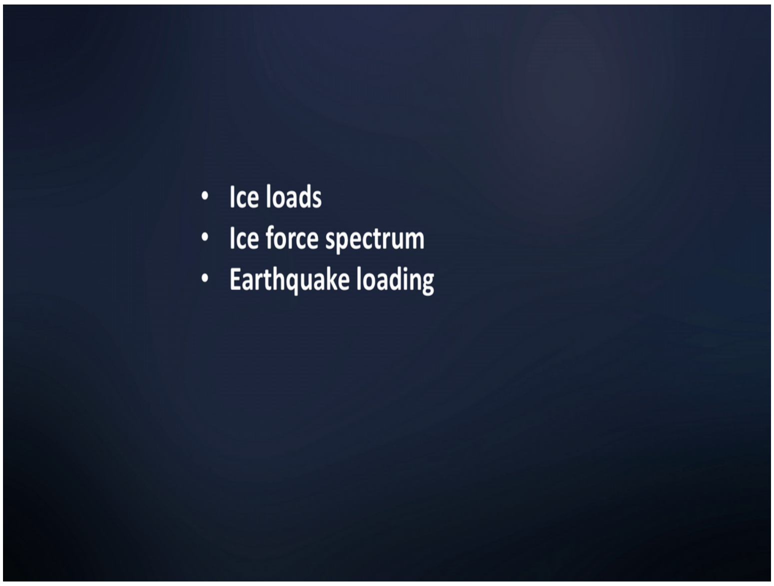
Computer Methods of Analysis of Offshore Structures
Prof. Srinivasan Chandrashekarn
Department of Ocean Engineering
Indian Institute of Technology, Madras

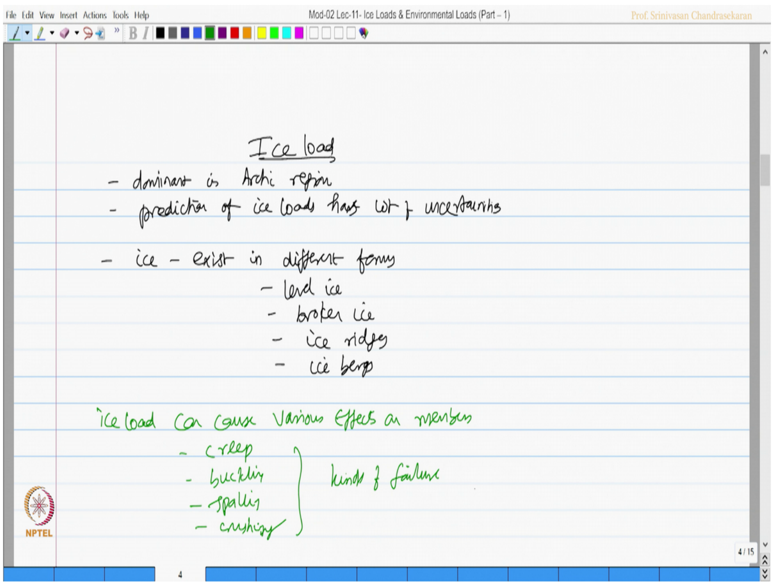
Module - 02
Lecture - 11
Ice load and earthquake load

(Refer Slide Time: 00:16)



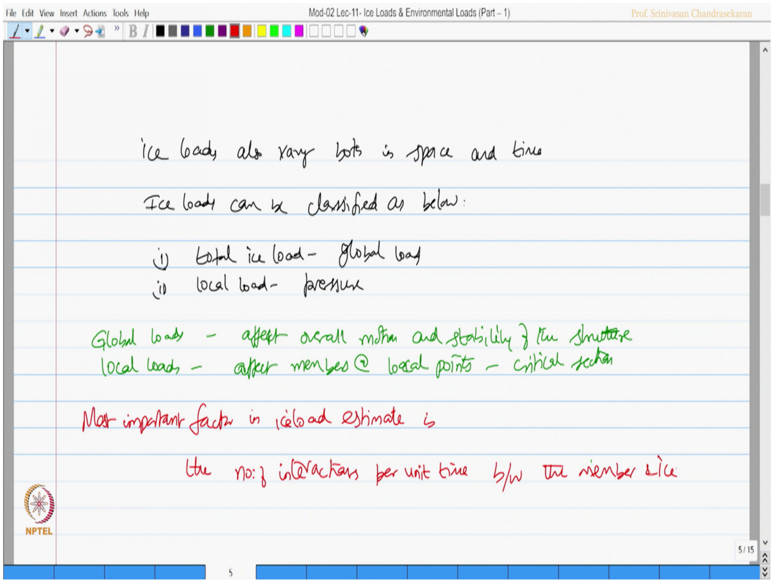
Let us move on to the next important load which is ice load.

(Refer Slide Time: 00:29)



Ice load are generally dominant in arctic region prediction of Ice loads has lot of uncertainties. Ice actually exist in different forms like level ice, broken ice, ridges and icebergs, ice can result in various effects. Ice loads can cause various effects on members it can cause creep, can cause buckling, it can cause spalling and the failure can also be due to crushing; these are all different kinds of failures which can be caused by ice on members.

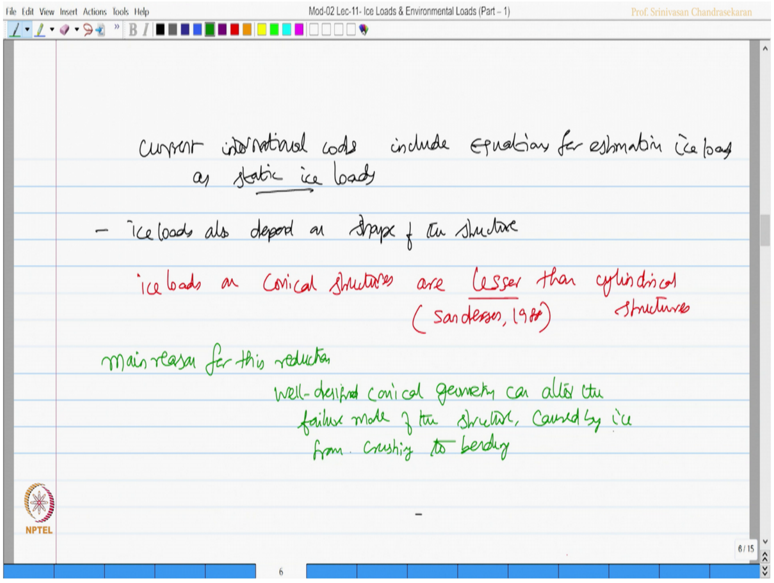
(Refer Slide Time: 01:44)



More interestingly ice loads also vary both in space and time.

So, ice loads can be classified as below one, total ice load otherwise called as global load to local load otherwise called as pressure. Interestingly the global loads affect overall motion and stability of the structure whereas, the local loads affect members at local points all it is a critical sections. So, the most important factor in ice load estimate is the number of interactions between the member and ice.

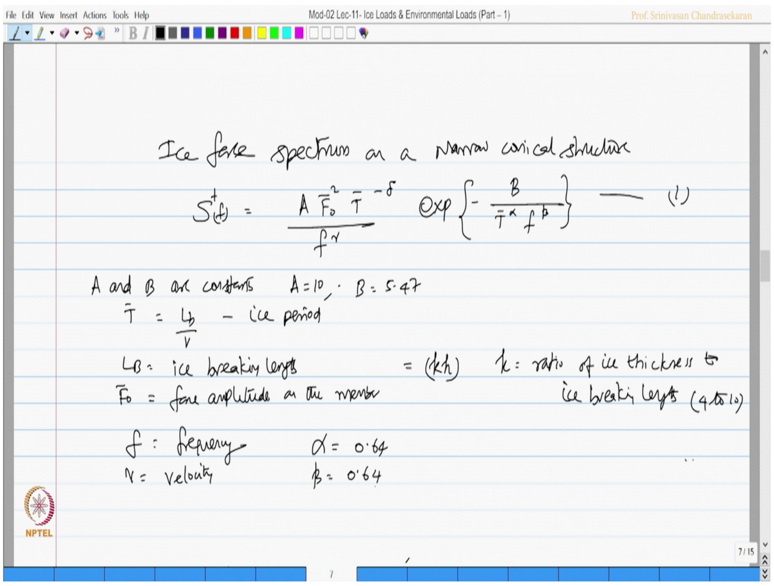
(Refer Slide Time: 03:45)



