Offshore structures under special loads including Fire resistance

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Lecture – 10
Environmental Loads – II

Friends, let us discuss the 10th lecture, title environmental loads second part of the online course on offshore structures under special loads. We are discussing the complexities which arise from the conventional loads before we understand these special loads and the responses of offshore platforms under the special loads. In the last lecture we were discussing about areas, linear wave theory and complexities arise from the linear wave theory.

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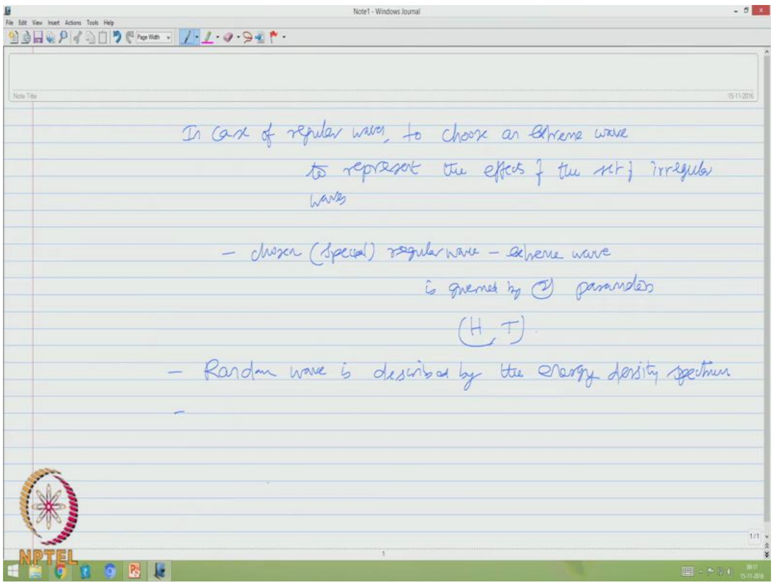

In case of regular waves, it is practice to choose an extreme wave to represent the effects of the set of irregular waves. So, the chosen let see special regular wave, which is extremely wave is governed by 2 parameters namely the wave height and the wave period. However, we agreed that random wave is describe by the energy density spectrum, random waves are generally use for design of offshore structures, then we understand this there are some basic terminologies which we understand in connection to the random wave.

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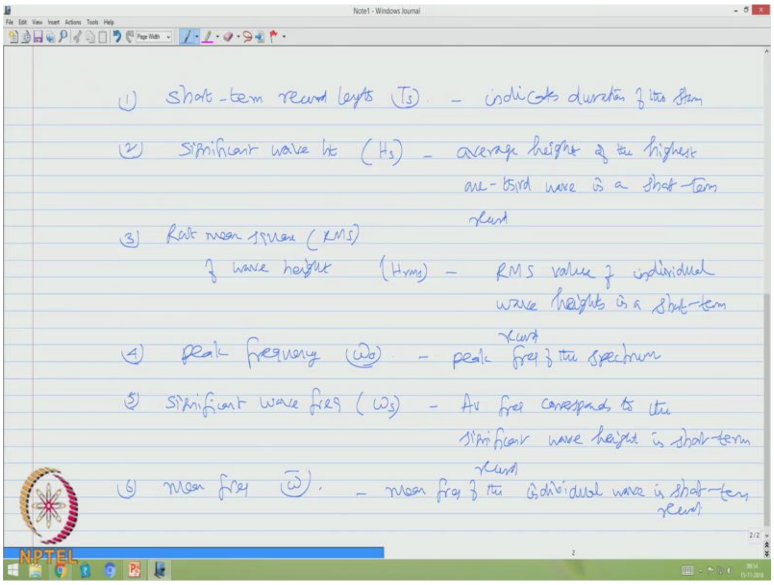

Let us say short term record length, it is Ts, which indicates the duration of strum; significant wave height Hs, which is average height of highest one-third wave, in a short term record root means square that is rms of wave height, which we called H rms, this is root mean square value of individual wave heights in a short term record.

The fourth one is peak frequency which is omega 0, which is the peak frequency of the spectrum, significant wave frequency which is omega s which is the average frequency corresponding to or corresponds to the significant wave height in a short term record, mean frequency which is omega bar, which is mean frequency of the individual waves in short term record.

