# EXPERIMENTAL STUDY ON BORE-INDUCED SWASH INTERACTIONS

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## ① INTRODUCTION

The swash zone is the region of the beach face with complex, high-magnitude, direction-reversing flows. Hydrodynamic processes in this region play an important role in coastal morphology. The fundamental aspects of the hydrodynamics of single swash events that collapse onto an essentially dry slope are well suited to a wave-by-wave analysis and therefore have been studied in detail (e.g. Kikkert et al. 2012). However, investigations on swash interaction by successive swash events still remain scarce. Since swash interaction has a significant influence on sediment transport and thus beach face morphology, the internal kinematics, velocity field distribution and wave energy dissipation of swash-swash interactions should be studied in detail. The current study reports the results from a new laboratory experimental investigation, carried out to improve understanding and modelling of the internal kinematics of swash interactions, and its role on beach face morphology.

## ② EXPERIMENT FACILITY AND SETUP

The experiments were carried out in the Water Resources Laboratory at the Hong Kong University of Science and Technology. The existing 12.5 m long, 0.45 m high and 0.3 m wide, glass-sided flume was modified to accommodate a double dam break mechanism, consisting of two reservoirs each fronted by a gate (Fig. 1) which can be raised at high speed to produce large plunging waves leading to bores that propagate towards an impermeable beach located downstream. The 1:10 sloped sandy beach, with $D_{50}$ of 2.0mm, intersected the bottom of the flume at a distance of 2997 mm from the first gate. The relatively large magnitude of the run up makes it comparable to that encountered in the field, eliminating any scaling issues with respect to the length of the roughness elements on the beach (O'Donoghue et al., 2010; Kikkert et al., 2012). In addition, the large scale of the event enables much more accurate measurements to be obtained than is possible for smaller wave-flume generated swash events.

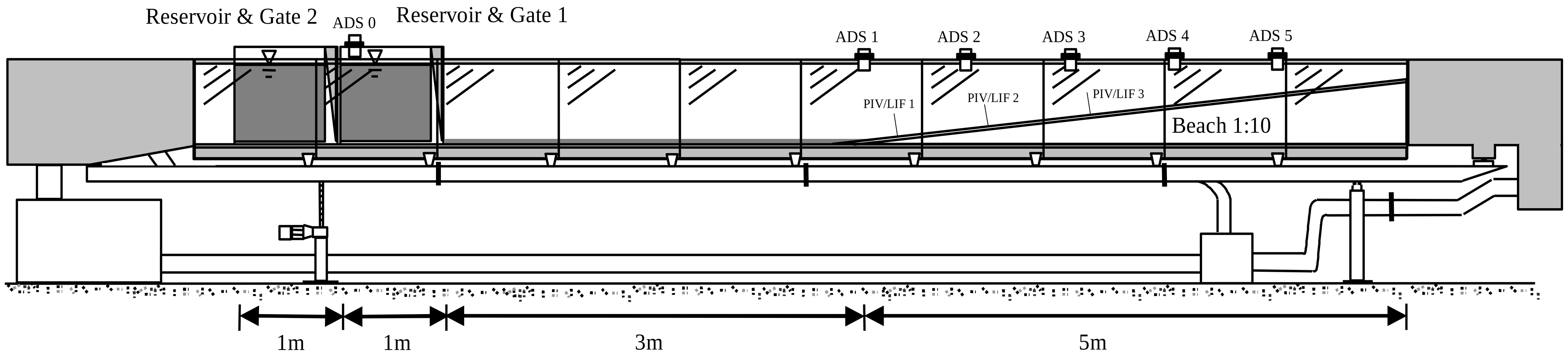


**Fig. 1. Diagram of swash rig and the layout of ADSs**

## ⑤ SUMMARY

1. Laboratory experiments have been carried out to investigate the overall behaviour of swash interactions, as well as measure the detailed hydrodynamics of wave capture interaction and wave-backwash interaction.
2. Different types of swash interactions may occur at different locations in the swash zone during the same swash event.
3. Compared with the wave capture interaction, wave-backwash interactions with strong collisions postpone the arrival of the second bore and reduce the maximum run-up of the swash event.
4. Time-series of depth, depth-averaged velocity and TKE were investigated at location 1 for the two types of swash interactions which showed significant convective turbulence induced by bore collisions. This may suspend a considerable amount of sediment, and is therefore potentially an additional source of shoreward sediment transport.

