Generation of Arbitrary Wave Field in Arbitrary Configured Wave Basin Composed by Element Absorbing Wave-makers

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ABSTRACT
The mathematical formula deriving the motion of element absorbing wave-makers closely installed on the circumference of an arbitrary configured wave basin is proposed with the aim of generating an arbitrary wave field in this basin. Through the asymptotic expansion of the Hankel function for large arguments, this formula is obtained. As numerical and experimental results of wave height of the long-crested regular wave obtained in the elliptic basin and the square basin, the proposed mathematical formula has been clarified to be able to provide long-crested regular wave field at the more distance of single wave length from wave-makers at least.

KEY WORDS: AMOEBA; element absorbing wave-maker; addition theorem; Fourier-Bessel series expansion; asymptotic expansion; Bessel function; Hankel function.

INTRODUCTION
Authors have been studied to generate an arbitrary wave field in a circular wave basin having the element absorbing wave-makers on the circumference of a basin. The element absorbing wave-maker is mathematically expressed as a periodical wave source put on a water surface represented by $H^0_{(1)}$; the 0th order Hankel function of the first kind given by a first order solution of the Laplace’s equation. Naito et al. (1994, 1998, 2006) have expressed this wave source by an element wave-maker. Furthermore, they have proposed an element absorbing wave-maker which can generate divergent waves and absorb incident waves at the same time. This wave absorption is based on the theory by Miligram (1970), Falnes (1978), Bessho (1980) and Salter (1981). Based on the concept of the element absorbing wave-maker, Naito et al. (1999) have developed AMOEBA: Advanced Multiple Organized Elemental Basin consisting of fifty units of element absorbing wave-makers as shown in Fig. 1. This photograph shows a letter S appearing on the water surface in the AMOEBA. This letter is written by many focused wave on the path of the letter. It is confirmed by experiments that the reflected waves on the wave-maker does not stand in the AMOEBA. According to the linear theory, an arbitrary wave field is described by the superposition of waves generated by element absorbing wave-makers.

The theory of arbitrary wave generation is usually based on the superposition of long-crested waves propagating forward. The long-crested waves is usually generated by the snake motion of element (segmented) wave-makers put on a rectangular basin (Madsen 1974, Ishida et al. 1984, Takezawa et al. 1992). However, this theory is not suitable for the basin filled by element absorbing wave-makers.

A theory of generating wave field composed of the Bessel function in the polar coordinates system has been proposed by Minoura et al. (2009). This theory enabled to generate an arbitrary wave field more accurately in the wider area of a wave basin. In this paper, the theory is developed for an arbitrary configured wave basin. The developed theory is verified experimentally and numerically by an elliptic wave basin and a square wave basin.

Arbitrary wave field can be expressed by superposing of Bessel functions with the Fourier-Bessel series expansion. According to the addition theorem, a Bessel function of which origin lies on the center of a circle is described by superposing of the Hankel...