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RELIABILITY OF OFFSHORE STRUCTURES

7.1 INTRODUCTION

Generally, in the design of any structure, the load and resistance/capacity values contain a certain amount of uncertainty, which cannot be determined with confidence. This is when statistical measurements and evaluation are important. Physical phenomena, if measured repeatedly, will give varied readings. This variability in measured readings is termed uncertainty, randomness and stochastic. For example, in a fabrication yard, similar steel pipes which are supposed to be used for the fabrication of any steel structure, if we measure their dimensional properties (diameter and thickness), will give varied readings, where the readings could be plotted to demonstrate the distribution, with mean and standard deviation values. In another example, if some similar specimens of steel bars are to be tested until failure in the laboratory, each specimen would fail at different values of the applied load/stress. These examples show that these variables are random quantities. Not only these, but all variables in engineering analysis and design also have some degree of randomness. In approaching the randomness, a deterministic technique is adopted while dealing with relatively small values, whereas stochastic/probabilistic techniques are preferred if dealing with significant values. Typically, in design, a factor of safety is utilized for the load and resistance variables to address the risk and safety inherent in the design process. But this does not cater for the randomness in the variables. Also, it is more likely that the use of factors of safety will produce a conservative design, which subsequently produces an expensive structure. Both load and resistance variables will have probability distribution functions, and the values will be scattered about their respective mean values. In addressing the randomness and ensuring the structure's performance, assurance could be demonstrated regarding the probability of success in satisfying the performance criteria. In engineering, this probabilistic assurance of performance is called reliability. Alternatively, the unsatisfactory performance of the design could also be measured, called the probability of failure. Both these are addressed under risk analysis (at times, risk also includes consequences of failure). In risk analysis, reliability

analysis is conducted to quantify structures' safety and estimate the probabilities of failure related to structural performance. Risk and reliability complement each other. Since risk and reliability analyses are based on probability, concepts of probability and statistical analyses to address the risks and uncertainties involved in design are crucial.

7.2 RELIABILITY ANALYSIS IN OFFSHORE STRUCTURE DESIGN AND ASSESSMENT

In offshore structure design and assessment, reliability analysis has been utilised to quantify the safety level of the offshore jacket platforms, considering the uncertainties available in the load and resistance design variables. In theory, reliability is the probability that a system will perform its function over a specified time and under specified service conditions. Reliability analysis is concerned with calculating and predicting the probability of limit state violations at any stage during the life of a structure [93].

The probability of an event, such as the limit state violation, is a numerical measure of the chance of its occurrence. The probabilistic approach is based on the theoretical foundation of the probability density function (PDF) information. It also uses random variables, processes, and fields to represent uncertainty. Various uncertainty analysis methods are available such as Spectral Stochastic Finite Element Method, First and Second Order Reliability Methods (FORM and SORM), Monte Carlo/Latin Hypercube Sampling, Random Process/Field Method etc. [93]. The use of Response Surface methodology, i.e. a limit state approximation technique to apprehend the inherent uncertainty in the load and resistance variables was deployed by many in the reliability analysis domain [95]-[100].

In industry practice, the reliability analysis technique is categorized into three levels. The higher order provides higher accuracy but is difficult from the practical application point of view. Hence, the typical practice comprises a simplified structural reliability analysis (SSRA) followed by a comprehensive structural reliability analysis (SRA), if necessary. The SSRA, the most utilized method, is adopted for structures meeting the code-prescribed acceptance criteria in deriving the safety indices. It is employed with finite element nonlinear collapse analysis results at the system level. The uncertainty parameters for the load and resistance are approximated to be lognormally distributed with bias and coefficient of variation pre-determined from region-specific past studies or literature. The method was developed in a joint study with DNV in 1997 [101]. SSRA has certain limitations in its application. Utilizing the prescribed uncertainty factors with no emphasis on material, geometry and model uncertainties are the shortcomings of this method. Thus, the accuracy of the results could be doubted. Furthermore, the platform and environmental-specific uncertainty variables are not included in the analysis to address the distinctive characteristics of the structure being analysed.