Abstract

A sequence of new experimental investigations is presented that addresses the modelling of the wave loads within the crests of limiting and breaking waves. This study identifies important sources of uncertainty within wave loading models that are applied to the steepest wave conditions. By examining the origins of this uncertainty, existing loading models are assessed and improvements proposed. In particular, the local wave impact loads arising on individual horizontal and vertical members in the crest region are evaluated.

In terms of wave modelling, the key factors are the wave shape and the associated water particle kinematics. In addressing these points, the present results have shown that only nonlinear modelling methods are capable of accurately describing a limiting wave profile. Indeed, the departures from established analytical solutions, commonly used in design, highlight the importance of high-order effects in steep waves approaching their breaking limit.

In predicting the wave impact forces on a body, the gradient or slope of the water surface is of fundamental importance. Detailed experimental analysis of the magnitude and direction of the impact force on a horizontal cylinder has highlighted an important source of uncertainty. This relates to the nonparallel nature of the normal to the water surface and the direction of the resultant water particle kinematics. The present work has shown that in the crests of large, steep waves, this angular difference creates an important variability in the force predictions. However, having taken account of this effect, the magnitude of the impact force can be reliably predicted using a slamming coefficient of $C_s = 5.19$. This is shown to be appropriate to a wide range of oblique wave-structure impacts.

When considering the wave forces on a vertical column the present study has shown that it is crucial to consider both the type of wave breaking and also the additional complexity of free surface deformation during the loading event. Overall, measurements of wave run-up are shown to be less dependent on the occurrence of wave impact forces than previously hypothesised. However, the extent of the column area subject to large impact loads is shown to be critically dependent upon the type of wave breaking.