Advanced Marine Structures

Prof. Dr. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Lecture - 9
Other loads - I

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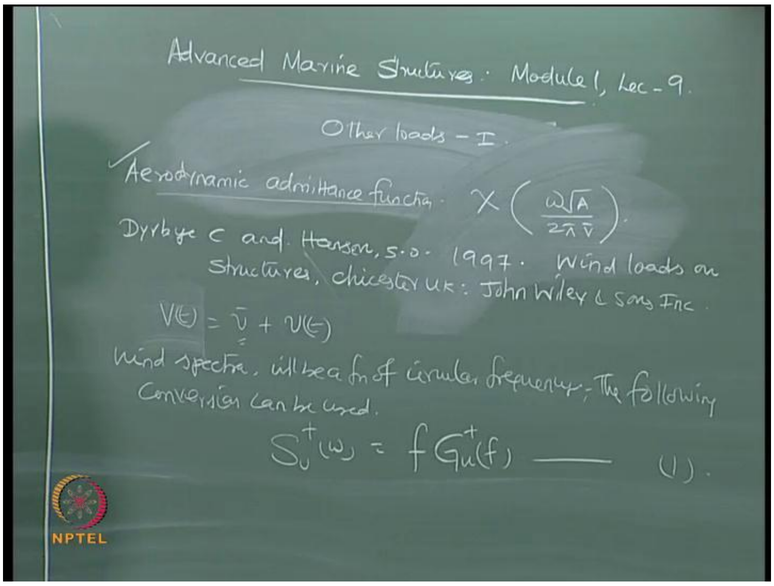

So, in the last lecture, we discussed about how the aerodynamic admittance function can be used to simplify the randomness involved in computing the wind loads on marine structures. For more information on this specific function, you can refer to this particular paper. So, this book will give you more information on the computation and the influence of aerodynamic admittance function, the wind loads.

So, we already saw in the last lecture, thats how the mean component, and the guest component are handled in the wind load calculation, provided we have the spectra define for mean wind, depending upon the one seventh power law. There is other spectrum available for average wind speed, which can be used for offshore application, which we will see in this lecture. Now the wind spectra, which will be given now, will be actually a function of, circular frequency, which is quite unusual, but the following conversion can be used to understand these spectra. So, here u plus omega will be actually a function of, which I say G u plus f; that is the conversion what we have to convert the frequency to circular frequency, when you have otherwise the frequency given in general.

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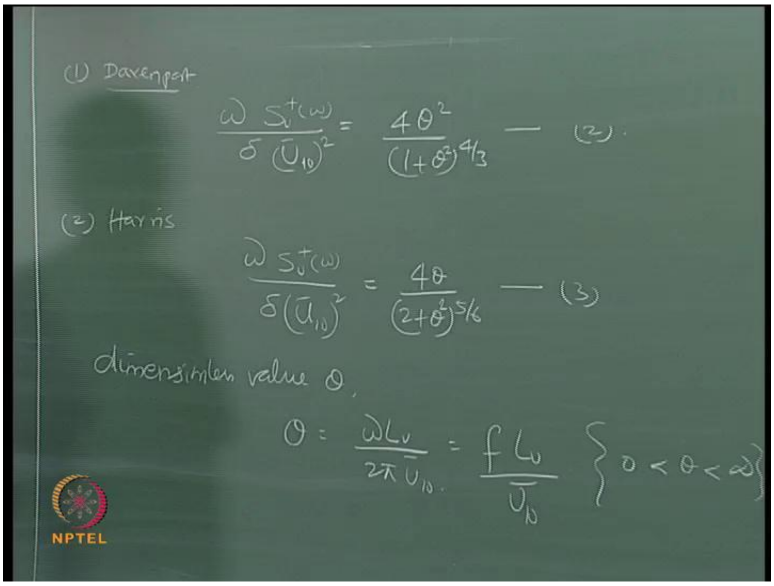

So, there are many spectra available, let us talk about few of them which are used for offshore application; Davenport is given as spectrum. There is another spectrum suggested by Harris, which is also used for marine structures. In both the spectrums, the dimensions value theta, is given by the following relationship, so this can be also 2 pie by omega is f we already know, for any value.

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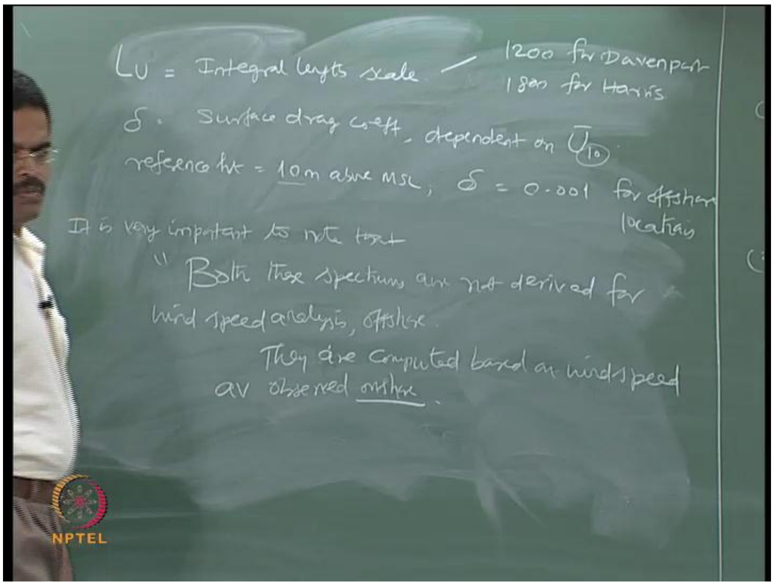

Now in this case, L ten L u sorry L u is called integral lengths scale, which is taken as 1200 for Davenport, and 1800 for Harris. Delta is called surface drag coefficient, which is dependent on u bar. Now that value till here, is called as reference height; ten meters above the mean see level, this vary generally compute the well velocity; that is called reference height. So, that value of delta is generally taken as 0.001 for offshore locations. So, these two spectrums are also popular, to compute the wind forces on offshore structures. There are some critical comments about these two spectrums. It is very interesting to note, it is very important to note that, both the spectrums are not derived, for wind speed analysis offshore. They are done, or they are computed based on wind speed average observed onshore.

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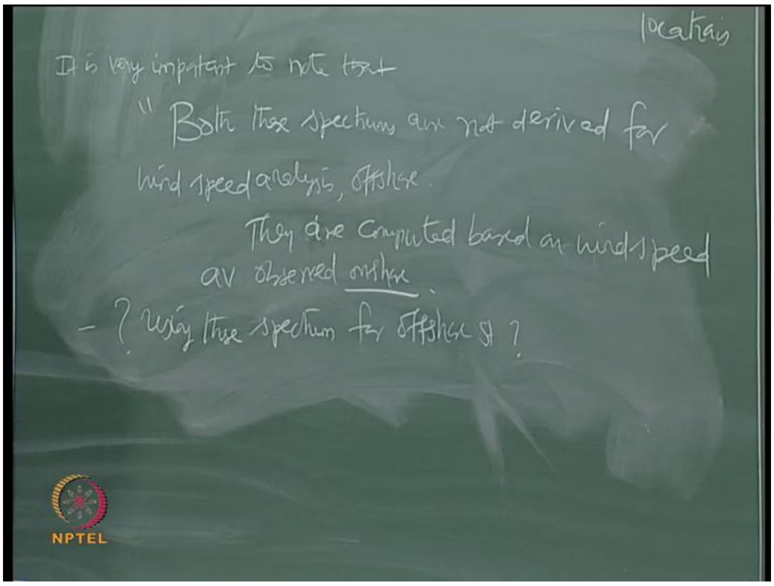

So, there has been a very serious problem, of using these spectrum for offshore. People have been using, questioning these spectrum. Now one by one that what could be the significance of using a wrong spectrum, which is not meant for an offshore location. Now ,as far as the bottom supported structures are concerned, we already discussed in the last lecture.

