**Seakeeping and Manoeuvring**

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**Module No. # 01**

**Lecture No. # 38**

**Rudder and Control Surfaces - II**

See, we will continue talking on rudders or you can say Rudder and Control Surface.

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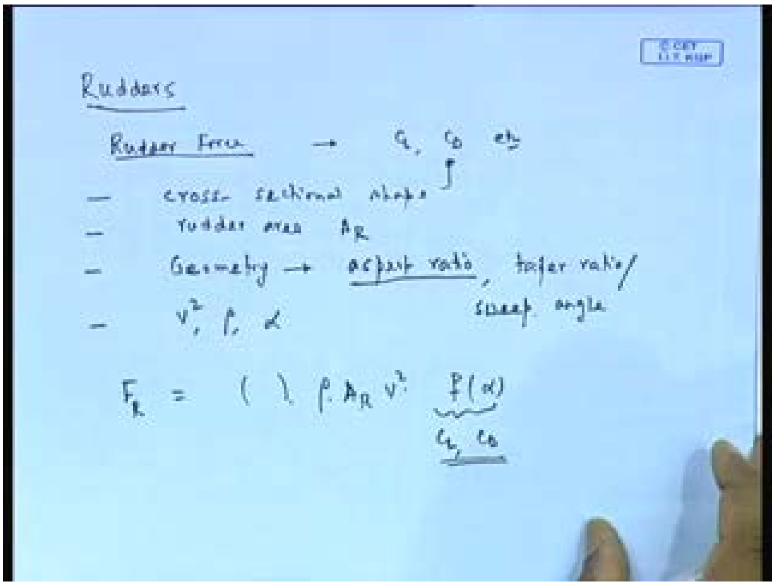


In the last lecture, know we actually I spoke about, how we you know describe a geometry of a all movable rudder and also in terms of C L C D, how you basically can end up getting the net forces, torque, whatever you require the two things are necessary; you know one is so called y r etcetera that is basically, the rudder force needed for manoeuvring equations. The other is for rudder design itself, the torque and moment that comes in the rudder stock.

Now, I today initially what therefore, what happens we require to make some estimates, so as I was telling last class, I will tell you today about some empirical semi empirical formula, about how we can find out this rudder forces and the related quantities. So, initially I am going to say even simpler than, what we have done in C L C D.

See, rudder force we have we have defined last class in terms of basically C L C D, etcetera we resolved it but, not going even to that you know there are some even simpler semi empirical formula, which would be very useful to make a quick estimate for other forces etcetera. Now, basically this force will depend as we know, obviously it depends on but, c l's we can say rudder force as C L C D is the same thing depends on cross in fact on this this to depend.

Of course the force will depend on rudder area, it will of course, depend on geometry, now this geometry primarily will be influenced by what is called aspect ratio you know it is very important span by chord, taper ratio sweep angle. Essentially, we discuss this that is how it is tapered it will of course, depends on v square it will depend on you know v square rho and angle of attack alpha, we all know that.

Why I wrote this because see instead of going to C L C D, I can simply write rudder force, where rudder force may be the force in the normal direction to rudder as a function of some constant into rho into A R into v square into, now this is nothing but, actually some force right. Why I am mentioning this, because you see there there are some before going to C L C D form, which also I will mention a more detail form, there have been some empirical formula based on just this very you know older kind of formula, where you just have a constant into this; so you can find out kind of a rudder force.

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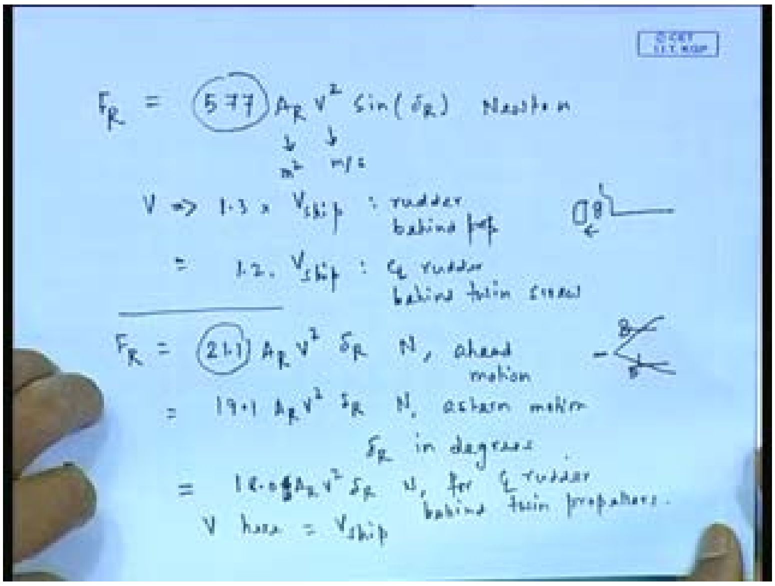

So, one of this old formula for example, say simply one, of this old one it says simply that it is 577 based on A R v square sin in Newton, when A R is area and meter square v of course, is speed in meter per second. And when you do v, it should be the fact that, the water flowing plus rudder is of higher speed; because propeller racing it you know the rudder will be always behind a propeller typically.

So, the v that comes into rudder is usually higher, so this in this formula one have to use v equal to 1.3 into v ship, if it is a rudder behind a propeller a single screw ship and if there is a central line rudder, this is for or one could use 1.2 into v ship for central line rudder behind twin screw. So, this is one of the formula, why one am mentioning that you will find out that you can very quickly, very easily you know found out the force.

And then I will mention about the momentum torque part, another formula this this one formula, another formula F R, what? No no no no it is true this why I say rudders behind propeller it can be single screw, twin screw as long as if you have the propeller, rudder behind the propeller but, there are ships, where rudder is not behind propeller the twin screw but, central line rudder.

See, there are ships there there is a propeller here, there's a propeller here but, the rudder is here, this is what we call central line rudder behind a twin screw ship, it is not necessary see what your question is that even in twin screw. I i will have rudder behind propeller but, no we are talking of that design, where there is a central line, rudder behind twin screw propeller; so it is not mandatory, that you must you must have a rudder behind a propeller.

Another formula is it says this is, it is all you know like sequential this is much older then next one is little more newer it says 21.1 A R all of them, see here if you look at the I will just mention that (No audio from 07:16 to 07:58), I equal to (No audio from 08:01 to 08:32) see, the question is like that you know when you do a semi empirical formula.

What you are doing? You are actually measuring or you have collected lot of data of forces, you know the force will look like a constant A R v square into some kind of delta sin or otherwise delta r they try to find the constant. So, in this formula what they have done is this v here, if you want to apply you have to use v as a v true ship, because that factor, whatever has been already embedded in this constant essentially.

