10th International Congress on Civil Engineering, 5-7 May 2015
University of Tabriz, Tabriz, Iran

Numerical Study on the Effect of Mooring Line Stiffness on Hydrodynamic Performance of Pontoon-Type Floating Breakwater

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Abstract

In this study a 2D numerical wave tank is built to simulate the wave-body interactions based Reynolds-averaged Navier-Stokes equations. The equations are discretized based on the finite volume method. In order to simulate the turbulence of flow in the wave tank the $k-\varepsilon$ model is used. The numerical model has been provided based on the open source C++ CFD toolbox named open field operation and manipulation (OpenFOAM). For applying the mooring line forces to the floating structure, the elastic catenary equations have been employed. In order to verify the model, calculated results of simulation are compared with the experimental data. Moreover, the mooring lines with different values of stiffness have been examined in different wave periods and the transmission coefficient of the associated data is illustrated.

Keywords: floating breakwater, mooring lines, transmission coefficient, motion response.

1. INTRODUCTION

In the recent decades floating breakwaters (FBs) have been in great demand as an alternative to traditional bottom-founded breakwaters in small marinas and recreational harbours in order to provide a sheltered area. They usually cost less than bottom-founded breakwaters and can be built in areas that the bottom foundation is poor or the areas in which the water depth is in a range that construction of the traditional breakwaters is not economical. They also can be conveniently removed and rearranged into a new layout [1]. In spite of their benefits, FBs are not able to fully attenuate the wave energy and a portion of the energy is always transmitted. The most determinant parameter in evaluating the hydrodynamic performance of FB is the transmission coefficient, defined by $C_t = H_t / H_i$, where H_i is the incident wave height and H_t represents the transmitted wave height. Among different layouts introduced for FBs, pontoon type is more common as a result of good wave attenuation and simple layout [2]. One of the effective factors in the performance of FB is the characteristics of mooring lines. In this paper a 2D numerical wave tank is built based Reynolds-averaged Navier-Stokes equations. The equations are discretized based on finite volume method. In order to simulate the turbulence of flow in the wave tank the $k-\varepsilon$ model is used. The numerical model has been provided based on the open source C++ CFD toolbox named open field operation and manipulation (OpenFOAM). For applying the mooring line forces on the floating body, the elastic catenary equations have been employed [3]. In order to verify the model, the calculated results of simulation are compared with the experimental data [2]. Moreover, the mooring lines with different values of stiffness have been examined in different wave periods and the transmission coefficient and the three modes of motion including sway, heave, and roll of corresponded data are illustrated. The responses are presented in terms of response amplitude operator, RAO (response due to unite wave amplitude).

2. GOVERNING EQUATIONS

Reynolds-averaged Navier-Stokes equations are the governing equations, are as follows [4]: