Ship Resistance and Propulsion
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Lecture - 16
Resistance of Advanced Marine Vehicles – II

Welcome back to a session here under ship resistance, we have all ready discussed about resistance of a conventional ships and also in the previous class; we started with resistance of advanced marine vehicles.

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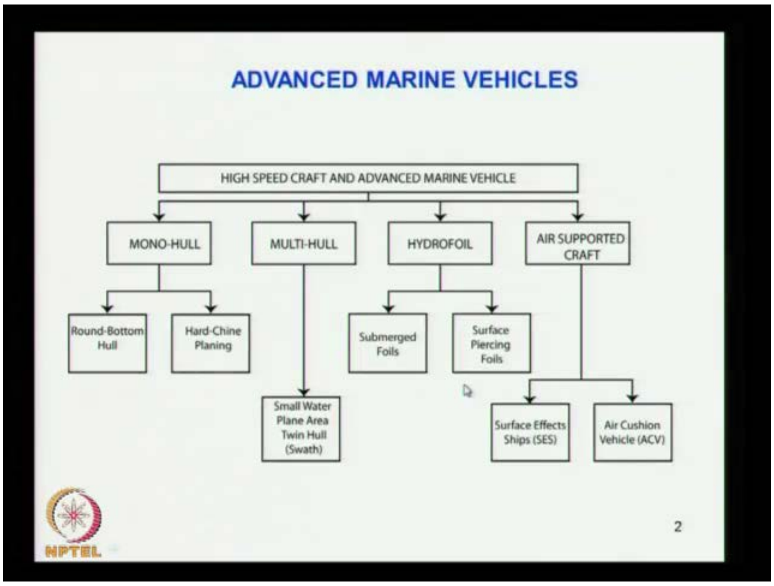

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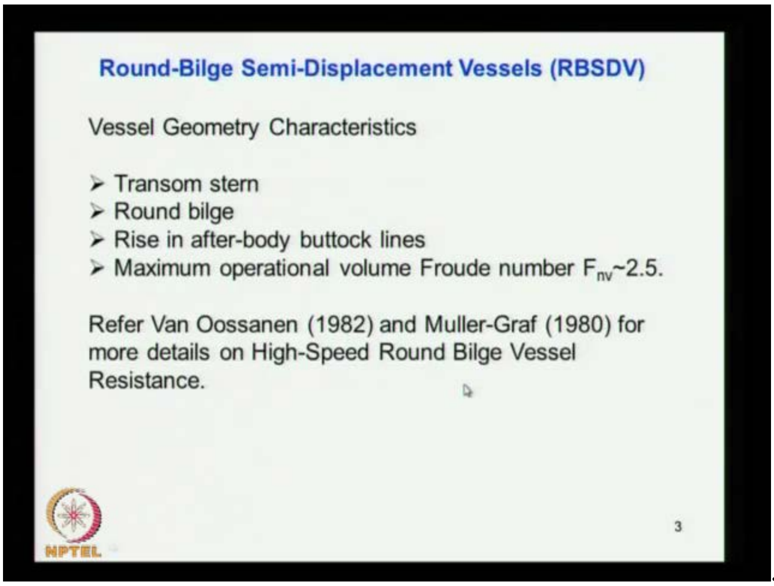

We have gone through you know what is the classification of advanced marine vehicles. These things we have covered and also we discussed about the resistance estimation of round bilge semi displacement vessel. Usually, these types of vessels, we have already discussed that it is round bilge is a conventional form, but with high speed meant to highest form high speed, which may plan after you know after this is a semi planning or semi displacement type.

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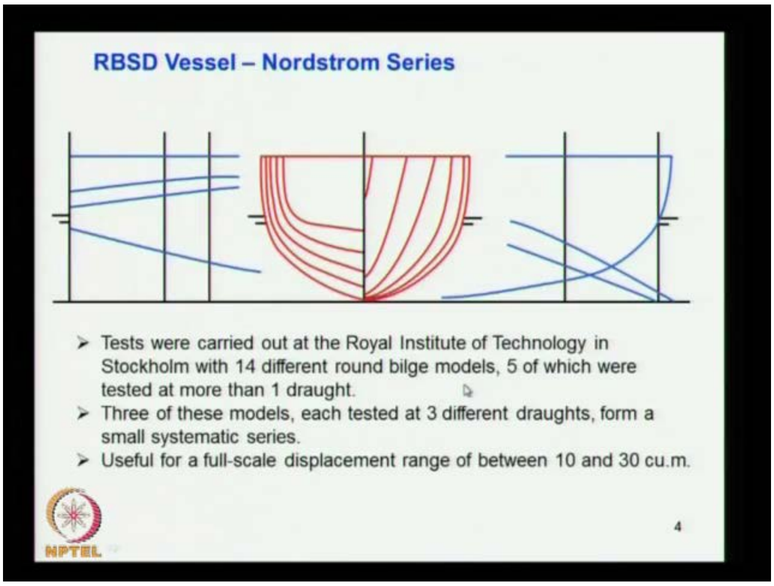

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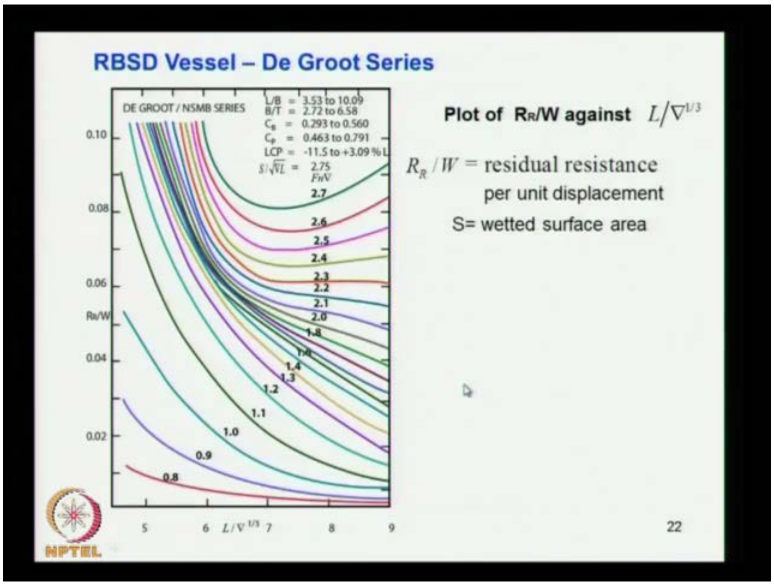

So, the round bilge displacement ship semi displacement ship got various series, we have seen series 63, then series 64 the forms are as shown. This I am repeating which has been covered before, so it is 64, then SSPA series, then subsequently we have for covered NPL series, then I think De Groot series and we have completed so far.

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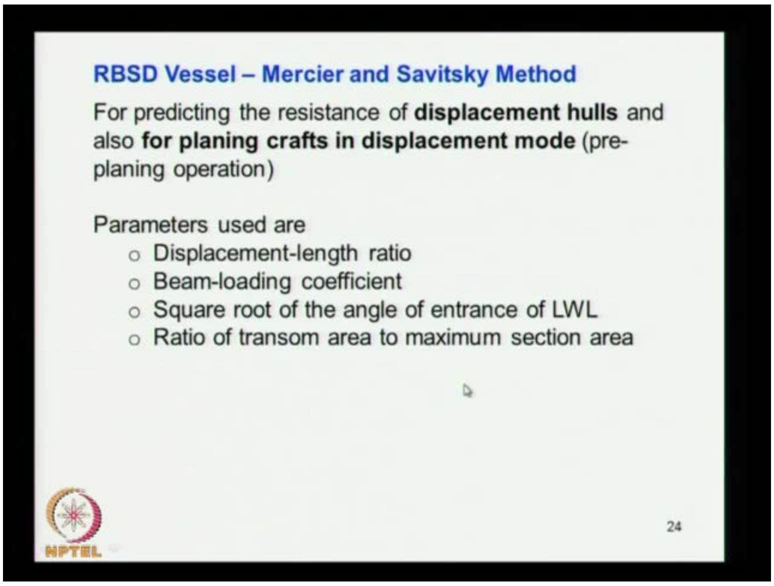

Now, we will look into again the same type of vessel round bilge semi displacement vessel put forward by Mercier and Savitsky which is they have done experiments on based on this type of vessels. It may be a planning craft and which operates at a displacement mode that is prior to the planning condition. It operates in displacement mode, so when the speed increases, it reaches a threshold speed where it start planning. So, before that, it is in the displacement mode if you want to estimate the resistance of the vessel and in the displacement condition, then you can use this method.

For that we will planning crafts in displacement mode where this pre planning operation of the vessel. That is because we know that planning crafts the resistance fix up to that the threshold point. Then it comes down and subsequently it fix up, so parameters used are a displacement to length ratio beam loading coefficient square root of the angle of entrance at LWL.

You know we have all ready discussed what is angle of entrance that would designed by water length, so you have to know, the smaller the angle, finer is the shape ratio of transom area to maximum section area. So, the transom you know its planning crafts going to a transom and the area of the transom to the maximum section area, what is the ratio of that?

