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Generation of Arbitrary Wave Field in Arbitrarily Configured Wave Basin Composed of Element-absorbing Wavemakers

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The mathematical formula for deriving the motion of element-absorbing wavemakers closely installed on the circumference of an arbitrarily configured wave basin is proposed, with the aim of generating an arbitrary wave field in this basin. This formula was obtained through the asymptotic expansion of the Hankel function for large arguments. Numerical and experimental results of wave heights of long-crested regular waves obtained in the elliptic basin have clarified that the proposed mathematical formula can provide a long-crested regular wave field at a distance longer than at least a single wavelength from the wavemakers.

INTRODUCTION

Authors have studied the generation of an arbitrary wave field in a circular wave basin with element-absorbing wavemakers on the circumference. An element-absorbing wavemaker is mathematically expressed as a periodical wave source placed on a water surface represented by $H_0^{(1)}$, the 0th-order Hankel function of the first kind given by a 1st-order solution of Laplace's equation. Naito et al. (1994, 1998, 2006) have expressed this wave source by an element wavemaker. Further, they proposed an element-absorbing wavemaker that could generate divergent waves and absorb incident waves at the same time. This wave absorption is based on the theory by Milgram (1970), Falnes (1978), Bessho (1980) and Salter (1981). Based on the concept of the element-absorbing wavemaker, Naito et al. (1999) have developed the *Advanced Multiple Organized Elemental BAsin* (*AMOEBA*), consisting of 50 element-absorbing wavemakers, 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 waves on the path of the letter. It was confirmed by experiments in the *AMOEBA* that the waves reflected on the wavemaker do not stand. According to linear theory, an arbitrary wave field is described by the superposition of waves generated by element-absorbing wavemakers.

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

A theory of generating a wave field composed of the Bessel function in the polar coordinates system has been proposed by Minoura et al. (2009). With this theory, generation of an arbitrary wave field in the wider area of a wave basin can be more accurate. In this paper, the theory for an arbitrarily configured wave basin is developed. The developed theory is verified experimentally and numerically using an elliptical and square wave basin.

An arbitrary wave field can be expressed by superposition of Bessel functions with the Fourier-Bessel series expansion. According to the addition theorem, a Bessel function with the origin at the center of a circle is described by superposing Hankel functions whose origins lie on the circumference of a circle. Applying the orthogonality of the Fourier function, we can obtain the reverse relationship, meaning that the Hankel function lying on the circumference of a circle is described by superposition of the Bessel functions lying at the center of a circle. Because the Hankel function represents a ring wave generated by an element wavemaker, the motion of each wavemaker to generate an arbitrary wave field is identified.

In the case of a circular basin, the Fourier function is applied as an orthogonal function. For elliptic and square wave basins, different orthogonal functions may be required. These functions

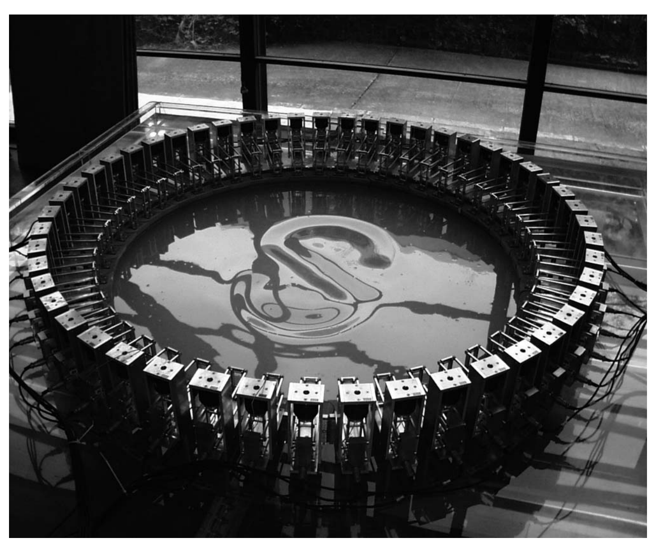

Fig. 1 Photograph of *AMOEBA*

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KEY WORDS: *AMOEBA*, element-absorbing wavemaker, addition theorem, Fourier-Bessel series expansion, asymptotic expansion, Bessel function, Hankel function.