

## Impact and Nonimpact on Vertical Truncated Cylinder Due to Strong and Weak Asymmetric Wave

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### ABSTRACT

This paper presents analyses of experimental data and an empirical model for horizontal forces on cylinders due to laboratory-generated asymmetric waves. Given the time history of the incident wave elevation, the model can predict the horizontal force. Four single cylinders of different diameters are tested in three transient asymmetric waves and two high seas.  $C_M$  and  $C_d$  are determined for each cylinder and the question of the effects of hydrostatic force fluctuations and convective acceleration has been clarified.

### INTRODUCTION

Column-supported structures, e.g., tension leg platforms (TLPs) are very sensitive to high seas. The ringings of TLP tendons are due to steep asymmetric waves (Natvig, 1993). The ringing hydrodynamic problems have not yet been completely solved, because the waves that can cause the ringings in association with springings are very special. In addition to this, one must literally measure the ringings experimentally or simulate ringing loads due to the waves and predict the ringing tensions.

Our research has begun with the study of the kinematics of laboratory-generated extreme waves including the transient wave group (TWG) (Kim et al., 1992). The TWG has a steep asymmetric crest, and the horizontal particle velocities in the crest are much higher than those of the Stokes 5th-order-like regular wave (SRW) whose height is equivalent to the TWG's. It was also found that the particle velocities in the crest of a typical high sea (HS) of significant wave height (SWH) 0.10 m are much lower than those of the SRW. It was clearly observed that the high particle velocity comes from the crest of the TWG's concave front and convex rear, while the lower velocity results from the crest of the SRW's convex front and convex rear.

Impact was measured on a vertical truncated cylinder fixed in the TWG of nominal slope 0.28 (Zou et al., 1995 and 1996). The TWG crest creates a horizontal impact whose time history has a crest of concave front and convex rear.

A universal linear system model by Kim et al. (1995) was found to predict horizontal forces on a vertical truncated cylinder due to HS of SWH 0.10 m. It was extended to predict impact due to the TWG of nominal slope 0.28 (Kim et al., 1996). The nominal slope hereafter will be called simply slope.

The present research deals with three items: Conduct the experiments and analyses of the horizontal forces of cylinders of four diameters in the TWG of three slopes and HS of two SWH; develop a practical prediction model for the horizontal forces applicable to a wide range of cylinder diameters affected by the TWG

and HS; determine the  $C_M$  and  $C_D$  of each cylinder and clarify the questions of the effects of fluctuating hydrostatic forces and particle convective accelerations on the prediction model.

### MEASUREMENT OF WAVES AND FORCES

The wave tank is 37 m long, 0.91 m wide and 1.22 m deep, and it is equipped with a Commercial Hydraulics RSW990-85 dry back, hinged-flap wavemaker, and downstream wave energy-absorbing beach. The water depth is kept constant at 0.8 m throughout the research work.

A steep asymmetric nonbreaking and repeatable TWG is generated by the wave flap, driven by a signal produced by PC, details of which are given in Kim et al. (1992). The driving signal for the energy-focused TWG is a synthesis of many harmonic component waves of a constant slope (nominal slope) and a constant phase at a prescribed location. The peak of the TWG occurs at the energy-focused point.

Froude similitude law with a length scale of 1/100 is used. The record length and scanning rate of each measurement are 20.47 s and 100 Hz. These are to avoid the reflection effect on the data and to record the rapidly changing wave elevation and impact.

The horizontal impact due to the TWG of slope 0.28 on the vertical truncated cylinder 0.164 m in diameter and 0.30 m in draft was experimentally studied (Zou et al., 1995, 1996). Cylinders 0.05 m, 0.10 m and 0.20 m in diameter and 0.30 m in draft are tested in the TWG of slope 0.24, 0.26 and 0.28 and HS of SWH 0.10 m and 0.125 m. All the cylinders are made of 6-mm-thick plastic tube, and the lowest lateral and vertical natural frequencies for the cylinder 0.164 m in diameter are 44 and 203 Hz, respectively. No resonance vibrations are observed for any cylinder. The experimental method for measuring impact forces due to the TWG is the same as that in Zou et al. (1995, 1996): The energy-focused point of the TWG is located in the transverse section passing through the frontal surface of the cylinder (Fig. 1). For the other irregular and regular waves the elevations are measured at the location of the cylinder axis. A SRW of equivalent height to that of the TWG of slope 0.28 was generated to measure the force on the cylinder 0.164 m in diameter, which was compared with the forces due to the TWG (Zou et al., 1995, 1996). These data will be employed in the present study for comparisons with others.

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