[FL] rho has to be there yeah yeah yeah yes yes rho has to be there here no no no sorry sorry no no rho actually here, rho is taken inside that that right rho is not, because rho is taken inside this all rho is around 1.025. So, it is already taken inside that see, actually speaking this is not a non dimensional this is a dimensional this this number, that is why these dimensions are mentions, you have to apply this dimension only, so this this constants actually includes that rho and other factors, it will not the same one if you use another unit basically.

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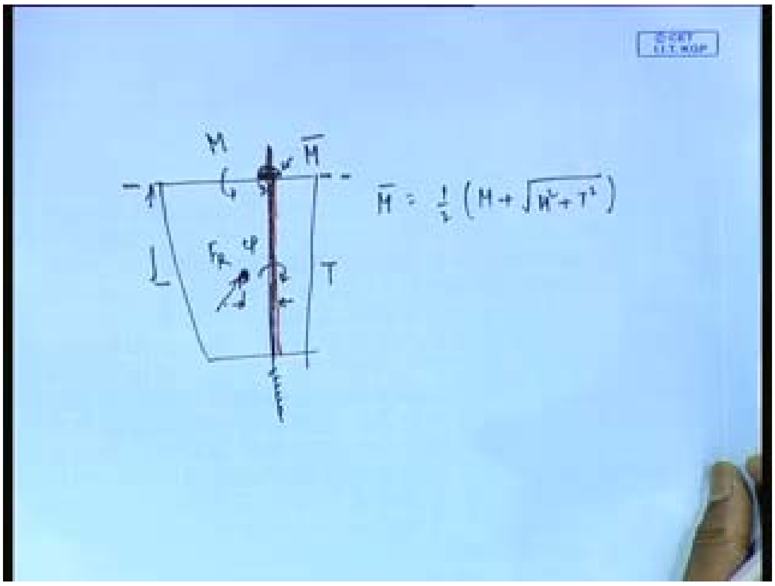


Now, if you know this force you know that, there is let me just tell you one thing, that suppose, this is the rudder some rudder here, there is a stock here, the force acts somewhere here right this this force is acting here F R we are calling that now there is going to be a torque T.

Now quite often there's going to be also moment M, why I am mentioning there see essentially you want to know this moment at this location on the stock, this is a stock this not there, this is basically the stock or this red line, if I brought this and you want to find the moment about that. So, yesterday we we mentioned there you know in terms of lift and drag also you can find the moment about the root section but, actually here, if you take the contribution of T and M you can also get this you know like moment.

And this turns out to be it turns out that moment here m dash becomes equal to half of I am, just let me just write it down, so that we can what what it means is see here, this about this root root section. I find the moment but, this is not acting on the stock, so there is a torque on this, so an equivalent moment can be found out at this point at this location by combining the two.

This is basically based on pure structure mechanics that, why I am mentioning is because from the design point of view of this stock; the max stress is maximum and you would like to know what is the bending stress coming we will do a problem of that later on. So in order to do that, what I need to do is to estimate F R; once I know the F R and of course, I have to also estimate these distances, that is, this is my centre of pressure c p.

I need to know the location of c p that that also I come to that, this you know formulas for c, this c p later on. Once you know that you can find out you can find out the moment coming and once you know F R you can also resolve this forces as we mentioned yesterday, how you can determine y d r, n d r etcetera this is a hull properties. These are these are two simple formula, I will mention a slightly more complex formula, which is more used, now a days this formula will be that formula is in terms of C L C D, remember this two formula, there is no C L C D it is much older formula.

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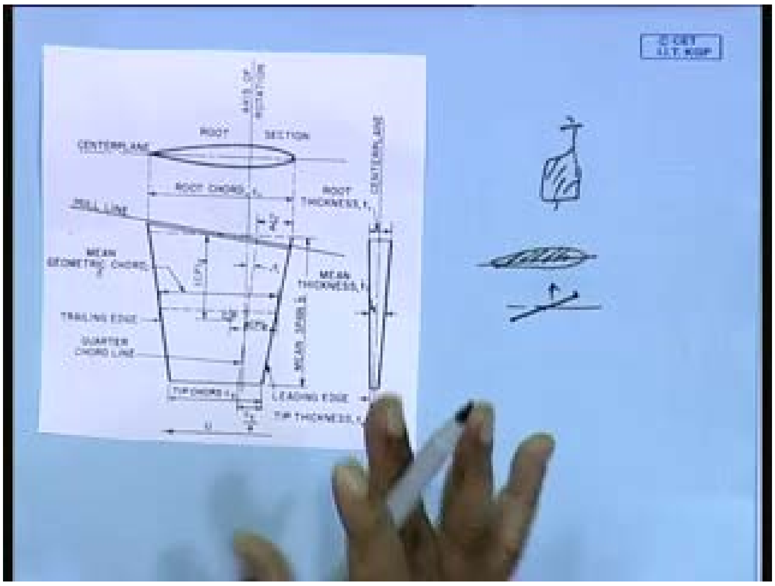


Now, there is a newer formula for getting C L and C D and C M, remember that yesterday we mention that we actually, have in terms of this in terms of this all forces moment, etcetera could be found out; we discuss that yesterday fully right.

Now these formulas I am not talking of C L C D, etcetera they are simply assuming them to be you know the function of alpha is embedded from the experiment but, later on what is happen. When people started using, remember this before I go that many you you would see it even now; many river boats you know you will find out the rudder is simply a plate, just a plate, rectangular plate, if you go to country boats you will find some kind of a wooden, just a stick like that sometime is the person is just you know just shifting.

So, these formulas evolved at at a time when there was not, so much of discussion or so much of knowledge based on aerofoil section was available, that is why there was no concept or use of C L C D, this word C L C D started coming more, when it is actually having an origin from aerospace engineering you know; when you are begin to think a lifting surface begin to think of an aerofoil section or a hydrofoil, etcetera.

So, later formulas all realize that you will get much better rudder performance, if you use aerofoil section, of some form then you can get see the as I if you take aerofoil section, you get for the shape also and lift and also angle of attack. Actually if you flat plate also if you look at angle of attack just a flat plate, you will get a lift but, not so much and those formulas are based on similar kind of idea. Now later on this C L C D came and as I said yesterday we we kind of expressed all the forces in terms of C L C D or L D, etcetera.