## ③ MEASUREMENTS

The first set of experiment investigates the overall behaviour of swash interactions through visual observations and measurements of flow depth time series at six different locations by using portable Microsonic mic+35/IU/TC Acoustic Displacement Sensors (ADS). The layout of the six ADSs in the flume is shown in Fig.1. Two water depth pairs for the reservoirs were selected, the first pair had 35cm of water in reservoir 1 and 50cm in reservoir 2 (35-50), and the second pair had 40cm in both reservoirs (40-40). Time delays between raising gate one and two were varied to generate different types of swash interactions. For the 35-50 group, the gate opening delay was increased from 1.5s to 6.5s in 0.5s intervals, and for the 40-40 group from 1.0s to 6.5s in 0.5s intervals. The experiments were repeated five times for each scenario, the final results were based on the averaged data from these five runs.

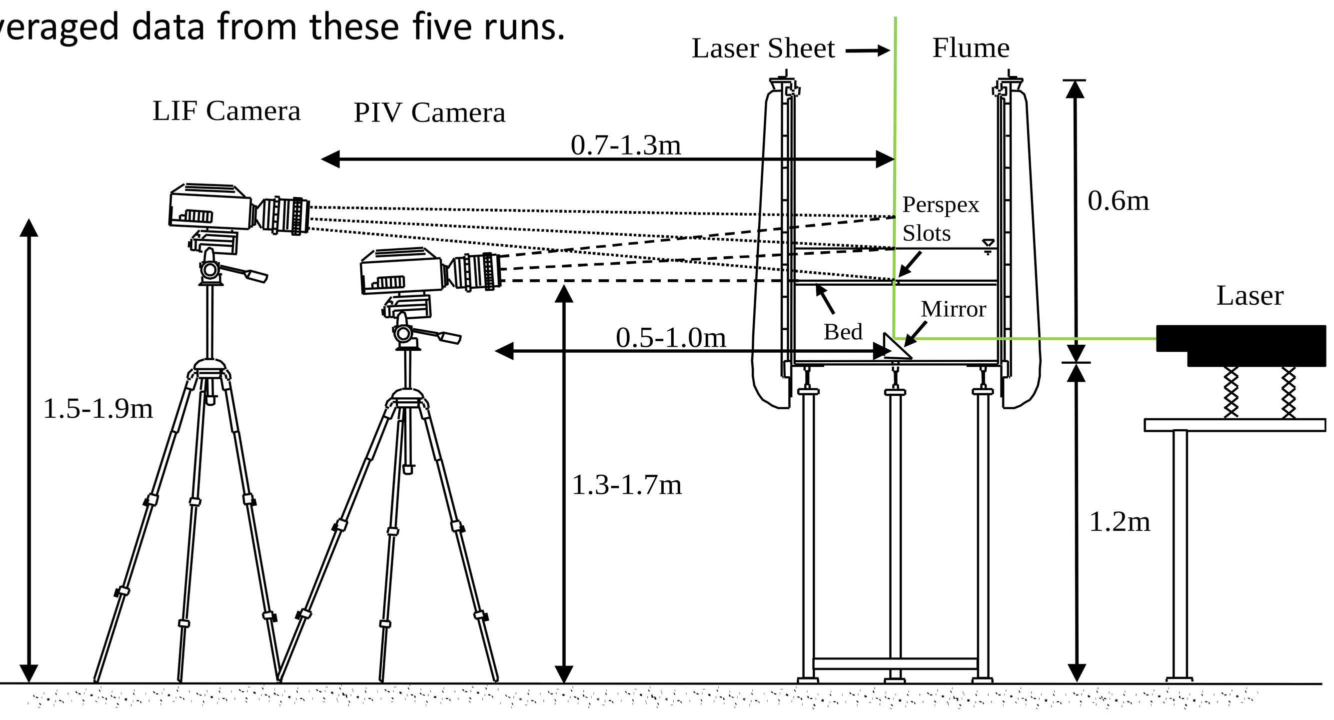


**Fig. 2. Experimental set-up for PIV/LIF (cross-sectional view of flume perpendicular to the direction of flow)**

Based on the results of water depth time series and visual observations in the first set of experiment, two particular groups were selected for further detailed hydrodynamics investigation by using a combined particle image velocimetry (PIV) and laser-induced fluorescence (LIF) system (Fig. 2) in the second set of experiment. They were a typical wave capture interaction with water depths of 35-50 and gate opening