ECOSYSTEM-BASED DISASTER RISK REDUCTION USING A COASTAL LAGOON

Saitama University Student Member ○Talpe Liyanage Chanaka Vinodh
International Institute for Resilient Society, Saitama University Regular Member Prof. Norio Tanaka

1. INTRODUCTION

Ecosystem-based Disaster Risk Reduction (Eco-DRR) is becoming more popular trend as it is a sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development. Conventional coastal engineering, such as the construction of sea walls, dykes and embankments, is widely perceived as the ultimate solution to tsunami risks. However, these defenses are seriously challenged in many locations as their continual and costly maintenance, as well as their heightening and widening to keep up with the increasing flood risk are becoming unsustainable. The importance of future coastal landscape planning, rehabilitation and coastal resource management by considering the aspects of forest, sand dunes, vegetation structures and their functions are reviewed after devastated 2004 and 2011 tsunamis, for instance, Tanaka et al. (2006), Tanaka et al. (2007) and Tanaka et al. (2009). The aim of this research is to understand how a tsunami like solitary wave phenomena occurs based on the physical characteristics of a lagoon in one horizontal dimension to identify the optimum mitigation measure on the surrounding area of the coastal lagoon.

2. EXPERIMENTAL DETAILS

In this proposed coastal lagoon model, to obtain the relationship of maximum runup (R) at the landward end, the identified physical variables are the upstream wave height (H_o), upstream water depth in the constant depth region (h_o), upstream wave celerity (V), dune height (h_D), beach slope (cotα), overtopping depth at entrance point to lagoon model (h_e), initial water depth inside lagoon (h_L) and length of Lagoon (L), as shown in Fig.1 and identified fluid properties are density of fluid (ρ) and dynamic viscosity of fluid (μ), and gravitational acceleration (g).

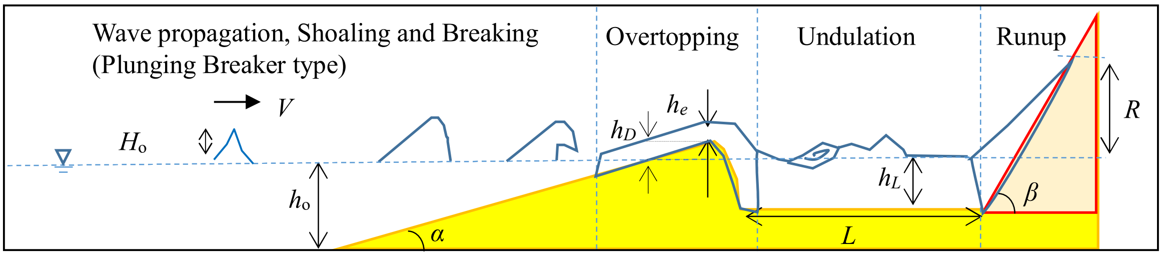


Fig.1: Physical variables for the experiment

The maximum runup at landward end without Lagoon model (R_o) with the same H_o and h_o for the maximum runup with the lagoon model R is introduced here to compare the runup phenomena. The nondimensionalized runup reduction factor (R/R_o) and other nondimensionalized terms can be defined as H_o/h_o, h_D/h_o, cotα, h_e/h_o, h_L/h_o, L/h_o, and initial Froude Number (Fr_o) and Reynolds Number (Re_o).

Experiments were performed in a flume which has the length of 20m, width of 30cm and height of 60cm in Saitama University. The solitary waves were used to study the wave phenomena. In this research the cotα was set to 1:30. The connecting sand dune ridge between the beach slope and coastal lagoon bottom is a curve with the radius of 100cm, length of 50cm and height of 15cm. It continues a horizontal bed followed by runup model having slope of cotβ equals to 1:4. Model scale is 1:100. The incident wave characteristics H_o ranging from 2.8cm to 7.8cm and h_o ranging as 20, 21 and 22cm, and lagoon parameters of h_L ranging as 12, 13 and 14cm and L ranging as 0.5, 1.5 and 4.5m, are used during the experiments to observe the maximum run-up at landward end.

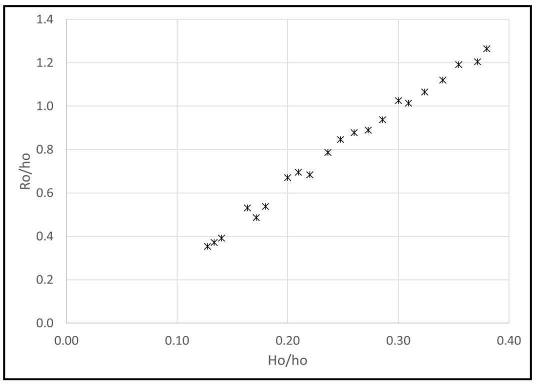


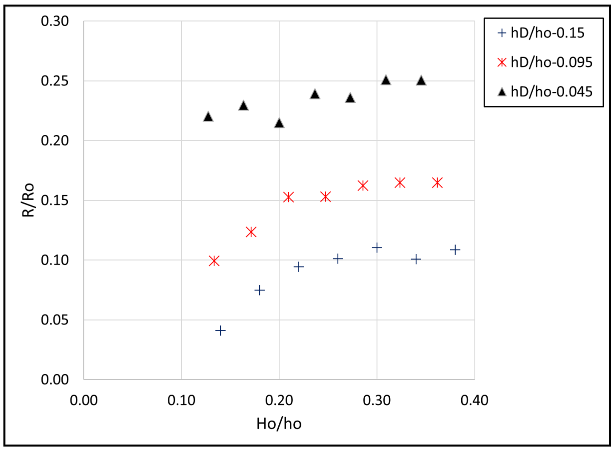
Fig. 2: Runup characteristics without lagoon model