So, now this present formulas are all the the more later formulas try to tell you, estimate C L and C D etcetera all this by some empirical formula, so this what we I am i'm going to write it down for example, C L is now here, this is this is meant for again before I do that meant for the the geometry, that I showed yesterday. Remember this is the spade rudder geometry, I showed fully movable this, the line there this is root section, tip section, the tip chord, this is the sweep angle, etcetera.

We we plotted that yesterday in terms of this parameters in terms of essentially, what is important as I mentioned before aspect ratio this by that, effective aspect ratio, because this is not exactly the same. So you can take the mean line or you could take an s square by area, if you call this to be a span this to be area, span square by area become effective aspect ratio that is extremely important; aspect ratio is extremely important sweep and taper angle can be this by that can be call taper, how much it is tapering this parameter.

So, these formulas are based on those parameters this here C L is written as may be I will write in a newer page because longer formula (No audio from 16:15 to 16:35).

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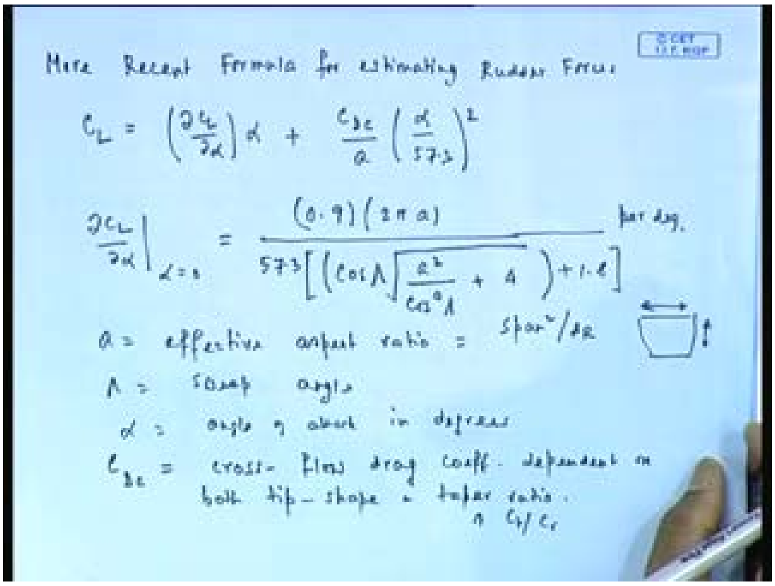


Let me, preamble this as that more recent formula for estimating rudder forces, so that we know here it says C L, it is d C L; now this another problem will come this of course, everybody knows it will be this but, the essential thing is that correction term, C d c by a alpha by 57.3; the alpha is the angle of attack and degree, that is why this divide by 57.3 degree comes in, alpha is I will write it down, this is one, then d C L by d alpha (No audio from 17:22 to 17:36), this is equal to this formula is going to be important, we will see it afterwards, why so (No audio from 17:48 to 18:21).

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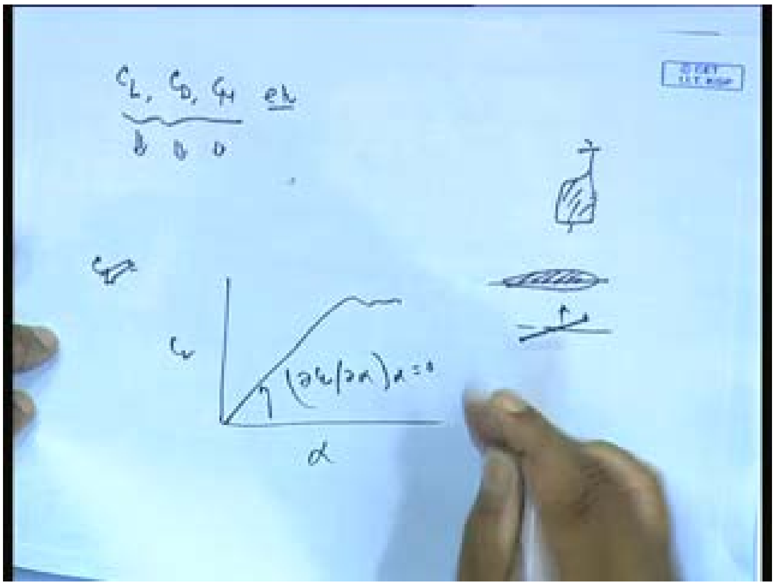

See, I will tell you the important point here, d C L by d alpha we have mentioned that yesterday if you recall yesterday we had this formula alpha versus C L and this slope is d C L by d alpha at alpha equal to 0. If you recall we had a approximate formula of y d r in terms of this this becomes the most important characteristic, actually at 0 the, what is known as this is what is known as slope of the lift curve at 0.

Now this is, so we know that a of course, is effective aspect ratio, there are different way of defining this but, normally one define this to be span square by area You know, because effective s by basically span by chord would be aspect ratio, this basically this know this this divided by this; what is the typical aspect ratio of a rudder you think of a ship. In this discussion let me let me just ask you approximately how much do you think is an aspect ratio of a rudder in which order is it 0.2, 0.3 or 1 or 2 or so 1.3, 1.5 right in that order.

So, you you have an idea we you you you keep this in your mind, because next class when we talk little bit about the ship hull derivatives, we will find out the ship can be treated as an lifting surface of very low aspect ratio, very low because you know T by L becomes the aspect ratio. But this is around 1.3, how do you get this supposing somebody ask you estimate that, see the t more or less this part will be same as the draft and area you can take as I was telling, yesterday to be about 22 percent of the you know like length into draft; so if you go by that you know you will find 2 percent is 150 of that L and L by T, if you use that formula you will end up getting some estimate.

So, any how you have an idea regarding that that I wanted to know that see of course, this we know the sweep angle, so we we any how this we already discussed yesterday alpha is angle but, I in degrees, in just still write and this is C d c [FL], this is this is important this is what is called this C d c. See, there is an extra term that comes you know d this this part everybody knows, there is no question the problem is or issue is with this correction term; so this is what is called cross-flow drag, which depends on both tip-shape and taper ratio.

Now, taper ratio is I mentioned this by this, this by this (Refer slide time 22:21), that is the taper ratio this divide by that, that is chord at tip by chord at root.

