NUMERICAL STUDY OF TURBULENCE DYNAMICS IN PLUNGING & SURGING BREAKING WAVES

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Breaking waves are of great importance in many coastal engineering applications. Nearshore breaking waves play an essential role in nearly all coastal processes including coastal currents and sediment transport. Breaking waves generate turbulence which increases the mixing rate and has an important impact on surf zone sediment transport. Wave breaking generated turbulence can stir up the sediments in surf zone and make them available for transport by mean flow. Therefore, in the study of sediment transport in surf zone, turbulence dynamics and spatial and temporal variations of turbulence kinetic energy should be well modeled for the direction and rate of sediment transport to be determined. Intensive researches have been carried out to achieve a better understanding of breaking waves, however, very few has been directly related to study of turbulence dynamics and transport in surf zone breaking waves.

Among the studies performed on surf zone turbulence dynamics, the experimental works of Ting and Kirby have had a unique place. They showed that turbulence kinetic energy under a plunging breaking wave is more transported landward and rate of dissipation is quite high [1]. For spilling breakers, what happens is quite the opposite. Turbulence kinetic energy is transported seaward and diffusion plays the most important roll in the transport of turbulence. Besides, compared to plunging breakers, turbulence dissipation rate is much slower for spilling breaking waves.

In this study, the turbulence dynamics in plunging and surging breaking waves have been investigated by means of a two-dimensional numerical model. The basic elements of the developed numerical model are, (i) Reynolds Averaged Navier-Stokes (RANS) equations that describe the mean motion of any turbulent flow, (ii) a $k-\varepsilon$ turbulence closure model that describes the turbulence transport and dissipation process and (iii) an efficient technique (Volume Of Fluid, VOF) for tracking the free surface. Some of the main conclusions obtained from the present study can be summarized as follows:

At the present time, it is believed that the main part of turbulence production takes place in the aerated region of the recirculating flow or the so called "surface roller". Due to difficulties with instrumentation in aerated water, experimental studies cannot provide details to support this hypothesis. The results obtained from the present study are quite consistent with this hypothesis.

Dynamics of turbulence in surging and plunging breaking waves completely differ to that of spilling breakers. According to experimental studies of Ting and Kirby, in case of spilling breakers, turbulence is more directed seaward and diffusion plays the most important roll in the transport of turbulence energy. As shown in this study (Fig.1) and also has stated by Ting and Kirby, turbulence transport in a plunging breaking wave is highly dominated by advection. Turbulence is much more advected horizontally landward than to be diffused vertically downward. This seems to be the case for surging breakers as well (Fig. 2).

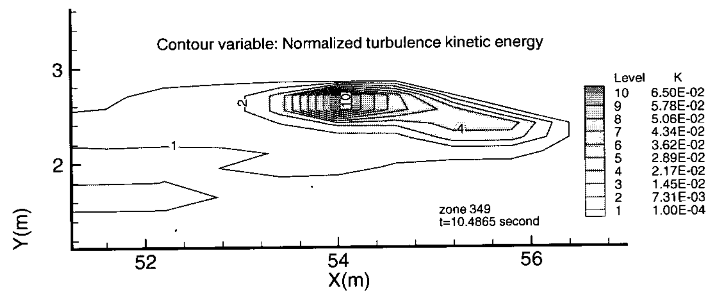

Fig. 1 Distribution of turbulent kinetic energy (Plunging Breaking)

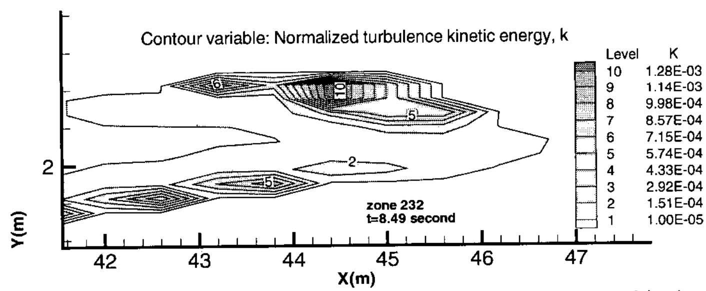

Fig. 2 Distribution of turbulent kinetic energy (Surging Breaking)

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