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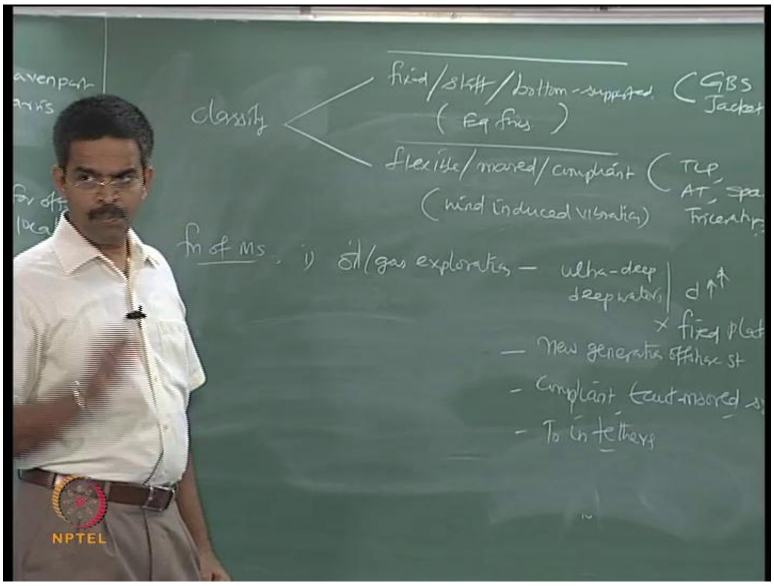

We can classify the marine structures in to two divisions; one is what we call fixed structures, you may say them as stiff structures, I can call them as bottom supported structures; examples can be gravity base platform, jacket platform etc. The other could be flexible moved compliant structures; examples could be t l p, articulated towers, spar, triceratop etc. We have already seen in the last lecture if u recollect, as per as forces acting on marine structures are concentrated, the fixed type structures will be more prompt to earth quake process. Whereas a compliant f structures will be more prompt to, what we call wind induced vibration; that is one part of a argument. Now, carrying this argument forward for modern application of marine structures.

Now, the essential function of a marine structure as on today, one of the major requirements of a marine structure could be, let see oil and gas exploration. The movement we agree, that oil and gas exploration, is one of main functional aspect of any marine structure as on the present requirement. Then we are looking for oil and gas exploration in ultra deep waters, or at least deep waters. The movement I say the water depth is increase, I cannot go or I cannot afford to go for fixed platforms, because they are completely obsolete. People go for what we call, new generation offshore structures. Essentially, these kinds of new generation offshore structures are compliant, and they are generally taut moored systems.

It means they are supported, by tension in tethers. Having understood that, the current purpose of marine structures are, oil and gas exploration in ultra deep waters, where new generation structural form, is evidently improving, or its important. Therefore, wind forces, or wind loads acting on these structures, which can cause wind induced vibration becomes dominant, apart from the wave load. Now when the wind induced for vibration or the wind loads become dominant in such structure, because of low frequency phenomena. It is important that we must select an appropriate spectrum, or defining a wind loads. So, in the present trade, people have replaced Davenport and Harris spectrum, by specific spectrums which are very applicable for flexible, taut moored, compliant of a structures, so what are those spectrums.

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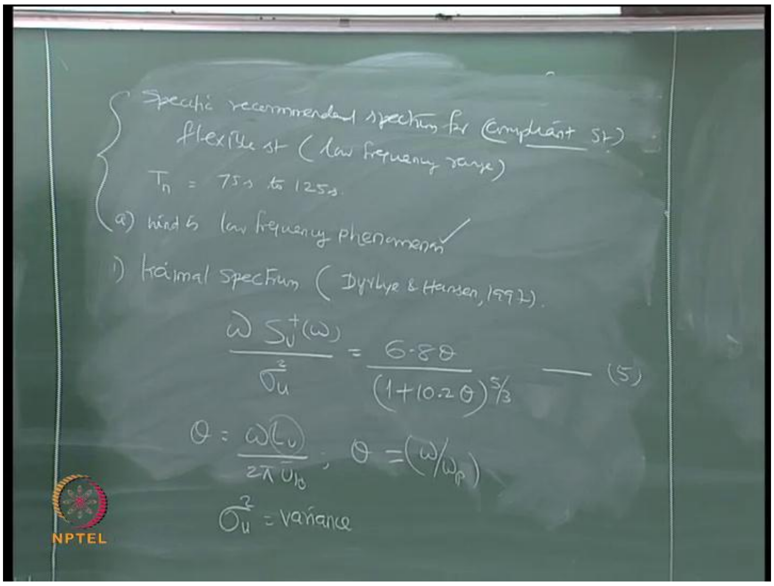

