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# Numerical Investigation of Floating Breakwater Effect on Coastal Waves Attenuation by Smoothed Particle Hydrodynamics Method

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**ABSTRACT:** Waves influence on breakwaters is vital for Prediction of harbors design. Floating breakwaters can be installed, displaced and can be used again in different conditions, even deep waters. But floating breakwaters are useful for special periods due to their complicated reaction to dynamic response of wave transmission. In this study, by an incompressible smoothed particle hydrodynamics method in three steps, coastal waves effect has been investigated on a pair of floating breakwaters and combination of floating-submerged breakwater. The floating breakwater behavior is assumed as a mass-spring system and the influences of inhibitor system tension and wind on the breakwater are neglected. For the validation, the oscillation amplitude variations are compared between the incompressible smoothed particle hydrodynamics results and experimental model which yields to a good adaptability. Breakwater hydrodynamic behavior is investigated versus the sinus-shaped wave different periods, less than 3 seconds. Based on results, using floating breakwater is optimized in wave period of lower than 2 seconds and The presence of a floating breakwaters in the vicinity of the immersion breakwaters helps to stabilize the pressure and reduce the fluctuations. It is also concluded that Floating breakwaters with heave displacement are better than floating breakwaters that are in sway motion.

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## 1- Introduction

Analyzing of free surface flows in coastal regions is very important for surrounding and industrial activities. A large number of coastal structures such as breakwaters have been built to protect of port facilities against wind and coastal waves attack. Floating Breakwaters (FBs) have been widely used as an alternative solution to protect coastal sites specially small harbors and certain areas. FBs characteristic and configurations alleviate some of limitations that oppose the construction of rubble mound breakwater. The efficiency of the FBs profiles and configuration can be quantified by its transmission coefficient. It is defined as ratio of the significant wave height at the lee side of FBs over the significant wave height at the front side [1]. Many researchers have investigated about the effect of different geometry and flow parameters on behavior and performance of breakwaters [2]. Martinelli et al. [3] studied the transmission coefficient and existence forces in various positions of floating breakwater. But majority of studies are experimentally. Because of decreasing the cost of experimental setup and its complexity, numerical models is necessary in this field [4,5]. The Smoothed Particle Hydrodynamics (SPH) mesh free method is a powerful policy for simulation of fluid flow, without the restriction of grid-based numerical models [6,7]. Up to now, three step incompressible SPH (ISPH) [8] has not been used for modeling of FBs. The purpose of this study is to use of this methodology for analyzing the floating breakwater behavior for two models: a double floating breakwater and combination of floating-submerged breakwater. The efficiency of these structures has been discussed for the period of below 3 seconds.

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## 2- Physics of Breakwaters

When the floating breakwater is set on static water, there isn't any force, but coastal waves push and move them as mass-spring system and additional effect (force) is resulted. This added effect is added mass. The added mass coefficients of heave and sway (vertical and horizontal) movement has been measured by vugts [9] for 2 dimensional rectangular structures with width/draft relations of 2, 4 and 8.

## 3- Geometry and Arranging the Particles

2D model of this research has been shown at Fig.1. Geometry is consist of two squares 0.5 m×0.5 m, with 0.3 m height of floating and on the left side, wave maker generates a sinus-shape wave. Fig. 2 shows arrangement of the SPH particles for solution.

## 4- Governing Equations and ISPH Formulation

System of equations governing the flow field including continuity and momentum equations, are as follows:

$$\nabla.\vec{u} = 0 \tag{1}$$

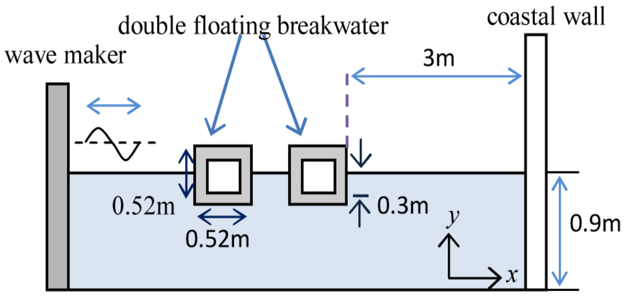


**Fig. 1. 2D geometry of a double floating breakwater**

$$\frac{D\vec{u}}{Dt} = -\frac{1}{\rho}\nabla P + \vec{g} + \frac{1}{\rho}\nabla.\vec{\tau} \tag{2}$$

The foundation of SPH is based on the interpolation theory [6,7]. This theory indicates that each arbitrary continuously defined function can be expressed as an integral form over a domain. Based on ISPH method, the velocity is corrected three times and in the third step a Poisson's equation is solved; finally Navier-Stokes equations are solved on a set of discrete points by definition of an interpolation kernel [6-8]. The current work uses a validation test case, corresponding to the experimental setup of Martinelli et al. [3] and the total trend of vertical displacement is consistent.

## 5- Results and Discussion

### 5- 1- Double floating breakwater

Transmission coefficient ($C_t$) is defined as Eq. (3). With considering both movement, period of 2 seconds is the best and heave breakwaters are better than sway ones.

$$C_t = H_t / H_i \tag{3}$$

First, in double floating breakwater, the pressure and sea surface elevation variation near the seawall for different periods has been investigated at the heave and sway motion, individually. Based on results, the heave movements are more than the other. Results for elevation variation has been presented at Figs. 3 and 4.

### 5- 2- Combination of floating-submerged breakwater

Then, the mentioned parameters in presence and in absence of the submerged breakwater (trapezoid shape) has been evaluated as shown in Figs. 5 and 6.

