Proceedings of the 9th International Conference on Physical Modelling in Coastal Engineering (Coastlab24)
Delft, Netherlands, May 13-16, 2024
©2024 published by TU Delft OPEN Publishing on behalf of the authors
This work is licensed under a CC BY 4.0
Extended Abstract, DOI: 10.59490/coastlab.2024.712

PHYSICAL MODELLING OF BOULDER TRANSPORT UNDER THE INFLUENCE OF TSUNAMI WAVES

STORM ROBERTS[1], ALISON RABY[2], SARAH J. BOULTON[3], WILLIAM ALLSOP[4], ALESSANDRO ANTONINI[5], IVO VAN BALEN[6], DAVID MCGOVERN[7], KEITH ADAMS[8], IAN CHANDLER[9], JONAS CELS[10], IRENE MANZELLA[11]

1 University of Plymouth, UK, storm.roberts@plymouth.ac.uk

2 University of Plymouth, UK, alison.raby@plymouth.ac.uk

3 University of Plymouth, UK, sarah.boulton@plymouth.ac.uk

4 William Allsop Consulting Ltd, UK, william.allsop51@outlook.com

5 Delft University of Technology, NL, A.Antonini@tudelft.nl

6 Delft University of Technology, NL, ivovanbalen@gmail.com

7 London South Bank University, UK, mcgoverd@lsbu.ac.uk

8 London South Bank University, UK, Adamsk10@lsbu.ac.uk

9 HR Wallingford, UK, I.Chandler@hrwallingford.com

10 University College London, UK, jonas.cels.19@ucl.ac.uk

11 University of Twente, NL & University of Plymouth, UK i.manzella@utwente.nl

KEYWORDS: Tsunami, Physical Model, Boulder Transport

1 INTRODUCTION

Tsunami events are traditionally represented in the geological record by a sequence of fine-grained sediments, but increasingly coastal boulder deposits are being used as indicators of past tsunami events. The emplacement mechanism of many boulder deposits, however, is heavily debated and determining whether the inundation event was a tsunami or storm remains an unresolved challenge (Cox *et al*., 2020). Using physical experiments, we aim to achieve a better understanding of how tsunamis move coastal boulders. This knowledge will aid field geomorphologists in the identification of the emplacement mechanism for coastal boulder deposits and allow for the determination of wave parameters. In January 2023, physical experiments using the HR Wallingford Tsunami Simulator were completed as part of the MAKEWAVES collaboration. These experiments investigated the movement of a cuboid and irregular shaped boulder model when impacted by different tsunami waveforms on a plane beach. We propose new empirical formulae to describe relationships between transport distance and different tsunami waves.

2 EXPERIMENTAL METHODS

A sketch of the experimental set up and instrument positions is given in Figure 1. A 1:50 scale model was used. Two boulder shapes were selected for the experiments and placed at the still water level. A cuboid-shaped boulder model with dimensions 2.7 x 3.3 x 3.4 cm (± 0.01 cm) was used to be comparable to previous studies. It had a dry weight of 82 g and volume of 30 cm^3. An irregular-shaped boulder model was also used, to be representative of real-world boulder movement, in particular elongate boulders. It had approximate dimensions of 7.5 x 3 x 2.3 cm, a volume of 28 cm^3, and a dry weight of 77 g. Both boulder models were made of the same limestone, which has a density of 2750 kg/m^3**.** Three short wave gauges recorded data on the slope the boulder moved along, whilst 8 long wave gauges recorded wave information in the length between the tsunami simulator and the toe of the 1:30 slope. Three different groups of waves were run during the tests: N-waves, which are trough led waves, E-waves, which are elevated, crest led waves (Fig. 2), and bores, which are more impulsive crest led waves with a steep wave front.

