PREDICTING PORT SEDIMENTATION AND NAVIGATIONAL DEPTHS ON MEDIUM/LONG-TERM TIMESCALES: COMBINING 2D AND SHORELINE MORPHOLOGICAL MODELLING

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INTRODUCTION

Navigational depths in entrances of ports located on open sandy coasts are governed by the supply of sediment from adjacent coastlines and the complex morphodynamics in and around the port. To predict the depths, a model encapsulating the transport along adjacent shorelines and the detailed morphology around the port structures is required. To resolve this in a fast and robust manner, a novel model which couples the features of DHI's shoreline model (MIKE 21 FM Shoreline Morphology) and the morphological area model (MIKE 21/3 FM MD) is developed. Morphological simulations with the new tool show very promising results, when predicting the development over relatively long periods. Such new advances in medium/long term modelling of the temporal changes of the bathymetry in and around ports is key to the prediction of the navigational depth, including seasonal and annual variations.

THE EXISTING SITUATION

The model has been applied to a port located on an open sandy coast exposed to a seasonally varying wave climate. At the location of the port, the annual littoral drift is westward. Since the construction of the port, sediment build-up along the beach east of the port and along the eastern breakwater has occurred, followed by significant infill of the port and entrance area. The seasonal variation in the wave climate causes the sediment transport and the adjacent coastline position to vary significantly over the year, resulting in a seasonal variation in the sediment supply to the port areas.

METHOD AND RESULTS

A morphological model complex was setup up to study the processes of the sedimentation and to predict the future development of the bathymetry in the port areas.

The combination of 2D morphological modelling in the port areas and the shoreline morphology of the adjacent coastlines ensured 1) a dynamic boundary condition for the 2D area, which gave the correct seasonal variation in sediment supply, and 2) a robust boundary condition, which guides the development of the 2D morphology within the port area.

The modelled seasonal changes are in agreement with local observations and observations from satellite images as indicated in Figure 1. The figure compares digitized shorelines from acquired satellite images as dashed curves and modelled shorelines are shown as solid curves. The model showed a remarkable agreement between predicted and modelled deposition and build-up of the updrift sand fillet over a three year period.

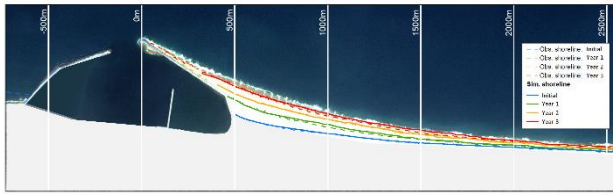

Figure 1 – Validation of the morphological model east of the port.

The strong seasonality was also included in the model, which responded by reproducing a cyclic behavior in the beach response, with the beach in front of the eastern breakwater appearing during the season with easterly waves and disappearing again during the following season with westerly waves.

The model complex is applied to predict the future development of the beach east of the port and the port sedimentation. The seasonal pattern repeats itself each year in the model simulations. During every season with easterly waves, more sediment is brought into the entrance area and harbor basin (Figure 2), until the deposition in the entrance area has built up a bypass bar, which allows the sediment to bypass the sediment around the port entrance. This happens after approximately six years of morphological evolution in the model for the present state of the system.

CONCLUDING REMARKS

The model simulations demonstrate the strength in treating the long uniform stretches differently from the more local and complicated morphology and to couple the two model strategies in a single model. The principle is strong and can be used in any case where local complex morphology affects the alongshore sediment budget and vice versa (coastal structures, headlands, submerged reefs, etc.). This brings us another step closer to the goal of forecasting bathymetry evolution in such areas.

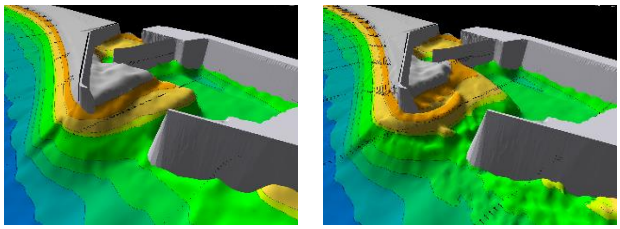

Figure 2 – The medium/long term development in port sedimentation is simulated by combining 2D morphological modelling (in port areas) and shoreline modelling (of the development along adjacent beaches). Left: Initial bathymetry. Right: Bathymetry after 1 year's simulation, when a bypass bar has started to develop. The upper left corner of the figures are towards the east.