Wave overtopping on steep low-crested structures: another climate change challenge

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Climate change is responsible for sea level rise and increase in the storminess (i.e. more frequent and more severe storms), posing risks to coastal communities. Floods on the coastline are expected to increase, leading to potential human life losses and significant economic damage. In this climate change scenario, the existing coastal structures protecting the Belgian coastline against wave attack should remain at least equally effective against future storms. Therefore, good knowledge of the coastal processes is required to correctly assess the safety of the existing coastal structures in this new scenario and to improve design guidelines. The main coastal processes involved are, among others, wave overtopping over the crest of the structures, wave run-up on sea dikes and wave forces and pressures exerted by the waves attacking the structures.

Wave overtopping is a key design parameter as it determines the necessary crest level of coastal structures (e.g. breakwaters) that limits the amount of water passing over the structure during wave attack. Traditional research has focused on analysing the average wave overtopping rate establishing its relation with diverse wave parameters of the sea state (wave height, wave period, wave steepness, etc.) and structural parameters (slope angle, crest freeboard, etc.). Furthermore, physical insights show that the damage on infrastructures and people near the coast during a storm is also related to individual volumes from single wave overtopping events.

Despite the large scientific literature available, there are still knowledge gaps to be covered in order to improve the understanding of wave overtopping under different conditions. This knowledge gap consists of overtopping data for steep low-crested structures (coastal structures with steep slopes and vertical walls, with a crest freeboard ranging from small to zero). This type of coastal structures with small freeboards are relevant in a climate change scenario where the sea level is increasing while the crest level of the existing structures is impossible or very expensive to modify. Improving the knowledge on various processes related to wave overtopping will eventually lead to more accurate overtopping prediction formulae with larger ranges of application, and hence to safer coastal defence structures under a climate change scenario.

The EurOtop (2007) manual is the reference manual in Europe about wave overtopping and overtopping assessment of coastal structures. It contains several overtopping prediction formulae for various types of coastal structures, lacking however prediction formulae valid for steep low-crested structures. An updated version, EurOtop (2016), is available with improved overtopping prediction formulae.

To extend the wave overtopping data available in the scientific literature, we performed 2D physical model tests at the large wave flume of Ghent University (Belgium). The experiments consisted in overtopping tests on smooth impermeable coastal structures, both with deep and shallow water conditions. The tests were focused on obtaining average and individual wave overtopping data for a range of slope angles α from steep to vertical walls and for a range of relative crest freeboards R_c/H_{m0} (where R_c is the crest freeboard of the structure and H_{m0} is the significant wave height) from large to zero. Four different datasets resulted from these physical model tests: dataset 'UG10', 'UG13', 'UG14' and 'UG15', all of them focusing on steep low-crested structures.

These new datasets obtained at Ghent University are useful to improve the accuracy of the existing prediction formulae on the range of steep low-crested structures. Recently, van der Meer & Bruce (2014) presented a new overtopping prediction formula fitted through the UG10 dataset and thus being in the range of application of steep low-crested structures. However, this formula underpredicts the results of the UG13, UG14 and UG15 datasets for very steep slopes and vertical walls, and for the zero freeboard limit case. By using the new Ghent University overtopping datasets, improvements on the accuracy of the prediction formulae can be made.

Keywords: coastal engineering; climate change; coastal structures; wave overtopping; steep low-crested structures; physical modelling

Reference

- EurOtop, 2016. Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application. Van der Meer, J.W., Allsop, N.W.H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., Schüttrumpf, H., Troch, P. and Zanuttigh, B., www.overtopping-manual.com.