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Simulation of wave breaking by SPH method coupled with LES turbulence modeling

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Abstract

In this paper a space-averaged Navier–Stokes approach was deployed to investigate the time-dependent wave breaking processes. The developed numerical model is based on the smoothed particle hydrodynamic (SPH) method. SPH is a pure Lagrangian approach which can handle large deformations of the free surface with high accuracy. In this paper a weakly compressible version of the smoothed particle hydrodynamics (WCSPH) method together with a large eddy simulation (LES) approach is used to simulate the wave breaking over a sloping sea wall.

The model results were compared with the experimental data and numerical data of Li et al. and demonstrated a good agreement with these results. The model results show that the SPH method provides an accurate way of tracking large deformations of the free surface.

Introduction

The breaking waves are of great engineering interest because of the tremendous forces they exert on the coastal structures. They also have ability to transport large quantities of the sediment and drastically reshape the coastal bathymetry. The wave breaking is generally classified as the spilling, plunging and surging, with a gradual transition between each regime [1]. In most natural beaches, the commonly observed wave breaking types are the spilling and plunging breakers, in which the latter displays especially spectacular phenomenon. The wave breaking processes must be clarified in order to solve many coastal problems. However, the study of breaking waves is a very difficult task for a number of reasons. For example, the velocity field during breaking is extremely chaotic and varies rapidly in time. The difficulties of measuring velocity due to the existence of air bubbles entrained by the plunging jet have hindered many experimental studies on the wave breaking. Field studies also suffer from the same difficulties as the experiments and, in addition, are hindered by limited site access and environmental variability [2]. The breaking waves experience the rapid wave shape deformation and fast energy dissipation. Thus the numerical studies of the breaking wave are