

A Theoretical Study on the Effect of Seaquakes on a Three-Dimensional Floating Body

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ABSTRACT

Seaquake forces acting on a three-dimensional floating body are studied numerically. Green function which satisfies the Helmholtz equation and fulfills the free surface condition and the sea bottom boundary condition is introduced. The solution of the seismic wave field and pressure distribution are obtained by making use of the boundary integral equation method and the seaquake forces are also obtained numerically. In order to understand the properties of the effect of seaquake forces acting on the three-dimensional floating structure from a view point of the structure safety, some typical calculations are carried out systematically.

Keywords : seaquake forces, Green function, three-dimensional floating structure, BIEM

1. INTRODUCTION

A very strong earthquake suddenly shook Kobe city in 1995. The damage caused by the earthquake was beyond our expectations, even though we experience frequent earthquakes in Japan. Seizing the occasion, we are turning our eyes to the vast spaciousness of the ocean. That is to say, the conception where main facilities, e.g. air-port, power plant etc., are made on marine structures for the sake of aseismatic design, is attracting our attention.

Marine structures had been generally considered to be aseismatic design. However, the effects of vertical motion of the sea-bed due to an earthquake may not be small, so that it is considered that a so-called seaquake, which is caused by propagation of seismic motion of the sea-bed through seawater, affects a floating structure. There are some reports about the damage due to seaquakes (Sato, 1978).

There have been a lot of studies about the sea load due to water waves, wind and current, but there hasn't been many studies concerning the effect of seaquakes (Hagiwara, 1986; Baba, 1987; Baba, 1988; Kiyokawa, 1989), even though seaquake forces acting on the floating structure should not be ignored. The ef-

fect of seaquakes on a floating structure may be one of the items to be taken into further consideration from a view point of the structure safety.

The author made clear in the previous reports (Higo et al., 1996; Higo et al., 1997a) that there are resonances corresponding to the eigen-value of the boundary problem on the seaquake forces and the effect of the compressibility of fluid cannot be ignored in the vicinity of these resonant frequencies, and it was also made clear the effects of marine sediment on seaquake forces (Higo, 1997b). However, all of these were treated as a two-dimensional problem.

Though Kiyokawa (1997) has studied the three-dimensional seaquake phenomenon, there was no floating body in the field. As mentioned before, the resonances between free-surface, rigid sea bottom and floating body is important on the seaquake forces, so that the interaction of the floating body should not be ignored.

The main aim of this paper is to develop the reasonable numerical calculation method of three-dimensional seismic wave propagation in seawater which is bounded by the free-surface, floating body and the rigid sea bottom.

First of all, the three-dimensional Green function which is a solution of differential equation governing the seismic wave propagation and fulfills free surface condition and the sea bottom surface condition is introduced. Secondly, the boundary integral equation by making use of the Green function and Green's theorem is also introduced. Finally, the pressure distribution and the seaquake forces on a floating structure by solving the integral equation are calculated. And then the effect of a three-dimensional floating structure on seaquakes is discussed.

2. PROBLEM FORMULATION

I make the assumption that the fluid is inviscid, irrotational and compressible. Let us suppose that a homogeneous medium is bounded by the free surface $z = 0$ and by the rigid sea bottom $z = h$ as in Fig.1. Furthermore, I make the assumption that one part of the sea bottom is oscillating vertically and harmonically due to the P-wave of earthquakes, and there is a rigid floating body having a length L_f , breadth B_f and a draft d , right over the epicenter. The seismic waves propagate in seawater, and these effect the floating body. The case of the perfectly rigid sea bottom will be considered.