Advanced Marine Structures
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Lecture - 7
Environmental loads -03

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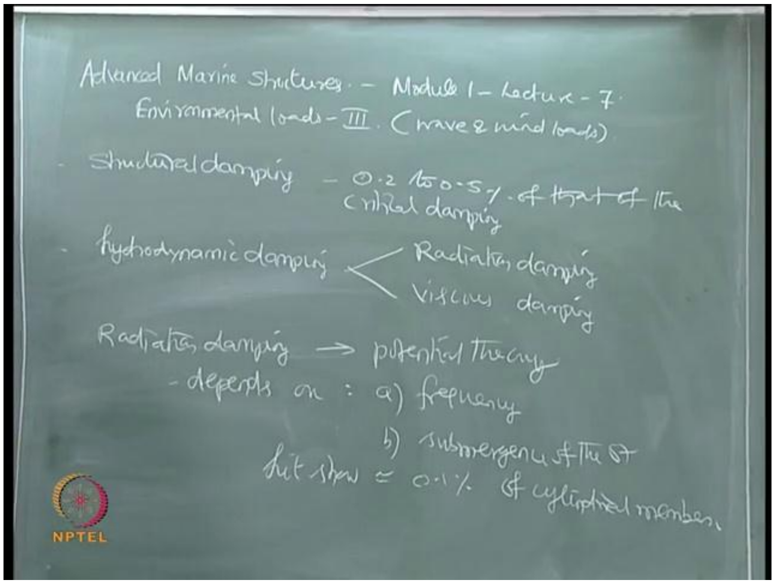

So, in the last lecture we discussed about the structural damping and we said that this value can varying from .2 to .5 percent of that of the critical damping. In addition to this we also have hydrodynamic damping which has got two components one is a radiation damping. Other is a viscous damping. The radiation damping essentially depends on it is evaluated using the potential theory and it depends on frequency and submergence of the structure. Let us show that this damping is closed to about .1 percent for cylindrical members.

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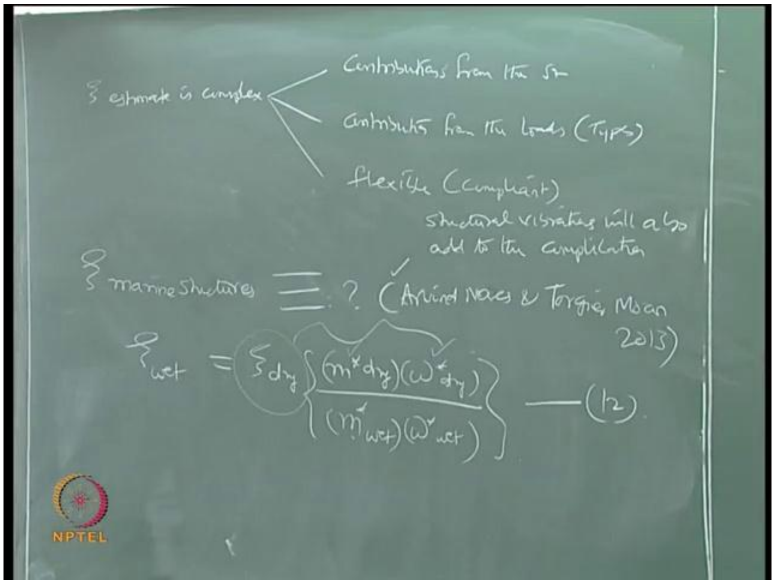

You can see here that the damping estimate is complex because of contributions from the structure and contributions from the loads or I should say type of loads further there is one more complication added to this if the structure becomes flexible or I should say compliant or I should say non stiff structure non rigid structure then there will be damping associated with this structural vibration therefore, interestingly the damping estimate in marine structures is given by a different algorithm by Arvind Naes and Targier Moan. This reference available in the web site of NPTEL.

You can see what Arvind and Targier said, as following, they say ,if you want to find any marine structure in a wet condition of damping then I can use a different equation. So, associate the value of dry damping of the structure with that of the mass of the structure in dry state and frequency structure in dry state. And find the ratio of this mass frequency in a dry state to that of the wet state and multiply this ratio with that of dry damping ratio you will get a damping ratio which includes or which involves the submergence effect also. So, I call this equation number 12, which were continuing.