Interestingly the current international codes include equations for estimating ice load as static ice loads, it is important to know that ice loads also depend on shape of the structure which it is encountering; study show that ice loads on conical structures like pyramids or lesser than cylindrical structures.

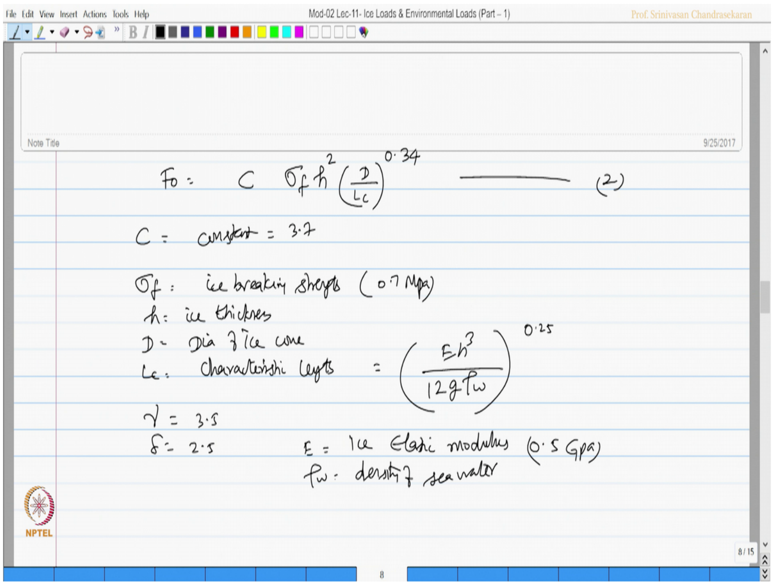
So, that is given by a good reference Sanderson 1988 the main reason for this reduction is due to the fact that, the well designed conical geometry can alter the failure mode of the structure caused by ice from crushing to bending that is the reason.

(Refer Slide Time: 05:53)



So, ice given again by ice force spectrum on a narrow conical structure, this is given by the following equation A F bar square T bar minus delta divided by f or exponential minus B by T bar alpha and f beta equation 1. Double equation A and B are constants whose values are A is 10 and B is taken as 5.47, T bar is Lb by v which is called ice period LB is called ice breaking length typically it is between 4to 10. F bar 0 is called force amplitude on the structural member, the ice breaking length is given by k into h where k is the ratio of ice thickness to ice length, where this lies between 4 to 10 not this value; f is the frequency is the variable in the spectrum and v is the ice velocity the constants alpha is 0.64 beta is 0.64.

