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Significance of boulder shape for the transport of boulders by tsunamis

Jan Oetjen[1], Max Engel[2], and Holger Schüttrumpf[1]
[1]Institute of Hydraulic Engineering and Water Resources Management (IWW), RWTH Aachen University, Aachen, Germany
[2]Institute of Geography, Heidelberg University, Heidelberg, Germany

Physical experiments and numerical models support investigations on the transport of boulders by tsunamis, and based on this, on hydrodynamic characteristics of the tsunami itself. We conduct physical experiments in a flume applying idealized (cuboid) as well as a naturally shaped boulder, the latter representing a downscaled model from a field site on the island of Bonaire (Lesser Antilles, Caribbean Sea). Besides the boulder shape, we study the influence of shoreline morphology and pre-transport setting on boulder transport by a tsunami (Oetjen et al., 2020).

The physical experiments show that the interaction between bore and boulder differ significantly for the idealized and natural boulders. In our experiments, the natural boulder model consists of a lower drag coefficient, leading to lower flow disturbances and transport distances, and an increased entrainment threshold compared to the cuboid boulder. Subsequently, the natural boulder is thus transported approximately 30 % shorter than the cuboid one of same volume and weight. Since idealized shapes like cuboids are non-existent in nature, the results indicate that existing equations predicting entrainment thresholds or transport distances, overestimate the actual values. However, it is not clear to which amount the influence of the boulder shape is superimposed by other boulder and wave properties (e.g., ratio between wave velocity and boulder volume or weight) or local conditions (e.g., initial boulder submergence).

Furthermore, especially for experimental setups leading to high transport distances, significant fluctuations, of the transport distances are observed (up to 650 % in a single setup). This shows the sensitivity and complexity of coastal boulder transport and clarifies, that evaluating such processes in nature need to be conducted as accurate as possible while attributing to the large uncertainties associated with the transport process which might not be solvable for particular events (e.g., due to remobilization processes or unknown transport mode).

For most transport properties our findings are in line with previous studies. However, in contrast to some of them, we only observe sliding transport and higher variations in the transport distances. A large percentage of the deviations between our results and other studies, may also be related to divergent experimental setups, especially in terms of wave - boulder property ratios (e.g., increased ratios between boulder density and wave height/velocity).

Subsequently, comparisons between the findings of different studies are not straightforward. For

simplifying this, we suppose a more coordinated research approach based on a standardized experimental setup. Such a setup would allow research to focus on single parameters and an easier comparison of results from other research groups, flumes and experimental campaigns.

Oetjen, J., Engel, M., Pudasaini, S.P., and Schuettrumpf, H.: Significance of boulder shape, shoreline configuration and pre-transport setting for the transport of boulders by tsunamis. Earth Surf. Proc. Landforms, 45, 2118–2133, 2020, https://doi.org/10.1002/esp.4870.