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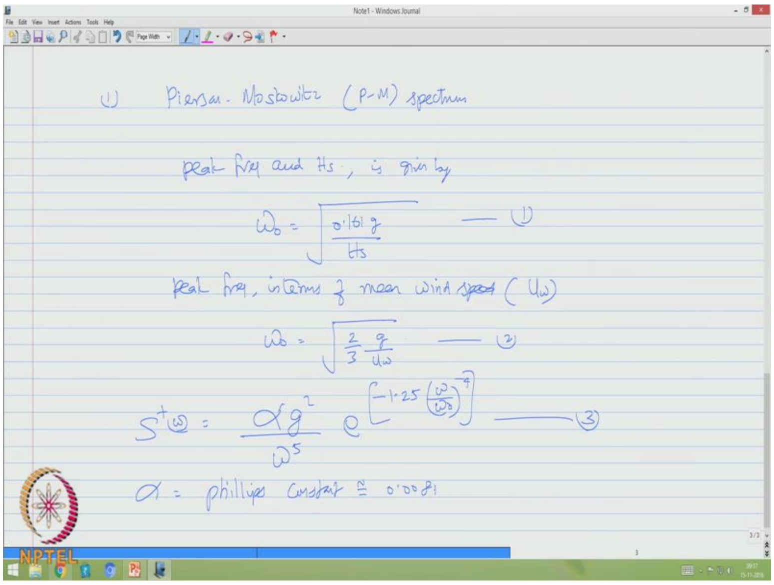

Having said this, the most conventional spectrum use for estimating wave forces on offshore platform is Piersas Markowitz spectrum famously known as P-M spectrum. We have an interesting relationship between the peak frequency and significant wave height which is given by peak frequency is 0.161 g by Hs.

So, if I know one is always find the other, one call also discuss and describe the peak frequency in terms of mean wind speed, which a called as Uw. So, peak frequency can also be given by two-third g by Uw. So, one may be interested why we looking about the peak frequency? Because Pieasas and Markowitz spectrum is defined based on the peak frequency, it says that the spectral energy S omega is given by alpha g square by omega 5 which is variable, e to the power of minus 1.25 omega by omega 0 the power of minus 4. So, where in this case alpha is called as Phillips constant, which is given by 0001 for offshore application this spectrum, is modified.

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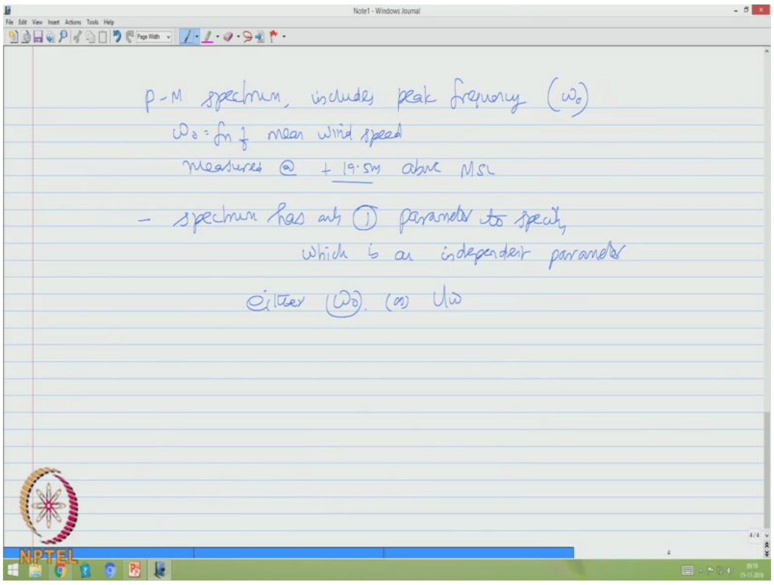

The P-M spectrum what is being describe includes the peak frequency, which is omega 0 in the equation which is actually the function of mean wind speed measure at height of plus 19.5 meters above the mean sea level. So, the spectrum has only 1 parameter to specify; which is an independent parameter, it is either the peak frequency or Uw because both of them you are interdependent if you know one I can find the other.

