

An Experimental Study and Numerical Simulation on Sloshing Impact Pressures with Two Identically Shaped Rectangular 2-Dimensional Model Tanks with Different Sizes

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ABSTRACT

Recent growth in LNG market has led dramatic increase in new buildings of LNG carriers and several large LNG carriers are now being constructed by shipbuilders in Korea. Large size LNG carriers have brought keen concerns on the issues regarding safety of cargo containment systems and sloshing impact load which is the critical source of loads on the membrane type containment systems. Up to the present, the best way to properly assess sloshing impact pressures on surrounding walls is a model testing for wide-ranged excitation conditions. These impact pressures obtained from model tests sometimes need to be interpreted to full-scale values and in the near future this necessity will be strengthened for more rigorous and direct safety assessment of LNG cargo containment system. In this paper, a basic experimental study is carried out with two different sized, 2-dimensional identically shaped model tanks excited in simple translational motions. Scales of two model tanks are selected as 1/50 and 1/25 in order to investigate the impact pressure characteristics according to the model tank sizes. Relationships between pressures of different sized model tanks are investigated for three filling heights and two excitation amplitudes per each filling height. For measuring impact pressures, about 15 pressure sensors are used on various locations of the model tanks and in order to compare the results from two different sized tanks, statistical values are used. All tests are carried out on the hexa-pod motion platform at Pusan National University, Korea.

KEY WORDS: sloshing; impact pressure; experiment; scale effect; rectangular tank

INTRODUCTION

Recently the size of the LNG carriers is increased and the first vessel of 210,000m³ LNG carriers which are being built in Korea was delivered to the ship owner successfully. The larger LNG carriers with about 260,000m³ cargo volume are now being constructed also in Korea. Demand on middle size LNG carriers and LNG floating storages as well as large LNG carriers is continuously increasing and makes sloshing issue be the more important and relevant research institutes, shipbuilders, and classification societies need to focus on detail level of the technology. The prediction of sloshing impact pressures on cargo

tank wall can be most reliably carried out by scaled model testing up to the present even though there are fast numerical codes dedicated to sloshing problem and commercial CFD codes for more detail prediction. Even in the most reliable way, model testing, there are several difficult problems to be solved, and one of them is how the measured pressures at the scaled model testing should be extrapolated to ship scale pressures. In this paper the relationship between sloshing impact pressures obtained from two different-scaled rectangular model tanks is investigated. Abramson(1974) described terms relating to the sloshing impact pressure and their meaning and importance. Pastoor(2005) mentioned things to be considered in pressure scaling from model test result to ship scale and especially the consideration of compressibility of fluid. Gavory(2005) also said that the method to extrapolate scaled model tank pressure to ship scale was difficult to be defined clearly. The model testing carried out in this paper used 6-DOF motion platform at Pusan National University, Korea and 2-dimensional rectangular model tanks. Length-height ratio of model tanks comes from the ratio of 140,000m³ LNG carrier's cargo tank shape. Scales between two model tanks are selected having difference of the factor of 2. Two tanks have geometrical similitude and excitation conditions are determined by Froude similitude. Pressures obtained from two different scaled model tanks are compared at the same locations of pressure sensor. And several interesting features of pressure signals are presented. For some test conditions, numerical simulations using commercial CFD code are carried out and impact pressure signals are compared with model test results.

MODEL TANKS, PRESSURE SENSORS and 6-DOF MOTION PLATFORM

Table 1. Dimensions of tank models

Tank Dimension	1/50 Model Tank	1/25 Model Tank
L(mm)	874.4	1748.8
M(mm)	70.0	140.0
H(mm)	535.2	1070.3

Model tanks are referred to the longitudinal section of 140,000m³ LNG carrier and the scales are 1/50 and 1/25 respectively. Table 1 shows the dimensions of model tanks. Fig. 1 shows the 6-DOF motion platform at Pusan National University (PNU), Korea and two model tanks. In order to measure sloshing pressures, pressure sensors are installed at geometrically same positions of two different sized model tanks and two combinations of sensor installation are considered according to the filling height of water in tanks. Fig. 2 and Fig. 3 show pressure sensor locations of 1/50- and 1/25-model tank for 40% water filling of tank