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The Irregular Wave Induced Seepage Force on the Bottom of a Circular Cylinder

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ABSTRACT

This paper presents the study of the irregular wave induced seepage force on the bottom of a circular cylinder resting on the seabed. The seabed is assumed to be a porous elastic medium, and the seepage flow in it is assumed to be Darcy's flow. The Transfer Function Method is used to calculate the irregular wave induced seepage force and moment spectrum in the frequency domain. Model tests were made in a wave flume. The experimental results show that the theoretical considerations presented here are acceptable.

INTRODUCTION

The action of the wave induced seepage flow in the seabed on structures resting on the seabed has been studied by many researchers in recent years. For the case of a circular cylinder resting on a rigid permeable seabed, the problem of wave induced seepage flow in the seabed was solved by Durand and Monkmeyer (1980). In general, the soil seabed is deformable, so the assumption of a rigid seabed is not acceptable in the case of most real projects. For a deformable permeable seabed, if we assume: (1) the wave induced seepage flow is relatively slow and can be assumed to be Darcy's flow; (2) the deformation of the seabed is relatively small and thus the seabed can be assumed to be a porous elastic body. Then Biot's equation can be considered the governing equation of this problem. Mynett and Mei (1982), Mei and Foda (1981) and Liu (1985) solved this problem for the 2D wave induced seepage flow in a deformable porous seabed. Kokkinowrachos and Asorakos (1985) suggested a method: They decoupled the displacement vectors and the pore pressure in Biot's equation and obtained a differential equation in the form of Poisson's equation with only pore pressure as its variable. By using this method, Qiu and Sun (1988) solved the 3D wave induced seepage flow in a deformable porous seabed for the case of a circular cylinder resting on it. The results show that the uplifting wave induced seepage force and moment acting on the bottom of the structures are important in calculating the wave loading on structures. All of these previously mentioned solutions are only available for the case of regular waves. In real seas, the study of the irregular wave induced seepage flow in the seabed and its action on structures is important.

In this paper, the irregular wave model suggested by Longuet-Higgins is used. The irregular wave is assumed to be composed of many linear cosine waves with stochastic initial phase angles. Thus, for each component wave, the results of the study on regular wave induced seepage flow can be used. Based on this assumption, taking the irregular wave as an input, the irregular wave induced seepage flow problem can be solved in the frequency domain by using the Transfer Function Method, and the uplifting irregular wave induced seepage force and moment for any cumulative probability can be obtained. In order to verify the theoretical results, model tests were made in the State Key Laboratory of Coastal and Offshore Engineering at Dalian University of Technology.

THEORETICAL CONSIDERATION

The sketch of the coordinate system is shown in Fig. 1. Under regular wave action, the governing equation of the wave induced pore pressure in the seabed is:

$$\nabla^2 p = C_s \frac{\partial p}{\partial t}$$

in which p is the wave induced seepage pore pressure in the seabed; C_s is the combined characteristic parameter of the seabed, which is determined by the physical and mechanical properties of the soil and can be calculated by the formula,

$$C_s = \frac{\rho g}{k_s}\left(\frac{\xi}{K} + \frac{1}{G}\cdot\frac{1-2\nu}{2-2\nu}\right);$$

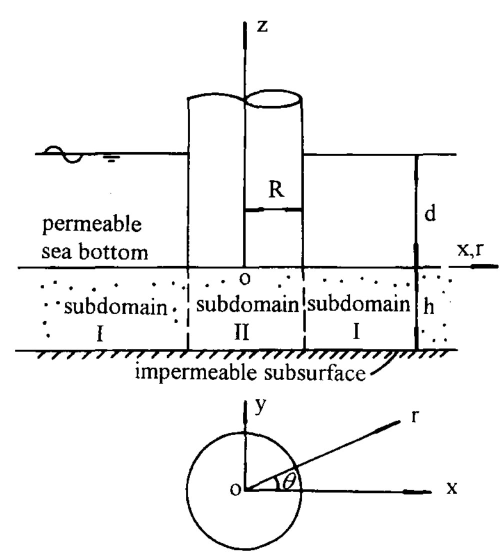

Fig. 1 Sketch of coordinate system

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