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SIMULATION OF PLUNGING BREAKING WAVES

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Introduction

In shallow waters in coastal zones, the shoreward wave propagation generally involves complex phenomena such as wave breaking and run-up, which are of fundamental importance in coastal engineering. 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.
In this study, a commercially available CFD software, called FLUENT has been deployed for modeling plunging breakers and their induced cross-shore currents. This software is designed to solve transient, free surface flow problems based on the solution of the Reynolds-Averaged Navier-Stokes (RANS) equations. The present 2D two phase flow contains k-ε turbulence model and a VOF model to track air and water interface. The dynamic mesh technique is applied to generate waves similar to piston-like wave maker. 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).

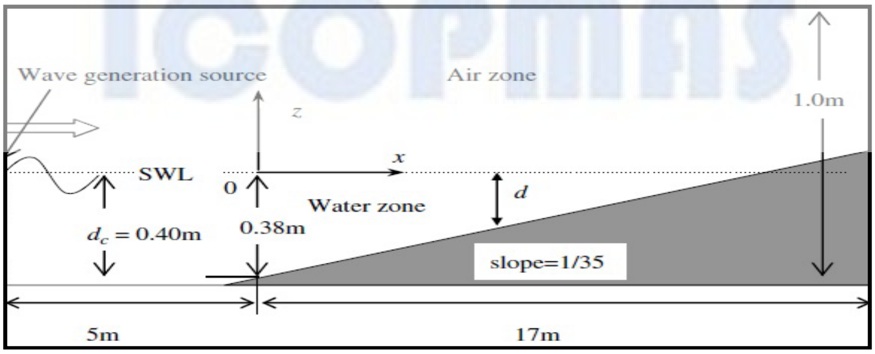

Fig. 1) Sketch of Simulation domain

Table 1) Incident Wave Characteristics

Breaker type	H_0 (m)	T (s)	H_0/L_0	x_b (m)	d_b (m)
Plunging	0.128	5	0.0023	7.795	0.156

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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).

$$\frac{\partial u}{\partial x}+\frac{\partial w}{\partial z}=0 \tag{1}$$

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

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

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

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

$$0\le F\le 1 \tag{5}$$

Model Performance

The water surface profile for three different times can be observed in Fig.2). Figs.3) presents the variation of water elevation in a period.

Fig. 2) Water Surface Profile (t=14.4T, 14.452T&14.5T)

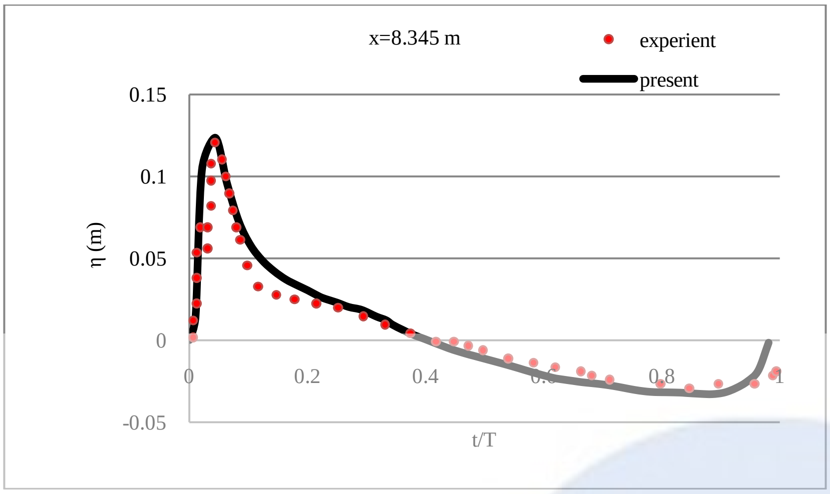

Fig. 2) The variation of water elevation in a period (x=8.345m)

In Fig.4) , the variation of horizontal velocity during a period for a specific point is depicted and compared with experiment.

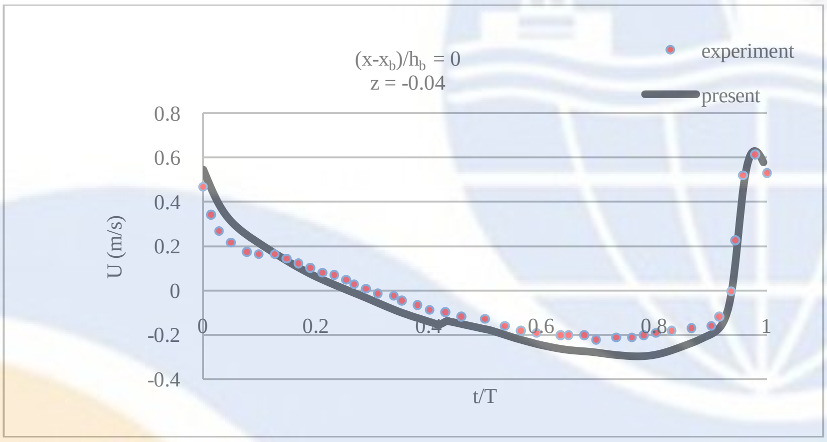

Fig. 4) The variation of horizontal velocity in a period (z=-0.04m)

Despite some small differences, the present results are in good general agreement with experimental results.

References

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