Measurement of the Variation of Shear Velocity on Bed during a Wave Cycle

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30.08.2012

PARIS 27-31 Aug, 2012
6th International Conference on Scour and Erosion

Overview

- Introduction;
- Setup and procedures;
- Experimental results;
- Conclusions.

Introduction

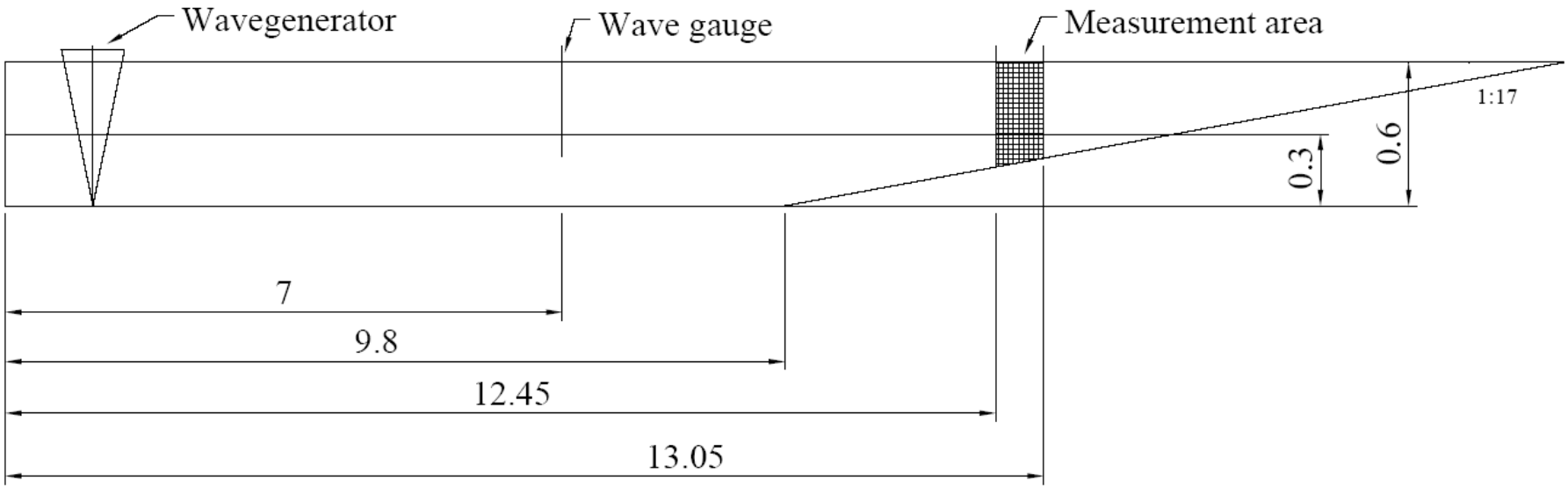
- The shear stresses and shear velocities on the bottom of the surf zone have been studied experimentally relatively little;

- Many theoretical researches in the field of breaking wave investigation are based on the experiments made in an oscillator U – tube;

- The theoretical work assumes that the velocity distribution is logarithmic during the whole wave period;

- All works so far have dealt with shear velocity in one point only – this means that based on the experiments it is impossible to evaluate the dynamics of the shear velocity.

Setup and procedures



T, s	h_b, m	d_b, m	x_b, m	H_0, m	H_0/L_0	H_b, m	H_b/d_b
2.0	0.106	0.111	2.90	0.072	0.012	0.118	1.06

Setup and procedures

- The shear velocity is evaluated using measured near bed velocities at the lower boundary of an open channel:

$$u^* = \sqrt{\frac{\tau_b}{\rho}}$$

- The bottom shear stress is calculated based on the measurements in the breaking waves:

$$\tau_b = \mu \frac{du}{dy}$$

- The velocity gradient was determined based on the 0-velocity on the boundary and the velocity measured closest to the bed. The height above the bed of the first measuring point:

