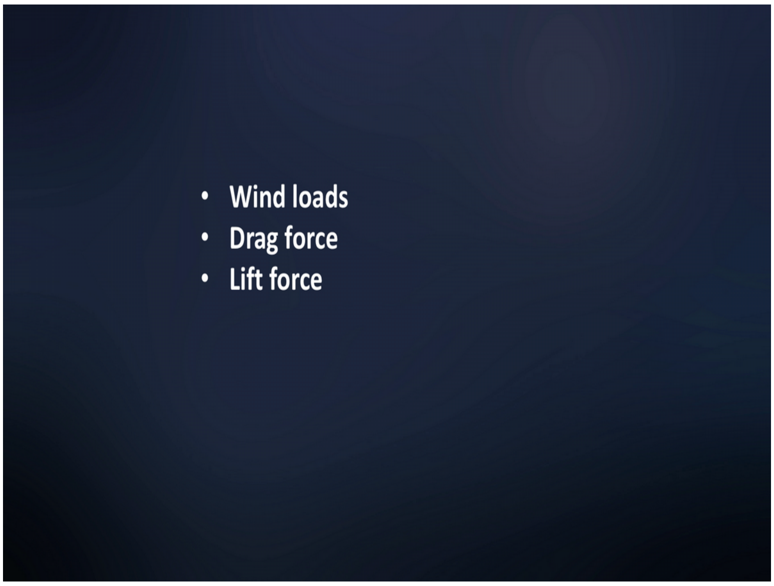
Computer Methods of Analysis of Offshore Structures
Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

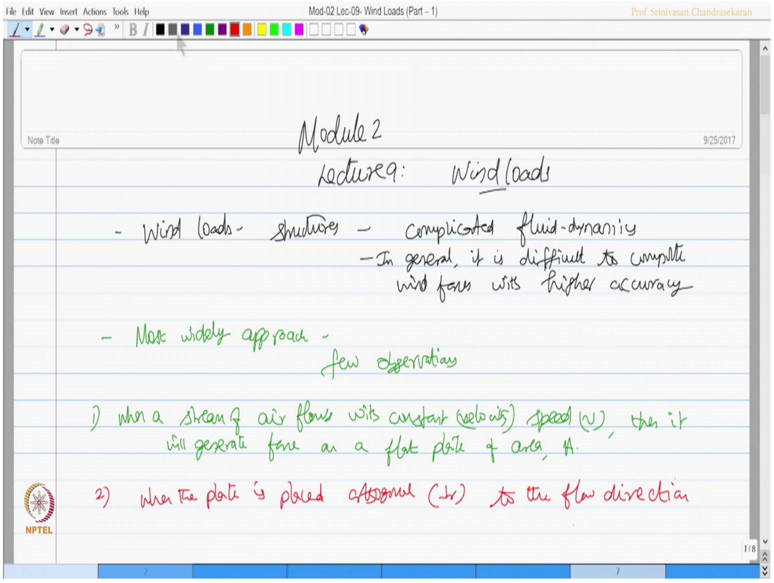
Module – 02
Lecture – 09
Wind Loads (Part – 1)

(Refer Slide Time: 00:16)



Friends welcome to the second module lectures, where this is lecture 9 in which we will discuss about wind loads. In the last lecture we discussed about wave spectra and one of the important source of offshore loads which is wave load. We also said what are the different varieties of loads acting on offshore structures, classification of loads where wave loads are predominantly important, let us talk about wind loads and see what spectra defines wind load and we will do some couple of examples then we will talk about the computer code to estimate wind loads.

