Risk and Reliability of Offshore Structures
Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Module - 02
Reliability Theory and Structural Reliability
Lecture – 21
Codes on Structural Reliability

Friends, let us continue the lecture on Risk and Reliability of Offshore Structures.

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We are now discussing lectures on module 2, where we are talking about structural reliability under module 2, we are talking about lecture 21, where we will extend the discussion for codes on structural reliability, we have already said in the continuation of last lecture the system reliability can be conveniently expressed using Boolean Variables because system reliability depends on the elements failure or non failures state.

So, it can be assigned either 0 or 1, such that whether the elements are in series or in parallel accordingly element state function can be generated and Boolean variables can be used. If the state of element is random, we already said that if the state of element is random in that case the Boolean variable which is used to express the element state which is s i becomes a discrete random variable. So, there are only 2 possible ways or rather 2 possible values. So, there are only 2 possible values, which can be 1 and 0.

Now, the probability associated with each of this value, is given by the expected value of s i, which can be one probability of s i equals 1 plus 0, probability of s i equals 0. Which can be said as probability of s i equals 1; equation number 1. One can interestingly note.

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Note that, probability of s i equals 1 is as same as probability of f i equals 0, because f i is 1 minus s I, also 1 can also note that probability of f i equals 0, plus probability of f i equals 1. So, the total probability will also be equals to 1, because the sum of all probabilities or equation number 2 because sum of all probabilities over the range of possible discrete values, this values can be either s i or f I, because f i is 1 minus s i must be equal to unity that is the reason why, equation 2 is said to be 1.

Now, let us substitute this and then, what happens that substituting we get expected value of s I, which is probability of s i equals 1, which is 1 minus probability of f i equals 1, equation number 3. Similarly one can also determine the expected value of f i.

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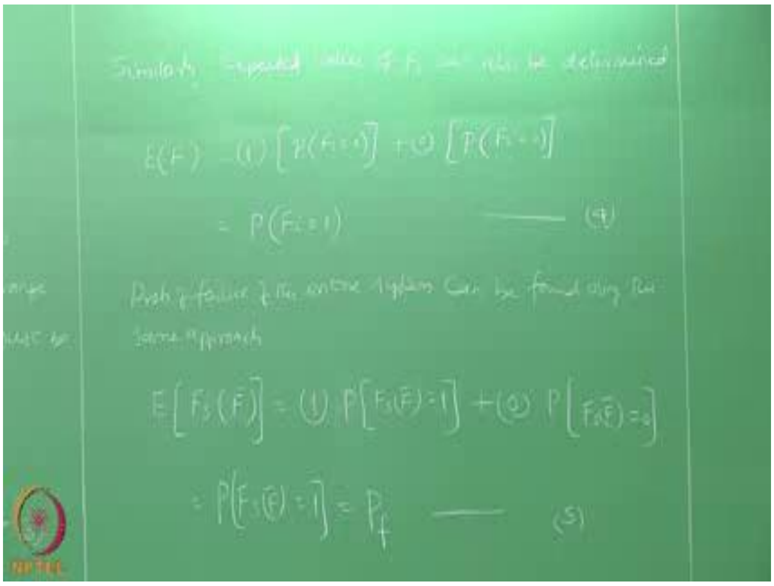

That is expected value of f is one probability of f i equals one plus 0, probability of f i equals 0, which can be said to probability of f i equals 1, which we call equation number 4. So, one can say the probability failure of the entire system p f can be found using the same approach. So, probability of failure of the entire system can be now found using the same approach as we just now discussed, probability of failure is nothing, but let us try to extend it slightly in a different manner the expected value of f s f bar can be said as 1 into probability of failure probability of f s f bar equals 1 plus 0. Probability of f s f bar equals 0 which is said probability of f s f bar equals 1, which is probability of failure equation number 5.

One can easily estimate the probability of failure of a given system using Boolean variables as we expressed and derived in the last lecture. We concluded in this lecture let us now, extend our discussion for application of structural codes on safety let us talk about structural codes on safety.

