Shahid Chamran University of Ahvaz

Irrigation Sciences and Engineering **Vol. 41, No. 3, Fall 2018, p. 89-102**

EXTENDED ABSTRACT

Evaluation of Dynamic Pressure on Compound Perforated Wave Screen under Regular Waves

N. Azam[1*], F. Salmasi[2], M.A. Lotfollahi Yaghin[3], J. Parsa[4] and A. Mojtahedi[5]

1*- Corresponding Author, Ph.D. Student, Department. of Water Eng., University of Tabriz, Iran.*(naval.azam@yahoo.com).*
2- Associate Professor, Department. of Water Engineering, Tabriz University, Iran.
3- Professor, Department. of Civil Engineering, University of Tabriz, Iran.
4- Assistant Professor, Department. of Water Engineering, Tabriz University, Iran.
5- Associate Professor, Department. of Civil Engineering, University of Tabriz, Iran.

Received: 30 October 2016 Accepted: 12 February 2017

Keywords: Wave Screen, Dynamic Pressure, Regular Wave, Shore Protection.

Introduction

Coasts play an important role in economy of each country for their strategic location for residential, recreational, and industrial activities. Hence, a need has arisen to protect and maintain these coasts against waves and currents. (Rageh et al., 2009).

The main cause of damage to coastal structures is the wave impact force. Protective structures such as submerged breakwaters, screen breakwaters, and various piles are often designed to provide additional attenuation of the impact force impact. The use of vertical slotted barriers can be a cost effective solution for wave energy dissipation when sloped rubble structures are not desirable. For a cost-effective design of such barriers, an accurate estimation of dynamic pressures characteristics is needed.

Many experimental and theoretical studies were carried out for determining the dynamic pressures acting on different shapes or structures supported on piles. Neelamani & Sandhya (2005) investigated wave reflections, run-up and run-down, and wave pressures on plane, dentate and serrated seawalls. Krishnakumar et al. (2010) studied the effect of wave screens on the reduction of pressures and forces on a vertical wall on its lee side due to directional waves. Shih (2016) investigated the performance of a pervious pipe screen breakwater installed in front of a seawall in terms of reducing the wave impact force and wave pressure. The preceding brief review suggests that there is not much experimental data published on the wave induced dynamic pressures acting on compound wave screen. In this study, experimental investigations on wave pressures on different compound wave screen configurations were carried out in regular wave. The wave screen consists of a perforated wall that extends from above the seawater to above the seabed. The gap between pipes allows the seawater exchange, the sediment transport and the fish passage and the results of this study can be used for a better hydrodynamic design of vertical structures.

Methodology

Froude scaling technique was adopted for physical modeling, which allows for the correct reproduction of gravitational and fluid inertial forces. A scale of 1:10 was selected for the selection of model dimensions and wave properties in the present study. The proposed breakwater can be used to model water depths ranging from 5 to 10 m. However, the present study is carried out in the laboratory for a constant water depth of 0.60 m, wave periods ranging from 0.8 to 1.3 s. These ranges correspond to 6.0 m water depth, 2.5-4.1s wave period in the prototype, respectively.

Several experiments were carried out in a wave flume with 13.0 m length, 1 m deep, and 1.2 m wide in the Marine Structures Laboratory of the Faculty of Civil Engineering, Tabriz University. A flap type wave generator was installed at one end of the flume. A wave absorber with slope of 3:1 was installed at the other end of the flume to absorb the transmitted waves. The tested breakwater model was placed at the middle of the wave flume. The wave screen consists of several horizontal pipes with constant distance between them. Details of the incident wave characteristics are shown in Table (1).

Table 1- Incident Waves Characteristics

T(s)	L(m)	k=2π/L (1/m)	c=L/T (m/s)	H_i/L	d/gT^2
0.8	1	6.28	1.25	0.06-0.08	0.096
0.9	1.26	4.98	1.40	0.048-0.063	0.076
1	1.54	4.08	1.54	0.039-0.052	0.061
1.1	1.83	3.43	1.66	0.033-0.044	0.051
1.2	1.12	2.96	1.77	0.028-0.034	0.042
1.3	1.42	2.60	1.86	0.025-0.033	0.036

This study investigated the acting dynamic pressure on elements of wave screen. Four pressure transducers were placed at different positions *(z/d)* where, *z* is the position of pressure transducer from the still water line, *d* is the water depth. Fig. (1) shows the wave screen model and layout of the pressure transducer on wave screen model used for the present study.

