Advanced modelling of wave overtopping for climate resilient coastal defence systems

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Only 67 km long, the Belgian coast represents a significant touristic, socio-economic and cultural value for the densely populated country. Historically, the coastal land-use planning was much less restrictive than that of the neighbouring countries. This caused a very high degree of local coastal development from the end of the 19th century on and increased considerably after the Second World War, with the rise of middle-class mass-tourism and apartment buildings on the sea dike. In addition, since the 1970's, beach nourishment was adopted as a complementary coastal protection scheme: millions of cubic meters of sand were artificially added to the beach and foreshore and pushed the sea further away from the sea dikes. This resulted in the typical Belgian coastal appearance as it is known today: an almost continuous row of high rise apartment buildings fronted by a sea dike with promenade and a mildly sloped beach.

The typical Belgian coastal defence system, in the urbanised coastal areas, is a nourished beach providing a long and (very) shallow foreshore in front of a sloped sea dike with promenade and buildings and/or storm wall(s) close to the dike crest. Climate change is expected to keep causing sea level rise and an increase in storm occurrence and intensity. The Belgian coastal defence system against flooding is therefore being adapted, according to the masterplan for coastal safety [1], by a combination of a beach nourishment and dike crest level increase by a storm wall.

In the functional design of these storm walls, the height of the storm wall is calculated by determining the wave overtopping, which is limited to a specific safety criterion. The wave impact forces need to be resolved for the design of the structural stability of the storm wall. Current state of the art methodologies to calculate the wave overtopping still contain simplifications that are too conservative for this kind of cross-section. For example, they do not take into account some important physical processes resulting from the complex geometry of the typical Belgian coastal profile. In addition, the design criterion for wave overtopping has focussed on the mean overtopping discharge. Individual wave overtopping volumes have not been investigated into much detail yet.

The present research focusses on advanced numerical modelling of wave overtopping over and wave forces on this typical Belgian coastal defence system, resolving the hydrodynamic flow in full 3D (or 2DV, disregarding the alongshore horizontal dimension). This should allow for a much more accurate prediction of the mean overtopping discharge and individual overtopping volumes. Furthermore, hydrodynamic experiments in both a wave flume (2D) and wave basin (3D) in addition to field measurements will be performed to provide data with which the numerical method can be verified. Field tests do not suffer from scale effects nor from model effects and are a crucial source of information to be integrated in the overall validation of the methodology. The field measurements will include an artificial dike constructed on the beach, close to the high water line, to allow measurement of wave overtopping and wave impact on the short term.

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Keywords: wave overtopping; wave impact; storm wall; very shallow foreshore; numerical wave modelling; hydrodynamic experiments; field measurements

Reference

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