Numerical Ship and Offshore Hydrodynamics
Prof. Ranadev Datta
Department of Ocean Engineering and Naval Architecture
Indian Institute of Technology, Kharagpur

Lecture - 38
Strip Theory Part - 2

Hello welcome to Numerical Ship and Offshore Hydrodynamics. Today we have the lecture 38.

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And this is the lecture continuation of the discussion of the Strip Theory, ok.

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And these are the key word that you have to press to get this lecture ok.

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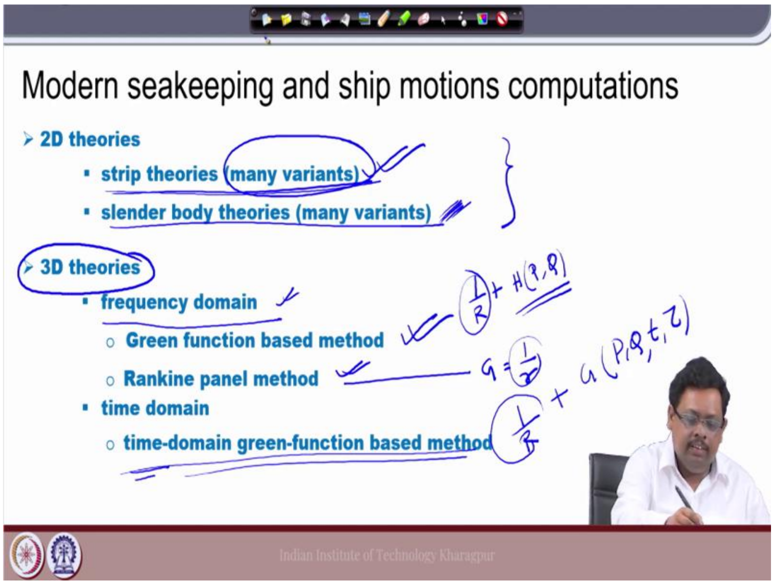

So, now let us start. Now, let us try to find out in the modern seakeeping and the ship motion computations that what are the available popular methods. Now, as you know that that one is that is we are discussing like this is the strip theory ok, and then of course, we have to here you can see that there are many variants of the strip theories available. Then, how these variants and what are the variants I mean we cannot discuss everything in a single course, but what we do is we are picking up one of the most popular one ok.

So, we are going to pick one of the most popular one from this strip theories, but remember that there are many variants are available in industry. In fact, you know some something has the slender body theories. So, there are also many variants are available. Now what is slender body? Definitely again we are going to discuss later on, but we really do not discuss much on this part.

And in case of a 3-dimensional body now these are where as we can call popularly call as 2-dimensional theories because here mostly we are finding out the disturbance at each strips and you can assume that each strip is a 2-dimensional body. So, that is why you can say, but at the end definitely we are going to get a effect for a 3-dimensional realistic surface. It is not like that, using strip theory you are getting a it is that that added mass damping for a strip. Of course, that is a primarily we do that, but at the end we can combine all this 2-dimensional effect and we can get the 3-dimensional effect out of it.

So, strictly speaking, telling two dimension theory may not be fully correct, but in a sense that we are interested to get the 2-dimensional property at a 2-dimensional strip and then from that property we try to find out that what is the overall effect for the 3-dimensional body. However, in 3-dimensional theories this one from the beginning we are taking a 3-dimensional body.

So, there we do not have to do any simplifications by cutting the ship in different sections, that we do not do for the 3D theories and you know that for the panel method what we did is we get a geometry and then we get a panel right. All the panels are 3-dimensional panel or 2-dimension I mean that 3-dimensional surface, inclined surface. And then we try to figure find out that what the quantity the pressure at each panels we integrate get the force over the body. So, that is what we call a 3-dimensional theories right.

Now, if I consider the 3-dimensional theory, then again you are having a frequency domain solution, you can call the Green's function based method, like the frequency domain Green's function for the forward speed. And also we can have the Rankine panel. Now, Rankine panel method as I discussed before also here this also could be in frequency domain could be in time domain also ok and then, but that why the difference is because this Rankine, the Green's function is nothing, but (1/r), it does not depend on the frequency or time. So, it can be applied here both.

