Advanced Marine Structures

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Lecture - 3

Introduction to reliability III

In the last lecture, we discussed about different types and different kinds of uncertainties. We also said that the second and third kind of uncertainty mostly associated with a mathematical modeling errors and the other one can be easily handled using, what we call as a Bayesianapproach. So, what we can make an important statement, in this lecture which is the continuation of the last lecture is that.

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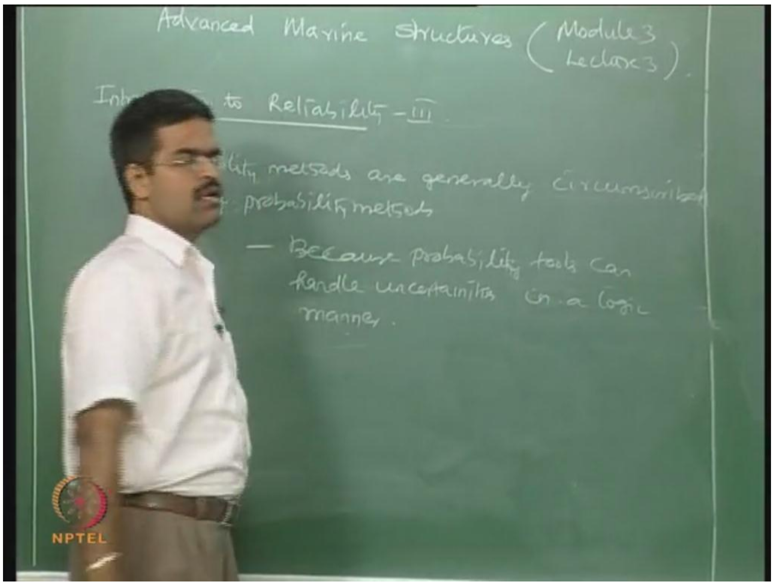

Reliability studies or reliability methodsor generally circum scribedbyprobability methods.On the other hand, probabilistic tools are used to carry out reliability analysis. We all know the answer for this question, butstill try to answer this, for becauseprobabilistictoolsor probability toolscan handleuncertaintieslogically.They are capable of handling uncertainties in a very logic manner.Therefore, generally reliability methods are circum scribe using probability tools. Now,we have seen 2 types of uncertainties, one is arisingfrom the randomness in nature which is auditory type. The other is from the modeling methods or analyst tools which is an epistemic type. Now, there are different groups, that is.

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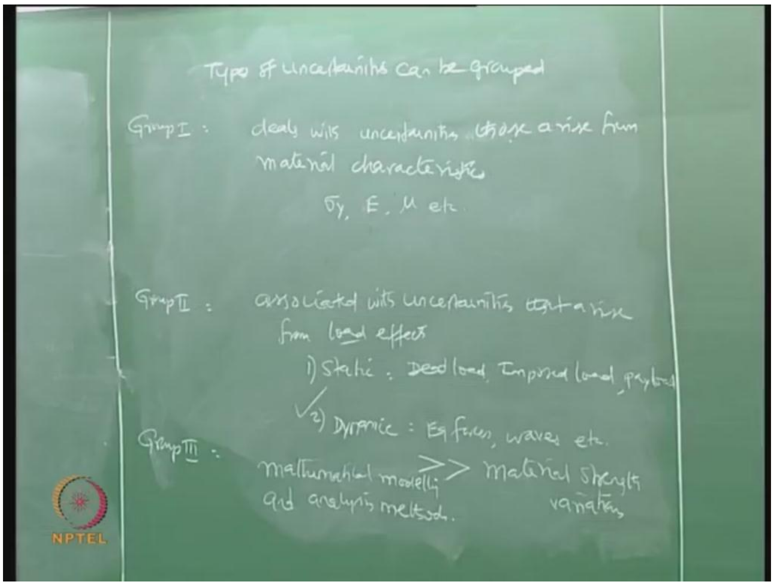

The types of uncertaintiescan be groupedasgroup1,group 2and group 3. There are 3 groups. group 1: deals withuncertaintiesassociated orarise from,those arise frommaterial characteristics,like young’s modulus of the material, modulus of elasticity etcetera5 7s ratio,which are all purely material characteristics,they are grouped as 1. The second group: are associated withuncertaintiesthat arise fromload effects.The movement, I say load effects, I have got 2 kinds, again one is staticother is dynamic.I can give example of static, dead load, imposed load. What we call as a live load, pay load on the top side of the platform etcetera, dynamic, earthquakeforces,waves etcetera.

