Wave Inundation at Mokpo Harbor
목포항에서의 풍파로 인한 범람

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Abstract

Tidal amplification by construction of the sea-dike and sea-walls had been detected not only near Mokpo Harbor but also at Chungkye Bay which is connected with Mokpo Harbor by a narrow channel. This brings about increase of tidal flat area and in particular increase of surge-wave combined runup during storms.

The purpose of this study is to examine an efficient operational model that can be used by civil defense agencies for real-time prediction and fast warnings on wind waves and storm surges. Instead of using commercialized wave models such as WAM, SWAN, the wind waves are simulated by using a new concept of wavelength modulation to enhance broader application of the hyperbolic wave model of the mild-slope equation type. Furthermore, The predicting system is composed of easy and economical tools for inputting depth data of complex bathymetry and enormous tidal flats such as Mokpo coastal zone. The method is applied to Chungkye Bay, and possible inundation features at Mokpo Harbor are analyzed.

Key words : Surge-Wave, Storm Surge, Chungkye Bay, Mild-slope Equation

1. Introduction

Storm surge is water that is pushed toward the shore by the force of the winds swirling around the storm. Along the immediate affected coast, storm surge is the greatest threat to life and property. In particular, the surge of high water topped by waves is devastating and it can cause severe damage to coastal structures. For civil and coastal engineers, accurate prediction of the wind waves is critical in their structural design and mitigation plan.

Tidal amplification by construction of the sea-dike and sea-walls had been detected not only near Mokpo Harbor but also at Chungkye Bay which is connected with Mokpo Harbor by a narrow channel. This brings about increase of tidal flat area and in particular increase of surge-wave combined runup during storms (Kang, 1999).

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In this study, an efficient operational model is presented in order that civil defense agencies use it for real-time prediction and fast warnings on wind waves and storm surges. Instead of using commercialized wave models such as WAM, SWAN, the wind waves are simulated by using a new concept of wavelength modulation to enhance broader application of the hyperbolic wave model of the mild-slope equation type. Furthermore, The predicting system is composed of easy and economical tools for inputting depth data of complex bathymetry and enourmous tidal flats such as Mokpo coastal zone. The method is applied to Chungkye Bay, and possible inundation features at Mokpo Harbor are analyzed.

2. Model Description

The linear version of mild-slope equation proposed by Lee and Park (2001) is used for the wind generating model for a large area, while the nonlinear model is used for the detailed wave inundation model at a small area. It is noticeable that the nonlinear and linear versions were proven to be equivalent to Boussinesq equation and Smith and Sprinks equation (1975), respectively. So the model is able to describe the nonlinear and irregular processes of waves to propagate with a group velocity.

The most critical step in the inundation calculation is the shoreline computation, which involves a moving boundary interface between liquid and solid. In our inundation computations, flooding has dry grids come into action allowing incoming flux into the grid cell due to the gradient of surface level as shown in Figure 1. In computing incoming flux, the water level at dry grid is assumed to be posed at the beach surface. When drying, the outgoing flux is not any more allowed if the calculated water surface is lower than that of the beach face.

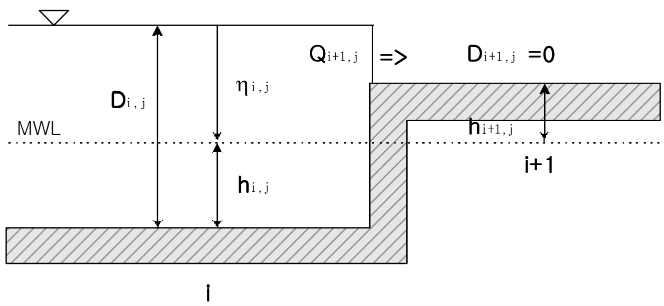


Figure 1. Incoming flux into the dry grid at flooding zion

The model is programmed in Matlab so that results can be easily visualized using Matlab graphic tools. It has been subsequently modified to include land points by adding appropriate logical masks and extensively using the GUI feature of the Matlab programming language. The system is to be used semi-automatically at any area of interest in the coastal waters of Korea. Consequently, the development of automatic system for the generation of bathymetry-related data and pre-determinable boundary conditions were accomplished in advance. The full set of depth-integrated non-linear equations is solved with an improved finite difference scheme for fast calculation.

3. Model Test

In order to verify the run-up model, a water surface movement in a parabolic basin (see Figure 2) and the propagation and run-up process on nearshore coastal zone are examined. Runs were commenced at the initial time t=0 with the specific basin factors. A grid system of 320×320 with a coarse grid size of 8km×8km, and a computational time step of 1.25sec were used. Model results were compared with Thacker (1981)'s exact solution of water surface motion in a parabolic basin. Agreement between the present model and the analytical solutions is quite good as shown in Figure 3. Therefore, it can be concluded that the model is sufficiently good for the simulation of run-up and run-down processes of tsunami waves.