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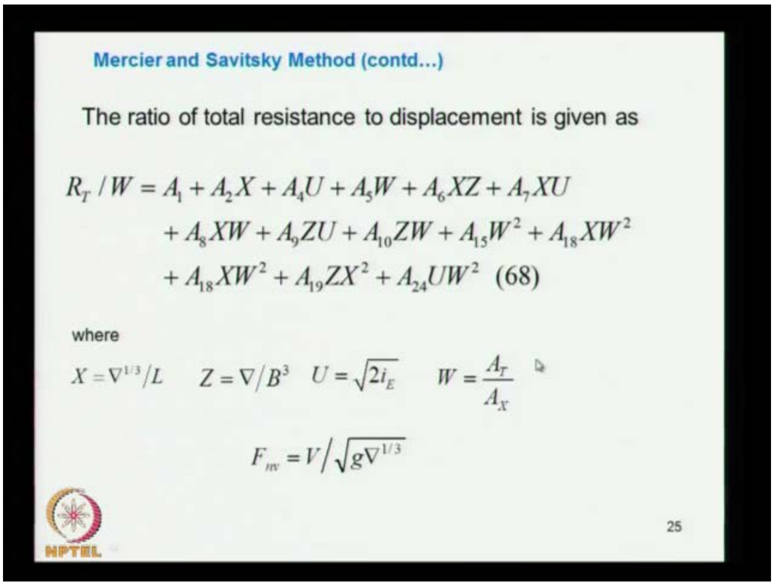

This is a method which we have already seen when we discussed about the different methods in one of the previous classes. Here, what is given is that it is a ratio of total resistance to the weight, so we get to actually displacement total weight to displacement. So, here it is given this is a given by this relation segregation expression here and all these coefficients we will see and what are the different terms you can see. It is represented by is the displacement to the length ratio displacement raise to one-third divided by length which is not dimensional.

Then, you have next term here is square root of 2 times half angle of entrance, it is half angle of entrance that is the load water length. We have seen half the angle of that the 2 times and the square root of this is the u and w is given by A t by A x, A t means is a transom area as a transverse area of the transom divided by the maximum section area of that. So, that is the w, so w appears here, then what you have is all this x z is known, so all coming in this terms and finally what you can do, you can find out what is the resistance by displacement.

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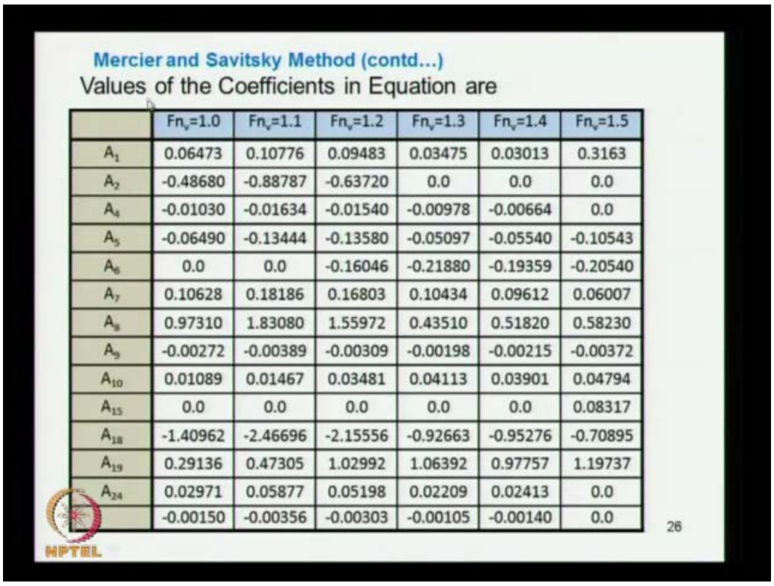

	Fn_v=1.0	Fn_v=1.1	Fn_v=1.2	Fn_v=1.3	Fn_v=1.4	Fn_v=1.5
A_1	0.06473	0.10776	0.09483	0.03475	0.03013	0.3163
A_2	-0.48680	-0.88787	-0.63720	0.0	0.0	0.0
A_4	-0.01030	-0.01634	-0.01540	-0.00978	-0.00664	0.0
A_5	-0.06490	-0.13444	-0.13580	-0.05097	-0.05540	-0.10543
A_6	0.0	0.0	-0.16046	-0.21880	-0.19359	-0.20540
A_7	0.10628	0.18186	0.16803	0.10434	0.09612	0.06007
A_8	0.97310	1.83080	1.55972	0.43510	0.51820	0.58230
A_9	-0.00272	-0.00389	-0.00309	-0.00198	-0.00215	-0.00372
A_{10}	0.01089	0.01467	0.03481	0.04113	0.03901	0.04794
A_{15}	0.0	0.0	0.0	0.0	0.0	0.08317
A_{18}	-1.40962	-2.46696	-2.15556	-0.92663	-0.95276	-0.70895
A_{19}	0.29136	0.47305	1.02992	1.06392	0.97757	1.19737
A_{24}	0.02971	0.05877	0.05198	0.02209	0.02413	0.0
	-0.00150	-0.00356	-0.00303	-0.00105	-0.00140	0.0

So, you can use that and this values A 1, A 2, and all the coefficients which appear in this taken expression A 1, A 2, A 3, all these are given here you can see for different fluid number. This is basically delta, we have v, this are volume fluid number which is defined by this one the volume fluid number is equal to v by square root of g into delta power one-third. So, this is the volume fluid number definition, so it is given for different volume fluid number. So, if it is a you are vessel is operating a volume fluid number 1, then you take this coefficients and substitute in the previous expression to get the total resistance or if it is in this range F n 1.1, you follow this coefficients.

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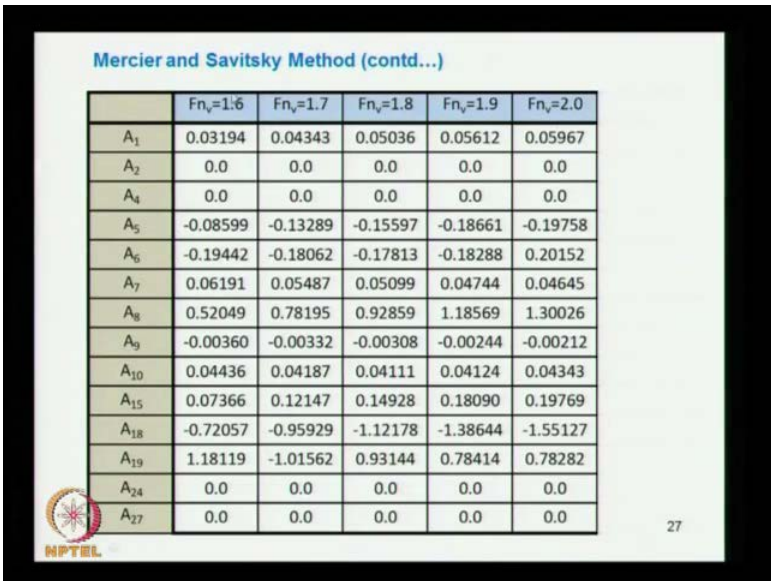
Mercier and Savitsky Method (contd...)

	Fn_∇=1.6	Fn_∇=1.7	Fn_∇=1.8	Fn_∇=1.9	Fn_∇=2.0
A_1	0.03194	0.04343	0.05036	0.05612	0.05967
A_2	0.0	0.0	0.0	0.0	0.0
A_4	0.0	0.0	0.0	0.0	0.0
A_5	-0.08599	-0.13289	-0.15597	-0.18661	-0.19758
A_6	-0.19442	-0.18062	-0.17813	-0.18288	0.20152
A_7	0.06191	0.05487	0.05099	0.04744	0.04645
A_8	0.52049	0.78195	0.92859	1.18569	1.30026
A_9	-0.00360	-0.00332	-0.00308	-0.00244	-0.00212
A_{10}	0.04436	0.04187	0.04111	0.04124	0.04343
A_{15}	0.07366	0.12147	0.14928	0.18090	0.19769
A_{18}	-0.72057	-0.95929	-1.12178	-1.38644	-1.55127
A_{19}	1.18119	-1.01562	0.93144	0.78414	0.78282
A_{24}	0.0	0.0	0.0	0.0	0.0
A_{27}	0.0	0.0	0.0	0.0	0.0

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Similarly, it is given for all the different range of fluid number volume fluid number, so you choose the coefficients according to the volume fluid number and if you find that a value the fluid number is lying between these ranges. So, suppose say 1.65, what you have to do is you estimate the resistance for this and estimate the resistance for this and then you interpolate to get the value for 1.65.