3. RESULTS & DISCUSSION

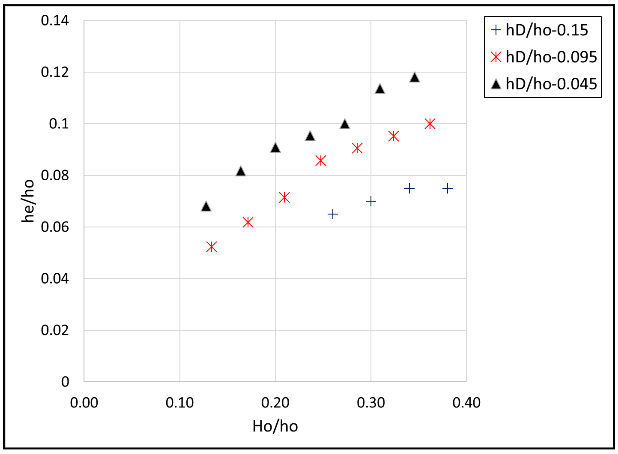
All the waves experimented for maximum runup without lagoon model (R_o) were observed as nonbreaking waves. The results of nondimensionalized R_o/h_o versus H_o/h_o is shown in Fig. 2.

Keywords: Ecosystem-based disaster risk reduction, Sand dune, Overtopping depth, Lagoon retention capacity
Contact address: Saitama University, 255 Shimo-Okubo, Sakura-ku, Saitama, 338-8570, Japan E-mail : tanaka01@mail.saitama-u.ac.jp

These results were used to obtain the relationships for both R/R_o and h_e/h_o against H_o/h_o for the cases of h_D/h_o equals to 0.15, 0.095 and 0.045 and it is shown in Fig. 3. In that case h_o was changed to 20, 21 and 22cm whereas h_L was changed to 12, 13 and 14cm respectively to emphasis the effect of sand dune height of h_D.



(a)



(b)

Fig. 3: Comparison between (a) runup characteristics with lagoon model and (b) variation of overtopping depth

It can be identified from Fig. 3 that after certain H_o/h_o value in each h_D/h_o value gives R/R_o almost constant after rapid increasing except for in case of h_D/h_o is 0.045. However, h_e/h_o shows increasing trend for all the same values of increasing H_o/h_o. In all these cases wave energy mainly dissipated at two locations before the runup at landward. At first, wave breaks at beach slope as plunging breakers and then followed by hydraulic jump caused inside lagoon by overtopping. For higher waves, most of energy dissipated by plunging breakers at beach slope. For smaller waves the loss of energy due to hydraulic jump is significant and reduce the runup effectively which is caused by the characteristic of sand dune. It implies that the lagoon has a certain capacity to mitigate tsunami wave heights with its feature of sand dune height.

The results by setting h_D/h_o in similar manner (i.e. same water level throughout the lagoon) for fixed value of H_o equals to 7.8cm and varying nondimensionalized L/h_o, are as shown in Fig. 4. It can be seen from the results that when the length of lagoon extent is increasing, the runup at the landward is getting decreased and hence the lagoon retention capacity is increasing. But the rate of change of retention capacity is getting decreased with the increment of lagoon length.

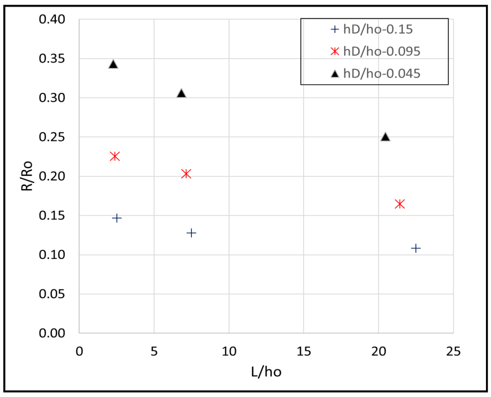


Fig. 4: Lagoon length characteristics

4. CONCLUSION

In this paper, the effect of sand dune and lagoon extent against tsunami wave were discussed and the following conclusions were made based on the results.

Runup due to tsunami wave can be reduced by increasing dune height and length of lagoon extent. The retention capacity of a lagoon consist of specified dune height is limited and that maximum wave height can be measured by following this approach which will be useful in coastal landscape planning by considering the optimum energy reduction on the surrounding area.

5. ACKNOWLEDGEMENT

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