

Experimental Study of Impacting Wave Force on Vertical Truncated Cylinder

J. Zou and C. H. Kim*

Department of Civil Engineering, Texas A & M University, College Station, Texas, USA

INTRODUCTION

TLP tether ringing occurs at resonant frequencies due to strong asymmetric wave action on TLP columns (Natvig, 1994). Records of storm seas in wave tanks consist of symmetric and asymmetric nonlinear waves. The latter appear to be elevated and asymmetric with respect to mean water level (MWL), as well as asymmetric with respect to the vertical axis through the crest. The asymmetric waves may be better described using new terms: concave inward, and convex outward of the crest shape (Fig. 1). The highly nonlinear wave given by Longuet-Higgins et al. (1976) is a strong asymmetric wave with distinct concaveness in the front and convexness in the back of the crest. The highly nonlinear wave due to Schwartz (1974) is a strong symmetric nonlinear wave with equal distinct concaveness both in the front and back. However, the asymmetric nonlinear waves generated in the wave tank have crests with negligibly small concaveness and convexness. It is difficult to generate strong asymmetric waves contained in the random model seas by the state-of-the-art technique. But it is possible to generate an isolated strong asymmetric wave or transient wave group (TWG). For instance, Kim et al. (1992) investigated a nonbreaking TWG of 25-cm height with 1.2-s period. The horizontal particle velocity in the crest was 1.47 m/s. Kim et al. also studied an equivalent-height regular wave to compare with the TWG. The regular wave is similar to the Stokes 3rd- or 5th-order wave.

The objective of the present study is to investigate a weak impacting force on a vertical truncated cylinder due to the TWG and use the result for a ringing analysis. Weak impact means an impacting force due to nonbreaking TWG (nonplunging breaker). To reach the goal, wave elevations, horizontal particle velocities below the crest, hydrodynamic pressure and wave-runup distributions over the body surface, and the horizontal wave force were measured simultaneously. From the analysis of the measured data the TWG and impacting force and impacting process were characterized. The action of the TWG on the cylinder produces the hydrodynamic pressure force, fluctuating hydrostatic force and viscous drag. The forces acting above the MWL were estimated using the measured dynamic pressure and wave-runup distribution on the body surface above the MWL, and the force on the submerged body below the MWL was calculated applying the linear Morison equation. The sum of these forces is compared to the measured force.

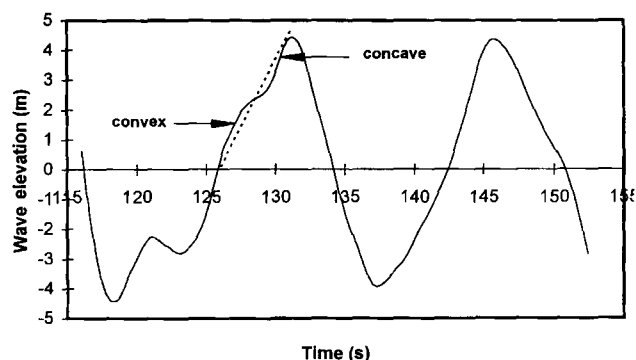


Fig. 1 Asymmetric waves generated in wave tank

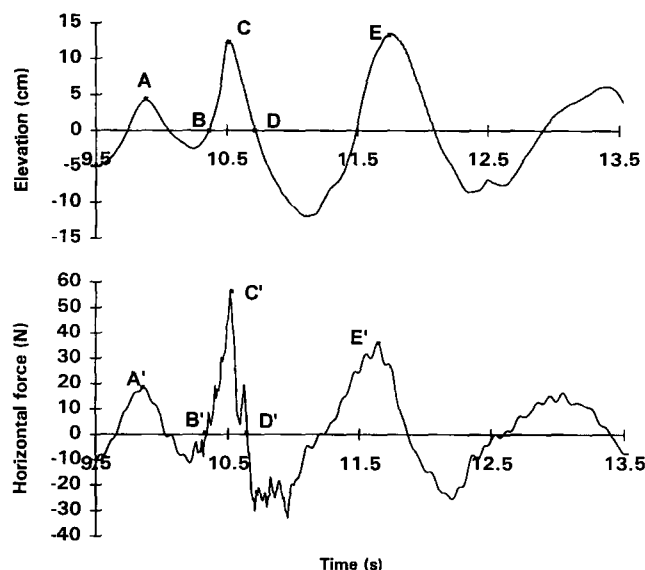


Fig. 2 Transient wave group and impacting force

MEASUREMENTS

The above-mentioned quantities were measured with the cylinder fixed in the 2-D wave flume at Texas A & M University (Zou and Kim, 1995). Employing the resistance-type wave gauges, laser Doppler anemometer and ARCTEC's platform-type dynamometer, wave elevations, particle velocities and forces were measured. With the PCB dynamic pressure transducers and flush wave gauges glued over the body surface, the dynamic pressure and wave-runup distributions were measured. Dynamic pressures were measured at 30 locations on the half-body surface and 5 flush gauges were used on the other half-body. The TWG was generated by inputting a constant slope 0.28 and a location of energy-focusing point into the wave generating computer. By

*ISOPE Member.

Received July 1, 1996; revised manuscript received by the editors September 19, 1996. The original version was submitted directly to the Journal.

KEY WORDS: Strong asymmetric wave, concave and convex shape, weak impacting force, impacting process, hydrodynamic and hydrostatic fluctuating force, wave-runup, ringing.