WAVE RUN-UP, RUN-DOWN STUDIES ON BERM BREAKWATER WITH CONCRETE CUBES AS ARMOUR UNITS

Chapter · November 2011

DOI: 10.1142/9789814366489_0062

4 authors:

Subba Rao
National Institute of Technology Karnataka
109 PUBLICATIONS 459 CITATIONS

Kiran G. Shirlal
42 PUBLICATIONS 135 CITATIONS

Balakrishna Rao
Manipal institute of Technology Manipal
18 PUBLICATIONS 71 CITATIONS

Prashanth Janardhan
National Institute of Technology, Silchar
22 PUBLICATIONS 20 CITATIONS

Indexed in
Scopus Compendex and Geobase Elsevier, Chemical
Abstract Services-USA, Geo-Ref Information Services-USA

ISSN 0974-5904, Volume 05, No. 04 (02)

www.cafetinnova.org

International Journal
of Earth Sciences
and Engineering

August 2012, P.P. 1052-1056

Wave Run-Up, Run-Down Studies on Reshaped Berm Breakwater with Artificial Armour Units

Prashanth J[1], Subba Rao[1], Kiran. G. Shirlal[1], Balakrishna Rao K[2] and Vishwanath N[1]

[1]Dept of Applied Mechanics and Hydraulics, National Institute of Technology, Surathkal. Mangalore 575025, India
[2]Department of Civil Engineering, Manipal Institute of Technology, Manipal 576104, India
***Email:** prashnitk.hsn@gmail.com, surakrec@gmail.com*

Abstract: The objective of this study is to investigate the wave run-up, run-down characteristics of berm breakwater using concrete cube as artificial armour unit with reduced weight of the armour. The experiments are conducted under following conditions, berm widths 0.3m and 0.45m, water depths ranging from 0.35m to 0.45m, breakwater slope 1:1.5. Reduced weights (25% & 50%) of armour unit are used in berm breakwater. From the experimental study it is found that the wave run-up is more for longer period waves in comparison with the shorter period waves. It is found that berm width has a great influence on wave run-up and wave run-down and is found to decrease with the increase in berm width. Dimensionless wave run-up varied from 0.52 - 1.85. Dimensionless wave run-down varied from 0.45 - 1.35.

Keywords: *Berm breakwater, wave run-up, wave run-down, wave steepness*

Introduction:

The conventional rubble mound breakwaters needs very big size stones in large quantities. The berm breakwater has been adopted at several places as an economic solution when large cover blocks of natural stones are not available. Priest et al. (1964), Brunn and Johannesson (1976), and Ergin et al. (1989), showed that S-shaped rubble mound breakwaters (berm breakwaters) are more stable than conventional breakwaters under certain conditions. Subba Rao et al. (2008) conducted a series of experiments to study the stability of non-reshaped berm breakwaters. They found that the slope of breakwater has much influence on wave run-up and with the change of slope from 1:1.5 to 1:2 the run-up was reduced by 36%. Also with the increase in wave steepness, the wave run-up was found to decrease. The run-down was found to be more significant than the run-up when SWL was above the berm and run-down was less than run-up when SWL was below the berm (Subba Rao et al., (2006)). Pilarczyk (1990) found that run-up on slope decreases with increasing artificial berm width and the reduction rapidly falls off once a certain minimum width is exceeded : for $B > 0.25L_o$ for non breaking waves and for $B > 4H_s$ for strong breaking waves i.e. for $H_s/L_o > 0.03$. In the present paper wave run-up and run-down studies have been done for different wave parameters.

Details of Experimental Work:

The present work involves an experimental study on the influence of change in different wave parameters and storm duration on the wave run-up and run-down of the berm breakwater. Weight of armour unit used for berm breakwater and conventional breakwater are calculated using Hudson equation (CEM 2006) for a design wave height of 0.1m and are 106gm and 79.5gm respectively. The seaward slope of berm breakwater and conventional breakwater are 1:1.5 and 1:2 respectively. Fig. 1 shows the sectional elevation of the berm breakwater model studied. Geometrically similar scale of 1:30 is selected for the present investigation. In the present model, the primary layer is divided into three zones crest ward slope, berm and toe ward slope, and the units in these regions are coloured as white, red and grey respectively.

