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# Stress analysis of anchor chain on the floating breakwater structure with cage culture function

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# Stress analysis of anchor chain on the floating breakwater structure with cage culture function

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**Abstract**：The physical model test of floating breakwater and cage structure is carried out. Under the action of irregular waves, the structure is obtained. Different depth of immersion, Cage depth and wave period work on its Stress analysis of anchor chain. The results show that, when the period is short, the stress on the anchor chain increases exponentially with the increase of wave height. However, under the condition of long period, the variation of anchor chain force with net depth is not obvious, so it is not recommended to hang net cage for breeding.

## 1. Introduction

Floating breakwater has the advantages of rapid construction, convenient movement and easy water exchange and is the most suitable breakwater for cage culture. In order to improve the culture density, a floating breakwater and cage structure is proposed based on the research on the structure of floating breakwater, net cage can be added to the existing breakwater.In this way, we can increase the density of mariculture without increasing the original scope of mariculture, and make more profits with less investment[1-2].Floating breakwater is usually made up of metal, reinforced concrete, rubber, plastic and other floating components and mooring system. Its main advantage is that the cost of sea water is much cheaper than that of sea water[3]. It can be easily applied to soft seabed water area without foundation treatment, and the placement position is easy to change. Floating breakwater is also an inevitable choice when there are coral reefs and other indestructible materials at the bottom of the sea area; In addition, the floating breakwater is also an ideal structure for protecting the water area of Marine Mobile wharf. In 1991, Mani proposed a Y-shaped floating breakwater with a row of cylinders at the bottom of the inverted ladder type floating tank[4]. In 1996, Xing Zhizhuang and Zhang RI proposed the structural type of floating breakwater with damping structure. The test results show that the long wave transmission can be reduced effectively[5]. Nobuhiro et al. Recently reported that the transmission coefficient of a floating breakwater called FBT designed by Saiki steel company in Japan was systematically studied by means of indoor wave flume test[6], Gesraha put forward Π - type breakwater, adding two baffles downward on the basis of the original rectangular box breakwater to enhance its wave dissipation capacity[7]. Murali and mani reported a kind of "cage type" floating dike, which is composed of two inverted trapezoidal pontoons at the front and the back, together with two rows of closely arranged vertical pipes under it[8]. Takayuki et al. Proposed a floating breakwater structure with rectangular pontoons on both sides of each unit[9].

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The above research is to study different types of floating breakwater structure, the structure of this paper is different from the previous floating breakwater. The structure of floating breakwater with aquaculture function is attached with additional components, and the hydrodynamic response of the breakwater is rarely studied. By means of physical model test, the hydrodynamic characteristics of floating breakwater and cage structure under two-dimensional wave action are observed and analyzed, The stress of anchor chain under different draft, different cage depth and different wave elements is analyzed to provide reference for the relevant design and application of this structure.

## 2. Physical model test

*2.1 Test equipment and instruments*

The experiment was carried out in Rudong experimental base, Jiangsu Province, China Academy of Fishery Sciences, The tank is 50m long, 1m wide and 1.5m deep, Equipped with single irregular wave maker, it can simulate regular wave and irregular wave.

figure 1 Cross section test flume

*2.2 Model design and layout*

According to the wave model test procedure[10] the model is based on the gravity similarity criterion, According to the performance of the test tank and the existing materials, When the model scale is satisfied, the model scale is 1:20, Transparent plexiglass plate with a width of 40cm and a height of 15cm is used to make the floating breakwater; After counterweight, the draft is 0.05m and 0.075m. The cage depth is 0.1M, 0.15m and 0.2m, The anchor chain diameteris 78 AM2, and the length of anchor chain is 1.68m. The anchor point is 1.4m away from the pontoon. The layout of the model in the flume is shown in Fig2. The model is located in the middle of the flume, with a distance of 30m from the wave making plate, There are three points in the back of the model, i.e., 0.5cm, 0.5cm, 0.5cm, 0.5cm, 0.5cm, respectively. The tension sensors are installed on the anchor chain near the end of the model. There are four tension sensors respectively arranged on the front and back of the floating breakwater.

