Abstract

This work presents two new sets of laboratory observations undertaken in a two dimensional wave flume. The objective of the first laboratory experiment was to simulate realistic ocean spectra evolving over a mild bed slope ($m = 1/100$); the chosen sea states allowing a systematic investigation of the role of local water depth, spectral peak period and significant wave height. A number of wave events propagating in different water depths were selected as part of the second set of laboratory observations. Using Particle Image Velocimetry (PIV) the kinematics underneath the selected wave crests were recorded.

This thesis investigates the statistical distribution of both the wave height (H) and the wave crest elevation (η_c). Following comparisons across a wide parameter range, the crest height distributions are shown to be in poor agreement with the Forristall (2000) and Tayfun (1980) distributions as these do not model effects beyond second order and do not consider wave breaking. In constrast, the wave height distributions in deep and intermediate water depths ($k_pd > 0.72$) are shown to be in reasonable agreement with the Mendez *et al.* (2004) distribution. Finally, in shallow water depths ($k_pd \leq 0.72$), none of the existing distributions provide a good description of the measured data.

The same water surface elevation data is used to investigate the importance of sea state and local parameters in determining the largest and steepest breaking waves and the sucess of a number of commonly used models to provide accurate maximum possible wave criteria. Detailed comparisons show that local wave parameters and a wave number based upon an up-crossing analysis provide the best description of the limiting conditions. The Goda (1970) criterion is found to be the most accurate acrross the broadest range of effective water depths. However, in very shallow water depths none of the breaking criteria are accurate as the the laboratory data shows very large wave height to water depth ratios, $(H/d)_{max} = 1.3$.

The kinematic measurements are used to investigate the influence of local wave parameters on the horizontal velocity underneath the wave crest and to assess the abilty of commonly used wave models to reproduce the measured velocities. This investigation showed that the steady wave theories could only reproduce the horizontal velocities associated with weakly nonlinear waves. The second-

order random wave theory proved very hard to apply as a result of the difficulties in finding an adequate linear spectral input. Conversely, a modified Wheeler empirical model is shown to be accurate for large waves in a broad range of effective water depths.