A Reflection Wave Attenuator by Using Wave Slamming Phenomena

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ABSTRACT

In coastal and harbor developments, constructions of vertical sea walls and breakwaters in the sea are often necessary to make a calm water region. Subsidiary effects of such a construction on the neighboring coastal and ocean environment would be a concern because of high reflection waves from the site.

In order to reduce such high reflection waves effectively, a structure consisting of a bundle of horizontal cylinders placed near the water surface is proposed as a reflection wave attenuator. The wave energy dissipation mechanism presumed in this study is a wave slamming phenomenon to a bundle of cylindrical members placed near the water surface. Firstly, to confirm the validity of the wave energy dissipation mechanism during the wave slamming, a wave tank test was carried out for fixed model structures consisting of a bundle of horizontal circular cylinders. Analytical modeling of the energy dissipation is also proposed by considering the slamming forces on a bundle of cylindrical members fixed near the water surface. Secondly, aiming a practical use of the reflection wave attenuator, a floating-type attenuator is further proposed. Model tests have shown that the floating attenuator is effective for reducing the reflected waves, especially for comparatively short waves. It was recommended that the floating attenuator should be placed near the anti node position of standing waves for a specially chosen wave.

KEY WORDS: Reflection wave attenuator, energy dissipation, wave slamming, floating-type attenuator, bundle of cylindrical members

INTRODUCTION

In coastal and harbor developments, a construction of vertical sea walls and breakwaters in the sea is often necessary to make a calm water region. Such a construction may sometimes cause beach deformations on the neighboring coast and higher wave climates than before around the construction site due to high reflection waves from the sea wall.

It is usually required to reduce such high reflection waves to preserve the environment around the construction site. In this study, a structure consisting of a bundle of horizontal cylinders placed near the water surface is proposed as a reflection wave attenuator. The wave energy dissipation mechanism presumed in this study is a wave slamming phenomenon to a bundle of cylindrical members placed near the water surface.

Kaplan and Silbert (1976) developed a solution for the wave slamming forces acting on a cylinder fixed near the water surface. It has become known that the wave slamming forces can be expressed by the similar equation to the fluid drag force that is proportional to the square of a fluid velocity. In the previous studies (e.g., Sarpkaya & Isaacsous 1981), the major interests are only the magnitude of impulsive forces acting on a cylindrical member during the slamming impact.

It is easily estimated that the work done by the wave motion to a bundle of cylinders near the water surface may be accounted as a part of the wave energy loss because of the nature of the slamming forces. This study examines such a dissipation mechanism to develop more effective wave attenuators. Moreover, a practical wave attenuator is also proposed by accounting the energy dissipation mechanism of the wave slamming.

Nakamura and Onozuka (1985) carried out a series of experiments on wave reflections and transmissions about a permeable breakwater consisting of concrete blocks, such as Tetrapods. They pointed out that a wave slamming phenomenon in the permeable breakwater consisting of comparatively large units, such as Tetrapods and other concrete blocks, is one of the major causes to dissipate the incident wave energy. They also reported that the wave reflection from the breakwater is effectively reduced by wave slamming to the units near the water surface inside the breakwater.

In this study, firstly, to confirm the validity of the wave energy dissipation mechanism due to wave slamming, a wave tank test using a bundle of horizontal circular cylinders placed rigidly near the water surface is carried out. In the experiments, for attenuating reflection waves from a vertical wall, the model structure is set in front of the vertical wall. Analytical modeling of the energy dissipation process is also proposed by considering wave slamming forces on a bundle of cylindrical members. In the analysis, slamming coefficients of a bundle of circular cylinders for various allocations are clarified theoretically. To check the validity of the analytical modeling, measured wave transformation characteristics, such as reflection coefficients and energy dissipation rates, are compared with the theoretically predicted results. Secondly, aiming a practical use of the reflection wave attenuator, a floating-type attenuator is further proposed. Here, the model structure is similar to the fixed attenuator examined in the early study except that the model is floating and moored by chain lines. Effective locations of a floating attenuator from a vertical sea wall are mainly examined in relation to the wave length corresponding to a resonance frequency of the heave mode response.

WAVE ENERGY DISSIPATIONS BY WAVE SLAMMING PHENOMENA