Wave Propagation in a Three-Dimensional, Fully-Nonlinear Numerical Wave Tank Based on Multi-transmitting Formula Coupled Damping Zone Method

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The objective of this work is to develop a novel numerical model solving the coupled internal sloshing and external sea-keeping interaction for small/medium liquefied natural gas (LNG) carrier. Currently, the work focuses on simulating wave propagation in a three-dimensional (3D) fully-nonlinear numerical wave tank (NWT) to model the sea. When simulating the nonlinear wave propagation through an unbounded domain in the time domain, it is necessary to truncate the computational domain artificially into a finite domain in order to reduce computational costs. Thus, non-reflecting radiation boundary condition is required for the truncated surface, however, there is no exact non-reflecting condition in existence. In this work, wave propagation in a 3D fully nonlinear NWT is studied based on the fully-nonlinear velocity potential theory. The governing Laplace equation with fully nonlinear boundary conditions on the moving free surface is solved using the indirect desingularized boundary integral equation method (DBIEM). The fourth-order predictor-corrector Adams-Bashforth-Moulton scheme (ABM4) and mixed Eulerian-Lagrangian (MEL) method are used for the time-stepping integration of the free surface boundary conditions. A smoothing algorithm, B-spline, is applied to eliminate the possible saw-tooth instabilities. An effective multi-transmitting formula coupled damping zone (MTF+DZ) radiation condition is employed to minimize wave reflection on the truncated surface. The numerical results are compared with analytical solutions. It is shown that MTF+DZ method can be used for simulating fully-nonlinear, irregular wave propagation.