Figure 1 (right): Full process of overtopping waves and their impact on a building on the crest of a multifunctional flood defense.

Figure 2 (below): Typical configuration of a Belgian coastal town in this case. Westende along the North Sea coast (photo courtesy: Klein House).
These permitted us to study wave overtopping and overtopping wave impact in the situation where a shallow foreland affects the wave overtopping of a coastal dike. Based on experiments done in a flume (see Figures 3 and 4), the results show that Generalized Pareto (GP) distribution gives a suitable fit among commonly used distributions for the extreme overtopping forces. The three key parameters of the GP distribution are threshold, scale, and shape. These were empirically determined by using incident wave conditions at the toe and dike geometry parameters. Based on the results of physical model tests, a new 7-step procedure was suggested as a simple tool for predicting the maximum force occurring during a certain storm peak; the tool shows an overall satisfactory performance (Chen et al., 2016a).

Using this tool, typical overtopping wave impact loads, expected to occur during 1 in 1000-year and 1 in 10,000-year storms, were calculated for the Belgian case. We assessed the vulnerability of buildings on coastal dikes caused by overtopping waves, by comparing the calculated impact load of overtopping waves and the strength of the buildings. We found that the majority of buildings on the coastal dike can withstand a 1 in 1000-year storm; but ground floor inundation can be expected from broken windows. If the building is located 10 to 15 meters from the seawall, non-structural walls are expected to fail during a 1 in 10,000-year storm. However, full collapse of the building may occur during a 1 in 10,000-year storm if the beach becomes badly eroded at the toe of the seawall side of the dike.

The findings of this study on the propagation of overtopping waves on a dike, was applied to the case of a Belgian seaside town. By characterizing the resulting impact load on a vertical wall, a model is developed to assess the vulnerability of existing and newly designed buildings on dikes that are exposed to the impact of overtopping waves in low-lying coastal regions. By extending the model to include the impact of overtopping waves on the foundation of the buildings and in potential dike failure, and different type of buildings, the model can become more general applicable.