The armour weight obtained using Hudson equation for berm breakwater is reduced 50% for model A and 25% for model B; their weights corresponding to the reduction are 79.5gm and 53gm respectively. The armour layer thickness is calculated using layer coefficient as explained in the CEM (2006). A crest width of 0.15m or a minimum of three cubes width is provided. The model characteristics are given in Table 1. Table 2 gives the range of experimental variables considered for the study.

Wave Flume:

Experiments were conducted by generating regular waves in a two-dimensional wave flume 50m X 0.71m X 1.1m as shown in Fig. 2. The ranges of wave height and periods that can be generated in this wave flume are 0.02m to 0.24m and 0.8s to 4s, respectively. The flume is provided with bottom hinged flap type wave generator. It has a smooth concrete bed for length of 42m. The wave generating chamber is 6m in length. Gradual transition is provided between the normal flume bed level and that of generating chamber by a ramp. The wave filter consists of a series of vertical asbestos cement sheets spaced at about 0.1m centre-to-centre parallel to the length of the flume. The far end of the flume has a wave absorbing beach with 1:12 slope consisting of rubble stones. Therefore, wave reflection in the flume is insignificant.

Wave run-up and Wave Run-Down:

Wave run-up is the phenomenon in which an incoming wave crest runs up along the slope up to a level that may be higher than the original wave crest. The vertical distance between still water level SWL and the highest point reached by the wave tongue is called the run-up (Fig. 3). Similarly wave run-down is the vertical lower level reached by backwash of a wave on a coastal structure (Fig. 3).

Results and Discussions:

Effect of Water Depth on Wave Run-Up:

The variation of Wave Run-up (R_u/H_o) with Wave Steepness (H_o/L_o) for different water depths is shown in Fig. 4. It is seen that for both the models there is decrease in wave run-up with the increase in wave steepness. The wave run-up for model A ranges from 0.94 to 1.79 and for model B it varies from 0.52 to 0.99. From the graph it can be noticed that run-up for model A is high compared to model B. Also it can be noticed that the decreasing trend in model A is steep compared to model B. This may be due to the shorter berm in model A as compared to model B. The reduction in run-up is 46% in model B when compared with model A.

Effect of Water Depth on Wave Run-Down:

The variation of Wave Run-down (R_d/H_o) with Wave Steepness (H_o/L_o) for different water depths is shown in Fig. 5. It is seen that for both the models there is decrease in wave run-down with the increase in wave steepness. For model A wave run-down varies from 0.84 to 1.24 and for model B it varies from 0.45 to 0.81. It is seen from the graph that variation of run-down is gradual decrease with the increase in steepness. The run-down is low for model B than model A. The reduction in run-down is 50% with model B when compared to model A. The reduction may be due to the presence of longer berm in model B than model A.

Comparison of Wave Run-Up and Run-Down with Conventional Rubble Mound Breakwater:

From the graphs of wave run-up and run-down it can be observed that the run-up and run-down has decreased considerably in case of berm breakwater models when compared to conventional breakwater. The reduction is due to the presence of berm in berm breakwater model. There is 15.19% and 35.91% reduction in run-up for model A & model B compared to conventional breakwater respectively and 23.81% reduction in run-down for model B compared to conventional breakwater. The wave run-down is 14.17% high for model A when compared to conventional breakwater. This may be because of smaller weight armour units undergoing a large reshaping, which results in increased down rush of water.

