Review on research progress of floating breakwater

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Abstract—**As a kind of permanent or temporary structure, floating breakwater has a wide application prospect in the fields of deep-water harbors, wharf waters, aquaculture and offshore construction. This paper summarizes the classification and application of floating breakwater at home and abroad, and finally puts forward the development status of the theory of floating breakwater. The key technical points are also shown finally.**

Index Terms—**Floating breakwater; Classification ; Key technology**

I. Background

With the development of the exploitation and utilization of marine resources from shallow water to deep water, how to deal with the complex and harsh marine environment and how to obtain marine resources while reducing the damage and impact on the marine ecological environment are the key problems to be solved. Therefore, floating offshore structures emerge as the times require.

Breakwater is a common port and coastal engineering structure, which is mainly used to defend the waves from the open sea, maintain the stability of the water area in the port, protect other port engineering buildings, and ensure the safety of ships in and out, berthing and loading and unloading operations.

In addition, in some sea areas, the breakwater can also prevent a large number of flowing ice from flowing into the harbor and reduce the sediment deposition in the harbor. The traditional breakwater structure usually adopts the fixed form. With the development of the ocean, the cost of the fixed breakwater becomes expensive and the construction becomes very difficult. Therefore, the research of floating breakwater has become one of the key technologies of port engineering construction in the world.

The advantages of floating breakwater are: single breakwater is small in volume, light in weight, easy to disassemble and assemble, easy to transport; simple in structure, many optional materials, assembly line production and low in construction cost.

Fig.1 Floating breakwater in Condamine

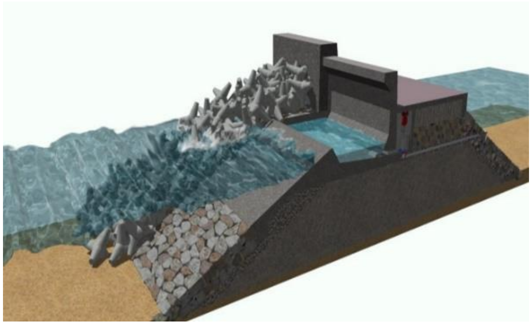

Fig.2 Floating breakwater model

Fig.3 Floating using in Israel

II. Classification of Floating Breakwaters

At present, according to the different structural types, floating breakwater can be divided into three types: floating box type, pontoon type and floating raft type.

Floating box type floating breakwater is the most common, the wave elimination mechanism of this type of floating breakwater is to use the wave front to reflect the incident wave, so as to reduce the transmitted wave. The box type floating breakwater is usually made of reinforced concrete, and the cuboid structure is a common geometry. The wave attenuation effect of the box type floating breakwater mainly depends on the water retaining area of the floating box and B/L (the ratio of the width of the breakwater to the wavelength). It can be explained theoretically that the deeper the water entry depth of the floating breakwater is, the greater the reflection of the floating body on the wave is, and the smaller the transmission coefficient is. The larger the width of the breakwater is, the larger the area that interferes with the water around it is, and the smaller the transmission coefficient is. The model can be seen in Fig.4.

Pontoon type floating breakwater is the second kind. The wave absorbing mechanism and construction materials of this type of floating breakwater are similar to those of pontoon type floating breakwater, and the wave absorbing performance is slightly better than that of box type floating breakwater. The common structural form of this type of floating breakwater is frame structure

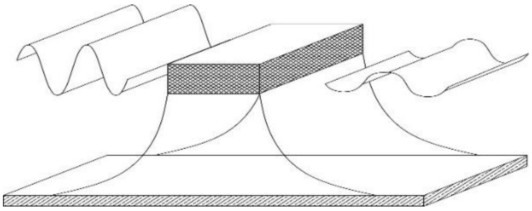

Fig.4 Model of breakwater

III. Application and development of floating breakwater

In 1962, Nanjing Institute of water resources and Hydropower Science designed the reinforced concrete rectangular section floating navigation breakwater, and arranged in Danjiangkou reservoir, Hubei Province. The floating breakwater is divided into two sections, with a total length of 134m, a reinforced concrete floating box with a width of 10m, a depth of 3M, a draft of 1.5m and a design wave height of 2.2m. In 2002, the first floating breakwater was built in the Taishan sea area of Lianyungang, Jiangsu Province. The breakwater is two rows of 90cm diameter automobile tires. The tires are connected with steel ring and U-ring, and anchored on 10 tons of reinforced concrete block by anchor chain. The dike type has the advantages of low cost, removable and movable, and the most important is that it will not affect the water exchange in the layout area, which is of great significance to the local marine aquaculture industry. The effect of short period wave on cage culture is very great, but the short period wave wave can be weakened obviously after the effect of wave cutting raft between two rows of tires in floating breakwater.

In 1930, Japan built the first floating breakwater in Aomori harbor to test its wave resistance and wave dissipation performance. In 1976, a rectangular box type floating breakwater was built in Fukuyama, Japan, with a total length of 275m. It consists of two 60m long and two 70m long pontoons. The pontoon is 10m wide, 3M deep and 2m draught. The longitudinal spacing between pontoons is 5m, and each pontoon is equipped with six anchors.

During World War II, in 1944, the Allies laid the famous bombardon floating breakwater along the Normandy coast 1.6km away. The dimensions of each unit were 60m long, 7.5m wide and 7.5m high.

