Large eddy simulation of breaking waves - DTU Orbit (06/04/2019)

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A numerical model is used to simulate wave breaking, the large scale water motions and turbulence induced by the breaking process. The model consists of a free surface model using the surface markers method combined with a three-dimensional model that solves the flow equations. The turbulence is described by large eddy simulation where the larger turbulent features are simulated by solving the flow equations, and the small scale turbulence that is not resolved by the flow model is represented by a sub-grid model. A simple Smagorinsky sub-grid model has been used for the present simulations. The incoming waves are specified by a flux boundary condition. The waves are approaching in the shore-normal direction and are breaking on a plane, constant slope beach. The first few wave periods are simulated by a two-dimensional model in the vertical plane normal to the beach line. The model describes the steepening and the overturning of the wave. At a given instant, the model domain is extended to three dimensions, and the two-dimensional flow field develops spontaneously three-dimensional flow features with turbulent eddies. After a few wave periods, stationary (periodic) conditions are achieved. The surface is still specified to be uniform in the transverse (alongshore) direction, and it is only the flow field that is three-dimensional. The turbulent structures are investigated under different breaker types, spilling, weak plungers and strong plungers. The model is able to reproduce complicated flow phenomena such as obliquely descending eddies. The turbulent kinetic energy is found by averaging over the transverse direction. In spilling breakers, the turbulence is generated in a series of eddies in the shear layer under the surface roller. After the passage of the roller the turbulence spreads downwards. In the strong plunging breaker, the turbulence originates to a large degree from the topologically generated vorticity. The turbulence generated at the plunge point is almost immediately distributed over the entire water depth by large organised vortices. Away from the bed, the length scale of the turbulence (the characteristic size of the eddies resolved by the model) is similar in the horizontal and the vertical direction. It is found to be of the order one half of the water depth.

General information
Publication status: Published
Organisations: Department of Hydrodynamics and Water Resources, Coastal, Maritime and Structural Engineering, Department of Mechanical Engineering
Contributors: Christensen, E. D., Deigaard, R.
Pages: 53-86
Publication date: 2001
Peer-reviewed: Yes

Publication information
Journal: Coastal Engineering
Volume: 42
Issue number: 1
ISSN (Print): 0378-3839
Ratings:
Scopus rating (2001): SJR 0.643 SNIP 1.07
Web of Science (2001): Indexed yes
Original language: English
DOIs:
10.1016/S0378-3839(00)00049-1
Source: orbit
Source-ID: 64102
Research output: Contribution to journal › Journal article – Annual report year: 2001 › Research › peer-review