CHAPTER 148

On the floating breakwater - a new arrangement

C.H. LEE* and S.W. TWU**

Abstract

A new type of floating breakwater composed of net-tubes and buoy-balls is presented in this paper. A series of model studies have been carried out for several arrangements of this structure. As wave damping effect is concerned, a case that the structure being set vertically is shown to be better than the one being set horizontally, while more than two rows of the structures are set vertically and separately, a case which being connected with ropes between adjoining rows is proved to be better than the case without connecting ropes.

1 INTRODUCTION

Breakwaters have been developed into many practical patterns. Most of them are made of rubble or/and caissions which are effective but expensive. It is known that most wave energy distributes over the upper portion of water depth. Hence it is economical to attenuate wave energy in the vicinity of free surface.

With booming of economics and a rise in population, Republic of China is in urgency searching any available resources to meet the demand of continuous development. Fortunately, Taiwan is situated on the continental shelf where is fit for aquaculture, knowever, the wave conditions make it difficult to run. Consequently a special device of floating breakwater may be the alternative.

In general, most floating breakwaters are designed to be laid over the water surface "horizontally". It is interesting to note what the effect is if a floating breakwater is set "vertically". A structure composed of net-tubes and buoy-balls has been developed by the authors as shown in photo 1, also named wave-fence for convience. This type of floating breakwater may meet the requirements of water-circulation and wave-dissipation effectively as well as economically if designed properly.

2. ANALYSIS OF WAVE DISSIPATION BY THE NEW ARRANGEMENT

It is reasonable that multiple rows of wave-fences will be more effective than single one. If each of them is linked by ropes, the water body within those rows can be regarded as a part of the damping system and the effect of wave damping will be better.

* Engineer, Planning Dept., BES Engineering Corporation, P.O. Box 335, Taipei Taiwan Republic of China.

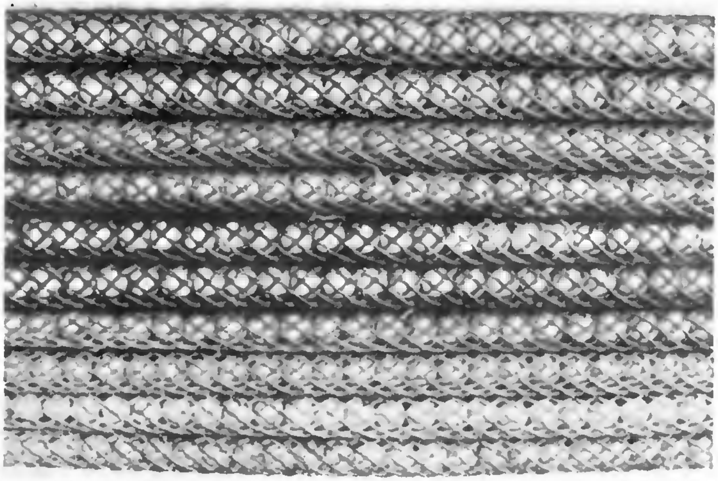
** Professor Hydraulics & Ocean Engg. Dept., Cheng-Kung University, Tainan, Taiwan, Republic of China.

According to the small amplitude wave theory, it is known that the water particles in the crest and the trough of a wave move in the same magnitude but opposite direction respectively. With this idea, we may set the interval of two rows to be half length of the incident wave and connect them with ropes simultaneously. When the crest and the trough are exactly on the two rows respectively, each of which will incur wave forces in the same magnitude but opposite direction. Then the two rows will stand still like a fixed system for a while and the exerting wave forces will be eliminated each other through such a system.

In fact the waves on the open sea cover a wide range of period. We may pick up some dominant waves, i.e. design waves, of different periods which are to be disposed, say N waves. The required number of wave-fences, M, is related with N by the formula

$$\frac{M(M-1)}{2} = N \qquad \text{where } M > 2$$

For example, when M=4, there are 3 spacing, say S1, S2, S3 in sequence, among these four rows of wave fences. Then the system has six effective intervals, i.e. N=6, they are S1, S2, S3, S1+S2, S2+S3, S1+S2+S3 respectively. If each effective interval coincides half length of a design wave, and the fences are linked with ropes, the damping system will work all the time.



