Extreme Loads due to Wave Breaking Against Platform Column

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ABSTRACT

The purpose of the paper is to compare impact loads due to breaking waves obtained using an available recommended practice with results obtained from model tests. Our focus is not to compare prediction and experiment on an event by event basis. Rather focus is given to the comparison of q-probability wave impact loads against platform columns. The q-probability value notation means the value corresponding to an annual exceedance probability of q. Model tests including measurements of impact loads on platform columns carried out some few years ago are available for this study. One of the tests was with a semi-submersible platform, while the other tested was a tension leg platform. In connection with introducing the model test setup, it will also be shown how effects of sensor dynamics can be eliminated. Following the environmental contour line method, the q-probability impact events are obtained by estimating the 90% and 95% value of the 3-hour extreme value distribution for the worst sea state along the q-probability contour. Uncertainties related to the estimation of the 90% and 95% value will be discussed. They are partly quantified using parametric bootstrapping, i.e. simulating many equally possible samples of model test size from an assumed true model. Finally, q-probability values estimated using an available recommended practice are obtained and compared with model test results. It is demonstrated that large uncertainties are associated with the model tests, due to a limited number of tests for the governing sea states. In spite of this, the conclusion is that the recommended practice is in reasonable agreement with model tests results for \( q = 10^{-2} \), whereas model test results suggest larger impact loads than the recommended approach for \( q = 10^{-4} \).

KEY WORDS: Breaking-wave; slamming; stochastic; contour line; platform column.

INTRODUCTION

Breaking waves may cause large and rather localized impact forces on offshore structure compare to non-breaking waves (Ochi and Tsai, 1984). Ochi and Tsai (1984) carried out an experiment by generating breaking waves in a 40-meter long wave tank. During the tests, impact pressure was measured at the front face of a circular cylinder representing a column of an offshore structure. They propose a method to statistically predict the magnitude of impact pressure (including extreme values) produced by deep water waves breaking against a circular cylinder.

Zhou et al. (1991) conducted laboratory measurements of the pressure distributions on surface-piercing vertical cylinders due to breaking waves. Despite repeatability of the controllable experimental conditions, they found that the highest impact pressures are subject to considerable variability, including pressure oscillations, from run to run. This high impact region is found to be localized in space and time, and the variability is attributed to the random dynamics of the breaking wave front and the entrapped air. They concluded that the largest pressures is essentially an inherent random phenomenon – even with identical wave conditions.

For design purpose, the magnitude of the breaking wave loads may be very important. The experienced load will vary depending on the breaking process at impact. In their experiment, Wienke and Oumeraci (2005) set up five conditions of wave breaking by adjusting the distance between breaking point and cylinder. This arrangement produced five different developments of breaking wave impact, which could represent breaking events in reality. As a note, the exact breaking location cannot be identified by wave gauges or other measuring instruments with a sufficient accuracy. They suggested visual evaluation (video records) as the most reliable determination tool for breaking detection.

In this study, we do not investigate the various impact events into detail, i.e. we do not know what is the actual breaking development at impact. The background for this is that we aim for the distribution function of the 3-hour maximum impact load for the governing q-probability sea state. Our hypothesis is that if a sufficient number of realizations of the 3-hour maximum impact loads are available, the distribution function thus obtained should represent a reasonable approximation to the underlying true distribution. That distribution will define a population representing a variety of breaking development.

The model tests for two platforms were carried out a number of years ago. A semi-submersible platform was tested by Marintek and a tension leg platform was tested by Marin. At that time no detail consideration of necessary sample size for obtaining proper estimates of q-probability impact loads was made. Here the number of observations is given by