Storm Surge in a Harbor Protected by Double Long Submerged Breakwaters in Laizhou Bay of China

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ABSTRACT

The storm surge is a coastal flood phenomenon of rising water, which is an important safe factor for harbor and coastal engineering. A mathematical model was established to help estimate the rising water during the No. 9711 typhoon in Weifang harbor, which is protected by the double long submerged breakwaters. It is shown from simulated results that the model is able to reflect the changes of tides and currents around the harbor reasonable. The maximum wind set up in the Laizhou bay located by Weifang harbor from the prediction results is analyzed.

KEY WORDS: Storm surge; submerged breakwater; Laizhou Bay; Mike21; No. 9711 typhoon.

INTRODUCTION

Weifang Harbor is located on the southwest coast of Laizhou bay and belongs to Shandong Province. After years of development, several terminals and basins, breakwaters and channels have been established. It has two submerged breakwaters which is 10.3km in length (Fig. 1). In the sea around the harbor, the characteristic of tide belongs to irregular semi-diurnal tide and the average tidal range is 1.6m (Yan et al., 2011). According to survey in field, the mean current velocities around the harbor are about 0.29m/s during spring tide and about 0.21m/s during neap tide. The flood current is slightly stronger than the ebb one. Here a mathematical model was established to help estimate the rising water in the harbor during the No. 9711 typhoon in summer of 1997.

NUMERICAL MODEL

Tide current model

The tide and current fields are simulated by the plane two-dimensional numerical model (MIKE21 FM) which developed by Danish Hydraulics Research Institute. The model is based on the solution of two-dimensional incompressible Reynolds Navier-Stokes equations, subject to the assumption of Boussinesq and hydrostatic pressure.

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\begin{align*}
\frac{\partial C}{\partial t} + \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} &= hS \\
\frac{\partial u}{\partial t} + \frac{\partial u^2}{\partial x} + \frac{\partial uv}{\partial y} &= f v - g C + \frac{\tau_{xx} - \tau_{yy}}{\rho h} + E_x \left( \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right) \\
\frac{1}{\rho} \frac{\partial p}{\partial x} - \rho \left( \frac{\partial S_{xx}}{\partial x} + \frac{\partial S_{xy}}{\partial y} \right) + u_x S
\end{align*}
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