Validation of Applicability of Dam-Break Flow to Green Water Prediction

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ABSTRACT

The Ritter’s dam-break flow solution was used to the prediction of overtopping green water on an offshore structure. The velocity of green water on a two-dimensional simplified model structure was measured using a newly developed technique called bubble image velocimetry (BIV). The Ritter’s analytical solution for the dam-break flow problem is examined and compared with the measurements under an extreme wave condition.

KEY WORDS: Green water; dam-break flow; particle image velocimetry; offshore structure.

INTRODUCTION

The phenomenon of water overtopping over an offshore structure may be similar to that of a dam-break flow. The assumption has been made and applied by engineers and researchers in the field of ocean engineering. Buchner (1995a) demonstrated the resemblance of green water to a dam-break flow but cautious about the shallow water assumption in the dam-break flow. Due to the possible similarity between green water and dam-break flow, there have been many studies that applied the dam-break theory to green water predictions. The standard design analysis approach to estimate the velocity in a green water incident is to use dam-break solutions (Schoenberg and Rainey, 2002).

Due to its highly aerated nature, the velocity of green water flow has rarely been successfully measured. Ryu et al. (2005) recently introduced a new technique called bubble image velocimetry (BIV) for velocity measurements in bubbly flows. Using BIV, they successfully measured velocity fields of green water on a model offshore structure in the laboratory (Ryu et al. 2006).

In this study, green water and dam-break flows were investigated and compared to examine the applicability of predicting the green water flow with a dam-break flow model.

EXPERIMENTAL SETUP

The experiments were performed in a wave tank that has a length of 36 m, a width of 0.9 m, and a height of 1.5 m. A two-dimensional rectangular model structure was placed 21.7 m away from the wavemaker. The structure has a height of 0.31 m, a length of 0.37 m (including a 0.22 m long extended deck) or 0.15 m (without the extended deck), and spans the width of the wave tank. The draft of the model structure is 0.20 m so the freeboard is 0.11 m. The dimensions of the model structure were chosen to be representative, in a two-dimensional sense, of a TLP with a scale ratio of 1:168 while the extension deck is to mimic the deck of a FPSO. The water depth was kept constant at \( d = 0.80 \) m throughout the experiments. The wave tank and model are sketched in Fig. 1.

A plunging breaker was generated using a wave focusing method from a wave train that impinged on the model structure and created green water on the deck. The primary frequency, wavelength, wave height, and phase speed (C) of the breaking wave in the deep water are 0.77 Hz, 2.54 m, 17.0 cm, and 1.95 m/s, respectively. The primary frequency is the frequency of the specific wave in the wave train that has the largest wave amplitude and leads to the breaking event. The breaking wave was carefully selected according to a hurricane storm condition based on Froude scaling with a scale ratio of 1:168. The