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Numerical and experimental study of extreme wave impacts on temporary flood-fighting structures.

Abstract

The expected sea level rise due to the global warming effect will provoke an increase of the impact severity of the coastal storms in the next decades, with more than 200 million people living under storm tide levels today. Rising sea levels does not only cause flooding, but also leads to a significant loss of wetlands expected between 5 and 20 % in 2080. Shoreline facilities protection techniques can be soft, hard or a combination of them. Temporary protection structures are a subset of the protection methods frequently used in touristic areas (e.g: La grande plage de Biarritz). Sandbags belongs for instance to this category. These kind of barriers are implemented for a given time period when a storm warning is issued which may result in considerable savings compared to hard protection techniques while safeguarding the coastal environment. The geographical position of la Grande Plage de Biarritz does not allow the implementation of a hard protection technique, soft protection methods are preferred and have been tested several times in case of coastal storms. The one meter high seawall of La grande Plage de Biarritz has been unable, on several occasions, to protect the downstream Casino from storm waves which can be very energetic at this location. Occasionally, the sand level can be as high as the seawall making it non-functional. Square cylinder shaped sandbags of one meter length and width and 1 meter height are placed above the seawall side by side.

The objective of this thesis is to check the effectiveness of sandbags against violent storm events (e.g. Justine). For this, the real wave-structure impact problem is reduced to simple configurations of dam release on wet bottom allowing to extract the evolution of the free surface, the pressure values, the intensity and the repeatability of the overtopping events and to compare them to the observation data collected in-situ. Numerically, BOSZ (model based on Nwogu, Boussinesq-type equations) is used to get the global pressure applied on the sandbag packs (frontal, rear and upper impact). At a smaller scale, OpenFoam governed by Navier-Stokes equations allows to reproduce the experimental tests. A fluid-rigid solid interaction displacement model will be implemented to predict the downstream displacement of sandbag units in the case of a severe impact.

Results

One of the results already found is the direct relationship between the mean water level recorded over different times and the occurrence and intensity of overtopping events during the storm Justine.

The analysis of the observation data shows that:

- In the hydrostatic hypothesis, the stack in front of the casino is the only one where the water height exceeds the upper level of the sandbags.
- This same stack shows the lowest number of seawall overtopping events (53), which is where the sandbags shifted.
- The bathymetric profile in front of the Casino of Biarritz is characterized by a significant increase of sand level. The sand level difference between 30/01/2021 and 31/01/2021 in this stack is twice that recorded in the two adjacent stacks.. The sediment transport is impressively high in front of the Casino. As a result, the distance between the upper level of the seawall and the sand level on 31/01/2021 is very limited compared to other stacks, which may eventually lead to the submergence of the seawall and the sandbags (as occurred on 31/01/2021 between 04:08:25 and 04:08:30) and their shifting.

The dynamic meshing method is very promising, since it allows to lift the dam-break gate at a constant velocity and to model the gate with real thickness in OpenFoam. Research is underway to lift the door at constant acceleration (7.g) in an analogous way to the experiment.