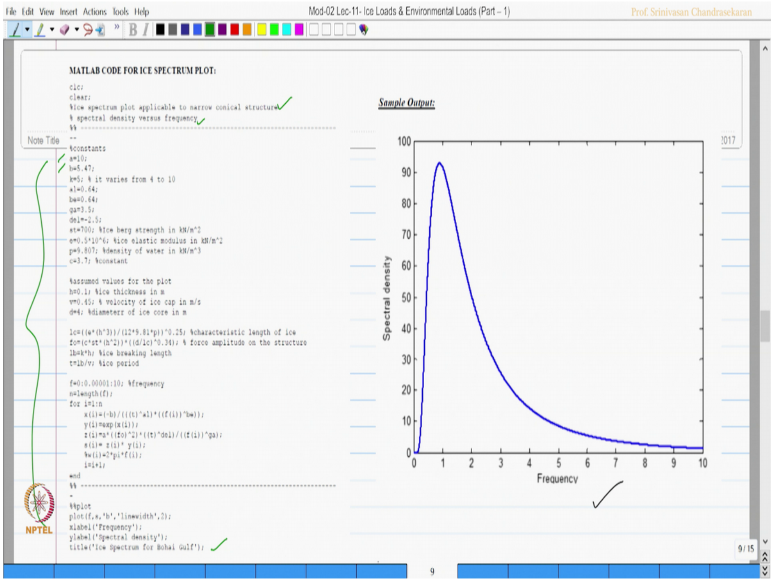
(Refer Slide Time: 08:28)



And F 0 is given by C sigma f its square D by Lc to the power 0.34 where C is again a constant which is 3.7 sigma f is ice breaking strength which is 0.7 mega Pascal, h is the ice thickness D is the diameter of the ice cone and Lc is the characteristic length.

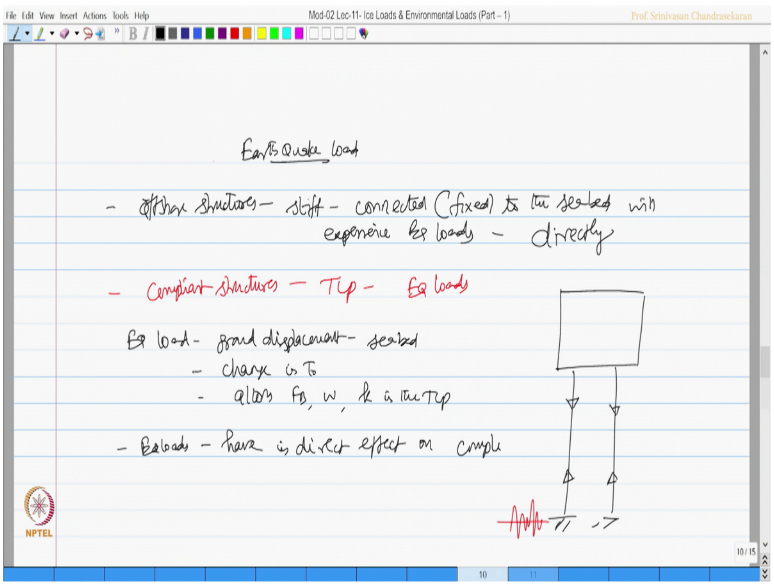
So, the equations the power gamma and or respectively 3.5 and 2.5 the characteristic length Lc is further given by Eh cube by 12 g rho w raised the power 0.25, where E is ice elastic modulus which is given by 0.5 Giga Pascal and rho w is density of seawater the typical I spectrum which can be plotted its looked into the figure here.

(Refer Slide Time: 09:50)



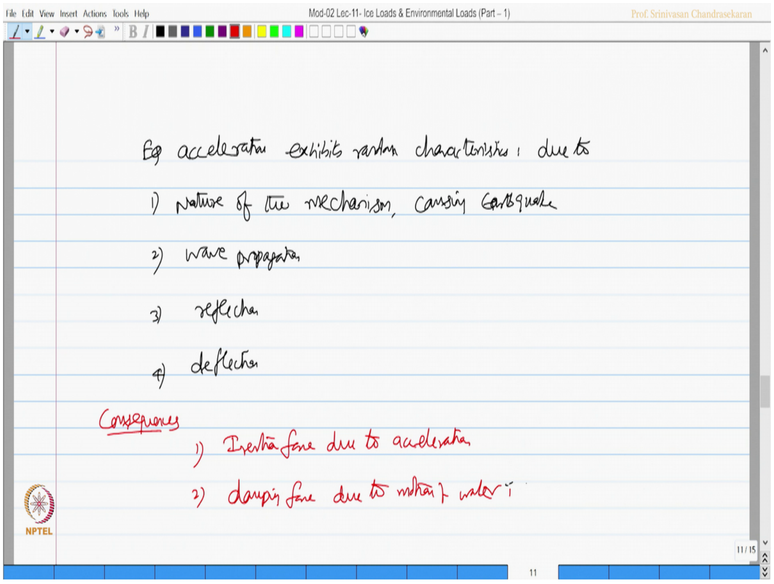
And we have given the program to plot by spectrum on a narrow conical structure, the plot shows the spectral density versus frequency, the constants as I said are already given in the equation a 10, b 5.47 and other constants are named as per the programming variables as alpha beta gamma and delta. Now, the plot is shown on the right hand side whereas, the coding required to plot the spectrum is given on the left hand side of the screen. So, you can use this coding directly to get the ice spectrum for Bohai gulf as you see here.

