Experimental Study on the Bow-Flare Slamming of a 10,000 TEU Containership

Sa Young Hong, Kyong-Hwan Kim, Byoung Wan Kim, Young-Shik Kim
Korea Research Institute of Ships and Ocean Engineering
Daejeon, Korea

ABSTRACT

Bow-flare slamming has been paid attention in ship classification societies because it causes local damage or severe whipping vibrations which affects the ultimate strength and fatigue life of ship. WILS JIP-III (Wave Induced Loads on Ships Joint Industry Project-III) has been launched and conducted by KRISO, Korea, of which aims are to measure the slamming impact loads, vertical bending moment, and torsional moment in regular and irregular waves. A 10,000 TEU containership with six segments was used with the scale ratio of 1:60. The segments were connected by a U-shape steel backbone where a number of strain gauges were installed to measure structural responses. A number of force and pressure sensors were distributed on the bow-flare section in order to measure the temporal and spatial distribution of slamming load during tests. Based on the measured data, characteristics of the bow-flare slamming loads are presented and discussed.

KEY WORDS: Slamming; bow flare; impact load; experiment, large containership, impact measurement.

INTRODUCTION

Recently, the size of container ships has been rapidly increasing due to the fast growth of global trade. As a result, the design of ultra large container ship has larger bow-flare and stern areas to maintain service speed with increased cargo capacity. These design trends lead to increased occurrence of bow-flare and stern slamming, which give rise to higher risk of slamming failure. It was reported that slamming-induced whipping can cause critical structural failure of ship (Storhaug, 2009). So the slamming load should be taken into account in the design of large vessels such as ultra-large containerships and cruise ships.

The study on slamming problem was initiated by the pioneering works of von Karman (1929) and Wagner (1932). During last century, more than 1,000 papers were published to investigate the hydrodynamic impact problems. A number of analytical, experimental, and numerical approaches have been applied. However, the subject is still far from being completely solved (Kapsenberg, 2011).

In terms of ship slamming, it can be categorized as bow-flare and bottom slamming, stern slamming, and wet-deck slamming. Each category has a little different characteristic, but those slamming loads are mainly governed by water entry relative velocity and dead rise angle relative to free surface (Faltinsen et al. 2004). In previous experiments, slamming loads on high-speed ships, cruise ships, and containerships have been mainly investigated. Kapsenberg et al. (2002) distributed a large array of pressure sensors on stern area and measured slamming pressures of a 1/49-scaled cruise ship. It was found that the force due to whipping vibration is ignorable. Rousset et al. (2005) carried out drop test of a three-dimensional cruise ship model. They distributed several pressure and force sensors on bottom and bow-flare surfaces and compared the pressure and force. Hermundstad and Moan (2005) distributed two pressure panels on bow-flare area of a Ro-Ro vessel. Experimental setup was introduced and numerical results in oblique sea were compared with measured data. Luo et al. (2007) measured stern-slamming pressures of 1/29-scaled containership. It was reported that stern-slamming load is decreased as ship speed is increased. A segmented model with an elastic beam was applied by Dessi and Mariani (2008). They attached load cells on the backbone and the segmented parts of hull were connected to the load cells. Slamming load was estimated from the measured force by eliminating the inertial and Froude-Krylov forces. Kapsenberg and Thornhill (2010) distributed many pressure sensors on bow segment of a 1/36-scaled ferry. The bow segment was connected to the hull and total force acting on the bow segment was measured by strain gauges. They presented that bow wave should be considered in estimation of bow-flare slamming load. Slamming load of FPSO on bow surface was studied by Voogt and Buchner (2004) and Xu et al. (2008). Similar to the previous experimental studies of ship slamming, bow-flare slamming loads were measured by multiple pressure sensors.

Among variety of previous experiments, however, most of studies mainly focused on comparison of numerical solutions and experimental results. A large array of pressure sensors was applied to measure slamming pressures with high sampling rates. An application of pressure sensor to measure the slamming pressure is a proper way since the slamming is a very local and instant phenomenon. In spite of many experimental approaches to slamming loads, however, a systematic experimental approach to measure spatial distribution of slamming force is not studied yet. Recently, demands to investigate the spatial distribution of slamming loads have been increased in ship classification societies. As a result, WILS JIP-III (Wave Induced Loads on Ships Joint Industry Project-III) has been launched and carried out by KRISO (Korea Research Institute of Ships and Ocean Engineering). WILS JIP-I and II aiming to measure structural responses of a large