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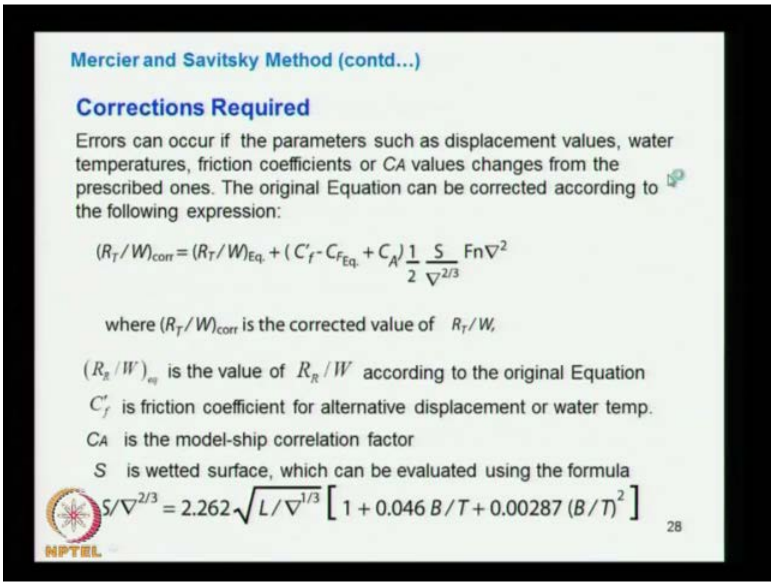

So, that is the procedure one need to adopt for the estimation of total resistance using the Mercier Savitsky method which is applicable for round bilge semi displacement vessels or even plan interrupts which operates at the up to the pre planning condition. Some corrections are required, you have to find out corrections required or errors can occur if parameters such as displacement values water temperatures friction coefficients or C A.

So, the formula has been derived based on the experimental results carried out with model selected for particular parameters. The test may be might have been done at particular temperature of water in the tank or the frictions of surface may be different, water may be different accordingly the temperature changes, viscosity changes, frictional coefficient changes. So, this variations need to be accommodated if it varies from the test conditions, so for that naturally, you need to apply the correction.

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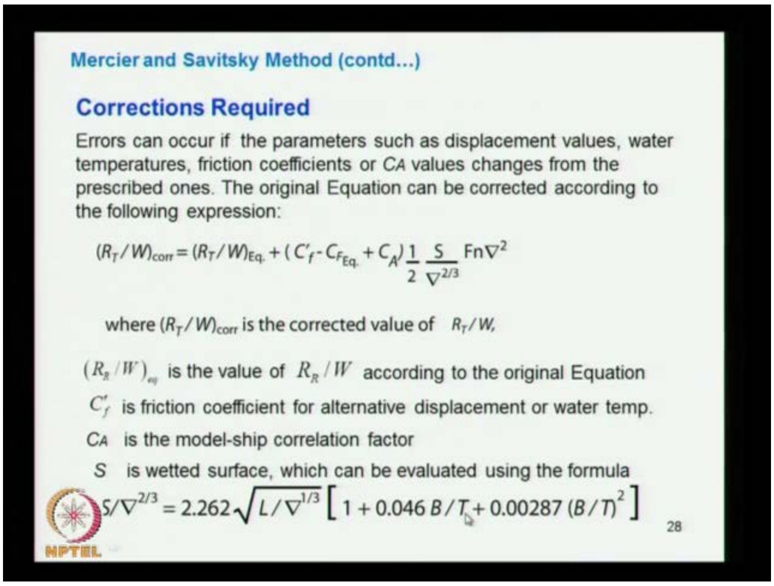

So, this correction it is given by this is R T by W means corrected. We can say is equal to this is the base value which you will get from the equation plus C f prime minus C f equal that is C f prime is the friction coefficient for alternative displacement or water temperature. So, if there is a variation in displacement or temperature, so you have the friction resistance coefficients changes you estimate this frictional coefficient normally using ITTC formula which we have all ready discussed many times.

Then, you have this result frictional resistance coefficient minus C f is the what the act actual vessel, so that difference will be considered, then this is the model ship correlation element C A which we normally use. They count for the roughness variation between the ship model and the actual ship, so that is the model ship correlation element which you have to give and I think you have recall that. Normally, we use the value of 0.0004 for the conventional ships so that you have to include here than half S that is a vector surface area divided by delta power two-third.

Then, this is the volume fluid number and square fluid, so you get the corrected value from this expression. If there is a deviation of the vessel, you consider and if its deviates from the test vessels and the test condition and also you can see that the wetted surface area S by delta power 1, two-third is equal to 2.26. This is the expression given for that which depends on length displacement breadth draft, so now you know you know all this main particulars of the vessel.

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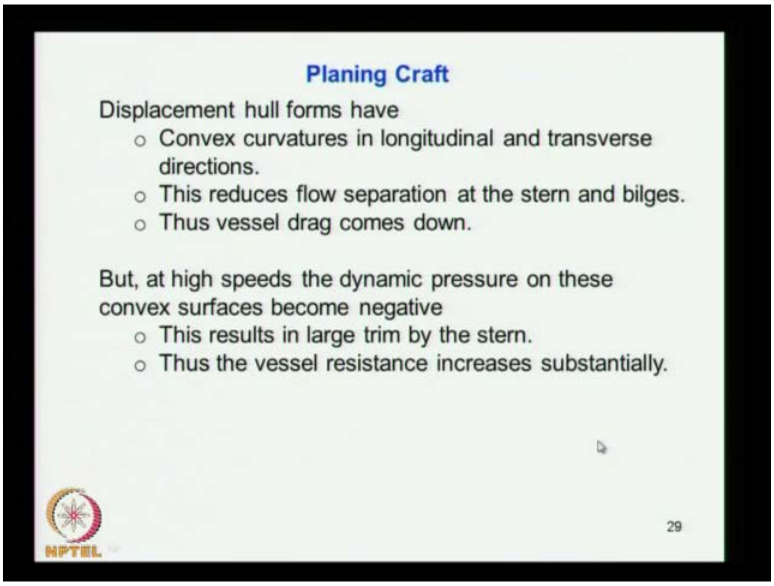

You know that you can use this to find out this quantity here, so that is the correction applied to the formula. So, when you come to the planning crafts, how it differs from the displacement form displacement form and planned the displacement vessels can achieve a higher speed or speed up to only a certain limit. If you want to have a vessel to operate at a higher fluid number, a higher speed, then you may have to go for different option like a planning craft and may be other types we come later. So, displacement hull forms, they only have a convex curvature, we know that the shape is convex may be in the next slide we may teach there.

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We can see that it is the shape you can see the transverse is convex and also you say longitudinal also, it is a convex shape. So, you can say that this is a displacement vessel which is having a convex curvature in the longitudinal and transverse directions. So, the convex curvature in the longitudinal and transverse directions, this reduces a flow separation at the stern and bilges. So, a smooth curve a convex curvature reduces that flow separation because it is a smooth shape.

Thus, the vessel drag also comes down, that is why the displacement hull forms are given as such a shape convex curvature, but at the high speed the dynamic pressure on this convex never become negative. When the speed increases naturally due to the curvature the velocity increases when the flow velocity increases pressure drops.

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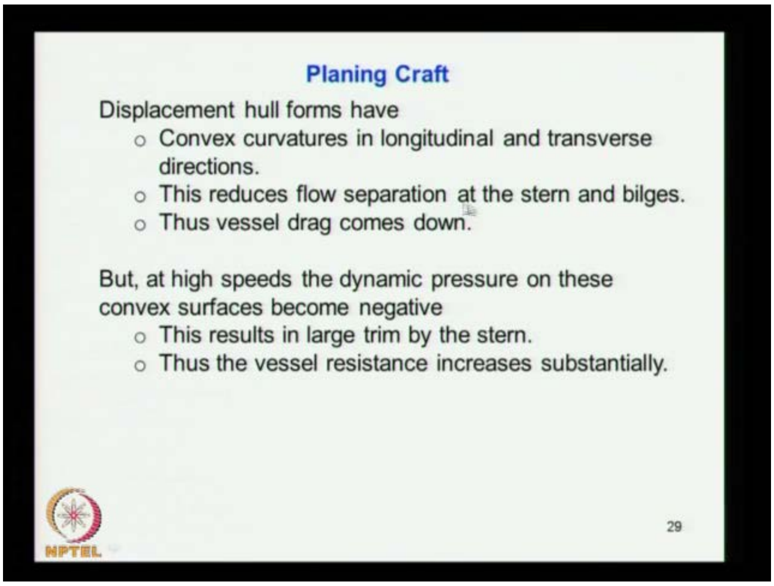

So, that is why it says there, it can be dynamic negative pressure mainly in the aft region, so what happens this results in the larger trim that is the pressure at the aft region gets reduced substantially due to the higher flow velocity. The subsequent reduced to pressure the vessel will trim more, thus the vessel when they trims more the hydro dynamic or the hydro performs the ship changes and the vessel resistance increases substantially.

So, if you plan to have a high speed vessel and if you adopt a convex curvature, it is similar to a displacement hull. Then naturally you may face in count of this situation which is not acceptable, so when it comes to the semi displacement type, this is another vessel which we have under taken to for project. So, you consider this is a semi displacement you can see that the shape is not so convex.

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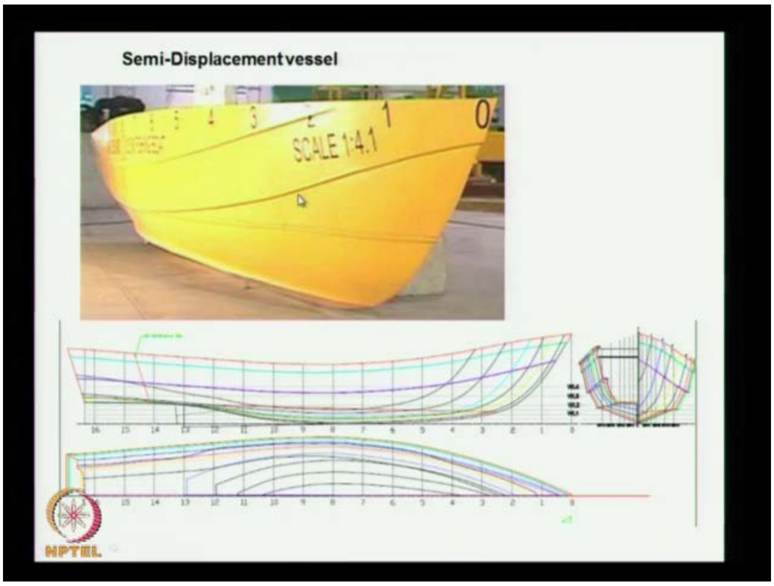

Then, you can see the spray raise here which you know, restrict the spray or arrest the spray and reflect the spray, so this is the form of a semi displacement vessel.