Conclusions:

The following conclusions are deduced from this study:

- As deep water wave steepness increases, wave run-up (R_u/H_o) decreases for all the variables considered in the present study. (R_u/H_o) ranges from 0.52 to 1.79.
- The wave run-down (R_d/H_o) decreases as deep water wave steepness increases, for all the variables considered in the present study (R_d/H_o) vary from 0.45 to 1.24.
- From the study it can be concluded that berm length has effect on wave run-up and wave run-down. With the increase in berm length both wave run-up and run-down reduces.
- The run-up and run-down values are reduced by 35.91% and 23.80% due to the presence of berm when compared model B with conventional rubble mound breakwater.
- The run-up and run-down values are reduced by 15.19% and 9.44% when compared model A with conventional rubble mound breakwater.

Acknowledgements:

The authors are thankful to the Director of National Institute of Technology Karnataka, Surathkal, and Head of the Department of Applied Mechanics and Hydraulics for the facilities provided for the investigation and permission granted to publish the results. Also the authors would like to thank INCH, Ministry of Water Resources, GOI for providing financial support to carry out the work.

References:

[1] Brunn P and Johannesson P (1976), Parameters affecting stability of rubble mounds, Journal of Waterway, Harbours and Coastal Engineering Division, ASCE, Vol. 102, pp. 141-163.

[2] Coastal Engineering Manual (CEM) (2006), Fundamental of Design, EM 1110-2-1100(Part-VI), U.S. Army Corps. of Engineers.

[3] Ergin A, Gunbak A R and Yanmaz A M (1989), Rubble mound breakwaters with S-shape design, Journal of Waterway, Port, Coastal, Ocean Eng., ASCE, 115(5), pp. 579-593.

[4] Pilarczyk K W (1990), Design of seawalls and dikes including overview of the revetments, Coastal protection, Balkema, Rotterdam.
[5] Priest M S, Pugh J W and Singh R (1964), Seaward profile for rubble mound breakwaters, Proc. 9th Int. Conf. on Coastal Engineering, ASCE, 553-559.
[6] Shore Protection Manual (1984), U.S. Army Coastal Engineering Research Center, Department of the Army, Corps of Engineers, U.S. Govt. Printing Office, Washington, DC.USA.Vol.1 and 2.
[7] Subba Rao, Balakrishna Rao K, Rajesh AVRP (2006), Stability aspect of berm breakwaters, Proceedings of National Conference on Hydraulics and Water Resources, HYDRO-2006.
[8] Subba Rao, Subrahmanya K, Balakrishna Rao K, Chandramohan V R (2008), Stability aspects of non-reshaped berm breakwaters with reduced armor weight, Journal of Waterway, Port, Coastal and Ocean Engineering, ASCE, March/ April 2008 Vol. 134, No. 2, pp. 81-87.
[9] Torum A (1998), On the stability of berm breakwaters in shallow waters and deep water, Proc. 26th Int. Conf. on Coastal Engineering, Copenhagen, Denmark, ASCE, pp. 1435-1448.
[10]Van der Meer J W (1992), Stability of the seaward slope of berm breakwaters, Journal of Coastal Engineering, 16, pp. 205-234.

Table 1: *Model Characteristics*

	Model A	Model B
Armour Weight	55.65 gm	79.5 gm
Thickness of armour layer	0.063 m	0.105 m
Size of the armour unit (D_{n50})	0.0285 m	0.0325 m
Berm Width (B)	0.30 m	0.45 m
Position of berm from sea bed	0.45 m	0.425 m

Table 2: *Range of Experimental Variables*

Variable	Expression	Range
Wave height	H	0.10,0.12,0.14,0.16m
Wave period	T	1.6, 2.0 & 2.6 sec
Storm duration	N	3000 waves
Angle of wave attack	[illegible]	90^0
Water depth	D	0.35, 0.40, 0.45m
Primary armour layer thickness	t_p	0.1047m
Secondary armour layer thickness	t_s	0.0490m
Shape of the armour unit	-	Cube
Slope	-	1:1.5