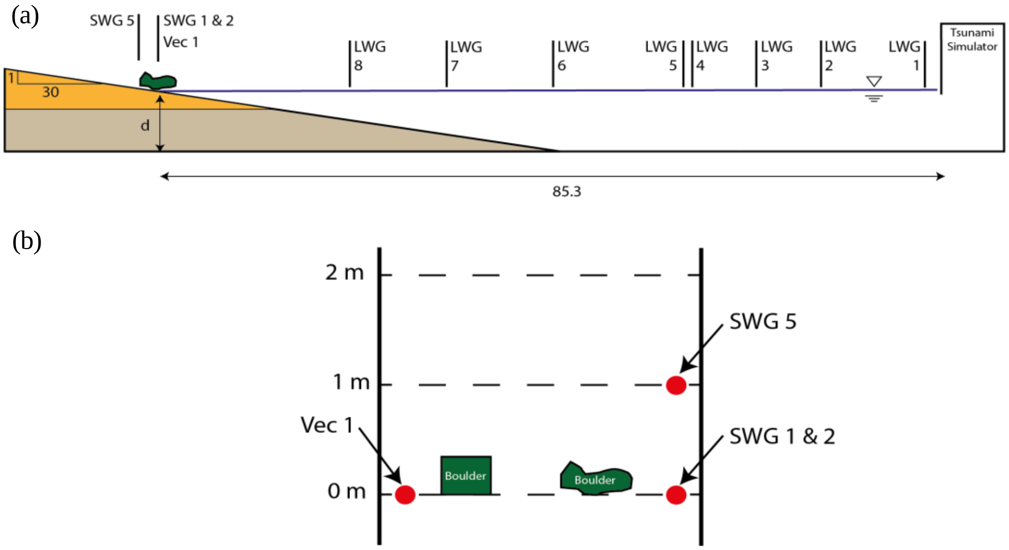

Figure 1. Experimental set up & Instrument position: (a) side view (b) plan view. SWG = Short Wave Gauge, LWG = Long Wave Gauge, Vec = Vectrino, d = water depth. All dimensions are in metres.

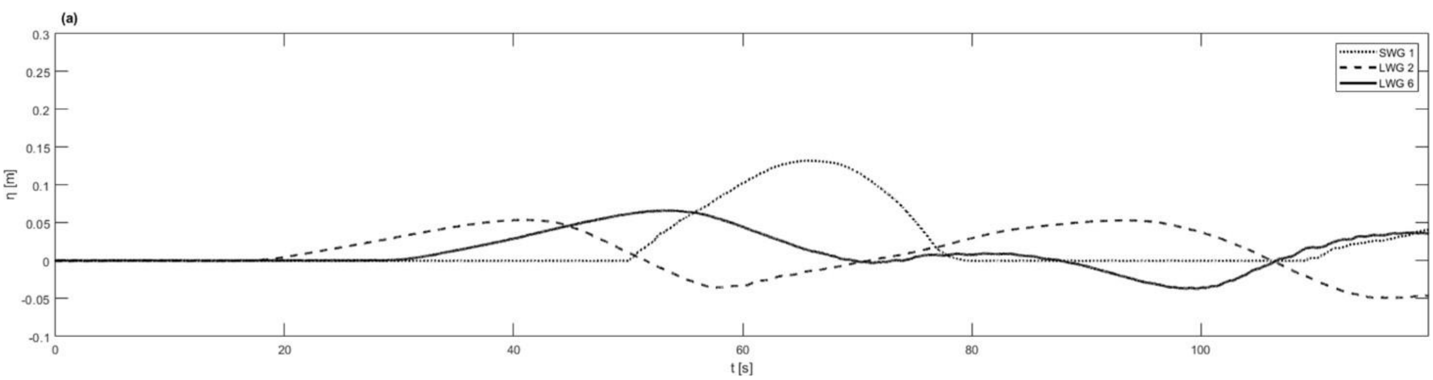

Figure 2. Wave gauge data example for an E-wave (d = 1.02 m).

3 PRELIMINARY RESULTS

A dimensional analysis approach has been taken to interpret the data. Through the use of Buckingham's Pi Theorem (Hughes, 1993), we have developed new empirical equations to describe relationships between boulder transport distance and different tsunami wave types. The dominant parameters seem to be boulder size, wave height and period.

ACKNOWLEDGEMENT

The data from large scale tsunami experiments presented in this paper derive from the Multidisciplinary Advancement of Knowledge on Extreme Waves – MAKEWAVES project led by Prof. T. Rossetto and Dr I. Chandler. MAKEWAVES includes a large number of academic staff and researchers from University College London, HR Wallingford, London South Bank University, University of Plymouth, Southampton University, Imperial College, Technical University of Delft, University of Naples Federico II and Athens Technical University who are acknowledged for their funding. Funding for the project was also received from AKT2I project 269 Innovate UK with PI Dr David McGovern.

The work contained in this abstract contains work conducted during a PhD study undertaken as part of the Centre for Doctoral Training (CDT) in Geoscience and the Low Carbon Energy Transition it is sponsored by The University of Plymouth and NeoEnergy Upstream whose support is gratefully acknowledged.

REFERENCES

Cox, R, Ardhuin F, Dias F, Autret R, Beisiegel N, Earlie C, Herterich J, Kennedy A, Paris R, Raby A, Schmitt P, Weiss R. (2020) 'Systematic Review Shows That Work Done by Storm Waves Can Be Misinterpreted as Tsunami-Related Because Commonly Used Hydrodynamic Equations Are Flawed', *Frontiers in Marine Science*, 7. DOI: 10.3389/fmars.2020.00004.

Hughes, S.A. (1993) *Physical Models and Laboratory Techniques in Coastal Engineering*. WORLD SCIENTIFIC. ISBN: 978-981-02-1540-8.