Now, in case of a Green's function based method, we are using of course, we are using this (1/r), but apart from that we have some kind of a function, we can call the harmonic oscillation right, which is the depending on the position P and then position Q. Now, by this time you should know what is position P, what is position Q and it is depending on the ω or you can call is a pulsating Green's function. And now we have not discussed yet that this last variant, which is time domain Green's function method.

Definitely we are going to discuss in future, but the primary difference is everything is same, this part is same for every panel method, but apart from that we can have some impulsive Green's function, which is function of P, Q, t and tau I mean what is all these things we are going to discuss later on. But ok so, but now here let us focus on the strip theory ok.

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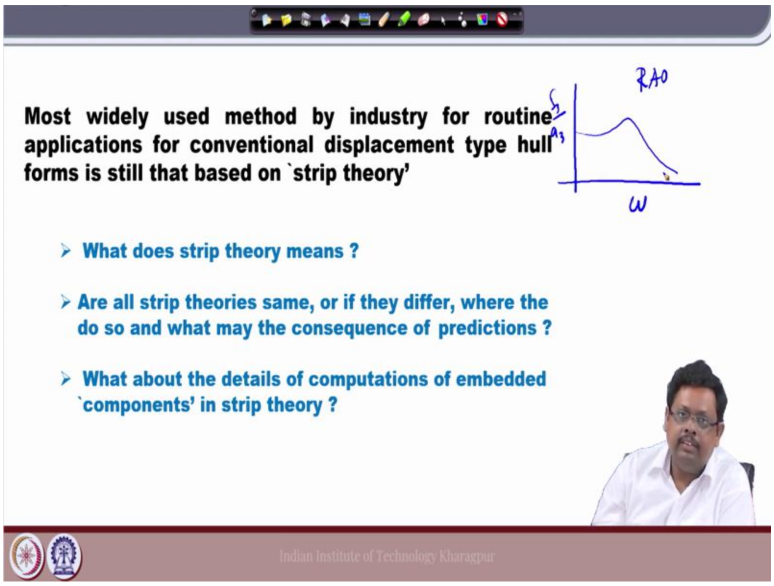

Now, most widely used method of course, like apart from all this method the panel method, the Rankine based panel method which is one upon r or frequency domain panel method you take everything most widely used is the strip theory. Now, you know people will I mean may be little bit skeptical, like why we can say why it is not skeptical I will say that maybe wondering why this strip theory is most popular because we know that if there is some sophisticated method people, would like to use the sophisticated method.

Now, if you look at the sophistication, definitely the 3-dimensional panel methods are much more you know sophisticated compared to the 2-dimensional strip theory. But still why it is so popular?

Now, surprisingly you know what we have seen that; now if I considering, if you considering that if you are considering that we are only looking for the global motion for example, I am looking for the RAOs only, sorry. So, now, if I look for the global motion for example, I am only interested in RAO. So, it is nothing but the frequency versus amplitude right, let us take ζ_3 by a_3.

Now, if my focus is this, then strip theory is very good, when we actually look for this global parameters, like the RAOs and then the global force etcetera etcetera. Now, sometimes actually we really try to understand some local pressure zone also, local pressure field also.

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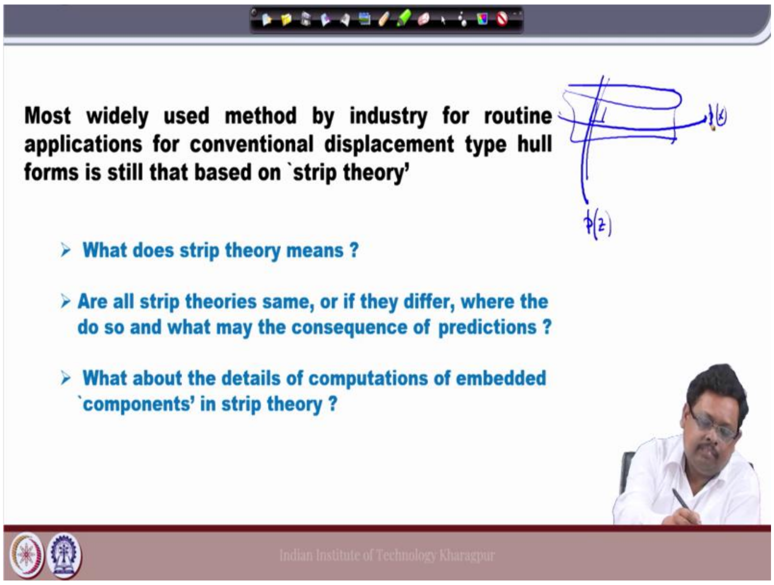

Now, suppose I have a shape let us take let us take try to get some 3-dimensional field. We have a ship like this, let us say and maybe we are try to figure out that pressure variation, pressure variation along the depth, the pressure variation along the depth may be it is Z and then you can say the pressure variation along the X also.

