The Effective Modelling of Wave-in-deck Loads

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Abstract

The present study addresses the effective prediction of wave-in-deck (WID) loads. This is of increasing concern for the design of offshore structures, particularly for existing structures that require re-assessment against changes in 'design' conditions.

To begin, the short-term crest-height statistics over a finite plan area (appropriate to WID loading) were investigated experimentally. When compared to measurements taken at a single point, large increases in the incident crest elevations were observed. These increases, caused by nonlinear amplification and nonlinear wave evolution, show clearly defined departures from 2^{nd}-order theoretical predictions.

A new experimental study has been conducted to investigate the underlying physics of WID loading. A wide range of incident wave properties (including variations in crest elevation, spectral peak period, directionality and spectral bandwidth) have been considered, together with the location and direction of the WID loading. This new data confirmed that the characteristics of the loading is fundamentally determined by a combination of the incident wave shape and the associated underlying water particle kinematics; their relative importance governed by the occurrence of wave breaking. Furthermore, a wide range of topside structure configurations have also been considered. In particular, these confirmed the critical influence of the porosity of the deck structure.

Based on the improved physical understanding, a new WID load model was developed. This adopts an improved momentum-flux formulation. The model does not instantaneously dissipated all of the incident wave momentum, and allows water to exit the deck structure with un-dissipated momentum. When coupled with a fully-nonlinear wave solution, the new load model accurately predicts both the magnitude and time-history of global WID loads.

Finally, the new load model was incorporated within a Monte-Carlo simulation to predict the short-term distribution of WID loads. The incident wave profiles arising within a random sea-state and the associated water particle kinematics were first predicted using a linear solution. These results were then corrected for nonlinear effects. This approach provides descriptions that are both accurate and computationally efficient, and therefore appropriate for use in a Monte-Carlo simulation. The predicted short-term load statistics were shown to be in very good agreement with experimental measurements.