（様式２）

学位論文の概要及び要旨

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題　　目　Three-dimensional Morphodynamic Model with Wave-current Interaction
（波と流れの相互干渉を考慮した３次元海浜変形モデルに関する研究）

学位論文の概要及び要旨

An accurate prediction of waves and nearshore currents is a key role in solving coastal engineering problems, especially of those related to beach morphological evolution. Previously, some three dimensional morphodynamic models using a two dimensional depth-averaged model, and quasi three dimensional numerical model around coastal structures have been proposed (e.g. Nishimura et al., 1988; Kuroiwa et al., 2002). However, the model prediction was not accurate. Zyserman and Johnson (2002) used a quasi three-dimensional model, dealing with random waves, to simulate flow, sediment transport, and morphological evolution. Although the model produced reasonable-looking results of wave, current, and sediment transport, no validation was made due to lack of measurement data. In almost all previous studies, the nearshore waves and current fields were independently determined without considering the wave-current interaction. Therefore, in order to predict the morphodynamics around the coastal structures with better accuracy, three-dimensional morphodynamic model that considering the wave-current interaction is needed.

The research is conducted to develop a robust and reliable numerical model of nearshore waves, currents, and sediment transport which can be applied in coastal engineering projects. The model consists of four modules to simulate the hydrodynamics and the morphodynamics around coastal structures. In the wave module, the current effects on wave breaking and energy dissipation were taken into account as well as the wave diffraction effect. The surface roller associated with wave breaking is modeled based on a modification of the equations by Dally and Brown (1995) and Larson and Kraus (2002). For the nearshore current module, a new quasi-three dimensional numerical model of wave driven coastal currents was developed by accounting the effects of the wave-current interaction and the surface rollers. Furthermore, the quasi-three dimensional model, which based on Navier-Stokes equations, was modified in association with the surface roller effect, and solved using frictional step method. A new iterative feed back technique between the wave module and the nearshore current module was proposed to obtain the steady state condition of waves and currents computations, with considering the wave-current interaction.

In chapter 3, the applicability of the model was verified by comparing with experimental and field observations. Firstly, the obtained result of wave height and longshore current velocity during experiments on the Large Scale Sediment Transport Facility (LSTF) basin was used to validate the model. Secondly, field observations of significant wave heights, the cross-shore and longshore current velocities which conducted at Hazaki Oceanographical Research Station (HORS) were used to evaluate the predictive capability of the model. Then, the model was applied around Akasaki port to verify the hydrodynamics around coastal structures.

For the LSTF model verification, the computed results of the wave height distribution and longshore current, respectively, with and without the wave-current interaction and the surface roller effect were compared with the experimental results. The model was run until the steady state with the consideration of wave-current interaction was reached. The prediction of significant wave height was in a good agreement with the measurements when the wave-current interaction was considered. The computed results of longshore currents

with the effect of the surface roller was not only shifted the peak toward the shoreline, but also increased the maximum current magnitudes in the surf zone. From these results, it was found that, by considering the wave-current interaction and the surface roller, the computed wave height distribution and longshore current were in a good agreement with the experimental results. For the HORS model verification, comparisons between the computed results and measurements of the significant wave heights, the cross-shore and longshore current velocities were conducted. These comparisons showed that the computed results of wave heights give a good agreement with the measured data. The computed cross-shore current velocities and longshore current velocities also give reasonable agreement with the measured data. For the model verification around Akasaki port, good agreements between computations and measurements were obtained with regard to the wave heights, wave directions, and the vector of currents near the sea bottom.

In chapter 4, three benchmark cases were carried out to investigate the model performance and accuracy. Model tests against coastal structures such as detached breakwaters; submerged breakwaters; and groins were carried out to investigate the performance of the model around coastal structures. Comparisons between the computed results of the model test around detached breakwaters without and with considering the wave-current interaction were conducting. From these comparisons, it was found that the wave height distribution and the magnitude of the current velocities behind the detached breakwater when considering the wave-current interaction were different from those without considering the wave-current interaction. Also, the produced shoreline behind the detached breakwater when considering the wave-current interaction was different from those without considering the wave-current interaction. The model was run until the steady state was reached with the consideration of wave-current interaction. Similar comparisons were conducted on the rest of model tests (submerged breakwaters; and groins), and the obtained results gave an assurance to the results above. It was found that the wave-current interaction was significantly playing an important role in the prediction of the hydrodynamics and morphodynamics computation around coastal structures.

Finally, model applications to the morphodynamics around two submerged breakwaters at Uradome beach and Kunnui port in Hokkaido in Japan, and Rosetta promontory groins at the shoreline of Rosetta Promontory in Egypt were carried out in chapter 5 and chapter 6. The developed Q-3D model, which considering the wave-current interaction and surface roller effects, was able to provide more accurate input for the numerical model used to simulate the sediment transport and morphological evolution.