So, specific recommended spectrum, for I should say here compliant structure essential they meant for flexible structures, which have low frequency range, what do you understand by low frequency range. The fundamental time period of compliant structures vary somewhere from 75 seconds to as high as 125 seconds. So, we all know frequencies 2 pie by t, so when the t is higher, frequency is lower. And we also know that, wind is a low frequency phenomena, we already seen this in the last lecture. Now, here I have a structure which has got a fundamental frequency very low. I also have a low which is having a low frequency phenomena, so there is a possibility that, the structure may resonate, under this combination of action of the wind loads, on this kind of structural action.

So, looking into this consideration, people are specifically recommended three spectrum, for wind loads on compliant structures. One is Kaimal spectrum; the reference of the spectrum can be seen from, Dyrbye and Hansen 1997 which I gave you, in the same lecture today. So, according to this spectrum I should say this equation number. So, theta in my case, is as same as the dimensions value as specified in the Davenport and Harris spectrum, which is omega L u 2 pi u bar. Since the L u value is associated, with a specific dimension related to Davenport and Harris, the imploration of Kaimal spectrum says; theta simply is replaced as ratio of omega by omega p, where omega p is a peak frequency, and of course, sigma u square is the variance.

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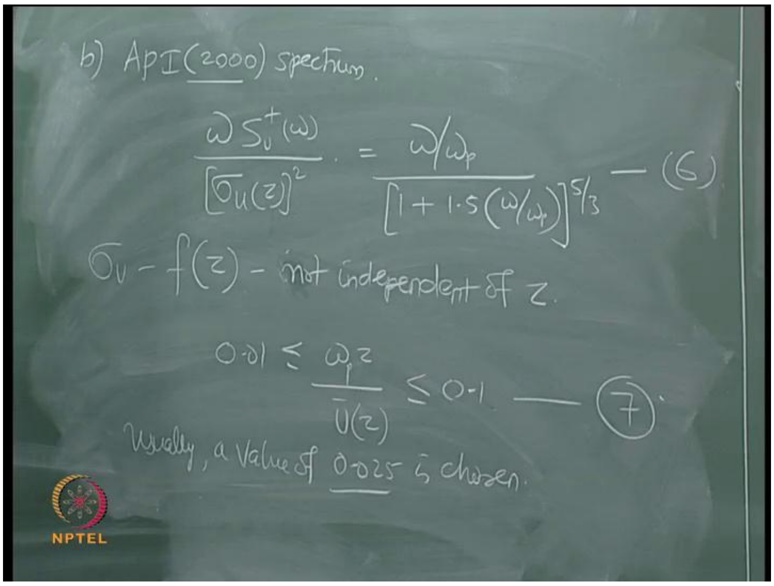

I will write it here, sigma u square it is the variance, of u of t at reference height of 10 meters. Subsequently, A P I 2000 also specified a spectrum, which is very much applicable for compliant structures. I call this is A P I 2000 spectrum. The equations number six. Now, one may wonder what is the variation, between the Kaimal spectrum and A P I spectrum, the major variation comes from the sigma u, which is made now as a function of z. Whereas in Kaimal spectrum, this was always taken as the reference develop 10 meters, now this is the function of depth observed, or I should say height. So, I should say that, this is not independent of z; that is the catch in A P I spectrum. So, they have given a range 0.01, is the value what you can select for, the specific application of this spectrum. Usually a value of 0.025 is chosen.

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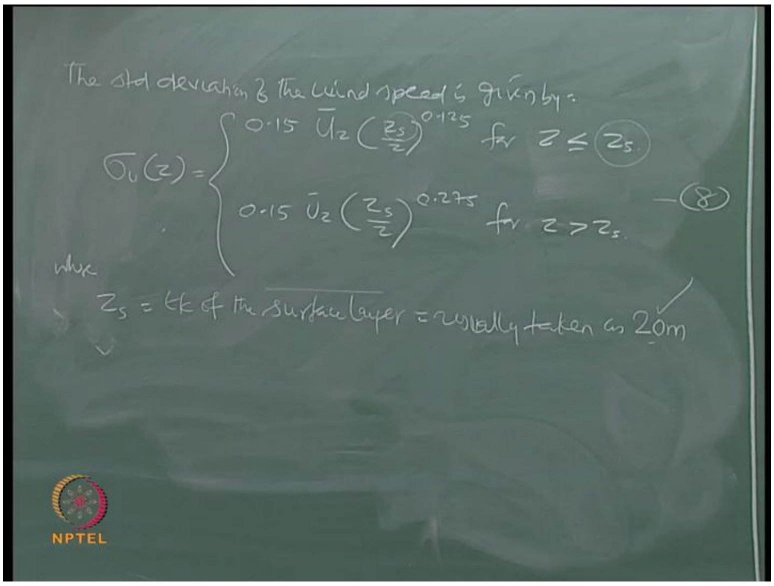

