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SIMULATION OF SPILLING BREAKING WAVES

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Introduction

Along with physical experiments, numerical simulations are useful tools for designing coastal structures as well as for understanding natural hydrodynamic processes in the field of coastal engineering. Among the numerical models, the VOF-type model(Volume Of Fluid) has been attracted as a potential tool to construct practical numerical wave channels in the past decade. The VOF model can simulate flows including the shape and evolution of the free surface, thus the complex free surface boundary can be efficiently simulated.

In this paper, a commercially available Computational Fluid Dynamics software called FLUENT has been deployed for 2D spilling breaking wave simulations. This software is designed to solve transient, free surface flow problems based on the solution of the Navier-Stokes equations in two or three-dimensions. We will compare the results with experimental data [1] and numerical models [2], [3].

Model Description

The condition similar to the laboratory experiment by [1] is used for testing the numerical simulation of breaking waves on a sloping bottom. In the laboratory experiment, a beach with uniform slope of 1/35 is connected to a region with constant depth d_c=0:40 m. Figure1) shows the schematic view of the numerical wave tank. The wave parameters are shown in Table1).

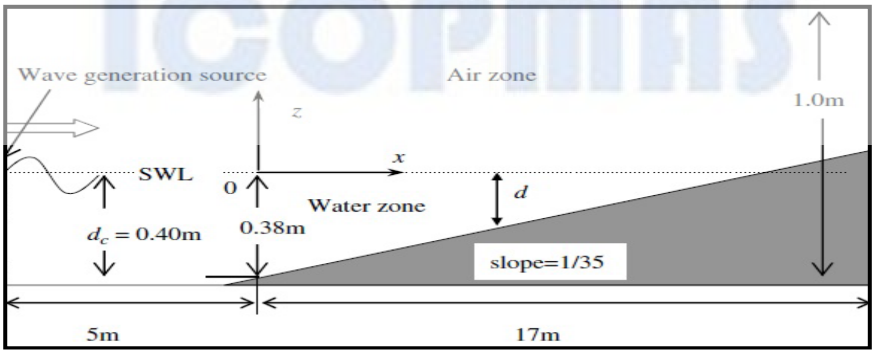

Fig. 1) Sketch of Simulation domain

Table 1) Incident Wave Characteristics

Breaker type	H_0 (m)	T (s)	H_0/L_0	x_b (m)	d_b (m)
Spilling	0.127	2	0.020	6.4	0.195

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Governing Equations

The governing equations for simulation of the unsteady turbulent flows (NS equations) in the near-shore zone are described with a two-dimensional k-ε turbulence model as follows. They are based on conservation of mass (1) and momentum (2)-(3).

$$\frac{\partial u}{\partial x}+\frac{\partial w}{\partial z}=0 \qquad (1)$$

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+w\frac{\partial u}{\partial z}=\left(\nu\frac{\partial^2 u}{\partial x^2}\right)+\left(\nu\frac{\partial^2 u}{\partial z^2}\right)-\frac{1}{\rho}\frac{\partial P}{\partial x}+\frac{\partial}{\partial x}\left(2\upsilon_t\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial z}\left[\upsilon_t\left(\frac{\partial u}{\partial z}+\frac{\partial w}{\partial x}\right)\right] \qquad (2)$$

$$\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+w\frac{\partial w}{\partial z}=\left(\nu\frac{\partial^2 w}{\partial x^2}\right)+\left(\nu\frac{\partial^2 w}{\partial z^2}\right)-\frac{1}{\rho}\frac{\partial P}{\partial z}+\frac{\partial}{\partial z}\left(2\upsilon_t\frac{\partial w}{\partial z}\right)+\frac{\partial}{\partial x}\left[\upsilon_t\left(\frac{\partial u}{\partial z}+\frac{\partial w}{\partial x}\right)\right]-g \qquad (3)$$

The VOF model is a surface-tracking technique designed for two or more immiscible fluids where the position of the interface between the fluids is of interest. In any given cell, the function F(x, z) is the proportion of the cell that is filled. The derivatives of F can be used for the definition of the fluid location in any cell. The governing equations for F are

$$\frac{\partial F}{\partial t}+u\frac{\partial F}{\partial x}+w\frac{\partial F}{\partial z}=0 \qquad (4)$$

$$0\le F\le 1 \qquad (5)$$

Model Performance

The water surface profile for time=15.28s can be observed in Fig.2). Figs.3) presents turbulent viscosity while a particular wave starts to break.

