waveSTEPS [03KIS118, 03KIS119]:

Energy Dissipation within the Wave Run-Up at Stepped Revetments

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Research rationale and objectives

Due to high demands on the coastal zone (i.e. tourism, recreation, infrastructure, businesses etc.) it becomes increasingly important that multi-functional coastal protection measures should be implemented. An example of such a multi-functional measure is a stepped revetment.

From a coastal engineering point of view, the main advantage of a stepped revetment (in comparison to a smooth slope revetment) is that the steps on the revetment create surface roughness which results in a reduction of wave run-up. In addition, a stepped revetment can be an aesthetically pleasing coastal protection measure that promotes tourism by providing access to water areas, creating walkways and/or serve as a bench. Another advantage is that a stepped revetment can be constructed from precast units.

A thorough literature review by Kerpen and Schlurmann (2016) identified and reviewed almost 30 publications on stepped revetments. Although a substantial number of publications exist, no study tested a wide range of geometry-related and hydraulic boundary conditions. Therefore, to provide design guidance on stepped revetments, systematic research is required.

The main objective of this research is to determine the influence of stepped revetments on wave run-up and wave overtopping. A thorough understanding of the energy dissipation mechanisms of the run-up process is therefore required. More specifically, the research aims to determine the influence factor for roughness of stepped revetments (γ_f, as defined by EurOtop (2016)).

Description of research programme

The research for the waveSTEPS project is divided into three work packages, namely AP1, AP2 and AP3. Each work package is described in the subsequent sections.

AP1: Physical model tests in the wave flume

In this work package wave run-up and wave overtopping of a stepped revetment will be researched systematically. Physical model tests with a wide range of geometric-related and hydraulic boundary conditions (scaled to Froude's law) will be conducted. The run-up, overtopping, pressure loads and reflection coefficients will be measured for the range of boundary conditions.

AP2: Physical model tests in the current flume

In this project part, an analogy between unsteady and steady flow is hypothesized to allow examination of the energy dissipation during wave run-up of stepped revetments (Kerpen et al., 2016). Common techniques employed in the study of air-water flows in hydraulic structures will be herein used. The proposed analogy will be also analysed and, finally, a relationship between the studied configurations and the roughness coefficients for run-up determination will be provided all through a fluid mechanic based analysis.

In free-surface flows over cavity bottoms (as in the case of a stepped revetment), a wide range of eddy length scales can be found, yielding a significant increase on the turbulence quantities when compared to the counterpart smooth bottom revetment. The resulting shear flow over the cavity produce a turbulent momentum exchange which has attracted researchers' interest in some other hydraulic disciplines. The slope and step height of the stepped revetment define the geometry that the approaching flow faces and, consequently, different structures inside the cavity can take place and others might be constrained. Evidently, the occurring flow structures are responsible for the consequent energy dissipation and thus the resulting roughness coefficient (γ_f) which can be found in the design manuals (e.g.: EurOtop, 2016).

AP3: Large scale model tests

Preliminary investigations (Kerpen et al., 2016) have indicated that wave run-up on stepped revetments create highly turbulent and aerated conditions. As a result, the wave run-up process simulated by scaled physical models are subjected to scale effects. Consequently, to accurately provide design guidance on stepped revetments, scale effects have to be studied. This work package will include full scale tests in the Great Wave Flume (GWK). By performing the full scale tests, the scaling error can be determined for various hydraulic processes.

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