University of Tabriz

Journal of Civil and Environmental Engineering
Volume 52 (2022), Issue 2 (Summer), 1-13

EXTENDED ABSTRACT

Experimental Analysis of the Effect of the Distance of a Submerged Berm in front of a Reshaping Rubble Mound Breakwater on Diminishing the Damage Parameter

Mohammad Taghi Alami [a,*], Ramin Vafaeipour Sorkhabi [b], Alireza Naseri [c], Alireza Mojtahedi [a]

[a] *Faculty of Civil Engineering, University of Tabriz, Tabriz, Iran*
[b] *Department of Civil Engineering, Tabriz Branch, Islamic Azad University, Tabriz, Iran*
[c] *Aras International Campus, University of Tabriz, Tabriz, Iran*

Received: 26 April 2021; **Accepted:** 29 May 2021

Keywords:
Rubble mound breakwater, Random wave, Damage parameter, Submerged obstacle, Photogrammetry.

1. Introduction

Numerous studies have been conducted on the performance of breakwaters. Armor layer stability and structural porosity, height, and size on reshaping rubbed mound breakwaters have been frequently studied. Sayao and Da Silva (2016) analyzed the relationships of breakwater parameters, e.g., wall slope, crest width, and height, with the behavior of incident waves. It is crucial to evaluate the stability and damage parameter of breakwaters. Research has shown that characteristic variables are important in the damage estimation of breakwaters to improve accuracy and reduce tests (Janardhan et al., 2015). Submerged breakwaters reduce wave energy and can be an effective alternative to protect the existing breakwaters (Bungin, 2021). The present study aimed to explore the effects of a submerged obstacle in the seaward (and its position) on the stability of a rubble mound breakwater based on the damage parameter. Tests were carried out in the absence and presence of a submerged obstacle at a distance of 0-20 cm with 5-cm intervals (seaward) to evaluate the effect of the distance on the breakwater damage parameter.

2. Details of experimental study

The tests were performed in a 35-m flume at the SCWMRI, and random waves with a JONSWAP spectrum were employed to evaluate structural performance. The features of breakwater and obstacle, are shown in Fig. 1.

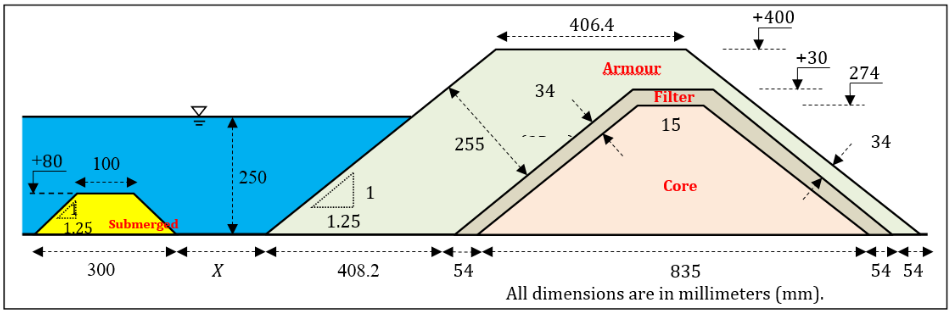

Fig. 1. Transversal section of the wave flume and the position of the breakwater and the obstacle

* Corresponding Author
E-mail addresses: mtaalami@tabrizu.ac.ir (Mohammad Taghi Alami), raminvafaei@yahoo.com (Ramin Vafaeipour Sorkhabi), alireza1naseri@gmail.com (Alireza Naseri), a.mojtahedi@tabrizu.ac.ir (Alireza Mojtahedi).

Research has shown that damage propagation is complex in the armor layer as wave incidence is stochastic. Hence, it is important to monitor breakwaters through advanced imaging equipment and damage propagation modeling and investigate the significant parameters of the process (Campos et al., 2020). Close-range photogrammetry was employed, developing a 3D model of the breakwater to plot the breakwater deformation profile through displacement imaging. The 3D plot measured the eroded area and damage parameter in eight transverse sections. A literature review suggests that stability was evaluated only in the side or middle section of breakwaters in earlier works. However, the present study used imaging to obtain the dense cloud and 3D integrated model with a realistic structure and different elevations before and after wave incidence.

3. Results and discussion

Tests performed in the research are shown in Table 1. By the test results, the first 3000 wave hits account for 90% of the breakwater's final erosion and profile transformation. As well, increasing the wave height increases the damage parameter; increasing the relative wave height from 0.36 to 0.48 and then to 0.6 increases the damage parameter by 39.12 and 44.44%, respectively. Also, the damage parameter increased with longer periods. Increasing the relative wave period from 0.6 to 0.8 and then to 1 increases the damage parameter by 22.94 and 28.26%, respectively. Also, Table 2 demonstrates damage parameters in sections, height, period, and the number of waves calculated based on the experiments. In this table, H_{wm} is the wave height defined for the wave maker, H_s, the significant wave height taken from the water surface, T_{wm}, the wave period specified for the wave maker, T_s, the significant wave period taken from the water surface, N, the number of waves expected and N_{pr} the number of waves taken from the water surface.