3. EXPERIMENTAL STUDIES

The wave periods ranged from 0.8 sec to 2.0 sec were carried out for the model test. The wave heights varied between 2 cm and 23 cm. The specific gravity of buoy-ball, γ_b, used in the experiments is 0.3.

First, the comparison of damping effect was made between the horizontally moored style, as Fig 1, and the vertically moored style, as Fig 2, of the same floating breakwater. The experimental results are shown in Fig 4-7, where the transmission coefficient K is the ratio of the average wave height behind the floating breakwater to the average incident wave height, and q is the immersing ratio of the draft of wave-fence h to water depth D. The cross-points and the solid lines represent the results of horizontal style, and the dot-points and the dash lines represent the data of vertical style. It is evident that the solid lines are always higher than the dash lines. It goes without saying that the wave-fence will be more effective if moored vertically.

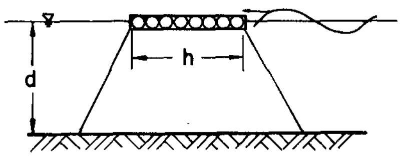


Fig 1. Horizontally moored style of wave-fence

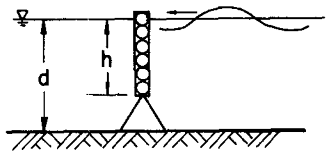


Fig 2. Vertically moored style of wave-fence

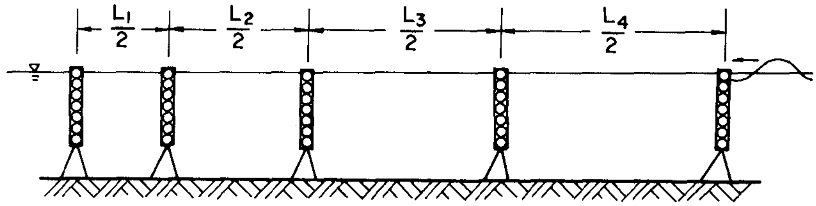


Fig 3. Five rows of wave-fences without/with connection which intervals correspond to half of designed wavelengths respectively

Since the wave-fence is flexible and swinging with the waves that diminishing the function of dissipation. The multiple wave-fences were then arranged to be tested. With the idea stated in previous section. if two rows of wave-fences which interval is equal to half of wave length of a certain wave period, the linking-effect would function only for that kind of waves. Therefore, for practical purpose, a system of more than two wave-fences is needed and set in to be tested in the wave channel. A system of this structure of five rows with four spacings is chosen for the model test, Four perids of 0.8 sec, 1.2 sec, 1.6 sec, 1.8 sec were chosen as the basic spacings for the experiments. For convenience, five rows of wave-fences were arranged with appropriate intervals matching each half wavelength. A series of model tests with wave periods ranging from 0.8 sec to 2.0 sec were performed. The results are plotted in Fig. 8 The solid line and dash line represent linked and unlinked conditions respectively, which indicates that the former is much better than the latter.

