Simulation of wave-induced motions of a moored floating breakwater using SPH method

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Abstract

In this study, the dynamic motions of a rectangular chain-moored floating breakwater with three degrees of freedom (heave, sway, and roll motions) are simulated using a weakly-compressible smoothed particle hydrodynamic (WCSPH) scheme. A regular wave is simulated using a piston type wave maker inside a numerical wave flume. Then, a rectangular moored floating breakwater is placed inside the developed numerical wave flume and the dynamic motions of the structure are recorded. In the developed numerical scheme, the wave-structure and mooring-structure interactions are evaluated by solving new SPH-based equations. In addition, the mooring system is simulated by the SPH particles. Comparing the obtained results from the developed SPH scheme with the experimental data reveals that the modified smoothed-particle hydrodynamic scheme is able to simulate the dynamic motions of a chain-moored floating breakwater with a reasonable accuracy.

Keywords: Wave-structure interaction, Floating breakwater, Chain mooring, Regular wave, WCSPH.

١. INTRODUCTION

Floating breakwater as a special type of breakwater is used for attenuation of the wave effects. In these types of structures, forces exerted by the propagating waves on the structure cause it to move. These motions can also influence the wave characteristics and affect the stability of the structure. To reduce the wave-induced motions, the floating breakwaters are constrained by pile or cable/chain mooring systems.

In literature, there are several experimental as well as numerical studies on the performance of moored floating breakwaters. Yamamoto [١] investigated the response of moored floating breakwater due to regular as well as irregular waves theoretically and compared the results with experimental data. Williams and Abul-azm [٢] studied the hydrodynamic properties of a dual pontoon floating breakwater consisting of a pair of floating cylinders with rectangular section, connected by a rigid deck, theoretically. Bhat [٣] investigated experimentally and theoretically the performance of a rectangular and circular twin-pontoon floating breakwater. His hydrodynamic analysis was based on the linear potential theory which utilizes Green's theorem. Sannasiraj et al. [٤] studied experimentally and numerically the behavior of a pontoon-type floating breakwater with three different mooring patterns. They used a two-dimensional finite element method for solving the potential-based equations. Williams et al. [٥] investigated theoretically the hydrodynamic properties of a pair of long pontoon-type floating breakwaters using the boundary integral equation method. Bayram [٦] conducted an experimental study to evaluate the performance of an inclined pontoon type breakwater under regular waves in intermediate water depths. Abul-Azm and Gesraha [٧] examined theoretically the hydrodynamic properties and dynamic responses of a long floating pontoon-type floating breakwater. Lee and Cho [٨] employed a boundary element method to solve the interaction between waves and a floating breakwater. In another work, a numerical investigation on a moored pontoon-type floating breakwater was carried out by Lee and Cho [٩] using the element-free Galerkin method. Loukogeorgaki and Angelides [١٠] studied the performance of a moored floating breakwater under the action of normal incident waves in the frequency domain using a three-dimensional panel method utilizing Green's theorem. Rosales and Filipich [١١] studied the dynamic behavior of a two-dimensional Catenary Anchor Leg Mooring (CALM) floating structure with a simplified SDOF equation using an algebraic recurrence algorithm. Rahman et al. [١٢] performed a numerical and experimental study to estimate the nonlinear dynamics of a pontoon type moored submerged floating breakwater under wave action and the forces acting on the mooring