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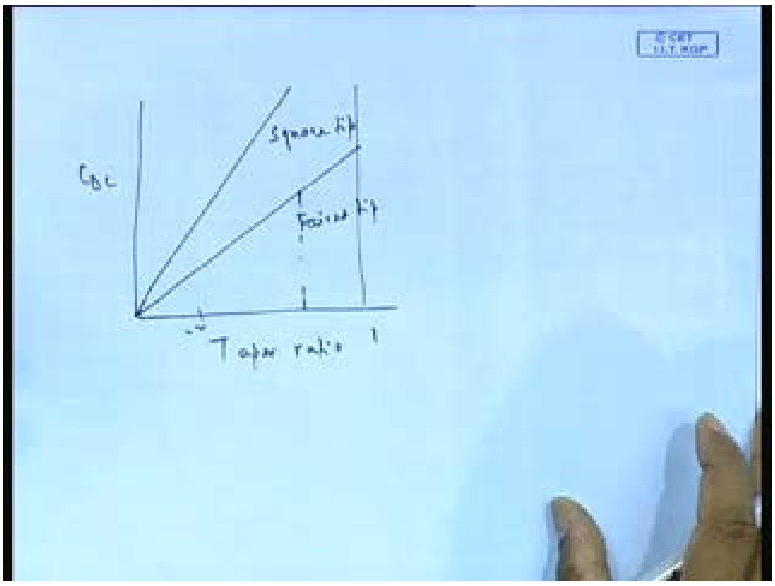


Typically for example, this value would look something like that you know if you are doing taper ratio this cross flow that C D c, C D c against taper ratio for different kind of tips there are plots available. Normally linearly varying this is what we call faired tip, what I mean that, what I want to tell you, is that I will, let me write it down. See, when you have an empirical formula you know you we we must realize what what is the meaning of the word first of all empirical, based on experience.

So, you have a formula, where the forms always has some scientific basis, that is 0.1 but, the unknowns you fill up from experimental data; so here C d c this term the form look like that but, you do not know C d c. So, people have done experiment and it turned out that if you did experiment C d c the values available, I am not putting the number, that you can see in any standard text book but, this seems to fit a linear variation with taper.

Taper ratio for example, here this may be 0.2, it it it can go up to 1 it cannot go up beyond 1 but, most of the you know most ships rudder taper ratio is about 8.9 in that order. So, this this is all like in any empirical formula, if you have the graphs available you can always apply that, having said that now let us see the other part drag coefficient that also you need know.

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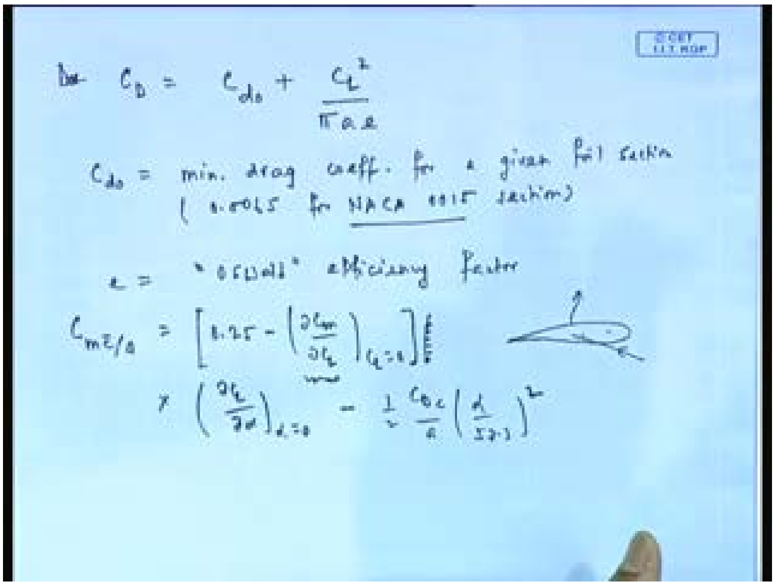

Now this was C L, so we have this drag coefficient C D let me just write C D this is given by formula of that C d o plus C L square by pi a e, now C d o is what is called minimum drag coefficient for the given section for a given section, given foil section for example, this turns out to be 0.0065 for again I will tell you this this is a very common section, used see NACA (( )) what is happening is that.

Again people have done experiment, you would have chosen certain set of well these are called as NACA profiles, that national aeronautical, what is this NACA I i do not remember this fully, this is aviation some something to do with this aeronautic and some aviation you know. So, there there are whole lot of profile, given for which experiments have been done for which the drag minimum drag is also available.

So, you use that value in this formula, e is an efficiency factor it is known as Oswald, somebody is as you can see, Oswald means based on the name, again is available in literature; then moment coefficient about quarter chord that is m c by 4. Remember yesterday we defined this this is moment coefficient about quarter chord, why quarter chord, because we have not yet found the c p there will be formula for c p also and obviously you do not know the stock position.

Remember, when you are doing you are doing this forces on a lifting surface, it does not matter where the stock is, so the that is that is arbitrary, these does not depend on where the stock is the flow comes this way, is going to give so much of lift does not it, does not depend on where the stock is, so there that is why that that is why this these formulas are for geometrically determined point, not on you know like as as you determine by design.

So, this is given something like let us see this this formula is bit, I will just write it down from here, somewhere again there is d c m by d c l as c l 0 this is this is into we will write may be here, into this minus half c d c by A. Maybe I should not write this too much, because these are all standard formula again, there is a formula available for moment, about quarter chord in terms of d c m by d c l, d c m by d c l and d c l by d alpha, this is what is known as the slope of the moment curve against slope of the lift curve.

Basically, moment curve slope of the moment curve against lift curve, d c m by d l these are very you know if you study aerodynamics you will find out that these are the kind of terms used for aerodynamic lift wing property, etcetera, etcetera. Formula for that is, since we are writing it might as well complete this, this formula for that comes to something like that (No audio from 28:30 to 28:45).

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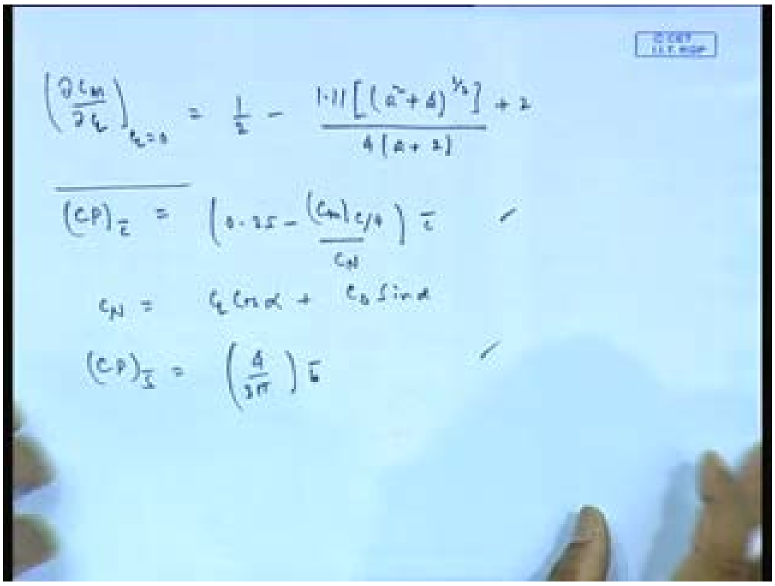

And of course, d c l by d alpha we have given already, this term is of course, given earlier, formula and now centre of pressure c p c, c bar remember c bar is cord wise, that is what we mentioned here, this distance measure from here leading edge. You are measuring basically the two coordinate system, you measure the x coordinate from the leading edge, front edge and the z coordinate or y if you call from the top, side that is root side that, is what you call.

