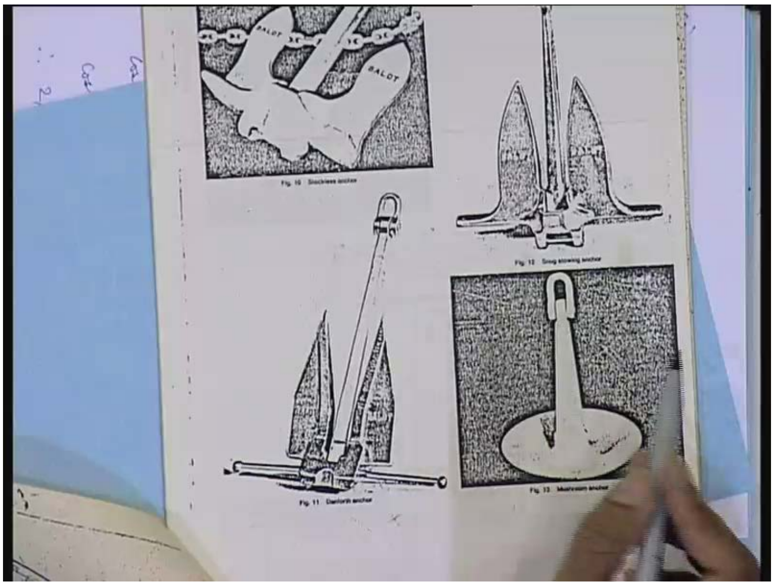

Now here you will find this diagram the equipments. So, this is the picture, or this is the larger diagram, and here you can see. Here actually there is the tanker, and this is where you have two windlasses because of the size of the anchor that has to be hold on. And also in tankers you will find the bow is quite wide. So, you cannot service from one anchor that is servicing both; from one windlass two anchor servicing is little bit difficult. So, what they do? Just where the hawse pipe is coming on the deck they position two different two anchors in this mode. And in tankers they do this because your deck is very large very wide. Another is in small ships you use instead of two windlasses you can go for one windlass.

So, here is you can see chain locker out here, and this is of course, the cargo this thing what is called the cargo cradle. So, that we are not much bothered. Now here you can see the diagrams of different anchors. Now there is one horizontal stock that is called a stock anchor, but here this is a stockless anchor. So, this portion of the anchor actually goes and claws into the sea bed, and your anchor chain is fixed to this top of the anchor. So, this is called a mushroom anchor. A mushroom anchor you do not use for normally mooring or anchoring your large ships. Normally these are for smaller ships or stream anchors; this is called a Danforth anchor.

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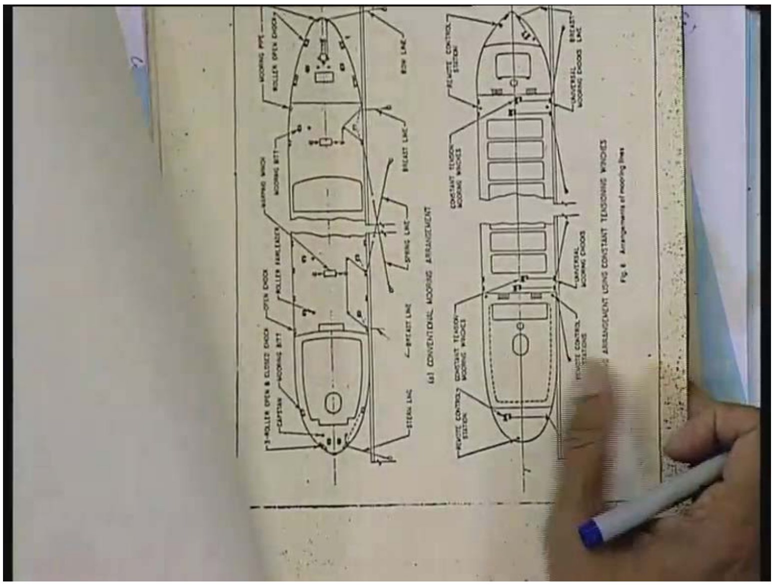

So, the other types of anchor the same anchoring system, the same thing is out here. Now I will just give you the mooring equipments that are used; this I have already talked about.