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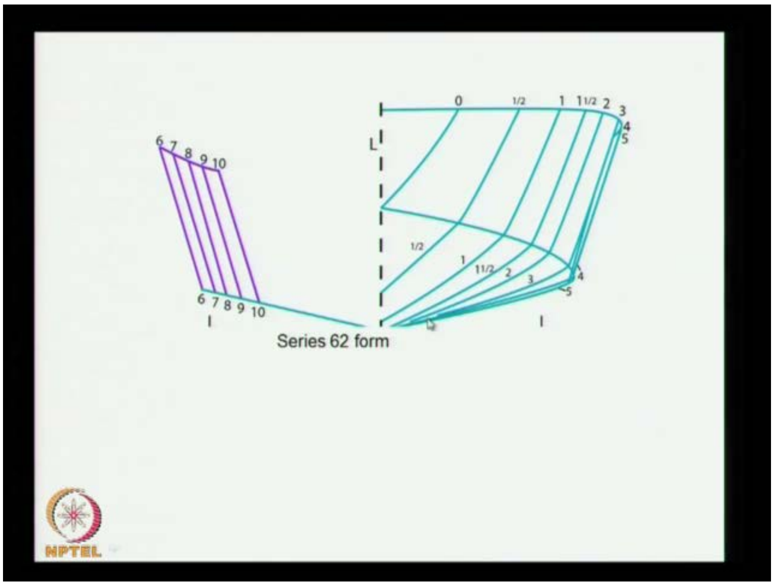

Then, typical disc, we know planning craft, there is a shape. So, there netted change between the bottom and the sight this is not smooth change, it is a broad change, you can see it is a general feature of a planning craft. You can see that there is a dead rise, strong dead rise here and then you have the side, suddenly deviating from the part.

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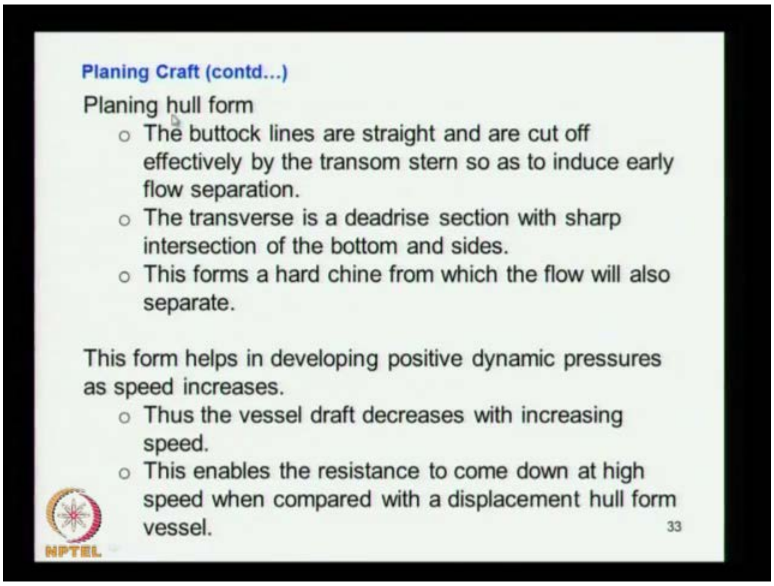

So, that is what the planning hull form buttock lines are straight and are cut off effectively by the transom. So, you if you find out that the buttock lines mean it is the longitudinal plain parallel to the longitudinal central line plain. So, if you curve a plane taken along the ship the longitudinal direction what I suggest is you consider a ship.

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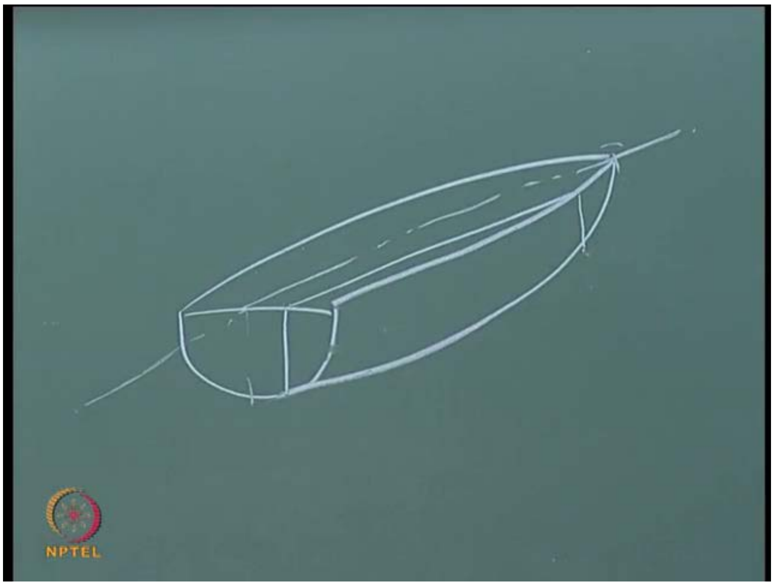

So, if you consider, this is the central line, you can say this is the central line of the ship and this is the longitudinal you take a plain as that is as the actual central line plane. So, if you take another plain parallel to this, you see you get another ship, so which you must have gone through in case of when the lines plain of the ship. When you draw the form lines plan of the ship one of that is the profile given, you will see there are lines drawn which represents the buttock lines. So, here in case of planning craft these buttock lines are going to be straight, there is not much curvature, it is all most a straight shape.

So, that means are cut off effectively by the transoms sterns so as to induce early flow separation. This results in an early flow separation the transverse is a dead rise section with a sharp intersection of the bottom and sides it is what we have seen the transverse section. If you take the transverse section, there is a sharp variation from the bottom and side, so that is the option that is the transverse is a dead rise section, dead rise means what you have seen here, this angle, if you consider the angle of this line with reference to the horizontal that is called the dead rise angle.

So, that is the transverse is a dead rise section with sharp intersection of the bottom and sides, so it is not going smooth it have changes uprightly. So, that is what is happening there, this form has forms a hard chine from which the flow will also separate, you can see that in this because of the sudden change, the flow separates here also. So, what is the advantage, this form helps in developing positive dynamic pressure that helps in all of a sudden. They will say dynamic pressure generated due to that form which is very well present in case of the ships speed is high.

So, high speed you will you will find this effect, thus the vessel draft decreases when there is a dynamic pressure. That means in addition to the buoyancy, you have the buoyancy supporting it, then in addition to that there is a dynamic pressure which is pushing the vessel up. So, now the ship is supported by dynamic pressure and buoyancy, you know in this case of displacement vessel the only support or the sole support for the weight is coming from hydrostatic pressure. It is called the buoyancy in this case, in case of the planning vessel due to the form of the vessel and due to the high speed dynamic pressure is created which pushes the vessel up.

So, that means the whole weight is now supported by buoyancy or hydrostatic pressure and also by hydro dynamic pressure. So, it thins a point that means the buoyancy component is reduced compared to displacement condition weight remains the same. So, the buoyancy component reduces when the buoyancy component reduces the underwater portion of the vessel reduces. That is submerge part of the vessel reduces the submerge part of the vessel reduces contact area or the wetted surface area of the vessel reduces when the wetted surface area reduces the resistance reduces.

So, that is advantage that is the principle behind the planning craft, so that is what the vessel draft decreases with increasing speed because more high dynamic pressure. So, with the buoyancy contribution becomes less and hence the draft reduces decreases this enables the resistance to come down at high speed if you compare to the displacement hull. If you consider a displacement hull operating at that speed and a planning craft operating at the same speed, you will see that the resistance of the planning craft is much less compared to that of a displacement hull operating at the same speed.

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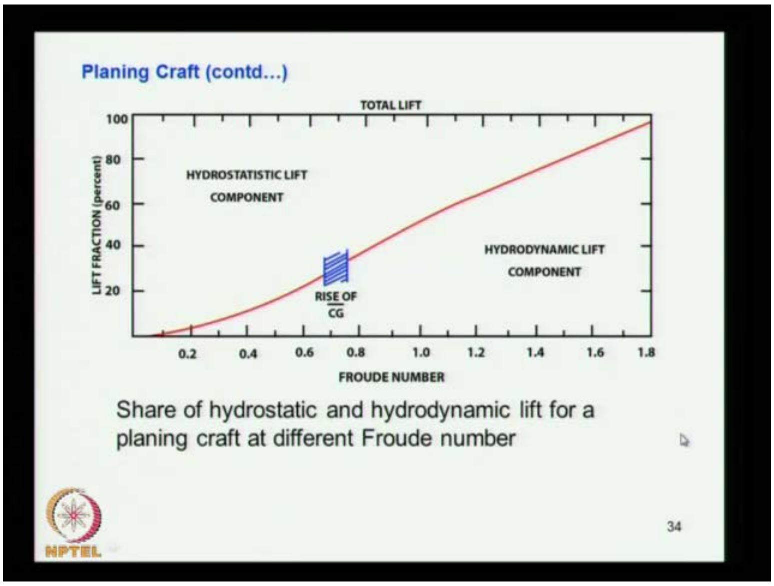

Here, this diagram gives an indication to that you can see that these are lift fraction percentage of lift is coming from the hydro dynamic support where you can see the total support. If it is 100 percent, it is given in percentage and it is against the Froude number that is the speed. So, at low speed you can see that the full support is coming from hydrostatic component, which is you can see this red line which differentiate the hydro static and hydro dynamic components of the lift.