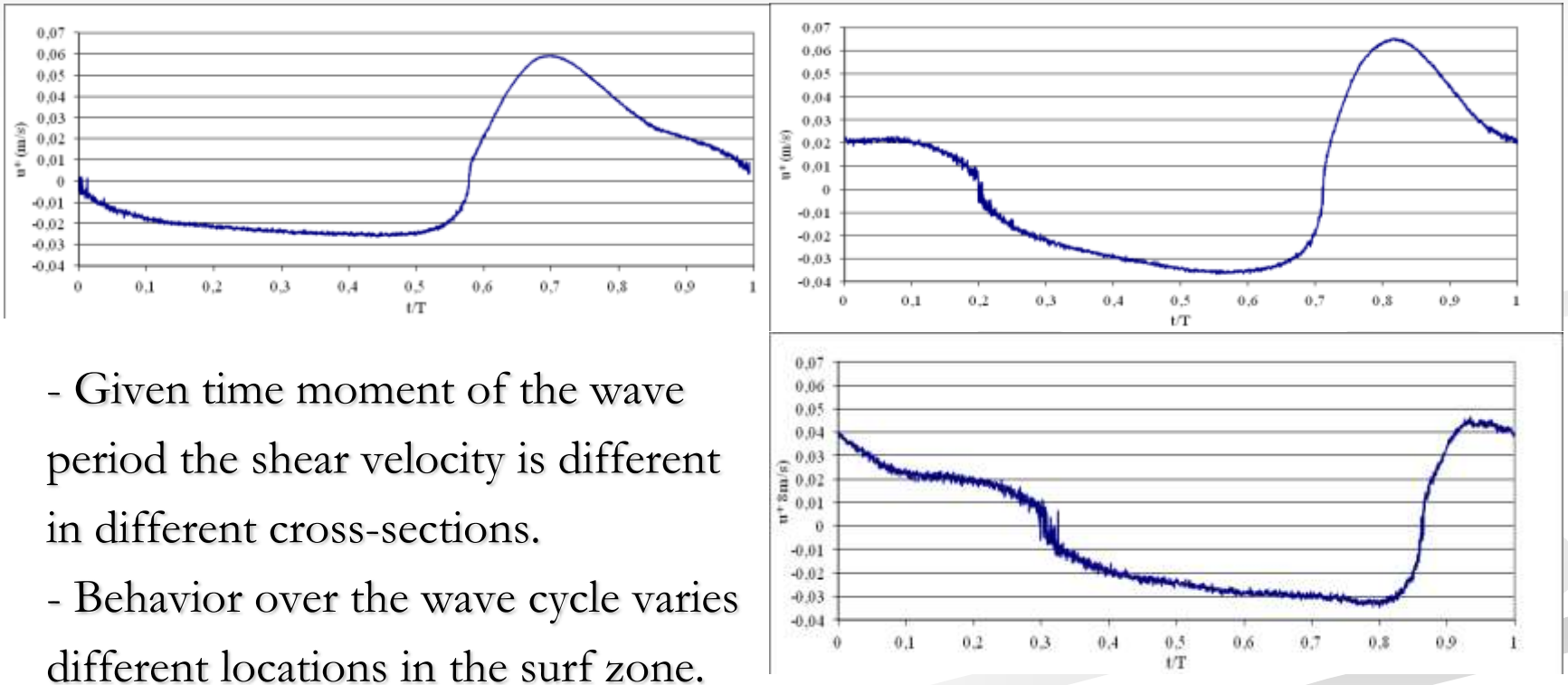
$$\delta_x = \frac{4F\lambda}{\pi E D_L \cos\left(\frac{\theta}{2}\right)} \quad \text{and} \quad \delta_z = \frac{4F\lambda}{\pi E D_L \sin\left(\frac{\theta}{2}\right)}$$

Experimental results

1. Ensemble averaged variation of the bottom shear velocity in different cross-sections;
2. The variation of shear velocity on the bottom over the surf zone.

Experimental results (1)