Fig. 2) Water Surface Profile (t=10.28s)

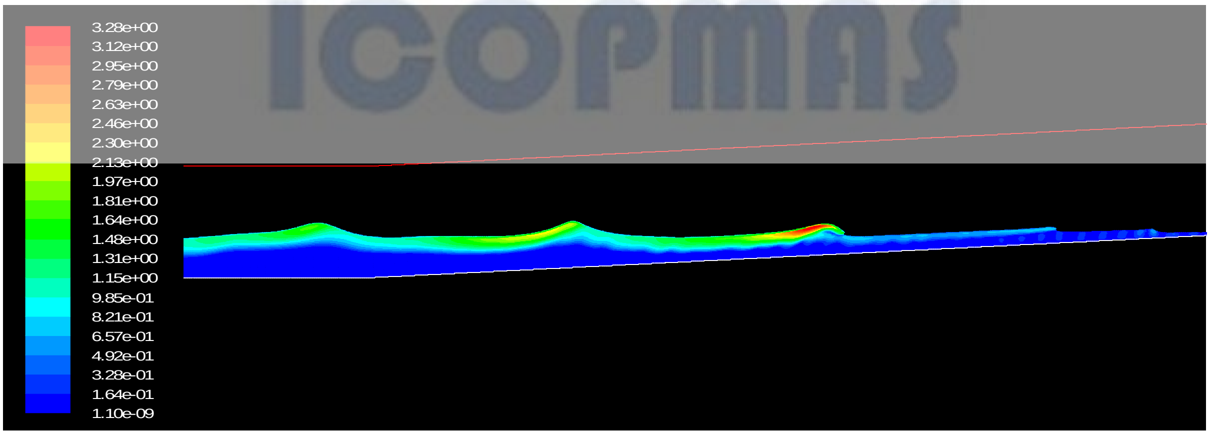

Fig. 2) Contours of Turbulent Viscosity (kg/m-s)-(time=10.504s)

In Fig.4) , the variation of water surface elevation during a period for x=4m has been illustrated. The model results show a difference about 25% in H_b and 22% in x_b which are breaking height and location of wave while breaking respectively.

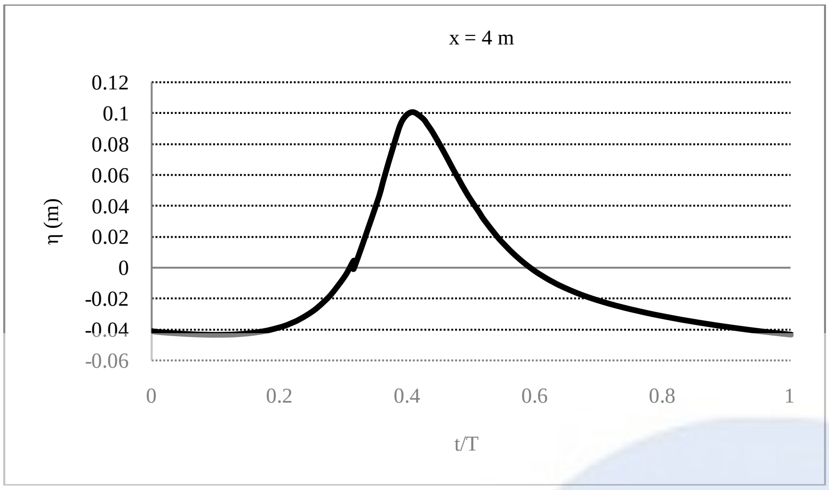

Fig. 3) The variation of water elevation in a period (x=4m)

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