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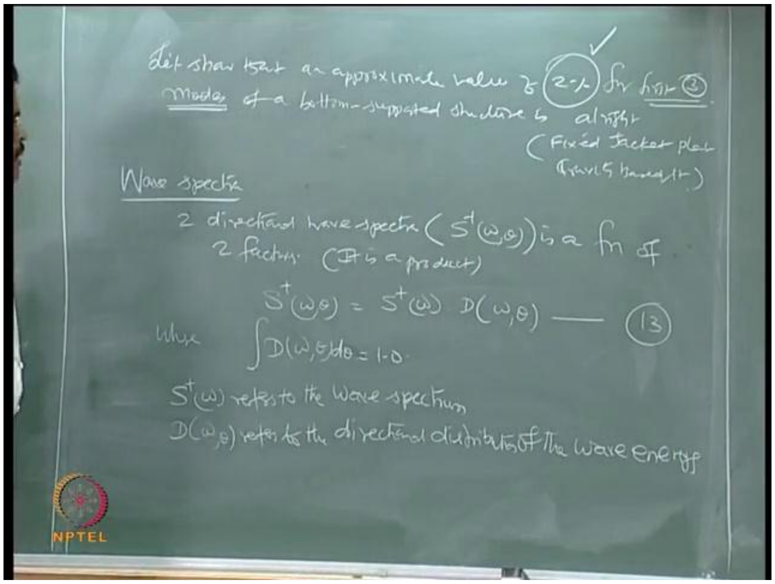

Having said this, the literature show that an approximate value of 2 percent for first 3 modes of a bottom supported structure is alright. So, the value of 2 percent is what is recommended literature for a bottom support structure. For example, fixed jacket platform gravity based structure etc. So, one can use 2 percent for the fundamental mode and additional two modes that is first 3 modes using 3 percent as the damping which gain accounts for radiation damping, which has an effect of the submergence as well as the frequency. Here, frequency contains all 3. Now, let us talk about the wave spectra.

We are on the verge of discussing about the environmental loads acting on marine structure; we start at the hydrodynamic loading; we moved on to the damping estimates; we will talk about now the wave spectra. Then will move on to the wind loads then at the wind loads completed we will talk about ice loads and f to f loads and current loads so will have a compress summary of a what are the different profile of a force acting on the marine structure. Then we will get an idea which load will combine with what to find out the altimation capacity of any member of a marine structure. So, will talk about wave spectra there are big confusion arising in wave spectra there different spectra recommended in literature.

Will quickly see all of them because this lecture is not focusing on the hydrodynamic aspects of working of the deriving wave spectra we have only looking at in design of perspective which wave spectra I should use for design of marine structure and why should I use. And what are the important critical points of the perspective wave spectra. Wave spectra actually is got in 2 directional wave spectra, which I call as S plus omega theta if the function of 2 factors essentially it is a product of these 2 factors.

S plus omega theta is S plus omega and D omega equation number 13, where D omega theta totally integral will be unity. S plus omega refers to the wave spectrum and D omega theta refers to the directional distribution of the wave energy. This is general combination of any spectrum, which is being marine structures, which has got a product of the wave spectrum and until the wave directional energy distribution.

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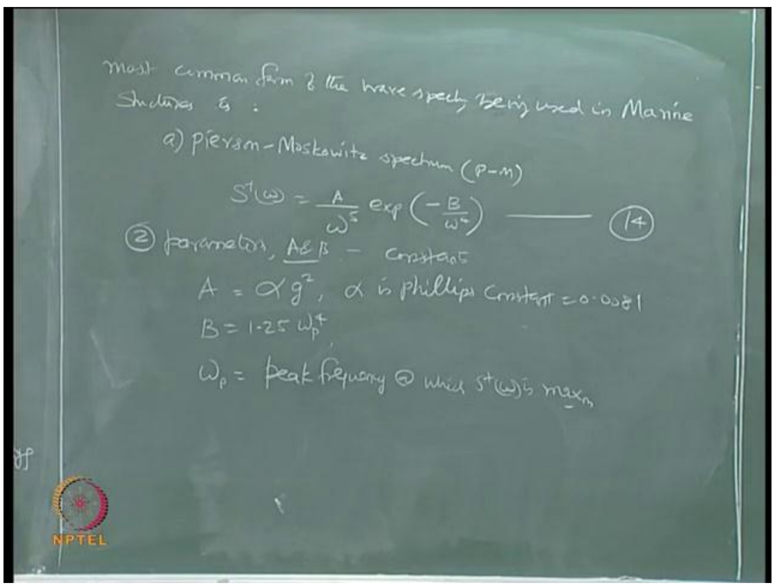

So, the most common form of the wave spectrum being used in marine structures is Pierson Moskowitz spectrum is famously called as P M spectrum. S omega is a omega pie exponential minus B by omega 4. Call this equation number 14. So, the Pierson spectrum essentially depends on 2 parameters A and B. And A and B are actually constants depending upon how these constants are defined, there are different forms of spectrum available in the for Example A is given by alpha g square, where alpha is known as Phillips constant, which is 0.0081. B is 1.25 omega p to the power 4, where omega p is called peak frequency at which S plus omega is maximum.

