DEVELOPMENT OF A THREE DIMENSIONAL NUMERICAL MODEL OF SEDIMENT TRANSPORT AND MORPHOLOGICAL EVOLUTION ON SANDY BEACH

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INTRODUCTION

In recent years, sandy coasts are suffering from erosion. It is of great importance to evaluate the state of coasts and assure the achievement of coastal protection measures. Therefore, a three-dimensional numerical model of sandy beach response was developed based on unstructured grids and with capability of describing nearshore hydrodynamics and sediment transports.

NUMERICAL MODEL

A three-dimensional hydrodynamic model was first developed based on a coupled wave-current model system that included the Simulating Waves Nearshore (SWAN) wave model and the Finite Volume Community Ocean Model (FVCOM) circulation model. Information exchange between the two models used Model-Coupling Toolkit (MCT) software following Chen et al. (2018). The new three-dimensional radiation stress including the bottom slope effects was employed (Ji et al. 2017). Based on the hydrodynamic model, a numerical model of sediment transport and morphological evolution on sandy beach was developed.

In the model, the suspended transport was calculated by solving the three-dimensional advection-diffusion equation. The concept of reference concentration was adopted and the exchange of sediment between the bed surface and the flow was modelled using source and sink terms (Lesser et al., 2004). The vertical distribution of sediment diffusion coefficient included the combined effect of waves and currents (van Rijn et al., 2007). The calculation of bedload transport has taken account of the wave-current interaction, wave asymmetry, phase lag and beach slope effect (Dong et al., 2013). Following the sediment transport simulation, the morphological evolution was obtained through the Exner equation. In return, the updated bathymetry affected the calculations of hydrodynamics and sediment transports (Figure 1).

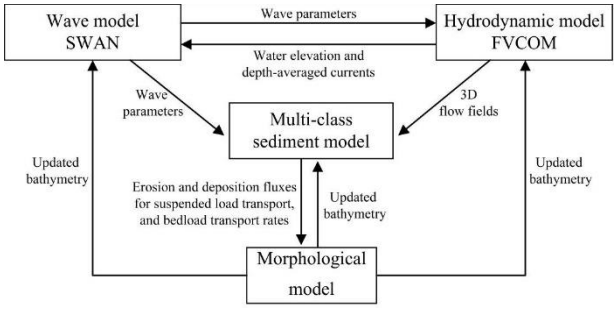

Figure1 - Model framework

MODEL VALIDATION

The model was validated through the simulations of shoreline changes around the breakwater under the coupled waves and currents (Sakashita et al., 2011). The waves at the open boundary was characterized by 0.04m significant wave height, 1.0 s period and wave angle of 20 deg. The median grain diameter of sand was 0.3 mm and the duration for the experiment was 10 hours.

Comparison of measured and simulated shoreline changes was shown in Figure 2. More complicated cases for beach profile and shoreline evolution were also investigated. The simulated results agree with the measurement satisfactorily.

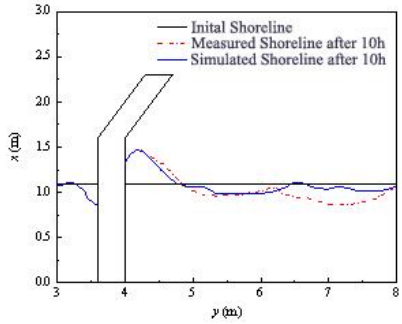

Figure 2 - Comparison between the measured and simulated shorelines in the lee of the breakwater

CONCLUSIONS

A three-dimensional model of nearshore sediment transport and morphological evolution has been developed in this study. The simulation results showed that the model could reasonably describe both the cross shore and longshore sediment transport and complicated beach evolution.

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