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Investigation of a Dynamic Property of Draupner Freak Wave

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ABSTRACT

This paper presents an experimental study of the dynamic property of the Draupner freak wave by simulating it in the wave tank. We measure the horizontal particle velocity and the horizontal force on a vertical truncated cylinder caused by the laboratory freak wave. These results are compared with those of the equivalent-size laboratory Stokes 5th-order wave. The peak particle velocity of the freak wave is 2.4 times that of the laboratory Stokes 5th-order wave, and the peak force of the laboratory freak wave is 2.8 times that of the laboratory Stokes 5th-order wave. The freak wave force measured in the work is one that causes an impact, while the Stokes 5th-order wave force is an ordinary one.

INTRODUCTION

Haver and Andersen (2000) discussed the real existence of a freak wave and reached a few conclusions, among them that it should be modeled as a transient phenomenon. Stansberg (2000) modeled a freak wave based on the wave evolution and nonlinear focussing of an energetic random wave group propagating along the wave tank, at a large distance from the wave flap. Kriebel and Alsina (2000) propose a method of embedding a large transient wave as a freak wave in a random sea. Zou and Kim (2000) generated a random seaway and picked the largest wave group in the seaway to create a strongly asymmetric wave in the random seaway. Clauss et al. (2001) produced a freak wave in a random seaway and changed it to fit to the target freak wave by an iteration minimizing the difference between the target and the simulation.

The method of producing the Draupner freak wave in the wave tank is similar to that of Kim et al. (1992) and Zou and Kim (2000). The difference is that the wave generations in the above two works are based on the theoretically designed wave amplitude spectra, while in this study we start with the Draupner field freak wave time series.

Kim et al. (1997) proposed that the laboratory extreme transient wave group be used for an investigation of the dynamic property of the transient wave, including the horizontal wave particle kinematics and the wave impacts on a series of fixed truncated cylinders. The work on the dynamic property is similar to the above.

The result of the work reveals that the field and laboratory freak wave are very similar to the 2-D laboratory extreme transient waves in shapes and in dynamic properties (Kim et al., 1997). The above observation supports the proposal by Haver and Andersen (2000) to use transient waves as a model for the freak wave and the proposal by Kriebel and Alsina (2000) to study transient waves as a freak wave. In order to interpret the very special characteristics of the laboratory freak wave, we compare the present results of the particle velocity and horizontal force with the equivalent-size laboratory Stokes 5th-order wave on the same cylinder in the same wave tank (Hitha and Kim, 2000). The peak particle velocity and the peak force of the equivalent-size laboratory Stokes 5th-order wave are much smaller than those of the laboratory freak wave.

TEST FACILITIES

The wave tank is 37 m long, 0.91 m wide and 1.22 m deep, and it is equipped with a Commercial Hydraulic RSW 90-85 dry-back, hinged-flap wavemaker, and a downstream wave-energy absorbing beach. The still water depth is kept constant at 0.8 m.

The wavemaker is of SEASIM make. The electromechanical components are operated in the frequency range of 2.0 rad/s∼12.0 rad/s and voltage range of ±1.5 volts. The outboard switches of the driving signal (analog) for the wavemaker are set for a range of ±1.5 volts to match the frequency of the wavemaker. The wavemaker is driven by the analog signal obtained from the computed digital signal, through the Strawberry Tree Digital to Analog (D/A) board installed in the computer for running the wavemaker. The voltage limits have recently been changed from the previous ±5.0 volts to ±1.5 volts to prevent the fatigue-induced damage of the old wavemaker due to an unexpected excessive motion.

Resistance-type wave gauges are used to measure wave surface elevations. The accuracy of the wave gauge is ±0.1 cm. The vertical and horizontal wave force are measured by an ARCTEC strain gauge platform with a capacity of 178 N, whose accuracy is ±1.0% of the applied force. The scanning rate of measuring the wave and force is 50 Hz. A 2-component fiber-optic laser Doppler velocimeter is used to measure the instantaneous horizontal and vertical velocities of the fluid particle below the freak wave surface. The fluid is seeded, using silver hollow spheres for processing the backscatter signal. The effective sampling rate is varied from 300 to 900 Hz and reduced to bin averaging 50 Hz, consistent with the free surface and the force measurements.

MODEL SETUP

After the generation of the freak wave in the wave tank at the location of the design wave $x = 3.4$ m, we set up the cylinder model with the wave gauge as shown in Fig. 1 to measure the horizontal force and wave elevation simultaneously. The cylinder

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KEY WORDS: Field freak wave, laboratory freak wave, transient wave, freak wave particle kinematics, freak wave impact, laboratory Stokes 5th-order wave.

ABBREVIATIONS: FEW = field freak wave. LFW = laboratory freak wave.