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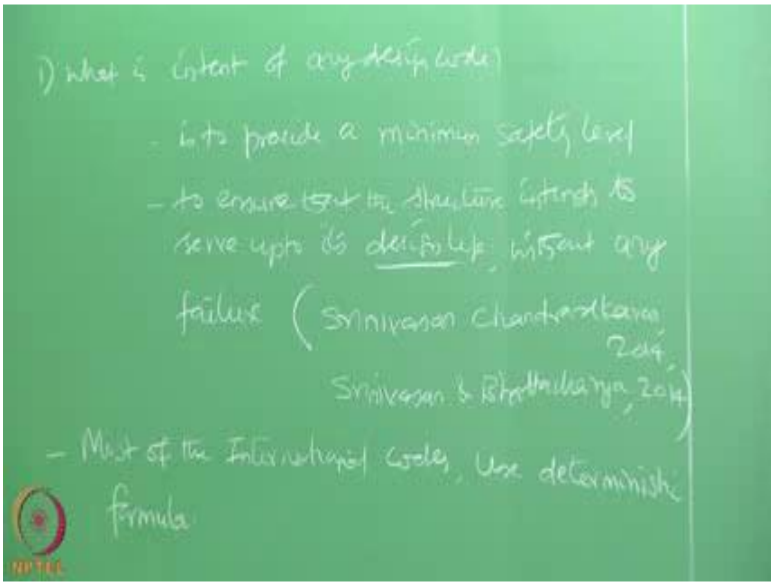

Now, let us quickly ask a question to ourselves what is actually the intend of a design code. What is intend of any design code? The intend of any design code, is to provide a minimum safety level, and to ensure that the structure intends to serve it intends to serve up to its design life without any failure that is important, 2014 Srinivasan and Bhattacharya 2014. Now keeping this in mind most of the international codes which are currently in practice use deterministic formulas.

Most of the international codes which are currently in practice use deterministic formulas or design. So, as a designer one can classify the design codes into 4 levels based on purely approached reliability. So, one can ask the question; how codes are related to reliability it is very interesting to answer this see codes are meant for design guide lines failure can happen. If the design is not properly done that is one of the parts of the failure as we have seen in the lectures in first module.

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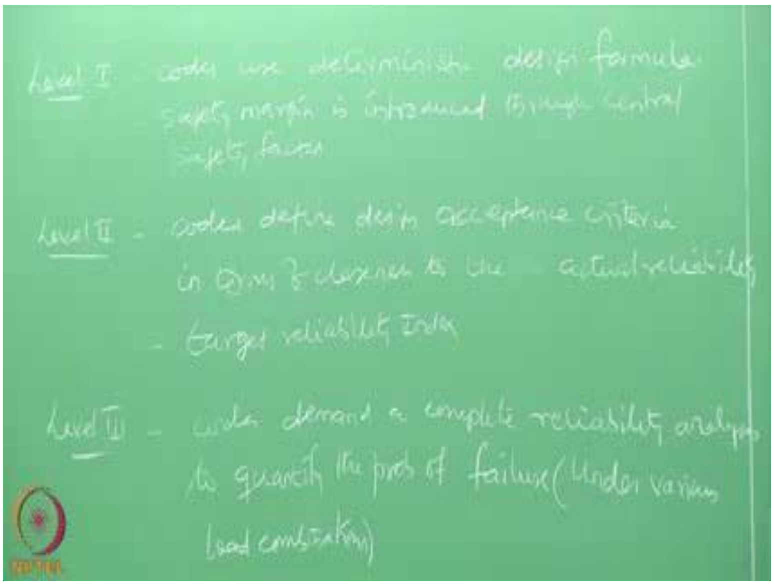

There are certain cases where the design was not properly carried out and the system failed. So, system is unable to perform the intended function when, the design is not proper it means system is not catered the requirement of the design under the given environmental conditions, and loads the codes are guiding the design for the structures and therefore, the structural codes can be classified into 4 levels purely based on reliability approach.

So, level one codes use deterministic design formulas the safety margin is introduced through the central safety factors we talk about level 2 codes. These codes define the design acceptance criteria in terms of closeness to actual reliability in terms of closeness to the actual reliability. What we call as target reliability index, now level 3 codes demand a complete reliability analysis to quantify the probability of failure under various loading combinations level 4 codes.

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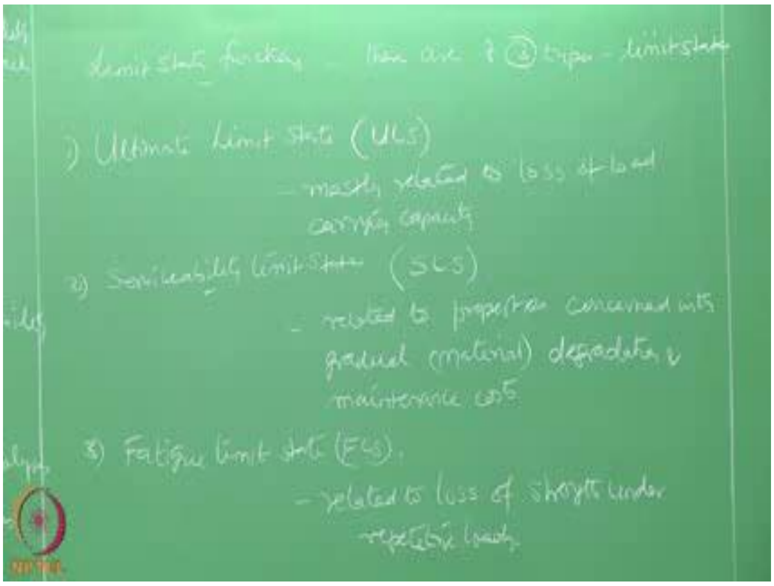