delay of 1.5s; and a typical weak wave-backwash interaction (Cáceres and Alsina, 2012) ,with water depths of 40-40 and gate opening delay of 3.5s. Measurements for the flow depth and flow velocity were obtained simultaneously at three locations, centered at 665mm (location 1), 1400mm (location 2), and 2110mm (location 3) from the starting point of the 1:10 slope beach. At each of these locations glass slots were inserted in the beach to enable the flow to be illuminated from below and the experiment of the individual swash event was repeated 50 times to enable the ensemble averaged quantities to be determined.

## ④ RESULTS

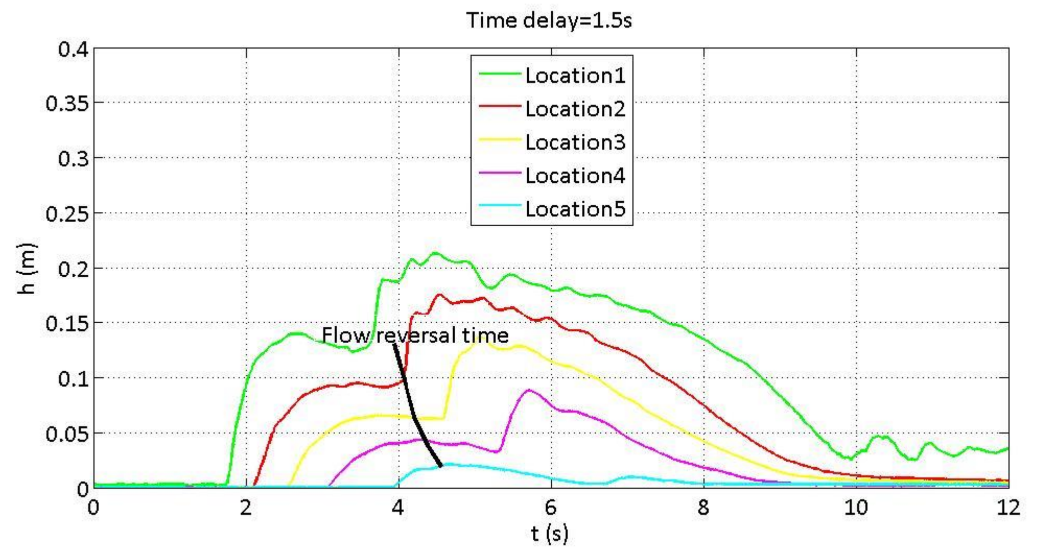


**Fig 3. Depth time-series at five measurement locations for 40-40 group 1.5s case**

In Fig. 3. the intersections between the black line and depth time series represents the flow reversal time of the first swash event. The arrival time of the second bore occur prior to flow reversal at the first and second locations, but later than flow reversal at the other locations. Therefore, at location one and two, there are wave capture interactions, while further shoreward, there are wave-backwash interactions.

For 35-50 group, Fig. 4. shows that the relationship between gate opening delay and bore arrival delay is almost linear at all the measurement locations. The 40-40 group shows a concave trend as the second bore is significantly impeded when it propagates shoreward due to wave-backwash interactions with strong collisions

