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Study on Excavated-in Harbor Basin Current Field

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Abstract. The current of excavated-in harbor basin are key issues to the coastal engineering and the ocean engineering. In this study, a numerical model was developed to simulate excavated-in harbor basin current field. Results show that, the current field of excavated-in harbor basin is influenced by topography, width of harbor entrance and tidal influx.

Introduction

The excavated-in harbor basin is a common form in the coastal engineering. And the current field of the excavated-in harbor is key issues to the coastal engineering. To have a better understanding of the impact factors, some numerical works have been done by researchers. [1-7]. The research shows the current field of excavated-in harbor basin is influenced by width of harbor entrance, tidal influx and topography.

In this study, a series of numerical ideal model with difference impact factors were conducted and the results were used to analysis the influence of topography, width of harbor entrance and tidal flux in this study. The current fields were simulated using assumed topography. The results from this numerical model proposed the influence of topography, width of harbor entrance and tidal influx on the excavated-in harbor basin current field.

Assumption and Method

Assumption. To have a better understanding of different factors' influence on the current field of the excavated-in harbor. Some conditions are idealized and assumed as:

The basin is square, the area A= L×L.

(1) H represents the harbor basin depth.
(2) Δl represents the width of harbor entrance.
(3) m represents Δl/L.

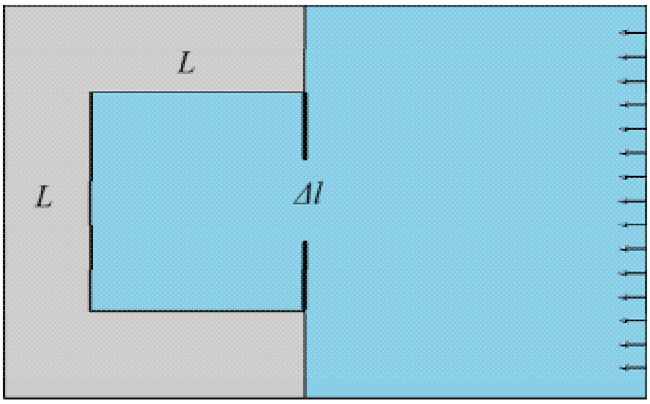

Fig. 1 Parameters of Ideal Harbour Basin

Method. In this study, a numerical model MIKE21 was used. DHI's Software contains a modelling system for estuaries, coastal waters and seas. Therefore, a two-dimensional model was built within the commercial MIKE 21 FM package to simulate tidal hydrodynamics in the study area. The main governing equations are the continuity equation and the in-compressible Reynolds-averaged Navier-Stokes (RANS) equations. The N-S equations are used based on the static pressure hypothesis and Boussinesq hypothesis. The vertical current acceleration is ignored compared to the gravity acceleration, and the turbulence stress is with respect to the time averaged velocity gradient. The basic equations to describe tidal hydrodynamics can be written as:

$$\frac{\partial h}{\partial t}+\frac{\partial h\bar{u}}{\partial x}+\frac{\partial h\bar{v}}{\partial y}=hS \tag{1}$$

$$\begin{aligned}\frac{\partial h\bar{u}}{\partial t}+\frac{\partial h\bar{u}^2}{\partial x}+\frac{\partial h\overline{uv}}{\partial y}= f\bar{v}h-gh\frac{\partial h}{\partial x}-\frac{h}{r_0}\frac{\partial Pa}{\partial x}-\frac{gh^2}{2r_0}\frac{\partial r}{\partial x}+\frac{t_{sx}}{r_0}-\frac{t_{bx}}{r_0}-\frac{1}{r_0}(\frac{\partial S_{xx}}{\partial x}+\frac{\partial S_{xy}}{\partial y})+\ldots\\ \ldots+\frac{\partial}{\partial x}(hT_{xx})+\frac{\partial}{\partial y}(hT_{xy})+hu_sS\end{aligned} \tag{2}$$

$$\begin{aligned}\frac{\partial h\bar{v}}{\partial t}+\frac{\partial h\overline{uv}}{\partial x}+\frac{\partial h\bar{u}^2}{\partial y}=-f\bar{u}h-gh\frac{\partial h}{\partial y}-\frac{h}{r_0}\frac{\partial Pa}{\partial y}-\frac{gh^2}{2r_0}\frac{\partial r}{\partial y}+\frac{t_{sy}}{r_0}-\frac{t_{by}}{r_0}-\frac{1}{r_0}(\frac{\partial S_{yx}}{\partial x}+\frac{\partial S_{yy}}{\partial y})+\ldots\\ \ldots+\frac{\partial}{\partial x}(hT_{xy})+\frac{\partial}{\partial y}(hT_{yy})+hv_sS\end{aligned} \tag{3}$$