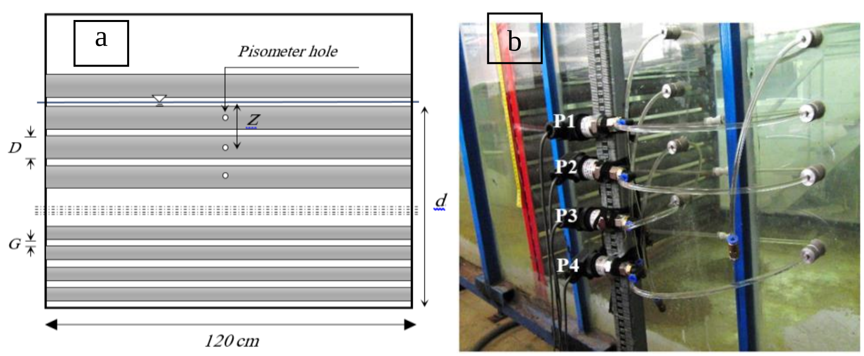


Fig.1- (a) Wave screen model, (b) Layout of the pressure transducer on wave screen model.

Waves for each run were generated for a total duration of 60 s. Data for each run was acquired with sampling speed of 20 samples/s. Several runs with regular waves were conducted with different wave heights, wave periods and structural parameters.

Results and Discussion

In general, when a structure is installed in a marine environment, the presence of that structure will alter the flow pattern in its immediate neighborhoods, resulting in one or more of the following phenomena; (1) contraction of flow, (2) formation of a horseshoe vortex in front of the structure, (3) formation of lee-wake vortices (with or without vortex shedding) behind the structure, (4) generation of turbulence, (5) occurrence of reflected and diffracted waves, and (6) occurrence of wave breaking. These phenomena affect the dissipation of wave energy in addition to the dissipation caused by the structure itself, (Rageh and Koraim, 2010; Reddy and Neelamanit, 1992).

In this study, time domain analyses were carried out on the pressure time series for obtaining information on the wave pressures. Schematic view of the compound wave screen model with circular horizontal elements and impact of the waves against the wave screen is also presented in Fig. (2).

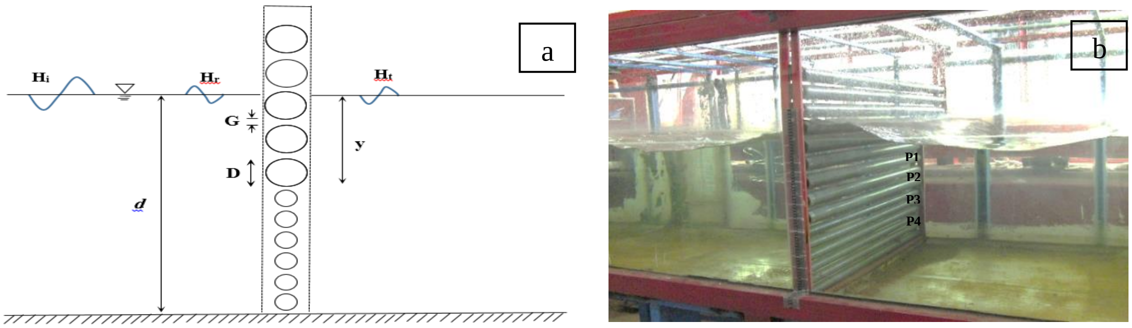


Fig. 2- (a) Schematic view of the compound wave screen model with circular horizontal elements, (b) Impact of the waves against the wave screen

In order to understand the dependence of the frequency, the variation of normalized pressure (p/H_i) with d/gT^2 for different layout of models for a constant $z=0.245$ for $H_i/d= 0.1$ and $H_i/d= 0.13$ is plotted in Fig (3). The plot shows that the dimensionless pressure on the wave screen decreases with an increase in d/gT^2. Furthermore, the normalized pressure increases with an increase in relative configuration depth *(y/d)*.