Now, the uncertainties associated with the dynamic forces of the load effects cost be dynamic forces, are much more then the top static,that is one comparison between this two.Further, the uncertainties associated with group 2 are much larger, much larger than that of material.So, one should focus more on uncertainties from group 2 is expected, butinterestingly group 1 and group 2 are combined. Very interesting and very silent, very valid example is that if he looks at one of the characteristic material, which is young’s modulus. If you study young’s modulus in static state of loading, it is different. We study young’s modulusin dynamic state of loading, it is different,whereas dynamic and static found group 2 of uncertainty variation of e itself of group one.So, this twoare linked;it means, in the given type of uncertainty, there are no harlin differences between the groups of uncertainties, they can loop over the other also.That third group of uncertainty, mathematical modeling,they arise from mathematical modelingandanalysis methods.

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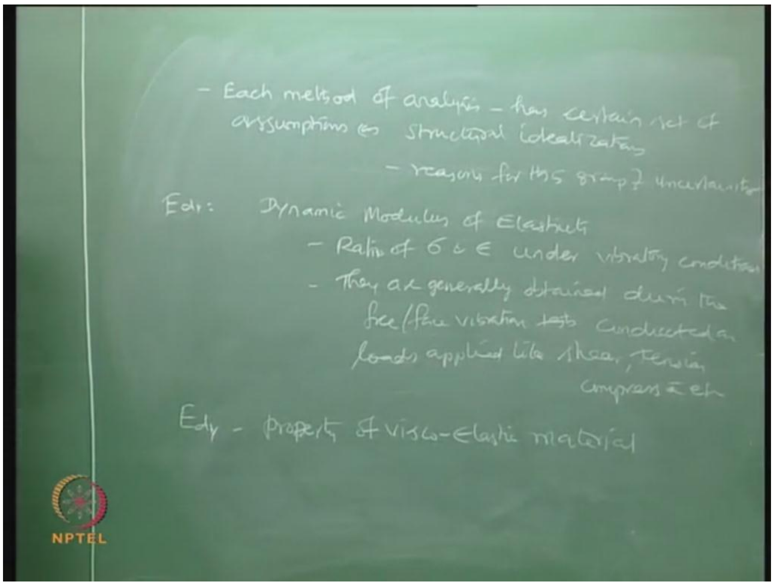

Why becauseeach method of analysishascertain set of assumptionsorstructural idealizations,which are reasonsfor this group of uncertainty.So, let us quickly highlight, what would be the effect of group 2 on 1. Let us talk about young’s modulus dynamicor modulus of elasticity or dynamic modulus of elasticity is nothing butthe ratio ofstress and strain undervibratory conditions.They are generally obtained,duringthe free vibrationsor post vibration test,conducted onloads appliedlike shear,tension,compression etc. Dynamic modulus of elasticityis a property of visco elastic materialwhere has static modulus of elasticity is a property of elastic material.