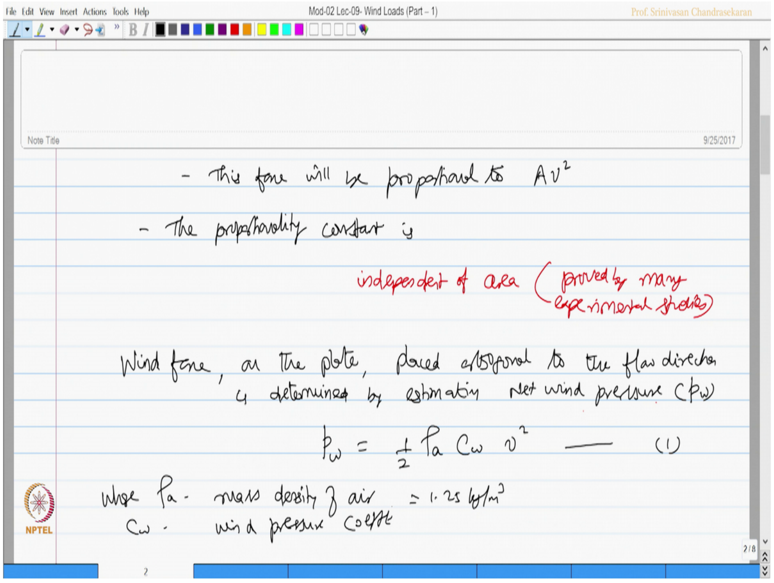
(Refer Slide Time: 01:06)



Wind loads actually add some structures which creates in fact, a very complicated fluid dynamics. In general it is very difficult to compute wind forces with higher accuracy, it is a general statement I will reinforce the statement slightly by showing you some theories of an examples, then the question comes what is the most widely used approach to estimate wind forces.

The widely used approach is based on few observations let us say what are they; one when a stream of air flows with constant velocity, let us the word speed because wind speed is important. Velocity v then it will generate force on a flat plate of area; interestingly this generates force on the plate when the plate is placed orthogonal that is perpendicular to the flow direction.

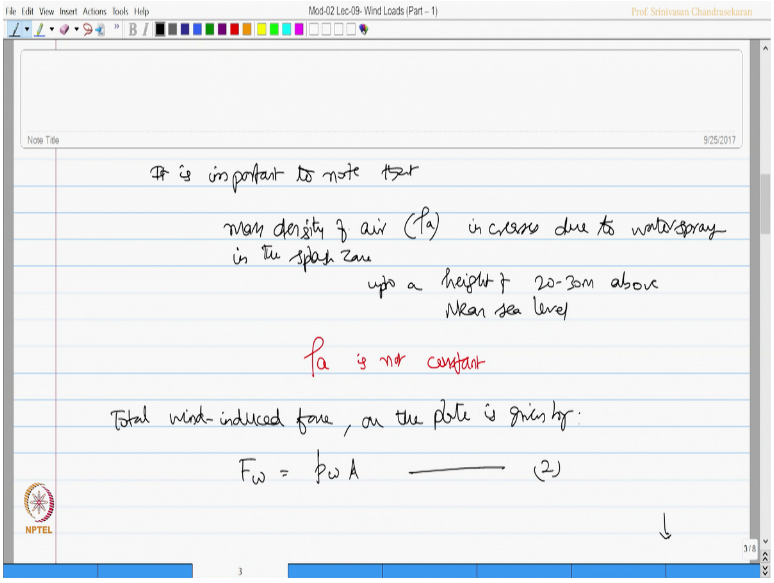
(Refer Slide Time: 02:36)



And this force which exerts on the plate will be proportional to A v square. Now the proportionality constant is interestingly independent of area, this is proved by many experimental studies. References can be seen from the list of paper sited in the nptel course of this specific syllabus. Having said this we now say that the wind force exerted on a plate placed orthogonal to the flow direction is determined by estimating something called Net wind pressure, which say as p w and w stands for wind small p stands for pressure.

So, small pw is half rho a C w v square equation 1 where rho a is mass density of air taken as 1.25 kg per cubic meter and C w is wind pressure coefficient.

