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Characteristics of Wave Forces on Vertical Cylinder Due to Two-Crossing Waves

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ABSTRACT

A series of experiments was carried out in an indoor wave basin in order to investigate characteristics of wave forces acting on a small-diameter vertical circular cylinder in a wave field comprised of two primary regular waves crossing at an arbitrary angle. In particular, the effects of wave direction and wave irregularity in relation to the Keulegan-Carpenter number (KC), the horizontal orbit of the water particle motion and the wave crossing angle are discussed. The ratio of the minor to major axis length in the wave force vector increases as that of the water particle velocity and KC increase. As the horizontal orbit of the water particle motion comes closer to a circle, the drag coefficient increases and the inertia coefficient decreases. In addition, it is also shown that the wave force coefficients near the highest wave are almost equal to the mean values of the wave force coefficients for all individual waves.

INTRODUCTION

Since Morison et al. (1950) first decomposed the wave force acting on a small-diameter circular cylinder into the drag and inertia forces, many excellent studies have been performed on the wave forces acting on the cylinders, based on laboratory experiments using regular waves. Several investigations in recent years have dealt with the wave forces acting on the circular cylinder even in multidirectional random wave fields (Borgman and Yfantis, 1981; Isaacson and Nwogu, 1988; Suzuki et al., 1994; Hiraishi et al., 1994), because sea waves in nature are generally multidirectional and random. She and Easson (1991) discussed the wave force on a circular cylinder in a two-crossing wave that is composed of two identical regular wave trains crossing each other. Regarding the force coefficients, although Koterayama et al. (1995) discussed their time histories in unidirectional random waves, the influences of directionality and nonlinearity of waves on the wave forces and force coefficients have not been sufficiently clarified as yet. For lack of data, the wave forces on a cylinder in the crossing wave field composed of two or more free waves are very little known.

In this study, a two-crossing wave field is employed in experiments in order to investigate characteristics of the wave force and wave force coefficients due to directional waves. The two-crossing wave is comprised of two fundamental regular wave trains which have different propagation directions, wave heights and wave periods, and is perhaps the most basic form of a directional wave field. A series of laboratory experiments was first carried out to investigate the characteristics of wave forces acting on a circular cylinder under every fundamental regular wave and the resulting bichromatic wave. Next, the wave forces and wave force coefficients were discussed in detail in relation to the Keulegan-Carpenter number (KC), the horizontal velocities and the crossing angle between two fundamental wave trains.

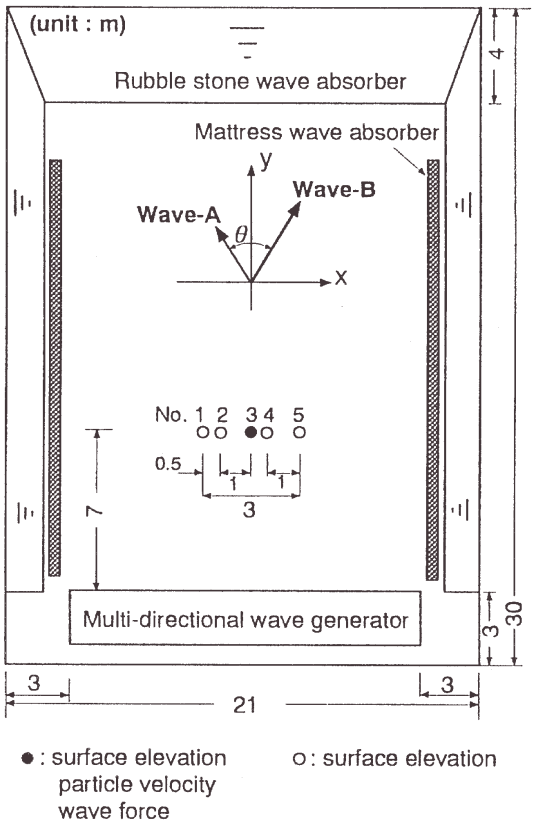

Fig. 1 Schematic view of wave basin and experimental arrangement

LABORATORY EXPERIMENTS

Laboratory experiments were carried out in an indoor wave basin which was 30 m long, 21 m wide and 1.5 m deep, as shown in Fig. 1, and was owned by the Technical Research Institute of Toyo Construction Co. Ltd. The snake-type wave generator was equipped in the basin to generate multidirectional irregular waves. The stillwater depth h was constant at 50 cm in the experiments.

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KEY WORDS: Wave forces, vertical circular cylinder, crossing waves, wave force coefficients, Keulegan-Carpenter number, water particle motion.