You can see here the buoyancy component is almost full, you get full support from, but when the speed increases the hydro dynamic effect, you know increases. So, you can see that somewhere at this point or may be somewhere here nearly 50 percent is coming from hydro static component. It may be 50 percent coming from hydro dynamic component, but when the speed increases further you can see that the contribution coming from hydro static or buoyancy is less where as the major contribution is coming from the lift hydro dynamic lift. So, this indicates what would be type of support and the planning craft gets during its course of operation that is when it is starting.

When it is in the displacement mode, buoyancy contributes the maximum or all most fully contributed by the buoyancy, but the proportion changes when the speed picks up. Here, high speed you can see that it is all most you know ball craft it is coming from the hydro dynamic lift.

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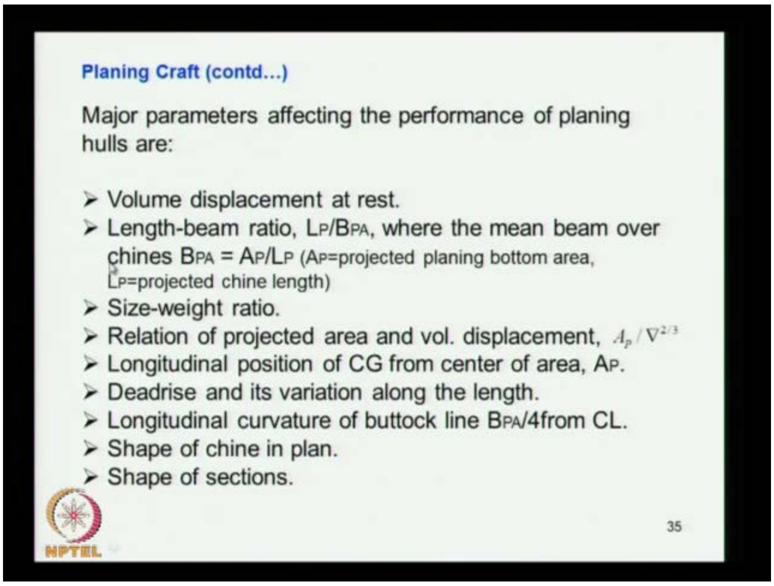

So, that is the one which diagram indicates major parameters affecting performance of planning hulls are volume displacement at rest. So, what is the displacement at rest which indicates whether the ship will generate sufficient hydro dynamic lift at higher speed? So, you can usually see that planning crafts are not big ones they are usually small to moderate, so the size is not so big length beam ratio that is L P by B P A, L P is a projected chain length.

So, we have already seen the chain of the form you can see this is a chain there is an intersection between the side and bottom. So, here that is L P is the projected chine length B P A, B P A is a mean beam of the chine. So, you have a chine plan may be in the next layer, you have there is a chine plan if you take the mean width. So, this is the maximum and if you take the mean of that, you guys get the BPA, so BPA is the mean beam over the chine plan. Then that is the ratio of these two, you call it is a length beam ratio there is another parameter which affect the performance of the planning craft then size weight ratio.

That is what is the size of the vessel and what is the weight displaces that is the important relation of projected area and volume displacement A P is a projected area of the planning bottom area that is you have the planning bottom. That bottom area divided by delta power two-third if that is called the relation of a projected area and volume displacement longitudinal position of C G from center of area. So, we have the A P, A P represented by these projected planning bottom area centroid of that from the centroid of that what is position of centre of gravity of the vessel.

So, that is important, central gravity should be aft sufficiently, similarly you get the proper trim and planning affect dead rise and its variation along the length. I have already mentioned what is the dead rise, so that is slopping of the bottom, so what is the dead rise angle and what is how the dead rise vary along the length. Is it same or is it going to be different longitudinal curvature of buttock line B P A by 4 B P A already sets a breadth you can see that breadth chine breadth.

So, buttock lines as I said the buttock line drawn through one fourth of B P A from central line. So, that is the one that is will say the curvature of that from central line, so what do you mean by that is B P A by 4, you can see that this distance this is a buttock line which I have already mentioned, so this distance is equal to B P A divided by 4.

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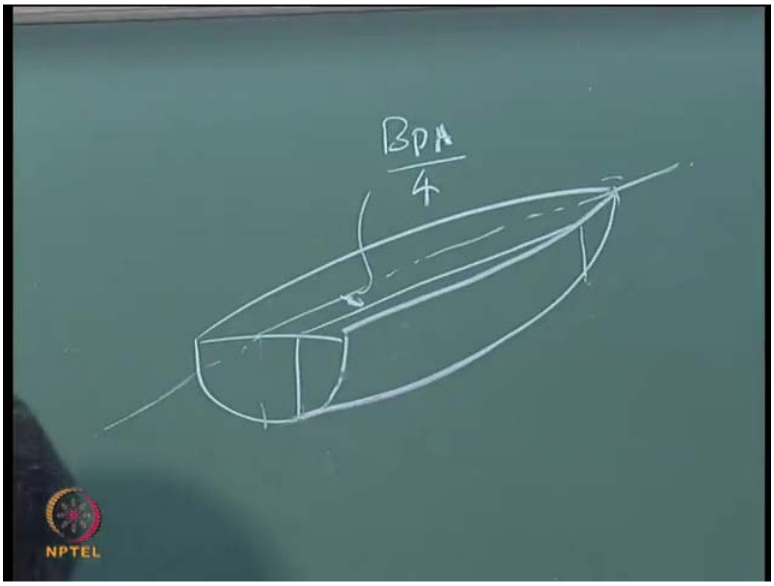

So, that is the B P A by 4 buttock line, so you look to what is the type of curvature you are getting at that point at that plan buttock plan. Then shape of a chine in plan what is the shape in the plan view and then shape of the sections all these are various parameters which will influence or affect the performance of the plan inverse, so this is the one what I said.

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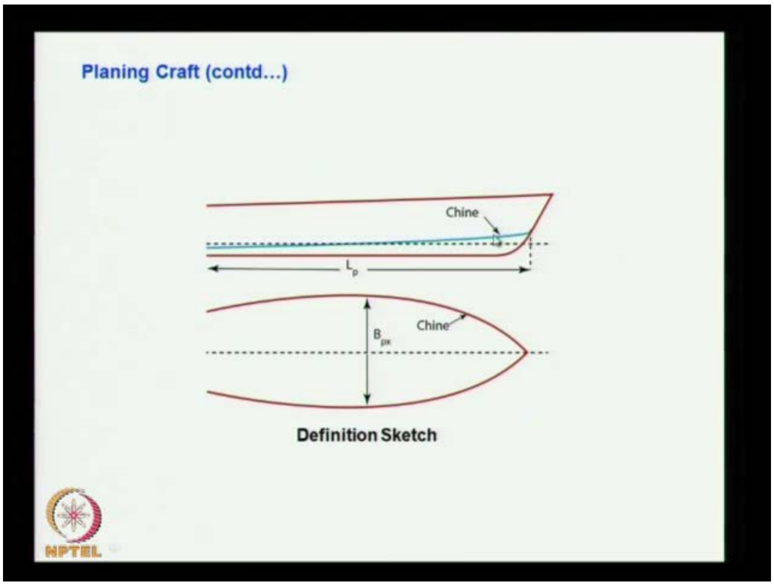

This is the bottom this is the chine that is a bottom will go up to the chine, here it is deferred this is there is a dead rise, it will comes here and then you have the side. So, this is the chine length that is you know neck hull, basically the point at which the curvatures changes uprightly. Then this is a chine in the plan view and this is the maximum B P X maximum breadth of the chine plan.