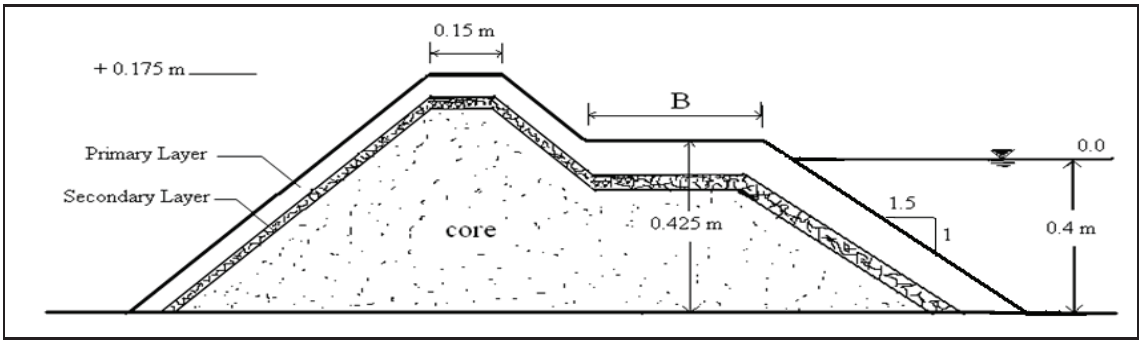

Figure 1: *Cross-Section of Berm Breakwater Model*

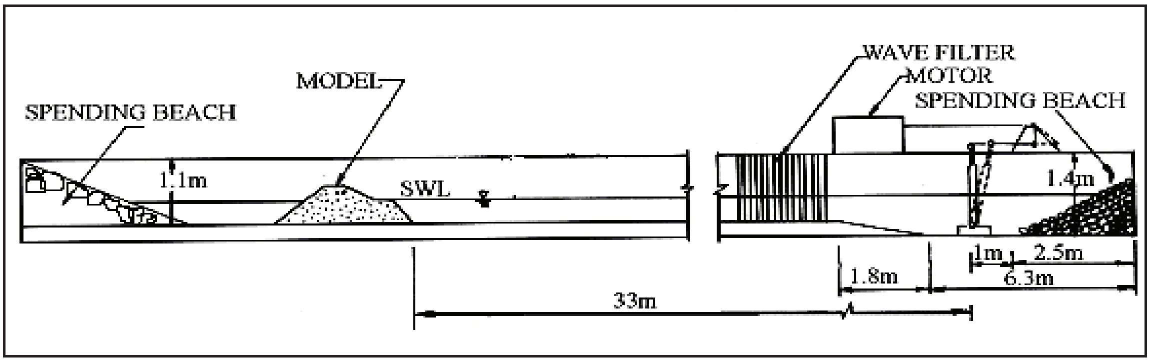

Figure 2: *Details of Experimental Setup*

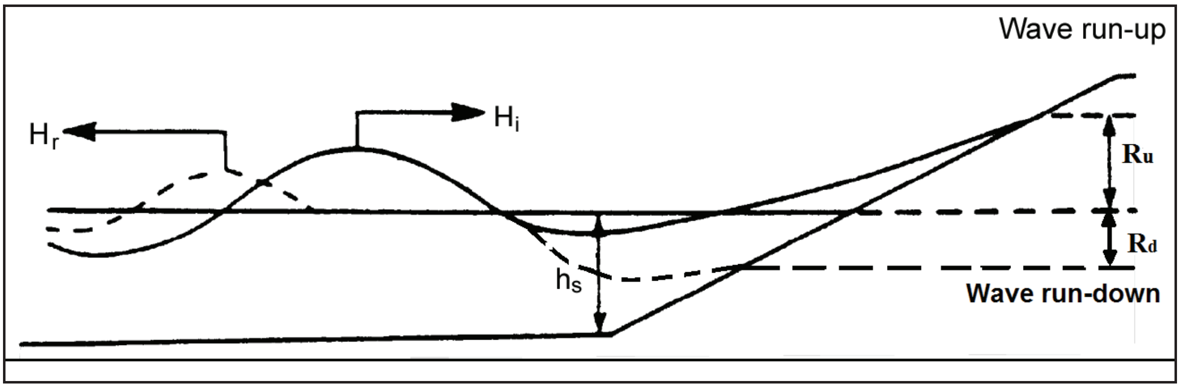

