International Journal of Offshore and Polar Engineering
Vol. 9, No. 3, September 1999 (ISSN 1053-5381)

Reliability Estimate Sensitivity to Multi-Peaked Random Seas

J.W. van de Lindt and J.M. Niedzwecki*
Department of Civil Engineering, Texas A&M University, College Station, Texas, USA

ABSTRACT

This study compares the reliability estimates of a flexible cylinder for seastates generated using single- and multi-peaked wave amplitude spectra. The horizontal response of a long, flexible cylinder that is representative of a riser or tendon was used for illustrative purposes. A method that characterizes the offshore loading environment independently of the structure, known as the environmental contour technique, was used to compute the reliability estimates for the cylinder. This technique allows one to identify the critical seastate for the structure being examined. The selection of this critical seastate for extreme response and reliability estimates is becoming a necessity as the offshore industry moves to probabilistic-based design codes. Two different simulation scenarios are examined that expand upon established procedures for single-peaked wave spectrum environmental contour. In the first scenario, the primary spectral peak is varied along the environmental contour while the secondary peak is held constant at the first harmonic of the flexible cylinder. For the second scenario, the most probable location of the secondary spectral peak given the significant wave height is used in the analysis. The environmental contour technique for investigation of the sensitivity of reliability estimates can easily be extended to address more complex behavior of a spar or tension leg platform. Conventional techniques for establishing a limit state function and estimating the system reliability could also be implemented.

INTRODUCTION

As the next generation of deepwater-compliant offshore platforms is being designed, there are concerns about how sensitive the platform designs are to the design wave spectrum and the statistics of ocean storms that are not commonly available for design. These concerns are being driven by desire of the offshore industry to move as quickly as possible towards probability-based design codes. One aspect that can be studied is the difference in response behavior obtained if the design seas are modeled using single- or multi-peaked spectrum. Recent studies have indicated that some offshore sites may require modeling for as many as four spectral peaks (Borgman, Bartel and Sheilds 1993, Borgman 1994). In this study though, attention is focused upon the comparison of reliability estimates obtained using 3 different spectral models. Specifically, these include the single-peaked JONSWAP wave spectrum model (Hasselman et al., 1976) and the bimodal wave spectrum models, the Ochi-Hubble (1976) and Torsethaugen (1993) models. The parameters used in these wave spectrum models were selected to be consistent with Gulf of Mexico and North Sea locations.

On floating offshore platforms, space restrictions often require the clustering of risers and tendons. As the water depths increase, the flexibility of these systems plays a more important role as the floating platforms used in deepwater can not provide adequate constraint to the motions in the horizontal plane. In order to calculate a lower bound estimate on the reliability, the environmental contour technique developed by Winterstein et al. (1993) was used as the basis for the reliability estimates. This technique describes a family of seastates, each with the same return period, rather than a single critical seastate. The environmental contour can then be searched for the critical seastate that may depend on the structure's harmonics or additional parameters. An environmental contour for the Gulf of Mexico is shown in Fig. 1, the o indicating the more conventional single critical seastate location often used in design and reliability estimation procedures. A contour represents all the possible seastates with the same probability of occurrence. Thus, it is conceivable that the conventionally selected critical design seastate may not provide the most critical design conditions for the platform or its structural members.

To explore these ideas, a series of 5 examples was used to illustrate the sensitivity of reliability estimates for the flexible cylindrical structural members to various design seas. In the first example, the probability of failure of the cylinder to excitation from seastates generated using a single-peaked JONSWAP spec-

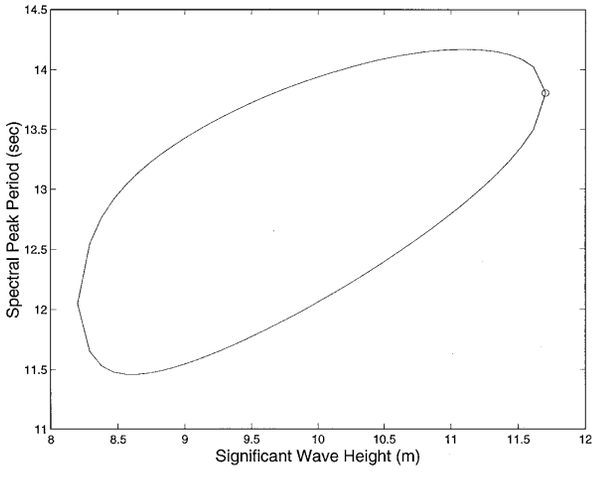

Fig. 1 Example of environmental contour for Gulf of Mexico

*ISOPE Member.

Received July 30, 1997: revised manuscript received by the editors April 21, 1999. The original version (prior to the final revised manuscript) was presented at the Seventh International Offshore and Polar Engineering Conference (ISOPE-97), Honolulu, USA, May 25-30, 1997.
KEY WORDS: Reliability estimates, environmental contours, Monte Carlo Simulation, JONSWAP, Ochi-Hubble, Torsethaugen, tendons, risers, deepwater platforms.