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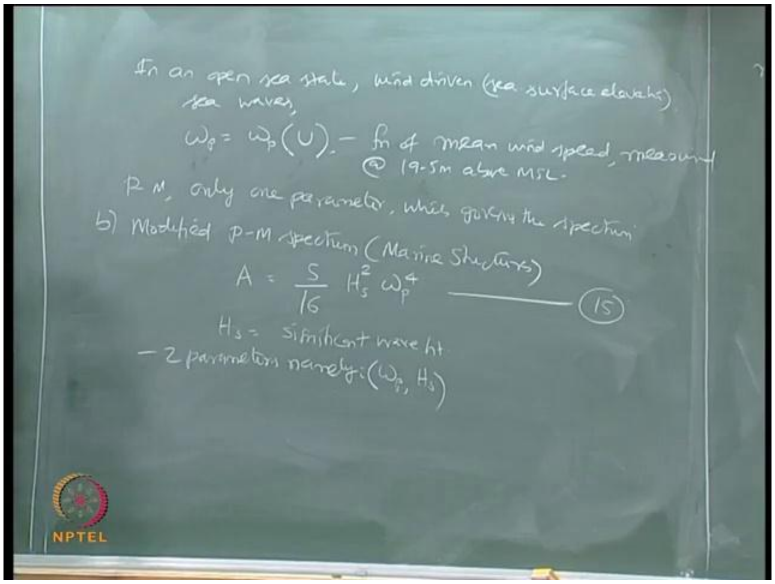

Now, we all know that in an open sea state is generated, because of the wind it is wind remain spectrumize wind driven. And therefore, we really wanted to find out the peak frequency at which S omega will be maximum then you must also specify what that wind condition which makes omega P maximum is. ?. So, omega P refers to actually omega of I say U, which is actually a function of mean wind speed measured at 19.5 meters above mean serial.

So, measure a mean winds speed at an elevation about 19.5 meters above the still the water level. And that wind speed will be giving you omega P. And that omega P is what I will used in parameter used in B here and of course A is a Phillips constant based value. I will get a spectrum is generated is for example, you can plot this spectrum for every value of omega. S theta is in y axis and omega will be in x axis then plot the spectrum. I will show you in this spectrum quietly later but, how this happens.

You can see here in the conventional P M spectrum, there is only one parameter, which governs the spectrum. What is the parameter is govern in this spectrum? What is the parameter, which is governed in this spectrum the parameter govern in this spectrum is omega P, because that is only the value, which is controlling B. A is of course, a constant, so omega P omega P on the other hand is.

The based on the mean wind speed at a specific elevation, so this is controlling the whole generation of spectrum now this spectrum is further modify, which is also used an applicable to marine structures. That is call modify P M spectrum. In this case a constant A is changed as, I call the equation number, where omega P has a same explanation as saw you here but, H s is what we call as significant. So, now P M spectrum when it is modified it has got 2 parameters. Now it is governed by 2 parameters namely omega P or average mean wind speed at a specific elevation on the m s l or the above m s l and significant wave.

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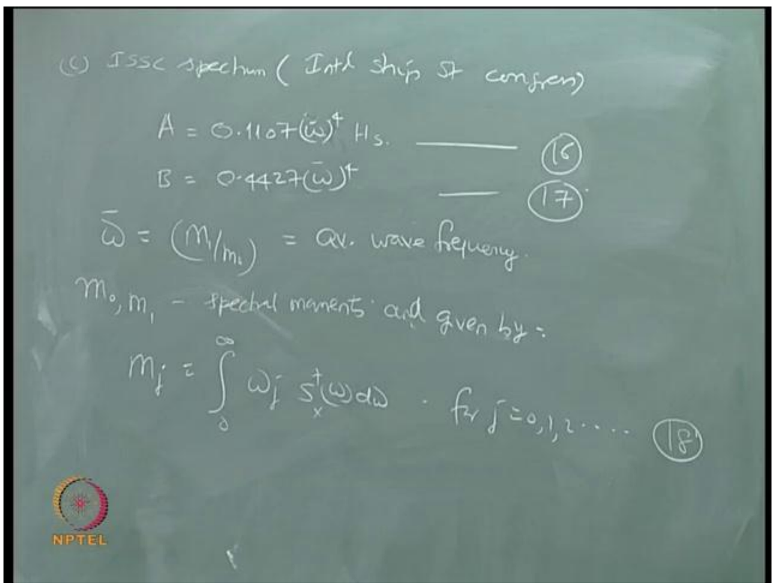

