II-568 A NUMERICAL MODEL FOR LOCAL SCOUR AROUND A CYLINDER DUE TO WAVES AND CURRENTS

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Introduction

The prediction of bottom topography change around structures is essential in the design and construction of large scale coastal structures. The purpose of the present study is to investigate local topography variation under waves and currents. A numerical model is presented to predict topography change based on the calculation of wave-current field and formation of vortexes around structures. Generally, if wave length is large enough compared to diameter of a cylinder, vortex is formed but there is no wave deformation due to the effect of cylinder. If wave length is small enough compared to the diameter, no vortex is formed but wave is deformed due to the effect of cylinder. The present study is to consider these two effects, wave deformation and formation of vortexes at the same time because in wave-current condition, vortex is usually generated by currents.

Numerical Model

A new model is proposed for two-dimensional local scour on the basis of wave, current and vortex calculation around a cylinder. Figure 1 shows the total procedure of the calculation. The model consists of two submodels, wave model and vortex model. The wave model is based on the model of Saito et al. (1990). The wave field around the structure is computed by using the linear diffraction theory. Figure 2 shows the computed wave height distribution where wave height is 7.9 cm, wave period 0.94 s, and water depth 16.5 cm. The mass transport velocity at the bottom is calculated analytically by using the boundary layer theory from computed wave field. Figure 3 shows the calculated mass transport velocity at the edge of bottom boundary layer. The steady current, induced by gradient of radiation stress, is determined through numerical calculation using depth integrated conservation equations of mass and momentum for the fluid motion. The steady current field is shown in Fig. 4. The distribution of sand transport rates are estimated by using the computed wave velocity, mass transport velocity and steady currents and then the change of local bottom elevations are computed by solving the equation of sand mass conservation.

The vortex model is based on the model of Shibayama et al. (1986). There are two types of vortexes, Karman vortex and horseshoe vortex. These two vortex formations around the cylinder is modeled and sand transport rates are estimated for each phase in a wave period by using computed flow field. Then the change of local bottom elevations are computed by solving the equation of sand mass conservation. Figure 5 shows one example of computed flow field under vortex formation for a certain phase in a wave cycle. The computed results of bottom topography by wave model and vortex model are linearly superimposed. The result of the bottom topography is shown in Fig. 7 and is in good agreement with the experimental result shown in Fig. 6.

Conclusions

The numerical model presented here gives a good estimation of bottom topography change around structures. The advantage of the model is that the model can be applied to wave-current condition, for example in the surfzone, where we should consider wave deformation and vortex formation at the same time.

REFERENCES
SAITO, E., S. SATO and T. SHIBAYAMA (1990): Local Scour Around a Large Circular Cylinder Due to Wave Action, Proc. 22nd Coastal Eng. Conf., pp.1795 - 1804.
SHIBAYAMA, T.,SAKINADA, M. and TSUKAMOTO, Y. (1987): Local Scour Around Small Circular Cylinder Due to Wave and Current, Proc. of Coastal Engineering, JSCE, Vol. 34, pp. 407-410, 1987 (In Japanese).

