EXPERIMENTAL AND NUMERICAL STUDIES ON THE EFFECT OF GROUND SLOPE ON SOLITARY WAVE RUN-UP

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Introduction

The run-up (R) is the maximum level that water runs up along a slope when a wave interacts with a beach-front or a structure. It depends on the incident wave characteristics such as the wave height (H) and the period (T) as well as the slope characteristics such as the slope angle (θ) and the surface roughness (r).

Many studies of wave run-up on slopes have been carried out with regular or irregular sinusoidal waves (e.g., Van der Meer, 1996), and results from such studies are usually applicable to wind generated waves. However, the behaviour of tsunami waves in the nearshore differs from sinusoidal Stoke's theory and approaches that of solitary waves (Liu *et al.*, 1991; Li and Raichlen, 2001). Accordingly, this paper presents results from experimental and numerical studies carried out to examine the effect of ground slope on the run-up due to solitary-like wave forms. The results from such studies are useful in tsunami hazard mitigation efforts as most of the damage associated with tsunamis is related to their run-up at the shoreline.

Methodology

In the experimental study, the run-up measurements were carried out in an open channel in the Fluids Laboratory of the University of Peradeniya. This channel was fitted with a device to generate solitary-like waves at one end and a slope at the other end. The numerical simulations were carried out by employing COMCOT software based on non-linear shallow water equations with solitary waves as input boundary condition. In this study, the run-up over both smooth and rough slopes was investigated experimentally and numerically for a range of slope angles and wave heights.

A schematic diagram of the model set up for both experimental and numerical studies is shown in Figure 1, where, h_0 is the still water depth.

Results and Discussion

Figure 2a shows the variation of computed run-up with ground slope for different solitary wave heights on smooth slopes. It is clearly seen in Figure 2a, that the run-up increases with increasing ground slope ($0.57 < \theta < 1.91$ deg.) and with increasing relative wave height ($0.125 < H/h_0 < 0.625$). The rate of increase in run-up with ground slope appears to be higher for smaller angles ($0.57 < \theta < 0.95$ deg.) than for larger angles ($1.43 < \theta < 1.91$ deg.) in the range tested. It is also seen that the variation of run-up with ground slope is qualitatively similar for all wave heights tested.

For comparison, Figure 2b gives the experimental results showing the variation of measured run-up with ground slope ($1 < \theta < 6$ deg.). It can

be seen that the numerical model results and the experimental results, on the whole, show qualitatively similar variation of increasing run-up with ground slope over the smooth slopes. The experimental results also show that the wave run-up increases with the relative wave height (H/h_0).

It must be added that no attempt was made for a direct quantitative comparison of numerical results with experimental measurements as the two studies have employed model configurations of two different scales: the length scale used in the numerical study is one order of magnitude larger than that of the experimental study. Moreover, a direct quantitative comparison using non-dimensional parameters was not successful as it was found that the run-up does not appear to scale well with the still water depth (h_0), at least in this study.

The numerical results for the rough slopes also found to show a qualitatively similar variation to the corresponding experimental results.

Conclusions

The numerical model results and experimental results show qualitatively similar variation of increasing run-up with ground slope over both smooth and rough slopes for the range of conditions covered in the present study.

Acknowledgement

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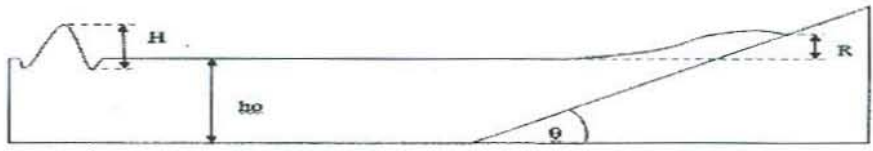

Figure 1. Schematic diagram of model set up for both experimental and numerical studies.

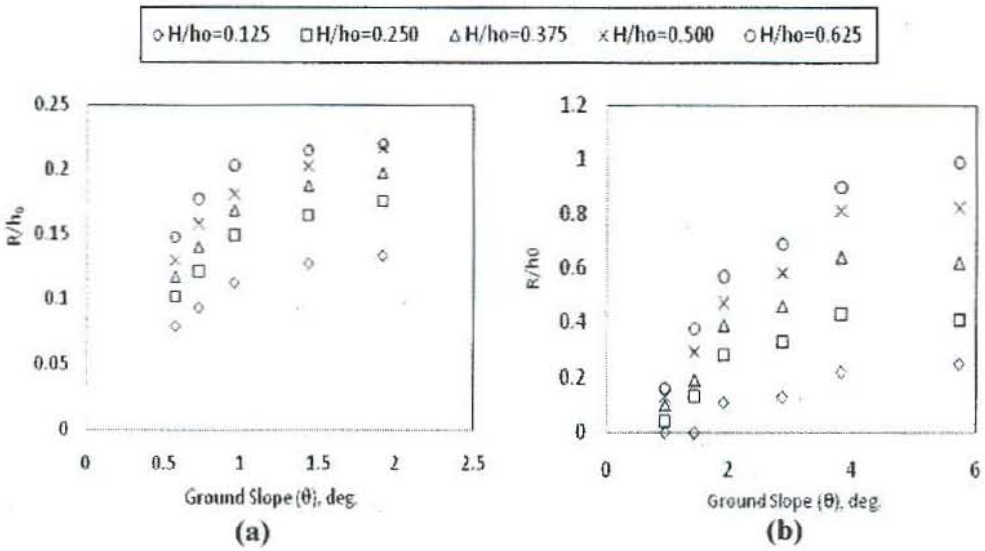

Figure 2. Variation of relative run-up (R/h_0) with ground slope (θ) over smooth slopes: (a) Numerical results, and (b) Experimental results.