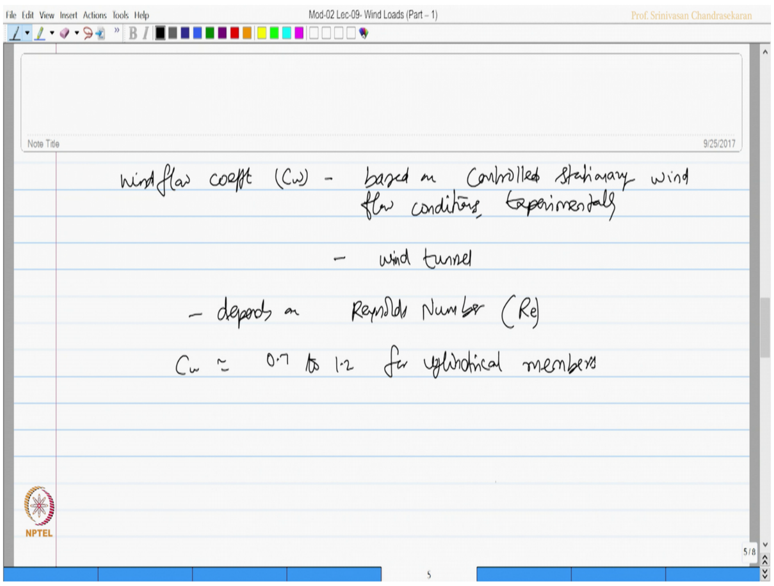
(Refer Slide Time: 04:40)



It is important to note that the mass density of air that is rho a increases due to water spray in this flat zone up to a height of about 20 to 30 meters above the mean sea level. So, it is important that rho a is actually not constant.

Now, the total wind induced force on a plate is given by capital F w sp w into A interestingly.

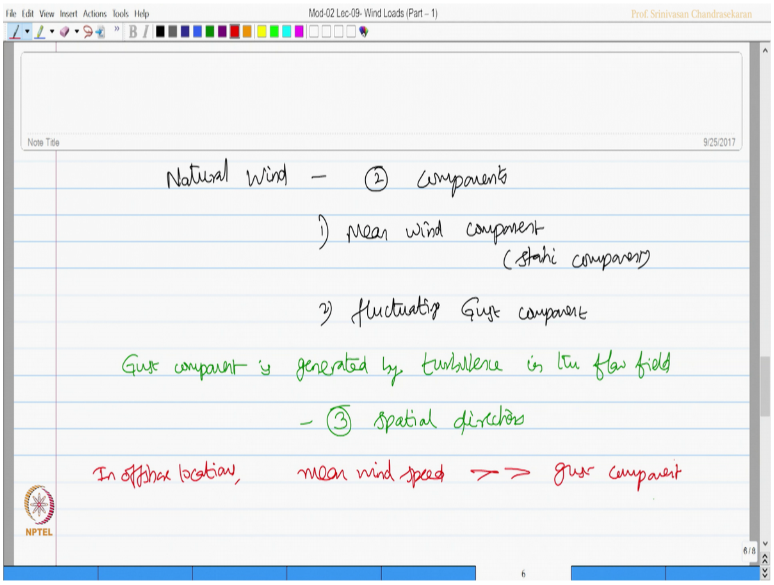
(Refer Slide Time: 05:45)



If the plate is placed at an angle theta with respect to the flow direction, then one need to work out the projected area accordingly. For example, if this is my plate, which is normal and this angle is theta and the plate has an area A, if this becomes my wind direction I need to work out the projected area ok.

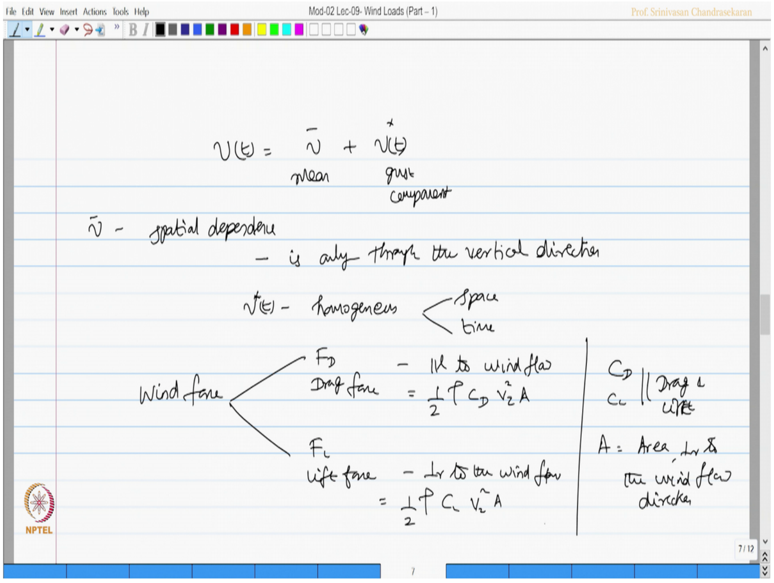
So, one has to really carefully workout the projected area in the flow direction. Having said this the wind flow coefficient C w is generally determined based on controlled stationary wind flow conditions experimentally, usually this is done in wind tunnel it depends on few factors the foremost important factor is Reynolds number of the flow usually C w is taken as 0.7 to 1.2 for cylindrical members.