Now, if you do some kind of this detailed analysis, that time strip theory is not good ok. But most of the time we are normally we try to find out the what is the response you know, the global response not the local response. Now, once you do that that time definitely strip theory is of course most preferred theory compared to the 3-dimensional sophisticated panel methods ok.

Now, what does strip theory means? Not yet, we have not yet discussed what strip theory means ok definitely we are going to discuss today. Now, are all strip theories same? As I said no or if they differ, then where is when I mean that what will be the consequence for the prediction. Like if I say that this is a strip theory 1, it is and then you have strip theory 2 and you have the strip theory 3 types of strip theory and you are trying to figure out the global motion using this strip theory.

Let us say that the ship is same. So, geometry of the vessel is same and then also the frequency also same, let us say or the frequency range is also same. Now, there should be unique answer right. Now, if I say that I am using the different level of numerical methods, then what is the implication or what is the consequence in the final answer? That also, that is something that we need to really bother right, because definitely results might differ, but it at which extent.

So, therefore, what we need to understand that what is the limitations of the strip theory and where people are making assumptions and then what would be the consequence of these assumptions on the global, when you get the global motion computable the global motion, right. So, that is what actually we need to understand more, like that is what this course all about to discuss that the limitations and their consequence in the final results.

Now, what are the details you know embedded a component of the strip theory? So, let us discuss then what is the details of computations that embedded in the strip theory.

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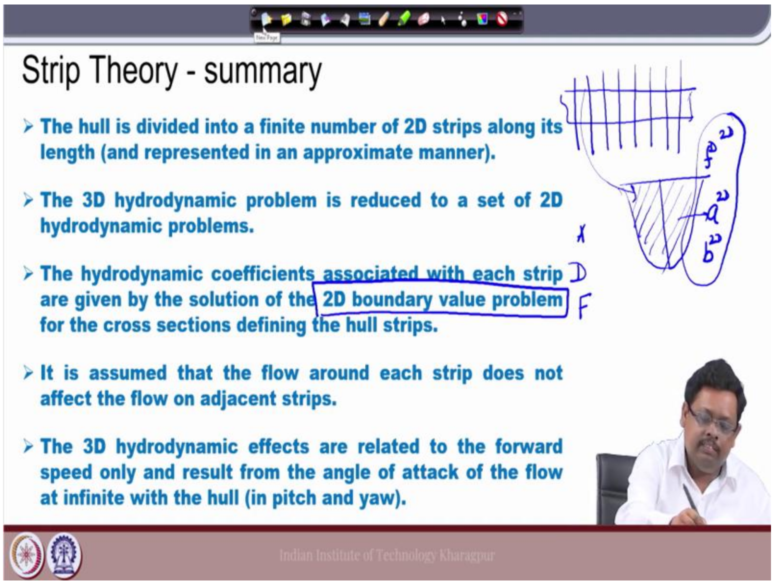

So, let us now here it is. So, so let us see that what actually we are doing when you solve the strip theory. Now, this hull is divided into a finite number of 2D strips. So, this is the first thing, that is why I call this a 2-dimensional method; because if I have a ship suppose I have a ship something like this. So, what I do is I make some finite number of strips, we cut the strip in this finite number.

Now, if I take out any of this then definitely, we can have some kind of different kind of I mean shape right. So now, this is your 2-dimensional body, right. So, that is why I said that is why normally people say that is a 2-dimensional theory right; however, one must anyway I said there is so many times the final results we are trying to figure out that that the pressure over the 3-dimensional body only right ok.