(Refer Slide Time: 10:44)



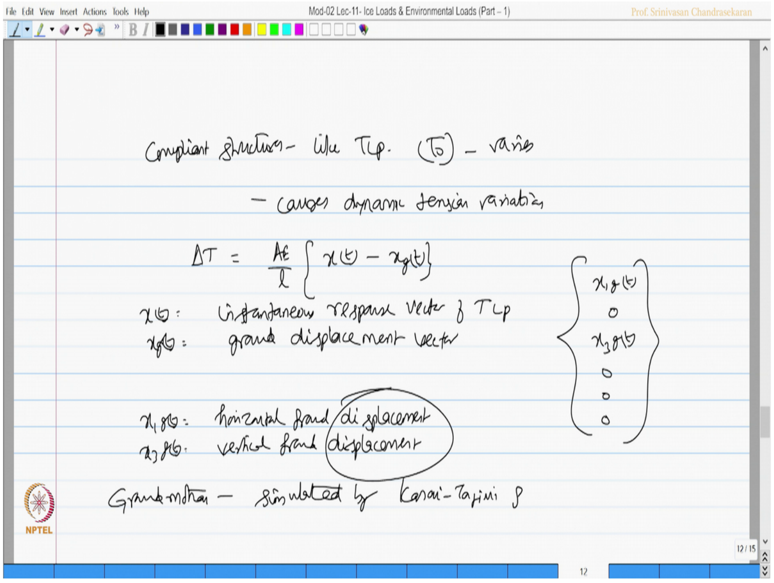
The next kind of loading is a earthquake load, we understand that offshore structures which are stiff and connected that is fixed to the seabed, will undergo all will experience earthquake loads directly. However, complaints structures like TLP will also experience earthquake loads let us see how. This is a superstructure of the TLP connected to the seabed using tendons the seabed experiences earthquake loads, earthquake loads cause ground displacement that is displacement of the seabed this induces change in T 0, this change in T 0 alters buoyancy and weight and stiffness in the TLP therefore, the earthquake loads have indirect effect here on compliant structures.

(Refer Slide Time: 12:44)



We all know from the literature that earthquake acceleration exhibits random characteristic, this is due to nature of the mechanism causing earthquake, it can be due to wave propagation, it can be also due to reflection and further can be due to deflection. What are the consequences of earthquakes on offshore structures; one it can cause inertia force due to the acceleration, it can result in a damping force due to motion of water particle.

