5 Dam Break Flow through Emergent Cylinders Array with Different Length

Hiroshima University Student member ○Adel A. MAHMOUD
Hiroshima University Member Tatsuhiko UCHIDA
Hiroshima University Member Daisuke KOBAYASHI

1. Introduction

Dam break flow occurs due to sudden collapse of the reservoir dam or tsunami which leads to huge damage to human lives and properties. Several studies regarding the dam break flows and the wave propagation through vegetation field have been performed. For example, Chen and Wang[1)] investigated energy dissipation of seagrass in a dam break flume, they found that the amount of energy dissipation increases by increasing grass height. Huang et al.[2)] studied solitary waves through rigid- emergent vegetation and concluded that increasing in vegetation density leads to increasing in wave reflection and energy dissipation. Peruzzo et al.[3)] investigated regular wave attenuation through artificial flexible vegetation with different densities and different arrangements and found that wave attenuation increases by increasing vegetation density. Fathi-Moghadam et al.[4)] investigated the effect of coastal green belt on absorption of breaking solitary wave and wave attenuation, they used artificial plastic trees to simulate coastal trees, they concluded that coastal forest significantly increases the breaking wave force absorption and reduces the flood energy and depth attenuation. Studies related to dam break flow through vegetation are needed as there are many types of aquatic vegetation and each type has its characteristics and effects in fluvial and coastal flow. In this study, the effect of rigid vegetation field length on dam break wave propagation was investigated by conducting a series of experiments.

2. Experimental Setup

The experiments of dam break flow through groups of rigid emergent cylinders with different installation lengths were performed in a horizontal rectangular flume with 16.10 m long, 0.40 m wide and 0.40 m deep at faculty of advanced science and engineering at Hiroshima University. The diameter of each cylinder is d =1 cm with 50 cm in height. The cylinders which represent rigid vegetation were installed in the flume using foam boards and glue individually in longitudinal and lateral intervals of $\Delta x = \Delta y = 3.3$ cm as shown in Fig. 1 with a constant volume density of the vegetation $\lambda = \pi d^2/(4\Delta x\Delta y) = 0.072$. Three vegetation field lengths L = 0.60 m, 1.60 m and 3.00 m were installed in the channel as shown in Fig. 2. As shown from Fig. 2, a movable gate was installed at 2.0 m from upstream end to separate two different water depths h_{up}=30 cm and h_{down}=2 cm upstream and downstream movable gate respectively. The upstream and downstream ends in Fig. 2 are bounded by walls. To generate dam break flow into the flume, the movable gate is suddenly removed manually. The servo-type wave height meter (KENEK) was used to measure wave height variation with time. The measurement sections were decided to investigate waves propagation characteristics through vegetation field and the effect of vegetation field length on wave propagation. Table 1 shows the location of each section. At each section, three runs were performed and the average of these runs was applied to obtain final results.

Another measurement section of the negative wave was installed at 30 cm upstream the movable gate to adjust the opening time of the gate for each experiment. A camera was installed at the upstream end to record the initial time of movement of the gate.

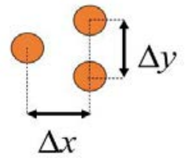

Fig. 1 Arrangement of cylinders

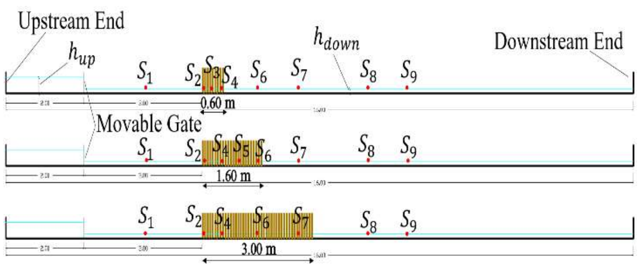

Fig. 2 Experiments setup

Table 1 Location of measurement sections

Section	Distance from Upstream End (m)	Section	Distance from Upstream End (m)
S_1	3.57	S_6	6.53
S_2	5.02	S_7	7.6
S_3	5.27	S_8	9.55
S_4	5.53	S_9	10.56
S_5	6.03		

3. Results and Discussion

Fig. 3 shows variation of wave height with time at S_1 with and without vegetation. A little difference in wave height of the first wave is observed among the measurement cases, which may be caused by the

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Contact address: Kagami-yama 1-4-1, Higashi-hiroshima City, 739-8527
E-mail: d223615@hiroshima-u.ac.jp

difference in movable gate opening time in each case. It is also seen that a small difference in reflected wave height and arrival time between the three vegetation field length cases.

Fig. 4 shows temporal variation of wave height within the vegetation field for the three vegetation field lengths. The rapid decrease in wave height caused by vegetation is due to the hydrodynamic forces of the vegetation, which also means that the vegetation dissipates wave energy. The wave heights at the same distance within a vegetation group are higher for longer vegetation lengths due to reflected waves from downstream.

The temporal variation in the wave height at S_8 and S_9 downstream vegetation field is shown in Fig. 5. Unlike Fig.4, the wave height decreases by increasing vegetation field length, because there is no reflection wave from the downstream area. Also, by increasing vegetation field length, wave arrival time increases.

