International Journal of Offshore and Polar Engineering (ISSN 1053-5381)

Vol. 16, No. 2, June 2006, pp. 112–117

Effect of Bow Flare Shape on Water Impact Pressure

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Model tests by means of a post-panamax container carrier were carried out to examine the relation between ship motions and water impact pressure on the bow flare. The impact pressure was computed by means of the nonlinear time-domain program. The present method is found to give good agreement with the measured peak value of the impact pressure. The measured impact pressure proved to be consistent with physical consideration. In addition, a prediction method of the probability density function of the water impact pressure was developed. Comparison of the present method with the measured probability clarified its usefulness.

INTRODUCTION

It is important for the safety of a container carrier to examine impact pressure due to bow flare slamming. In particular, because the number of large container ships such as the post-panamax container carrier is increasing, further examination of wave loads for a large container carrier is required.

With regard to flare slamming, much research has been carried out, and some prediction methods have been proposed (Technical Committee of West-Japan Society of Naval Architects, 1974; Takegawa, 1976). However, because these methods were constructed based on the model experiments or the damage record of container carriers of those years, further verification for recent container carriers is required.

Although the relation between relative motion in calm water and impact pressure was studied (Chuang, 1970), there is little quantitative examination between relative motion in waves and impact pressure (Arai et al., 1994, 1995). In addition, it is often verified that the magnitude of pressures measured in the towing tank is different from the estimated pressure based on the damage record of the bow flare. Hence, further quantitative examination of the relation between ship motions and water impact pressure needs to be carried out.

Based on this background, a series of free-running tests was undertaken, first using a model of a post-panamax container carrier. The water impact pressure on the bow flare, ship motions, vertical acceleration and relative water height were measured in head seas and bow seas, and the wave height is found to have a significant effect on the water impact pressure and ship motions. It is verified that a small relative angle of the flare against the wave can cause a great deal of the impact pressure. It is also verified that the impact pressure measured in the long-crested wave is smaller than the estimated pressure based on the damage record of the bow flare.

Second, relative motion and vertical acceleration, which have significant relation to water impact pressure, were computed by means of the nonlinear time domain simulation program. It is found that taking into account time-varying sectional hydrodynamic forces gives good agreement with experiments. In addition, the water impact pressure was estimated in accordance with the procedure of a nonlinear strip method. It is found that the present method gives good agreement with the measured impact pressure. It is verified that the measured pressure is consistent with physical consideration.

Finally, the practical prediction method of the probability density function of the water impact pressure on the bow flare was proposed. The probability density function of the water impact pressure is derived by expanding Chuang's equation (Chuang, 1970). The relative velocity and probability density function of the relative water height were computed by means of the present nonlinear method.

Comparison with experiments confirmed that the present method gives good agreement.

EXPERIMENTS

Model and Measuring Instruments

A detailed explanation of the experiments has been published previously (Ogawa et al., 2002). However, the part relevant to this study is repeated here. A series of a free-running test in waves by means of the model of a post-panamax container carrier was carried out to measure the water impact pressure on the bow flare. The tests were conducted at the Square Basin (80 m × 80 m) of the National Maritime Research Institute of Japan. Fig. 1 shows the body plan of the model ship; it is found that the angle of the bow flare is larger than that of the conventional container carrier. Table 1 presents the ship's main particulars. Before the test, the model was ballasted to the correct draft, trim, the GM, the natural roll period and its longitudinal and transverse radius of gyration. The model's rudder was controlled by the autopilot system to maintain a correct heading angle.

Received July 28, 2005; revised manuscript received by the editors March 25, 2006. The original version (prior to the final revised manuscript) was presented at the 15th International Offshore and Polar Engineering Conference (ISOPE-2005), Seoul, June 19–24, 2005.

KEY WORDS: Bow flare slamming, water impact pressure, nonlinear strip method, wave height, long-crested wave, probability density function of impact pressure, post-panamax container ships.