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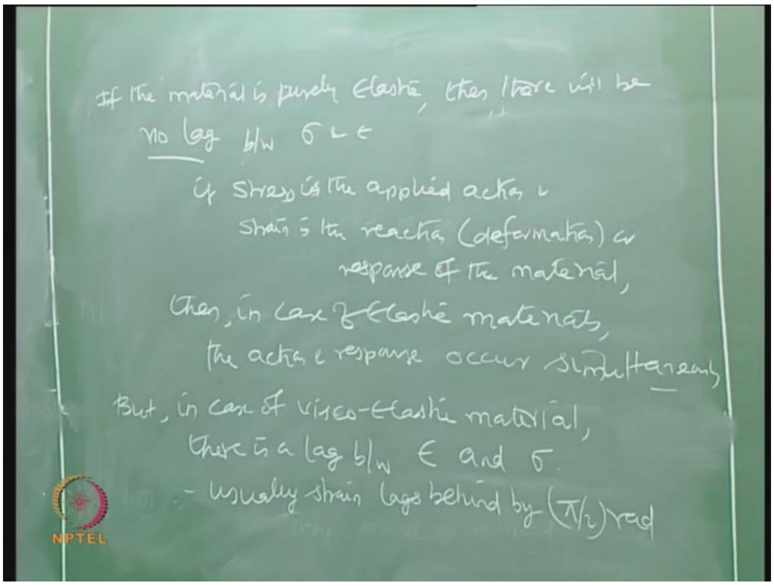

Ifthe material purely elasticthen there will beno lagbetween stress and strain, what does it mean? If stress is the applied, actionand strainis the reactionor deformationor responseof the materialthen.In case of elastic materials,theactionand response occurs or occursimultaneously.There is no lag, butin case of visco elastic material,there is always a lagbetween the strainand the stress usually,strainlags behindby pi by 2 radius.So, they are out of phase by 90 degrees.The strain will notoccurrat the maximum point, where the stresses occurring in the same phase can be shifted by 90 degrees,that is a property in viscous elastic materials.

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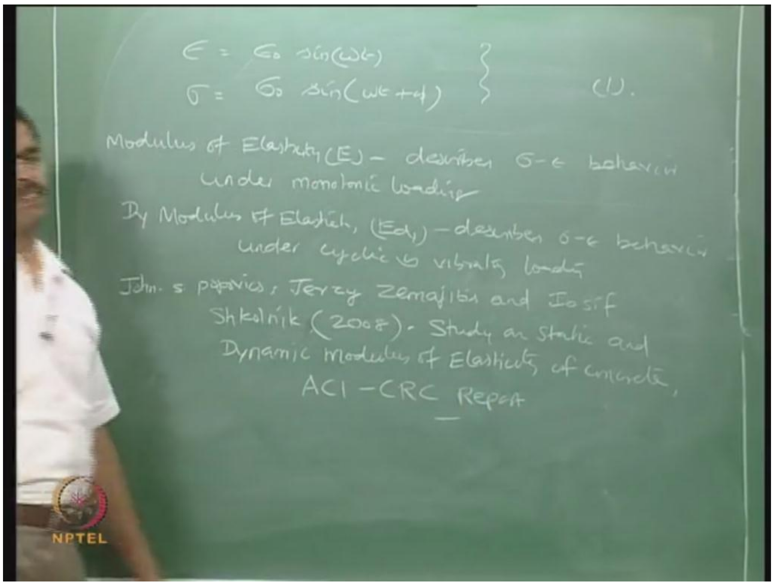

So, strain can besin omega t,whereas stress can bephi,it is an advance state. Equation number 1,more interestinglymodulus of elasticitywhich is simply E describes Stress strain behaviorundermonotonic loading,where has dynamic modulus of elasticityindicated by E dynamicdescribesstress strain behaviorunder cyclicor vibratory loading.If he look at the research conducted by people in the recent past, people have conducted modulus of elasticity observed assist on the same material.

On different specimens and different loading patterns,they did not show the same behaviorvery interesting reference.There is a very interesting report given bypopovics.A talent in 2008,explaining a difference between the characteristics of modulus of elasticity and dynamic modulus of elasticity on a specific material concrete under different. So, he has listed that various factors which influence dynamic modulus of elasticity of concrete as a materialare per any material in general of the following.

