OPTIMAL DESIGN IN PHYSICAL MODELLING OF TWO ADJACENT RUBBLE MOUND BREAKWATER AGAINST PERPENDICULAR WAVE INCIDENCE. INFLUENCE OF THE SLOPE AND OF THE WEIGHT OF PARALLEPIPED BLOCK

J.Sande[1], J.Ferreras[1], L. Priegue[1], E. Peña[1], E. Maciñeira[1,2], F. Sánchez-Tembleque[1]

Paper topic: Laboratory and field observations and techniques

1. Introduction

Growing activities in the A Coruña Port have resulted in a significant lack of space for activities. For this reason the Port Authority decided to build a new harbour in Punta Langosteira with main breakwater of 3.3 Km long.

Currently the A Coruña Port Authority proposed two parallel rubble mound breakwaters to protect the water inlet of an electric company from the sediment transport and improve the services in the harbour. Those two groins have a length of 550 and 340 meters. These structures are located in front of the main breakwater, and the wave incidence front is almost perpendicular to the breakwater axis.

In order to obtain an optimal and more effective design of the structures projected the Water and environmental Engineering Group (GEAMA) of the University of A Coruña (Spain) and the construction company Dragados S.A. carried out physical model test with the design alternatives proposed. Those considered different section slopes and the use of parallepiped blocks in the armour layer.

2. Experimental facilities and procedures

The experiments were made in the wave tank at the CITEEC (R+D Centre in Building and Civil Engineering) of the University of A Coruña, where both two– and three– dimensional tests could be conducted. The wave tank is 34 m long, 32 m wide and 1.10 m deep.

Figure 1 The two adjacent breakwaters at the CITEEC wave tank

The bottom of the wave tank was modified in the way that it reproduces the real bathymetry of the study zone. A dissipative beach was set up at the opposite end and in both sides of the wave tank to prevent the reflection of transmitted waves. The selected geometric scale was 1:45 (Froude similitude).

The test reproduce the extreme wave conditions (T=140 years): Tp=18 s and Hs=5.8m at the roundhead of the longest breakwater. Also, two different tide levels (the low +0m and high tide +4.5m) and three wave height (Hs=4, 5 and 5.8m) were reproduced in accumulative test of 1500 wave each one.

Measurements consisted in digital photography and video for the concrete block armour layer to determine the percentage of damage in those zones (figure 2), and laser profiles of the rock armour layer (figure 3) to quantify the possible erosion, accretion after the wave tests and determinate the optimal slope between 3:2 and 2:1 in the model.

[1] Water and Environmental Engineering Group *(GEAMA). Civil Engineering School - CITEEC, University of A Coruña.*

[2] A Coruña Port Authority

Figure 2 Damage in the armour layer for the 2nd typology tested (Initial –Left– and resulting –Right– state of the roundhead).

3. Results

It was analyzed the stability of the both breakwaters differentiating the roundhead and the armour layer which is formed by blocks. It was tested three models to determinate the optimal solution using parallelepiped blocks (15, 20 and 35 tons). One and two layers of parallepiped blocks were analyzed. Moreover the slope cross section was modified in the different model tested and in different sections of the structure. The rest of the model was formed by 5 and 2 tons weight rubble.

No significant damage was produced in the rock armour layer for any of the typologies tested. In the initial ones, the damage was concentrated in the parallelepiped blocks of 15 tons and in the zones with only one layer. Thus zones were redesigned and moving them away from the roundhead, in someone zones it was changed the one layer by two layers and the weight of the blocks incremented.

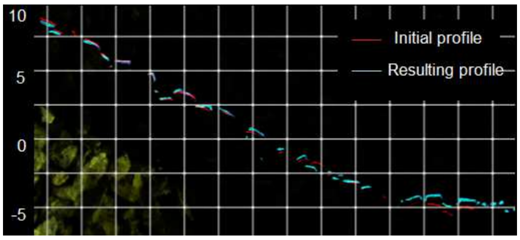

Figure 3 Initial and resulting profile of the rock armour layer for the 2nd typology tested.

The final configuration was built and validated with blocks of 35 tons in the longer breakwater with 20, 15 tons block, in the transition zones to rocks, and 20 tons in the adjacent breakwater with zones the only one layer.

4. Conclusions

The structural behaviour in the blocks transition it´s fragile as a consequence of the wave front incidence. One the damage begins, it follows to the end and to the inside of the breakwaters, also causing a stream along the breakwater producing in the outer sides of bigger blocks a potential damage zone to start the failure.

The arrangement is random because of it we observed the difficulty to propose corrections or assessment due to the randomness of the failure.

The mutual interaction of both breakwaters is not determined, it´s possible that exists reflections between breakwaters and this effect would generate water accumulation in the middle of the roundhead breakwater and that is why appear wave fronts with more energy, which cause more damage in the outer slope of the shortest breakwater.

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