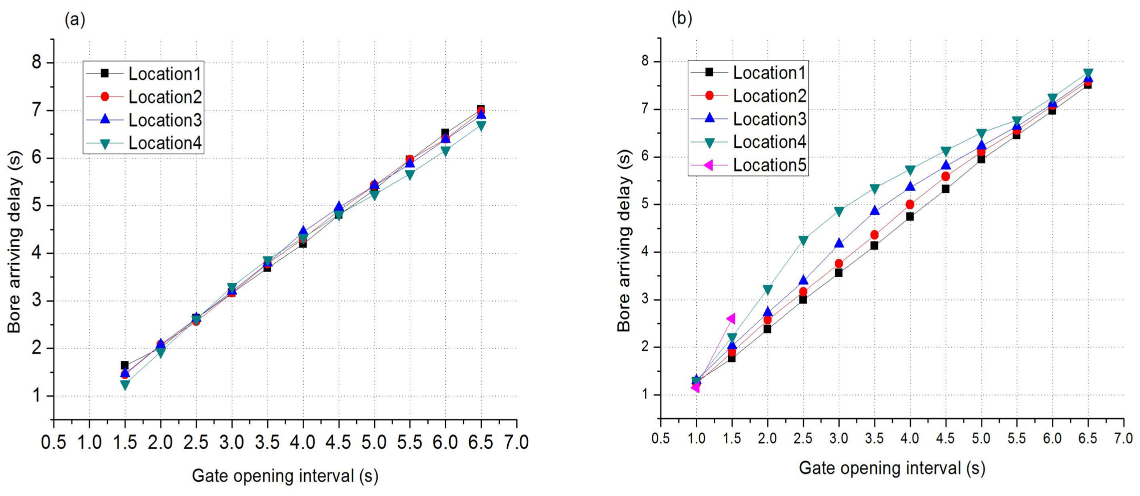


**Fig. 4. Relationship between gate opening interval and bore arriving delay at all five locations for (a) 35-50 group, (b) 40-40 group .**

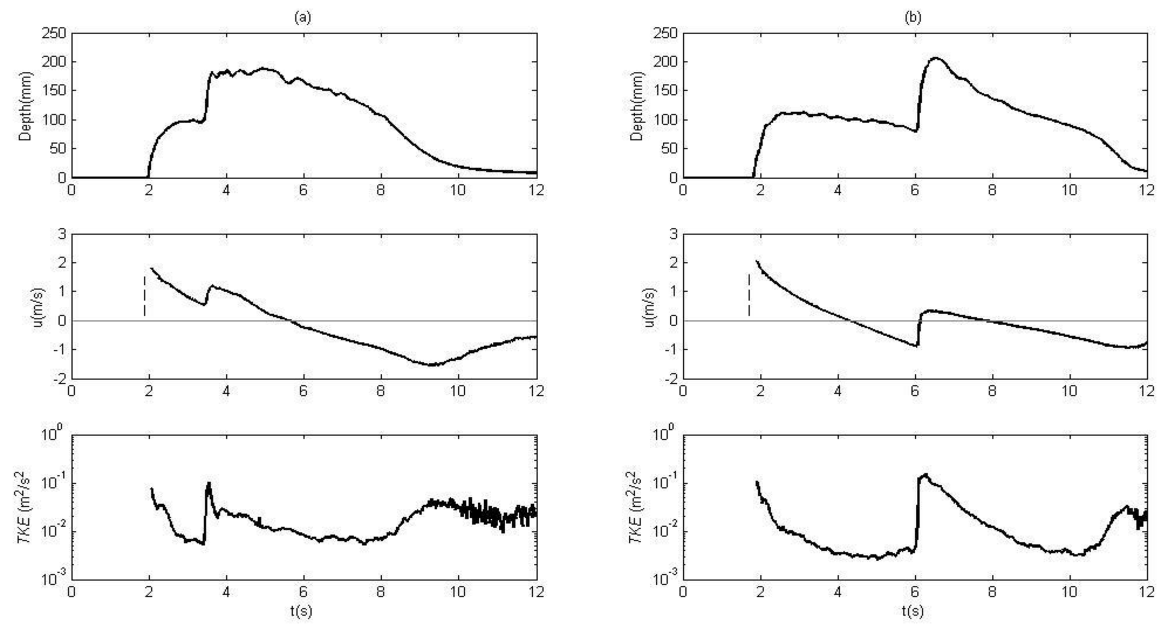

**Fig. 5. Time-series of depth, depth-averaged velocity and TKE at location 1 for (a) 35-50 group 1.5s case; (b) 40-40 group 3.5s case**

The time-series in Fig. 5. show that during the interaction process both wave capture interaction and wave-backwash interaction result in high magnitudes of depth averaged TKE, but especially for the case of wave-backwash interaction (Fig. 5b). This convective turbulence may suspend a considerable amount of sediment, which is then transported with the flow to the upper swash zone.

## REFERENCES

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