Oblique wave scattering by thick barrier with a backwall in deep water

S. Singh[1a] and R. B. Kaligatla[1a]
[a] Dept. of Mathematics and Computing, IIT (ISM) Dhanbad, India.

1. INTRODUCTION & OBJECTIVE

The considerable research interest has been driven toward the wave–structure interaction problems involving fixed or floating obstacles of various geometrical shapes for the past few decades. The problems of surface water wave scattering by an obstacle in the form of a thin vertical barrier, which is infinitely long in one horizontal direction, are well studied in the literature on linearized theory of water waves. For normally incident surface wave trains in deep water, these problems have the property that they can be solved explicitly by employing a number of mathematical techniques [Ursell (1947)]. When the obstacle is in the form of a thick barrier with rectangular cross section present in water of uniform finite depth, the corresponding water wave-scattering problems for normal incidence of a wave train have been investigated earlier by Mei and Black (1969). They considered surface-piercing and bottom-standing thick vertical barriers and used a variational formulation as the basis of numerical computations of the reflection and transmission. Bai (1975) studied the problem of oblique wave scattering by a surface-piercing long cylinder in finite depth water by employing finite element technique and presented graphically the numerical results for the reflection and transmission coefficients when the cylinder is of rectangular cross section. When the obstacle is in the form of a thick wall with a submerged narrow gap in finite depth water, Liu and Wu (1987) used the method of matched asymptotic expansion to obtain an approximate analytical expression for the transmission coefficient assuming the width of the wall to be of the same magnitude as the wavelength. However, their results are not valid if the gap is not narrow. It may be noted that a comprehensive review of wave reflection by uneven bottom has been presented in the book of Dingemans (1997). Recently, Das et al. (2020) analyzed derived scattering coefficients explicitly for oblique wave interaction with a surface-protruding and a fully submerged rectangular beam in the water of infinite depth. This breakwater enhanced wave reflection and reduces wave transmission.

In the present problem, we investigated oblique wave scattering by the thick horizontal barrier with a backwall floating in the water of infinite depth, with potential function formulation and under the assumption of small wave steepness. The objective of the present study is to estimate the scattering characteristics of thick barrier with a backwall.

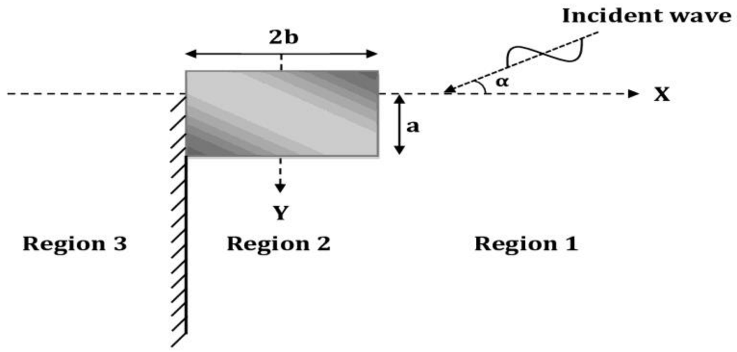

Figure 1: Schematic of thick horizontal barrier with a thin backwall in the water of infinite depth.

2. OUTLINE OF THE SOLUTION METHOD

In the present manuscript, Under the assumption of linearized theory of water waves, a train of progressive surface water waves is obliquely incident on a thick horizontal barrier with a backwall. The velocity potentials satisfy the Helmholtz equation. The barrier in Fig. 1 is used to simplify the associated mixed boundary value problem. The potential functions within the region of the barrier and outside of it are expressed by Havelock's expansions [Ursell (1947)]. An integral equation is derived by using the continuity of fluid velocity and pressure at the interface. Its solution is obtained numerically by applying the collocation method. The scattering coefficient are derived explicitly with the forcing terms of the integral equation. Further, the wave scattering coefficient on the breakwater are analyzed for different wave and breakwater parameters.

3. RESULTS & HIGHLIGHTS OF IMPOINTANT POINTS

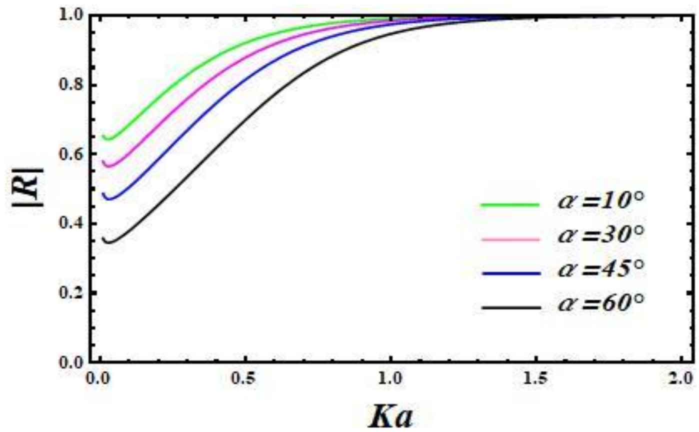

Figure 2: Variation of reflection coefficient |R| versus wavenumber Ka for different angle of incidence α when b/a=0.1.

Figure 2 illustrates wave reflection coefficient |R| and against wavenumber Ka for different angle of incidence α. Results reveal that wave reflection is enhanced by the attached backwall to the thick horizontal barrier. Moreover, reflection is high for small angle of incidence. Thus, the attached backwall is beneficial for the increase in wave reflection.

REFERENCES

1. Mei, C. C., and Black, J. L., 1969, ‘‘Scattering of Surface Waves by Rectangular Obstacles in Waters of Finite Depth,’’ J. Fluid Mech., 38, pp. 499–511
2. Bai, K. J., 1975, ‘‘Diffraction of Oblique Waves by an Infinite Cylinder,’’ J. Fluid Mech., 68, pp. 513–535.
3. Liu, P. L.-F., and Wu, T., 1987, ‘‘Wave Transmission Through Submerged Apertures,’’ J. Wtry., Port, Coastal Ocean Engng., 113, pp. 660–671.
4. Dingemans, M. W., 1997, ‘‘Water Wave Propagation over Uneven Bottoms,’’ Adv. Series on Ocean Eng., 13, World Scientific, pp. 138–141
5. Das, B. C., De, S., Mandal, B. N., 2020, “Oblique water waves scattering by a thick barrier with rectangular cross section in deep water,” Journal of Engineering Mathematics, 122, pp. 81-99.
6. Ursell, F., 1947, ‘‘The Effect of a Fixed Vertical Barrier on Surface Waves in Deep Water,’’ Proc. Camb. Phil. Soc., 43, pp. 374–382