Use the total expected cost of the design as a, optimization criteria. So, the structural codes which are now in prevalence can be classified in groups into these 4 levels, one can easily see and understand and experience the code. What are currently using in design, office pertains to which level of safety implementation as we said the limit state functions are essentially the backbone of the reliability analysis. Because once you mark upon the failure domain which depends on the limit state function then, one can easily locate whether the performance function is on the failure domain or on the non failure domain.

So, when you extend the discussion on limit state functions these functions are of 3 types; based on the limit states 1 is what we call ultimate limit state these are mostly related to the loss of load carrying capacity. The second one is serviceability limit state these are related to the gradual iteration and maintenance costs gradual material degradation and partly the maintenance costs also periodic maintenance cost. The third one is a fatigue limit state these are related to loss of strength under repetitive loads. So, each limit state is associated with the particular limit state function.

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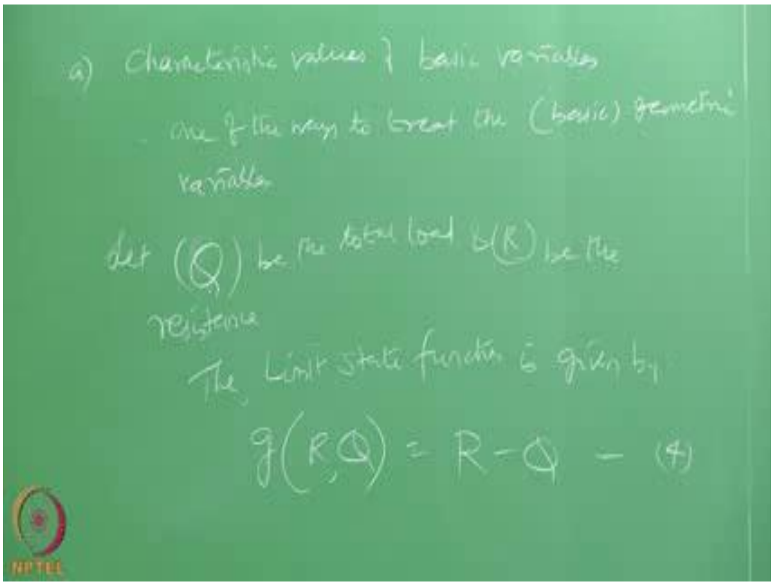

Let us start with discussing these functions now in detail, to start with. Let us talk about the characteristic value of basic variables interestingly. It is one of the way how the basic variables are treated. So, it is nothing, but one of the ways to treat the basic geometric variables let q the total load and r lets capital and r is the resistance of the entire system then, we know that the limit state function is given by g of r and q which says r minus q equation number 4.

So, one can also treat the geometric variables in this form.

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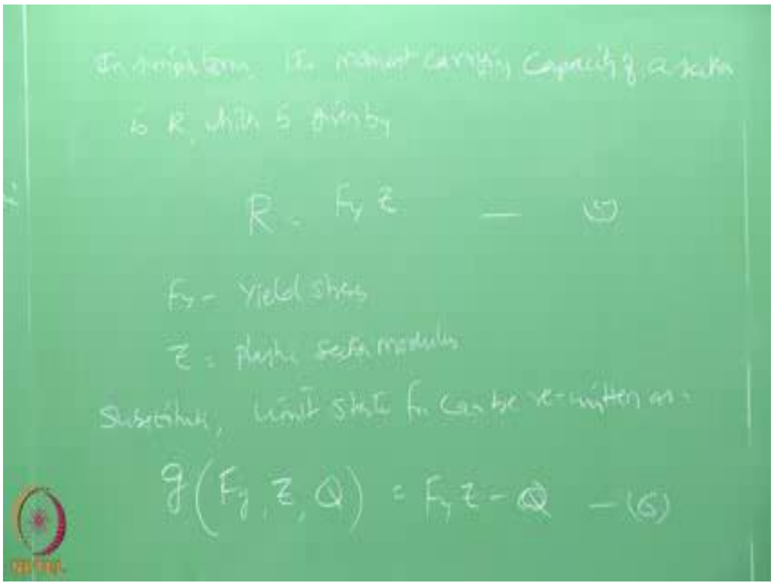

Alternatively one can treat the material properties also in simple terms the moment carrying capacity of a section is r. Which is given by r is equal to f y into z, where f y is the yield strength and z is the plastic section modulus substituting this. A limit state function can be re written as g of f y z n q because; r is now functions of f y and z which is f y z minus q.

