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Added Mass and Damping on an Oscillating Surface-Piercing Column with a Horizontal Cylinder: Square Cross Sections

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ABSTRACT

Added mass and damping on a long horizontal cylinder of a square cross section (Model A) and a vertical surface-piercing square cylinder or column with a long horizontal cylinder of a square cross section (Model B) oscillating in water of finite and infinite depths, are measured using a planar motion mechanism. The width of both the vertical and horizontal cylinders is 22.86 cm. The horizontal cylinder comprises a test section of 91.44 cm in length at the center and two 91.44-cm dummy sections on each end of the test section. The model was forced to sway and heave sinusoidally with small amplitudes for several submergences below a free surface. The added-mass and wave-damping coefficients are shown to be influenced strongly by the free-surface effect and are presented as a function of water depth, frequency and direction of oscillation and of depth of submergence from the free surface. There clearly exists a critical nondimensional frequency near $\omega^2 a/g = 0.3$ for the heave oscillations near the free surface, as was measured previously but not predicted by a potential theory for a long, 2-D horizontal cylinder in infinite depth (Chung, 1977). Also, negative added mass is measured at $\omega^2 a/g = 0.4$~0.8 for the shallow subergence, and it was cinfirmed by the present computation. The general trend of the added mass curve shows a behavior similar to the results of the previous 2-D horizontal cylinder except for the differences in their values. The added mass coefficients are larger for finite depth, while a limited number of submergences was tested. The experimental values are generally larger than theoretical predictions. As the model is placed closer to the bottom, the discrepancy becomes larger.

INTRODUCTION

This paper experimentally investigates the hydrodynamic coefficients of the harmonic oscillations of a model in still water of finite and infinite depth having a free surface. Model A is a long horizontal cylinder of a square cross section, and Model B comprises vertical surface-piercing and submerged horizontal cylinders of a square cross section (Fig. 1b), which are similar to many semisubmersible structures. The hydrodynamic coefficients of the 2-D horizontal cylinder in infinite depth influenced by the free-surface effect as calculated using potential theories (e.g., Frank, 1967) were previously compared with the experimental data in Chung (1977). Members of many floating ocean structures can be approximated as two-dimensional *except* for those parts close to the joints of the members.

Recently three-dimensional (3-D) potential theories and computational methods have made much progress in contributing to the 3-D theoretical prediction of hydrodynamic forces and motions of floating structures. However, the accuracy of theoretical predictions needs to be confirmed by experimental results. The added mass and wave damping computation by 3-D potential theory for the computation of motions of the floating structures

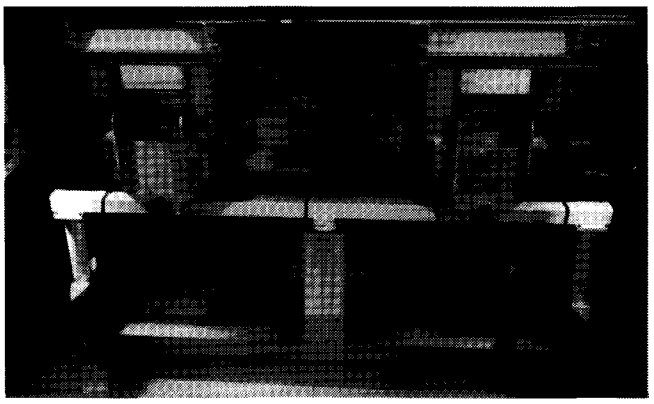

Fig. 1a Model B as rigged to PMM system over false bottom: Model A is identical to Model B with column removed.

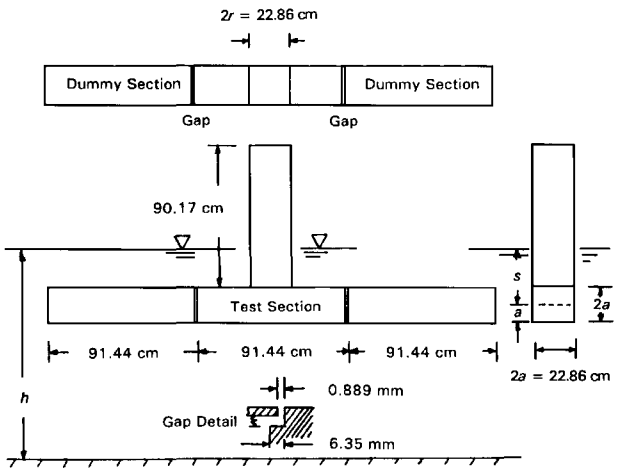

Fig. 1b Schematic of Model B: Model A is identical to Model B with column removed.

*ISOPE Member.
Unit conversion: 1 in = 2.54 cm.
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KEY WORDS: Added mass, radiation damping, vertical square cylinder, horizontal square cylinder, column effect, three-dimensional effect, sway, heave, oscillations, infinite depth, finite depth.