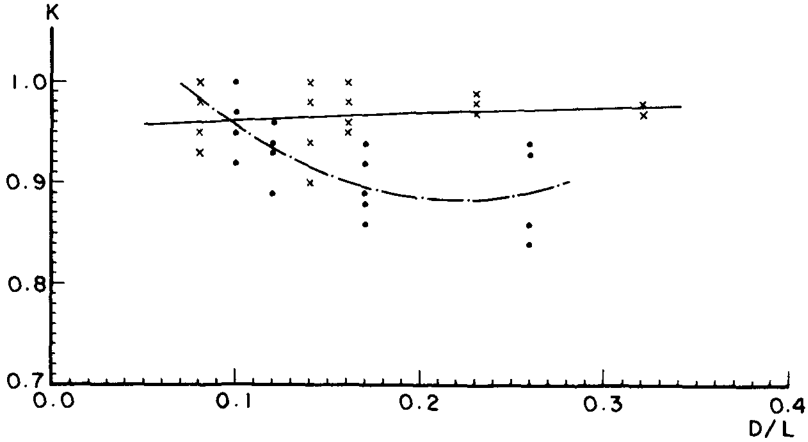


Fig 4. Transmission coefficient VS. relative depth for q=0.3,γ_b=0.3

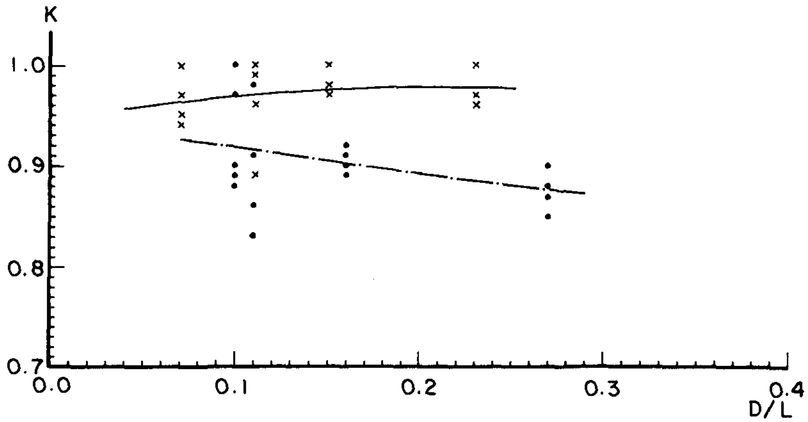


Fig 5. Transmission coefficient VS. relative depth for q=0.4,γ_b=0.3

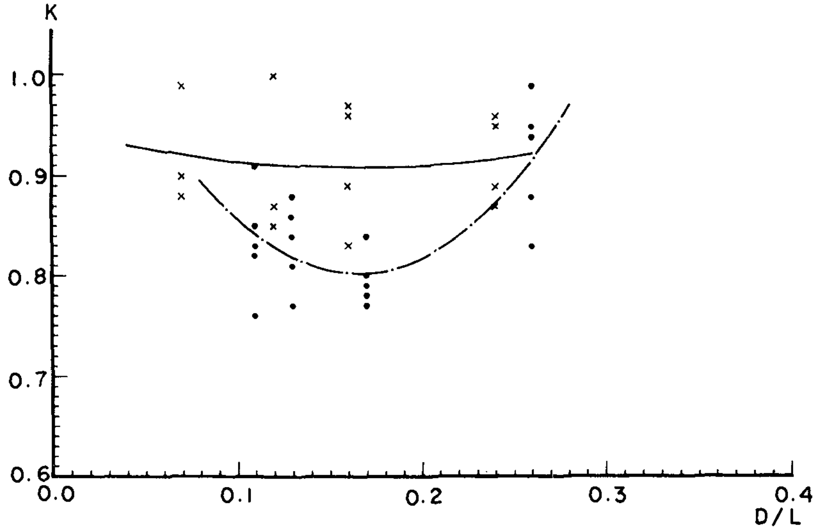


Fig 6. Transmission coefficient VS. relative depth for q=0.5, γ_b=o.3

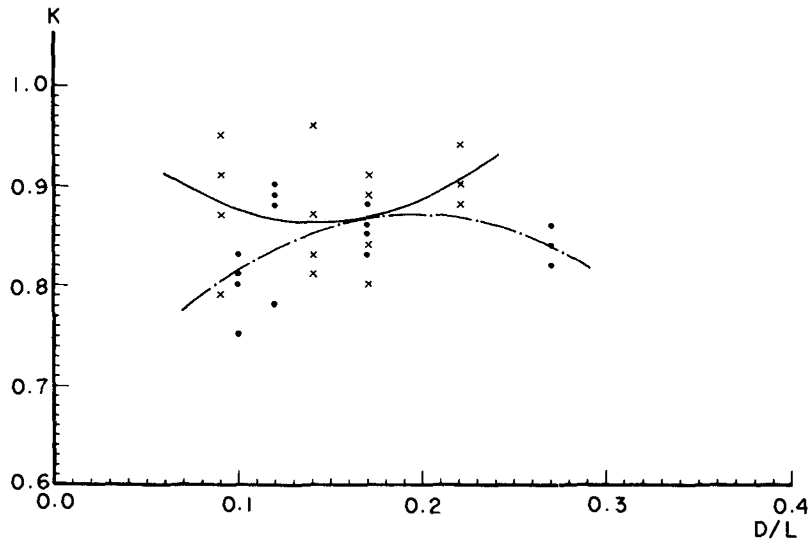


Fig 7. Transmission coefficient VS. relative depth for q=0.6, γ_b=0.3

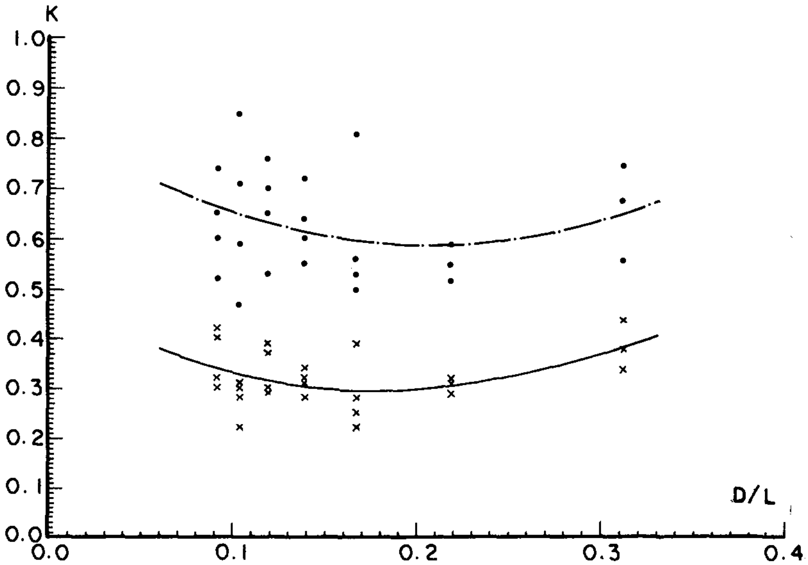


Fig 8. Comparison of transmission coefficient of connected and un-connected conditions for five-row wave-fences

4. CONCLUSION

(1) As wave dissipation is concerned, it is better to lay the wave-fence vertically than horizontally.
(2) The system of more than two rows of wave-fences being connected with ropes is always more effective than that without connection.
(3) If each "effective interval" of the system corresponds to each half length of a number of design waves, and the adjoining rows are linked with ropes, this system will serve as a good wave-fence.

REFERENCE

1. Kennedy, R.J. & Marsalek, J. (1968). Flexible porous floating break-waters. Proc. 11th Conf. on Coastal Engineering, 2, 1095-1103.
2. Marks, W. (1966). A perforated mobile breakwater for fixed and floating applications. Proc. 10th Conf. on Coastal Engineering, 2, 1079-1129.
3. Terrett, F.L. (1966). Model studies of a perforated breakwater. Proc. 11th Conf. on Coastal Engineering, 2, 1104-20.
4. Lee, Cheng-hsiun (1983). "Wave Transmision in Shallow Water under the Arrangements of Net-tubes and Buoy-balls". M.E. Thesis, Cheng-Kung University.
5. Twu, S.W., Kao R.C. & Huwng, H.H. (1986) "On a wave dissipation method for offshore aquaculture areas" J. Aquaculture Engineering. England. pp271-286