So, this is given as (No audio from 29:21 to 29:35) y C N, C N of course, is available from C L and c d C N or rather this we mentioned last class and I the final thing is c p s equal to 4 by pi bar. Now this completes my all the required quantities to find out the lift drag and therefore, force and moment, so this is a more advanced formula, that is available today for a particular type of rudder, that you can apply.

Now before I go to other thing I want to tell you about this little bit about this formula for this this one, because this formula is going to come later on that is see, see here this term d C L by d alpha this one, slope of the lift curve, it turns out there actually different formulas available for that you know depending on the kind.

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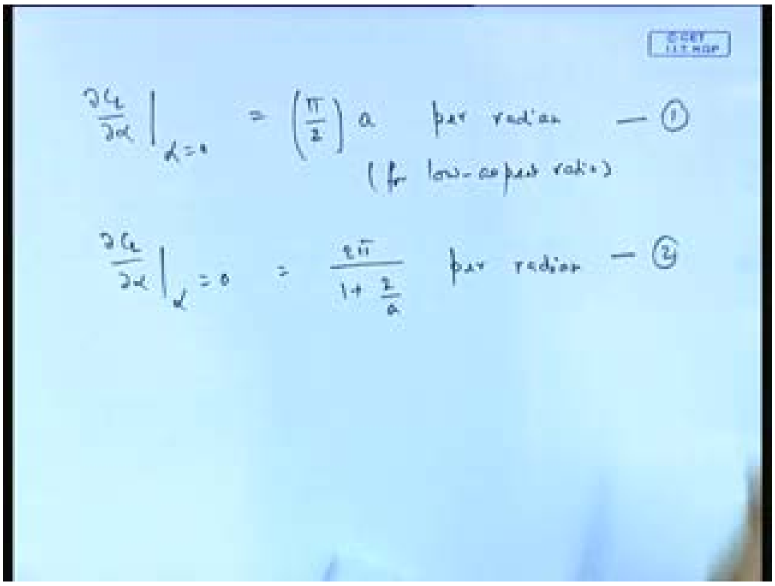


There are two simpler formula for d C L by d alpha at alpha 0, one of them says simply I will just write it down here, pi by 2 into a per radian, another formula for that slightly more advanced, let me write it down (No audio from 31:31 to 31:43); so if I were to look this three formula this one, this is the most simpler one, I call it 1, this I call it 2.

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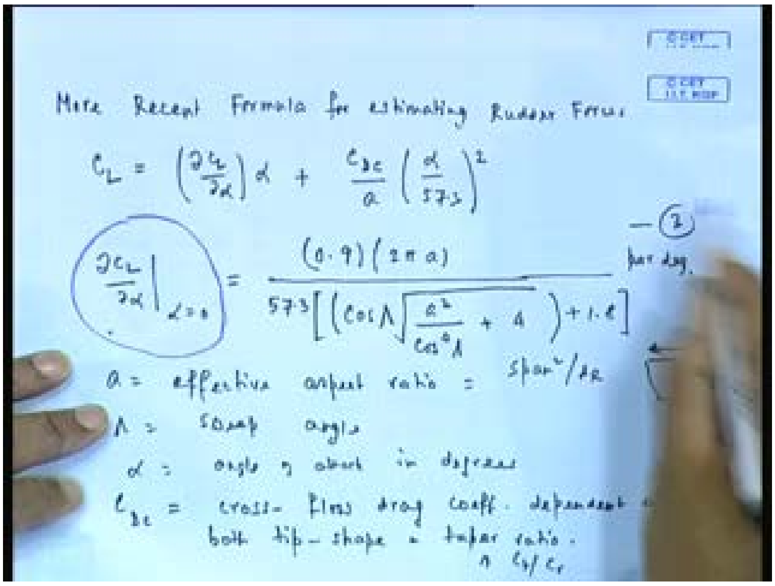


This I call it 3, I will bring back to this this three formula.

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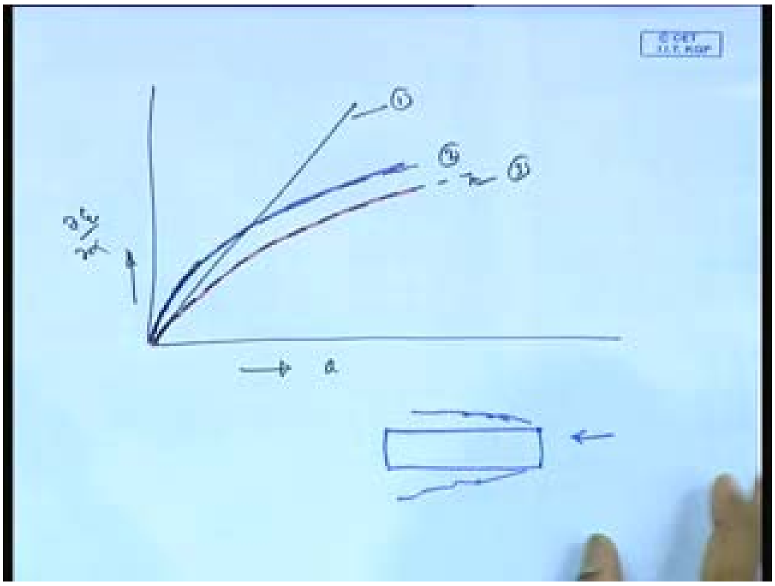

There is a reason for my telling this it at it turns out the graph nature looks like that, here a here, this straight line is of course, formula 1, remember d C L by d alpha is here the first formula provided by John's you know somebody has given this estimate.

It says d c value is simply proportional to a see, why I am saying this you know there is an important point this tells me that, if you have aspect ratio low, then you do not get much lift. So, therefore, you do not want to make aspect ratio low, that is why I was trying to tell you about this 0.1, 0.2, 1.3 aspect ratio, remember we will I will come back to this this aspect ratio part, this one, second one, we will show a graph which has been going like that, this is 2, that will that shows like that against a it is this this this 2.