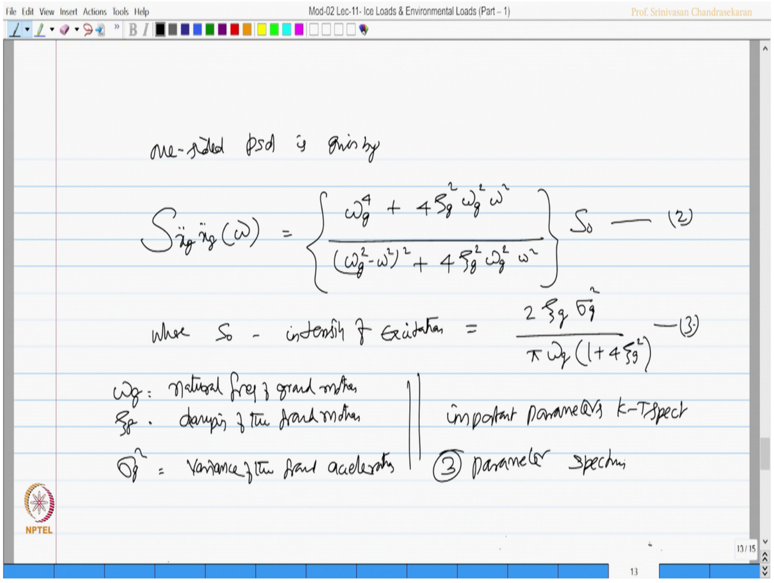
(Refer Slide Time: 14:05)



So, as I said in compliant structures like TLP the T 0 varies, this causes dynamic tension variation. So, this variation is given by a factor of the axial stiffness which is xt minus xg of t, where xt is the instantaneous response vector of TLP, on xg of t is ground displacement vector one can quickly look at this vector it is going to have the effect in such degree no effect in sway Hitler effect in heave degree no effect in roll pitch and yaw.

So, I should say now that the x 1 of g is actually horizontal ground displacement and x 3 of g is vertical ground displacement. So, earthquake causes displacement and the ground motion which is caused by earthquakes is simulated by Kanai Tajimi ground spectrum.

(Refer Slide Time: 16:07)

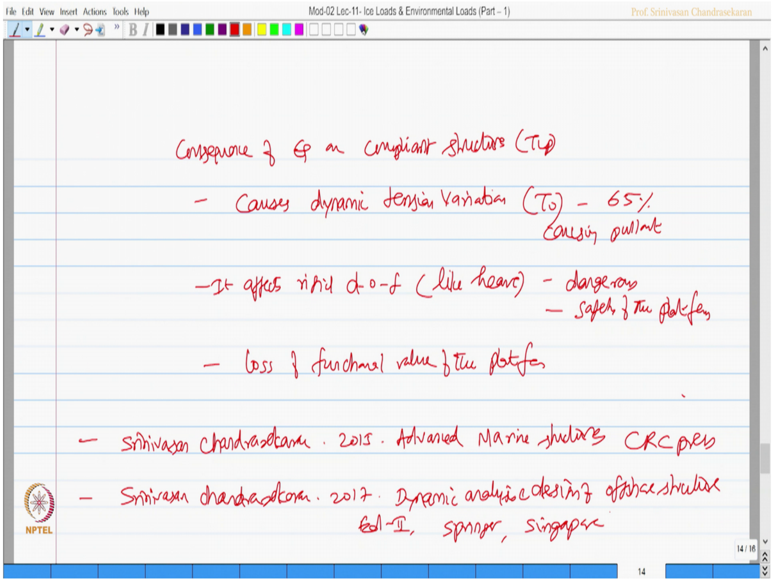


The one sided power spectral density function is given by S x double dot g of omega is omega is omega g to the power 4 plus 4 zeta g square, omega g square omega square by omega g square minus omega square the whole square plus 4 zeta g square, omega g square omega square off S 0, where S 0 is called intensity of excitation which is given by 2 zeta g sigma g square by pi omega g 1 plus 4 zeta z square, omega g is natural frequency of the ground motion, zeta g is damping of the ground motion and sigma z square is variance of the ground motion.

So, these three are important parameters of Kanai Tasimi spectrum.

So, Kanai Tajimi spectrum is a three parameter spectrum, what will be the consequence of this?