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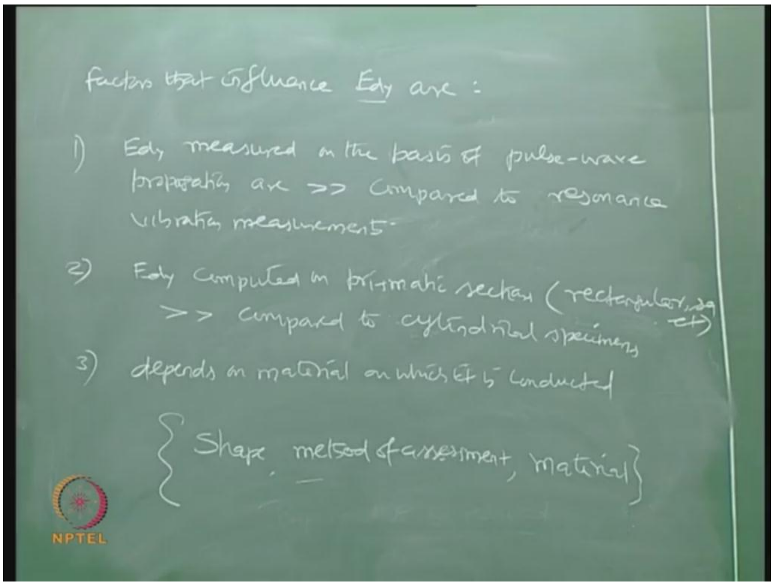

E dynamic measured on the basis ofpulse wave propagationare higher compared toResonance vibration measurements.So, method by which are estimating the e dynamic is also on important factor, which influencesthe modulus of elasticity. So, there are 2 techniques by which one can find out, one is a simple force of free vibration on to the resonance condition. Other is what we call pulse wave propagation technique.So, both give different dynamic modulus of elasticity contained on the same specimen on the same material.

Two dynamic modulus of elasticity,computer on prismatic sectionslike for example, rectangular, squareetc are highercompare to that ofcylindrical specimens.And they also said that dynamic modulus of elasticity depends onthe material on which it is conducted.So, one can say the factof influencing dynamic modulus of elasticity could be shape of the specimen taken for the test,method of assessment.Whether, you are using pulse wave propagation technique or using force simple free vibration method on resonance condition etc,2 of 3 could be off course, the material characteristic itself.So, you will give you some relationship established by different researches on computing dynamic modulus of elasticity.

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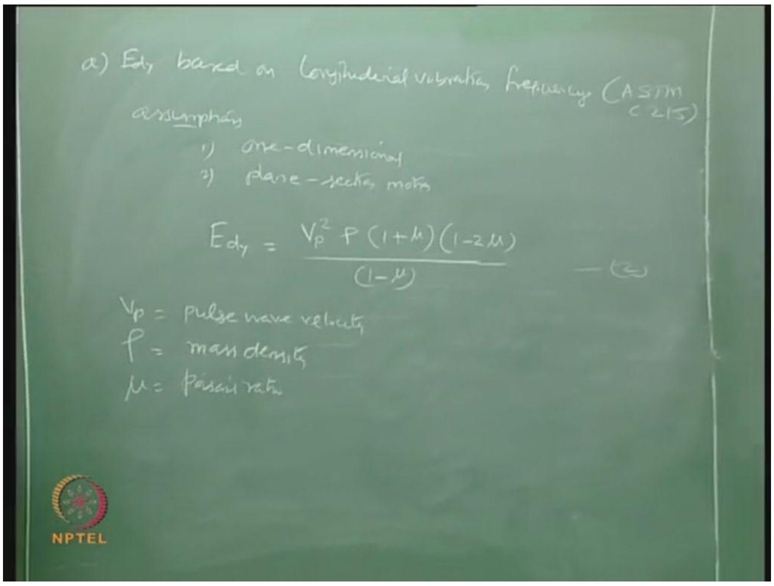

So, let us saye dynamicbased onlongitudinal vibration frequency.This is based onASTMC215 technique. There are certain assumptions for this experiment conducted.It is one dimensional,the other is it is a plane section motion.This isnot distortion being invoked in the material, say as e dynamic can be given byVP square row. The equation number 2, where VPis thepulse wave velocity,rowmass density,and mupoisons ratio of the material. So, using this equation,I can find out dynamic modulus of elasticity, if he knows for varying of a various pulse velocity waves.