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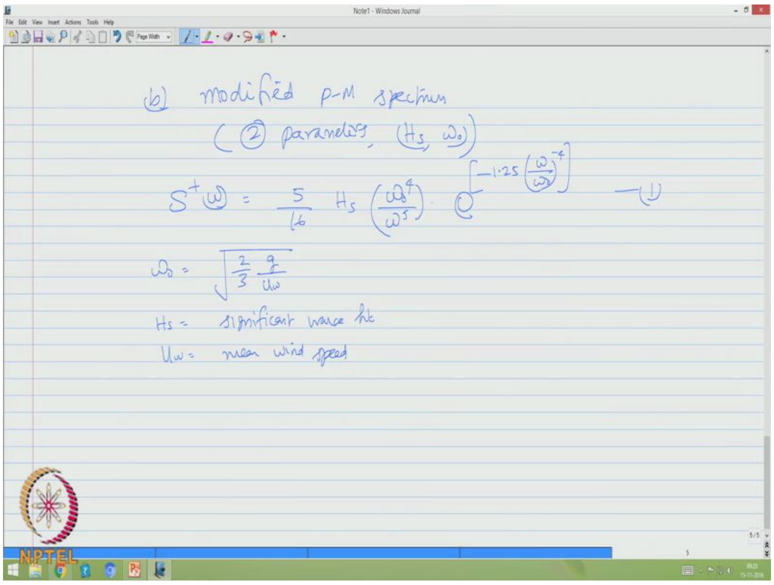

This spectrum is further modified which is now being used in design of offshore platforms. This has 2 parameters namely significant wave height and peak frequency, this equation is given by where in this equation the peak frequency is given by two-third of g Uw, Hs is significant wave height and Uw is the mean wind velocity.

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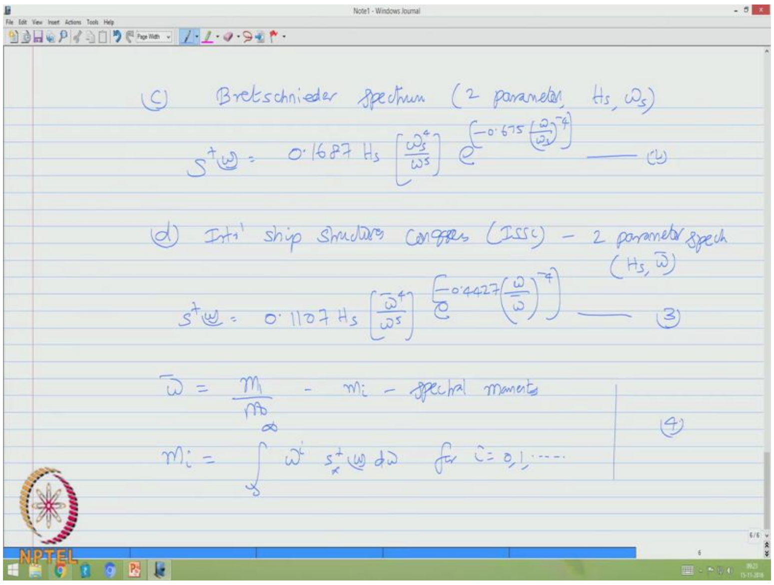

The second spectrum we have is bretschneider spectrum, which again as 2 parameters namely significant wave height and significant frequency, which is given by 0.1687 Hs omega s by omega e to the power of minus 0.675 omega by omega s to the power minus 4. Alternative spectrum is given by international ship structures congress, which is ISSC spectrum, which is again a 2 parameter spectrum, which is Hs and omega bar. In this case the spectrum waves the function is given by the following equation - omega bar 4 by omega 5 e to the power of minus 0.4427 omega to the power minus 4 this is equation 3, where omega bar is given by m 1 by m 0 and m i is called spectral moments, m i can be simply given by omega i s x plus omega d omega for i equals 0 1 etcetera.

