VELOCITY CHARACTERISTICS OF BOUNDARY LAYER FLOW INDUCED BY A SHOALING SOLITARY WAVE PROPAGATING OVER A SLOPING BOTTOM

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KEYWORDS:

Main subjects: solitary wave shoaling on sloping bottom
Fluid: bottom boundary flow
Visualization method(s): particle trajectory technique, high speed particle image velocimetry
Other keywords: similarity profile

ABSTRACT: Velocity measurement of shoaling bottom boundary layer flow induced by a solitary wave propagating over a sloping bottom could be achieved by using both particle trajectory technique and high speed particle image velocimetry (HS-PIV). The former one was used near the shoaling bottom boundary to visualize the flow field, especially the phase-lag phenomenon of reversal flow very near the sloping bottom. From the velocity fields (as shown in Fig. 1), it was found that the pressure gradient decreases after passing of solitary wave-crest across the measuring section, which results into the reversal of the velocity in the shoaling boundary layer flow. The flow reversal occurs in the earlier stage with the location of flow reversal zone close to the center of the area with respect to the relative wave height (= wave height H_0 / water depth h_0). The flow pattern can be classified into two types from the point of view of similarity analysis: one pre-passing and other post-passing phases of the crest of the shoaling solitary wave.

The velocity distributions in the shoaling bottom boundary layer for pre-passing phase of solitary wave were regressed using two hyperbolic tangent functions. The unsteady free stream velocity $u_\infty(t)$ and the all four traditional representative thicknesses of boundary layer flow (boundary layer thickness δ, displacement thickness δ^*, momentum thickness θ and energy thickness δ_e) are found to be the suitable characteristic velocity and length scales to obtain the similarity profile (as depicted in Fig. 2a). However, all the four characteristic boundary layer thicknesses are found to be inter-related with each other. On the other hand, to attain the similarity profile for the velocity distribution for post-passing phase of the shoaling solitary wave, the characteristic velocity scale ($u_\infty - U_m$), where U_m (< 0) is the maximum negative velocity, and length scales half-velocity-deficit b_h were used (as demonstrated in Fig. 2b).

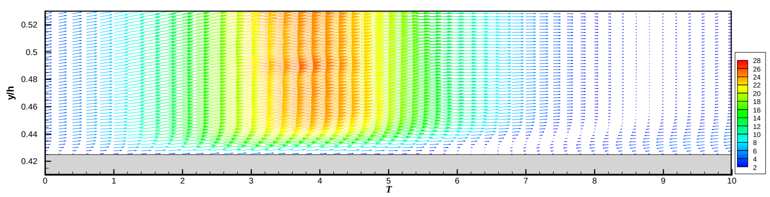

Fig. 1. Velocity fields obtained at x = 34 cm on sloping bottom near and in the boundary area for H_0/h_0 = 0.25.

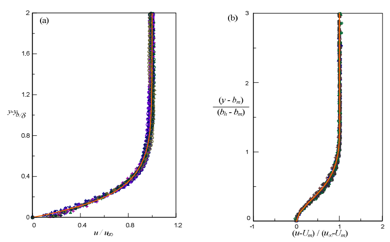

Fig. 2. Similarity profiles for u for pre-passing and post-passing of solitary wave.

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