One more additional spectrum is also given by international shift structure conference ISSC. In this case A and B constants are redefined as, call this equation number 16 17. So, in this case omega bar is defined as ratio of different moments m 1 by m naught is called average wave frequency, where m 0 and m 1 are different spectral movements where m 0 and m 1 are of all spectral movements. And they can be given by. There is one more spectrum, which is very commonly used in the literature for analyst and design in marine structure is the JONSWAP spectrum but, you will see JONSWAP spectrum has got a specific parameter, which when middle with will land up in modified P M spectrum will see that.

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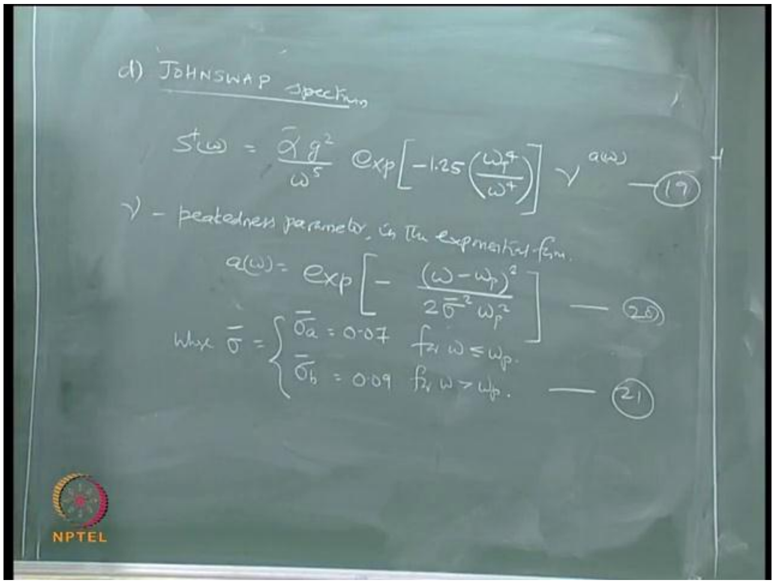

So, D is JONSWAP spectrum this is not exactly in abbreviation, where it is been applied so, not it's not somebody name it should be written in capital. There are expanded terms actually. This is the classical JONSWAP spectrum. The value gamma is called peatedness parameter. And it is in the exponential form, exponential means e power, so this a omega is again an exponential form.

It is not the equation 20, where sigma bar has got two values is nothing but equal to sigma a of 0.07 for omega less than the peak frequency. The equal to sigma b I can put sigma bars here, because that is what literature says sigma bar a and sigma bar b 0.09 for omega greater than omega p. This equation is 21.Ihave not still explain the spectrum completely we are only talking about the Peatedness parameter, which is again an exponential form, where I am talking about the omega, a omega is a variable. Here, I am coming back to spectrum again. We have alpha bar here of course, omega p already has been explained.

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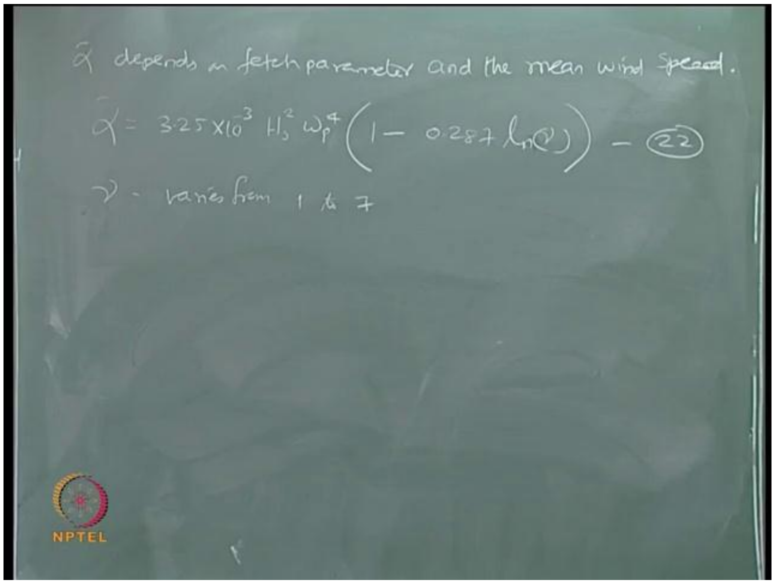

Alpha bar depends on the fetch parameter and the mean wind speed, which can be given by natural logarithm of mue. I call this equation number 22. As I said at the beginning mue is a peatedness parameter, which varies from the value of 1 to 7 at a specific value of this the JONSWAP spectrum will become, let us try to plot it to show I will remove this.

