Towards a climate resilient coast: Numerical modeling of wave overtopping and wave loads considering the influence of sediment transport

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The Belgian coast is only 67 kilometer long, but has nevertheless a high touristic, socio-economic and cultural value. Throughout history, the shoreline has been significantly modified. From the end of the 19th century until after the Second World War a series of high apartment buildings were constructed on the sea dike. Furthermore since 1970, millions of cubes of sand were artificially added to the beach as coastal defence measures, pushing the sea further away from the dikes. This resulted in the typical Belgian coast as it is known today: a mildly sloped beach in front of a dike with a promenade and an almost continuous line of high rise buildings.

Coastal safety against flooding is provided by a hard dike structure, fronted by a nourished beach and a storm wall on the crest of the dike. However, due to the climate change, the sea level is expected to rise and the severity and frequency of extreme storm events will increase. The Belgian coastal defence system is therefore adapted according to the Master Plan Coastal Safety by a combination of beach nourishment and dike crest increase by a storm wall, providing as such enough safety for the entire Flemish coast until the year 2050.

Within the design of these coastal defence measures, data such as wave loads and wave overtopping volumes are taken into account. Though, an accurate prediction of wave overtopping and wave loads on structures at the Belgian coast is not straightforward.

At present, traditional EurOtop prediction formulae are used to provide a quantitative description of the overtopping processes according to the original Master Plan methodology. However, these empirical formulas are based on assumptions (e.g. concerning geometry, wave boundary conditions...) that are too conservative for this type of cross-section.

New research actions are organized to improve understanding of processes and development of more accurate design tools within CREST (Climate Resilient coaST, www.crestproject.be). Within the CREST project, an integrated modeling of wave, flow and sediment in the swash zone will be carried out. A numerical (2DV) model will be developed employing the OpenFOAM code, solving the Reynolds-averaged Navier-Stokes (RANS) equations. Navier-Stokes type models resolve the flow over the complete water depth and allow modeling of the complex overtopped flow.

Sediment transport is known to have a significant effect on wave propagation during a storm, and thus also on the wave overtopping and wave loading processes. Therefore, our research will first focus on the incorporation of a sediment transport module within the OpenFOAM source code to capture all relevant sediment transport processes (i.e. bed load and suspended load transport). With this model, we aim to reduce empiricism in the present bed load formulations under combined current-wave action. On the other hand, we aim to study the loss of energy by mobilized sediment and the changing morphodynamics of the beach before waves reach the dike. Wave flume experiments including sediment transport documented in literature will be used to validate the numerical model.

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Keywords: openFOAM; sediment transport; wave overtopping; wave loads; Belgian coastal safety; CREST

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