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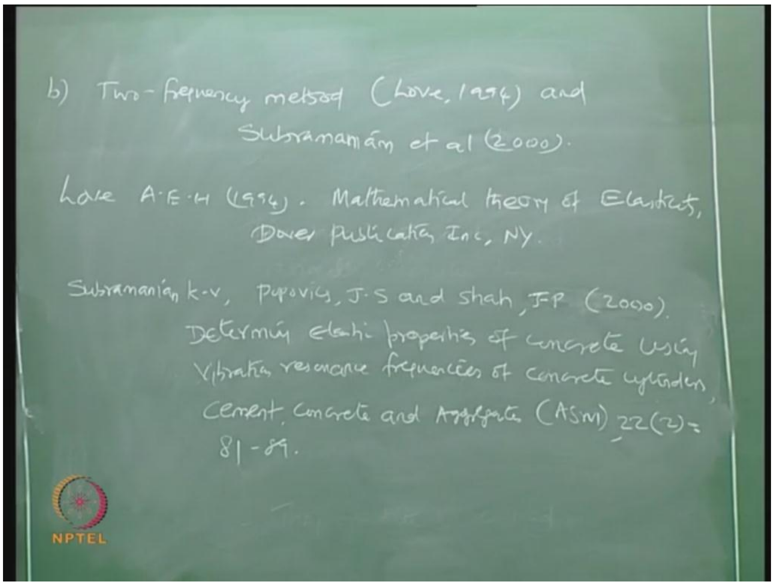

The other methodis usingtwo frequency techniquesgiven byLove 1994 and Subramanian etal2000. LoveA E H1994 mathematical theory of elasticity,Drovers publication,NewYork,SubramanianPopovicsdetermining elastic property is of concreteis J P shah.Let me write,determining elastic properties of concrete usingvibration resonance frequenciesof concrete cylinders,cement concrete, cement concreteand aggregatesASM22 2 82 89, it is 81 89. According to this technique, two frequencies they have been used,which first identifies the dynamic poisons ratio. Then based on new dear dynamic young’s modulus or the modulus of the elasticity dynamic is been estimated.

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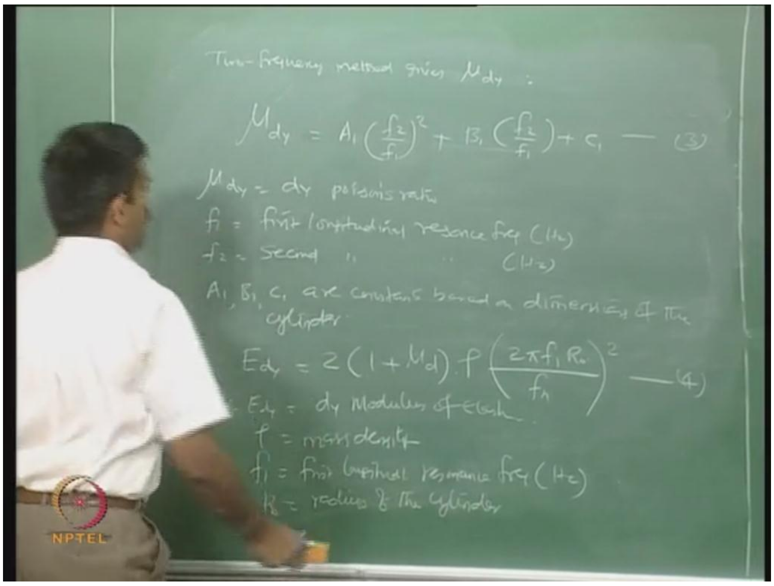

So, two frequencymethod gives mu dynamic as below.So, mu dynamic1 is first longitudinal resonance frequencyin hertz, f 2is a second longitudinal resonance frequencyin Hertz.A1 B1 C1 are constants based ondimensions of thecylinder.Once I know mu dynamic, then I can find E dynamic using this equation,whereE dynamicis dynamicmodulus of elasticity, row is the mass density of the material,f 1 is the firstlongitudinalresonance frequencyin Hertzare 0 is a radius of the cylindrical specimen.

