International Journal of Offshore and Polar Engineering
Vol. 8, No. 4, December 1998 (ISSN 1053-5381)

Effect of Water Inside a Ship on Its Damage Stability

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INTRODUCTION

Loss of static stability and capsizing due to damage and flooding of ships are well known. Their effect on dynamic stability, however, is not very clear. To study the effect of damage and flooding on the damping and motion of ships in waves, motion measurements were done with (a) no damage and water inside midship compartments and (b) damage opening on midship compartments (Roby, Hamano and Ikeda, 1997).

MOTION EXPERIMENTS

Experimental Setup

A 1/60-scale model of a passenger ship, 120 m in length, 18.0 m in breadth, 4.8 m in draught and 0.569 in block coefficient, having a bulbous bow and transom stern, is used for the motion experiments with water inside compartments, both damaged and intact. Two midship compartments are used to flood the model, a small one 0.333 m long and a large one 0.5 m long. The model was kept beam to waves measuring the motions of heave and roll, sway being kept free. Surge, pitch and yaw motions were prevented. Wave heights of 3.3×10^{-2} m and 6.67×10^{-2} m with wave periods between 0.8 s and 1.98 s were used.

Experimental Results and Discussion

Heave motion amplitudes for all the cases of flooding, for both lower and upper compartments, were found to be almost close to the heave amplitudes, when the model was not flooded or damaged.

Lower-compartment flooding without damage hole. A lower compartment is one extending below the waterline. Different stages of damage from intact to flooding and equalisation are modeled using the intact model at load draft and with 2 kg, 4 kg, 9 kg and 11 kg (mass) of water inside the small compartment. The following observations are made from the peak roll motion amplitudes measured in regular beam waves: a) Peak of the roll motion amplitudes occurs at the resonant periods; (b) peak roll motion amplitudes with water inside the ship are less than those of the intact ship; and (c) roll motion amplitudes when the amount of water inside is the same as that which will flood the compartment upon damage are found to be similar to the motion amplitudes without floodwater.

Lower-compartment flooding with damage hole. Motion measurements of the flooded model with and without a damage hole are made for both small and large compartments, keeping the amount of floodwater in the damaged and undamaged cases constant. The roll motion amplitudes of damaged and undamaged compartments are found to be almost the same. In this model, the righting lever curves with compartments intact and damaged are also found to be similar.

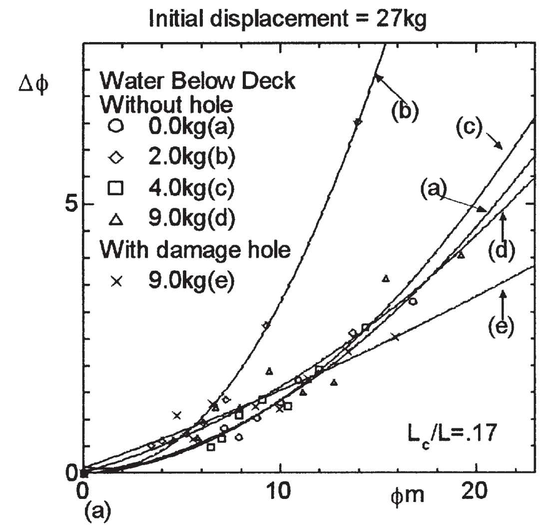

Fig. 1 Roll extinction curve for below-deck flooding

Damping due to lower-compartment flooding. Roll extinction curves obtained from free decay tests for lower compartment flooding are plotted in Fig. 1. For 2 kg of water inside, the extinction curve is steeper and the roll damping is increased by inside water, which reduces the roll amplitudes.

Upper-compartment flooding. An upper compartment is one wholly above the water level. Our studies also show that the flooding reduces with increase of freeboard (Roby, Hamano and Ikeda, 1996), and that when the ship is running into waves, the flooding rate through bow damage is high enough to capsize the ship within a few waves (Shimizu, Roby and Ikeda, 1996).

A deck is made 11.5 cm above the keel in the small compartment, and the region between this intermediate deck and the main deck is used for the floodwater in upper-compartment study.

Motion experiments were carried out for the initial draft of 80 mm and with 0.5 kg, 1 kg and 3 kg of water in the upper compartment. Maximum roll angles are plotted in Fig. 2 and the peaks found to be much less than those for the nonflooded case. This shows that the effect of water in the upper compartment on the roll motion is damping. However, studies done at Hokkaido University found that, sometimes, shallow water does not act as a roll damper (Amagai, Ueno and Kimura, 1996). Further studies are necessary to ascertain whether the upper-compartment flooding can endanger the dynamic stability of ships.

Damping due to upper-compartment flooding. Roll motion in roll decay tests with water in the upper compartment is quite different from that without any water. From the roll decay traces it is found that the natural period of roll changes with roll angles, and

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Received March 10, 1997: revised manuscript received by the editors June 16, 1998. The original version (prior to the final revised manuscript) was presented at the Seventh International Offshore and Polar Engineering Conference (ISOPE-97), Honolulu, USA, May 25-30, 1997.
KEY WORDS: Damage stability, floodwater, model experiments, ship motion, survivability criteria, safety.