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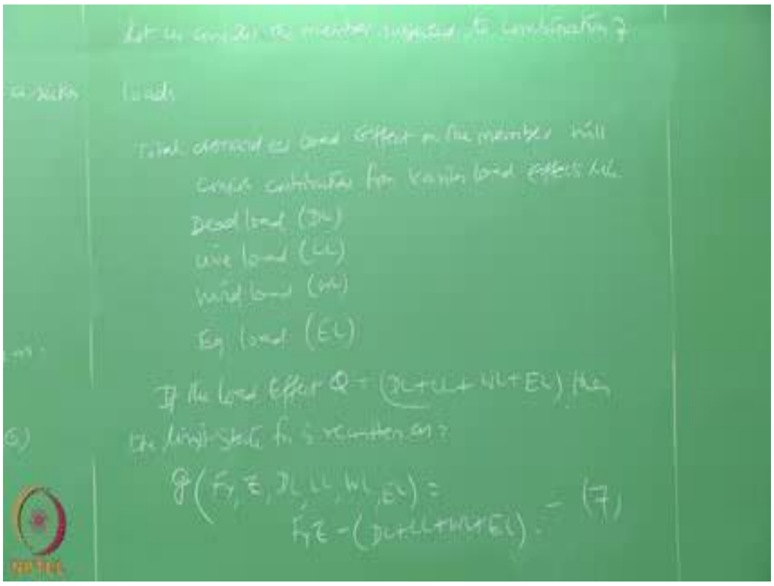

One can also treat load and other actions. Now let us consider the member subjected to combination of loads the total demand or the load effect on the member now, will be consisting of contribution from dead load live load etcetera, will consist contribution from various loads like, dead load, live load, wind load, the earthquake load, etcetera. If the total load effect q is the combination of these then, the limit state function is re written as g of, we already had f y and z, f y and z now q is the function of different components.

Now, therefore, I should say dead load, live load, wind load, earthquake load, which now says, f y z that is what we already have minus of d l plus l, l plus w l plus e l equation number 7. On the other hand limit state function can also be a function of many variables like, load components influence factors resistance parameters material properties geometric dimensions analysis factors etcetera.

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Now, a limit state function can be again a function of different variables, in such case it is very important to evaluate the partial coefficient. It becomes important to evaluate what we call partial coefficient. So, if you look at the basic form of load resistant factor design equation is actually given by phi r or equal to sum of y i q i and I is the summation of all the members I will call this equation number 8.

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So, the design equation contains partial safety factors phi and gamma this is not y, its gamma phi i partial safety factors phi i and gamma they must be calibrated based on the target reliability index which is generally adopted with the code. Implicitly; however, there are many complexities present due to the combination of these factors, which influences the limit state function. So, many complexities arise due to the variables that influence the limit state function as a result of which, the limit state function becomes complex. Now how to handle this this can be handled using stochastic modeling. So, the solution to handle this could be through stochastic modeling. In stochastic modeling the modeling of elementary variables imply that we have some information; however, they inadequate.

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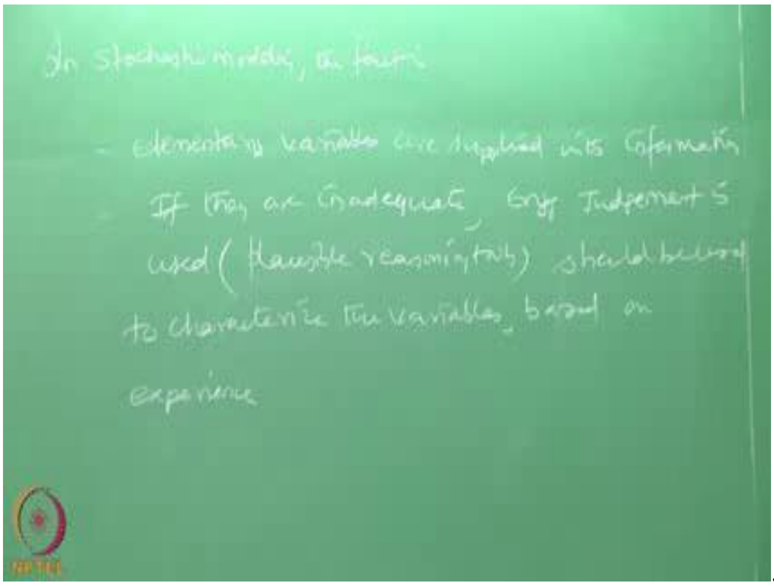

In stochastic modeling, the fact is elementary variables are supplied with information. If they are inadequate as the case may be in general then engineering judgment is used.