IOP Conf. Series: Earth and Environmental Science **567** (2020) 012008 doi:10.1088/1755-1315/567/1/012008

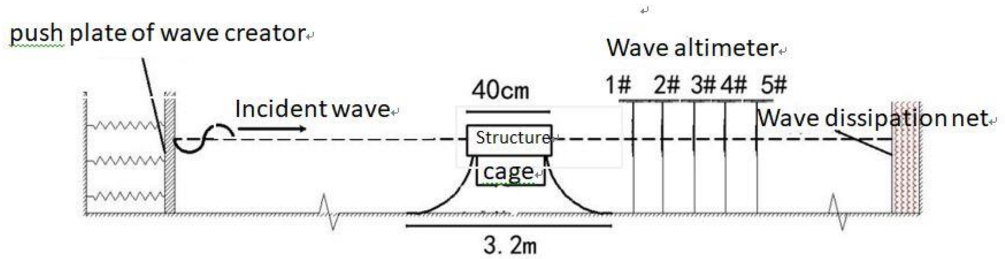


figure 2 Model layout

*2.3 Test methods and wave elements*

In this test, floating breakwater model was used in this test，Under the conditions of 0.05m and 0.075m draft. The cage depth of 0.1M, 0.15m and 0.2m was compared with that without cage, and three repeated tests were conducted in each group.

*2.4 data acquisition and processing*

In this research, the transmission coefficient K is defined to evaluate the wave dissipation effect of floating breakwater.

$$K=H_t/H_i$$

$H_t$： incident wave height. $H_i$:wave height behind the breakwater structure

Wave height and tension are selected as 1 / 3 value. The tensile stress of each group was measured three times, the average value of three times was calculated, and the maximum value of tension was taken out.as shown in figure.

**3. Analysis of test results**

When the draft of floating breakwater structure is 0.05m, and the cage depth is 0.1M, 0.15m, 0.2m and there is no cage, the stress situation of four anchor chains in the same period with different wave heights is shown in the figures.

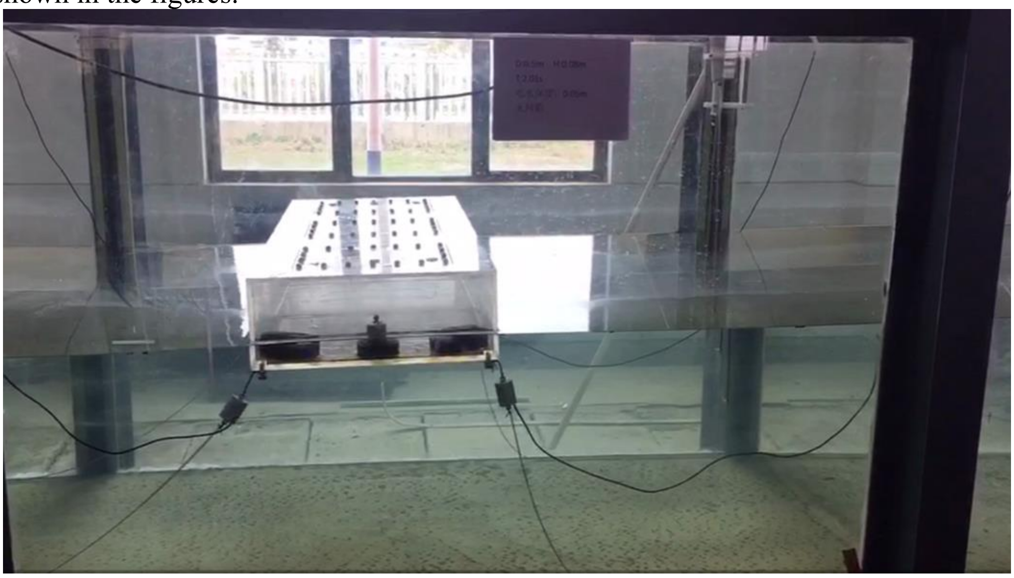

figure 3 without cage

Table 1 stress of four anchor chains without cage when draft of floating breakwater model is 0.05m