And third one that is this one, this is the one, that is the most advanced one, which is been obtained by fitting data on what I should say experimental, much more experimental data fitting, it it looks like this is 3. What you find out at very low aspect ratio the formula 2 over estimate, because this is formula 2 or maybe we could use color, this is formula 2 and this is 3.

See, in low aspect ratio formula 2 that is this this formula over estimates, compared to formula 1, in higher aspect ratio formula 1, over estimate compared to both of them reality is found out that it is more like this means, basically you cannot over estimate it then, you are going to design, under design because you are kind of thinking it will be, so much lift, where it does not produce, so much lift.

So, this is the situation you know that there is a reason for my telling that, because you see it tells me that, you should not actually have very low aspect ratio it it is not good. What is the what is the physical reason behind that, suppose you take a rudder like that flow comes this way, what happens water actually may separate out, there is much more three dimensional effect, much more.

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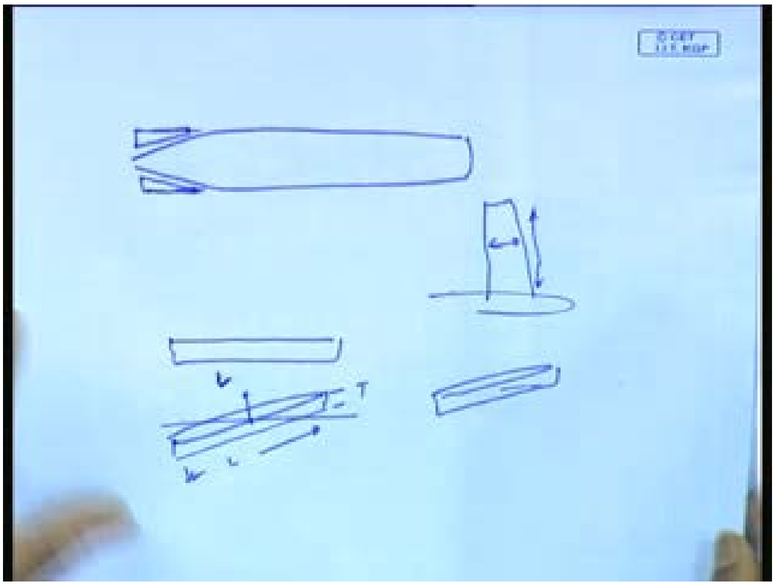

Now, why I, there is a why I mention you know in certain bodies take a take a torpedo type ship, we are working on that, so I can tell you you have to have the entire rudder within this limit, because you know it has to go through a tube, only place you can do rudder is to have very long aspect ratio. You see, you do not want to do it but, you have no choice, so what happen low aspect ratio wings are not good, what what about air craft if you see aircraft wings you know the aspect ratio is very high, because after all the width direction chord is much smaller compared to the wing.

I mean you have this aircraft within this with wing here, so this compared to this is much smaller, right you always want to do that but, some of the cases you cannot avoid doing it and this is also important from one point. Take a ship which we will discuss next, as I said, I want to estimate the ship's you know like derivative, the ship's profile is like that; and if you are turning it is like this ship itself or rather if I were to see this is a two dimensional case, there you know it is kind of going this way like that.

So, if you view from this side that is this plane it is like a aerofoil or a lifting surface of very low aspect ratio t by L, so we will find out as I said that you can make estimates of hydrodynamic derivatives, assuming the ship to be a low aspect ratio, lifting surface and the lifting force, that you get C L is connected to my y, y forces essentially, we will be seeing that later on, we will see that.

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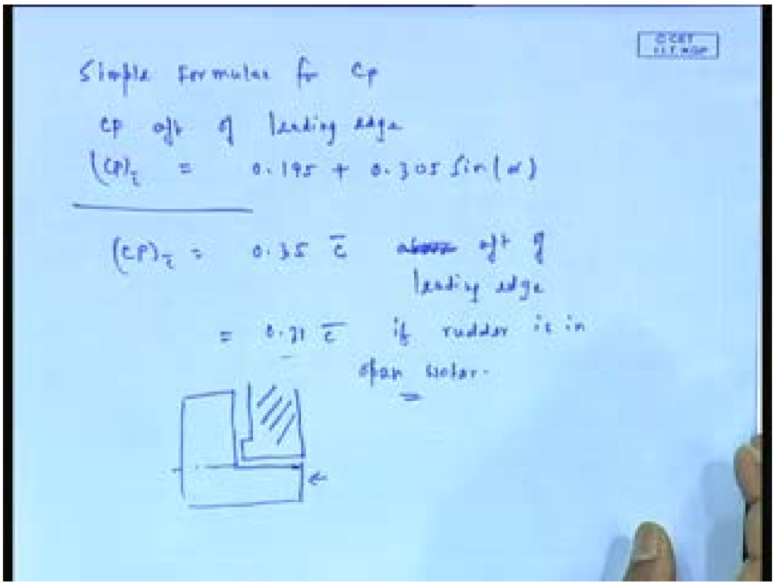


So, that is why low aspect ratio is important and this discussion I just want to mention these points, we will have to quickly go to the next two points, now this is c p what I said so there are simpler formulas for c p. And then we will do a problem quickly, see there is a simple formula it says, in fact this is actually this is actually c p c this is given by very simple sin alpha another formula, this is one of formula (No audio from 37:57 to 38:36) and this I will mention about this part.

See, here what is happening suppose, what what is known as this open water you know there can be rudder, horn type rudder remember yesterday I mentioned there is a horn here and I can have a rudder which is like that. In such case why I mentioned this because this term or even for this term, this this part this part of the rudder this bottom part, this phase this facing water directly. So, it is for that c p c for that will be .31 c bar c bar being a whereas, for this part which is obstructed or something in front it will be this.

So, these are very simple empirical formulas, fairly simple, empirical formula, what we can do is that depending on the problem, suppose I have to do quickly and estimate very quickly, say somebody has given me rudder and what what happens you are a designer you have to design the rudder stock; how thick it will be you can very quickly estimate the bending stress and the stresses coming on that based on these formulas.

If you want more sophistication, obviously you for the c L c d formula means, the the better formula which uses c L, c d's big bigger expressions, so it is a very simple thing really speaking, when you talk of rudder, what I wanted to do was to just mention the possible formulas, available, remember all of them are ultimately formula to eight a designer.

