Non-linear transient waves

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The behaviour of the largest waves in an ocean environment is critical to the safe design and performance of offshore structures. Recent work has suggested that these waves occur as transient events within distinct wave groups. However, considerable uncertainty remains about the behaviour of non-linear transient water waves.

This dissertation presents the results of a new study on 2-D transient waves, formed through the focusing of wave energy. An extensive laboratory investigation has been undertaken for large number of wave groups with a range of amplitudes and frequency bandwidths. The results show that the focusing of wave energy can produce highly non-linear wave groups, where the non-linearity increases with amplitude but decreases with increasing bandwidth. The underlying kinematics are also highly non-linear. The results show that linear and second order wave theories may significantly under-estimate both the maximum crest elevations and the near surface kinematics. However, a numerical model, which uses a Fourier series solution and a least-squares minimisation of the free surface boundary conditions, is shown to be in excellent agreement with the measured data.

The non-linearity of the transient waves results in the transfer of energy to both higher and lower harmonics. This is consistent with an increase in the local energy density and the formation of steep waves. Furthermore, phase shifts within the group reduce the rate of dispersion, shift the focal point, and appear to increase the group velocity. These effects appear to result from variations in the “effective” gravity, a concept introduced by Longuet-Higgins and Stewart (1960), and are consistent with the notion that the individual wave components become “bound” to the dominant waves within the group. A variation on a mechanism proposed by Lighthill (1978) qualitatively explains both the increased non-linearity and the bandwidth dependence.