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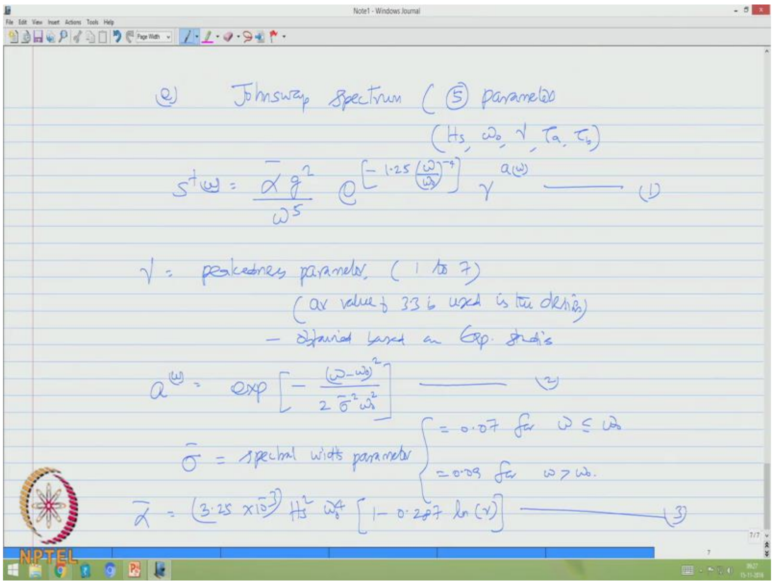

People also use Johnswap spectrum, which is for 5 parameters namely Hs, omega 0 gamma, the spectral density function is given by alpha bar g square by omega 5, e to the power minus 1.25, omega by omega 0 to the power minus 4 of mu omega. The mu is called peakedness parameter, which varies from 1 to 7, usually an average value of about 3.3 is used in the design, this essentially have time based on experimental studies a w is given by exponential minus omega, omega 0, square by 2 sigma square omega 0 square, where sigma dash is actually called spectral widths parameter, which is actually 0.07 for omega less than omega naught and 0.09 for all omegas more than omega 0. Alpha bar is constant which is 3.25 into 10 power minus 3, H s square omega 0 4 of 1 minus 0.287 natural algorithm.

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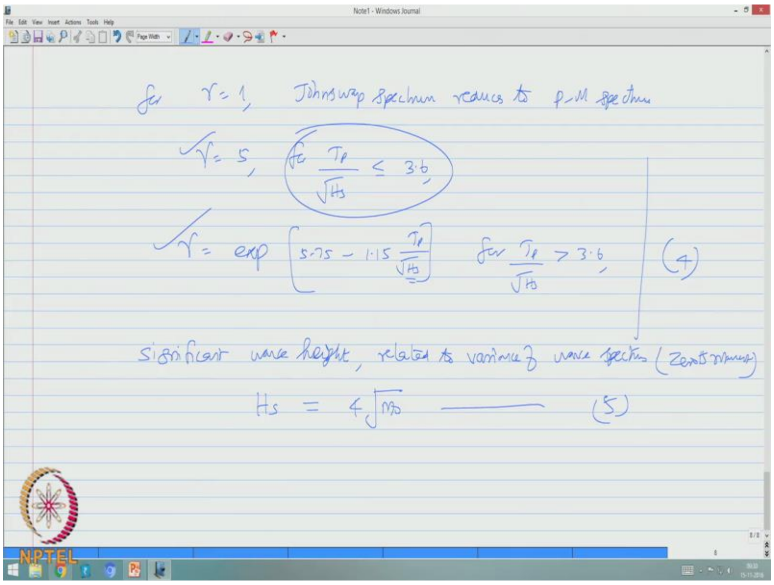

Interestingly for gamma equals 1, the Johnswap spectrum actually reduces to the conventional P-M spectrum; a mu is equal to 5 and for Tp by root significant height is less than 3.6, gamma is given by separate equation which is 5.75 minus 1.15 Tp by root Hs, gamma as taken as 5 if this value satisfied, for any other value of Tp by root Hs more than 3.6 this equation can be used. One can also compute the significant wave height which is related to the variance of wave's spectrum; significant wave height is related to zeroth moment which is the variant because variance is spectrum is also called zeroth moment on the spectrum. So, if you know this zeroth moment spectrum can always fine the significant wave height which is require in estimating the parameter gamma because you have some Hs here and then substitute back in the Johnswap spectrum to get this spectral density function distribution or all (Refer Time: 20:10) of omega.

