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Inspection Planning of Offshore Steel Jacket Structures for Fatigue Damage

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This paper presents a methodology that combines the probability of loss of the structure, which accounts for structural redundancy, and the probability of fatigue failure of joints. The method identifies joints most critical to the structural integrity, enabling the inspection effort to be concentrated where it can be most effective. Using a Bayesian approach, a method has been developed whereby the joints most influential to the integrity of the structure can be identified. This enables the inspection effort to be concentrated where it can be most effective.

INTRODUCTION

Fixed offshore steel jacket structures (see Fig. 1) are subject to degradation under normal operating conditions due to a number of mechanisms including fatigue crack growth, corrosion, and extreme loading. Thus, structures must be maintained to ensure the safety of personnel and the environment. Financial losses such as deferred production and the cost of rehabilitation are also important. During the past several decades, significant progress has been made in the area of inspection and maintenance planning, especially for steel jacket structures subject to fatigue crack growth, e.g., Skjong (1985), Madsen et al. (1989), Moan et al. (1999), Moan (2005), and Heredia-Zavoni et al. (2008). Fatigue reliability analyses of jacket-type offshore wind turbines considering inspection and repair have been presented by Márquez-Domínguez and Sørensen (2012), Sørensen (2011), and Dong et al. (2010) among others. Some applications of these methods are given by Pedersen et al. (1992) and Faber et al. (2005).

DNV GL has published the recommended practices, DNVGL-RP-C210 (2015) and DNVGL-RP-001 (2015) for the use of probabilistic methods for inspection planning of fatigue cracks in jacket structures, semisubmersibles, and floating production vessels. These also include guidelines for the fatigue analysis of these structures as required for probabilistic analysis.

The reliability of fixed offshore steel structures is affected by the uncertainties in the operating environment (the wave, current, extreme event, etc.) and in the structural properties (the material properties, geometries, corrosion, imperfections, etc.). These uncertainties are accounted for in the traditional design through the use of a suitable safety factor.

The current practice for fatigue design uses S-N curves and the Miner rule together with the wave scatter diagram and the wave occurrence to size joints so that their fatigue lives are more than a prescribed multiple of the service life. The factor for the fatigue life is set so that the probability of failure is acceptably low.

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In any given year after installation, there is a possibility of no joint failure, one joint failure, two joint failures, and so on due to fatigue. It is assumed that failure of a joint makes the connecting member ineffective. Failure of a joint changes the stress distribution, and hence the time to failure of all remaining joints may change, and the previous sequencing of failure may no longer apply. However, for the purpose of illustration, it is assumed that if the failure of a joint goes unnoticed, the time to failure for all joints does not change.

Selecting critical joints for an inspection program on the sole basis of the calculated fatigue life can be misleading. For example, a joint may have a low fatigue life but is not essential for the system survival; namely, that member may be a redundant member, and hence it has no significant influence on the overall reliability of the structure when it becomes ineffective. Conversely,

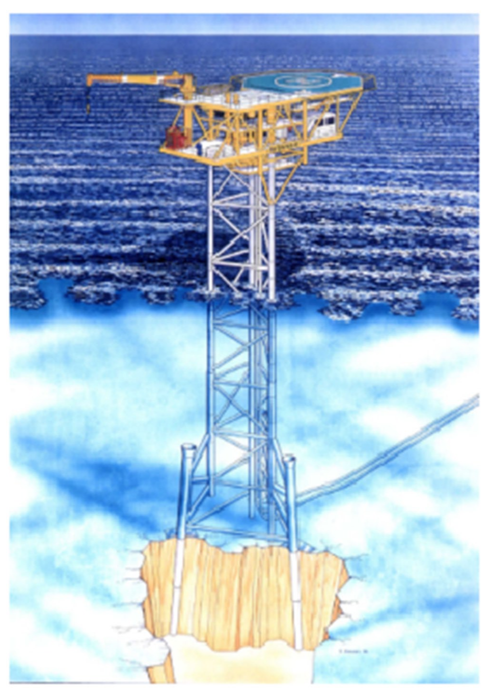

Fig. 1 A minimal facility fixed steel jacket