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Laboratory Study of Eddy Viscosity Structure under Wave-Current Interaction

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Both waves and currents are present in the ocean by many different ways. Many research work, both theoretically and experimentally had been contributed on understanding the interaction mechanism of combined wave-current flow, because of its important effects on the infrastructure stability, sediment transport and some environmental problems. Many researchers, theoretically have studied the velocity profile in wave-current interaction with the assumption of eddy-viscosity concept. Most of the experiments were conducted in wave flumes which facilitated only wave-current parallel case. Moreover, very few experiments, reported in wave basin for wave-current arbitrary interaction, did not investigate the eddy viscosity profiles. The purpose of the experiment was to determine the distribution of terms

$$\left\{ -\overline{uw} - \overline{\tilde{u}\tilde{w}} - \overline{u'w'}, -\overline{wv} - \overline{\tilde{w}\tilde{v}} - \overline{w'v'} \right\}$$

experimentally which are dominant in describing eddy viscosity profiles $\{\nu_x, \nu_y\}$felt by the steady and periodic flow components for the condition of current acting perpendicular to waves. Experiment was carried out in a 3-D wave basin (25 m × 10 m × 0.9 m) in the National University of Singapore, reproducing the physical system of waves and current stream (7.2 m × 2 m × 0.6 m) acting perpendicular to each other over a fixed bed. Instantaneous velocity was decomposed into mean, fluctuation and periodic components in calculation of eddy viscosities dominant terms. The derivation and use of Reynolds equation for combined wave current flows, proposed by P. Nielsen 1992, was used in the data analysis. The results showed a linear variation of eddy viscosity dominant terms and their magnitude variation was significant with change of wave height, but different current strength produced the same magnitude. It was also observed that overall change of eddy viscosity felt by periodic $\{\nu_z\}$component over a wave cycle was nearly zero over the whole depth, but its magnitude was increased linearly with height above the bottom. Therefore consideration of the time dependent liner eddy viscosity assumption above wave boundary layer, may be appropriate in the derivation of current directional velocity profile and steady part of eddy viscosity $\{\nu_x\}$alone could be considered in determination of mean shear distribution, sediment transport budget under wave-current perpendicular interaction.

Keywords: Wave-current interaction; eddy viscosity; wave cycle

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