The Experimental Study on Stability of The Berm Breakwater

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ABSTRACT

By 2D and 3D wave physical model test, the stability of a berm breakwater which was built in Qingdao, China was studied. The purpose of 3D model was to study the breakwater stability under the oblique wave action. The cross-section of breakwater and plan layout which meet the design requirement were obtained by experiment. Comparison was made for the difference of rocks moving form on the slope and the final dynamical equilibrium section under the oblique wave action and normal wave action. When incidence wave direction is normal the shape of the final dynamical equilibrium section presents reverse “S” and the movement of stones is the reciprocating motion along armor slope in the vertical direction range. When wave incidence direction is oblique, the armor stones except in the movement of vertical and there still exists in the horizontal transportation. When the armor stones at the place existed horizontal transportation can not be supplemented, the breakwater may be unstable. The research results can provide the valuable experience for the similar projects.

KEY WORDS: Berm breakwater, normal incident wave, oblique incident wave, wave physical model, dynamical equilibrium section, armor block, stability.

INTRODUCTION

The berm breakwater is a new type rubble mound breakwater which is popular internationally in recent years. The width of berm is above 2 times design wave height and more than 6m. It depends on the dynamical equilibrium section formed by long time wave action to carry out anti-waves protection (Xie, SL 1999). By allowing the slope deformation, the dynamic stability conditions of armor stone is much lower than the static stability condition of the conventional sloping breakwater, and thus armor stone weight is lighter. Furthermore, its construction is simple. So it has better economy when the stone source is rich in the project region. Such as the above characteristics, many berm breakwaters had been completed or being built in the world since 1983 when the world first berm breakwater was built in Iceland. In China, the first berm breakwater was built in Dalian Beiliang grain transshipment port in 1996, achieved good effect from the economic construction and the use results (Liu, ZQ 1999). In order to provide the basis for design, we need grasp the characteristics of structure and layout. The stability under wave action is a very important factor for the berm breakwater design and construction.

In this paper, the stability of a berm breakwater project which was built in Qingdao, China was studied by 2D and 3D model. And the objective of tests is to get the cross-section and plan layout meeting the requirement of design and compare the difference of armor stones moving form on the slope and the final dynamical equilibrium section between 2D and 3D test. The project overview is as follows. The project includes the south breakwater and east breakwater, south breakwater is 150m long and east breakwater is 605m long. The south and east breakwater are joined by an arc segment named the transitional part. The project location and plan layout is shown in Fig.1. The cross-section adopts the berm breakwater structure and the width of berm of original cross-section is 18m, the weight of armor stone is 1~3ton, average weight is 1.93ton, the stone gradation as: 1.0~1.5ton accounted for 22%, 1.5~2.0ton accounted for 25%, 2.0~2.5ton accounted for 40%, 2.5~3.0ton accounted for 13%. The berm top elevation is +5.0m and the crown wall top elevation is +11.0m. 9ton accropode blocks are adopted as armor block from crown to the berm. The detail of cross-section structure is shown in Fig.2. The prevailing and strong wave direction is all SE in the project area. The angle between SE direction and the axis of east breakwater is 65° and the angle between SE direction and the axis of south breakwater is 23°.