

BEACHFACE EVOLUTION UNDER TWO SWASH EVENTS BY TWO SOLITARY WAVES

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INTRODUCTION

Swash zone morphodynamics is of great significance for nearshore morphological change, and it is important to provide reliable numerical prediction for beachface evolution in the swash zone. Most of the numerical work on swash zone morphodynamics carried out so far has focused primarily on beach evolution under one single swash event. In reality, multiple swash events interact, and these swash interactions have been recognised as important in the beachface evolution. Swash-swash interactions leads to energy dissipation, enhanced bed shear stresses and sediment transport (Puleo and Torres-Freyermuth, 2016). In this paper, we investigate the beachface evolution under two swash events using numerical simulations, in which shock-shock interactions are described by dam-break problems.

GOVERNING EQUATIONS

The approach is to solve the one-dimensional shallow water equations, a bed-evolution equation, and suspended sediment advection equation (Zhu and Dodd, 2015). All the results are presented in non-dimensional form, and the non-dimensionalisation follows that in Zhu and Dodd (2015).

The non-dimensional governing equations are

$$h_t + hu_x + uh_x = 0, \quad (1)$$

$$u_t + uu_x + h_x + B_x = 0, \quad (2)$$

$$B_t + 3\sigma u^2 u_x = M(c - u^2), \quad (3)$$

$$c_t + uc_x = \frac{1}{h} \tilde{E}(u^2 - c), \quad (4)$$

where x is cross-shore distance, t is time, h is water depth, u is water velocity, B is bed level, c is sediment concentration, σ and M are bed mobilities as bed and suspended loads, and \tilde{E} is sediment settling velocity.

BEACHFACE EVOLUTION

At $t = 0$, there are two solitary waves of height 0.6 on a still water depth of 1, with crests located at $x = -70$ and $x = -22$ over an erodible beach of bed mobility as bed load $\sigma = 0.01$, suspended load $M = 0.001$, and sediment settling velocity $\tilde{E} = 0.01$ (see Fig. 1). The right solitary wave is identical to that in Zhu and Dodd (2015), and the left wave contains more water volume to ensure the second swash has a strong magnitude. The waves then climb up the sloping (initial slope 0.0667) part of the beach. Furthermore, bed shear stress is also included by the description of Chezy drag law with $c_d = 0.01$.

The contour plots for water depth, velocity, bed change, and suspended sediment concentration are shown in Fig. 2. We can see that there are two incoming shocks creating climbing up the beach two swash events. The flow velocities in the second swash event is generally smaller than that in the first swash event. There is always erosion near the initial shoreline position $x = 5$. Fig. 2 shows that the erosion near the initial shoreline

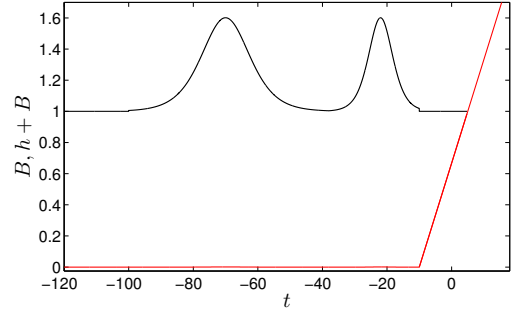


Figure 1: Initial conditions of a swash event driven by two solitary waves over an erodible beach with $\sigma = 0.01$, $M = 0.001$, $\tilde{E} = 0.01$ and $c_d = 0.01$.

position is because the flow velocities in this region is generally larger which results in large amount of suspended load.

From the shock paths in Fig. 2, we can see that there is one weak backwash bore forming in the first swash event, and it interacts with the second incoming bore. The wave structure after interaction is still a shoreward moving bore, and we still call it the second incoming bore. The second incoming bore terminates at $t = 82.22$, and it collapses because the shock is not stable anymore. The characteristics on the two sides start to diverge, and it is not a physical shock. This is because the flow velocities on the two sides of the incoming bore becomes negative, and the shock has changed from a hydrodynamic shock into a morphodynamic shock when Froude number $Fr < -1$. The wave structure after the collapse are continuous flow. In the second swash event, there is also a backwash bore forming, indicated by the green line in Fig. 2. It gradually slows down, and it changes from a hydrodynamic shock into a morphodynamic shock when Froude number $Fr > -1$. It disappears when the flow velocity becomes positive. This is consistent with the finding of Zhu and Dodd (2015) for one single swash event.

The final bed changes for one single swash event and two examined swash events are shown in Fig. 3. Similar bed change patterns are obtained. There are less deposition and erosion in the middle swash under the action of two swash events. This is because the backwash bore is less developed, and less sediment is moved shorewards. There is slightly more deposition in the upper swash, which is barely noticeable.