So, I should precise to say in this case plausible reasoning tools should be used to characterize the variable based on the experience now the variables can be represented in 4 different forms.

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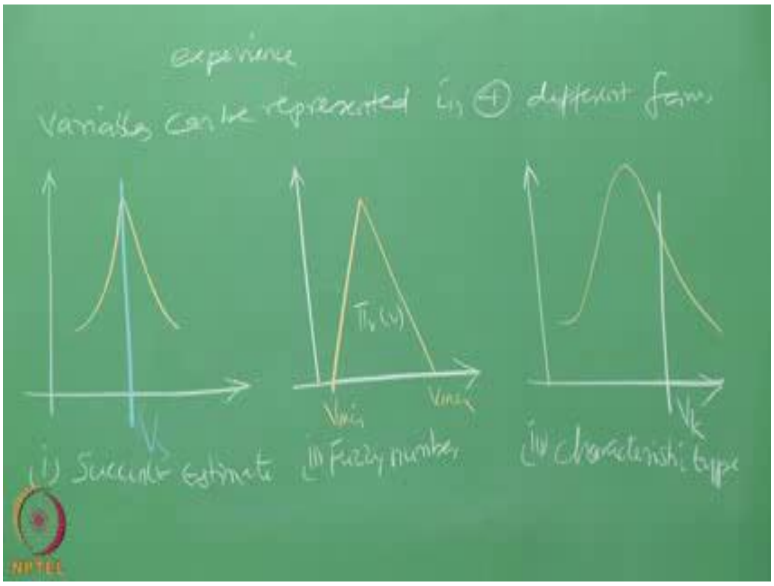

We call this value, let us say as v s and the variable this type of representation is called Succinct Estimate. The second kind of variable let us say the variable of this order which is got a range of v max to v min. So, this is nothing, but a variable of order pi v f v this call fuzzy number the third kind of variable is representing a characteristic value, which we call v k; k stands of course, for the characteristic value. So, these are called characteristic type variable the forth is not all as general case is a random variable which is f v f.

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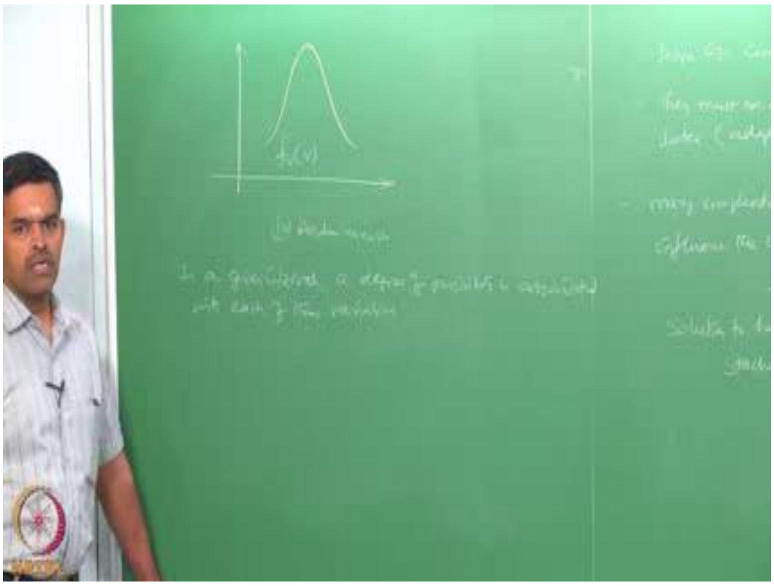

So, can represent the variables to include the complexities arising from various subsets involved in limit state function, in any of these following forms in an a given interval the degree of possibilities substituted with each of this variable a degree of possibility is, associated with each of these variable.

We will discuss that range of possibilities of these variables, and extend the study of structural reliability based on this concept in the next lecture. So, in this lecture friend we talked about, various limit state functions how actually codes handle reliability. In reliability prospective how codes can be grouped or leveled as 1, 2, 3 and 4 and how limit state function can have complexities, which arise the various factors which are essentially used to represent either the strength or the load combinations etcetera, related to material properties etcetera, in expressing the limit state function.

Thank you very much.