## 6- Conclusions

2D model of this research investigates FBs by ISPH method. Based on results, using FB is optimized in wave period of lower than 2 seconds and the presence of submerge breakwater in vicinity of FB lead to reduce sea surface oscillations and pressure stability and also floating breakwaters with heave displacement are better than floating breakwaters that are in sway motion in this specific periods.

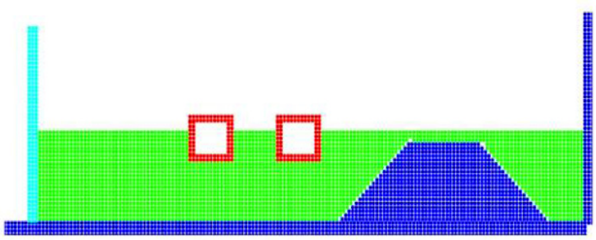

**Fig. 2. Arranging of the SPH particle, Combination of floating-submerged breakwater**

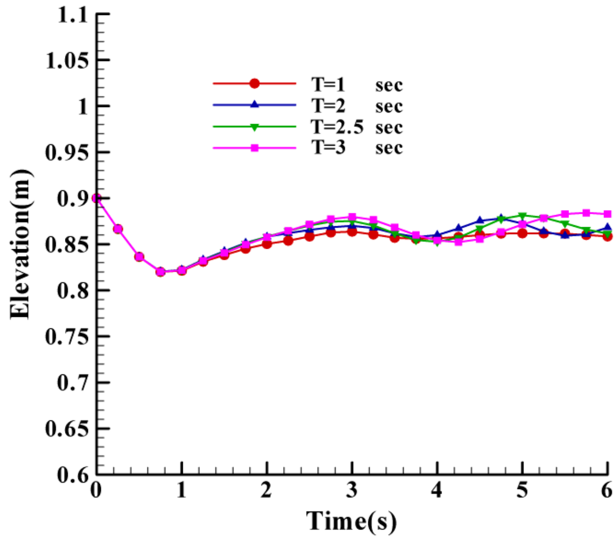


**Fig. 3. Sea surface elevation near the seawall, sway.**

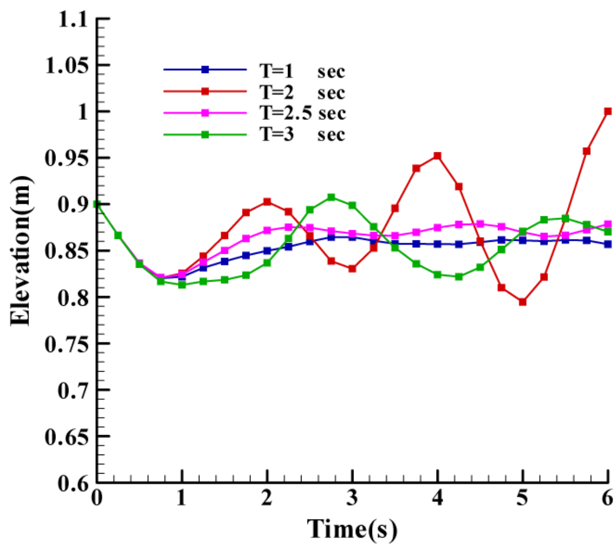


**Fig. 4. Sea surface elevation near the seawall, heave.**

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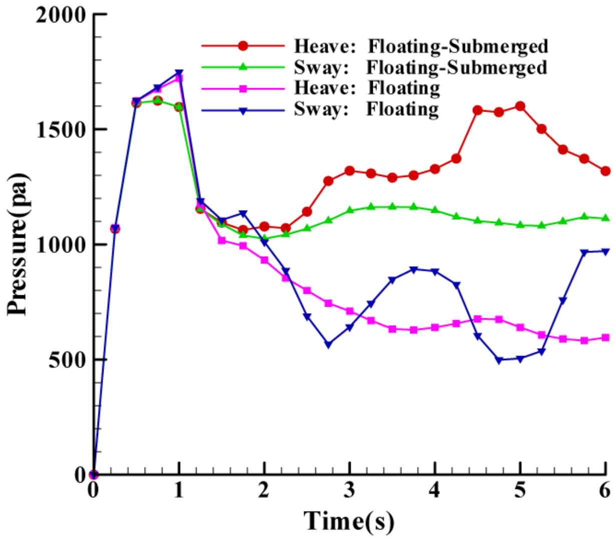


**Fig. 5. Pressure variation versus time near the seawall**

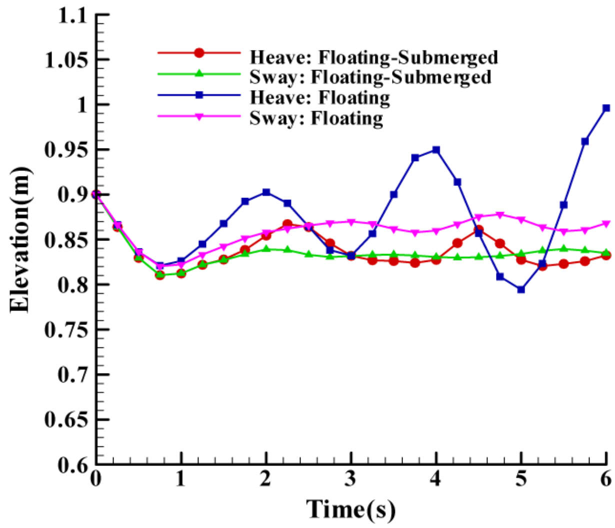


**Fig. 6. Elevation variation versus time near the seawall**

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