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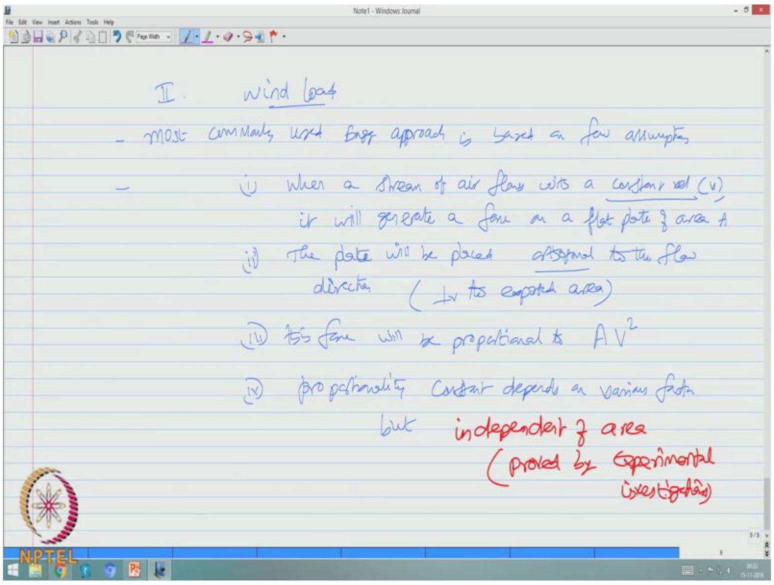

The next conventional load, what will take will be the wind load, for estimating wind forces the most commonly used engineering approach is based on few assumptions.

So, therefore, one can say these assumptions lead to uncertainties or complexity in estimating this wind forces; assumption are when a steam of air flows with a constant velocity V, it will generate a force on a flat plate of area A, so at the constant velocity. The plate will be placed orthogonal to the flow direction. So, wind forces or perpendicular to the exposed surface area, this force will be proportional to A into V square. So, the proportionality constant depends on various factors, but independent of area this is proved by experimental investigations.

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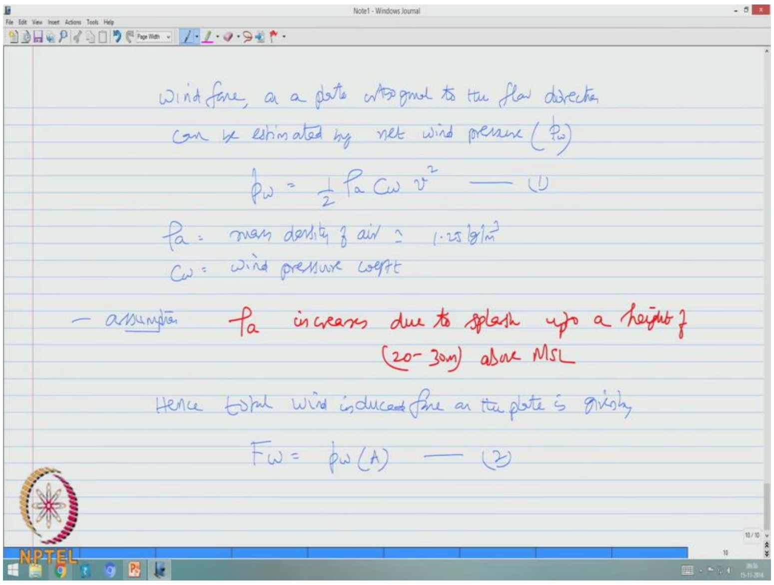

So, therefore, wind force on a plate, which is orthogonal to the flow direction can be estimated by net wind pressure which a called as Pw. Pw is given by half rho a Cw, v square; where rho a is mass density of air which about 1.25 kg per cube meters, Cw is called wind pressure coefficient. There is very important assumption which is made in estimating wind forces and offshore platforms, the assumption is mass density of air increases significantly due to the splash happening on the members up to a height of 20 to 30 meters above mean sea level, hence total wind induced force on a member or on the plate is given by F w is this multiplied with area.

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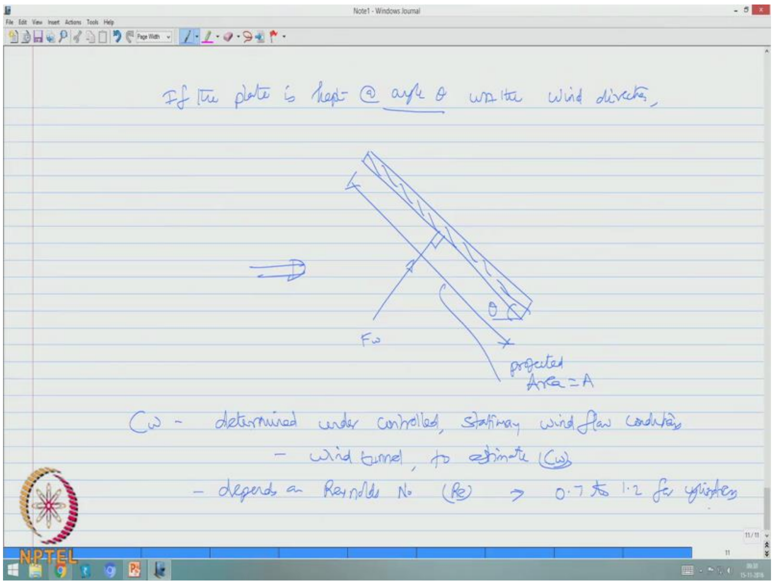

If the plate is kept an angle theta with respect to the wind direction for example, let see this is my (Refer Time: 26:03) right, this may under theta, I know the projected area, I should say projected area this becomes my wind direction. So, the wind force will be normal wind force will be normal to be plate; they have to find the resolved value of this in the direction normal to the plate if you know the theta. The wind pressure coefficient Cw is generally determined under controlled stationary wind flow condition, usually experiment is conducted in wind tunnel to estimate Cw, it of course, depends on Reynolds number they value usually is 0.7 to 1.2 for cylindrical numbers.

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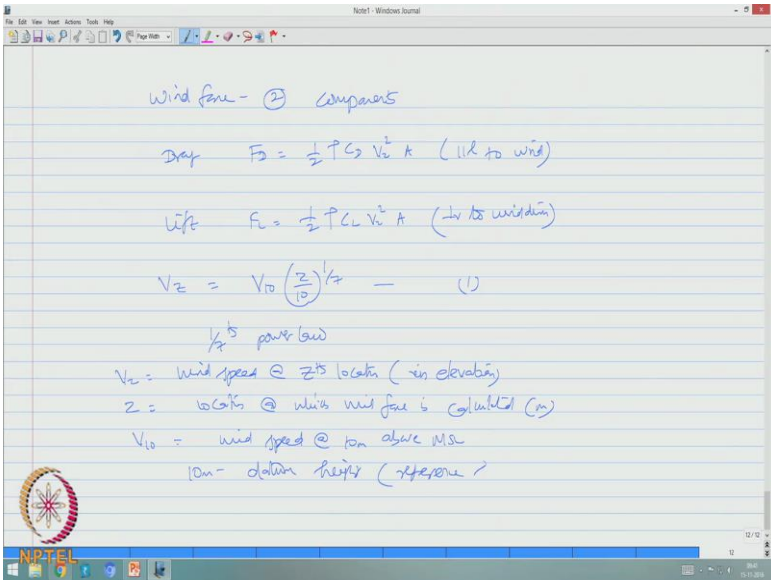

So, wind force will have 2 components; one is the drag force other is the lift force, which is given by these equations where drag will act pearlier to the wind direction and lift will have normal to the wind direction, so it is called drag; this called lift force. C D and C L are respectably drag and lift coefficients in both the cases area is measure normal to the wind surface. V Z is given by an empirical (Refer Time: 29:00) which is z by 10 1 over 7, which is called one-seventh power law, where V Z is called wind speed at Zth location in a elevation. Z is called the location at which wind force is calculated will be meters V 10 is called the wind speed at 10 meters above mean sea level.

So, this 10 meter is called datum height or reference height.

