Computer Methods of Analysis of Offshore Structures
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Module – 02
Lecture – 08
Wave Spectra (Part - 1)

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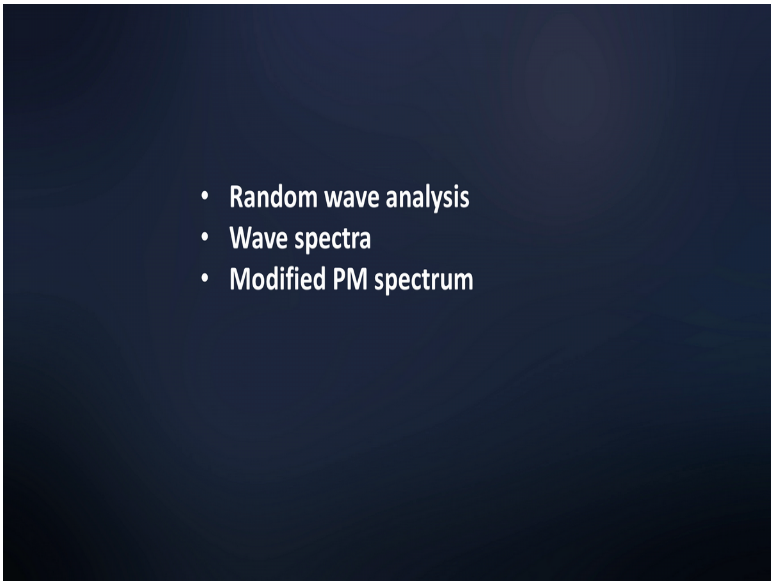

So, friends, let us continue to discuss more on wave spectra, which are used as an input for environmental loads in offshore structures.

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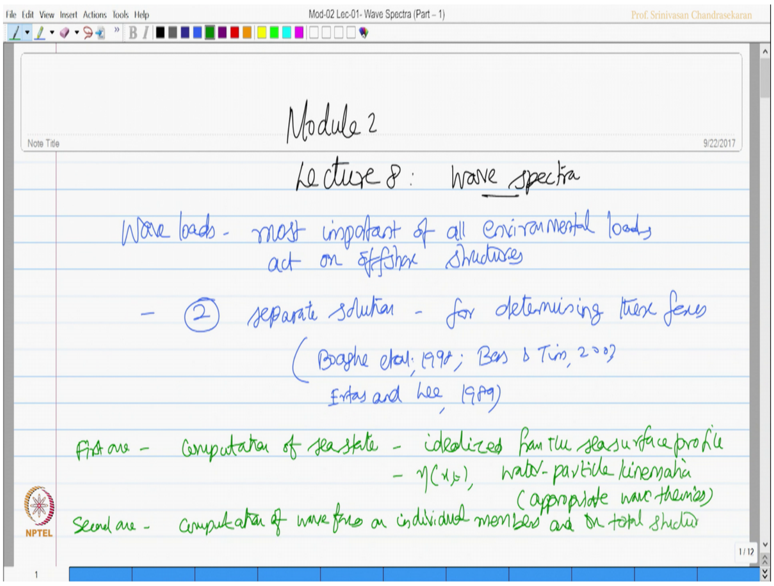

We already said that wave loads are most important of all environmental loads acting on offshore structures. So, determining these wave forces has got two separate steps for determining these forces. This was verified interestingly by Boaghe Etal 1998 Bas and Tim 2007, Ertas and Lee 1989 what are these two steps? The first step is computation of sea state which is generally idealized from the sea surface profile; sea surface profile needs eta x of t and water particle kinematics which can be taken from appropriate wave theories. There are various number of wave theories available in the literature, I have discussed only Airy's wave theory.

I request the readers to read parallelly other theories available from the reference literature given in the website of NPTEL of this specific course, the second one is computation of wave forces on individual members and on total structure. So, there are two structures involved in this.