| Period T（s） | Wave height H（m） | 7# | 8# | 11# | 12# |
|---|---|---|---|---|---|
| 1.12 | 0.04 | 0.47 | 0.47 | 0.565 | 0.57 |
| | 0.06 | 0.49 | 0.465 | 4.725 | 3.59 |
| | 0.08 | 0.41 | 0.545 | 13.35 | 11.805 |
| | 0.10 | 0.705 | 0.925 | 42.035 | 31.305 |
| 1.565 | 0.04 | 0.48 | 0.51 | 0.735 | 0.49 |
| | 0.06 | 0.5 | 0.485 | 0.725 | 0.52 |
| | 0.08 | 0.455 | 0.53 | 0.685 | 0.795 |
| | 0.10 | 0.875 | 0.805 | 4.36 | 4.785 |
| | 0.12 | 2.48 | 2.305 | 20.035 | 17.465 |
| 2.01 | 0.04 | 0.425 | 0.545 | 0.56 | 0.525 |
| | 0.06 | 0.535 | 0.495 | 0.595 | 0.57 |
| | 0.08 | 0.455 | 0.555 | 0.59 | 0.655 |
| | 0.10 | 8.47 | 8.175 | 11.075 | 11.82 |
| | 0.12 | 4.395 | 7.085 | 21.41 | 16.38 |

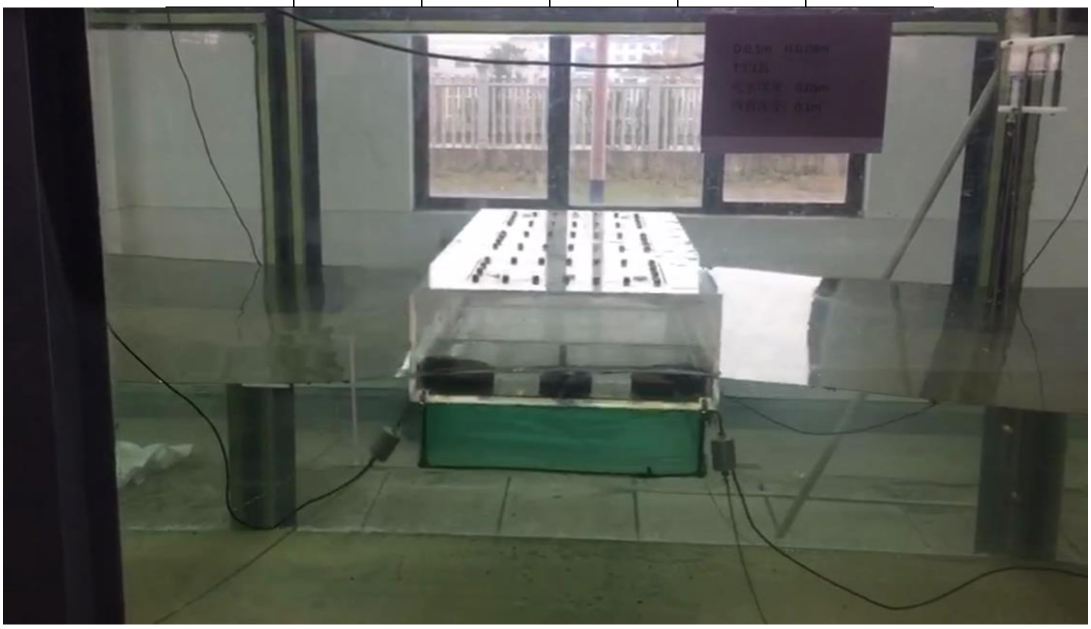

figure 4 with cage depth is 0.1m

Table 2 stresses on four anchor chains when draft of floating breakwater is 0.05m and cage depth is 0.1m.

| Period T（s） | Wave height H（m） | 7# | 8# | 11# | 12# |
|---|---|---|---|---|---|
| 1.12 | 0.04 | 0.45 | 0.36 | 0.53 | 0.54 |
| | 0.06 | 0.47 | 0.47 | 2.99 | 3.58 |
| | 0.08 | 0.44 | 0.47 | 14.19 | 12.21 |
| | 0.10 | 0.45 | 0.45 | 32.35 | 30.84 |
| 1.565 | 0.04 | 0.54 | 0.55 | 0.56 | 0.55 |

| | | | | | |
|---|---|---|---|---|---|
| | 0.06 | 0.42 | 0.51 | 0.60 | 0.51 |
| | 0.08 | 0.49 | 0.52 | 1.21 | 1.83 |
| | 0.10 | 0.45 | 0.43 | 3.68 | 4.03 |
| | 0.12 | 0.53 | 0.51 | 22.07 | 22.80 |
| 2.01 | 0.04 | 0.44 | 0.53 | 0.66 | 0.57 |
| | 0.06 | 0.49 | 0.48 | 0.45 | 0.57 |
| | 0.08 | 0.44 | 0.48 | 0.67 | 0.84 |
| | 0.10 | 0.92 | 0.58 | 4.03 | 4.55 |
| | 0.12 | 2.79 | 0.52 | 12.25 | 12.58 |

figure 5 with cage depth is 0.15m

Table 3 Stress on four anchor chains when draft of floating breakwater is 0.05m and cage depth is 0.15m.