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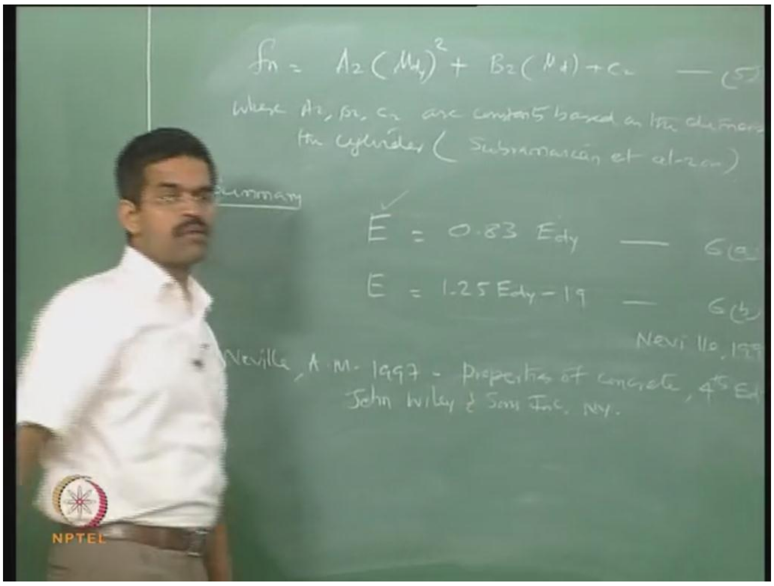

Andf nis given bywhereA2 B2 C2are constantsbased on the dimensions of the cylindergiven by Subramanianetal.So, as a summary,it is seen thatstatic modulus of elasticity, a simply modulus of elasticity is about0.83 of dynamic, that is one equation.The other equation says this can be also equal tominus19 both are given byNevielle 1997. So, one can see that, if you are using static modulus of elasticityor simply modulus of elasticity in your calculations for the design or analysis your actually underestimating in capacity, because the modulus of elasticity. The material varies depending upon the shape of the material, the material actually being used and the dimensional the cylinder of the material and the loading methodology.

So, once stud strictly used dynamic modulus of elasticity in my estimating the parameter of the design, where you are using static values. So, this one important uncertainty which comes from group number 2, which influence on group number 1 on a specific type of uncertainty which is an important parameter in reliability studies. So,it is very important that we must know what a variation is approximately, which compares the modulus of elasticity with that to the dynamic modulus of elasticity,there is a variation having understood this.

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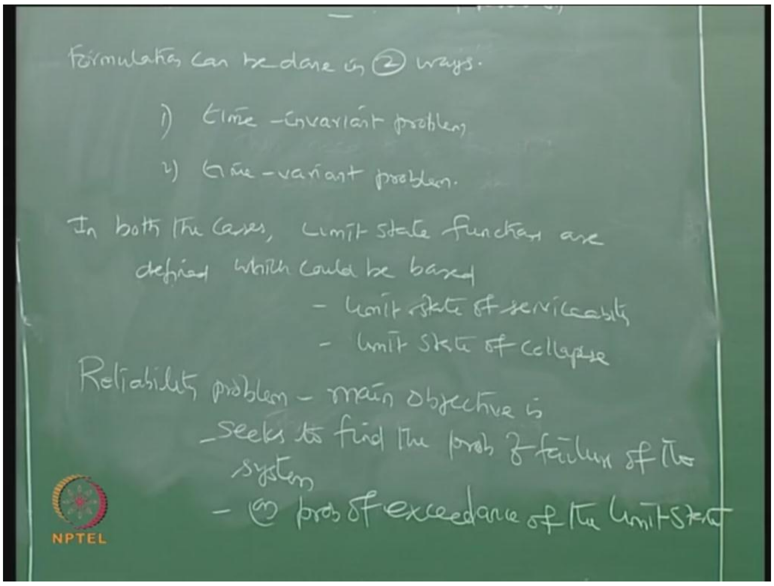

Let us now talk aboutformulation of a reliability problem.How do you formulate a reliability problem?Formulation can be broadly done in 2 ways.1: a time invariant problem, 2: a time variant problem.In both the cases,limit state functionor definewhich could be based oneitherlimitstate of service ability orlimit state ofcollapse,either way. So, the main objective of reliability problem seeks to findthe probability of failureof the systemareprobability of accidence of the limit state.