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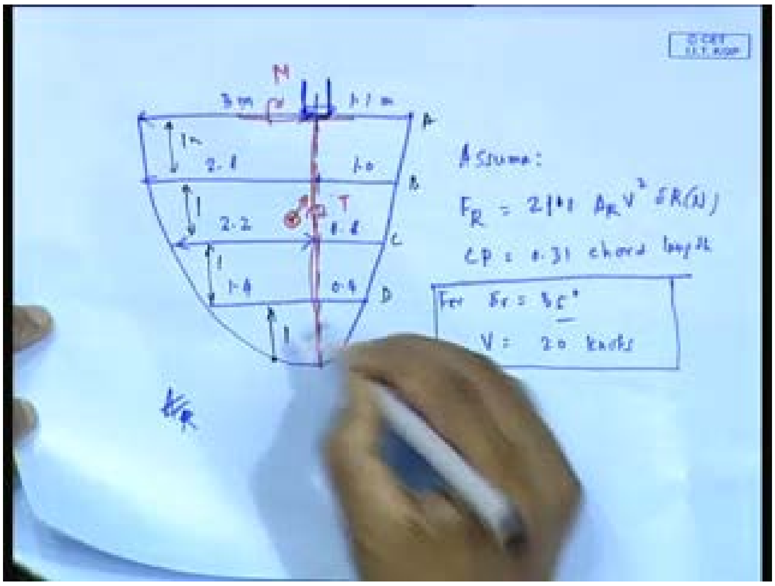


Now let us say for example, we will try to just work out a small problem here, based on one of the simpler formulas to find out, what is the bending stat ionic stock, so this is this rudder given here, I will just work it out from this example, this rudder is a odd shape rudder; it is a profile is given something like that and here 1, 2 these values are given here, this is a stock here 3 meter, this 1.1 meter, 2.8 in meter, 1 and this is the stock.

So, this here the it says this a rudder here (No audio from 41:32 to 42:15) see, the the problem was something like that you know in fact this two, the problem says that there is a rudder of I mean a simple problem of this type. This very this not very uncommon for small boats and all you know country boat type of thing, find out what will be the bending stress coming on that point.

At this point, because it is it is a you know it is a you know supported rudder you are supporting it here, obviously you want to find out, how much will be the stock, the stress coming up. Speed is 20 knots and obviously the rudder can go up to 35 degree, so obviously the maximum force will come at 35 degree and it did not say but, I said that in such case, what you do, you have to choose one of the formulas.

So, the formula we use here is 21.1 A R V square V R N Newton as of rudder force, the formula that was the later of the simpler formulas, if you recall that, there are three simpler formula, I gave these are later of the one. But, simpler than the later C L C D form and c p is also similarly, a simple formula .31 is, because we have seen it that, it is .31 if there is obstruction before, because it is suppose to be a single screw propeller a ship with one propeller.

Now, there is a there there is some obstruction in front, so any any how it says that, we just are using this value, now how we proceed A R actually what we have to do is to do this way. See, see in this cases we need to do a, how will you proceed we what what do we want to find out remember, I want to see what is necessity we find out is the two things; one is this location and the force that acts.

In fact, you may not want to find the location, what you want to find out is, again moment about this line, moment about this line and moment about this line (Refer slide time 44:32), that is T and M because we can combine them to get M here, that is what I mentioned before. Once again if you pay attention, why I need to find out the torque coming on this, on along this line that is T and I need M here; now I can find C P but, instead of doing C P also I can do integration.

So, and so here, I have to do an integration, I have to find out section by section for each one I want to find out, what is the center of pressure for that .31, c formula, then I can add it all up to find out combined C P or for each one, I i would also know the force and therefore, I can use the formula for force. So, what we will do is like this see here, I we will look at this and get back to that, so here, we are calling this to be in various level you know if you call this A B C D E, then at this I will have 1 meter, I did not mention that these are all 1 meter.

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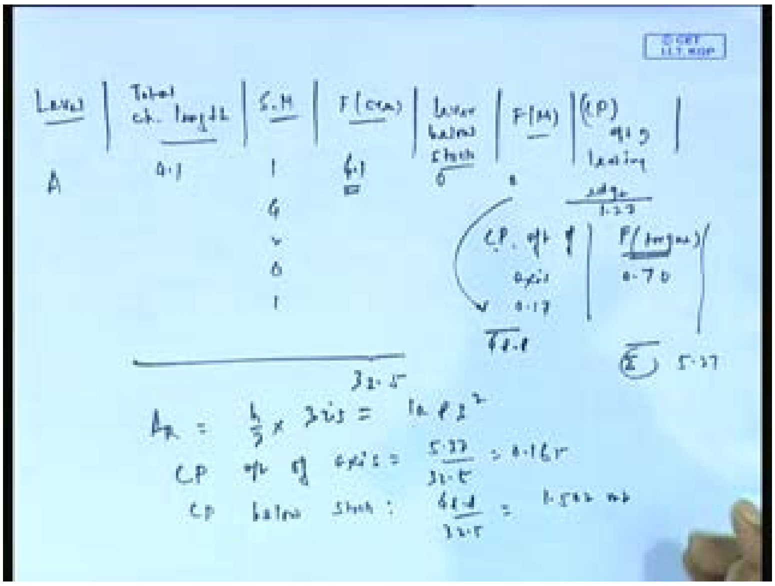

So, you have a things like this is a quick thing, to chord length, then Simpson's multiplier then F function of area and then lever, this is to find M and function of moment then C P aft of leading edge; actually I will just show you one and then of course, I have more terms will be C P of axis and function of torque.

I will tell you just one, see for example, for level a remember this level A, my total chord length is 4.1 meter, 4.1 meter this of course, I write 14241, etcetera you know whichever way this (( )). Now, function of area of course, we will have whatever function of area is 4.1 etcetera; now lever below stock see, what we are trying to do you know is that lever below stock means, we are trying to find out the force know, so it is basically Simpson's multiplication.

Lever below torque for this 0, because it is 0 meter below torque this is 1 meter, etcetera so this is basically 0, function of moment is going to be obviously, like 0 here see, now here C P after leading edge from here, aft how much it is suppose to be .31 times, 4.1 that will be 1.27; I i just not very clear here, 1.27 what I am trying to say you know that you have to do this point by point.

Then, C P aft of axis if it is 1.27 here, then beyond the red line it is 1.27 minus 1.1, so this will be 0.17 and of course, the function of torque is going to be obviously this 0.17 times you know like that; basically this the force into that part, that is force well, this actually this function of torque.

