



Fully Non-linear Investigation of Freak Waves and their Interaction with Winds and Currents

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Currently, the research related to freak waves includes two main categories. One is the statics of the freak wave generation, which studies the possibility of the occurrences of such extreme wave events. The second one is the local properties of the freak waves. Its outcome benefits accurate estimation of the possible maximum load on the offshore structures. Both are equally important for ocean engineering. We aim to extend our understanding in the freak wave properties related to the second category and the numerical modelling is chosen for the purpose. Furthermore, most of the studies related to the freak wave dynamics are carried out, either experimentally or numerically, in ideal conditions, i.e. ignoring the effects from other waves, the wind effects and the current effects. However, in reality, the effects from the wind and/or currents may be significant and the waves are always observed to be accompanied with other wave groups travelling in different directions. The presentations will summarise our recent studies related to the freak wave dynamics, local wave properties and breaking procedures by using the in-house Quasi Arbitrary Lagrangian Eulerian Finite Element Method (QALE-FEM) based on fully non-linear potential theory, which is able to handle 3D overturning waves and has been proved to be much faster than other numerical tools at the same accuracy level. Three areas will be covered.

- (1) Three-directional freak waves in crossing sea. In this investigation, two focusing wave groups travelling in different main directions are numerically modelled. The change of wave profile or spectrum at the focusing point/time will be reported;
- (2) Wind effects on freak waves. The feature of the air flow and free-surface pressure distribution will be explored by using an numerical approach which combines the QALE-FEM and StarCD software package. Based on this, an empirical formula to impose wind-driven pressure is developed, which is better than other empirical formula in certain conditions and is coupled with the QALE-FEM model to investigate the significance of wind actions on freak waves in the cases with different frequency spectrum;
- (3) Freak waves under action of uniform current. we mainly reveal how the local properties of freak waves under uniform currents are affected by the non-linearity, overturning and wave blocking . The breaking type and breaking limit in the cases with different input wave amplitudes and the current speed will also be discussed.

For all the investigations, the non-linearity in the cases with different wave amplitudes up to wave breaking and different frequency spectra is of special concern.

Keywords: Fully Nonlinear; Freak Waves; Wave-wave interaction; Wind effects; Current Effects; QALE-FEM; Numerical simulation