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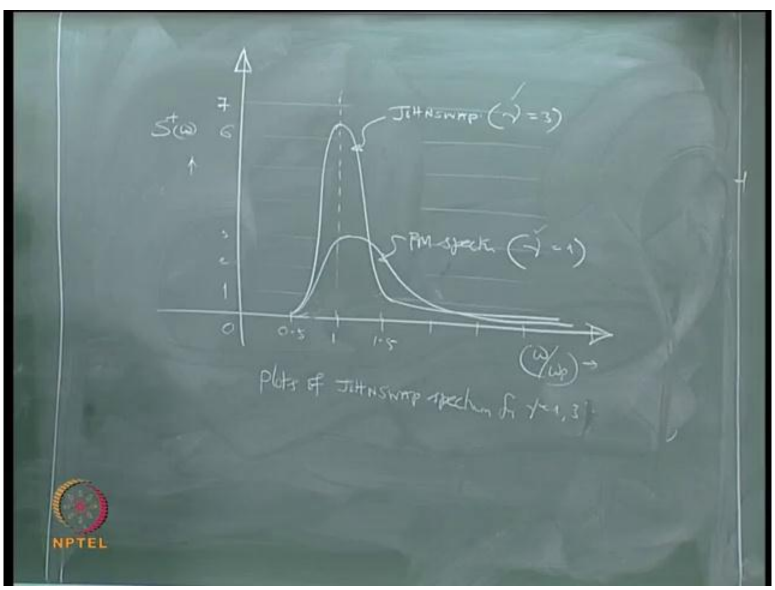

So, typical value of mue at three that is what JONSWAP spectrum will look like when we substitute the peatedness parameter as unity in the JONSWAP spectrum equation. I will get the Pearson mass spectrum, which low at peak three and broad spectrum. This is P M spectrum, I should say mue equal to one. So, the figure shows essentially the plots of JONSWAP spectrum for mue equals one and three the peatedness parameters one and three it shows two different spectrums. Now P M spectrum, yes, a modified version of john swap spectrum where, the peatedness parameter assumes the specific value of mue.

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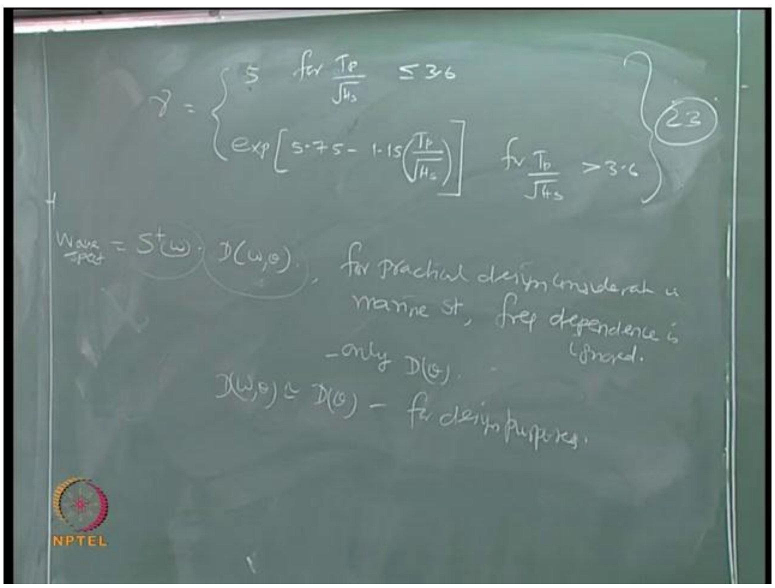

Now, the peatedness parameter, mue is also given by an equation it has got two values it can be equal to 5 for T p by root H s less than or equal to 3.6 T p is nothing but, two pi by omega p. Omega p is the peak wave frequency is the period of peak wave frequency. T p H s is significant wave height if this ratio is less than 3.6. you must use mu as five in the john swap spectrum otherwise exponential value of for T p by root H s greater than 3.6. These are the equation number 23. So, you will interestingly see that S plus omega multiplied by d omega theta was giving me the spectrum the wave spectrum, which has got the wave spectrum multiplied by the distribution of the energy in terms of frequency and direction.