where x and y are horizontal Cartesian coordinates; η is the surface elevation; t is time; h is the total water depth; $\bar{u}$ and $\bar{v}$ are depth-averaged velocity components in x and y directions, respectively; P_a is the local atmospheric pressure; ρ_0 is the reference of water density; ρ is the density of water; f is the Coriolis parameter; S_{xx}, S_{xy}, S_{yx}, S_{yx}, S_{yy} are components of radiation stress tensor; T_{xx}, T_{xy}, T_{yy} are the lateral stress including viscous friction, turbulent friction, and differential advection; (τ_{sx}, τ_{sy}) and (τ_{bx}, τ_{by}) are the components of wind stress and bottom stress, respectively; S is magnitude of point source discharge.

Result and Discussions

Current fields and average velocities. Figure 2 present the current field of excavated-in harbor basin during a tidal periodicity. When m=0.7, $V=V_0$, $H=H_0$, the maximum velocities 0.38m/s appears in the both side of the harbor entrance. A strong oval-shaped current is distributed near the harbor entrance.

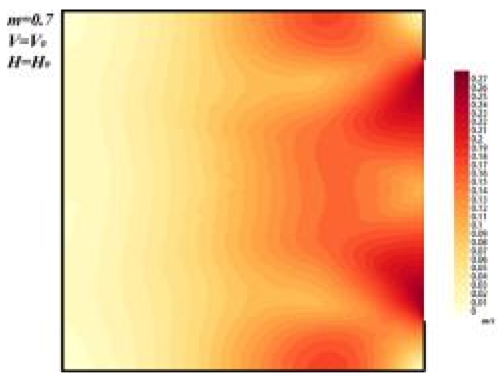

Figure 2 The current field of excavated-in harbor basin

Impact factors of excavated-in harbor basin current field

(1) Width of harbor entrance

On the assumption that tidal flux, water depth is parameter, the current field changes in some pattern as the width of harbor entrance changes.

When m=0.1, the current field is like jet-flow current field. The maximum velocities 1.19m/s appears in the middle of the harbor entrance. A strong jet-flow current is distributed from the middle of the entrance to the center of harbor basin. When m=0.3, the maximum velocities 0.52m/s appears in the both side of the harbor entrance. A strong oval-shaped current is distributed in the center of the harbor basin. When m=0.5, the maximum velocities 0.38m/s appears in the both side of the harbor entrance. A strong oval-shaped current is distributed near the harbor entrance. When m=0.7, the maximum velocities 0.38m/s appears in the both side of the harbor entrance. A strong oval-shaped current is distributed near the harbor entrance. The velocities decrease as the width of harbor entrance increase.

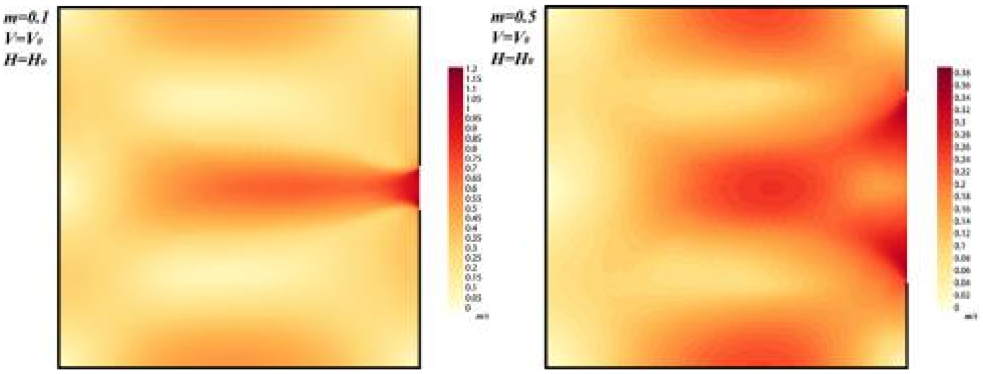

Figure 3 The Current field with different width of harbor entrance

(2) Water depth

On the assumption that the width of harbor entrance, tidal flux is parameter, the current field changes in some pattern as water depth changes.

Figure 4 presents that the current fields with different water depth are like the current field with different harbor entrance width. The velocities decrease as the water depths increase.

