Abstract

This thesis concerns a fundamental study of the loading and dynamic response truncated and domed cylinders. A potential application of the work is in the design of wave energy converters; therefore the body geometries chosen are of a similar size to such devices. Using a combination of a nonlinear potential flow model and an extensive experimental programme, nonlinear aspects of the body response in long irregular sea states have been established. Two primary sources of nonlinearity arise: the first due to nonlinear wave-structure interaction, and a second due to vortex shedding dissipation. The quantification of the relative importance of the two sources in the loading and dynamic response of the body is one of the principal achievements of this study.

The competition between these two effects is studied in the context of regular waves and irregular sea states. The regular wave investigation provides a detailed explanation of nonlinear wave-structure interaction using a newly-developed potential flow model, ICRD3D, in order to inform the results arising from the realistic irregular sea state experiments. Each of a number of irregular sea states captured in excess of 15,000 individual waves, resulting in a total data set of approximately 850,000 wave events.

The statistical distributions arising from the irregular sea state experiments demonstrate that nonlinear wave-structure interaction, the first source, dominates in the excitation problem. The nonlinear wave-structure interaction leads to amplifications in (absolute) force minima in excess of the linear prediction, whereas the force maxima are smaller than linearly predicted. This maxima-minima asymmetry arises from the set-down present under the largest incident wave events and increases with the underlying sea state steepness. The second source, due to vortex shedding dissipation, does not significantly affect the excitation problem, but is of crucial importance in the dynamic response. The effects are pronounced at the body resonance frequency, leading to reduced displacements with increasing sea state steepness despite the nonlinear force amplification. This second source is further examined by first considering a truncated cylinder with sharp corners, followed by a domed cylinder with a hemispherical base. The vortex shedding dissipation is much reduced in the latter case.

Perhaps of most importance to design practice is the specification of ‘design conditions’. The maximum body displacements were not found to arise from the largest wave crests. Instead, a wave group in which a large wave crest and trough precede the maximum surface elevation cause a gradual build of energy that permits the maximum dynamic response of the body.