Then in that case, the standard deviation of the wind speed is given by; that is sigma u of z, which is a function of z, 0.15 of whereas in this case, z s is thickness of the surface layer, usually taken as 20 meters, so I can call this as equation number eight. So, if you know the thickness of the surface layer, which can be it considered as 20 meters. You can always find out what z you want to compute, your standard deviation, pickup the equation, square that you get the spectrum define, because we already know omega p, for every value of omega, you will get s plus omega from this equation, which A P I specifically applies or advises for compliant structures. Let us quickly see, what is the plot variation of Davenport, Harris, and for example A P I, and see in which range this particular spectrum is more effective.

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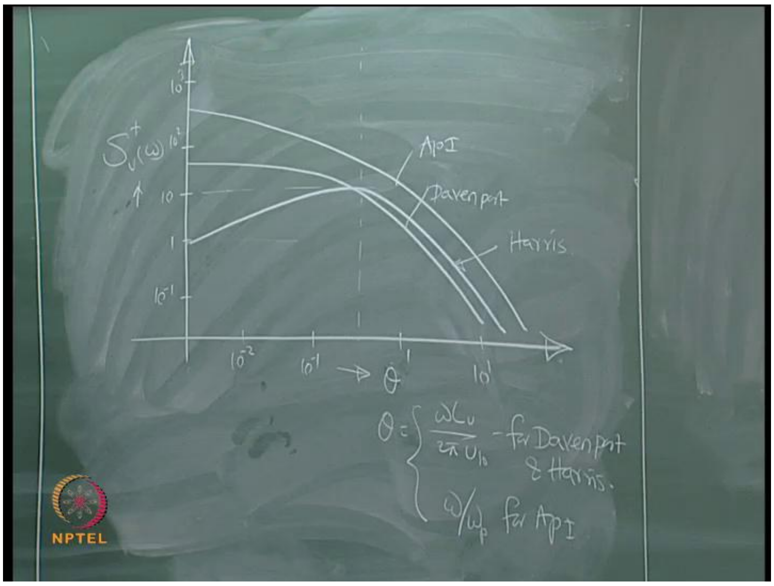

So, I m trying to plot, the variation of theta in the spectral of unit for these three spectrum for Davenport, Harris and A P I for which we already have the equations. This is the Harris spectrum, this is Davenport this is A P I. So, we draw very important information from these figures.

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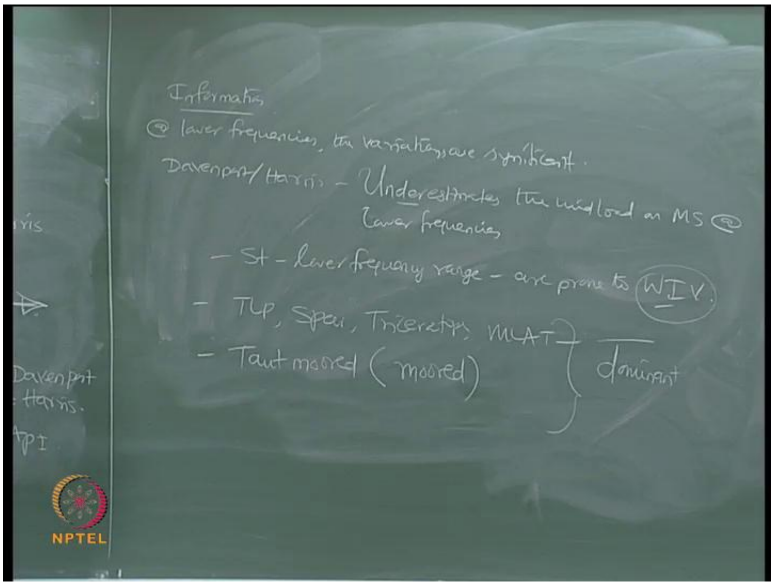