Then, how they are dividing a finite number of 2-dimensional strips along its length? And then the 3-dimensional hydrodynamic problem is reduced to set of 2-dimensional hydrodynamic problem so. That means, now I am solving this 2-dimensional problem of this is my body and I try to figure out that all this component like which is necessary to get the equation of motion; that means, that added mass.

So, we can call this added mass 2D, we can call the damping 2D right, we can call the exciting force or f or we can call that the f D ok that is also a 2-dimensional component. So, we try to figure out all this 2-dimensional component for each strip. So, therefore, this 3-dimensional. So, finally, my aim is to get the 3-dimensional added mass right ok, or maybe the 3-dimensional damping and also may be the 3-dimensional exciting force.

However, I am having all this parameter for each strip. So, then how can we you know combine everything to get the 3-dimensional feel? Right. So, we do the opposite this 3D body I split into set of strips and each strip I am getting try to find out the hydrodynamic parameters. So, that is the same thing written over here, the hydrodynamic coefficient associated with each strip are given by the solution of the 2-dimensional boundary value problems, so this.

So, this is also very important thing right, we are finding out a 2-dimensional boundary value problem. Now, whatever discussed here till today, when you do the frequency solution we have discussed the 3-dimensional boundary value problem all the time right. But here we are going to discuss what would the 2-dimensional boundary value problem right ok. It is assumed that flow around each strip does not affect the flow on the adjacent strip.

So, this is a very important approximation, because here you know otherwise you know we have lot of problems if you do not do this approximate. Now, people had come up with some somebody called that 2.5D method, where they do consider this, but in strip theory what we are trying to say is as follows.

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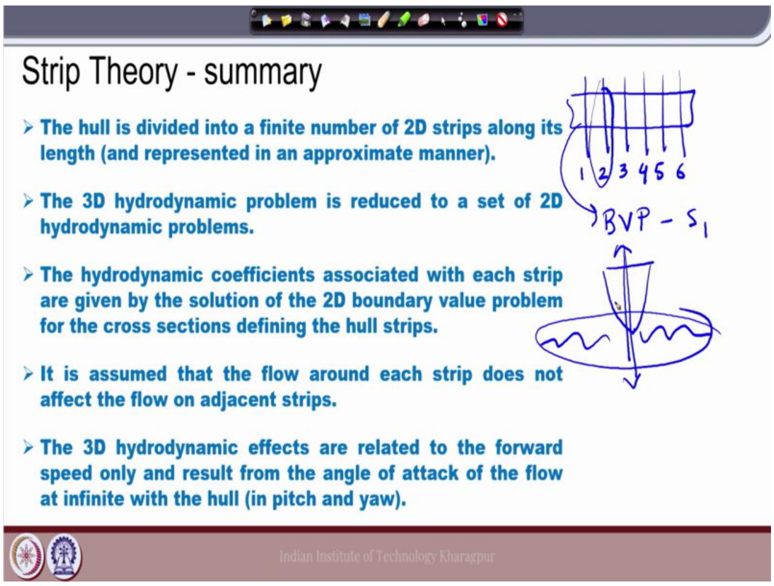

Suppose I have a shape and let us cut into number of pieces this way. Now, when I saw let us say section 1, this is section 2, this is 3, this is 4, this is 5, let us say this is 6.

Now, I say when I solve the boundary value problem we can call the BVP, Boundary Value Problem for strip 1. So, then you know you have the flow in all direction right, I mean therefore, the effect. So, now, what happened like one is solve the let us say radiation problem. So, it means that this strip if I let us say this is the strip, now what is happening radiation problem is that I am oscillating in this let us say some heave mode ok.

Now, when I oscillate this in the heave mode, then definitely I have I get some waves in all the side. So, therefore, we are going to solve for the 2nd strip, there should be some effect of the wave that coming from the 1st strip. Normally, it that should have some effect right so; that means, what I am trying to say as follows.