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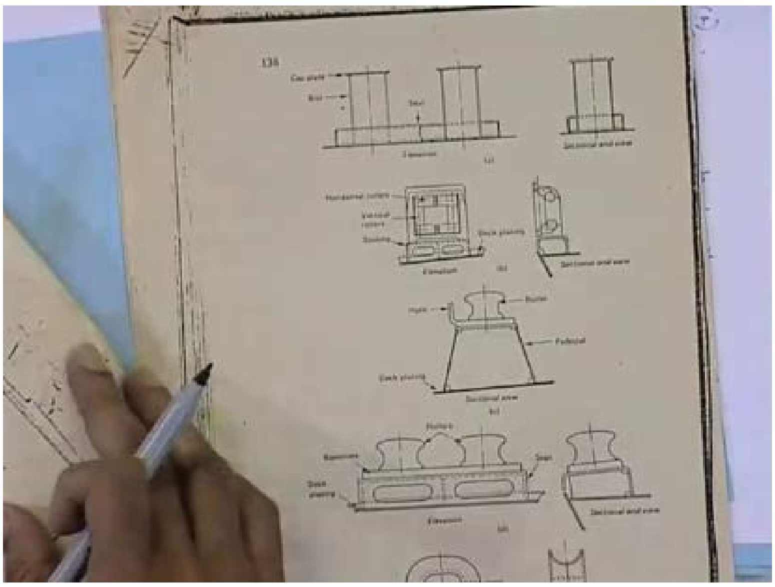

So, these are the different mooring equipments that are used on board. So, this is normally called this a bollard. So, this you will find at the deck of the ship, but you have to position the bollards very near to the edge of the deck. So, bollards, fairleads, chocks are normally placed along the deck line just inward of the deck line. You do not place bollards out here, because if you take away or take up the mooring ropes this much space you will not be able to save. So, the rope is going to chap on the deck. So, it is going to break the mooring ropes, and normally bollards you place out here.

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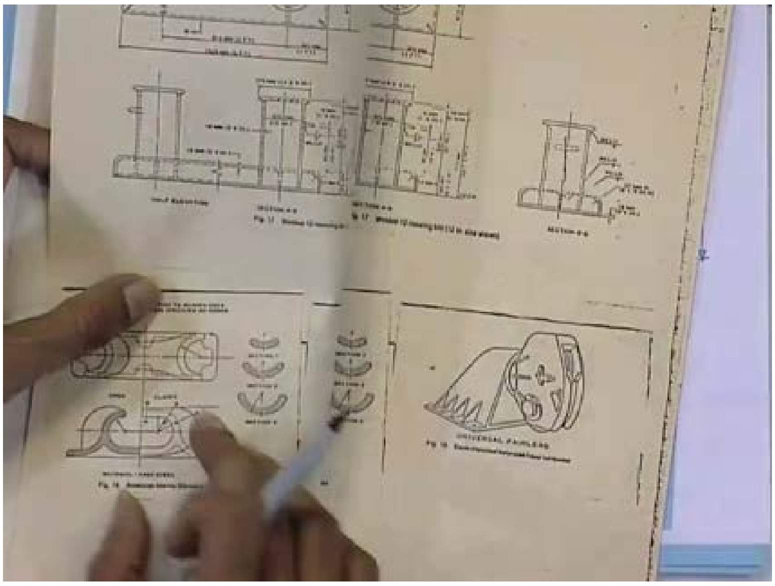

So, here in the diagram you can see these bollards. So, there is this is the inside of a bollard. The bollards are normally fabricated in the ship. Now here you will find this is what is called the fairlead, no it is chock. They are coming as fairleads you have rollers, but since you are not having rollers this is called a chock; that means you just slip in the mooring rope from the top. You are slipping, and the mooring rope will slide inside the chalk. Yeah, this is the fairlead. This is one example of a fairlead this thing rotates and takes in the rope, and this is your bollard.

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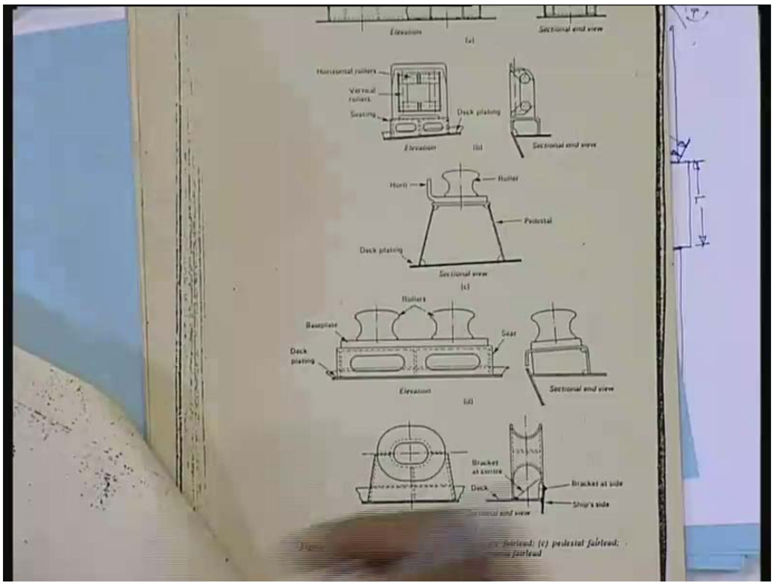

This is what is called you can call it this normally we call it a roller fairleads. So, the mooring ropes, they pass between these two rollers. So, when the mooring line is taken on board the ship; these are the double fairleads. So, there you can see only one roller; this is a single roller fairlead. So, the mooring roller is passed through this gap. So, roller actually serves some kind of bearing over which you pass your rope such that your rope does not chap or break. Now this is your deck line in ships; if you take a section this is your deck line, and this is your side shell, okay. Now you will find that you have to maintain a gap between the side shell and the deck line and this region.

