OTC 20297

Further Work on the Effects of Nonlinear Wave Spreading and its Impact on Current Jack-up Assessment Practice

M.J.R. Hoyle, Noble Denton Consultants Ltd.; S.F. Smith, Noble Denton Consultants Ltd. (now with Sandwell Engineering Inc); R.V. Ahilan, Noble Denton Group Ltd.; R.J. Hunt, Shell U.K. Limited; and M.R. Marcom, Rowan Drilling Company

Copyright 2009, Offshore Technology Conference

This paper was prepared for presentation at the 2009 Offshore Technology Conference held in Houston, Texas, USA, 4–7 May 2009.

This paper was selected for presentation by an OTC program committee following review of information contained in an abstract submitted by the author(s). Contents of the paper have not been reviewed by the Offshore Technology Conference and are subject to correction by the author(s). The material does not necessarily reflect any position of the Offshore Technology Conference, its officers, or members. Electronic reproduction, distribution, or storage of any part of this paper without the written consent of the Offshore Technology Conference is prohibited. Permission to reproduce in print is restricted to an abstract of not more than 300 words; illustrations may not be copied. The abstract must contain conspicuous acknowledgment of OTC copyright.

Abstract

This paper builds upon two previous studies by Smith et al. (2001) and Smith et al. (2006) which addressed the effects of wave spreading on jack-ups. In Smith et al. (2001), load reductions that could be obtained for a LeTourneau 116C jack-up operating in 60m of water in the North Sea and 100m of water in the Gulf of Mexico were considered. In Smith et al. (2006) this was developed further by considering a wider range of environment and operating conditions and further rig classes, the results of which were used to derive simplified methods for inclusion in SNAME T&R 5-5A (SNAME, 1994), to represent the effects of 3D and nonlinear waves in an assessment context, without having to perform the more complex and time consuming direct evaluation.

In this paper, the matrix of test cases has been further expanded, and the resulting simplified formulations exercised and explored. This investigation revealed that the original formulation presented in Smith et al. (2006) was not as well conditioned as had been intended. Additional work has been carried out for shallow water, and further cases have been added. From the further results a more robust version of the simplified formulation has been developed. The results continue to show that significant reductions may be gained for TRS areas, whilst more modest reductions are obtained for non-TRS areas.

Existing analysis methods which ignore irregularity, nonlinearity and directionality in the description of the kinematics associated with extreme ocean waves may significantly overestimate the hydrodynamic loads on offshore structures. The explicit consideration of short-crestedness provides benefits for the design and assessment of jack-ups, extending their versatility for operations in a wider range of locations and water depths. The simplified formulation proposed here, derived from a comprehensive analysis of 59 cases, makes this robust and tractable in routine site assessment analyses. Therefore it is recommended that it is incorporated into the next revision of the SNAME T&R Bulletin 5-5A and into ISO 19901-5.

Introduction

In short-crested waves, the wave energy propagates in different directions around the main wave direction. The peak particle velocities under waves become smaller as the waves become more spread. As a result, the directional spreading of waves tends to result in peak loading that is somewhat smaller than that predicted for uni-directional seas. Design codes and practices have accounted for spreading by introducing a factor on horizontal kinematics (either directly or via the wave height) in conjunction with the regular wave approach. The reduction factor reflects the reduced kinematics under the highest point of the wave crest, and is thus appropriate for the calculation of quasi-static loads on a single pile. However, it does not account for all the effects of spreading. In particular, previous work involving the simulation of extreme directional waves has shown that the loads on offshore structures are reduced further due to the spatial distribution of the wave-loaded structural components (Sharma and Dean, 1981 and van Weert and Harland, 1998).

The present work builds upon two previous studies. In the first of these studies reported in Smith et al. (2001) and Noble Denton (2000) it was shown that for a Le Tourneau 116C jack-up operating in 60m of water in the North Sea and 100m of water in the Gulf of Mexico with the directional spreading formulation as recommended in ISO (2005), the 2nd order wave theory proved to be adequate for modelling the kinematics under extreme directional waves when tested against a fully nonlinear computational procedure (Bateman et al., 1999).

At the time of the first study (2001), the kinematics reduction factor implemented in SNAME T&R 5-5A (SNAME, 1994) was in the form of a reduced wave height, $H_{det} = 1.6H_s$. However, since the relationship between H_s and H_{max} for non-cyclonic