A UNIFIED ANALATICAL SOLUTION FOR WAVE SCATTERING BY RECTANGULAR-SHAPED OBJECTS

Jie Hu, National University of Singapore, e0013640@u.nus.edu
Philip Li-Fan Liu, National University of Singapore, dprllfp@nus.edu.sg.

INTRODUCTION

This paper presents a general solution for wave scattering by stationary objects, which consist of a submerged rectangular plate and a floating rectangular dock (Figure 1). The objects can be either permeable or solid. The general solution is capable to cover all the existing single rectangular objects, such as a surface-piercing breakwater, a bottom-mounted submerge breakwater and a submerged plate. Furthermore, this general solution can also yield new analytical solutions for different combinations of objects, i.e. a single floating breakwater, and a combination of a floating and a bottom-mounted breakwater. Based on the general theory, a MATLAB computer program has been developed. It can be used to further explore different breakwater configurations with different properties.

METHODOLOGY

Within the framework of linear potential flow theory, the method of eigenfunction expansion is adopted to solve the wave scattering problem. Two auxiliary potentials are introduced in each flow regions to facilitate the eigenfunction expansions. It should be noted that a similar approach is first developed by Lee (1995) for wave scattering by submerged porous breakwater and then employed by Liu et al. (2012) and Liu and Li, (2013) for a submerged horizontal porous plate with finite thickness and by a surface-piercing permeable breakwater, respectively.

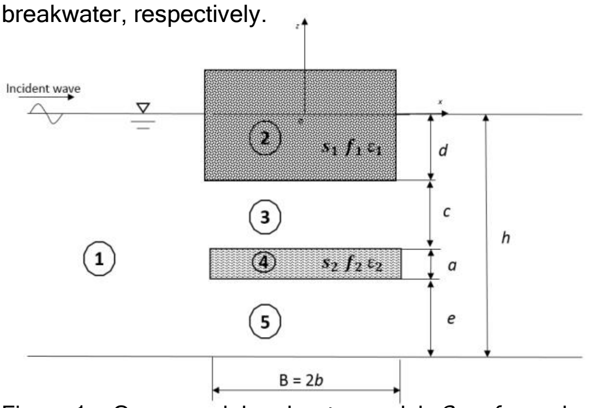

Figure 1 - General breakwater model: $\varepsilon_{1(2)}$, $f_{1(2)}$ and $s_{1(2)}$ are, respectively, the porosity, the linearized resistance coefficient and the inertial coefficient of the porous medium of region 2 and 4. The general model can be reduced to the suspended plate by replacing the breakwater of region 2 with pure water (i.e. ε_1=1, f_1=0, s_1=1). Furthermore, shrinking the gap width "e" to zero, this turns out to be the submerged rectangular breakwater case. Also, the general model can be reduced to the fully extended surface-piercing breakwater by shrinking both the gap widths "c" and "e" to zero. It is noted that by replacing the porous region 4 with pure water (i.e. ε_2=1, f_2=0, s_2=1), the general model turns out to be a floating stationary case. The breakwater becomes a solid when the porosity becomes zero ($s_{1(2)}$ = 0).

RESULTS

The general analytical solution form is very lengthy and will not be presented in this abstract. A numerical model based on the general solution has been developed and it has successfully reproduced the special cases such as, submerged breakwater, submerged suspended plate, fully extended surface-piercing breakwater. Moreover, it can yield analytical solutions for the floating breakwater, and a combination of a floating and bottom-mounted breakwater. The verification has been conducted based on the previous results of Lee and Liu (1995), Liu and Li, (2013) and Liu et al. (2012). In Figure 2, it is clear that the solutions for a single surface-piercing breakwater can be reproduced from the general model by shrinking both "c" and "e" to zero, and removing the permeable plate. The reflection (transmission) coefficient C_R (C_T) converges very well to the reference ones of Liu and Li, (2013). It should be mentioned that other special cases have been checked out but will not be presented here. We note that the solutions for a stationary floating breakwater are new. An extensive comparison between the present solutions and solutions in Rojanakamthorn et al. (1989) for a submerged permeable breakwater will also be presented at the conference.

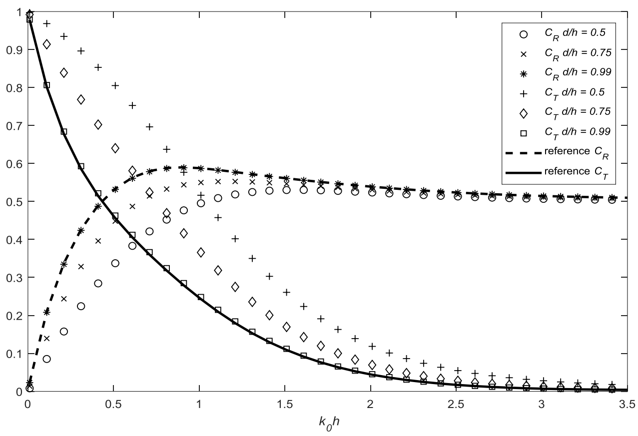

Figure 2 - Reflection (transmission) coefficient, C_R (C_T) versus relative water depth k_0h, for floating permeable breakwater with different draft. The physical parameters are B/h=1.0,ε_1=0.45, f_1=2.0, s_1=1.0, ε_2=1.0, f_2=0.0, s_2=1.0, c/h=a/h=e/h=(1-d/h)/3, d/h=(0.5, 0.75, 0.99). The dash/solid lines are C_R (C_T) from Fig. 4 of Liu and Li, (2013) for a fully extended surface-piercing permeable breakwater. The symbols (O, ×, *, +, ◊, □) represent the C_R(C_T) from the model with different dimensionless draft d/h.

REFERENCES

Lee, J.F., Liu, C.C., (1995). A new solution of waves passing a submerged porous structure. In: Proceedings of the 17th Ocean Engineering Conference, 593-606.
Liu, Y., Li, H.J., Li, Y.C., (2012). A new analytical solution for wave scattering by a submerged horizontal porous plate with finite thickness. Ocean Eng. 42, 83-92.
Liu, Y., Li, H.J., (2013). Wave reflection and transmission by porous breakwaters: A new analytical solution. Coastal Eng 78, 46-52.
Rojanakamthorn, S., Isobe, M., Watanabe, A., (1989). A mathematical model of wave transformation over a submerged breakwater. Coastal Eng 32(2), 209-234.