Nonlinear wave interactions with multiple bodies in close proximity

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Abstract

This thesis describes the interaction of waves with multiple bodies in close proximity. The case of two-dimensional fixed bodies is first considered, where large wave excitation is found to occur within the gap between the two bodies at the so-called resonance frequency. The width of the gap is identified as the most important factor in determining this frequency; an increase in the gap width leading to a decrease in the resonance frequency. Subsequently, the effect of the motion of one of the bodies (with a single degree of freedom) is investigated using a newly developed floating-body application of the boundary element method. In the floating-body case, the resonance frequency is found be higher than in the fixed-body equivalent. In addition, a large amplification of the nonlinear water surface elevation within the gap is identified.

In order to determine whether the observations within the two-dimensional study can be applied to the practical case of side-by-side offloading of Liquid Natural Gas (LNG), similar investigations are undertaken in a three-dimensional analysis. The latter involves both numerical and experimental studies. The three-dimensional studies confirm the effects identified in the two-dimensional analysis; specifically the effects of the gap width, the motion of one of the bodies, and the nonlinear effects arising within the gap are all clearly established. Furthermore, consideration of both beam-sea and head-sea incident wave conditions eliminates the orientation of the bodies relative to the incident wave direction as a key factor in determining the resonance frequency. Finally, consideration of the motion of the bodies shows that some unexpected higher order motion of the moored body arises when the two bodies have significantly different hydrodynamic properties. As a result, it is concluded that the numerical modelling of side-by-side offloading must be fully nonlinear, incorporate the body motion and include the forcing of the fenders and the mooring lines.