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A Technical Framework for Probabilistic Assessment of Existing Offshore Platforms in Persian Gulf under Extreme Environmental (Wave) Loading

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Abstract

In this paper, a new probabilistic method (reliability analysis) under extreme environmental wave loading is introduced. This method is a direct probabilistic performance assessment using numerical method, in which the expression for mean annual frequency (MAF) of exceedance is derived by taking into account the aleatory and epistemic uncertainty in environmental hazard, structural response and capacity. A more realistic approach is used to calculate the system demand and capacity called "Incremental Wave Analysis" (IWA) instead of current nonlinear pushover analyses, in which multiple performances from onset of damage through global collapse can be assessed. The uncertainty propagation is estimated by Monte Carlo simulation and the reliability analyses are performed by using a numerical method. As a case study, the MAF of exceeding a given level of response and also the probability of failure are evaluated by this new approach.

Keywords: Offshore platforms, Mean annual frequency (MAF), Incremental wave analysis (IWA), Probability of Failure.

1. INTRODUCTION

Offshore jacket structures have been used in petroleum industry for decades. In an economical point of view, performing reconstructions and repairs to an existing installation is much preferable than constructing a new one. So, structural safety control of platforms beyond their design life has always been a matter of consideration. Due to the large uncertainties associated with the assessment of offshore platforms, there has been increasing interest in establishing assessment methods which are based on explicit considerations of reliability. Recently, American Petroleum Institute has developed recommendations for reliability-based assessment of offshore structures [1-3]. Target reliability levels and consequences of failure were explicitly addressed in the API guidelines, and criteria for assessment of offshore platforms against wave and seismic loads were developed. In a reliability and performance context, seismic loads, especially, have been the subject of important studies recently, for example the introduction of the Load Resistance Factor Design Code [4] and the ISO developments [5,6]. A major proposed procedure employed alternatively for probabilistic assessment for extreme wave loading is to verify that the jacket structure has the desired reliability. One approach is to estimate the probability of failure in terms of the structure's capacity considering its uncertainty as determined from nonlinear static pushover analyses; and a probabilistic description of the external wave loads. A convenient analytical format for such risk computations may be found in [7-9]. In recent years, an effective foundation and a conceptual framework for the development of seismic performance-based guidelines is presented by Pacific Earthquake Engineering Research Center (PEER) [10,11]. In this new procedure, the evaluations of structural performance (or seismic risks) can be expressed in terms of the mean annual frequency (MAF) of exceeding a given level of response. The present paper addresses similar issues for offshore structures with a focus on extreme environmental wave loads. The objective of this research is introducing the new PEER novel approach (used in seismic performance evaluation) for estimating the probability of failure due to extreme wave loading and MAF of exceeding a given level of response.