Table 1. Performed tests

Test	Breakwater arrangement modes with obstacle
RB	Breakwater without obstacle
RBS0	Breakwater along with the connected obstacle
RBS5	Breakwater along with the obstacle at 5 cm
RBS10	Breakwater along with the obstacle at 10 cm
RBS15	Breakwater along with the obstacle at 15 cm
RBS20	Breakwater along with the obstacle at 20 cm

Table 2. Damage parameter in sections, height, period, and number of waves calculated in tests

Breakwater	*H* (cm)		*T* (s)		*N*		S									
	H_{wm}	H_s	T_{wm}	T_s	N_0	N_{pr}	S_{10}	S_{20}	S_{30}	S_{40}	S_{50}	S_{60}	S_{70}	S_{80}	S_{max}	$S_{min(Final)}$
RB	12	11.52	1	0.95	3000	2783	1.033	1.116	1.075	1.099	1.048	1.014	1.017	0.959	1.116	0.679
RBS0	12	11.29	1	0.96	3000	2593	0.626	0.574	0.572	0.701	0.699	0.698	0.660	0.516	0.701	
RBS5	12	11.38	1	0.98	3000	2729	0.613	0.591	0.613	0.601	0.679	0.495	0.402	0.474	0.679	
RBS10	12	11.63	1	0.94	3000	2801	0.517	0.541	0.583	0.591	0.768	0.647	0.630	0.471	0.768	
RBS15	12	11.73	1	0.98	3000	2855	0.642	0.627	0.826	0.736	0.758	0.746	0.734	0.662	0.826	
RBS20	12	11.41	1	1.01	3000	2699	0.824	0.763	0.822	0.945	0.872	0.894	0.993	0.845	0.993	

Fig. 2. compares the reshaped rubble mound breakwater profile in all test conditions. Analysis of the test results shows that a defender distance of 5 cm from the breakwater was the most effective distance and minimized the damage parameter; it led to a 39.15% reduction in the damage parameter. From a physical perspective, it was observed that the submerged obstacle in front of the breakwater served as a support structure and reduced sliding, preventing armor layer erosion. The distance between the submerged obstacle and breakwater would be filled with the eroded portion of the armor layer, which becomes a part of the breakwater and contributes to its stability.

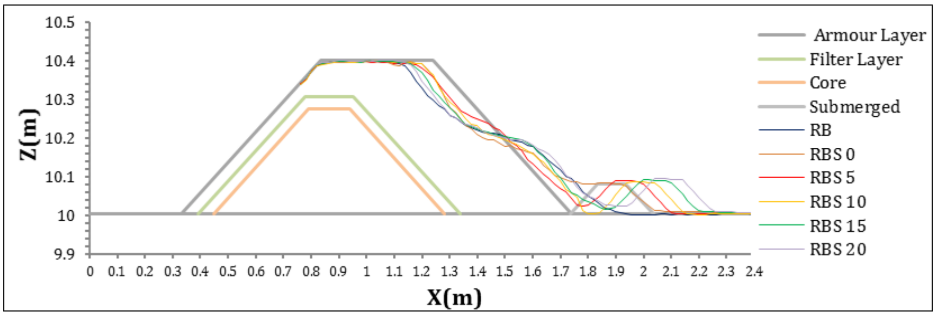

Fig. 2. Reshaped Rubble mound breakwater profiles in all test modes

4. Conclusions

Using a submerged obstacle in front of the main structure to protect against the waves intense effect can be considered a suitable and effective method. The tests revealed that at 5 cm, spacing between the submerged obstacle and the rubble mound breakwater was the most effective in lowering the damage parameter by 39.15%. Accordingly, a 5 cm distance was proposed between the submerged obstacle and the rubble mound breakwater. It should be mentioned that the calculations were carried out merely based on the damage parameter, and future studies are required to evaluate other parameters.

5. References

Bungin ER, “The effect of square submerged breakwater on wave transmission in the coastal area”, AC2SET (2020), IOP Conference series: Materials Science and Engineering, 2021.

Campos A, Castillo C, Sanchez RM, “Damage in rubble mound breakwaters. Part I: Historical review of damage models”, Journal of Marine Science and Engineering, 2020, 8, 317.

Janardhan P, Harish N, Rao S, Shirlal KG, “Performance of variable selection method for the damage level prediction of reshaped berm breakwater”, ICWRCOE, Aquatic Procedia, 2015, 4, 302-307.

Sayao O, Da Silva RF, “Analysis of rubble mound breakwater damage: Case study of existing breakwater rehabilitation”, IX Pinac Copedec Conference, 2016.