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Modification of endurance wave analysis based on New-wave theory

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The main objective of this investigation is to modify endurance wave analysis (EWA) based on New-wave theory for convenient assessment of offshore structures under extreme waves. EWA is a novel time history based approach to evaluate structural performance in various excitation levels of wave loading by intensifying wave records. In this article, modifications are proposed to determine appropriate time duration and intensifying trend for reliable and practical assessment of offshore structures. In this way, a simplified model of a real jacket platform is utilised to investigate the application of this approach under extreme wave conditions in the Persian Gulf and results are compared with typical three hour random wave simulations. It is shown that in extreme waves, except resonance states, proposed method can estimate the structural response with acceptable accuracy and very low computational costs.

Keywords: New-wave theory; endurance wave analysis; jacket platform; extreme waves; assessment

1. Introduction

Resistance of the structure under extreme wave conditions plays a key role in the assessment of offshore structures. Investigation of safety, serviceability and production activities is another viewpoint that implies the importance of such assessments. However, assessment is a challenging issue because of complicated geometry and different kinds of interactions such as fluid–structure interaction and soil–pile–structure interaction (Sekhar and Nallayarasu 2013).

As usual, wave loading is the most important load exerted to the offshore platforms, and thus the guidelines and papers are mandating the evaluation of the structural behaviour under extreme wave conditions (API RP2A-WSD 2007; DNV-RP-C205 2010; Hirdaris et al. 2014). Various studies have been carried out for the assessment of offshore structures in the design or ultimate capacity state (Rey et al. 1998; Jia 2008; Jayakumar and Rangan 2014; Bai et al. 2015). But, nowadays, by growth of computer processing power, researchers have been interested in assessment of structures in multi-extreme wave conditions. Golafshani et al. (2011a) introduced incremental wave analysis (IWA) for assessment of structures in different excitation levels. This method was developed based on incremental dynamic analysis (IDA) which is a well-known method in seismic assessment (Vamvatsikos and Cornell 2002). In IWA method, the interval that has the maximum wave height in a three hour time history has been considered. In this approach, the nature of wave loading is not simulated properly so the authors emphasised on the possibility of obtaining unreliable results in other case studies. Zeinoddini et al. (2012) presented endurance wave analysis (EWA) for simulation of extreme events. In this method, the offshore structure is exposed to a stepwise intensifying time history of waves. Despite valuable advantages of EWA, this method requires modifications especially in selection of time duration and increasing trend.

Recently, modifications based on random wave theories have been introduced (Dastan Diznab et al. 2014, 2015; Jahanmard et al. 2015); however, regular wave theories are more practical in typical design process due to their convenience and low computational costs. In this paper, New-wave theory is utilised to describe the modification procedure, and to achieve optimum time duration. In addition, the concept of the return period in extreme waves is used for the increasing trend of the modified records. This method can be perfectly used in the assessment or design of offshore structures.

2. Modification of endurance wave analysis

EWA is a time history based method to assess offshore structures under various extreme waves. In this method, the structure is subjected to a predefined increasing sea surface elevation called intensifying wave train function (IWTF) indicating various sea state conditions. The concept of EWA can be best explained by considering a hypothetical

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