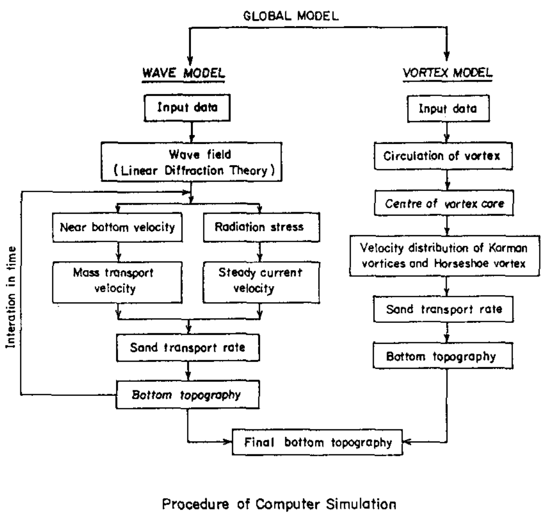

Fig.1: Procedure of computer simulation

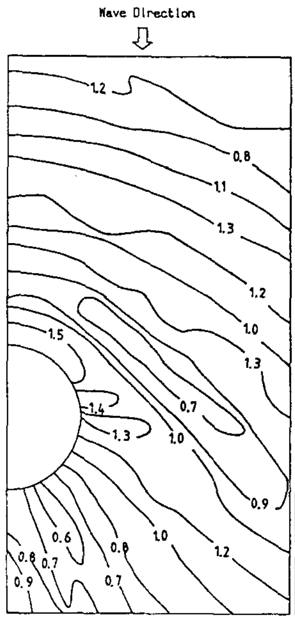

Fig.2: Computed wave height

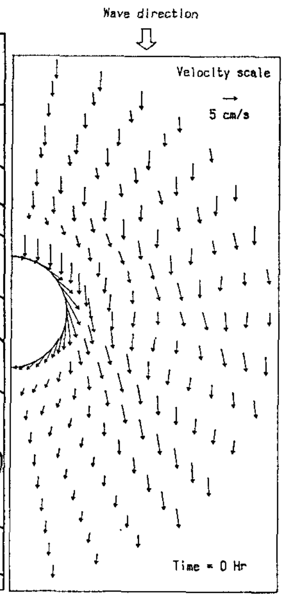

Fig.3: Distribution of mass transport velocity

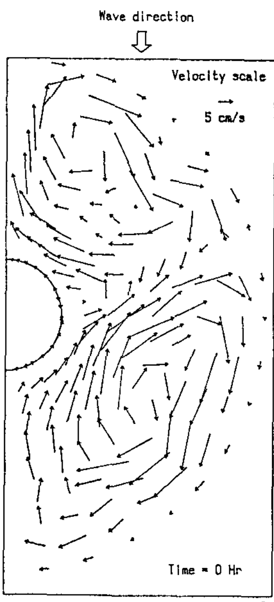

Fig.4: Distribution of steady current

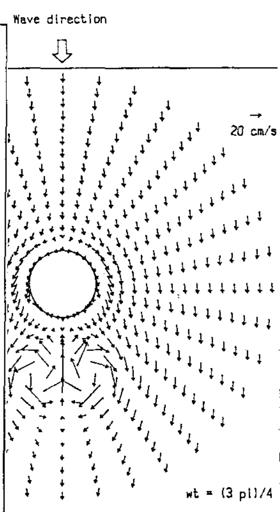

Fig.5: Flow field of vortex model

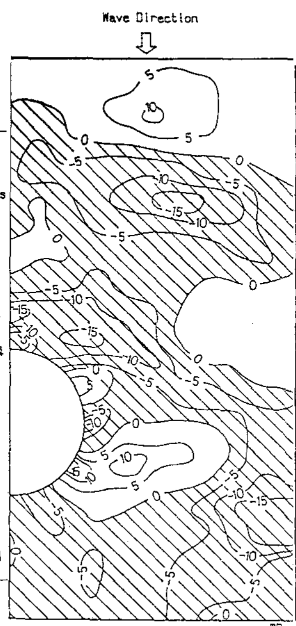

Fig.6: Measured bottom topography
(Saito et al., 1990)

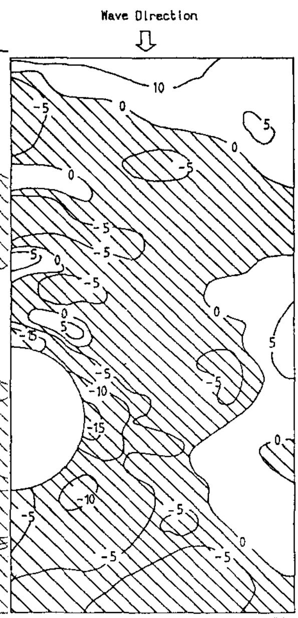

Fig.7: Computed bottom topography