QUANTIFYING THE BELGIAN COAST'S RESILIENCE AGAINST SEA LEVEL RISE (USING XBEACH & SWASH MODELLING)

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INTRODUCTION

Sea level rise directly impacts low-lying coastal areas. In Belgium, 400 000 people are protected by a first line of sea defense consisting of dunes or dikes. Every 6 years, the safety level of this sea defense against an extreme storm surge (return period of 1000 yrs) is evaluated.
To maintain however a safe and climate resilient coast, it is utterly important to bridge the knowledge gap between its current safety level and its safety level under sea level rise. That's why this year's safety assessment includes also 3 mean sea level rise scenario's: +0.3, +0.8 and +1.5m. It allows us to quantify the strength of the sea defense under changing hydraulic conditions and, possibly, identify its tipping point.

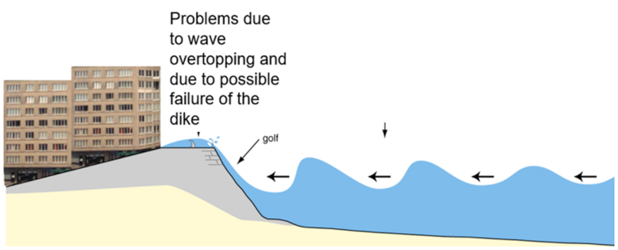

Figure 1 – Storm surge impacting on the dike and resulting in wave overtopping towards the (apartment)buildings

CHARACTERISTICS BELGIAN COAST

Situated between the French and Dutch border, the Belgian coast stretches out over merely 67km. The densely populated coastal plain is protected by dunes (2/3 of the alongshore length) and dikes (1/3) (Figure 1). The foreshore is generally very shallow, making wave breaking and infragravity wave motion important physical phenomena to take into account.
To facilitate the safety assessment, the Belgian coast is subdivided in 255 coastal sections (alongshore).

HYDRAULIC BOUNDARY CONDITIONS

Applying joint probability analysis and extreme value statistics on long time series of field data (monitored on the Belgian continental shelf) results in combinations of wind, water level and significant wave height having a specific (higher) return period. These combinations are then transformed from offshore to nearshore (= just outside the surf zone) using SWAN. Calculation of their exceedance frequencies leads to the boundary conditions for water level and waves (height, period, directional spreading) of the extreme storm surge at every coastal section, and for all sea level rise scenarios (Vuik et al., 2020). The inclusion of wave directional spreading is essential since it reduces the energy transfer from short to infragravity waves, and hence, influences erosion, wave run-up and overtopping.

DUNE AND BEACH EROSION MODELLING USING XBEACH

The Belgian coast is subdivided in alongshore coastal areas having similar median grain sizes. For every area, a 2DH XBeach model is set up, making use of a digital elevation model (DEM) of the present situation (February 2022). The new XBeach kernel is therefore validated in 1D (Deltares, 2022) and 2D (De Roo et al, 2022).
A synthetic extreme storm surge lasting for 45h (3 tidal cycles) is then modelled for all sea level rise scenarios (De Roo et al, 2021). The resulting post storm bathymetry is further used in the safety assessment.

'DUNE' RESILIENCE: BREACHING

The post storm dune area is analyzed to 1) evaluate whether or not breaching occurred, 2) quantify the erosion volumes and 3) estimate the magnitude of the remaining dune volumes ('buffer against breaching').
If buildings are situated in the dune area, their structural stability is additionally assessed (see method below).

'DIKE' RESILIENCE: STABILITY OF BUILDINGS

Mean wave overtopping rate is used as indicator to assess the structural stability of buildings on top of the dike (Figure 1). On that account, the post storm dike area forms the input of a SWASH 3D model. Mean wave overtopping rate is as such quantified along the entire dike section. The simulation is limited to the peak of the storm surge (roughly 500 waves) for all sea level rise scenarios. To account for the inherent stochastic nature of wave overtopping, 3 runs are done for every scenario/coastal area.

RESULTS OF THE 2022 SAFETY ASSESSMENT

The presentation will highlight the main findings of the 2022 safety assessment, focusing on the coastal resilience capacity against sea level rise.
It is expected that, under current conditions (no sea level rise), the coast is generally safe because it benefits from the further realisation of the Master Plan Coastal Safety (started in 2011).

REFERENCES

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