NPTEL course offered by IIT Madras

Risk and Reliability of Offshore structures

Tutorial 10: Risk assessment

Answer all questions **Total marks: 25**

1. Why is risk assessment in offshore industry important?

Offshore structures, which are essentially constructed for oil and gas exploration and production do perform these operations under very high risk. Risk involved in this set of operations are relatively high in comparison to any other process industry, which does parallel extent of business. Financial risk involved oil gas industries are very high. Risk is implicitly present in the system, which cannot be isolated. It can arise from the environment, production methodology, processing techniques, sea states, type of platform used, method of construction, method of commissioning and decommissioning etc. Hence risk assessment is carried out essentially with a motive to risk reduction but not risk aversion.

2. Highlight the difference between risk and reliability

Offshore structures will have to perform the intended function under the critical environment. Failure of the intended function on demand is the window of reliability; consequences caused because of its' failure, in economic perspective is risk. So, risk will more or less touch the performance level of the offshore structure rather reliability would touch the design level or the geometric form level itself in offshore structure system. So, risk can be in higher end use of failure assessment of consequences assessment compared to reliability. One is of course scientific, and one is of course scientific plus economic perspective. It is therefore necessary to understand the risks involved in oil gas industry in detail, so that efficiency of such industries can be improved and can be examined with more confidence. In addition offshore platforms in general and other installations present in offshore platform are entangled by higher degree of uncertainties, so result of which this makes the whole assembly under the coverage of risk picture.

3. Why accuracy of estimating stress concentration factor is vital in tubular joints?

As the fatigue performance of the tubular joints depends essentially on the stress concentration factor recommended either by the international course or derived based on the detailed experimental and numerical investigations. It is very important to actually know the accuracy of the computed stress concentrations to design the tubular connections. In the reliability perspective, it is interesting and important to know the accuracy of computed stress concentrations at the intersections and this is more critical in case of tubular joints. Thanks to researchers, close-form solution is available in terms of parametric equations for obtaining

stress concentration factor of tubular joints. But, in relative sense, estimating fatigue life of the joints and ultimate strength are also equally important for a designer. Incidentally, comparison between those estimated from the experimental investigations on a tubular joint with that of equations suggested by various researchers shows a serious disagreement. Stress concentration or the ultimate strength of tubular joints under various combination of forces like axial and out of plane bending become very crucial. Uncertainties involved in estimating (or deriving) stress concentration factors need a better understanding, which can be better estimated by experimental investigations. For example, if these relationships are very conservative, method of recommending the ultimate strength and the fatigue life can be judiciously decided by the Designer. From the experimental investigations, one can observe that the fatigue life of tubular joint significantly increases because there is a significant reduction in the stress concentration factor. On comparison with other parametric equations and considering uncertainties with respect to life prediction of offshore structures, one can realize the importance of estimating stress concentration factor, wisely.

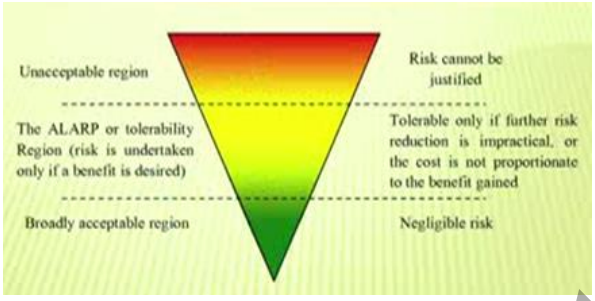
4. What are the vital informations that evolve from post-accident diagnosis of offshore platforms?

Offshore installations also involved in risks of major accidents, which have been demonstrated by evidences in the literature. There can be many examples: i) explosion and fire on the UK production platform, Piper Alpha; ii) capsized Norwegian accommodation platform, Alexander Kielland; iii) Failure of oil tanker, 'Torrey Canyon' in the English Channel; iv) Exxon Valdez incident; v) oil storage terminal failure in Buncefield Fire; and vi) pipeline rupture in Usinsk area, Russia. In all the above cases, there is a high degree of risk involved in the offshore installations as it resulted in major accidents.