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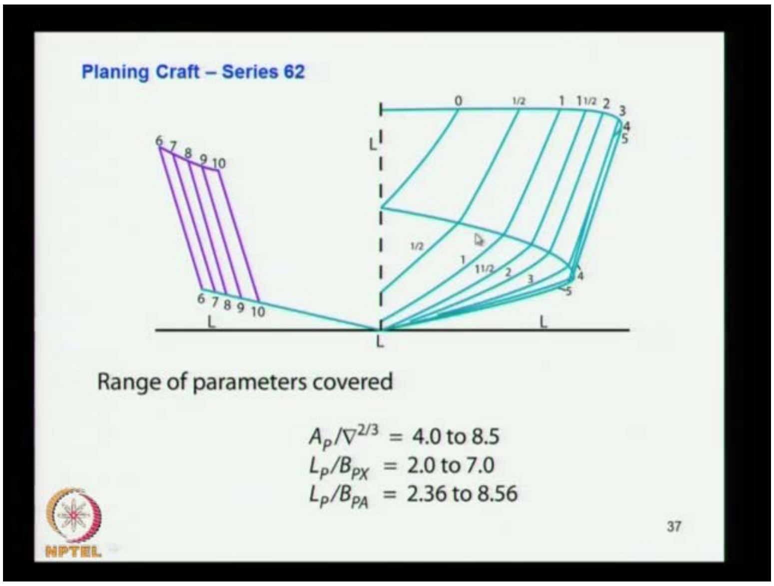

Here, same thing you can see that this is a chine, so if you have this chine line means that is the point length at which where this ranges in the curvature all of a sudden the curvature changes all of a sudden above this line. So, the range of parameters covered in this arm in this series 62. We are saying in the planning craft the series 62 is one of the series of the planning craft.

This series this are the series of models which have been tested which comes under the planning craft category that is the shape something like this and they have a variation you can see that the variations are A P by already the terms I have explained. So, this ratio 4 to 8.5, these are the validity range of this series 62, so if you have a planning hull form which fall in this range, this parameters falling in this range, then you can use the data resistance predictions put forward by the series 62 form.

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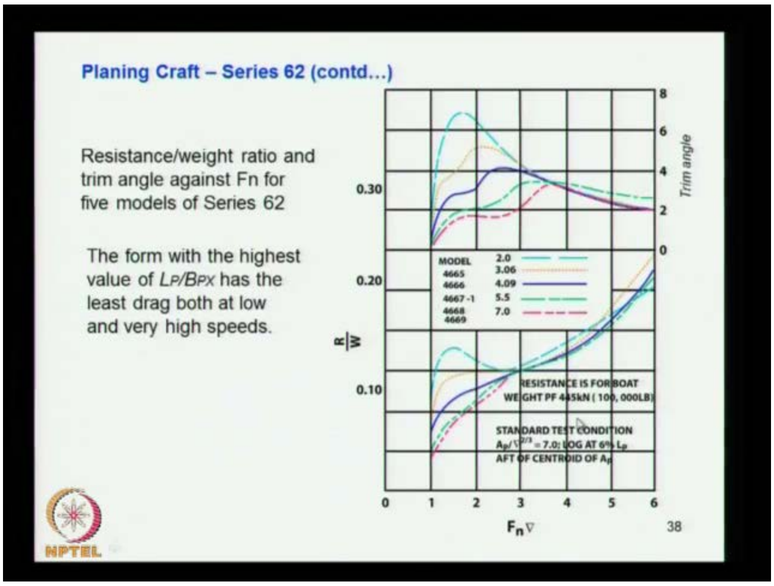

You can see here that the resistance predictions here series 62 what you have here is R by W that is resistance by displacement against volume Froude number. So, this is the plot and it is plotted for different models, you can see that different resistance of different models. There is a variation of these parameters, you can see what is the parameter here this is the form with the highest value you can say L P by B P X. This ratio refers to L P by B P X, L P and B P X and L P, I have already mentioned from the previous diagram, you can see this is the L P the chine length.

This is the maximum breadth, so you know that from the form once you get that you will be able to find out what is L P by B P X. Then use two appropriate curve from here which is where it falls and then you follow the curve for different Froude number. So, directly you get the total resistance for displacement, so you have this and you can see here the form in the highest value that is this one of the whole L P by B P X. The highest one is 7 which is a red line, you can see that red line is having the least resistance at the lower portion.

Here, it is a lightly fixed no, here also it is coming to the lower length this is for this one. So, here this highest the form with the highest value of L P by B P X has the least drag both at low and high tem high speeds. So, it is going to this is the better option that is you prefer to a vessel with high B P L, B L P by B P X to have least resistance and here you can see that trim angle. This is the trim angle degrees 2 degree, 4 degree, 6 degree, 8 degree, you can see how for which vessel or for which model is changing again the trim is very less.

Here, trim is very high when it comes to the lowest L P by B P X ratio, so high trim is actually there will be a resistance mode and when it comes to this range high speed range it becomes more or less same all the types. Here, you can see that the trim is very high at this region and you can see the corresponding change and resistance either resistance picks up trim is high, so it is not at draft to resistance for the vessel.

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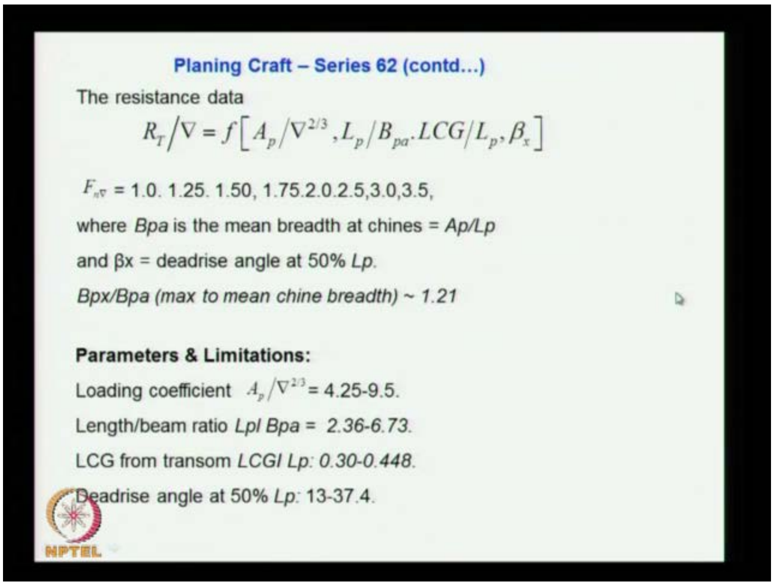

So, same we are continuing with series 62 planning craft resistance delta data is given by R t by displacement which is going to function of all these parameters A P by delta two-third and L P by B p a. This is average breadth of the chine plan L c g by L P, this is a position of L C G with respect to L P, and then this is the dead rise angle. So, here this is valid for Froude number of 1.25 it goes up to 3.5, so these are vessels have been tested in this range where B P A is the mean breadth of the chine B P A. Mean breadth of the chine which is given by A P by total area of the chine plan divided by length of the chine and B X beta X is the dead rise angle at 50 percent L P that is you taken over L P from the previous diagram.

So, middle of that 50 percent what is the dead rise angle for that section at that position then have the risk ratio the maximum to mean chine breadth that is equal to 1.21. So, these are the parameters used in the model test and the data of resistance is presented based on are based on results or test carried out using these parameters limitations. You can say these are the parameters limitations here for this this L P by B p a L c g by L P all this ranges are given. So, provided the vessel which you consider for designed come under this range of parameter, then you can use the method or this series 62 resistance prediction by that to estimate the power of the vessel in the designed stage of the planed craft.

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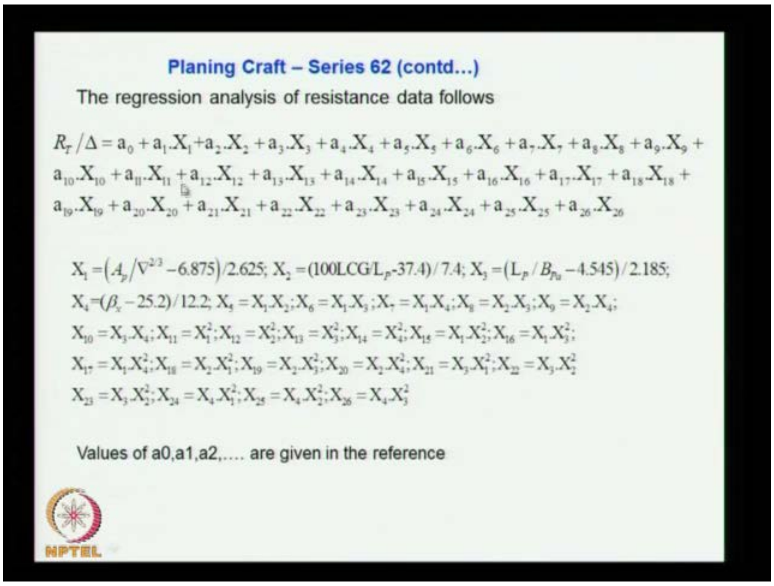

So, still continuing with series 62 do you for this is further analyze, we have seen the gross are further taken for regression analysis and regression X would have been put forward by researchers. So, you can see that the resistance to displacement ratio is given by this expression over here. Now, as we discussed before for different regression expressions the regression expression or regression analysis give you the coefficients which come from in the data from the experimental data. So, here you can see these are the coefficient, all these coefficients I am not reproducing it here.

I have taken from that, you can refer that and here the x 1 is given by A P delta power 2 third so is the expression for x 1, x 2 expressions is given by this. Again, depends on L c g L P and all that which are known at the initial stages of design x 3 given by this. These quantities and x 4 given by again depending on dead rise angle and x 5 and further it depends on the x 1 to x 4 quantities.

I think you can see that other things, so once you know A P delta L C the L C g l, P b a beta x, then you can find out the all the x components. Then put all the x component and the coefficients regression coefficients you get its also known then you will get what is the resistance total resistance to displacement.

