On the absorption of breaking wave energy in fully nonlinear potential flow model

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In the past 30 years, increasingly accurate and efficient models have been developed to simulate nonlinear wave propagation and transformations over a varying nearshore bathymetry as well as their interactions with submerged and surface piercing fixed or floating structures. One successful approach has been based on models solving Fully Nonlinear Potential Flow (FNPF) theory, by a higher-order Boundary Element Method (BEM), in 2D [e.g., 2, 6, 7, 8, 9, 10, 11] or 3D [e.g., 1, 3, 4, 5, 14, 15]. Such models can accurately simulate overturning waves and have been used to investigate their physical properties just before breaking [e.g., 3, 5, 10]. However, in many naval hydrodynamics and ocean/coastal engineering applications, it is desirable to prevent steep waves from overturning as this eventually leads to instabilities and stops computations. A number of methods have been proposed to do so, some based on specifying an "absorbing surface pressure" [12, 13], similar to the method used in absorbing beaches [6, 7]. Here, we investigate such methods in the context of a hybrid model combining a 3D-BEM FNPF Numerical Wave Tank [14, 15] and a Navier-Stokes (NS) solver, based on a Lattice Boltzmann Method (LBM), for fluid-structure interactions [17]. Impending breaking is detected based on a local maximum free surface slope/steepness criterion, and wave energy is absorbed using a local "absorbing pressure" patch whose strength is calibrated with a physical criterion [e.g., 6, 7, 12, 13]. In the hybrid model complex, the absorbed energy is reconciled with that actually dissipated in the NS-LBM solver. Validation cases of this new "breaker model" are presented for strongly nonlinear waves interacting with a vertical cylinder, for which filtering of free surface instabilities had otherwise been necessary [16].

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