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A Floating Pontoon Breakwater with a Wave-Wall

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ABSTRACT

The wave attenuation properties of a long, floating pontoon breakwater of rectangular section with a vertical wave-wall on the front face are investigated theoretically. The structure is partially restrained by vertical piles and can respond only in heave-to-wave excitation. The fluid motion is idealized as 2-dimensional, linearized potential flow, and the solution for the fluid motion is obtained by the boundary integral equation method using an appropriate Green's function. Numerical results are presented to illustrate the effects of the various wave and structural parameters on the efficiency of the breakwater as a barrier to wave action. It is found that the wave reflection properties of the structure depend strongly on the draft of the wave-wall and that, by varying the wall draft and the pontoon draft and width, acceptable wave attenuation can be achieved over a range of wave conditions. The practical efficiency of this kind of wave barrier is then demonstrated by considering a typical prototype pontoon wave-wall system and studying its behavior in a random wave environment.

INTRODUCTION

Floating breakwaters offer an alternative to conventional fixed breakwaters and may be preferred in relatively low wave energy environments, or where water depth or foundation considerations preclude the use of a bottom-founded structure. Further, in certain applications, aesthetic or water circulation considerations may require that the breakwater not pierce the free surface and/or extend down to the seabed. This paper studies the behavior of a long, floating pontoon breakwater of rectangular section with a vertical wave-wall on the front face.

Several investigators have been studying various aspects of the 2-dimensional problem of wave interaction with long, submerged, bottom-founded or floating, surface-piercing structures of rectangular cross-section. Both the diffraction (waves incident on fixed structure) and radiation (structure oscillating in otherwise calm fluid) problems have been treated. Mei and Black (1969) and Black et al. (1971) have presented a variational formulation approach for rectangular bodies either on the free surface or on the seabed. For bottom-founded rectangular bodies, approximate solutions for long waves have been developed by Ogilvie (1960); for long obstacles, by Newman (1965); and for low-draft structures, by Mei (1967). Drimer et al. (1991) presented a simplified approach for a floating breakwater where the breakwater width and incident wavelength are taken to be much larger than the gap between the breakwater and the seabed. Mullarkey et al. (1992) utilized an eigenfunction expansion approach to calculate the hydrodynamic coefficients for rectangular TLP pontoons. Naftgzer and Chakrabarti (1979) and Anderson and Wuzhou (1985) presented an integral equation formulation for the calculation of hydrodynamic coefficients for long, horizontal cylinders of arbitrary section. McIver (1986) investigated hydrodynamic interference effects between a pair of semi-immersed bodies of rectangular section using both the method of matched eigenfunction expansions and a wide spacing approximation. Williams and Abul-Azm (1997) analyzed the behavior of a dual floating pontoon breakwater, consisting of a pair of pontoons of rectangular section connected by a rigid deck, based on a boundary element approach. Recently, Williams et al. (2000) utilized the same technique to study the wave attenuation properties of a pair of independently moored floating pontoon breakwaters deployed in series.

In this paper, a boundary element technique is utilized to carry out the hydrodynamic analysis of a floating pontoon breakwater of rectangular section with a vertical wave-wall attached to its front face. The structure is restrained and may respond only in heave-to-wave excitation. The fluid motion is idealized as linearized, 2-dimensional potential flow. The fluid domain is divided into 2 regions, and the boundary integral equation method is applied on each domain using an appropriate Green's function. The integration contours are discretized into small elements, and the fluid velocity potential and its normal derivative are assumed to vary linearly in each. The resulting discrete algebraic systems are then solved simultaneously by standard matrix techniques. Numerical results are presented that illustrate the effects of the various wave and structural parameters on the efficiency of the breakwater as a barrier to wave action. It is found that the wave reflection properties of the structure depend strongly on the draft of the wave-wall, and that, by varying the wall draft and the pontoon draft and width, acceptable wave attenuation can be achieved over a range of wave conditions. The practical efficiency of this kind of wave barrier is then demonstrated by considering a typical prototype pontoon wave-wall system and studying its behavior in a random wave environment.

THEORETICAL DEVELOPMENT

The geometry of the problem is shown in Fig. 1. The system is idealized as 2-dimensional, Cartesian coordinates are

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