Fig. 6 shows relation between distance traveled by waves and corresponding arrival time for different vegetation field length cases through vegetation field (a), and downstream vegetation field (b). After plotting distance with corresponding arrival time, best line fit was plotted for each case, in which the gradient of these lines represents wave celerity. As it is shown in Fig. 6, the gradient decreases with increasing vegetation field. The wave celerity decreases in the downstream direction, by comparing wave arrival time at each section for the different cases, it can be noticed that through vegetation there are small difference in the wave arrival time among the three cases, but this difference increased at the downstream vegetation sections where the effect of vegetation field length appears clearly.

4. Conclusion

From the analysis of the experimental results, the following main conclusions may be obtained:

1) Due to hydrodynamic forces of vegetation, wave height rapidly decreases through the vegetation field.
2) Vegetation field length does not have a significant effect on the arrival time of the reflected wave upstream from the vegetation but the wavelength increases with longer vegetation field.
3) Wave height and celerity downstream of the vegetation field decrease by increasing vegetation field length.

5. References

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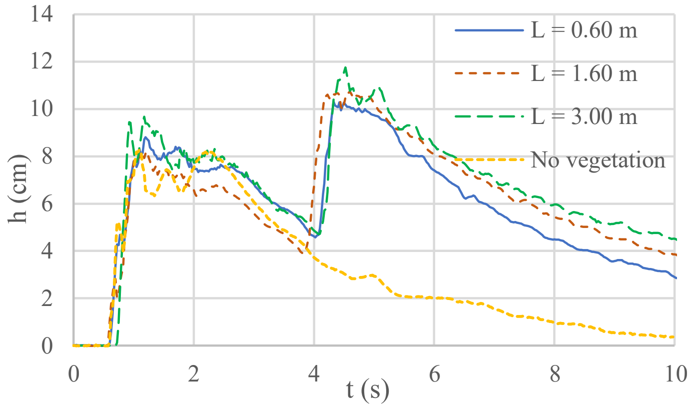

Fig. 3 Temporal variation of wave height at S_1 with and without vegetation.

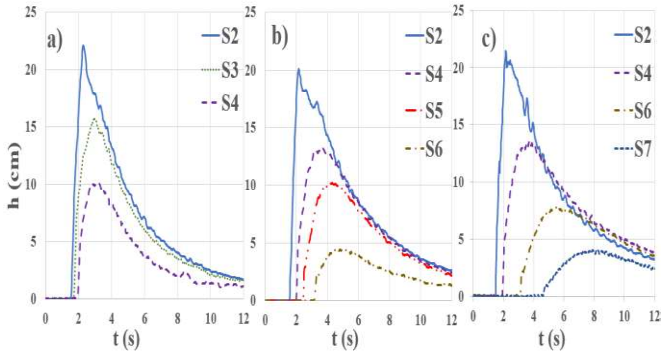

Fig. 4 Temporal variation of wave height through each vegetation field length a) L = 0.60 m, b) L = 1.60 m and c) L =3.00 m.

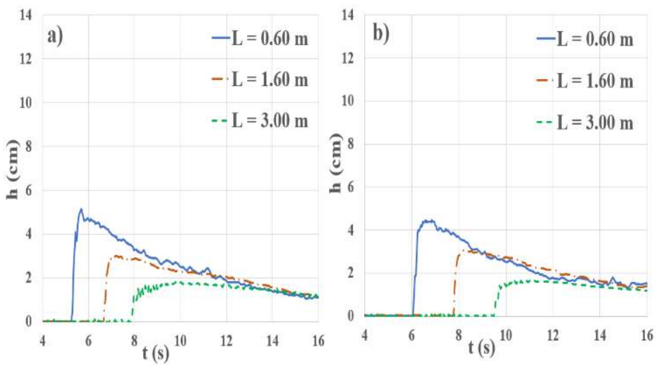

Fig. 5 Temporal variation of wave height through downstream vegetation field. a) at S_8 and b) at S_9

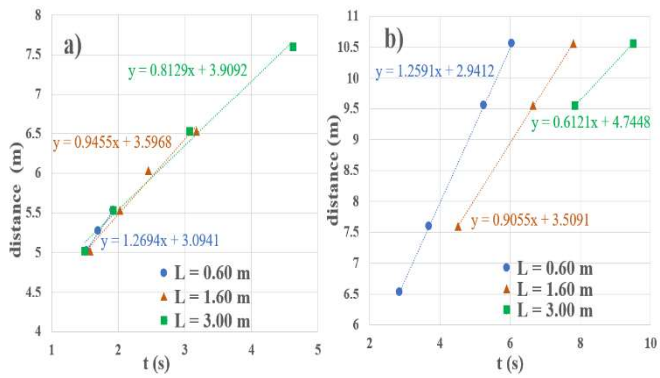

Fig. 6 Relation between traveled distance by waves and corresponding arrival time (a) through vegetation (b) downstream vegetation.