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Experimental Study on Hydrodynamic Loads on a Horizontal Slab and Pile

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ABSTRACT
An experimental study has been carried out to investigate impact pressures on a slab and a vertical pile due to regular waves. The pressures on the bottom of the slab are measured by the pressure transducers and hydrodynamic loads acting on the pile are measured by a four-component balance. It has been found that in a wave period, wave pressure undergoes periodic variation along with time. Moreover, the influences of relative clearance height and length of the slab on the impact pressures are discussed. On the other hand, comparison is carried out thoroughly between the hydrodynamic force exerted on the single pile with and without the effect of the slab.

KEY WORDS: waves; slab; single pile; impact pressure

NOMENCLATURE

C_{sx}	effect coefficient of slab
d	water depth
F_{dx}	wave-direction force exerted on pile without slab
F_{sx}	wave-direction force exerted on pile with slab
F_x	wave-direction force exerted on pile
F_y	transverse force exerted on pile
H	wave height
L	wave length
L_s	length of slab
L_s/L	relative length of slab
p	wave pressure exerted on slab
s	clearance height of slab
s/H	relative clearance height of slab
T	wave period

1. INTRODUCTION

The problem of wave force acting on structures is of significant importance for the security of piers, platforms and slabs. A particular illustrative case is that the Ekofisk platform (Gebara, Dolan, Pawsey, 2000; Jha, Kiciman, Gebara, 2000). Isaacson and Prasad (1993) found that the slamming phenomenon was of a high frequency in nature. A number of publications related to wave slamming on horizontal cylinder or horizontal plate have been published. Both theoretical analysis and experimental results have been presented and discussed. Kaplan and Silbert (1976) developed a solution for vertical force exerted on a horizontal cylinder from the instant of impact to full immersion. For cylinders, wave slamming force is generally expressed by a slamming coefficient Cs. It has been found that slamming coefficients exhibit a considerable degree of scatter, ranging from about 1.0 to 7.79 (Dalton, Nash, 1976; Miller, 1977; Sarpkaya, 1978).

In recent years, experimental studies on the distribution of pressure along a horizontal plate have been performed in ever increasing numbers, and correspondingly various empirical relationships are proposed (Song, Bai, 1997; Zhou, Chen, 2003; Zhou, Chen, Huang, 2003; Ren, Wang, 2004). Zhou (2004) proposed that the maximum total uplift forces did not necessarily occur with the maximum impact pressure intensity synchronously. Smith (1998) presented that a slam force coefficient could be as a function of wave steepness and angle of relative to wave for the ranges of parameters tested. Suchithra and Koola (1995) carried out a laboratory study to investigate the slamming effect on horizontal slabs by regular and irregular waves. Ren (2007) investigated the instantaneous properties of wave slamming on the plate structure by PIV. Lan and Liu (2004, 2005, 2006) carried on a series of experimental study on the foundation structure of the Donghai Bridge, and gave the hydrodynamic characteristics. Yao and Liu (2009) proposed a project method for calculating the hydrodynamic loads on the circular slab and pile. The influences of water depth, the radius and clearance height of slab on the parameters of slab and group piles were discussed in detail. From the available literature, the variation rules of the hydrodynamic loads on the composite structure of slab located near the water surface and piles need further research. In the paper, an experimental study has been carried out in a wave flume to investigate impact pressures on a slab and a vertical pile due to regular waves.

2. EXPERIMENTAL SET-UP AND MODEL DESIGN

2.1 Test Equipment and Instrument

The experiment is carried out in the wave flume of Mechanics Department at Shanghai Jiao Tong University. The wave flume is 65 m in length, 0.8 m in width and 1.2 m in depth. The maximum operating water depth is 0.8 m. At one end of the flume there is a wave maker. At the opposite end of the wave maker there is an absorbing beach that damps out the incoming wave energy.

The model of slab and pile is located in the middle of the wave flume. Time series of wave forces and moments on pile are obtained by using a four component balance, which is designed and processed specially for a series of experiments. It can be wholly installed in the pile and may work underwater, which is shown in Fig.1. 12 pressure transducers are distributed over slab to measure pressure on slab. The housing locations of these pressure transducers on side wall and bottom over slab are shown in Fig.2 (a) and (b), respectively. The pressure transducers numbered by A1~ A3, B1~ B4, and C1~ C3 locate on the bottom of slab, and D1, E1 on the side wall facing and back to the incoming wave, respectively.