TIME-MEAN VELOCITY FOR WAVES PROPAGATING AGAINST A TURBULENT CURRENT OVER A ROUGH BED

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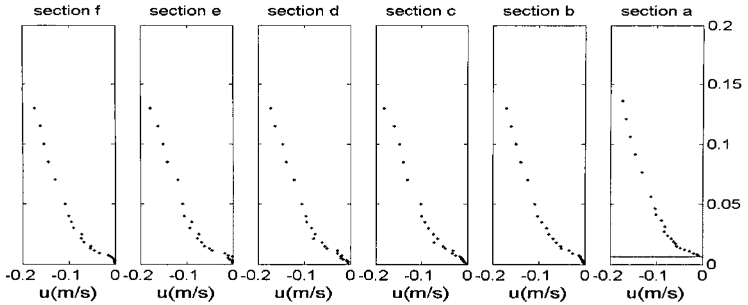
The effects of waves on the turbulent current are an important topic for both academic interests and practical applications. In shallow water, waves can stir up the sediment grains on the bottom and the mean current is responsible to carry them to other places, causing erosion/accretion and affecting the quality of coastal water. The initiation of the sediment motion is strongly influenced by the bottom wave-current boundary layer.

It is well known that the time-mean drift in pure waves is positive close to the smooth bed. For rough bed, the time-mean velocity is not uniform in space, due to the present of the roughness elements. Recently, Ridler and Sleath (2000) systematically measured the time-mean drift induced by pure waves over two types of rough beds. They found that, next to the rough bottom, the maximum of the spatially averaged-drift can be either positive or negative, depending on wave amplitude a and the distance between two roughness elements λ. For combined wave and current boundary layer, many works have been done in the past several decades, both experimentally and theoretically. For wave following current, Mathisen and Madsen (1996a, 1996b) found that the wave-induced time-mean drift might be important for the time-mean velocity next to rough bed. For wave opposing current, Kemp and Simons (1983) measured the wave-induced change in the mean current over a bottom roughened by triangular strips. The purpose of this paper is to measure the time-mean current in combined wave and current for a/λ =0.33 and 0.45, which would result in a near-bed negative time mean velocity according to Ridler and Sleath (2000). A typical spatial distribution of the time-mean velocity profile is shown in Fig. 1.

It was found that near the rough bottom the time-averaged current is strongly affected by the presence of the roughness elements. To verify the wave-current boundary layer theory under laboratory conditions the spatially averaged velocity profiles was used. It was found that GM theory could give reasonable prediction of the boundary layer flow under the conditions studied here (a/λ =0.33 and 0.45). Vortex shedding for wave alone is dramatically different from that for combined wave-current. In terms of the friction velocity and the apparent roughness for the time-mean flow outside the bottom wave-current boundary layer, the negative time-mean drift current over rough bed found in pure waves does not appear to affect the validity of the wave-current boundary layer theory (GM model) for the combined wave-current over rough bed. This work is supported by the Research Grants Council of Hong Kong (No. RGC-DAG03/04.EG39 and No. RGC-HKUST6227/04E).



Spatial distribution of time-mean velocity profile for wave maker setting (ii). Waves propagate from left to right; Current is from right to left.

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