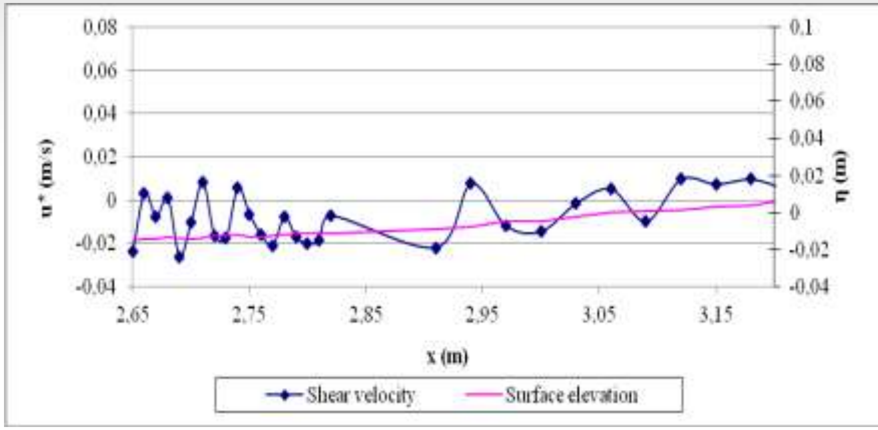
Ensemble averaged variation of the bottom shear velocity in different cross-sections:

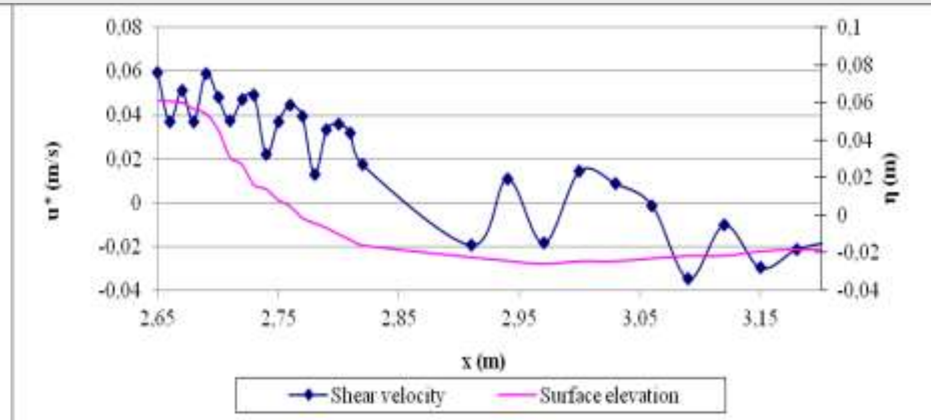


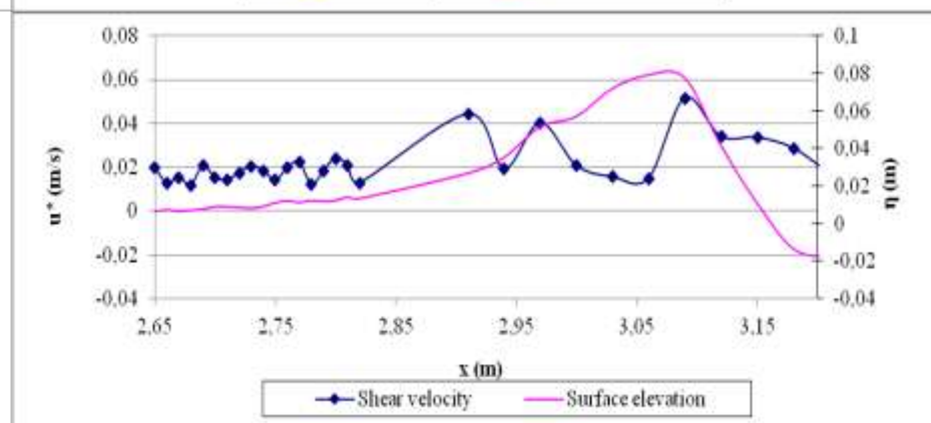
- Given time moment of the wave period the shear velocity is different in different cross-sections.
- Behavior over the wave cycle varies different locations in the surf zone.

Experimental results (2)

Variation of shear velocity on the bottom over the surf zone:

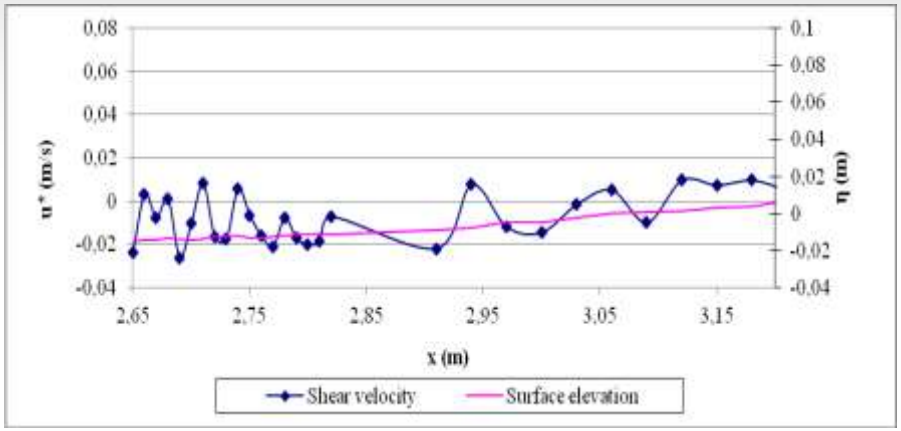






Experimental results (2)

Variation of shear velocity on the bottom over the surf zone:



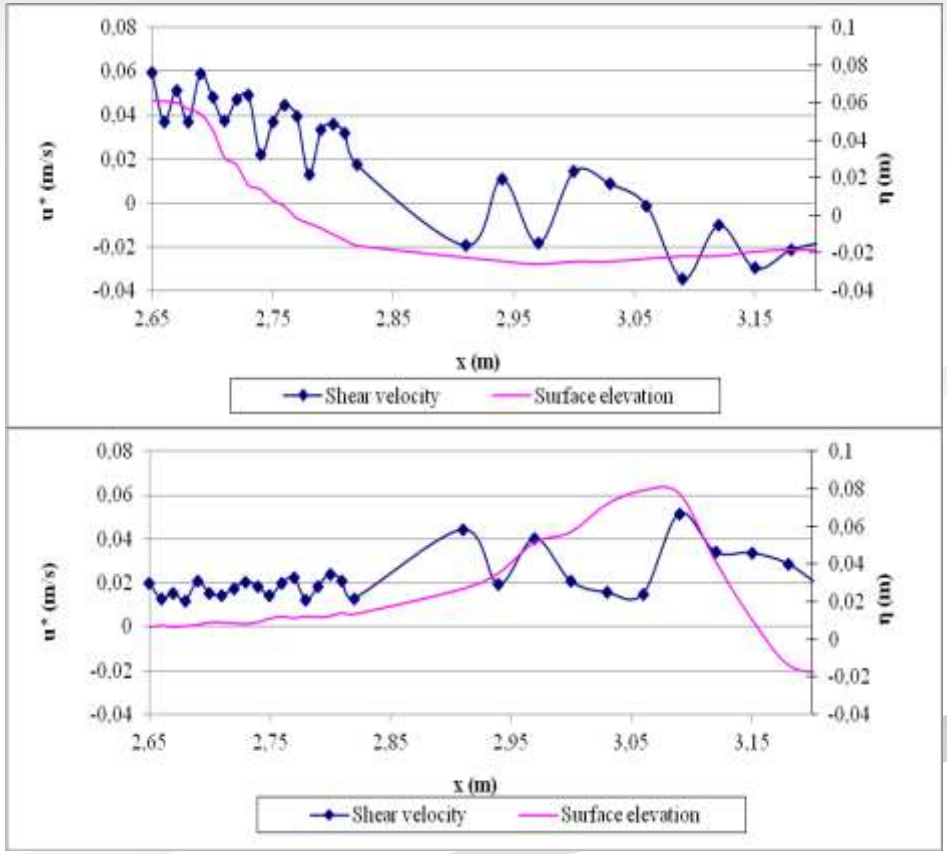
- Time moment, when the measuring area was located entirely in the wave trough.

- The value of the shear velocity is nearly constant.

Experimental results (2)

Variation of shear velocity on the bottom over the surf zone:

- Approaching wave crest increases the values of bottom shear velocity.
- The value of shear velocity drops rapidly in the wave trough and levels after the passing of the wave crest.
- Shear velocity stays constant under the wave trough.



Conclusions

- Shear velocity under the breaking wave changes both in time and space – the common approach to describing the velocity in the boundary layer under a breaking wave is not adequate;

- U-pipe and open boundary flow experiments do not give same results – the presence of the free surface allows a rapid change of the cross-sectional area due to wave motion;

- The steady flow velocity distribution is not valid under the wave crest – this means that the mixing processes and momentum transfer are more effective in the described area.

Thank you for your attention!