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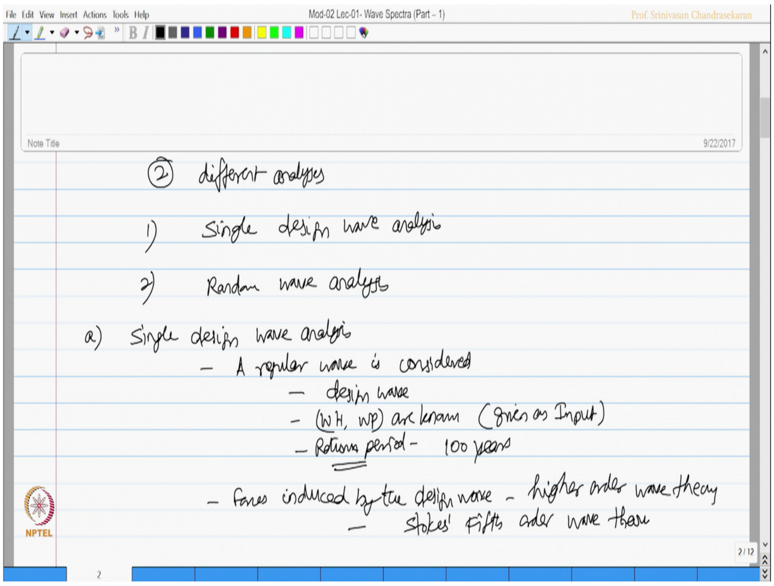

One can look into two different analyses, one could be single design wave analysis other could be random wave analysis. In single design wave analysis a regular wave is considered, this wave is termed as a design wave whose wave height and wave period are known. In fact, they are given as input return period of this wave, the design wave is generally chosen to be 100 years. We already know return period we already understood this concept. So, forces induced by the design wave are computed using higher order wave theory, just for our understanding one of the higher order wave theories is stokes fifth order wave theory.

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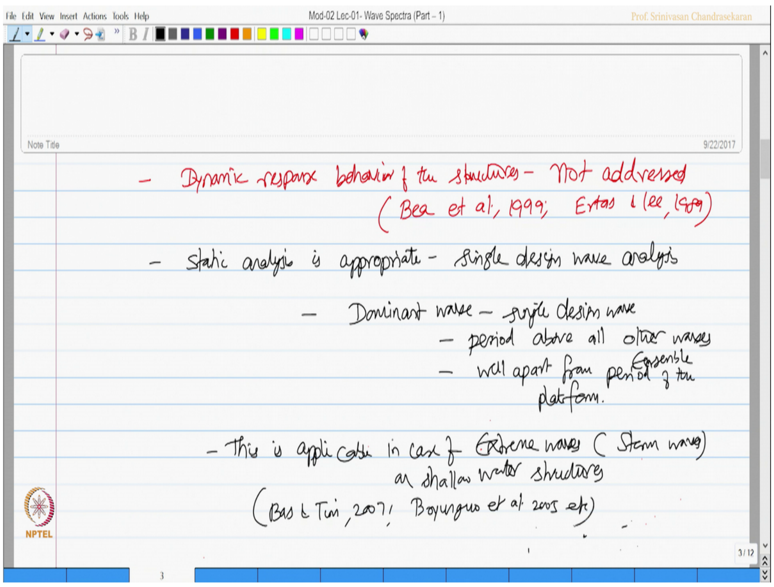

It is very important to note dynamic response behavior of the structure is not addressed in this design methodology, references can be seen at Bea et al 1999, Ertas and Lee 1989. Usually static analysis is considered to be appropriate for design wave approach, for single design wave analysis.

This is due to the simple reason that the dominant wave which is considered as a single design wave has wave periods above all other waves in the ensemble and this period is well apart from period of the structure. Generally this is applicable this method is applicable in case of extreme waves, which can be a storm wave on shallow water structures this can be verified by papers published Bas and Tim, Boyunguo et al etcetera.

