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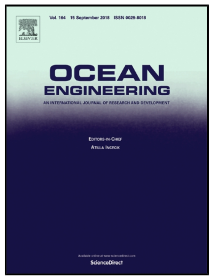

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Wave Diffraction by Vertical Cylinder with Multiple Concentric Perforated Walls

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Abstract: Multiple concentric perforated cylindrical walls are newly suggested for the protection of both the internal cylinder and themselves. The porosity parameter is introduced to measure the ability of the perforated wall in dissipating the energy when the fluid passes through it. The 3-dimension linear potential theory based upon the eigenfunction matching method considering the nonlinear boundary conditions is used for the hydrodynamic analysis of the structures. The wave forces on the inner cylinder and protective walls are calculated considering various porosity parameters and radius ratios. The wave elevations at the free surface in the fluid domain for a considered parameter proportion and radius ratio with various numbers of porous walls are further examined. The numerical results are vividly depicted and show that the wave loads on the inner cylinder can be highly reduced by setting one or more porous walls externally. When there is only one perforated wall, whether it is fully or partially perforated at the upper part has little influence in reducing the wave loads on the inner cylinder. In this case, the frequencies where the wave excitation forces approach zero on the outer wall and approach maximum on the inner cylinder are explained by introducing the sloshing problem and further confirmed by the analytical formulas. More numbers of protective walls can better balance the wave elevations and excitation forces on themselves by adjusting the porosity parameter proportions and radius ratios of them.

Key words: Multiple permeable walls, Porosity parameter, Radius ratio, Eigenfunction, Sloshing problem

1. Introduction

Perforated breakwater has been applied to the reduction of the wave excitation forces on the protected structure and also have been usually port and coastal engineering structures for their significant effect on defensing the waves, maintaining the waters in harbor smooth, protecting the engineering buildings and ensuring the safety of ships' entering and leaving, berthing, loading and unloading. In addition, they can also prevent floating chunks of ice and enhance the water quality with minimum environmental impact by allowing water circulation. One famous example of permeable breakwater being applied is the gravity offshore structure Ekofisk (see Fig.1) located in the North Sea 1973. Owing to its scientific and engineering significance, wave interaction with porous structures such as porous plates, slotted walls and perforated wall caisson type breakwaters has attracted considerable attentions of many research scholars.

Fig.1 Ekofisk gravity structure (Courtesy ConocoPhillips).

Fig.2 The perforated breakwater with five perforated walls built for Dalian chemical production terminal, China.

The pioneer work on the porous medium was described by the Darcy's law (Darcy, 1856) and further modified by Sollitt and Cross (1972). They proposed the matches boundary conditions of water passing through the perforated walls