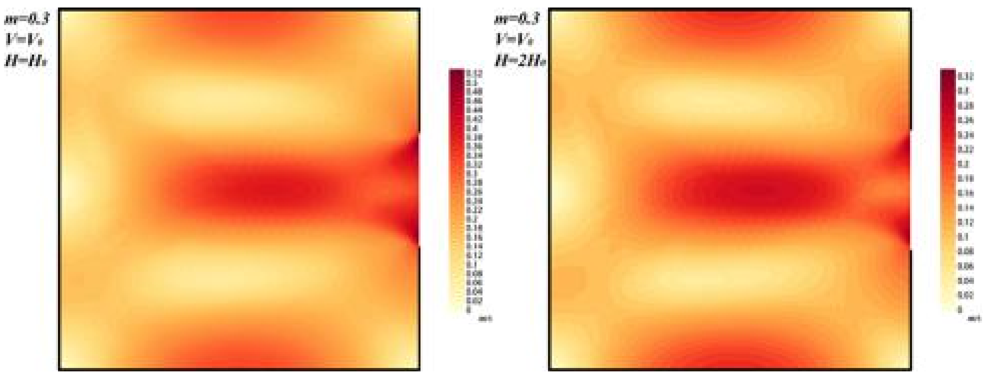

Figure 4 The Current field with different water depth

(3) Tidal flux

On the assumption that the width of harbor entrance, water depth are parameter, the current field changes in some pattern as tidal flux changes.

Figure 5 presents that the current fields with different tidal flux are similar to the current field with different harbor entrance width. The velocities decrease as the tidal flux decrease.

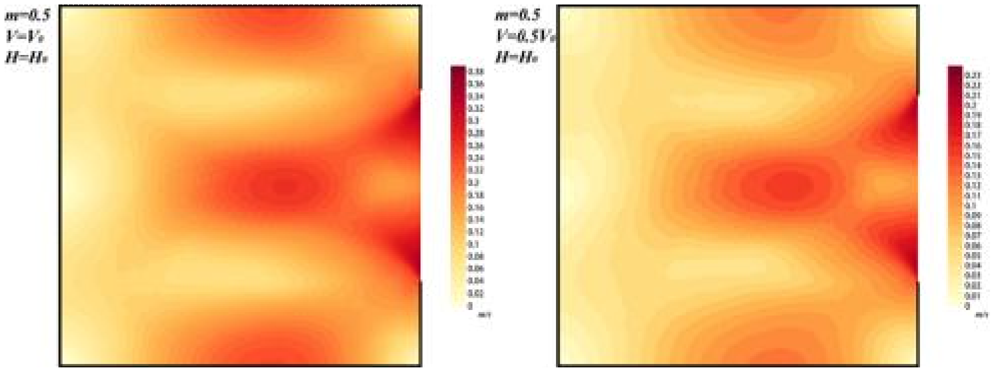

Figure5 The Current field with different tidal flux

Conclusions

In this study, a numerical model was developed to simulate excavated-in harbor basin current field. Results show that, the current field of excavated-in harbor basin is influenced by width of harbor entrance ,tidal influx and topography, It shows that:1) when tidal flux, water depth are parameter, the velocities decrease as the width of harbor entrance increase;2) when tidal flux, the width of harbor entrance are parameter, the velocities decrease as water depth increase;3)when the width of harbor entrance ,water depth are parameter, the velocities decrease as tidal flux decrease.

References

[1] de Saint-Venant B. Note à joindre au Mémoire sur la dynamique des fluides[J]. Comp. Rend, 1843, 17: 1240.

[2] Prandtl L. Bericht über Untersuchungen zur ausgebildeten Turbulenz[J]. Z. Angew. Math. Mech, 1925, 5(2): 136-139.

[3] Leendertse J J. Aspects of a computational model for long-period water-wave propagation[M]. Santa Monica, California: Rand Corporation, 1967.

[4] Takasugi Y, Fujiwara T, Higo T. Structure of the strong tidal jet in the Naruto Strait[J]. Journal of the Oceanographical Society of Japan, 1990, 46(3): 69-83

[5] Byun D S, Holloway P E. Tidal characteristic adjustment due to dyke and seawall construction in the Mokpo Coastal Zone, Korea[J]. Estuarine, Coastal and Shelf Science, 2004, 59(2): 185-196.

[6] Rafik Absi.An ordinary differential equation for velocity distribution and dip-phenomenon in open channel flows[J]. Journal of Hydraulic Research,2011, No.1