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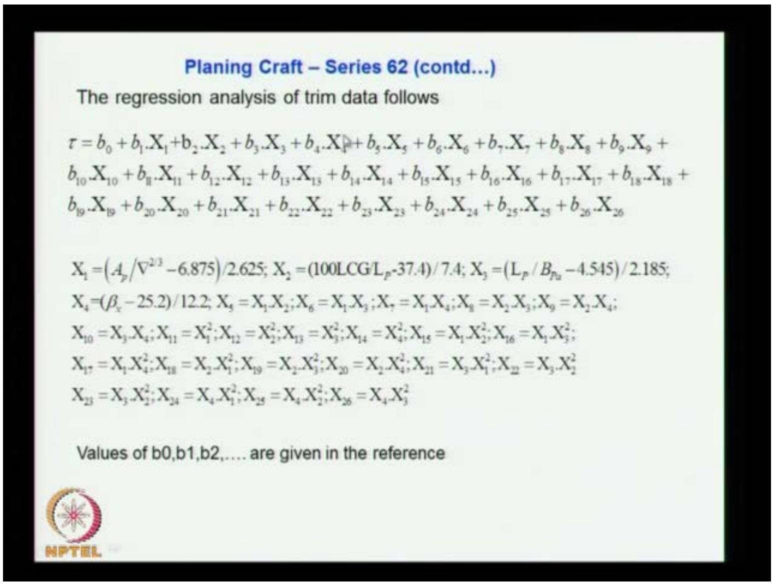

Similarly, then what do you need is the trim tau represents the trim angle, so trim also is given by using an same will approach regression expression from which all the values are defined here. So, from which you will be able to assess all these quantities and the coefficients also given and from which you will be able to find out the trim angle, so resistance to displacement is known and the trim angle is known.

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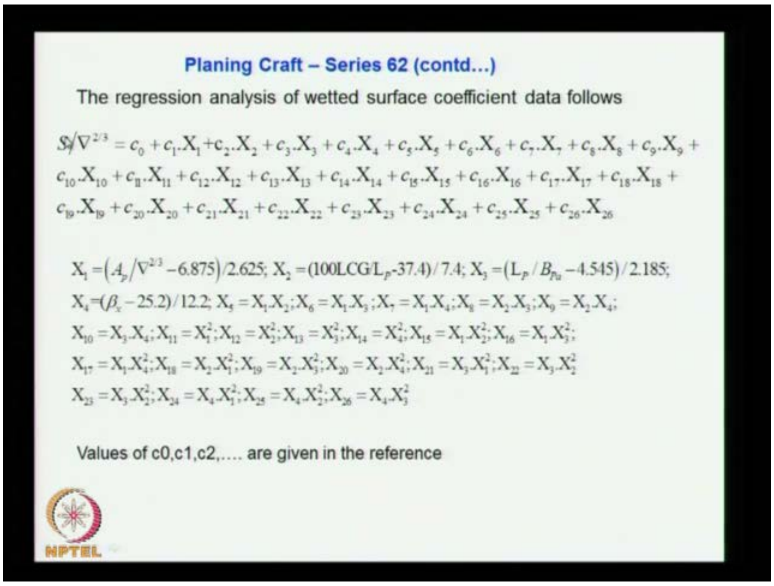

Now, you know want to know what is the wetted surface, the surface again put in non dimensional form S by delta power two-third, so you have this value is given by this expression c 0 c 1 etcetera. Again, it is given in the reference and so then x 1 all other quantities are explained here, so from which you will get this quantity now we know you have regression expressions for total resistance to displacement ratio for the trim angle.

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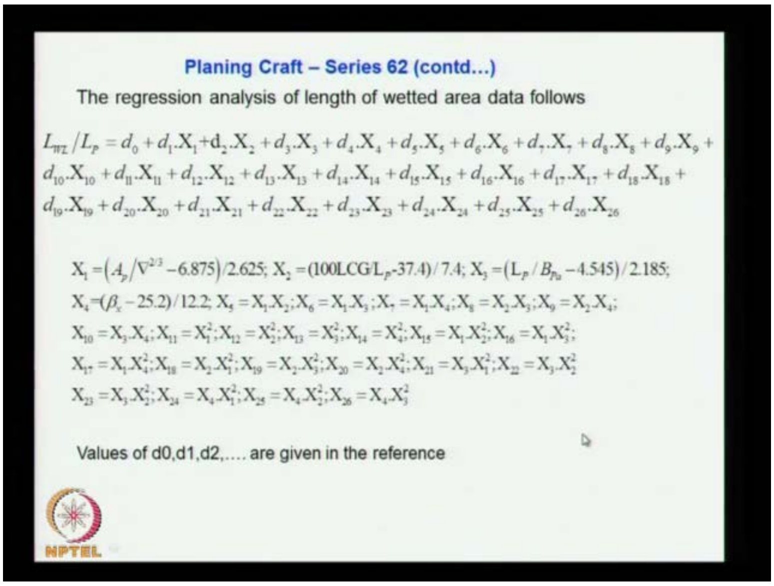

For the wetted surface, then you can find out what is the L W L by LP ratio that also again given by another expression. You can see there is a same procedure followed, so if here also you can see and from that d 0, d 1 coefficients is obtained.

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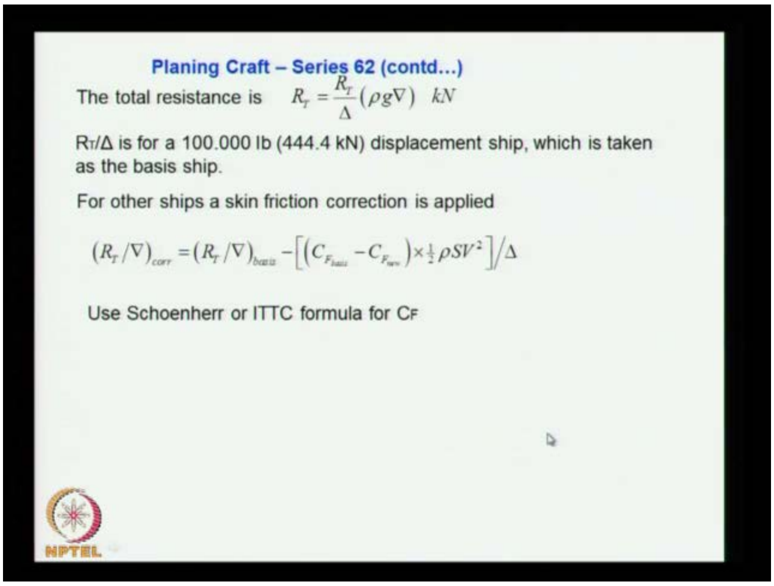

So, you get all these parameters and from which you will be able to ascertain whether trim is proper. So, the total resistance is given by R T is equal to R T by delta into row G into volume displacement. So, get total in kilo Newton's usually you know displacement is given in kilograms, so volume displacement the whole use kilograms, so this will get cancelled this is same row into this one volume displacement is same as this one. So, R T is given in kilograms or in tones into g that gives a kilo Newton's, so that is how its estimated here, then this vessel is done for R T by delta is equal to 10,000 pound or same as much 4400.4 kilo Newton's displacement ship which is taken as the basis.

So, for which for other ships a skin friction correction is applied using this expression over here, so where the C F formula use ITTC or Schooner expressions. Now, we have seen what the planning craft how the form looks like and the series 62 of the planning craft or planning hull form. If you are adopting that, then how do you get the resistance estimation of that vessel, so that is the procedure what we have seen?

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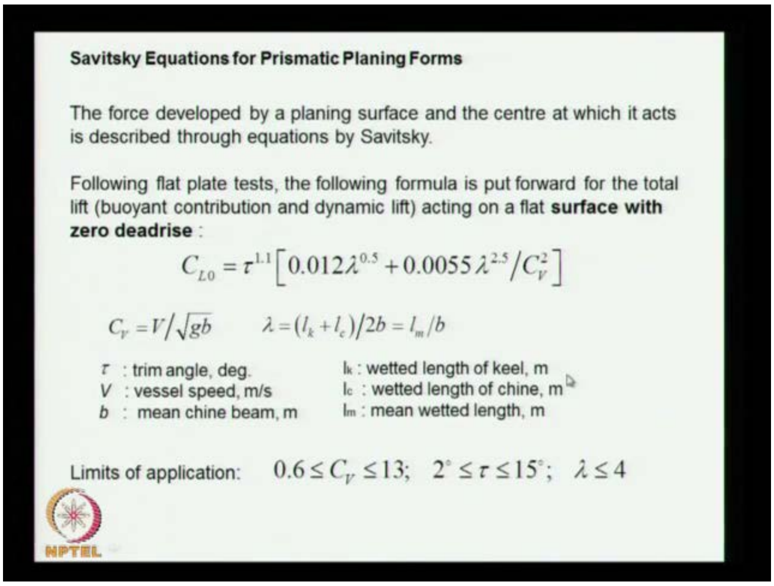

So, we see also that the Savitsky equation for prismatic planning form prismatic means it is a you know when you say prismatic hull if that a form is the cross section remains over the length. So, you consider same as a prismatic form the force developed by a planning surface and the centre at which it acts is described by equation given by Savitsky, what is this? If we see what is the force we consider a following flat plate test, the following formula is the put forward to total lift. So, here if this formula represents the total lift that is total up ward thrust, so total up ward thrust is 1 is the contribution coming from buoyancy force.