So, why this gap is maintained? So, you can see in the elevation also there is a certain gap. So, these are for the discharge of water which is going to accumulate in the deck, and the area also you have to calculate. From Lloyds they have a there is a special name for this I think in your ship. They call this as lightening holes, not lightening holes; there is a special name. And you have to calculate the area of these holes from, you calculate from Lloyds or you use IMO rules, lobe line rules. So, these are specially given for ships to drain water on the deck. Otherwise, you have lot of free surface break on the deck which will harm your stability, and it will decrease your G M. And there is a special name I will tell you definitely when you go, because I am forgetting. This is called, it is not side snorting. So, this is normally your bollards and fairleads, and this is your hawse pipe you can see.

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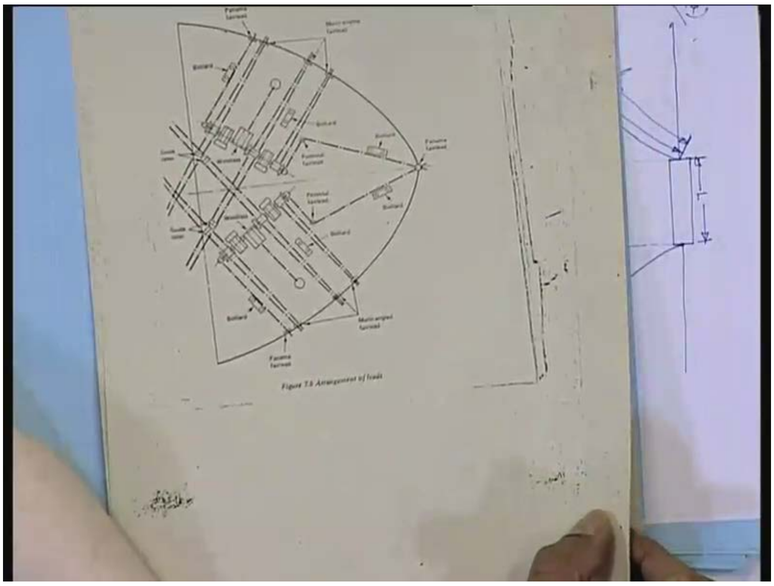

So, this is an arrangement of a tanker arrangement, tanker fairlead mooring system. So, here is a case of a single windlass. Here you can see a smaller ship, smaller ship with a single windlass, but you can winch both the anchor lines from these winch drums. So, either you can use a single anchor windlass, or for tankers normally you have two windlasses.

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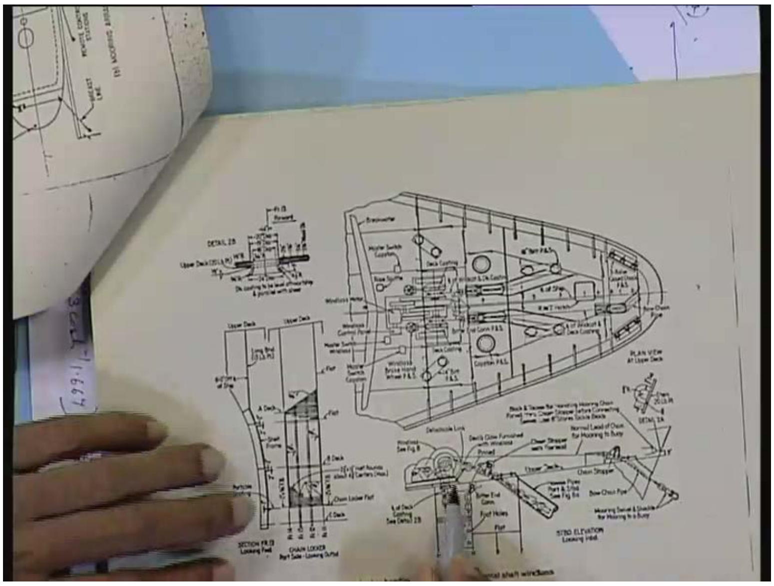

So, this is the normally the machinery arrangement. So, here also you will find the elevation of your; this is the top portion of the chain locker that is shown. It is heaved in this manner, okay. So, with this we finish our mooring systems. And so this we can see the anchor that is kept snag on the side shell. Anchor is to be kept in this fashion. Anchor, obviously, you cannot draw to the hawse pipe. There is a huge structure, is it not; you keep it snag on the side shell.