NPTEL course offered by IIT Madras

Risk and Reliability of Offshore structures

<u>**Tutorial 8: Reliability analysis: Variables**</u>

Answer all questions   **Total marks: 25**

1. Explain how randomness of the variables are handled in reliability analysis?

   It is important that reliability approach, what we follow should be compatible with the available information because randomness of the variable is a subset of a space of elements and the approach. What we follow should be able to compatible with this space of this event. Therefore, people have chosen the use stochastic model. So, it is better to use a stochastic model to represent the random variable because they will able to include the representative variability with an appropriate probability density function, stochastic models can include the representative variations with the help of appropriate probability density function.
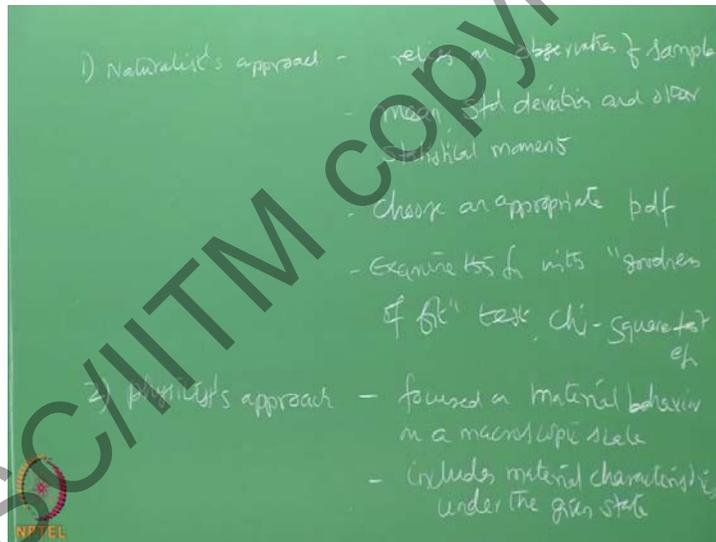
   A chosen probability distribution function should be verified with the goodness of fit test. Therefore, one can choose an appropriate probability density function and examine this function with goodness of fit test chi square test etc. Alternatively, physicists approach relies on understanding the variable of the material behavior on a microscopic scale. This includes material behavior and their characteristics under a given set of exposed (environmental) conditions.

2. Highlight the necessity of mechanical models in reliability analysis

Models should be evaluated for their closeness in response behavior to physical phenomenon. Mathematical models on the other hand should explain and represent the physics as close as possible. Alternatively, we look at numerical modeling they should control the accuracy of the results, so that if there is any deviation between the physics and that of the represented value that should be the least as far as possible. Mechanical model should always give, irrespective of the uncertainty in data, a low deviation between the physical reality and the image of the reality, as it appears in the mechanical model.

Various factors dominate reliability analysis towards stochastic modeling. However, they are handled with a little bit of compromise either in space or in time in stochastic models. This is due to the fact that classical distributions do not give information on rare events especially on the tail ends on the distribution curves. So, reliability analysis if done, with this conversational distribution pdf's may give error because the sensitivity of the rare data is not sufficient in terms of the distribution properties when use the standard probability density functions. Alternatively, stochastic modeling should be able to represent the physical behavior as close as that of mechanical modeling.

Of course, comparisons between various models should be a measure of the bias of the model and indicate deviations on the random variable as far as possible. Focus is to check or assess the deviations on the random variables when one validates a mechanical model with a closeness of its behavior to that of the physics model. Hence, mechanical models are of high significance in reliability analysis.

3. Explain sensitivity of reliability index. List the factors that influence this sensitivity

Computation of statistical parameters like mean and standard deviation of the output variables with respect to that of the input data is actually called sensitivity of reliability analysis. Mechanical model should depict as close as possible the physical phenomenon, but in most of the cases the failure scenarios identified or derived from the mechanical model does not really predict or explicitly show the physical phenomenon. This is due a set of constraints in mechanical modelling. Therefore an efficient reliability analysis should provide decent reliability sensitivity. This can be achieved by applying a coupling between the mechanical and stochastic models. Mechanical model ensures transition between the input data and the output variables. Sensitivity index consists of computing a gradient around a point, which is called a s the design point. Gradient will be an indication of deviations of random variables from that of the physical model. Therefore, reliability sensitivity analysis presents a relationship between the respective coefficients of variation, in particular. Estimate of standard statistical parameters of the mechanical model is a function of variability of the input data around a known value. Deviations in the

input data, as given by the mechanical model can be handled by two methods namely: Monte Carlo method; and perturbation method.

4. Explain design point and its importance in reliability analysis

Design point is that point, which indicates the minimum distance from that of the origin or the performance function. Graphically, if there are many number of design points for a non-linear performance function one can always land up and estimating what we call not the correct reliability or safety coefficient, but partial safety coefficients it is because of this problem that exactly the reliability index cannot be obtained for a non-linear performance function, people always use these safety coefficients as partial safety coefficients. If the random variables representing load effects or internal strength of the material are simulated using numerical procedure to obtain the failure of the performance function, reliability analysis shall amount to identifying or locating design point of the performance function. Hence, it is vital to compute the design pint as it governs the failure domain of performance function.

5. What are the complexities that arise while coupling mechanical model with reliability analysis?

Accuracy of the mechanical model depends on the data required (or the input variables which are fed) to develop the model. They will be strongly coupled to reliability analysis. Complexities that arise when connecting mechanical model to the reliability analysis can be handled in four stages. They depend on the modalities and definition of the complexity. First criteria arise from coupling of external action and resistance. External action arise from the loads or forces and internal resistance arise from material characteristics that are used for the mechanical modeling. Boundary conditions which are used for the mechanical modeling also contribute to the complexity at this stage. Second level could be essentially from the state of loading; for example, cyclic loads. A significant modifications are required on the input variables used in mechanical modeling to account for such variations, which contributes to the second level of complexity. The third level of complexity arise from the method of analysis or method of modeling. For example, elasto-plastic material characteristics cannot be captured using a linear modeling technique; issues that arise from geometric nonlinearity add to this complexity. Fourth level could arise from the estimates of internal strength and resistance characteristics. For example, does the internal resistance has a strong curvature with respect to its moment characteristics? Hence, choice of performance function should depict the correct behavior of both internal strength and resistance, which is a major factor and contributes to fourth level of complexity.