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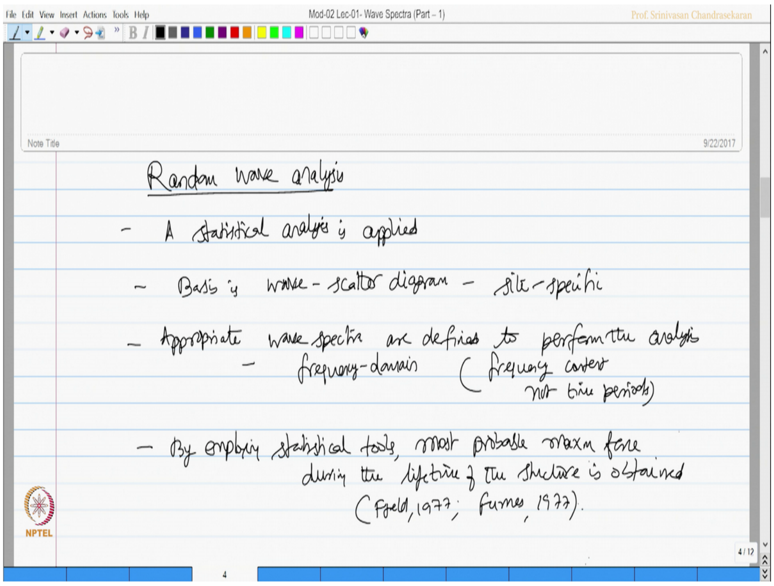

The other approach is random wave analysis, in this approach a statistical analysis is applied the basis is wave scatter diagram this is of course, site specific. So, one has to choose an appropriate wave scatter diagram for a specific offshore installed site and do statistical analysis on that.

So, an appropriate wave spectra are defined to perform the analysis, the analysis is usually carried out in frequency domain. So, the frequency content will be focused not the time content. Once you do this by choosing an appropriate wave spectra, then by employing statistical tools, one can get the most probable maximum force during the life time of the structure. This can be verified by Fjeld 1997 and Furnes 1977. So, it is important to choose appropriate wave spectra.

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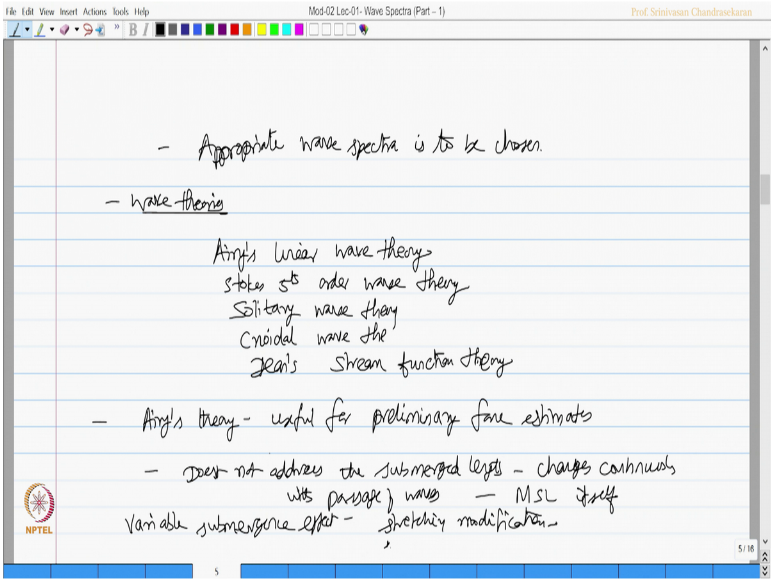

So, different wave theories will give different water particle kinematics just to name them common theories are Airys linear wave theory, stokes fifth order wave theory, Solitary wave theory, Cnoidal wave theory, deans stream function theory.

So, in general Airy's theory is useful for preliminary force estimates as we all know Airy's wave theory does not address the submerged length which changes continuously with passage of waves whereas, Airy's theory stops at MSL itself. So, this variable submergence effect is generally addressed by stretching modifications which we briefed in the last lecture.

