Application of Dynamic Crenulate Shaped Beaches Behind Detached Breakwaters

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ABSTRACT

Shoreline changes play important engineering topics in near-shore morphology. During the last decade, shoreline changes can be predicted by several sediment transport model. In this paper, the calculated model and hydraulic experiments are carried out to study the dynamic shoreline and sediment transport behind single or multiple detached breakwaters. The effective factors are considered, including artificial nourishment, sediment properties, wave characteristics, coastal zone topography, and breakwater configurations. It is different form the researches of static equilibrium shoreline in the past. Following the shape distribution function of artificial headland derived by Wind (1994), the proposed model of dynamic shoreline is developed to calculate the shoreline change. The wave height distribution function, applied in the calculated model, is calculated by a wave model (mild-slope equation) containing the shoaling, reflection, refraction, and energy dissipation. The proposed model is used to predict a dynamic shoreline behind a detached breakwater. The proposed function and shoreline changes observed in the experimental data have good agreement.

KEY WORDS: shoreline, dynamics, detached breakwater

INTRODUCTION

In the past decades, the detached breakwaters were widely used to against coastal erosion. The detached breakwaters are generally constructed away from and parallel to the shoreline to dissipate wave energy and cause sand deposition in the sheltered area of them. An accurate shoreline-response prediction is very important in the design of detached breakwaters as well as other coastal structures. The detached breakwaters are generally constructed away from and parallel to the shoreline to dissipate wave energy and cause sand deposition in the sheltered area of them. The hydodynamics and sediment transport mechanism around the breakwaters are complicated and have not been fully understood. Many physical model tests have been conducted to study the formation of salients and width of the tombolo in the lee of breakwaters. Most of them focus on the investigation of salient size and sediment deposition for the case of a single detached breakwater with incident waves approaching normal to it (Shinohara and Tsubaki, 1966; Rosen and Vajda, 1982; Mimura et al., 1983; Suh and Dalrymple, 1987; Ming and Chiew, 2000). The beach lines of salients are dictated by the wave diffraction and refraction lee of the breakwater. Therefore, previous works have given much attention the apex position to distances from the structure, some important geometric variables involved in the apex position have been analyzed and empirical equations were proposed.

The process of sand deposition behind a detached breakwater with normally incident waves depends on several parameters, such as the length of breakwater (B), the distance of the breakwater to the initial shoreline (S), the water depth at the breakwater (h0), the incident wave steepness (H/Î», the sand size (D50), the sand density (ρs), the beach slope (tanβ), and others. Existing experimental and prototype data appear to show that B and S are the primary parameters affecting equilibrium shape of the salient behind the breakwater, whereas the other parameters are of secondary importance (Hsu and Silvester, 1990; Ming and Chiew, 2000). Empirical equilibrium shorelines behind the breakwater have been proposed by Hsu and Silvester (1990), McCormick (1993), and others. Assuming that the equilibrium shorelines depend only on B and S, Hsu and Silvester (1990) proposed a second-degree polynomial model to describe the shape of the salient behind the breakwater. For example, they proposed that the equilibrium distance (X) from the salient apex to the breakwater could be written as

\[
\frac{X}{B} = -0.1626 + 0.8439\left(\frac{S}{B}\right) + 0.0274\left(\frac{S}{B}\right)^2
\]

According to their own experimental data, Ming and Chiew (2000) concluded that the sand accreted area (A) behind the breakwater depended on B and S, and had the following relation for

\[
\frac{A}{S^2} = -0.384 + 0.043\left(\frac{S}{B}\right) + 0.711\frac{B}{S}
\]

McCormick (1993) believed that the equilibrium shorelines not only depend on B and S but also on the ratio of the incident wave steepness to the beach slope, and proposed that the shorelines responding to a single breakwater with incident waves could be described by an elliptic geometry. Hsu et al., (2003) collected the experimental and prototype data of shoreline behind a detached breakwater, and re-examined the McCormick’s elliptic shoreline model by mainly using new