Because what we are trying to find out is this that area that comes here, because this proportionate that into this distance we are going to we are writing, there as that is basically 4.1 into 0.7 and 4.1 into 1.27. This function of torque right with the Simpson's multiplier. Now what what I am trying to say is that ultimately, when you add it all up you see then what would happen, when you do this you will end up getting say function of area to say somewhere here 32.5.

Therefore area will become h by 3 into 32.5, which will become 10.83 meter cube and C P aft of axis that will be, when you multiply this function of torque this part this part which turns out to be 5.37, become 5.37 by area 32.5 see, what I am saying here, I will tell you this is, you are trying to find out centroid of this point.

You are trying to find out here, where this point will occur kno,w what are you doing you are trying to take the formula for the the forces coming and the C P for the individual one, obviously there is so much force coming at this so much force coming at this, so you are adding this up to find the net moment you know divide by that, you get C P, so that is what you are getting.

You get this C P aft and C P below stock, this will be when you take this function of moment, because what you are doing is here again each force multiplied by distance, so that gives you the net force moment about this; so when you do, that you end up getting this you know that moment if if I do that this is this is basically, this part F M, this part in this problem 48.8 by something like, let me see this you will end up getting 1.502 meter, so what we end up getting is something like this, that this point is a a distance of 0.165.

And this distance turn out to be 1.502 that is what you end up getting the center, just by using this formula and then having done that, what we can do is to find out the total bending moment of a combine.

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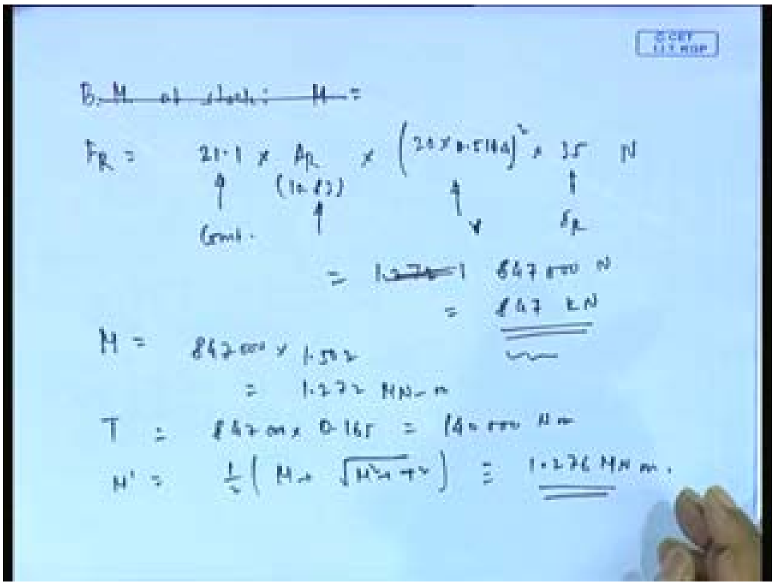

Now, First of all B M at stock that is M, this is going to be well before that the force on rudder, before that we can F R this is 21, what the formula 21.1 into see here, yeah we will do A R yeah this is 10.83 multiplied by v, v is 20 knot into well 0.5144, if I do here, into delta R, is this A R and this is a constant.

That many Newton's this will turn out to be 1.272 know not turn out to be 84 have a look at this number you know 847 kilo Newton, how many tons equivalent approximately yeah, so around 84, 85 tons. So, this is the kind of like force comeing remember, so you see why I am saying that have a kind of a feeling over the kind of numbers we get 85 tons is not a very small you know like force.

If you consider a average commercial cars weighs 1 ton it is like 85, weight of 85 cars right so in ships everything is quite big and this size is only 4 meter by about 4 meter right 16 meter square, 4 meter is 12 it is huge plate but, look at the force, that is coming, so what do you think the stock you have to made of that, is what we are coming that.

Let us look at bending moment, about the stock this is going to be 847000 into 1.502, because that is what the distance is it not, it see here I have got a 847 kilo Newton into 1.502 that is my bending moment M. So, this turns out to be equal to 1.272 mega Newton meter, then torque yeah torque is coming to be same 847000 into 0.165, that will give you 140 Newton meter, that is the torque coming here, torque on this bending moment on this.

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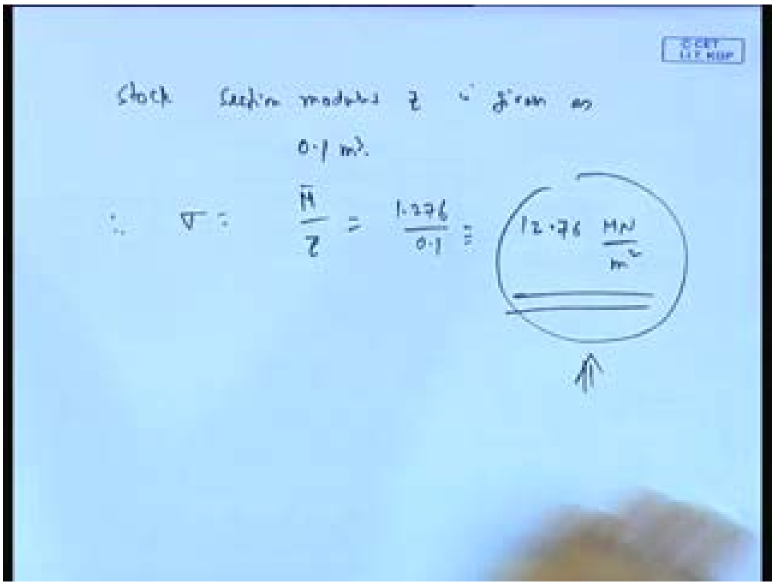


So, you end up getting equivalent bending moment, half of M plus square root of m square plus g square equal to 1.276 mega Newton meter, so the stress now here, actually this if you want to now this you know; now actually this problem the stock z is also given I believe, section modular's (No audio from 54:36 to 55:00), this 1.276. Now (No audio from 55:01 to 55:10) see, this stress 1 12.76 mega Newton point meter square, if you compare you will find out that you actually need very strong like you know this stress you cannot have wooden stock or something you need solid.

See, so this problem is very simple what i we I did try to do quickly but, essentially what I mean is that, this will give an idea regarding the kind of stress is that will come on your stock. You you can be off by say 10 percent, 20 percent depending on, what formula you use but, for design purpose it is good enough, initially and these kind of numbers should give you a feel of the kind of stresses, that we deal with in even in rudder stock and rudder force; so this is the you know just the simple example.

So, anyhow I will end it here today and we will see next, how we can talk little bit about some empirical formula for hull derivatives, we talked about experiment but, certain formula, so with that I end it today.