(Refer Slide Time: 07:38)



So, friends natural wind has actually got two components, one is the mean wind component which is a static component other is the fluctuating gust component. So, gust component actually is generated by turbulence, in the flow field. This happens in three spatial direction, but one good news is that in offshore locations it is been observed that the mean wind speed is much greater than the gust component. Having said this we can now say v of t is v bar plus v of t.

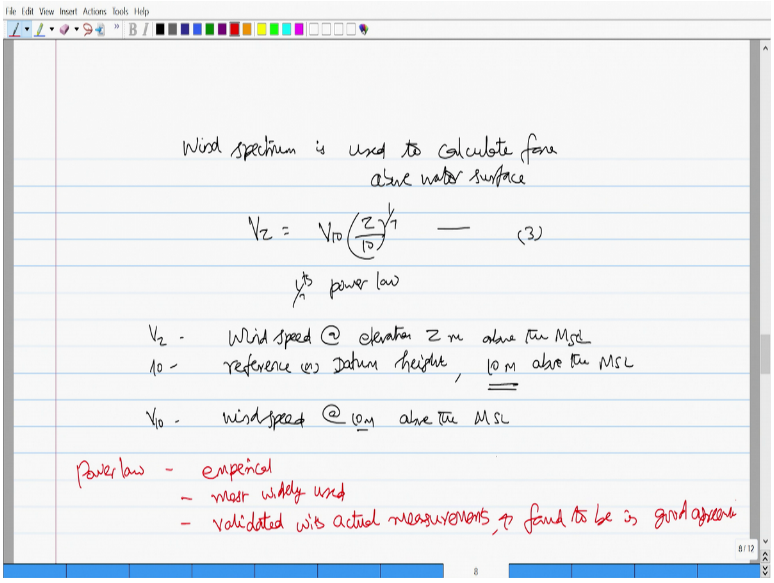
(Refer Slide Time: 08:38)



So, this is my mean component, this is my gust component now mean component as also have the spatial dependence, but it is assumed that the special dependence is only through the vertical coordinates. V of t is considered to be homogenous both in space and time. So, now, wind force in offshore structure can be calculated by 2 one is F D other is F L, F D is a drag force and F L is called the lift force which actually happens in the direction parallel to the wind flow.

This happens in the direction normal to the wind flow, this is given by half rho C D V z square A and this is given by half rho C L V z square A, where we already know C D and C L are drag and lift coefficients respectively and A is the area perpendicular to the wind flow direction.

(Refer Slide Time: 10:48)



So, now wind spectrum is being used is used to calculate the force above water surface, which is given by V z is equal to V 10 z by 10 to the power 1 by 7 this is also called as one seventh power law because the power is 1 by 7.

V z in this equation is the wind speed at elevation z meters above the mean sea level 10 refers to a reference or a datum height which is actually 10 meters above the mean sea level. So, friends it is very simple if you substitute z is equal to 10 here, you will see that up to 10 meter wind velocity remains constant of course, V 10 is that wind speed at 10 meter above the mean sea level. So, there are some comments about the power law this is called as the power law power law is purely empirical, but most widely used and it is validated with actual measurements and found to be in good agreement. So, it is fairly a correct estimate.