Examination of Mangrove Modeling in Numerical Calculation

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INTRODUCTION

A number of studies which handle wave height attenuation effect due to coastal vegetation such as mangroves and coastal forests have been performed. In recent years, for considering effect of the mangrove roots, actual trees have been used for laboratory test. Chang (2019) proposed a formula for calculating C_D and C_M from Re and KC through experiments using a mangrove 3D model printed using actual tree. The C_D and C_M have been estimated experimentally under the condition that the water depth is relatively large and the waves don't break. However, the relationship between the Re number and the KC number and the C_D and C_M have not been investigated. Therefore, we conducted experiments focusing on the arrangement and density of the forest zone and trunk thickness. Then we demonstrated the validity of our analysis based on the comparison of our result and results of previous studies. The aim of this study is to establish a modeling method for coastal vegetation in order to enable calculation of the wave attenuation effect due to mangroves using numerical calculation.

METHOD

Firstly, laboratory experiments were conducted at the Chuo University in Japan. The dimensions of the cross-sectional wave tank are as follows: 36.0 m in length, 0.5 m in width, and 1.0 m in height. Two types of mangrove forest: the one with a staggered array and the one with regular array, were reproduced using cylinders with a diameter of 20 mm. In order to generate the high Re number in the vegetation area, the experimental conditions are determined as shown in Table-1.

Secondly, we conducted numerical calculation using CADMAS-SURF/3D-2F proposed by Arikawa (2009.) The basic equations are the Navier-Stokes equation and the continuity equation for a three-dimensional incompressible fluid. When the shape of water surface was changed due to breaking waves, the calculation result is strongly affected by the grid size and the difference scheme. In order to ensure the stability of the gas phase region and the accuracy of the liquid phase region, this model uses different scheme values depending on the region.

RESULT AND DISCUTSSON

The deformation characteristics of C_D value, C_M value, Re number, and KC number obtained from the numerical calculation results are shown (Fig.1.) The estimated average of C_D and C_M values obtained for each cylinder and the range of maximum and minimum values are plotted. When the Re number exceeds 2000, the C_D value becomes almost constant. Even if the C_D value doubled, its tendency was consistent with the empirical formula described in Kobayashi (1972.) In this study, there was no significant change in the C_D value even if the KC number was changed. Therefore, the C_D value is considered to be almost constant regardless of wave length. The change characteristics of the C_M value with respect to the KC number were consistent with the empirical formula by Chang (2019) with KC > 9.0.

CONCLUSION

Using 3D numerical simulation, the calculated C_D and C_M values were compared with the results obtained by some previous studies. As a result, it was confirmed that the tendencies obtained in this study were consistent with the previous studies. We also suggested that a fine grid size is necessary for simulating wave breaking using CS3D-2F. In addition, in order to consider the effect of vortices generated around the cylinder, it is necessary to conduct more detailed hydraulic experiments and numerical calculations.

Water Depth[m]	Periods(s)	Wave Height(cm)	Model
0.05	1.0	6	Without
0.10	1.5	9	Staggerd
0.15	2.0	12	Regular

Table 1 - Experimental Conditions

RFERENCES

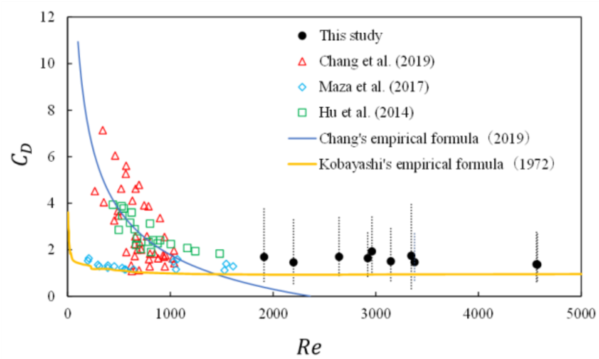

Figure 1 - Drag coefficient C_D vs. Reynolds number

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