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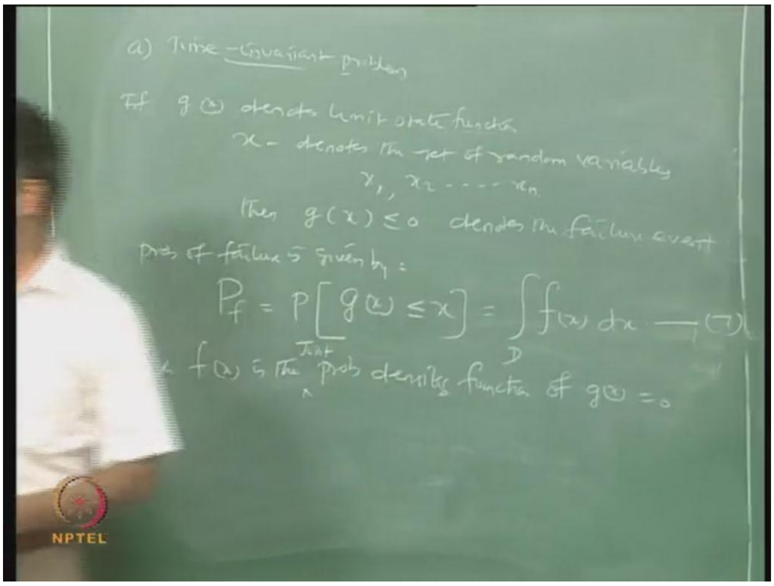

Let us talk abouttime invariant problem.Ifg of x denotesthe limit state functionand x denotesthe set of random variables x1 x 2 x n. Theng of x less than equal to 0 denotesthe failure limit.The probability of failureis given byP f isthe probability ofg of x less than equal to x which is nothing, butintegral of f of x or the domain bdx.I call the equation number, is it 57,wheref of xis the probability density function.Since, x is having combination of x1 x 2 x 3, I can say even this asjoint probability density function ofg of x equal 0, we can plot this.

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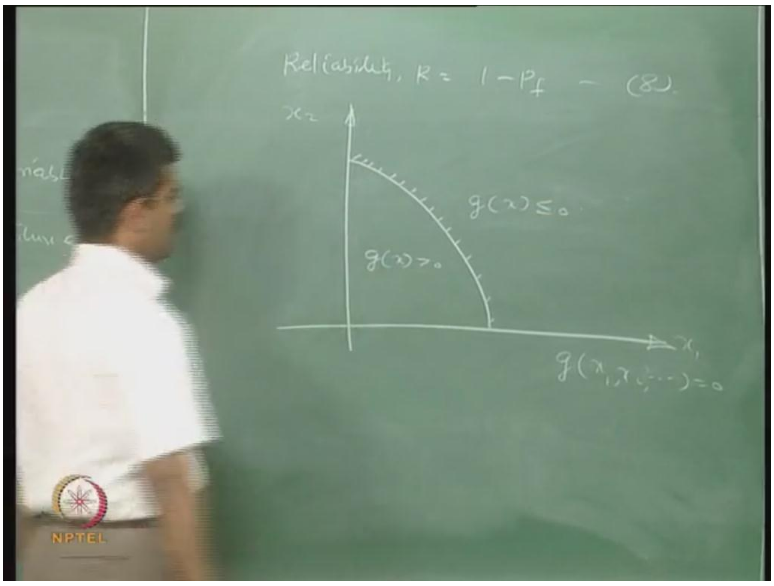

Now, reliability will be given by1 minusprobability of failure.Let say, you can plot this domain,let say x 1g of x 1 x 20. So, this x 1 and x 2, Iam plotting in a two dimensional domain, this, my failure domain, anything outside the domainis a failure.So, this is safe domain, so you must integrate the joint probability density function over this domain that is one of the typeof uncertainty is very complex that is why it cannot be accurate. Now, let us talk about time invariant problem,sorry time variant problem,now the dependency of time will also need to be established in this kind of reliability problems.