The floating breakwater system of port Tiffany wharf is located in the Gulf of Georgia in Midland, Ontario, as part of a new wharf and apartment development project. In this project, the floating breakwater system is used as a wharf to save space and cost. The protection range of the floating breakwater is about seven to eight thousand meters.

At present, the largest pontoon type floating breakwater in the world is located in Rabat port, Morocco, with a length of 352m, a width of 28m, a total weight of 13000 tons and a cost of 330 million euros. It is a reinforced concrete structure with a length of 352m, a width of 28m and a total weight of 13000 tons.

Fig.5 Construction of bombardon floating breakwater

Fig.6 Breakwater in Port Orchard Washington State, USA

Fig.7 Floating breakwater of port Tiffany Wharf

IV. Research status of floating breakwater technology

Karmakar et al. [1] studied the interaction between the surface gravity wave and several vertical wall type membrane breakwaters in finite water depth based on linear wave theory. The reflection and transmission coefficients were analyzed by comparing the results of different boundary conditions of fixed and mooring type. The results show that the reflection coefficient increases with the increase of film length and membrane tension in the case of single side wall film, and the multilayer film is helpful to reduce the wave transmission. Peng et al. [2-3] established a two-dimensional numerical model to study the interaction between submerged rectangular floating breakwater and wave. The reliability of the numerical model was proved by comparing the numerical and experimental results. Sanasiraj[4] studied the performance of the pontoon Breakwater by using two-dimensional finite element model, and measured the motion response and mooring force of the breakwater under three different mooring modes. The boundary element method is used to describe the diffraction and radiation boundary value of mooring floating breakwater in waves. The hydrodynamic performance of floating breakwater with single and double floating bridges in conventional waves was evaluated and the influence of average drift force on mooring system was studied. Wei [5] using the numerical wave model based on Navier Stokes solver proposed by Lee and Mizutani, the interaction between water waves and floating breakwaters moored by inclined tension legs is studied. Based on the coupling theory, Belibacsakis[6] studies the influence of the slope and curvature of the seabed on the hydrodynamic performance of floating structures.

At present, the existing general hydrodynamic analysis software(Aqwa, SESAM) can analyz the wave dissipation effect of floating breakwater on the island and reef, because of its extremely complex physical process, it is impossible to consider the complex terrain and viscous effect, and the influence of radiation potential on wave evolution after the dike, which greatly limits the researchers to carry out in-depth research work, and solves the floating type of the island reef There are many limitations in the dynamic characteristics of breakwater. The above results are of great significance to the study of the theory and numerical value of floating breakwater. However, due to the wave evolution under the influence of topography and the complexity of multi system coupling of floating breakwater, the relevant theories are in the development stage. Many important mechanical problems still need to be explored, and the theoretical and numerical research still need to be further studied.

Integral experiment of floating breakwater with flexible structure

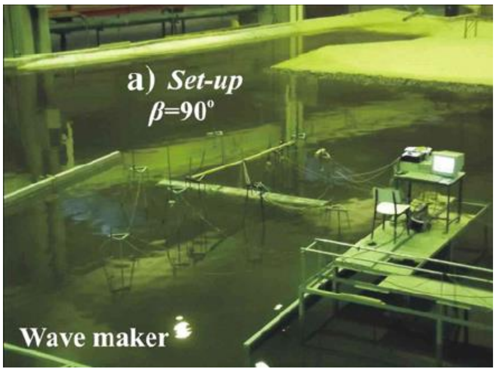

Fig. Experiment on integrated system of pontoon breakwater under transverse and oblique waves

In 1994, Monaghan [7] first implemented the simulation of two-dimensional dam break problem in SPH method based on the isolated wave theory, but the method can only generate simple isolated theoretical wave.
Edmond y.m.lo[8] (2002) and others used incompressible smooth particle hydrodynamics and LES to simulate isolated waves near shore, which is consistent with the experimental data.

Based on the study of Monaghan, colagrossi[9] (2003) proposed that the density correction term was used to modify the density continuously in the SPH calculation for the first time, and the calculation simulation of two-dimensional dam break was carried out. The results show that the technique can improve the problem of pressure oscillation in the process of SPH calculation. In the same year, Lo et al. Carried out two-dimensional numerical simulation of dam break based on improved IspH method [10].
Gotoh[11] (2009) et al. Improved the semi implicit method of moving particles by introducing pressure gradient term and Poisson pressure equation. The wave impact problem is studied by the cosine wave generated by the push plate wave making method. The improved method is proved to be accurate by comparing with the experimental data.

Zheng J h[12] (2010) and others have simulated wave breaking and irregular waves in two-dimensional water trough based on improved SPH algorithm (NNPs). The results show that the results show that the results show that the results are consistent and the calculation efficiency is high.

V. KEY TECHNOLOGY OF EXPERIMENT

The test of floating breakwater is generally divided into two-dimensional section wave tank test and three-dimensional wave tank test.

1.The selection of similarity criteria. Both the two-dimensional section test and the three-dimensional test need to consider the relationship of scale ratio. The model making and mooring line selection need to determine the size parameters based on different similarity rules.

2.The selection of scale ratio. If the main structure model is too large, it is easy to be affected by the pool wall effect, resulting in excessive wave reflection, thus interfering with the test results

3.The particularity of three-dimensional model test. It is necessary to comprehensively consider the test equipment, wave making capacity, implementation cost, and Simulation of breakwater model sea environment. The layout of measuring points should take into account the wave attenuation performance, shielding area, transmission characteristics, overall movement, relative movement, and division of pulling force.

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