Research and application of floating breakwater
Taoran Zhou, Zichao Li

Abstract—As a kind of technical equipment for wave prevention and wave dissipation, floating breakwater has attracted more and more attention of researchers. Starting from the research progress and application status of the floating breakwater, this paper combs the research status of the floating breakwater, summarizes the application status of the floating breakwater, and obtains the key points of the technical improvement of the floating breakwater. Finally, the future development of the new type of floating breakwater is summarized in terms of its application prospect, wave dissipation principle and application of new materials, which provides a strong reference for the relevant research of the floating breakwater.

Index Terms—Floating breakwater; Wave elimination; Research progress

I. BACKGROUND

In recent years, with the continuous advancement of the ocean development process, ocean development has gradually shifted from near coastal areas to deep-water areas with rapid waves and complex foundation conditions. The coastal and offshore engineering fields are also facing unprecedented opportunities and challenges. How to save the construction cost and extend the service life of the marine structure is particularly urgent under the premise of ensuring the safety of the operation of marine structures.

In order to further develop and utilize the island resources, more and more marine auxiliary structures appear in the coastal area and the sea area near the island, as shown in Figure 1. Various types of floating structures have been proposed one after another, including offshore floating wind power generation device, offshore floating island, deep sea cage and super large offshore floating structure.

As an important technical equipment of wave prevention and wave dissipation, breakwater has attracted the attention of scholars all over the world. As shown in Figure 2, as the core of wave elimination technology, floating breakwater has lower cost and stronger adaptability to foundation. Floating structure also determines its strong exchange capacity with sea water and has lower impact on environment during construction.

II. RESEARCH PROGRESS OF FLOATING BREAKWATER

In recent years, with the increasing application of floating breakwaters, as many as dozens of different types of floating breakwaters have been proposed. Different types of floating breakwaters have different wave attenuation methods, as shown in Figure 3.
Md. Ataur Rahman\(^1\) (2010) based on the coupling method of SOLA-VOF method and porous model, established two-dimensional numerical models of box submerged breakwater with three different mooring methods, and carried out relevant two-dimensional flume tests. The results show that the numerical simulation method is accurate. As shown in Figure 4.

Piero Ruol\(^2\) (2013) conducted physical model tests on eight types of Π type floating breakwaters of 16-76kg in total for the purpose of defining the empirical method applicable to the prediction of the performance of conventional floating breakwaters. An empirical correction method of the transmission coefficient between the test results and the standard drawing system is proposed. The accuracy is higher by comparing the test results. As shown in Figure 5.

Huang\(^3\) (2014) carried out a comparative test on the wave attenuation performance of rectangular floating breakwater with and without channel grids, as shown in Figure 6 (a). The results show that: 1) adding slot grid to the rectangular floating breakwater can improve the wave attenuation performance without increasing the heave and surge response of the breakwater; 2) adding slot grid to the rectangular floating breakwater can reduce the surge response of the floating breakwater for the wave with small period. For waves with large period, the increase of channel grid will intensify the pitching motion of floating breakwater.

H. M. Teh\(^4\) (2015) takes H-type floating breakwater as the research object, through physical model test, study its wave attenuation performance characteristics, as shown in Figure 6 (b). The results show that: 1) the H-type floating breakwater can reflect the wave in front of the breakwater well and consume wave energy; 2) the wave attenuation performance of the H-type floating breakwater is greatly affected by the relative draft, but less affected by the wave load factors.

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Figure 3 Three typical floating breakwaters.

Figure 4 Box type breakwater with different anchoring forms

Figure 5 Π type floating breakwater with different structure

Figure 6 Different box floating breakwaters
Then the United States, Japan, Australia, Canada and the Netherlands have launched the application of the floating breakwater. The specific application situation is as follows:

The pontoon type floating breakwater established in Port Orchard Washington state in 1974 has a total length of about 450m, a width of about 3.66M and a height of about 0.9m, which is used to protect the berthing safety of ships, as shown in Figure 7.

Figure 7 Orchard Harbor Floating Breakwater

In May 1999, Department of the United States conducted a 10-day sea wave attenuation test on the V-type floating breakwater code xn99 at Canaveral port, Florida, as shown in Figure 8. Xm99 is a new type of steel truss structure based on the soft shutter. Each support is about 77m long, 2.4m wide and 7.3m deep. The angle between the two supports is about 60 degrees.  

Figure 8 V-shaped floating breakwater test

The floating breakwater project of Hercule port in Morocco is the largest box type floating breakwater put into use at present, with a construction cost of more than 320 euros per cubic meter. The floating breakwater is jointly constructed by Spanish ship enterprises and construction companies. It is composed of reinforced concrete with length of 352.5m, width of 28m and draft of 16m. Parking lot and shopping center are set inside the empty structure. As shown in Figure 9.

(a) Construction of floating breakwater in Morocco
In order to ensure that the progress of the project will not be affected, the Hong Kong Zhuhai Macao Bridge construction company temporarily arranged a container floating breakwater with a total length of about 600m in the northwest of the artificial island. The floating breakwater consists of 30 containers, 136 anchor chains, 50 anchor blocks and auxiliary materials, with a total cost of about 4.8 million yuan. In order to prevent the container from being damaged under the wave load, the construction company shall add channel steel, angle steel, diesel barrel and other reinforced structures inside the container, and add anti wave plate on the top of the container. As shown in Figure 10.

Figure 10 Hong Kong-Zhuhai-Macao Bridge Container Floating Breakwater

Summary of application of floating breakwater: 1) although the application of floating breakwater started earlier, it has not been widely used so far; 2) the floating breakwater is mostly used to protect aquaculture areas, the application waters are limited to the coastal areas, and the application of far-reaching sea and other related products and concepts are relatively less; 3) The floating breakwater has a variety of structural materials, including traditional reinforced concrete, new container steel structure and high-density polyethylene (HDPE) structure; 4) the floating breakwater has a variety of configurations, including traditional box type floating breakwater, new double channel floating breakwater, floating raft and floating island. With the upgrading of domestic mariculture industry, the development of lake management market, the implementation of cross Lake Bridge, cross sea bridge and other projects, and the promotion of South China Sea development process, the development and application of floating breakwater related technologies will usher in a high-speed development stage.

From the application of the floating breakwater mentioned above, at present, the floating breakwater is mainly used in the coastal waters near the shore, and the rectangular floating breakwater with reinforced concrete structure is mostly used. At present, the use of the floating breakwater which is suitable for deep water area to eliminate long-period waves is less, which needs further research and development.

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First Author Taoran Zhou, School of Naval Architecture & Ocean Engineering , Jiangsu University of Science and Technology, Zhenjiang, Jiangsu, China

Second Author Zichao Li, School of Naval Architecture & Ocean Engineering, Jiangsu University of Science and Technology, Zhenjiang, Jiangsu, China

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