NUMERICAL ASSESSMENT OF FLOATING BREAKWATER EFFECTS AT INTERTIDAL FLATS

Hydro-morphodynamic study using Delft3D.

Intertidal flats in the Eastern Scheldt, a tidal basin in the southwest of the Netherlands, have been encountering severe erosion issues after the closure of the Eastern Scheldt Barrier. The erosion of, for instance, the Roggenplaat causes a decrease in the intertidal area and, consequently, reduces the foraging opportunities for various bird species. Various mitigation strategies could potentially be applied. For instance, large-scale nourishments have been placed by Rijkswaterstaat to maintain the intertidal area, but they only have a limited lifetime and, therefore need recurrent maintenance nourishments. Floating breakwaters (FB) can potentially protect the intertidal area like Roggenplaat against erosion in a more structural way. The local conditions seem promising, with relatively short wind waves in the Eastern Scheldt and the presence of deep tidal channels that ensure deep-water conditions. However, even though the FB has potential, the effects of the floating breakwater on the hydrodynamics and morphodynamics under local conditions are not fully understood yet. Therefore, the current study aims to assess the hydrodynamic and morphodynamic effects of a floating breakwater (FB) under varying wave conditions, water depths at FB position, and bed slopes of the intertidal flats.

In this study, two research phases are undertaken. The first is to understand whether the Delft3D model can be used to reproduce the evolved cross-sections due to of FB intervention in the laboratory experiment by Shimoda et al. (1991). In the second research phase, a total of 180 unique simulations with varying wave conditions, water depths at FB position, channel slopes, and intertidal area slopes were carried out. From these simulations, three hydrodynamic parameters, such as wave height, near-bed orbital velocity, and bed shear stress, and three morphodynamic parameters, such as bed load transport, suspended load transport, and cross-sectional erosion area, are used for the interpretation.

Based on the results in the first research phase, it was found that Delft3D could not predict the erosion and sedimentation pattern observed in the laboratory study. This was presumably due to the simplification of FB with transmission coefficient and no data of hydrodynamic measurements to validate the model. Nevertheless, Delft3D was able to reproduce the effects of FB in terms of reducing erosion and sedimentation on the lee side of FBs. Furthermore, results in the second research phase showed that an FB is less effective as the wave conditions become more extreme. Under mild wave conditions, H_0 = 0.40 m and peak wave period T_p = 1.7 s and H_0 = 0.70 and T_p = 2.3 s, hydrodynamic parameters, bed load, and suspended load transport were effectively reduced. As a result, erosion could be fully diminished with a 100% reduction. Next, with slightly more extreme wave conditions, H_0 = 1.20 m and T_p = 3.0 s, erosion was reduced by 92.7% - 96.4%. Meanwhile, with a more energetic wave, H_0 = 1.8 m and T_p = 3.8 s, erosion was reduced less by 57.4% - 62.6%.

Overall, the floating breakwater demonstrates potential for erosion mitigation of intertidal areas, though more in-depth technical and cost-benefit analyses are needed. Other key findings of the current study are firstly that wave conditions determine the effectiveness of FB in reducing erosion at the intertidal area. In this case, the FB is effective in reducing erosion under mild wave conditions and less effective as the waves become more extreme. Second, the FB located in deeper water (10 m, 15 m, and 20 m) reduces erosion more significantly than in shallower water (5 m). Third, with FB intervention, neither channel slope (1:15, 1:25, 1:55) nor intertidal area slope (1:200, 1:400, 1:600) affects the erosion mitigation considerably.

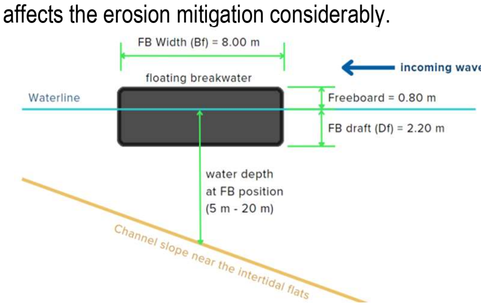

Figure 1: Determined dimension of the FB to calculate the transmission coefficients (using Macagno relation) as input of Delft3D for the second research phase

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