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Wave Generation and Absorption in Wave Basins: Theory and Application

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Experimental research remains important for evaluating the performance of offshore structures and ships in waves. To conduct useful experiments, it would be advantageous to first develop a high-performance absorbing wave-maker that can generate both regular and irregular waves. The construction of such a wave-maker is investigated in this study via wave-maker theory and wave-absorbing theory. Concerns have been raised recently regarding the configuration of wave basins, because researchers are doubtful as to whether the commonly used configuration of a rectangular wave tank is a suitable geometry within which to conduct experiments.

This review paper presents a summary of the theory of wave generation and wave absorption in wave basins, as well as a new experimental concept and results of investigations based on the above theories.

Due to space constraints, a pneumatic-type wave-maker is not reviewed here. For this type of wave-maker, a completely different approach is required. And nonlinear problem-related wave generation and absorption are also not reviewed. Those important subjects will be reviewed at some other time.

INTRODUCTION

There are many towing tanks throughout the world, almost all of them rectangular in geometry. A rectangular configuration became popular because Dr. W. Froude first carried out a resistance test in still water within a rectangular towing tank. With increased demand for information on the performance of ships in waves, wave-makers have gradually become standard equipment in the terminals of towing tanks. A tank equipped with a wave-maker is called a wave-making basin (or wave-making tank) from the perspective of seakeeping and ocean engineering research groups. In terms of results, experiments that focus on head waves and/or following waves can be conducted effectively using a wave-making basin.

To assess the economic, safety and reliability aspects of ships more accurately, it is important to evaluate their performance when subjected to directional waves. Naturally, the scope of experiments using wave-making basins has expanded over time to consider the performance of ships in real-sea conditions. To estimate such conditions, the rectangular basin must be widened and equipped with wave-makers on 2 sides. While the ultimate suitability of rectangular wave-making basins is unknown, this shape creates problems in simulating real-sea conditions because of the problem of reflected waves from the basin sides. To simulate the real sea within the basin, it is first necessary to investigate not only the absorption of waves, but also the optimum configuration of the wave-making basin.

Ordinarily, there are 2 methods of absorbing waves within the basin: by a Beach, and by a body with an external dynamic system (Milgram, 1970; Bessho, 1980; and Kyozuka, 1985). Because a beach is a passive absorber, it cannot absorb waves perfectly. As the external dynamic system is an active absorber, it is possible to perfectly absorb regular waves by tuning the external dynamic system over a wide range of frequencies. By extension of this theory, it is possible to completely absorb irregular waves theoretically. But this system lacks causality (Naito and Nakamura, 1985). This is an annoying problem. Equipment that possesses both the functions of wave generation and absorption has already been developed, thus providing the means of simultaneously generating and absorbing waves.

The history of wave-making basins equipped with absorbing wave-makers is a brief one. On an absorbing wave-maker, Dr. Salter's contribution is significant. The development of wave basins has advanced with the development of control theory and control devices. Researchers seek to realize an ocean wave-field within a restricted water area such as an experimental wave basin (Salter, 1981; Takezawa, 1992). For this purpose, workers have investigated an absorbing wave-maker that can simultaneously generate and absorb waves. Recently, basins equipped with absorbing wave-makers have become increasingly popular. As a result, high-quality data have been presented in international journals and at conferences. The results of experiments conducted using these basins are largely in agreement with the results of theoretical calculations, with some exceptions. Considering the state of research in this field, I propose that it is possible to carry out experiments using a smaller wave basin than the usual design, and that it is not always necessary for the configuration of the basin to be rectangular. A circular basin may well provide a superior performance to that of a rectangular basin. There are few studies that address the problem of wave-basin geometry from this perspective. A brief historical review of the development of experimental basin design is shown in Fig. 1.

For naval architecture and ocean engineering, there are 4 main experimental fields: the propulsive and resistance test; maneuverability test; seakeeping test; and ocean engineering test.

Each test should be carried out within a suitably configured basin. For seakeeping tests, it is necessary to use a basin that can simulate a ship with forward speed in waves. In contrast, ocean engineering tests generally do not require forward speed, so even

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