PARAMETRICAL ANALYSIS FOR DIFFERENT TYPOLOGIES OF MOORING LINES IN THE DESING OF FLOATING BREAKWATERS. APPLICATION TO XUFRE PORT.

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Paper topic: Laboratory and field observations and techniques

1. Introduction

From some decades ago, the use of floating breakwaters has been reached a very significant increase due to its less harm to the environment than other structures. That is why these breakwaters are usually designed to recreational ports that are just affected by waves with short periods. In order to analyze their structural behavior, a physical model becomes a necessary study. Although the type of anchoring does not change the hydrodynamic situation, it is an element with a great importance in order to analyze the efforts suffered by the floating breakwater.

There were three different parameters referring to the mooring lines that have been developed in these tests, according to the project natural environment, located in Xufre (Galicia, Spain) with the target of determining the most efficient combination of these typologies. To achieve this goal, different lengths, touchdowns and types of mooring lines were tested.

2. Physical Model

The experiments were conducted in a 32x34m wave tank divided with brick walls in order to obtain a 12 meter wide wave front, at the R+D Centre of Technological Innovation in Building and Civil Engineering (CITEEC, www.udc.es/citeec).

The Xufre Port floating breakwater (5.06x 1,82x 20,24) was modelled as 8 pontoons of stainless steel, working on a 1:21 scale. Each pontoon was connected to the next one with a cylindrical neoprene joint, and anchored to the bottom of the wave basin with the 54 different anchorage points created for this investigation.

Figure 1: Physical model of the Xufre Port floating breakwater with perpendicular incident wave (left) and detail of the module connector (right).

Three different typologies of mooring lines, with his own variations, were used to carry out the tests: 1) rigid mooring lines with a 2.48 m length chain and catenary shape, with three different perpendicular distances from the anchorage points to the module; a) 2.09, b) 1.90 and c) 1.67m, with a simulated weight of 34.4 Kg/m 2) rigid mooring lines with different touchdown distance, modifying the chain length, 3) elastic mooring lines with an elastic coefficient of K=12 kN/m stressed to a) 30% b) 43% and c) 61% of their elongation. In addition to this, a safety by-pass was installed to prevent an elongation of the elastic anchoring higher than 80%.

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Regular wave tests were developed with wave heights from 0.4m to 1m, and wave periods from 0.4s to 1s. Test with perpendicular incident waves represent perfectly the common wave propagations in the study zone.

3. Results and discussion

In the results obtained for the 3 different typologies, a uniform trend was observed in the wave attenuation, which it is optimal for wave periods less than 3.2 s, being the transmitted wave height between 20-35% the incident. For higher periods the attenuation decreases.

Regarding to the mooring lines forces, the tensional results of the chains and elastic mooring line are slightly different. At high tide, where the elastic mooring line is subjected to an initial elongation of 61%, the medium tension ranges from 4 to 5 Tons, with a maximum around 7 Tons, whereas the chains get a maximum value of 2.7 Tons.

According to the influence of the touchdown, three different lengths were measured, in order to simulate all the conditions of the floating breakwater, where the maximum effort recorded is 4.36 t, for a touchdown of 20 m.

4. Conclusions

In this study, 1D load cells were successfully used to register the mooring lines loads of the floating breakwater, which is and of great importance in the design of these kinds of structures.

According to the results obtained for the different anchoring typologies, the hydrodynamic behavior of the floating breakwater is very similar for all configurations of the reproduced anchoring lines and the wave conditions analyzed, even though tensions registered with the elastic mooring system are generally higher than those generated by chains.

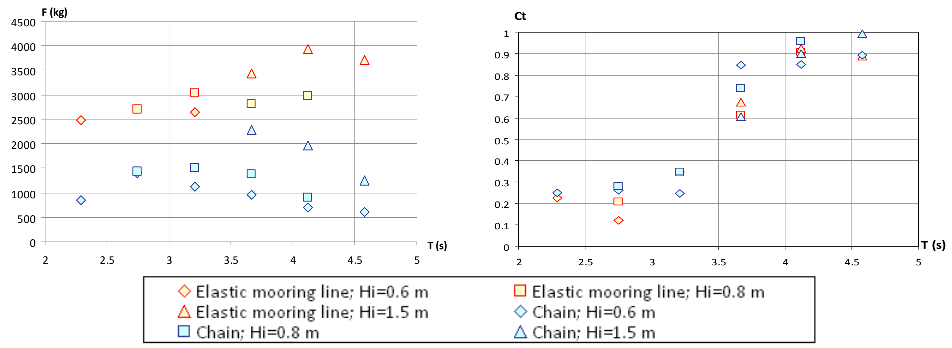

Figure 2. Mooring line forces (right) and transmission coefficients (right) with mid tide.

Different positions were tested from the anchorage point, 35, 40 and 44m to the axis of the floating breakwater with the same chain length. In mid tide and low tide the influence on the wave transmission is null, while the efforts registered are very similar, being these efforts affected only by the touchdown. Therefore, the design is suitable for the floating breakwater from any anchorage distance between 35 and 44 m in order to optimize the geometry of the catenary.

With a lower touchdown, higher efforts were registered. Thus, the main criteria of design of this kind of mooring line will be characterized by this parameter.

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