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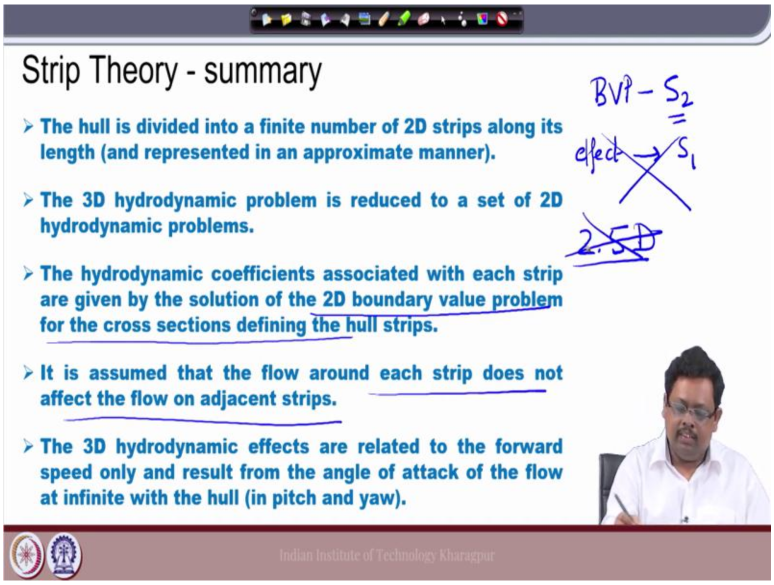

When I am solving the boundary value problem, BVP for the 2nd strip there must be some effect that comes from the first strip that that so we assume that there is no effect.

So, we treat the each boundary value problem, each strip this 2-dimensional boundary value problem is independent of the effect of the adjacent strip ok. And therefore, this is a huge assumption right, because we are assuming that the flow it does not propagate in the longitudinal direction right, that that effect. And then; so because of that there must be some kind of you know, may be some effect we do not know ok.

That is why later on people have come up with some we call this that 2.5 D method. So, it is not it is not 2D method, 2.5D method, that time they are doing again the strip, but again they considering some effect when they calculate the adjust is 3 point try to figure out this added mass damping.

They do consider the effect from the adjacent strips. But we are not we are not going to discuss this ok, we only we focus only on the strip theory. Now, last point say that the 3-dimensional hydrodynamic effect are related to the forward speed only right and the result is coming because of the angle of attack ok.

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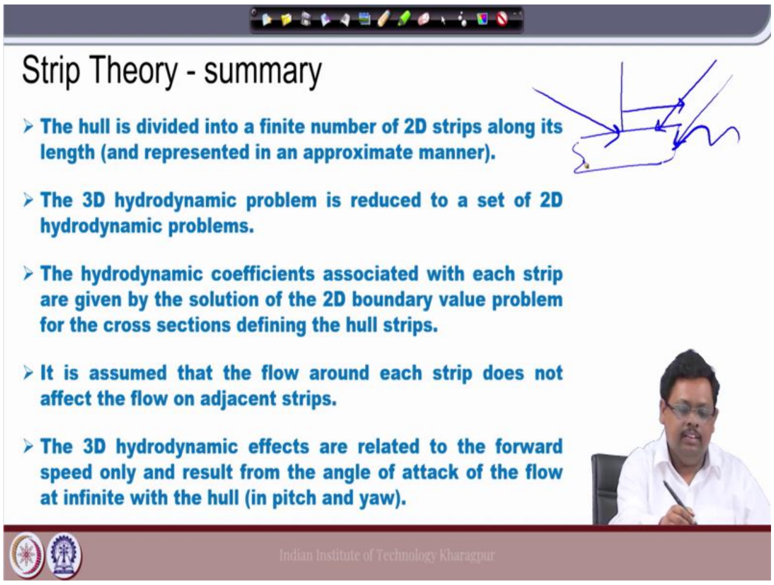

So, it means that, it means that here this forward speed effect is I mean that 3-dimensional effect are associated with the forward speed and then the angle of attack.

So, normally all the time you do not you know you are not encountering the head wave, sometimes that wave may be coming from the beam sea location 90 degrees, sometimes from here sometimes from here right. So, therefore, this 3-dimensional effect is related to this one ok.