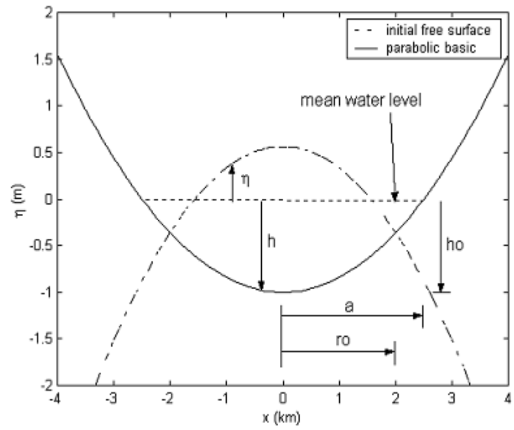
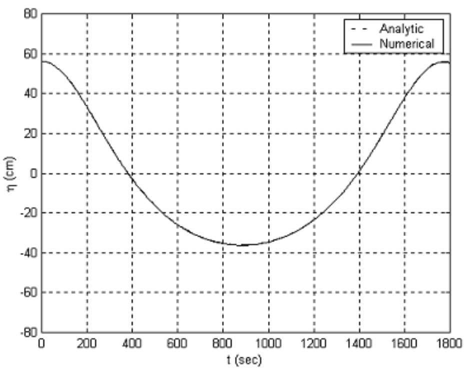


Figure 2. Schematic diagram of water surface oscillation in a parabolic basin

(a) r = 0 km



(b) r=1km

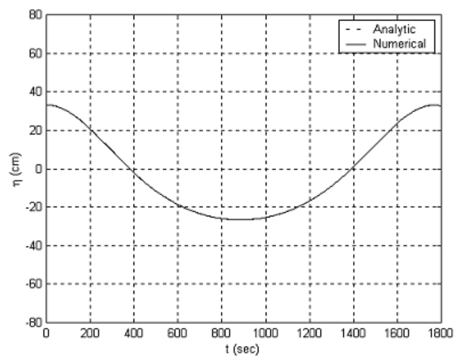


Figure 3. Temporal comparison with analytical solution

4. Application to Chungkye Bay Zone

The computational domain for the present simulation is composed of a large area covering Chungkye Bay (see Figure 4) and small region of Mokpo district covering the coastal lands and waters (see Figure 5). Mokpo harbor is located in the northwestern part of low plane coasts. Grid systems of 316×625 with a coarse grid size of 60m×60m and 360×320 with a fine grid size of 5m×5m were used. Runs were commenced from an initial calm state. Figures 6 and 7 show the computed wave heights and inundated zone flooded by storm waves, respectively, at high tide level.

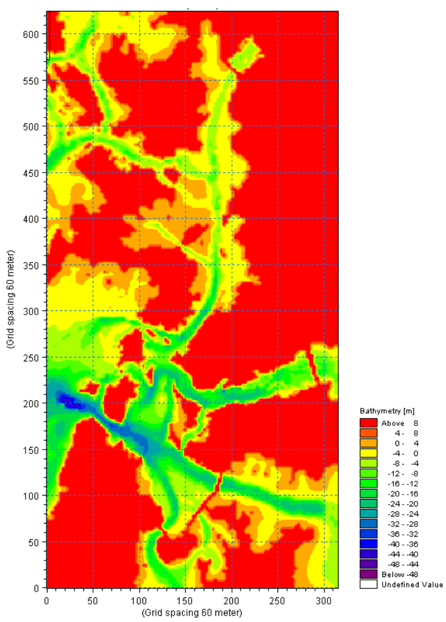


Figure 4. Chungkye Bay

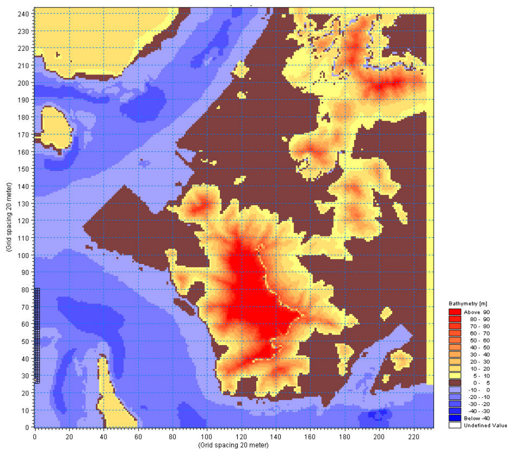


Figure 5. Mokpo coastal zone

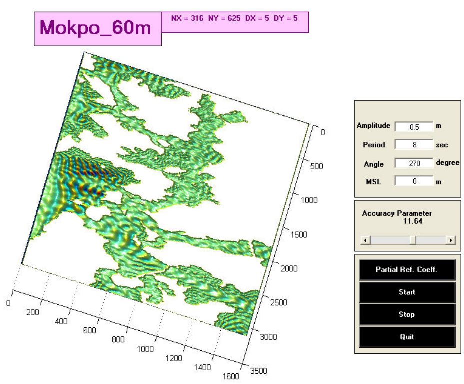


Figure 6. Generated waves (wavelength extended)

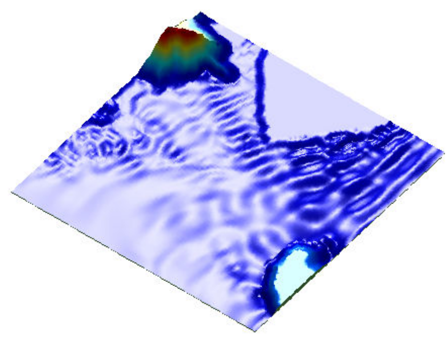


Figure 7. Wave flooding in Mokpo Harbor

5. Conclusion

The wind-wave generating and inundation model system is applied to Chungkye Bay, and possible inundation features at Mokpo Harbor are analyzed. The model has been developed for a warning system which is ready to use for emergency management officials to play a major role in protecting life and properties more effectively. Although this system needs to be improved against further measured data, it is also urgently suggested for such a warning system to be installed as soon as possible for future uses. Owing largely to development of better warning systems, inundation-related loss of life is expected to decrease dramatically in the near future.

We have to recognize that scientific information is often misused or not used at all because of rigidities and practicalities of decision-making processes. This system is only useful if it can be incorporated into the decision process of particular users. Therefore, it is likely that the value of such forecasts will not be self-evident to most users even if forecasts of storm waves demonstrate increased skill. Hence it may be worthwhile for producers of forecasts to conduct an ongoing parallel research effort targeted at actual and potential users.

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