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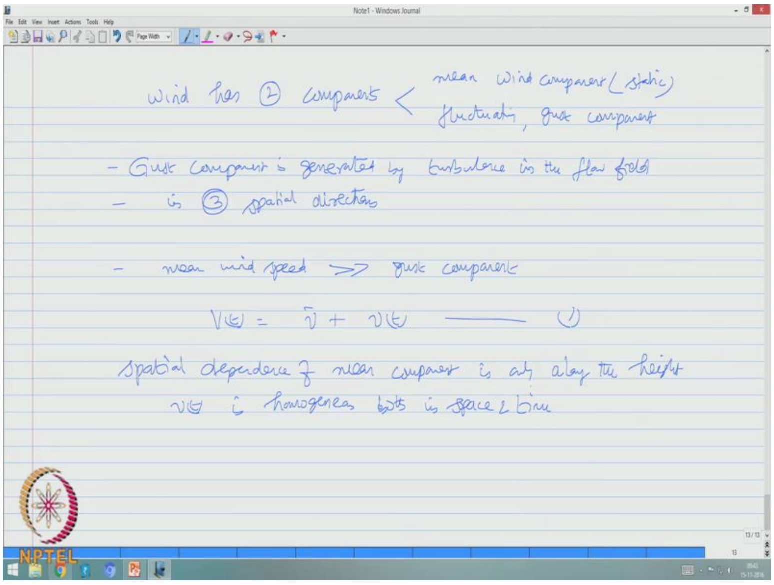

Generally wind has 2 components; the mean wind component which is more or less is a static component, the next one is the fluctuating component, which is called the gust component. Usually the gust component is generated by turbulence in the flow flied, this generally generated in 3 spatial directions, it is also a fact that the mean wind speed is for greater than the gust component V of t as the mean component plus the gust component. It is interesting to note the spatial dependence of the mean component is only along the height V of t is assume to homogeneous both in space and time.

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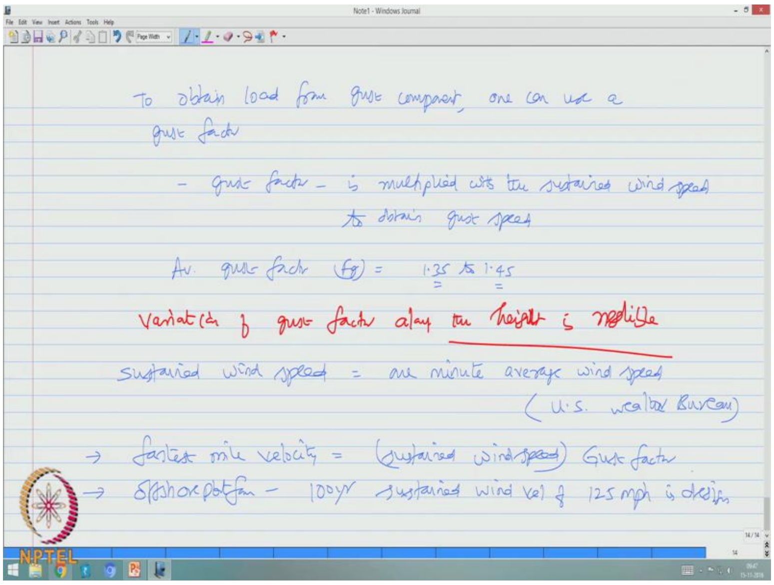

Since wind velocity is got 2 components, to generally obtain load from gust component one can use the gust factor, the gust factor is generally multiplied with sustained wind speed to obtain the gust speed, average gust factor which we called as Fg is about 1.35 to 1.45. So, there is an increase (Refer Time: 33:35) 35 to 45 percent in the gust speed is very important to note that variation of the gust factor along the height is negligible. So, people can only use sustained wind speed to calculate forces on offshore members, we usually one minute average wind speed this is as well U.S weather Bureau. Another interesting terminology which causes complexity in estimating wind load is fastest mile velocity is nothing, but the sustained wind speed which you estimate and multiplied this with gust factor, to obtain the fastest mile velocity usually if (Refer Time: 35:10) offshore platforms, people use 100 year sustained wind velocity of about 125 miles per hour in design.

