ABSTRACT

Aeration effects on impact have been investigated by dropping a flat plate onto the water surface, in which the water is aerated to various degrees. An experimental study has been carried out in the newly commissioned Ocean Basin at Plymouth University’s COAST Lab. The falling block comprises a rigid impact plate connected to two driver plates and its total mass can be varied between 32 kg and 52 kg. The impact plate is 0.25 m long, 0.25 m wide and 0.012 m high. The impact velocity is varied between 4 m/s and 7 m/s. Preliminary results of the impact tests are presented here. Visualised results show that there are significant differences between jet formation after impact of the plate in pure water and in aerated water. There is significant reduction of the maximum pressures from those measured in pure water to those measured in aerated water.

KEY WORDS: Slamming; pressure; force; jet formation; aeration; void fraction.

INTRODUCTION

Slamming of an impact plate into pure water has been investigated over several decades using both theoretical and physical models. The first theory was developed by von Karman (1929) for a wedge and then for a horizontal plate impact into pure water. Later, Wagner (1932) developed the theory for a wedge with very small dead-rise angle, small enough not to trap air. There are a number of experimental studies undertaken to investigate slamming by dropping a wedge (Chuang, 1966a; Zhu, 1995; Zhao et al., 1997), a horizontal bottomed body (Chuang, 1966a&b; Verhagen, 1967; Zhu, 1995; Bullock et al., 2001; Kwon et al., 2003; Ob et al., 2009) and a horizontal circular cylinder (Lange et al., 2011; Van Nuffel et al., 2014) onto a still pure water surface. Smith et al. (1998) conducted a series of drop tests of a horizontal plate onto waves of different steepness.

If the compressibility of the water can be taken into account then the peak pressure at the instant of the impact of a horizontal plate onto still water, is equal to the acoustic pressure (von Karman, 1929) \[ p_a = \rho c v, \]
where \( \rho \) is the fluid density, \( c \) is the speed of sound in the fluid and \( v \) is the plate velocity just before the impact.

In practice, the maximum acoustic pressure never occurs because an air layer is trapped between the flat plate and the water surface and this air layer acts as a cushion layer. In the experiment of Chuang (1966a&b) the maximum impact pressure is found to be proportional to \( \rho c_a v \), where \( c_a \) is the speed of sound in air. In the theory developed by Chuang (1966a & b), the compressibility of both the air and water was considered in a general solution of the problem. Since the maximum impact velocity was limited to 1.92 m/s, the finding in Chuang’s tests may not necessarily apply to high impact velocity. The compressibility of the water and the elasticity of the body are neglected by Verhagen (1967). In his explanation, compressibility effects are neglected because the events of interest are expected to happen in a timescale of the order required by an acoustic wave in air to travel over a distance \( l \), i.e., \( \Delta t = l/c_a \) which is large compared with \( l/c \) (\( l \) is the half width of the flat plate). His experiments indicated that this assumption is fully justified. However, his experiments are limited to small values of the mass of the body compared with the added mass.

In particular, uncertainty exists in the understanding of the influence of the presence of air in the water (both entrapped pockets and entrained bubbles) leading to variability of wave impact pressures and forces. There are limited studies on the slamming impact onto aerated water so far (Bullock et al., 2001; Lange et al., 2011). In this paper, those aeration effects on impact have been experimentally investigated by dropping a flat plate onto the water surface, in which the water is aerated to various degrees.

EXPERIMENT

The experimental work has been carried out in the newly commissioned Ocean Basin at Plymouth University’s COAST Lab (http://plymouth.ac.uk/pages/view.asp?page=39210). The ocean basin is 35 m long by 15.5 m wide and has a raisable floor that allows operation at different water depths up to 3 m. The falling block includes a rigid impact plate connected to two driver plates and its total mass can be varied between 32 kg to 52 kg. The impact plate is 0.25 m long,