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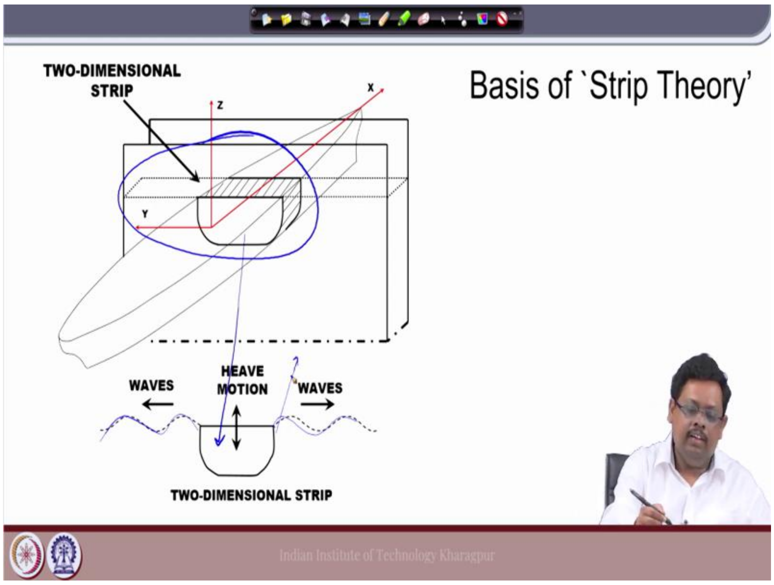

So, now this is the overall picture now, now it is little bit clear to everybody. So, that is how we just in this picture, we have we have cut this. So, this strip in this Y Z plane right and then this is the corresponding diagram. Now, you see here, when we oscillate this so we assume that this wave is created in this transverse direction right. So, there is no flow in this the longitudinal direction, right fine. So, this is how actually you know graphically you can represent what I said, right.

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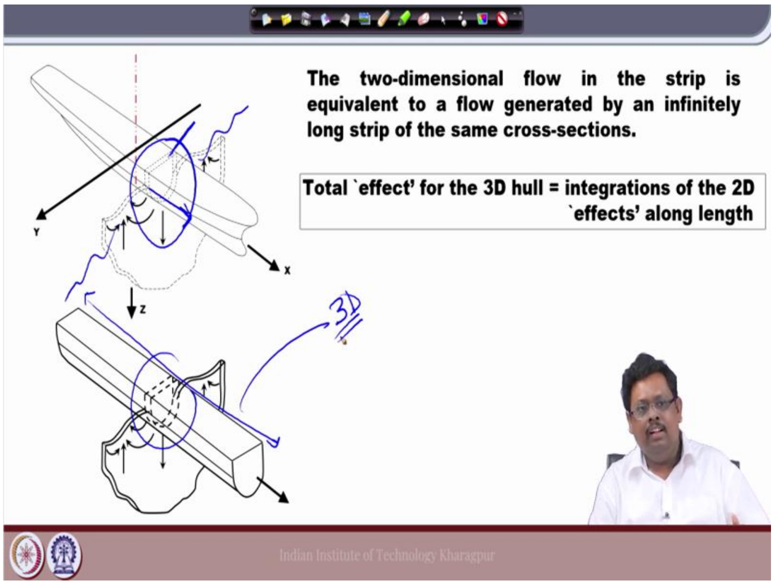

Now, this 2, as I said that 2-dimensional flow in the strip there is no, there is no flow around this longitudinal body. So, it means that when you oscillate this 2-dimensional strip over here, this flow does not affect the this direction right. It can only go you know this way right and then now we can consider these as a 2-dimensional effect here.

Now, if you integrate along here to here, we can say we can get the 3-dimensional effects right. So, now, till this point people might think that this 2-dimensional effect, I mean this 3-dimensional effect is coming only by integrating the 2-dimensional effect right, that might be the that might be the general notion right.

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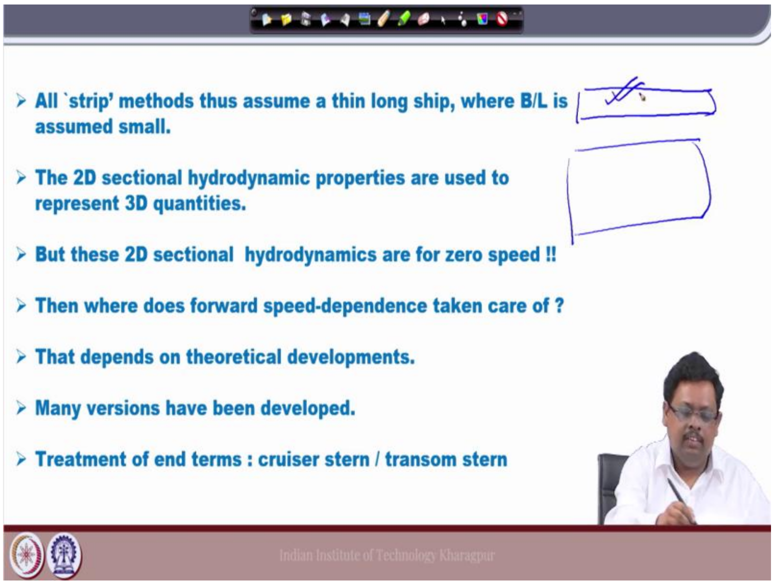

