Abstract

題　目　**Numerical Modelling of a Circular-Water-Basin for Multi-directional Ocean Waves Using a Particle Based Method**

（粒子法を用いた多方向海洋波を再現可能とする円形型数値水槽モデル）

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Compared to shallow water waves, deep water waves tend to be multi-directional (short-crested) waves, rather than uni-directional waves, because of their dispersion, and sea states being far away from shore occasionally become crossing. The multi-directional waves (short-crested and crossing waves) are one of the important design considerations for ocean structures such as ocean energy devices (OED) and vessels; several renewable energy projects have been installed OEDs in deep waters recently for exploiting abundant renewable energy, and a number of vessels have been sunk by freak wave in crossing sea states. Engineers have been considering these, by means of theoretical analysis, laboratory and field experiments, and numerical tools. However, conventional numerical wave tanks tend to be limited to the generation of uni-directional (long-crested) conditions and struggle to properly model large fluid deformations along with wave-induced floating body motions.

The aims of this thesis are to develop a new numerical wave basin for reproducing multi-directional wave fields and to numerically investigate a freak wave, so-called 'Draupner wave', in two crossing wave systems in order to provide further insight into properties of the waves created such as their kinematics and geometry. We use a Smoothed Particle Hydrodynamics (SPH) method to solve the full-3D Navier-Stokes equations (NSE). This Lagrangian and NSE-based-method can fully recreate deep water waves including their non-linearity and dispersion, and enables large fluid deformations to be automatically modelled. The geometry is based on the FloWave facility at the University of Edinburgh and encircled by 168 hinged-flap type paddles on which rotation angle data are individually imposed to reproduce several sea sates. The simulated surface elevations are compared to experimentally-obtained data.

First, we reproduce and validate uni-directional (long-crested) regular/irregular wave trains and dispersive focusing waves (a spike wave) with different particle sizes. Overall, wave fields below 1 Hz show good agreement with experimental data. Then, we simulated and validated multi-directional (short-crested) waves in the proposed numerical basin, varying a combination of four different spreading parameters and two (low and high) peak wave steepness values. The modelled surface results show acceptable agreements and both long, and short-crested waves are reproduced well.

Finally, we numerically reproduce the Draupner freak wave in two crossing wave systems, main and transverse waves with angle θ between them. The validation against experimental data show good agreement in the time domain, and we numerically reproduce wave breaking observed in experiments, where the jet formation and breaking phenomena are qualitatively similar in appearance. For large crossing sea states, we found that the upward jet breaking observed in the experiments could be possible in the forward face of the crest, as the vertical fluid velocity on the face is at least 1.2 times greater than the vertical crest speed. It is also possible that the upward breaking can occur because of the combination of a spilling type breaker and splash-up generation.