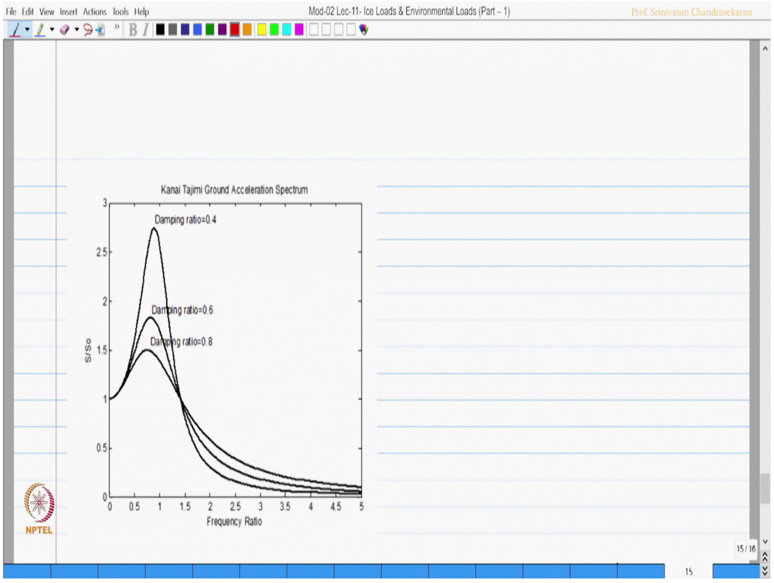
(Refer Slide Time: 18:21)



The consequence of this on let us say compliant structures like TLP could be, it results in dynamic tension variation in T 0 and this variation can be as high as 65 percent causing pullout. It affects rigid degrees of freedom like heave which is quite dangerous because it can challenge the safety of the platform. This ultimately also results in loss of functional value of the platform.

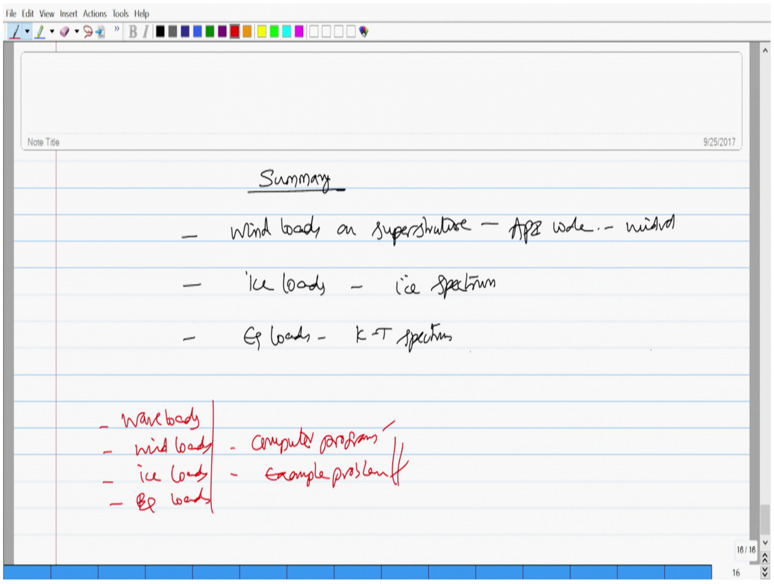
So, detailed results can be seen from the following textbooks: advanced marine structures authored by me published by CRC press; there is one more book which also discusses the behavior again authored by me dynamic analysis and design of offshore structures addition to Springer Singapore.

(Refer Slide Time: 20:36)



So, friends for different damping ratio the typical Kanai Tajimi ground spectrum looks like this as you see on the screen now.

(Refer Slide Time: 20:45)



Let us see the summary what we learned in this lecture we did one more numerical to understand the wind loads on superstructure of the platform, we have used API code to compute the wind velocity, we have learnt how to estimate ice loads we have seen ice spectrum, we have also learnt how to calculate earthquake loads we have learnt Kanai Tajimi spectrum. So, far we have learnt wave loads, wind loads, ice loads earthquake loads including the computer program to calculate them solving example problem to understand.

I hope you follow these lectures and you will be able to write these programs on your own and check the results and compare the answers what we have in this screen here.

Thank you very much.