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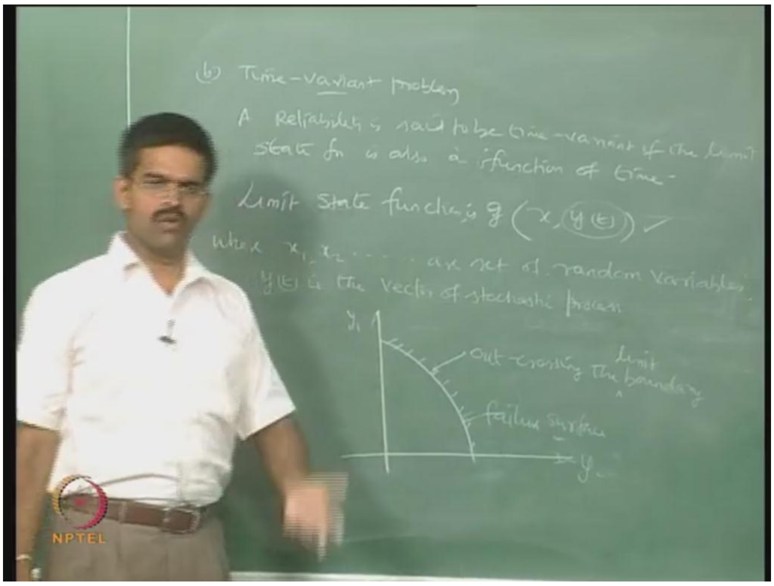

A reliability problemis said to be time variant,if the limit state function is also a function of time. Now, the limit state functionis g of x and y of t also,that is time variancy, time dependency is also there. Where x 1 x 2 x 3 areset of random variablesand y of t is the vector of stochastic process.Now, if I try to plotthis failureas y 2 and y 1 and this becomes my limit boundary. Failure is expressed asout crossing the boundaryor I should say out crossing the limit boundary. So,it is a failure surface,so my failure surface is out cross, I construct the divined as a failure event.

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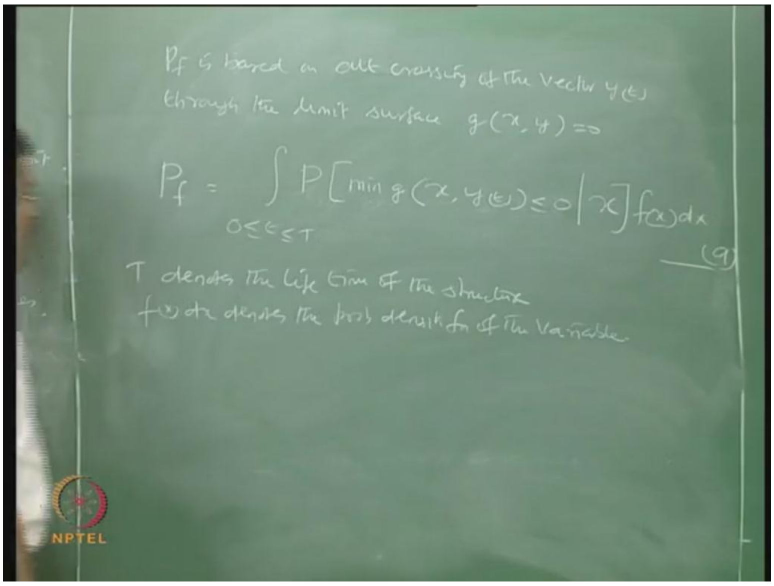

So, probability of failureis based onout crossing of thevector y of t,through the limit surfaceg of x comma y.So, probability of failureis now given byintegral 0 t less than t of probability of minimum gx y of tless than 0given x for any given value of x intof of x d.Equation number, what is the number here?Here in this expression capital t denotesthe life time of the structure.And of course, f of x d x denotesthe probability density functionof the variable. We stophere;we willdiscuss this in the next class as an extension ofthe time variant problem, any questions?

Thanks.