NUMERICAL INVESTIGATION OF BREAKING IRREGULAR WAVES OVER A SUBMERGED BAR WITH CFD

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INTRODUCTION

The study of breaking irregular waves is of great practical interest, because of the waves found in the nature. Regular waves are seldom found in the field. Irregular waves can be viewed as the superposition of a number of regular waves (wave components) with the different frequencies and the amplitudes. The breaking process for irregular waves is more complex as compared to breaking regular waves. The energy transfer between the individual wave components of different frequencies also takes place during the breaking process. Due to this, the spectral characteristics of the incident wave spectrum change during the breaking process. The main purpose of the study is to investigate the hydrodynamics during the interaction of breaking irregular waves with a submerged bar.

NUMERICAL MODEL

The numerical model REEF3D (Bihs et al., 2016) is based on the Reynolds-Averaged Navier-Stokes equations. For temporal discretization, the 3rd-order accurate TVD Runge-Kutta scheme is employed. For temporal discretization, the third-order accurate TVD Runge-Kutta scheme is employed. The non-linear convective terms of RANS equations are discretized by the 5th-order WENO scheme. The irregular wave free surface is captured by the level set method. High-order temporal and spatial discretization is used for the level set function, which avoid unphysical damping of the propagating water waves. The turbulence generated during wave propagation and wave breaking is modelled with the $k - \omega$ model. The code is parallelised using the MPI library.

NUMERICAL SETUP

The submerged trapezoidal bar has a weather side slope of 1:20 and 2 m horizontal crest followed by a 1:10 lee side slope at a distance of 6 m from the wave board. The numerical setup can be seen in Fig.1 The numerical results are compared with the experiments by Beji et al. (1994) in order to validate the numerical model.

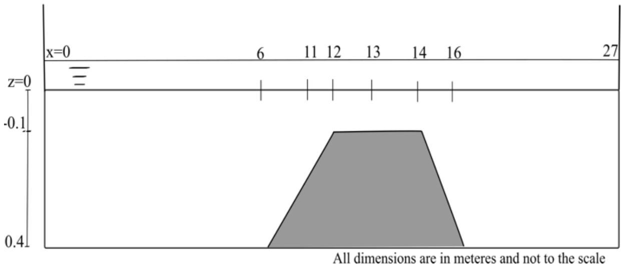
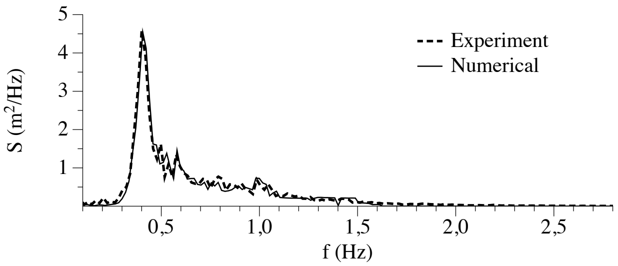


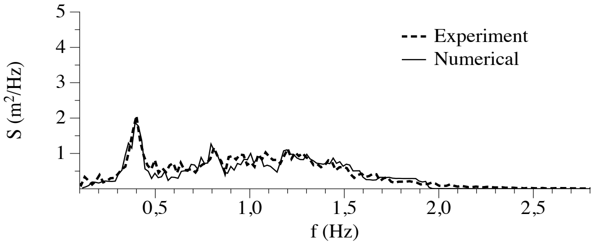
Figure 1 – Numerical wave tank setup

RESULTS AND DISCUSSION

The comparison of the experimental and numerical wave spectral density for two different wave gauge locations (x = 11m and 16m) is presented in Fig.2. The spectral characteristics of breaking irregular waves during propagation, shoaling and breaking are well represented in the numerical simulation. This is observed by a good agreement between the numerical and experimental results. Numerical free surface with the velocity variation over a submerged bar for a wave breaking event is presented in Fig. 2. The breaker tongue with higher wave crest velocities during the irregular wave breaking can be seen in Fig. 3(a). After the wave breaks, a reduction in the wave crest velocities is noticed due to the loss of wave energy during wave breaking (Fig. 3(b)). These observations are consistent with the experiments.



a)

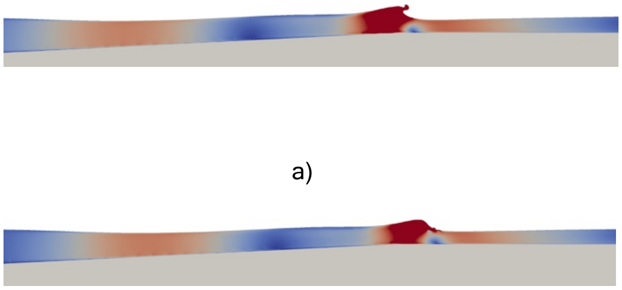


b)

Figure 2 - Comparison of numerical and experimental spectral wave density at a) x= 11m b) x=16m

CONCLUSIONS

The wave spectrum becomes broader due to the growth of the higher-frequency components and redistribution of the energy across the wave spectrum via non-linear energy transfers. Therefore, the shoaling process leads to the widening of the wave spectra (i.e. energy transfer from the peak region to other frequency components due to the non-linear interaction). After wave breaking, the spectral peak is reduced but energy contribution towards the higher frequency components is increased.



a)

b)

Figure 3 - Computed wave profile with the velocity variation (m/s) during the wave propagation over a submerged bar at (a) 42.3s (b) 42.39

REFERENCES

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