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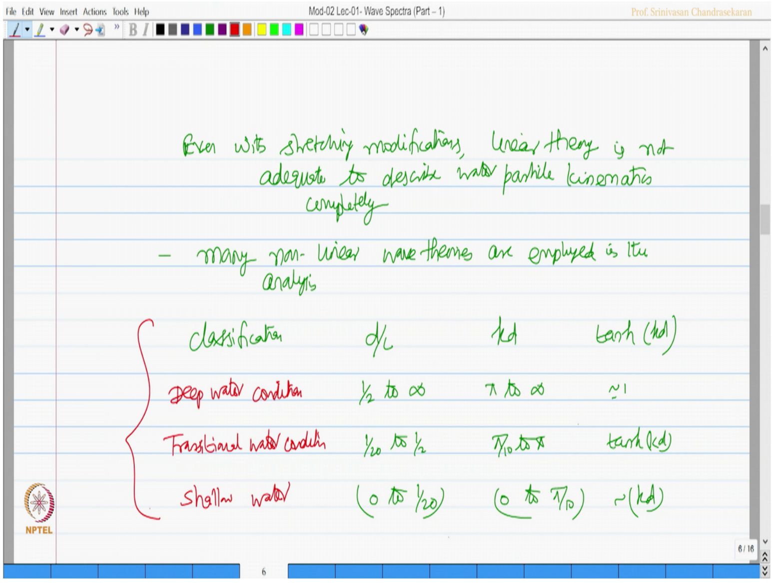

But; however, literature show even with stretching modification, linear theory is not adequate to describe the water particle kinematics completely.

Therefore many non-linear wave theories are employed in the analysis, now the theory is also related to different classifications depending upon the water depth, there are various ratios d by L, k d and let us say tan hyperbolic k d. If this value is between half to infinity and if this is between pi to infinity and this is approximately one we call this as a deep water condition if this is between 1 by 20 to half and this is pi by 10 to pi and this is simply tan hyperbolic k d itself then we call this as transitional water depth, if this anywhere from 0 to 1 by 20 and 0 to pi by 10 and this is minus approximately k d itself we call this as shallow water, as per the definition in the literature. Once we agree that linear theory cannot express the forces satisfactorily then wave spectra are being employed for calculating forces in offshore structures.

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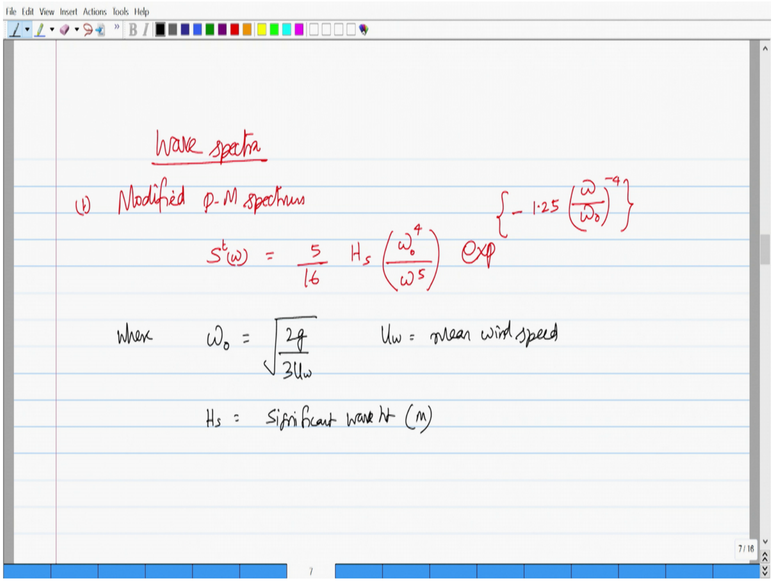

The first one is a very common form being used this is called modified Pierson Moskowitz spectrum, this says the spectral density is 5 by 16 H s omega 0 to the power 4 by omega 5 exponential minus 1.25 omega by omega 0 to the power minus 4 where omega 0 is given by 2 g by 3 u w, where u w is the mean wind speed for the specific site h s is significant wave height in meters.