Numerical Modelling of 3D Oblique Waves by L-type Multiple Directional Wave Generator

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ABSTRACT

The improvements on the oblique planar wave train in a basin generated by multiple irregular wave generators are investigated numerically in this study. Though oblique waves of any desired incident angle can be generated by serpentiform wave generators as they were settled in a single line, the generations of waves are limited in specific areas in the basin, which the effective experiment area with uniform wave field is narrow; therefore, most landforms and/or model are located too close to the wave generators. In this study, numerical simulations of desired oblique waves are generating separately but simultaneously by the two series of serpent type wave generators set in L-shape to enlarge the effective experiment area. Based on the Lagrangian description with time-marching procedure, a three-dimensional multiple directional wave basin was developed to simulate ocean waves by using the BEM with quadrilateral elements. The simulations of perpendicular waves are executed in the first instance to verify the scheme, and proceed with the generations and propagations of oblique waves in larger angle. Accordingly, the comparison of waveforms variation confirms the estimation of oblique waves a feasible scheme.

KEY WORDS: Boundary element method; quadrilateral element; 3D wave basin; serpent-type wave generator; oblique wave.

INTRODUCTION

To evaluate wave impact on coastal structures, the variations of oceanic physical characteristics must be accurately predicted, e.g. the deformation of wave profile, distribution of wave pressure and the velocities of water particles. Studies of wave-wave and/or wave-structure interactions can be carried out either physically in a wave basin or numerically with 3D numerical model field experiments, accordingly, numerous investigations on 2D and 3D numerical models regarding the simulation of nonlinear waves were enthusiastically established in virtue of the considerably high-speed development of science and technology of electronic calculator during the last two decades, the capability of generating multidirectional waves using the snake principle has been investigated for nearly half a century, but only in the past two decades are they widely used to study these problems numerically in three dimensional computer algorithms. Even though there have been a large progress in computer technology, development of 3D numerical wave tank in practical application have still been an arduous task so far due to its considerable quantities of arithmetic units, i.e., computational workload and memory requirement, therefore, simulations of fully nonlinear waves in three dimensional models are still in straitened circumstances, they are generally restricted to two dimensions, consequently, 2D models have been extensively used for the simulations of higher nonlinear water waves at the beginning. Since the propagating directions and the amplitudes as well as the periods of waves in real sea are quite unorganized, model tests in multi-directional three dimensional wave basins are undoubtedly necessary; hence over the last few years, challenging works are on going and continuous efforts are made to develop practical three dimensional NWTs. Multidirectional wave can be generated by a serpent type wave generator according to the basic of linear wave maker theory (Dean and Darlymple) of each segment. Practical application of this theory with reality is the generator so-called “snake-type” or “serpent-type” wave generator in a physical laboratory. Unidirectional as well as multidirectional waves can be generated spatially by the sinusoidal motion and by the basic of the “snake principle” of the segments of a serpent-type wave generator, respectively. The incident waves are generated by prescribing motions as a series of piston wave makers.

3D NWTs have been used by Xu and Yue (1992) to simulate multidirectional steep waves and their nonlinear interactions with 3D bodies. A THOBEM 3D-model based on the potential theory and perturbation procedure was developed by Boo et al. (1994) for the simulation of linear and nonlinear Stokes 3rd-order irregular waves, the applications of the 3D-NWT were first verified by the studying of the reciprocal effect between wave and stationed obstacles. Three dimensional fully nonlinear waves and wave-body interactions was also studied in a 3D numerical wave tank (NWT) by Celebi et al. (1998) using desingularized boundary integral equation method (DBIEM) and mixed Eulerian and Lagrangian (MEL) scheme. By using a number of wave-makers as absorption facility, a method for active absorption of multidirectional waves in a 3D numerical wave tank model (NWT) has been present by Skourup and Schäffer (1998) based on a traditional 2D active absorption method, i.e. 2D-AWACS (active wave absorption control system). Furthermore, a finite-difference scheme combined with a modified marker-and-cell (MAC) technique was initially developed for the investigation on the characteristics of non-linear