It should be noted that the overall bed change under two swash events is smaller than that under one single swash event. This maybe because of the counteracting effect of the second swash event. When there are more swash events, the bed change may reach an equilibrium state.

CONCLUSION

The beachface evolution under the action of two swash events created by two solitary waves have been investigated. It is

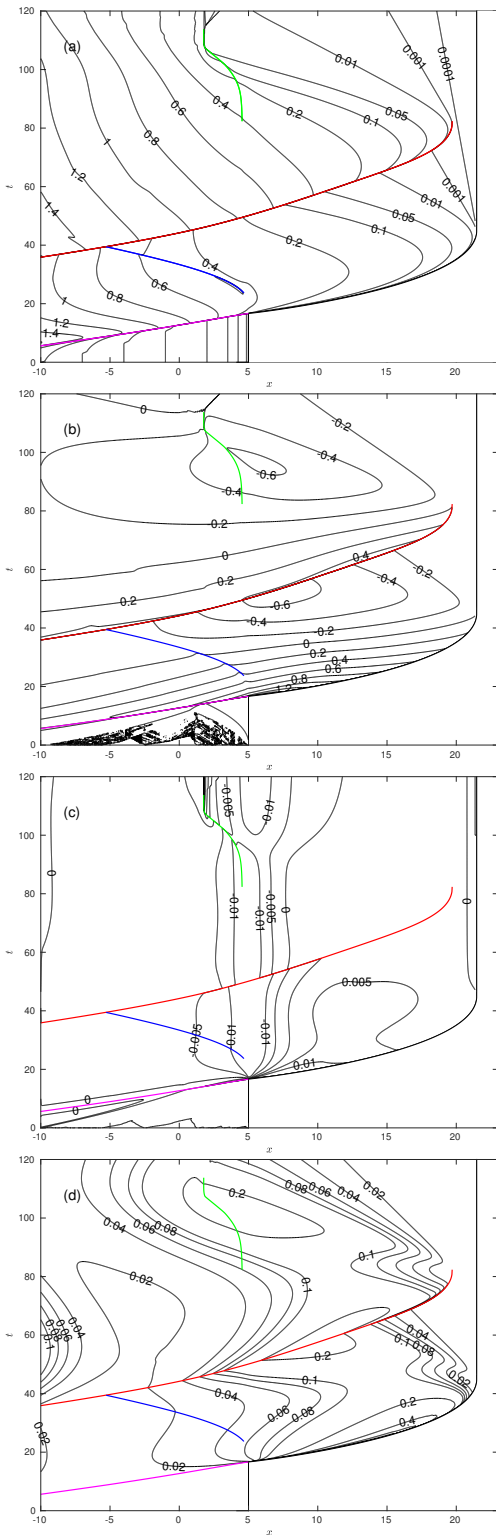


Figure 2: Contour plot of water depth h (a), velocity u (b), bed change ΔB (c), and sediment concentration c (d) for two solitary waves simulation with bed shear stress over an erodible beach. Colour lines indicate shock paths.

shown that shock-shock (incoming bore and backwash bore) interaction occurs in two swash events. However, in the present examined events, the shock-shock interaction is weak, and the structure after interaction is an incoming bore. The second incoming bore disappear because the flow velocity becomes

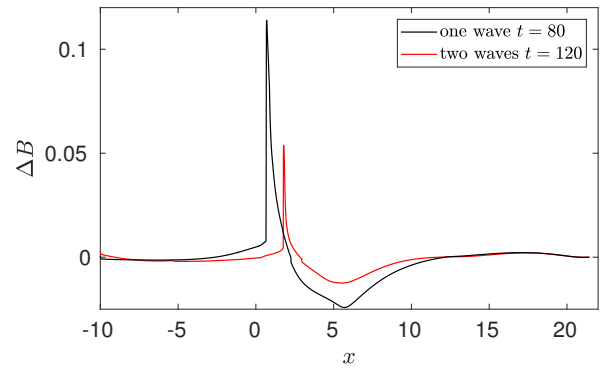


Figure 3: Bed changes for the swash simulation with one and two solitary waves.

positive. The final bed change pattern under two swash events is similar to that under one single swash event but with smaller magnitude.

REFERENCES

Puleo, Torres-Freyermuth (2016): The second international workshop on swash-zone processes, *Coastal Engineering*, 115:1–7.
 Zhu, Dodd (2015): The morphodynamics of a swash event on an erodible beach, *J. Fluid Mech.*, 762:110–140.