Wave Breaking and Undertow Characteristics in Front of a Seawall

Kagoshima University Student Md. Azharul Hoque
Kagoshima University Member Toshiyuki Asano
Kagoshima University Student Daisaku Minamisaki

Introduction

Although the physical processes of the seawall-beach interaction are of great engineering importance there have been only few studies, which are again suffering from the lack of any complete theoretical model. Under normal sea condition, the sea wall might provide little interactive effects on the wave field and beach deformation. But under stormy conditions, the sea level surges up and waves may attack the wall directly. As a result, not only the wave field but also the wave.breaking structures will be altered, which will cause the changes in eroding and depositing patterns of sandy beaches. Undertow velocities in front of partially reflective seawalls have been investigated by Asano *et al.* (1999) where the effect of reflective waves have been considered in viewpoints of wave transformation, mass flux by broken waves and resultant wave set-up. But the presence of reflective waves can modify the breaking criteria and change the turbulence intensity in the surf zone, which is yet to be studied.

This study investigates the physical processes and mechanisms of wave breaking and turbulence structures in the surf zone for monochromatic waves in presence of seawall. As the wave fields are highly complex due to the presence of broken incident wave with large vortex and interaction of reflected waves, the visualization techniques are used as the first attempt. Significant differences have been observed compared to normal beach topography. Next, a numerical model is being developed for predicting the breaking phenomenon under the influences of reflective waves.

Experimental Facilities and Arrangement

Laboratory experiments were carried out in a two-dimensional wave flume having dimensions 17.5 m long, 1.5 m deep and 1.0 m wide. Waves were generated at one end of the tank. A plane beach profile with a constant slope of 1:10 was built at the other side of the tank. Experimental arrangements are shown in figure 1. Water surface elevations were measured by using resistance type wave gauges. The measured points were in the middle of the flume. Water surface elevations have been measured at different location with 20 cm spacing up to a distance of 6 m from the shoreline. Two wave gauges were mounted further offshore to measure the incident waves. Data were acquired and analyzed using a personal computer with a sampling rate of 20 Hz for each channel.

The physical transformation mechanisms of breaking waves were observed using a video camera. The cross-shore and vertical positions were identified by 5x5 cm fluorescent grid placed on the glass wall of the flume. Many trials were made to enhance the visibility of wave breaking phenomenon in the surf zone. A black lamp lighting system was placed both above the tank and in front of the glass wall in order to enhance the visibility of the turbulence structures in the 5x5 cm grid frames.

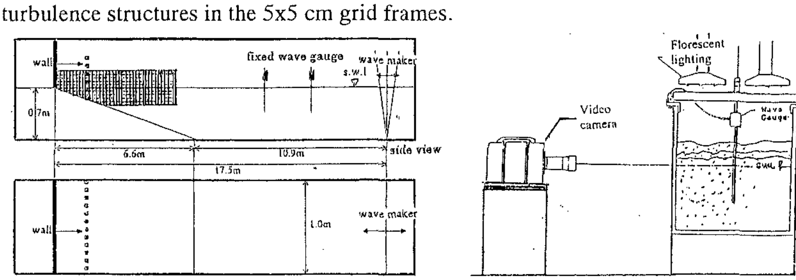

Figure-1 : Experimental set-up of (a) wave flume arrangement and (b) visualization technique

Experimental Wave Conditions

Several sets of tests were performed with varying wave parameters and location of the model seawall from the shoreline. Five types of incident waves have been selected in the monochromatic wave experiments. The incident wave parameters and the breaking characteristics of the experimental waves are shown in table-1

Table 1: Characteristics of monochromatic waves

	H_o (cm)	T (sec)	L_o (m)	H_o/L_o	$\frac{\tan\beta}{\sqrt{H_o/L_o}}$	Breaker Index	h_b (cm)	X_b (m)
Case-1	17.6	1.5	3.50	0.050	0.2236	Spilling	6.25	1.25
Case-2	18.6	2.0	6.24	0.030	0.2896	Spilling	8.00	1.60
Case-3	20.5	1.25	2.44	0.084	0.1725	Spilling	10.0	2.00
Case-4	20.0	1.5	3.50	0.057	0.2094	Spilling	6.75	1.35
Case-5	15	2.0	6.24	0.024	0.3227	Spilling	7.00	1.40

Results and Discussion

Figure-2 illustrates the comparison of wave height distribution for the conditions of without wall and with wall at the shoreline for case-3. It can be seen that wave-shoaling pattern has been changed and the breaking point has been shifted seaward. The on-offshore distributions of wave heights without wall for the other four cases are shown in figure-3. Some reflection can be observed even without using seawall. The reflection coefficients are analyzed by comparing the experimental wave height distribution with theoretical wave height distribution in a sloping beach for different reflection coefficient.