The important information what I get by comparing these two, these three spectrums is that, for lower values of theta. When the value of theta will be lower, because L u u 10 2 pie are all fixed, when omega is lower, theta will be lower. It is true in case of A P I also, because omega p is fixed, for omega to be lower theta will become lower. It means, for lower frequency range, the variations between the spectrums are significant. So, at lower frequencies, the variations are significant. On the other hand, Davenport and Harris underestimates the wind load on marine structures, at lower frequencies, the variation is very significant. Now one me ask a question that, why we interested in lower frequencies, because structures which has lower frequency range, are prom to wind induced vibrations. So we are very much focused on the lower frequency ranges; for example, in case of let say T L P, in case of spar, in case of triceratops, in case of M L A T; that is multi leg articulated towers, the fundamental frequencies are a very low order.

So, these structures are also taut moored or I should say, simply moored. Therefore, the effects of wind induced vibration on such structures are dominant. So, it is necessary that, I must compute the wind loads, on these structures, which has lower frequency band in an appropriate manner, because if you compare the classical spectrum available in the literature, at lower frequency bands, the variations of the spectral ordinate, given by the spectrum are significantly different. So, that is why people use A P I 2000 for flexible structures, and Davenport and Harris also had a very serious constrain that, they were not validated, depending upon the wind speed average measurements done on off show, they are all done on measurements based on onshore, so there is a difference. So, the question is whether they can be applied to off shore is an issue, this is about wind spectrums, this is clear. So, this will be the discussion what we will end up, for the wind forces on marine structures.

We had discussed aerodynamic loading, we are now discuss aerodynamic loading, we have understood that the aerodynamic loading at two components; one is what we call the mean wind speed, or the mean component of the wind velocity. The second one is the gust component, which is the variable component, which can cost dynamic effects on the structures. The static component which is the mean wind velocity will not cause dynamic effect; it is going to cause static effect. So, generally coats preferred to do cause static analysis, but it is very important that, structures with low frequency range, should be accounted for the dynamic amplifications happening, because of the gust factor, coming from the wind load on low frequency structures, which because this can cause wind induced vibrations.

Therefore, it becomes necessary that I must know how to handle, the gust factor also into mean account. Now, the question is, as far as earthquake loads are concerned, though it's a random process we can do deterministic analysis, but as far as wind loads are concerned, people generally do probabilistic analysis. Therefore, I want to convert, or handle this probabilistic analysis into a confine closed form, in wind load computation. So, I used or introduce, what we call aerodynamic admittance function, in to mean calculation. So, with the help of that function, I can always compute, the wind loads which will also account for the gust factor in my problems. And we already compared, started comparing wind, wave, and earthquakes.

Earthquake creates inertia forces, they never create a drag force on the structure, they are highly sensitive to structure which are bottom supported, and large of course, massive structures. Whereas, wind has a drag component also, wave has a drag component inertia component both. So, we have now completed two discussions; one on aerodynamic or the wave loading, we started of withary's theory, we understood there are higher order theories available like stokes fifth order etc, they are available in the literature, this course will not cover those aspects in detail. We also discussed about how to handle, the non-linear drag part. We have also discussed how to handle the damping part, and what is approximate value suggested by the literature, for flexible or for bottom supported cylindrical structures, or structures having cylindrical members.

Then we moved on aerodynamic loading, we started with understanding the aerodynamic behavior, on different class of structures. Aerodynamic aspect is divided in two parts; one the way in which you model the loading itself is a problem, two where do you want to apply this load, to a fixed structure or to a flexible structure, it is a problem, or it is varying. So, we must specify very clearly, what spectrum I must apply for different kinds, because certain spectrums show. Seen we can variations in the low frequency bands, and those all the structures which are highly aerodynamic sensitive, so we have understood this. Now, we will talk about additional loads, like for example, ice loads, then we will move on to earthquake loads, then we will move on to conventional dead loads, live loads, current forces etc, so that we will comprehensively complete.