Generally, for practical design considerations, in marine structures the frequency dependence is ignored. You consider only D theta only the directional dependence. So, I should say D omega theta is approximated to D theta for design purposes we neglect the frequency dependence of the function this about the wave loading. Let us talk about the wind loading and see which are the complications present in the wind loading and what is the spectrum which defines the wind loading. As we have seen, the spectrum defining the hydro dynamic loading and see how the complications of wind loading is handled in a simplified manner in the literature by providing what is called hydro dynamic admittance function will see how this can be derived so will talk about now the second loading.

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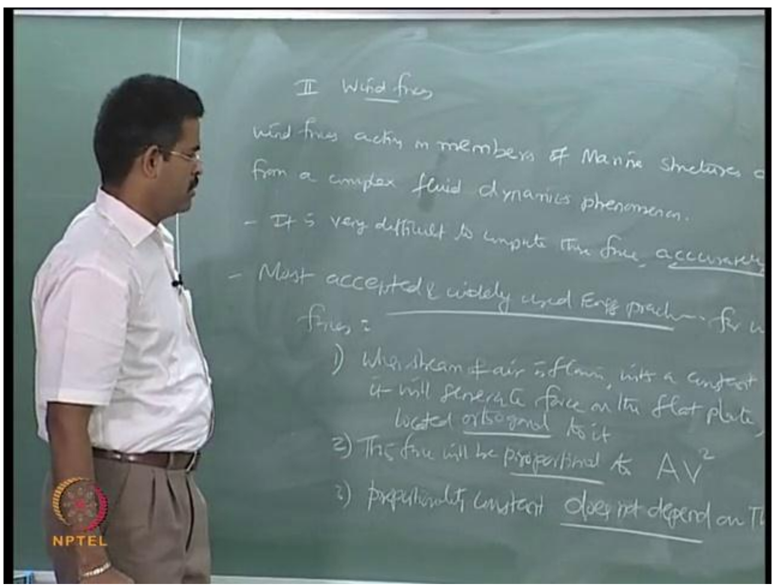

Which is wind forces do you have any questions on the wave loading we have discussed about the wave loading. We have seen what are the kind of damping arising from the wave loading a fundamentally. We saw how the wave loading is acting on marine structure then we saw the water particle kinematics defined by simplified Airi's theory and what are the stretching modification suggested by various researches in the literature and why these modifications are implemented necessarily in a Airi's form, because Airi's form will agree or accept values only till, where as the submergence effect is not accounted for. The second important issue what we had is a phase difference or the phase lag between the members off shore structures have larger dimensions in terms of the plan dimensions, so the central leg spacing can be as high as 120 meters or 100 meters compared the wavelength to work out the phase lag or phase difference it may come to 1.2 times of pie which can have a negation effect on.

The loading simultaneously, that is one of the decent parameters of which the spacing of the legs are fixed in an off shore structure so that the force on the members are getting cancel to each other so that is a phase effect on the loading of course, will talk about the loading where mounting to what we call as a spectrum we found out there are different spectrum available in the literature. And, we have seen the common spectrum and 1.1 parameter dependent spectrum like P M spectrum or the modified version is got two parameters one is omega p and other one is significant wave height and then we have also seen how JOHNSWAP spectrum can be modified down to spectrum.

Therefore, people have used in marine structures commonly JOHNSWAP or modified P M structure for finding out the force on marine structure. This is about hydro dynamic loading. Let us come to the wind forces. Now wind forces acting on members of marine structures actually arise from a complex fluid dynamics phenomenon. Therefore, it is very difficult to compute these forces accurately that is the so very difficult to compute these forces accurately or with high accuracy. Then what is engineering so most accepted and widely used engineering practice for computing wind forces has the following assumptions. One when stream of air is flowing with a constant velocity v, it will generate a force on the flat plate located orthogonal to it. That is normal when the plate is placed normal to the direction of flow of wind it generates or exerts force on this plate. This force will be proportional to A V square, where A is a projected area and V is the wind speed.

Now, the proportionality constant I should say does not depend on the projected area remember this very important. Now, in these assumptions we have got three important key words one we are always trying to work out the force on a plate, which is flat if it is curvilinear then we have no idea how this force will get modified then there should be a factor to get multiplied with these which will account for the curvature on the plate or the member the second is plate should be always placed normal to the flow direction if it is inclined then you must use appropriate projected area.

