NUMERICAL SIMULATION OF TWO-DIMENSIONAL FREE-SURFACE FLOW AND WAVE TRANSFORMATION OVER CONSTANT-SLOPE BOTTOM TOPOGRAPHY

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Abstract

A method for the numerical simulation of two-dimensional free-surface flow resulting from the propagation of regular gravity waves over topography with arbitrary bottom shape is presented. The method is based on the numerical solution of the Euler equations subject to the fully nonlinear free-surface boundary conditions and the appropriate bottom, inflow and outflow conditions using a hybrid finite-differences and spectral-method scheme. The formulation includes a boundary-fitted transformation, and is suitable for extension to incorporate large-eddy simulation (LES) and large-wave simulation (LWS) terms for turbulence and breaking wave modeling, respectively. Results are presented for the simulation of the free-surface flow over two different bottom topographies, with constant slope values of 1:10 and 1:20, two different inflow wave lengths and two different inflow wave heights. An absorption outflow zone is utilized and the results indicate minimum wave reflection from the outflow boundary. Over the bottom slope, lengths of waves in the linear regime are modified according to linear theory dispersion, while wave heights remain more or less unchanged. For waves in the nonlinear regime, wave lengths are becoming shorter, while the free surface elevation deviates from its initial sinusoidal shape.

Keywords: Free-surface flow; Wave transformation; Euler equations; Numerical simulation; Constant-slope bottom.

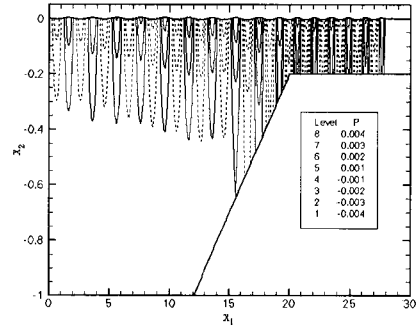

Fig. 1 Pressure contour plot for bottom slope 1:10, inflow wavelength 2 and inflow wave height 0.005 (solid lines for positive values; dashed lines for negative values).

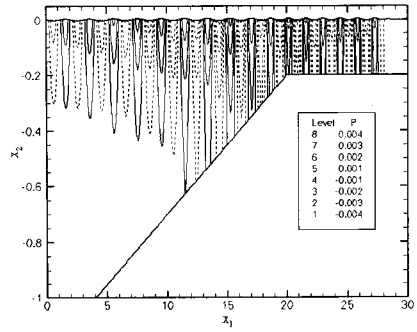

Fig. 2 Pressure contour plot for bottom slope 1:20, inflow wavelength 2 and inflow wave height 0.005 (solid lines for positive values; dashed lines for negative values).

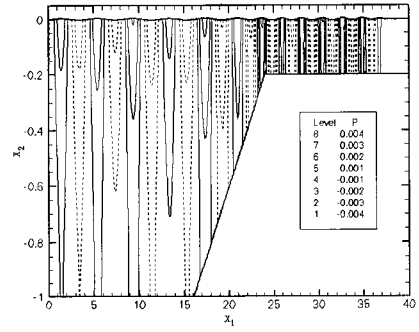

Fig. 3 Pressure contour plot for bottom slope 1:10, inflow wavelength 4 and inflow wave height 0.005 (solid lines for positive values; dashed lines for negative values).

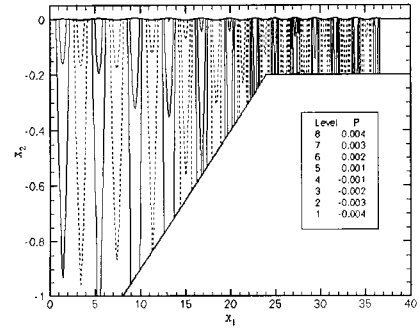

Fig. 4 Pressure contour plot for bottom slope 1:20, inflow wavelength 4 and inflow wave height 0.005 (solid lines for positive values; dashed lines for negative values).

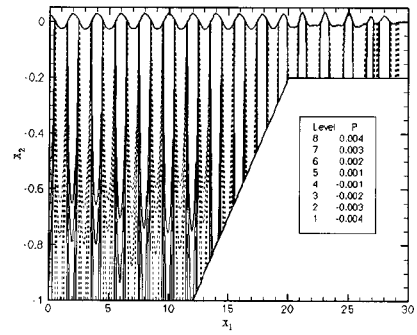

Fig. 5 Pressure contour plot for bottom slope 1:10, inflow wavelength 2 and inflow wave height 0.05 (solid lines for positive values; dashed lines for negative values).

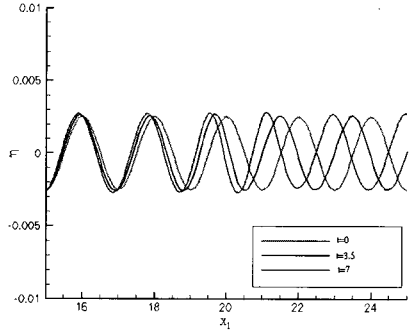

Fig. 6 Free-surface elevation at three time instants for bottom slope 1:10, inflow wavelength 2 and inflow wave height 0.005.

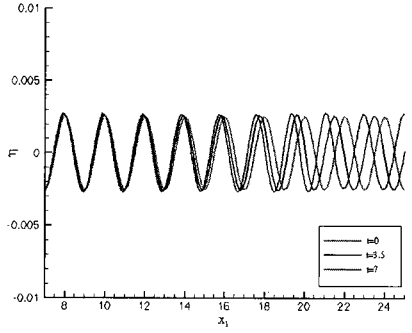

Fig. 7 Free-surface elevation at three time instants for bottom slope 1:20, inflow wavelength 2 and inflow wave height 0.005.

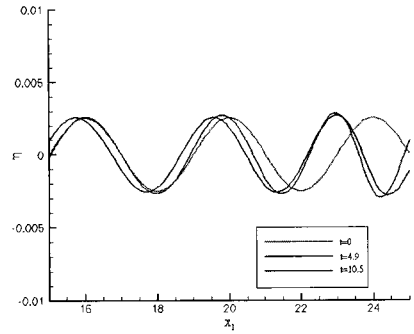

Fig. 8 Free-surface elevation at three time instants for bottom slope 1:10, inflow wavelength 4 and inflow wave height 0.005.

REFERENCES

Dimas, A.A., Fialkowski, L.T., 2000. Large wave simulation (LWS) of free-surface flows developing weak spilling breaking waves. J. Comput. Phys., Vol. 159, pp. 172-196.

Gotlieb, D., Orszag, S.A., 1977. Numerical Analysis of Spectral Methods. Theory and Applications, SIAM.

Hur, D.-S., Mizutani, N., 2003. Numerical estimation of the wave forces acting on a three-dimensional body on submerged breakwater. Coast. Eng., Vol. 47, pp. 329-345.

Lin, P., Liu, P.L.-F., 1998. A numerical study of breaking waves in the surf zone. J. Fluid Mech., Vol. 359, pp. 239-264.

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