EGU2020-14532
https://doi.org/10.5194/egusphere-egu2020-14532
EGU General Assembly 2020

Runup of long waves on composite coastal slopes: numerical simulations and experiment

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The goal of this study is to investigate the effect of the bottom shape on wave runup. The obtained results have been confronted with available analytical predictions and a dedicated numerical simulation campaign has been carried out by the team. We study long wave runup on composite coastal profiles. Two types of beach profiles are considered. The Coastal Slope 1 consists of two merged plane beaches with lengths 1.2 m and 5 m and beach slopes tan α = 1:10 and tan β = 1:15 respectively. The Coastal Slope 2 also consists of two sections: plane beach with length 1.2 m and a beach slope α, which is merged with a convex (non-reflecting) beach. The latter is constructed in the way, that its total height and length remain the same as for the Coastal Slope 1.

The study is conducted with numerical (in silico) and experimental approaches.

Experiments have been conducted in the hydrodynamic flume of the Nizhny Novgorod State Technical University n.a. R.E. Alekseev. Both composite beach profiles were constructed in 2019. The Coastal Slope 1 consists of three parts made of aluminum. The plain beach part of the Coastal Slope 2 is also made of aluminum, and the convex profile consists of two parts made of curved PLEXIGLAS organic glass. The water surface oscillations are measured using capacitive and resistive wave gauges with recording frequencies of up to 80 Hz and 100 Hz respectively. Wave runup is measured by a capacitive string sensor installed along the slope.

A series of experiments on the generation and runup of regular wave trains with a period of 1s, 2s, 3s and 4s were carried out. The water level was kept constant for all experiments and was equal to 0.3 meters. Up to now, 21 experiments have been carried out (10 and 11 experiments for each Coastal Slope respectively).

A comparative numerical study is carried out in the framework of the nonlinear shallow water theory and the dispersive theory in the Boussinesq approximation.

As a result, we compare the long wave dynamics on these two bottom profiles and discuss the influence of nonlinearity and dispersion on the characteristics of wave runup. It is shown numerically that, in the framework of the nonlinear shallow water theory, the runup height on the Coastal Slope 2 tends to exceed the corresponding runup height on the Coastal Slope 1, that also

agrees with our previous results (Didenkulova et al. 2009; Didenkulova et al. 2018). Taking dispersion into account leads to an increase in the spread in values of the wave runup height. As a consequence, individual cases when the runup height on the Coastal Slope 1 is higher than on the Coastal Slope 2 have been observed. In experimental data, such cases occur more often, so that the advantage of one slope over another is no longer obvious. Note also that the most nonlinear breaking waves with a period of 1s have a greater runup height on Coastal Slope 2 for both models and most experimental data.