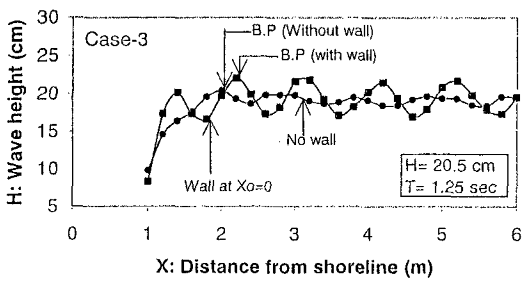

Figure-2: Comparison of wave height distribution with and without wall

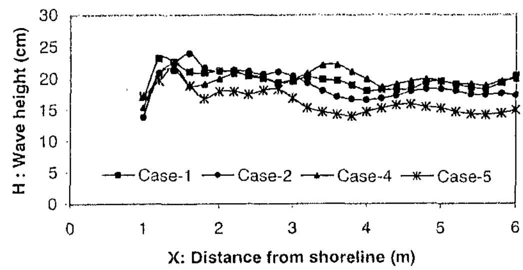

Figure-3: On-offshore distribution of wave height without wall

From the observation of the video records remarkable changes in turbulence structures and breaking characteristics can be observed. Figure-4 shows the analysis of video record of breaking structures for case-3. The earlier formation and growth of eddies can be observed in presence of reflective waves. Breaking points are shifted seaward. From different stages of splash up formation zone as shown in the figure, it can be observed that upon mixing with reflected water mass, strong turbulence was generated with high splash up of water. It is also observed that maximum splash-up is followed by two smaller splash-up in presence of seawall whereas it is followed by one smaller splash-up in case of no wall.

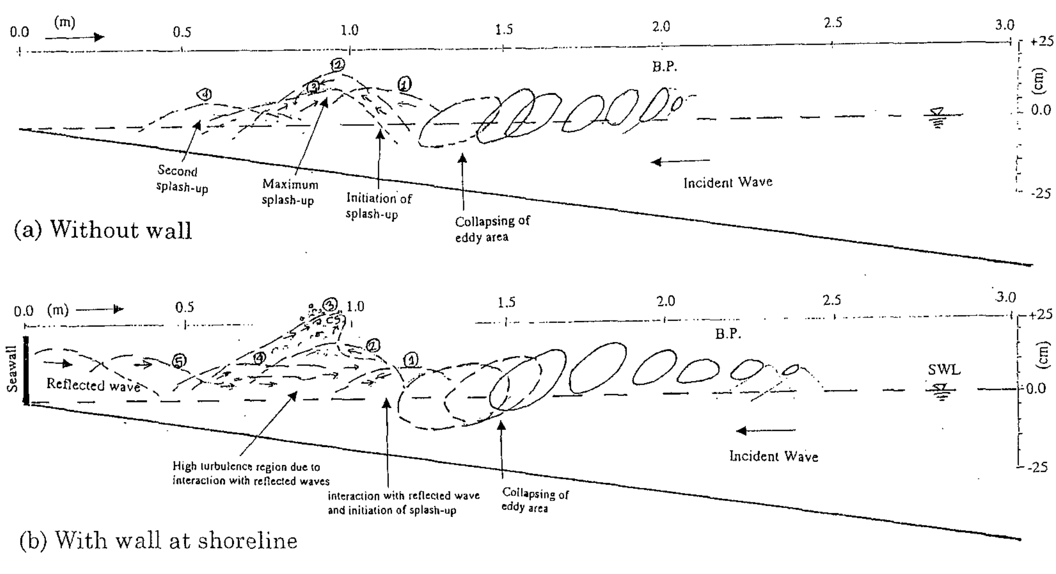

Figure-4: Wave breaking characteristics of case-3

Conclusion

Finally, It can be concluded that the existence of reflective condition results in a change in wave breaking structures in terms of the formation and growth of eddy, mechanism of splash-up formation, air entertainment, deformation of wave profile and generated turbulence.