Major accidents represent the ultimate most disastrous way in which a set of offshore platform can be tossed off. Accidents cause death, suffering, pollution the environment, and disruption of the business. As these values of incidents are very high and they are so dramatic in nature, they also attract attention from the news media. It remains in the memory of public for longer time causing concern about the safety. Accidents happened on offshore installations post concern about societal safety and economic stability. Interestingly in both cases, indirectly risk is accounted. Therefore, to understand risk involved in offshore installation, it is necessary and vital to understand the basic fact that oil industries operate under the brackets of acceptable risk; risk is never zero in offshore installations. All the time, efforts are made only to reduce level of risk to a specific level called ALARP. The acceptable level of risk is called ALARP, which explains as "as low as reasonably practical". But offshore industries installations do not attempt to mitigate it completely as no attempts are successful in mitigating the risk completely.

Risk mitigation is one of the most expensive schemes in any industrial investment. As oil companies are competitive in limiting the production cost, investment towards risk mitigation to make it zero level is too far from an imaginative process until optimizing the production cost do not become prevalent in this industry.

5. What do you understand by risk acceptance criteria?



6. The steel member in an offshore platform is subjected to loading. The member fails on exceeding the yield stress. The mean and standard deviations of the yield strength and the loadings are given as follows:

$\mu_R = 350$, $\sigma_R = 35$ MPa and $\mu_S = 250$, $\sigma_S = 40$ MPa

The yield stress and the loadings are found to be following a normal distribution. Estimate the reliability index.

The limit state function is given by:

$$G(x) = r\text{-}s$$

$\mu_M = 350\text{-}250 = 100$

$\sigma_M = \sqrt{35^2 + 40^2} = 53.15$

The reliability index is:

$$\beta = \frac{\mu_R - \mu_S}{\sqrt{{\sigma_R}^2 + {\sigma_S}^2}}$$

$$\beta = \frac{100}{53.15} = 1.88$$

7. What is the expected outcome of risk assessment?

Risk is a combination of likelihood and severity, which leads to an approximate estimate of hazards present in any (given) system. Risk level, therefore is very important to recommend any actions considering the deviations. Where assessment of risk cannot be done with a team, there is always a critical concern. Risk should lead to recommending safeguards, which are different control mechanisms or methods that can be used to protect the assets. It can be a combination of hardware instrumentation, operating practices and training modules. Risk is therefore, an overall perspective

which is an extended generic form of reliability, where reliability focuses only on failure of a specific system under the given load effects or even combinations over a specific period of time.

Reliability assessment includes load effects, wave period, sea states, and structural system to model all possible uncertainties for accounting the probability of failure of that system. But, risk is the extension of this in terms of economic perspective. Risk assessment is a bigger picture in asset management of offshore industry compared to that of reliability. Reliability can also be used as a design tool whereas risk is used as a performance assessment index. Risk is directly connected to economic perspective while reliability is not except in level IV. In general, risk assessment is a step forward in the direction of economic perspective of asset management where reliability is a prelude for risk assessment. Hence, expected outcome should be a detailed report, indicating potential risk parameters and their safeguards.

8. List the factors that governs the complexities that arises in coupling the mechanical model to reliability analysis.
    - *Time variant properties of load and material.*
    - *Degree of approximation used in the analysis.*
    - *Second order effects due to geometric and material nonlinearity.*
    - *Choice of limit state function.*

9. What are the data necessary to foresee different failure scenario in a process industry?
    - *Composition of material*
    - *Inventory of material stored in plant*
    - *Flow rate of materials*
    - *Operational parameters*
    - *Storage tanks, pipeline layout*

10. Explain FMEA in brief

FMEA is a component level analysis to assess consequences of failure. It is a common method of risk analysis as applied to Mechanical systems. This method is primarily used to study equipment failure based on the failure of its vital components. Offshore structural systems involve lot of mechanical equipments, whose failure can be always be diagnosed based upon the failure of each component of those systems. A component level analysis is useful to determine the consequences of failure of those components on the overall failure of the complete system. FMEA quantifies a component level failure in terms of it is consequences on the overall failure of the system. For example, select a mechanical electrical system in which one can identify a multiple failure modes. Then for each failure mode, one need to identify it's effect on the overall performance. If the mechanical system or the electrical system has multiple

modes of failure, which are very common, then one need to find the consequences of each modes of failure on the overall performance of the system. FMEA is useful in such diagnosis.