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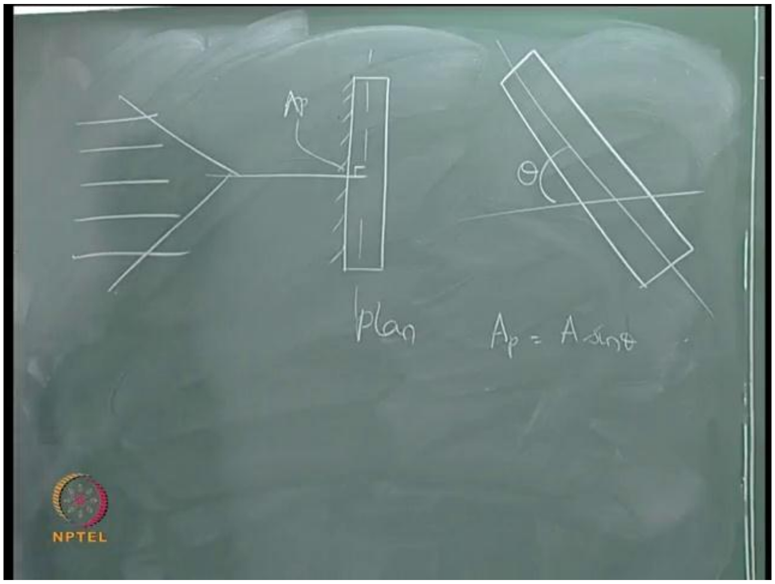

For example, if this is my wind flow direction if this is my member in plan and this one length and of course, a height, which is normal to the board and I call this as a projected area because natural the member is normal. To the directional flow of wind, if the member is inclined whose axis has a value of let us say theta with that of the direction then I must use equivalent area of projection will be A sin theta is that this is. So, it is always computed normal to the flow velocity or the direction and of course, this force generated will be proportional to A V square and that proportionality constant is independent of the area of projection, that is very very important. This has been accepted and proved by wind tunnel testing and experiments it does not depend on the projected area. It depends on some other factor will talk about that is that clear, having understood this.

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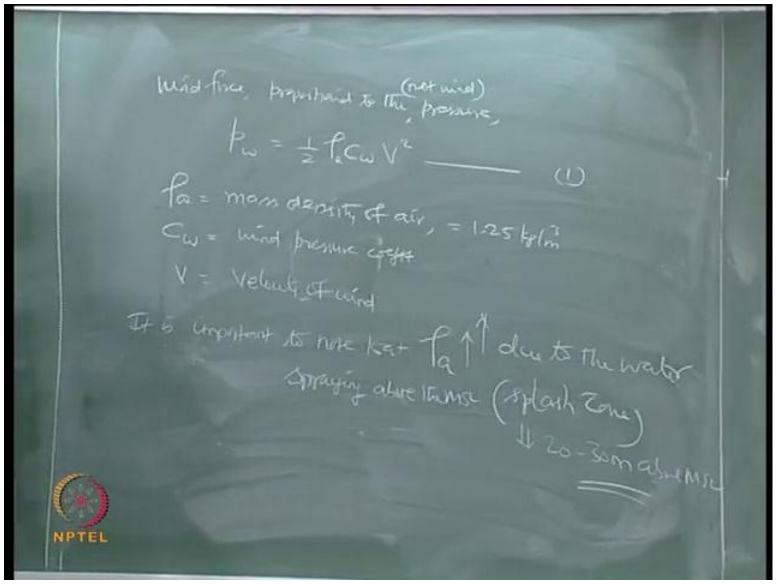

As we all know, the wind force is proportional to the wind pressure. I should say the net wind pressure, which is given by half row C w v square is equation number 1 in the wind forces is the mass density of air, which is 1.25 kg a cubic meter. C w is the wind coefficient I should say wind pressure coefficient. And of course, v is the velocity. Interestingly it is important to know that the mass density keeps on increasing due to the water spraying above the m s l that is what we call as splash zone. So, this keeps on increasing, so estimate what you make with this number as a pressure acting on the member is not accurate whenever we talk about members in the submergence zone or in the splash zone. And that splash can happen to a value of 20 to 30 meters above m s l. You see this as high as this value.