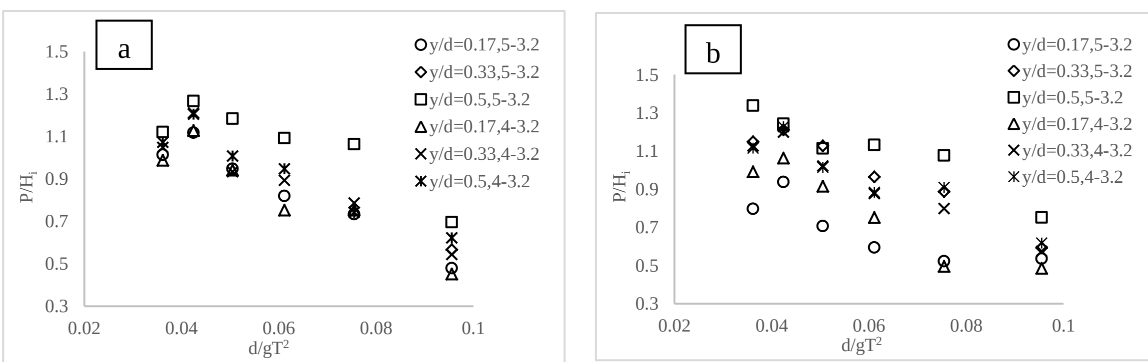
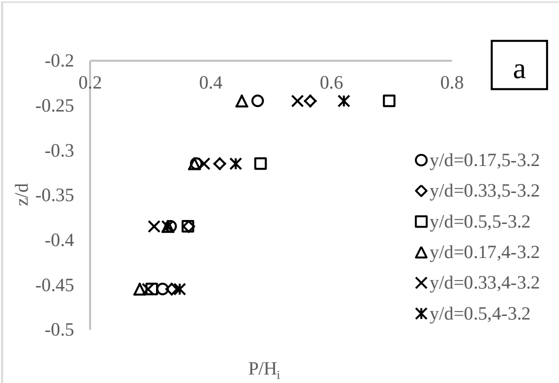


Fig. 3- Variation of dimensionless pressure with relative water depth on the different layout models for z/d=0.245 (a) for $H_i/d=0.13$, (b) for $H_i/d=0.1$.

Variation of dimensionless pressure with water depth on the different layout models for $d/gT^2=0.095$ for $H_i/d= 0.1$ and $H_i/d= 0.13$ is plotted in Fig (4). Experimental results indicated that the dimensionless pressure on the wave screen increases with a decrease in relative water depth.



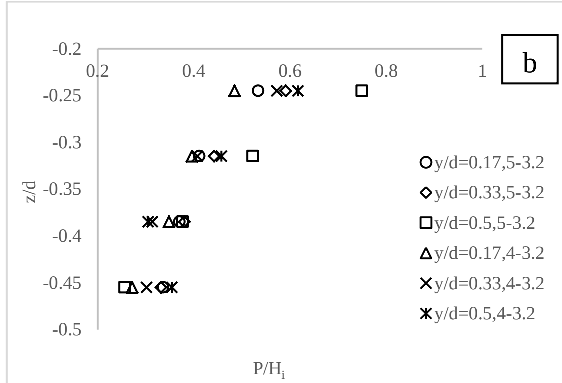


Fig. 4- Variation of dimensionless pressure with water depth on the different layout models for d/gT^2=0.095 (a) for H_i/d=0.13, (b) for H_i/d=0.1.

Conclusions

A wave screen is tested in a small scale test set-up (at scale 1:10) using regular waves for six different values of wave height and wave period. Pressures on the models have been measured by 4 pressure sensors using 20 kHz sampling frequency. A parametric analysis of measured pressures on the scaled model is conducted. Resulting from the experiments, the following conclusions are drawn:

Experimental results revealed that the dimensionless pressure on the wave screen under regular waves increases with a decrease in relative water depth and an increase in relative configuration depth. This increasing due to the increasing in configuration depth for 5-3.2 compound structure is around 52% and for 4-3.2 compound structure is around 47%. Furthermore, the effect of configuration depth change on wave pressure extent is greater than diameter of pipes structure change.

References

1- Krishnakumar, C. Sunder, V. and Sannasiraj, S. A. 2010. Pressures and forces due to directional waves on a vertical wall fronted by wave screens. Applied Ocean Research. 32 (1): 1-10.

2- Neelamani, S. Sandhya, N. 2005. Surface roughness effect of vertical and sloped seawall in incident random wave fields. Ocean Engineering. 32: 395–416.

3- Rageh, O. S. Koraim, A. S. 2010. Hydraulic performance of vertical walls with horizontal slots used as breakwater. Coastal Engineering. 57: 745–756.

4- Rageh, O. S. Koraim, A. S. Salem, T. N. 2009. Hydrodynamic efficiency of partially immersed caissons supported on piles. Ocean Engineering. 57: 1112–1118.

5- Reddy, M. S. Neelamanit, S. 1992. Wave transmission and reflection characteristics of a partially immersed rigid vertical barrier. Ocean Engineering 19(1): 313–325.

6- Shih, R. S. 2016. Investigation of random wave impact on highly pervious pipe breakwaters. Ocean Research. 58 (1): 146–163.