But now let us see the ok. Now, let us see that actually the assumptions and then as I said that we have some you know feeling that only integration of the 2-dimensional strip over the length gives you the 3-dimensional effect right. And that is the all about for the strip theory. Now, let us see what is written over here.

Now, here again is just a summary type. Now, all strip method, all the strip methods all strip theory methods thus assume that thin long ship that b by l ratio assume to be assumed to be small. That means, that length is much larger, I mean if you compare to the B. So, we can assume that it is the thin ship; that means, if I look at the you know from the top, then we can assume that the ship is like this, it is not like this. So, this is called the slender body, ok fine.

And then the 2-dimensional section hydrodynamic property I mean we are getting by and if we integrate it we are getting the 3-dimensional quantity. Now, look at the 3rd point. It says that this 2D section hydrodynamic for the zero speed. Now, my question is this, if we assume that strip theory means that integration of the 2-dimensional property along the length, but then how it works for the forward speed, because all this 2-dimensional property actually we are doing it for the zero speed.

Now, how can this apply for the forward speed. Now, you see if you think of the you know the strip theory mean like, that very simplified statement is I am having the 2-dimensional you know strips I integrate it, I get the 3-dimensional overall you know the property. No, it is not like that, because this 2-dimensional property the added mass, that damping, the 2-dimensional added mass, 2-dimensional damping all you are getting for the zero speed.

So, the strip theory means how actually we can incorporate this forward speed effect. So, that is the next point. Then where this forward speed dependence taken care of and that does is the essence of the strip theory ok. So; that means, again this again that how we are accounting the forward speed that is also not very unique, it is not that there is only one method.

So, there are many theoretical development is there. So, because of many theoretical developments, then many theory exist for that and also sometimes that we need to give a special treatment for different type of ship, with something that cruiser stern, something has the transom stern. So, based on that also we can have some truncated conditions also I need to put.

So, it is a, it is a the huge you know huge development huge thinking on each methods, right.

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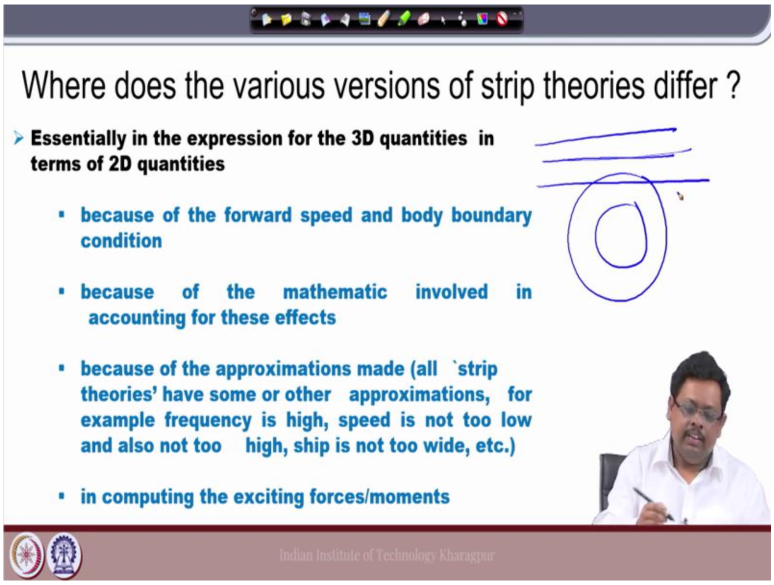

So, then where this various versions of the steep theory differ. Now, you see that first is accounting of the forward speed how way I can taken care of the forward speed. So, there is a there is a different theory available for that.