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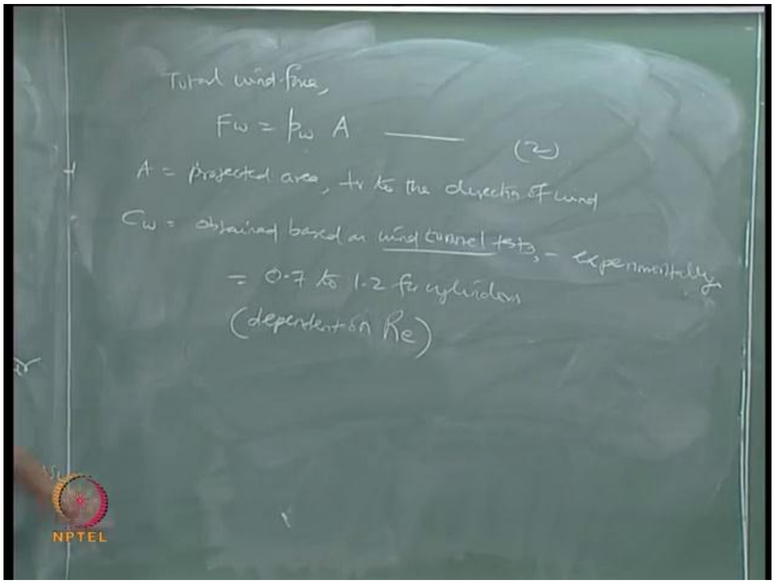

Now, the total wind force is given by p w into A, where p w is what I computed from equation number 1. And of course, A is a projected area, which is normal or orthogonal to the direction of wind if the member is inclined then you must find out appropriate projected area, which is orthogonal to the directional flow of wind. Now, one is interested to know how the C w that is wind pressure coefficient is obtained C w is obtained based on wind tunnel tests experiments. And this value varies from .7 to 1.2 for cylindrical members of course, this dependent on the renose number. When we talk about estimating in forces wind velocity has got two components we must understand. Natural wind has got two components one is what we call as the normal or the mean wind speed, which is a statistical parameter statistical.

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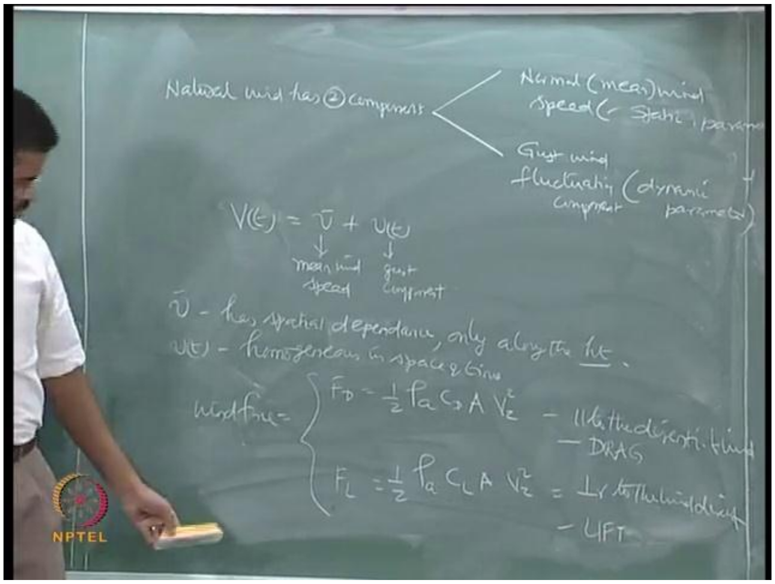

It is not dynamic, I should say static parameter the other one is the gust wind, which is the fluctuating component who is a dynamic parameter. So, I can now say velocity of wind can be mean plus v t. This is the mean wind speed and this is gust component, v bar has spatial dependence only along the height this is very important it varies along with z only along the z axis where as v of t the gust component is homogeneous respect to space and time it varies but, homogenic. So, therefore, wind force generated by the wind on members of marine structures has got two components one is called F d, other is called as F l.

The drag force and the lift forces, which is half row C D A v z square half row C l A v z square only variation is C L and C D the coefficient is varying. These acts parallel to the direction of wind. These acts normal to the direction, so this is called drag force. This is called the lift force,.So, we stop here now will continue in next lecture what is the spectrum which would advise me to compute wind forces on the members and how the complexity and randomness of wind loading can be handled in the literature to make it simple for computing the force on members using hydro dynamic admittance function. So, that will be target plus will also discuss about the ice load and the earth quick load coming on members of marine structures. Therefore, will compressively discuss the environmental loads coming on members.