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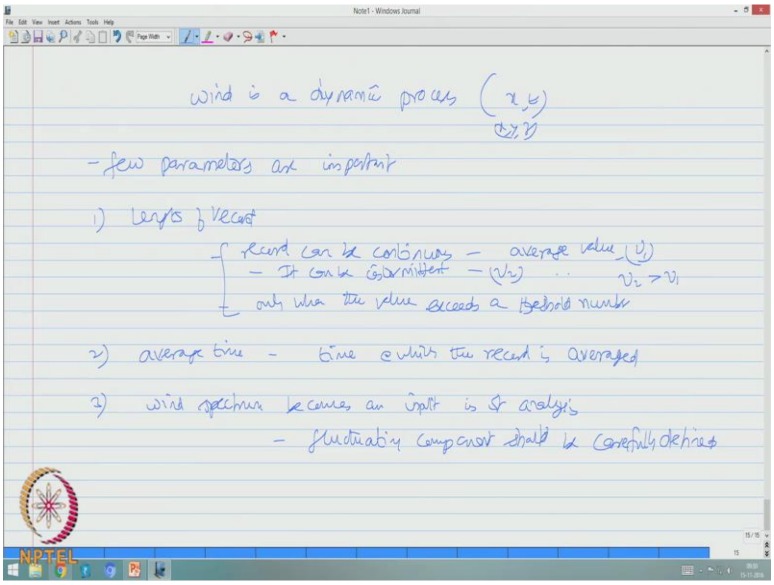

We all agree that wind is a dynamic process, because it varies with both space and time, space and sense, both x y and z therefore, few parameters are important because these parameters cause complexities in wind loads, the first parameter is the length of record. The record can be continuous, it can be intermittent with equal intervals between the observation, can also measure the record only when the value exceeds with threshold number. So, there are many ways by which we can fix up the length of the record, for the recording continuous one looks for an average value, let say V1, for intermittent one looks for value V 2, you will see that generally V 2 is greater than V 1.

The second issue is average time of the record, is important to know that average time is different as the time at which or over which the record is average. The third issue is that the wind spectrum becomes an input in structural analysis therefore, the fluctuating component should be carefully defined the fluctuation component sense the gust factor.

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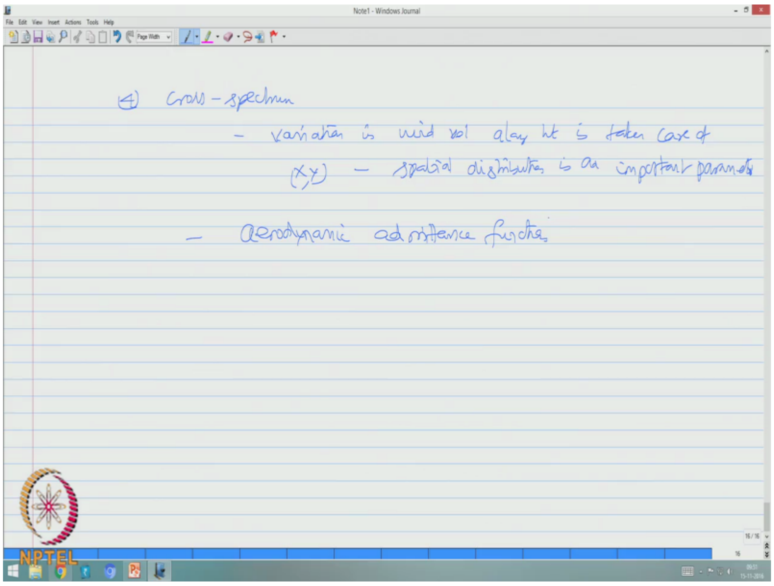

The fourth issue is the cross spectrum; variation in wind velocity along the height is taken care of, but along xy which is the variance or dependent on the special distribution is an important parameter, this is generally handled by considering aerodynamic admittance function.

So, friends the next lecture will talk about various wind spectrum and aerodynamic admittance function and then list the complexity that arrives from the wind load of offshore platforms. So, in this lecture we discussed about various spectrums, the use various estimating wave loads then we also start understanding some important limitations based on which wind forces are estimated on offshore members.

Thank you very much.