Now, if you account in different way then your mathematical derivation of also different right. So, so these are the difference that is how the difference strip theory, that different strip theory exist because of I do not say limitation I say that by this incorporation of the forward speed ok.

Now, because you have made an approximation that all theory has some approximation. So, therefore, most popular approximations are the - it is a, we can call is a high frequency and low speed phenomena. So, you know we can say that this strip theory mostly we can account for the high frequency and also is a low speed phenomenon.

This allow to make a simplified solution for this problem, otherwise you know because you see if is a, if it, if you do not consider these thing then how we account for the disturbance created by ship for the longitudinal directions right, and then how we can you know deals with the radiated wave?

Now, you see now if you remember that we are throwing a stone in a pond and then we have seen that this radiated wave field is going in a circular fashion right, in this way.

But, however, in 2-dimensional case, we cannot see this phenomenon we assume that all this way propagated in this manner in 2-dimensional manner right?

So, how we can account for all these things right? And also as I said that in exciting force also there are lot of assumptions people are making lot of simplification to compute the exciting force. So, that also affects the final results ok.

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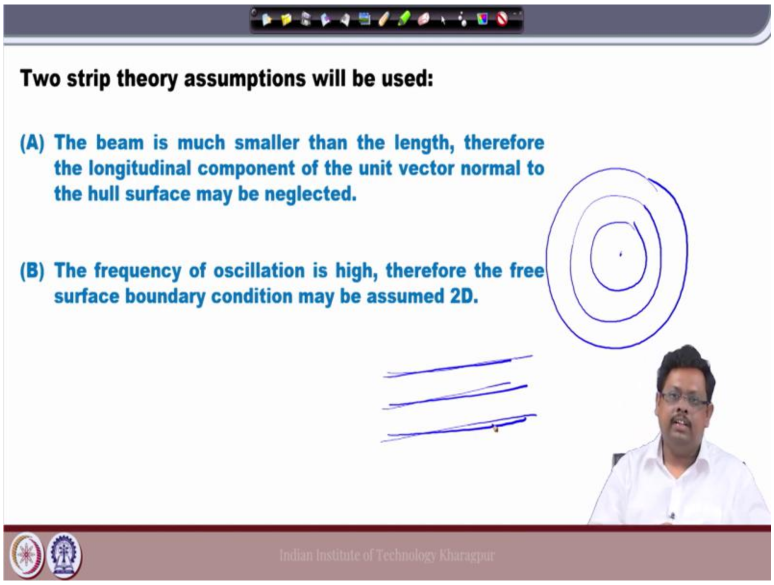

So, now, in this class normally we focus on two major assumptions, one is the beam is much smaller compared to the length ok therefore, the longitudinal component of the unit vector normal to the hull surface and that may be neglected. So, this is number 1 and then the frequency of oscillation is high therefore, the free surface boundary condition may be assumed 2D, ok.

Now, you know that is how like as I said in other words if I do not assume this in high frequency still it is valid that all this propagation is a parallel to each other. However, most of the time if you as I said that if I put a stone in the pond, then we see that wave is propagating in this fashion, since wave is propagating in all direction, it does not propagate in one direction right.

So, therefore, but as I said if I assume this frequency of encounter is very high, in that region one can assume that this forward speed I mean this effect the radiated waves are not propagating in the 3-dimensional way, they can propagate in a 2-dimensional fashion ok.

So, you know this is why we are assuming all these things right, because we try to find out some way. So, that these 2-dimensional theory can be applicable. Now, we can understand at least we can understand at this point, it is not applicable everywhere right the radiation field it is 3-dimensional field. So, only in high frequency zone it could be approximated as a 2-dimensional field.

Also, this longitudinal direction we really do not consider any effect that, right. So, therefore, that ship has to be slender. So, therefore, this strip theory is not popular for the offshore industry, because we are dealing with some offshore structure where this l/b ratio is more or less 1. So, that time you really do not under, you really cannot use this sort of approximation ok.

So, today we stop here and then from the next class we are going to discuss the mathematical equations, we started the 3-dimensional equation and under these assumptions how we can write the 2-dimensional equation. All these things we are going to discuss in the next class ok.

Thank you.