Dynamic Characteristics of Breaking Wave generated by Single Impact Wave in Low Filling Condition

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ABSTRACT

This research investigates the flow inside a two-dimensional tank under wave impact motions on its wall through experimental and numerical analysis. The impact development process and characteristics are analyzed for a 20% filling condition using a Single Impact Wave (SIW). Prior to the SIW study, statistical processing loads were compared to apply a simplified 1-DOF sway motion that has a dominant effect on sloshing load in breaking wave analysis. The Single Impact Wave experiment was performed with the excitation amplitude and period as parameters by applying 1-DOF sway motion. This study defines the wave that generates the breaking wave and reveals the dynamic and flow characteristics of breaking wave under low filling conditions.

KEY WORDS: Sloshing; Breaking wave; Single Impact Wave (SIW);

INTRODUCTION

Fig. 1 Critical sloshing under low filling condition & 90° wave direction

he sloshing phenomenon is a highly non-linear problem that is difficult to define. It occurs when fluid inside an LNG tank moves, especially at low filling levels and when the tank is at a 90 degree heading. Wave breaking accompanies sloshing under low filling conditions, and there have been many studies on this (Ryu et al., 2005). Generally, wave breaking occurs when the wave height to wavelength ratio is less than 1/7 or when the particle velocity of the crest is faster than the phase velocity. When the horizontal velocity of the wave crest exceeds the phase velocity, an overturning jet is generated on the upper part of the crest and eventually breaks (Yuichi et al., 1971). Wave breaking can be categorized into plunge and spilling types. Plunge type breakers typically occur on coasts with steep slopes and cause a large sloshing load due to rapid energy dissipation. The breaking wave occurs at low filling levels, leading to a significant sloshing impact load (Lee et al., 2005; Macdonald, 2008; Pastoor et al., 2004; Park et al., 2009; Zhao et al., 2004). To simplify and analyze the sloshing problem, assumptions were made from the geometric and kinematic viewpoints. First, a 2-dimensional tank experiment was conducted to ignore the 3-dimensional flow effect caused by the complex tank shape. Additionally, the problem was simplified from the kinematic perspective by considering only the motion in the 1-DOF sway direction.

In the paper, Sloshing assessment was performed by defining a breaking wave that generates a large sloshing load, using the excitation period and amplitude as parameters under the 20% filling condition. Through this assessment, the dynamic characteristics, elevation, type, slope angle, and free surface shape of the breaking wave that occurs under low loading conditions were investigated.

RECTANGULAR TANK FOR SLOSHING MODEL TEST