| Period T（s） | Wave height H（m） | 7# | 8# | 11# | 12# |
|---|---|---|---|---|---|
| 1.12 | 0.04 | 0.43 | 0.52 | 0.84 | 0.55 |
| | 0.06 | 0.39 | 0.44 | 3.62 | 4.54 |
| | 0.08 | 0.35 | 0.45 | 15.86 | 15.68 |
| | 0.10 | 0.45 | 0.50 | 45.79 | 51.34 |
| 1.565 | 0.04 | 0.42 | 0.52 | 0.63 | 0.47 |
| | 0.06 | 0.47 | 0.57 | 0.73 | 0.61 |
| | 0.08 | 0.47 | 0.42 | 1.01 | 0.98 |
| | 0.10 | 0.48 | 0.51 | 5.85 | 5.39 |
| | 0.12 | 0.48 | 0.58 | 15.06 | 14.26 |
| 2.01 | 0.04 | 0.40 | 0.50 | 0.68 | 0.49 |
| | 0.06 | 0.44 | 0.57 | 0.65 | 0.51 |
| | 0.08 | 0.48 | 0.55 | 0.72 | 0.71 |

| | | | | | |
|---|---|---|---|---|---|
| | 0.10 | 0.54 | 0.59 | 5.42 | 5.45 |
| | 0.12 | 1.45 | 2.18 | 13.49 | 14.03 |

When the draft of floating breakwater is 0.05m, the stress curve of anchor chain varies with wave height under different cage depths. It is shown in the table below.

Table 4 anchor chain stress on wave coming side at 0.05m draft

| Period T（s） | Cage depths | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 |
|---|---|---|---|---|---|---|
| 1.12 | None cage | 0.57 | 4.16 | 12.58 | 36.67 | |
| | 0.1m | 0.53 | 3.28 | 13.20 | 31.59 | |
| | 0.15m | 0.69 | 4.08 | 15.77 | 48.57 | |
| | 0.2m | 0.69 | 3.48 | 20.02 | 47.91 | |
| 1.56 | None cage | 0.61 | 0.62 | 0.74 | 4.57 | 18.75 |
| | 0.1m | 0.55 | 0.56 | 1.52 | 3.86 | 22.43 |
| | 0.15m | 0.55 | 0.67 | 0.99 | 5.62 | 14.66 |
| | 0.2m | 0.63 | 0.75 | 3.64 | 6.98 | 21.80 |
| 2.00 | None cage | 0.54 | 0.58 | 0.62 | 11.45 | 18.90 |
| | 0.1m | 0.61 | 0.51 | 0.75 | 4.29 | 12.42 |
| | 0.15m | 0.58 | 0.58 | 0.72 | 5.44 | 13.76 |
| | 0.2m | 0.51 | 0.61 | 1.11 | 5.51 | 14.91 |

## 4. Discussion

It can be seen from the figure that, in different periods, the stress on the anchor chain on the wave front has the same change trend with the wave height, and increases with the increase of the wave height. When the period gets longer, the stress on the anchor chain decreases gradually. When the period is 1.12s, the stress on the anchor chain on the wave coming side is much greater than that at the period of 1.565s and 2.01s. The maximum stress of anchor chain is 48.57n.

## 5.conclusion

The research object of this paper is the combination of box floating dike and cage culture. Its most important function is wave dissipation and stability, The maximum tension of the anchor chain on the wave side will change exponentially with the increase of wave height. It is not recommended to hang the cage in the case of large wave height, In order to meet the stability in practical application, the greater the cage depth is, the better, Considering the wave dissipation performance of the cage, the transmission coefficient of the floating breakwater will decrease with the increase of the depth of the cage attached. However, under the condition of long period, the variation of anchor chain force with net depth is not obvious, so it is not recommended to hang net cage for breeding.

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