The other one coming from the hydro dynamic lift is a dynamic lift and acting on a flat surface with zero dead rise that means the bottom is flat 0, dead rise means the flat bottom that is what I said the flat plate test. So, based on the flat plate test CS is found out these quantities, so what is the total lift equal to tow is trim angle in degrees raise to 1.01 to lambda raise to 0.5, lambda is given by this relation.

Here, lambda is equal to L K plus L C divided by 2 be or is equal to L M by b what is L K, L K is the vector length of the keel it is the keel of the vessel vector length when it is planning L C is the weather length of the chain. So, that also you can find out then divided by 2 b what is b, b is a mean shine b that is also from the geometry of the vessel then l m is average of these two that is L K by L C L K plus L C divided by 2 divided by

b. So, you know, and then you have that is lambda known here from which the geometry we can get what is lambda.

Then, you know what you need to know is C V, C V is given by this relation is equal to v by route of G b, b already you know is the speed of the vessel. So, you know what C b, so you get what is the limit of application. So, if you can find out C V the C V should lie between point 6 and 13 and tow lies between 2 degrees and 15 degrees and lambda less than or equal to 3, so that is the limit.

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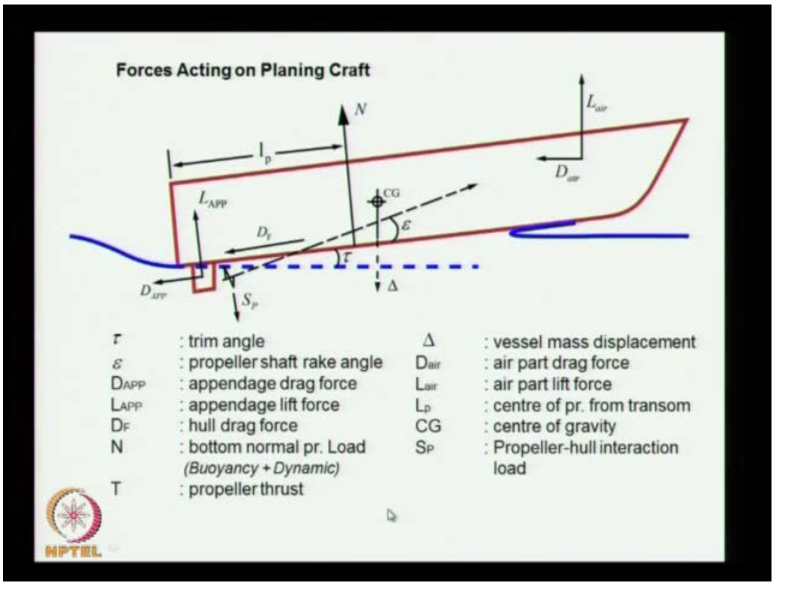

So, here you can see this is a vessel in you know planning elegance, you can see that this is plane water level coming like this, it generates hydro dynamic pressure. So, if you consider this you can see this center of the gravity of the vessel, then this is the popular shaft like popular may not be straight you have an in client because of small vessel. So, that is hap salon represents the popular sharp range, then you have the trim vessel is not you know horizontal is a trim is a tow is a trim angle.

Then, you have you have appendix may be a you know lifting surface going rider out, so the forces produced by that so that is appendix, this is an appendix this is a drag which allow direction of velocity perpendicular to the lift of the appendix. Then you have the drag of the hull represents hull drive force and this is a normal force, this force is due to the line like both bonds and dynamic pressure static and dynamic pressure.

So, it was static and hydro dynamic pressure you get this one and you have the air above water portion subject to air. Then due to that there will be a drag due to the air and lift due to the air is not it, but here it will be small because air density is only one by eighth 100 of water density. So, that effect the centum of force may be less, but again depends on the speed plus planning draft operates at high speed and wind load is proportional to wind velocity square, so that depends on that so this all the terms I have explained.

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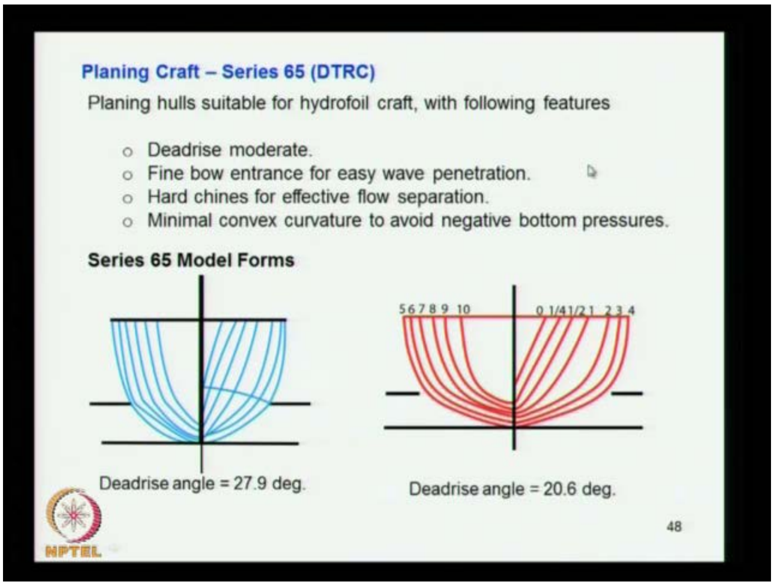

Now, we move on to the planning craft series 65 that is another type, you have this you can see that dead rise angle is 27.8, you can see that dead rise angle 27.9 and is 20.6 small flag, so you can see that differences formed just to give an idea. So, planning craft forms dead rise moderate fine bow entrance with easy wave penetration. Here, you find shape hard chines for effective flow separation effective flow separation resulting in the hydro dynamic pressure, then minimal convex curvature to avoid negative pressure.

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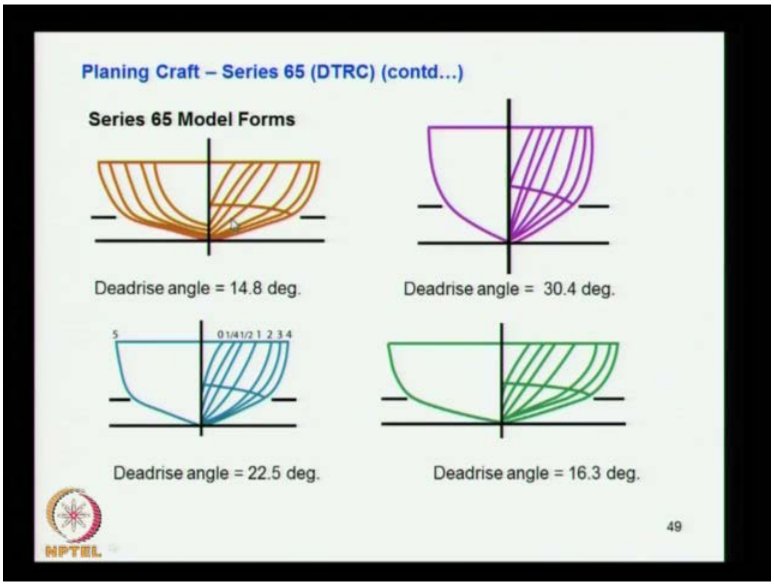

So, you can see the variations dead rise angle and the form variations this is 14.8 dead rise 30.4, 22.5 and 16.3, you can see that variation of this is series 65 vessel with different dead rise angles.

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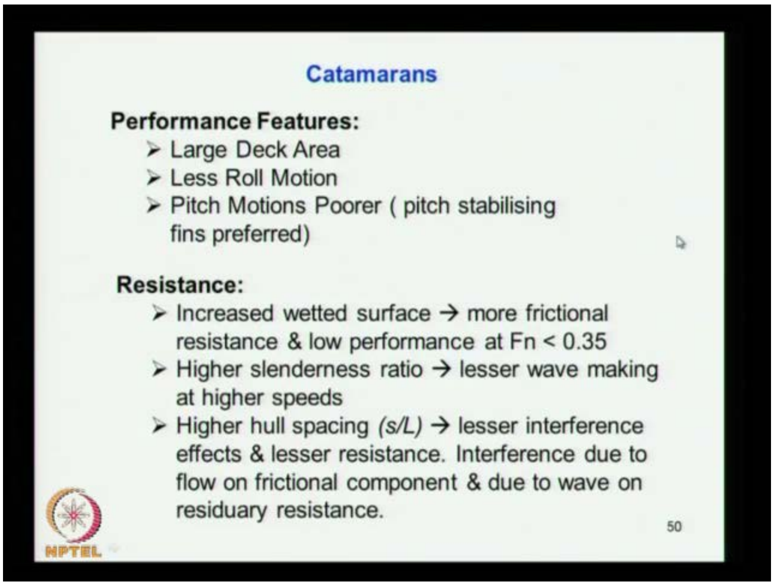

So, this is you know different types of planning crafts normally used for I mean you have seen that the series 65 and 62 and also the prismatic one and that is used by service keel. So, with this I think we conclude the part of planning crafts, next we will move on to other types of vessels like you know Catamaran’s and other hydro foils. Then surface affect ships and other you know surface effect ship and core crafts and all that air cuisine vehicles, so we will feel that we will continue with this in the next class.