Figure 3: *Wave Run-Up and Wave Run-Down*

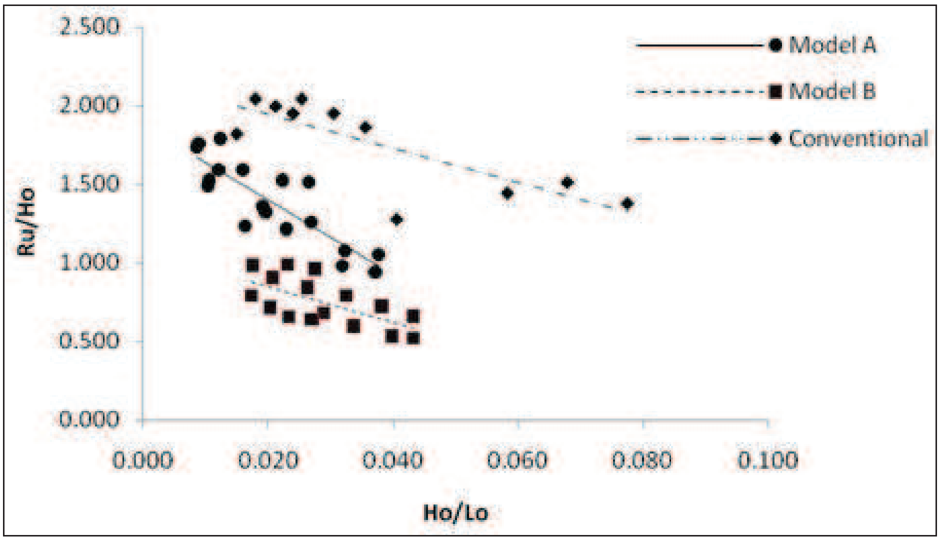

Figure 4: *Variation of Wave Run-up with Wave Steepness*

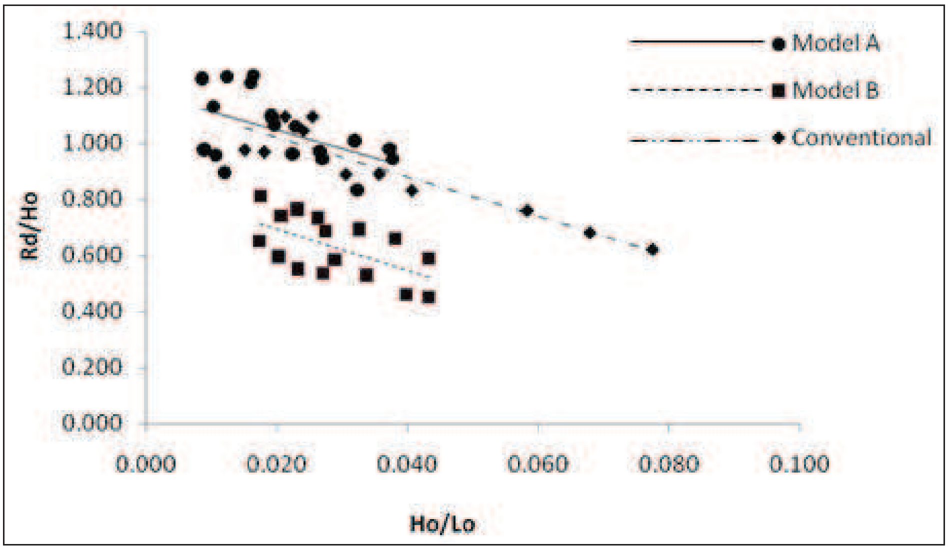

Figure 5: *Variation of Wave Run-down with Wave Steepness*